European Commission

SUPPORT FOR THE IMPACT ASSESSMENT OF THE LEGISLATIVE PROPOSAL FOR A NEW EU FRAMEWORK ON FOREST MONITORING AND STRATEGIC PLANS

Final report

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FINAL REPORT

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1. Introduction and policy landscape

1.1 The policy landscape

Forests and other wooded land cover close to half of the EU's land surface. The ecosystem services they provide are crucial, including material and immaterial resources for human health and wellbeing, the socio-economic basis for industries and communities, as well as habitat for numerous species. However, forests and their multiple functions are under increasing pressures due to a changing climate, increased human activity and the associated land use changes.

The European Green Deal[1] called for action to improve the quantity and quality of the EU's forested areas to reach climate neutrality and a healthy environment, to improve human health and wellbeing, to improve the resilience of forests and to promote the circular bioeconomy. The ensuing EU Biodiversity Strategy for 2030[2] echoes that ambition and sets out a comprehensive, systemic, and ambitious long-term plan for protecting nature and restoring essential functions, reversing the degradation of ecosystems, including forests. The new EU Forest Strategy for 2030[3] is one of the flagship initiatives of the European Green Deal. It recognises the multifunctional role of forests, including the contribution of the entire forest-based value chain to achieving a sustainable and climate-neutral economy by 2050. Building on these premises, the strategy establishes a vision and defines concrete actions for improving the quantity and quality of EU forests and strengthening their protection, restoration and resilience. Adapting Europe's forests to the new conditions, weather extremes and high uncertainty brought about by climate change is a precondition for forests to continue delivering their socio-economic functions and to ensure vibrant rural areas.

The Forest Strategy foresees strategic forest planning in all EU Member States (MS), supported by robust forest monitoring across the EU. It states the following:

> *"[T]here are several scattered monitoring and reporting mechanisms, but no strategic framework, which would bring these together and make it possible to comprehensively and jointly with Member States demonstrate that the EU is on the right track and that the forests can actually deliver on their multiple demands and functions. Strategic forest planning in all EU Member States at national and, where applicable, regional level, that is based on reliable monitoring and data, transparent governance and coordinated exchange at the EU level, is needed for the delivery on the commonly agreed EU objectives can be ensured, especially regarding the transition to a climate neutral economy and the achievement of the biodiversity and circular economy ambition, including on the achievement of the removal targets as set out in the proposal for a revised Regulation on Land Use, Land Use Change and Forestry."*

Forests in the EU and the forest sector are subject to a complex policy framework, which sets ambitious targets and objectives that focus mainly on carbon storage, sustainable forest management, biodiversity and ecosystem services. Policy areas have different sets of tools: EU-level legislation, non-binding policy documents (e.g. strategies and guidelines) and financing from the EU budget.

[1] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE EUROPEAN COUNCIL, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS The European Green Deal COM/2019/640 final. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52019DC0640

[2] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS EU Biodiversity Strategy for 2030 Bringing nature back into our lives COM/2020/380 final. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52020DC0380

[3] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS New EU Forest Strategy for 2030 COM/2021/572 final. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A52021DC0572

Forest management operational choices lie predominantly with the MS. However, forests and forestry do not fall within the exclusive competence of MS and consequently the EU has set high ambitions for the EU bioeconomy, climate and energy. In general, the development of and adherence to sustainability goals, and the promotion of environmental compliance and governance is a cross-cutting element in EU policies.

The European Commission (EC) has been implementing policy instruments and regulations that directly or indirectly affect forests, such as the EU Regulation on land use and forestry,[4] the EU Renewable Energy Directive,[5] the EU Bioeconomy Strategy,[6] the European Green Deal, the EU Biodiversity Strategy, the EU taxonomy,[7] the Climate Law,[8] the EU Adaptation Strategy,[9] the Circular Economy Action Plan,[10] and finally the new EU Forest Strategy. The new forest strategy is anchored in the European Green Deal and the EU biodiversity strategy for 2030, with several legislative processes ongoing for the Fit for 55 package,[11] including the Renewable Energy Directive (Commission proposal of July 2021). Additionally, upcoming EU policy instruments are being developed, such as the Soil Health Law and Nature Restoration Law, which are currently in the process of legislative proposal drafting and consultation.

Coherent information infrastructure can support evidence-based policy and decision-making. This is needed both for monitoring by public authorities, as well as for research and innovation on sustainable forest management under changing climate conditions. Directives laying down the basis for sharing environmental information (access to public authorities, and availability and dissemination to the public[12]), and the general rules aimed at the establishment of Infrastructure for Spatial Information in the European Community,[13] together with the availability and development of Earth Observation (EO) data illustrate the means to develop both compliance promotion, compliance monitoring, follow-up and enforcement.

[4] Regulation (EU) 2018/841 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework, and amending Regulation (EU) No 525/2013 and Decision No 529/2013/EU (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32018R0841

[5] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L2001

[6] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A sustainable Bioeconomy for Europe: Strengthening the connection between economy, society and the environment COM/2018/673 final. See: https://eur-lex.europa.eu/legal-content/en/ALL/?uri=CELEX%3A52018DC0673

[7] Regulation (EU) 2020/852 of the European Parliament and of the Council of 18 June 2020 on the establishment of a framework to facilitate sustainable investment, and amending Regulation (EU) 2019/2088 (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32020R0852

[8] Regulation (EU) 2021/1119 of the European Parliament and of the Council of 30 June 2021 establishing the framework for achieving climate neutrality and amending Regulations (EC) No 401/2009 and (EU) 2018/1999 ('European Climate Law'). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32021R1119

[9] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS Forging a climate-resilient Europe - the new EU Strategy on Adaptation to Climate Change. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2021%3A82%3AFIN

[10] COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS A new Circular Economy Action Plan For a cleaner and more competitive Europe COM/2020/98 final. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2020%3A98%3AFIN

[11] See, for example: https://commission.europa.eu/strategy-and-policy/priorities-2019-2024/european-green-deal/delivering-european-green-deal/fit-55-delivering-proposals_en

[12] Directive 2003/4/EC of the European Parliament and of the Council of 28 January 2003 on public access to environmental information and repealing Council Directive 90/313/EEC. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32003L0004

[13] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). See: https://eur-lex.europa.eu/legal-content/en/TXT/?uri=CELEX%3A32007L0002

Evidence is needed on how the status of forests develops in Europe, where risks emerge and preventive/mitigating measures across MS are needed, as well as where infringement cases are found. Access to reliable environmental information is also a means to improve inclusive governance.

The framework on forest monitoring and strategic plans is placed in this evolving landscape: on one hand to ensure compliance with existing EU-level legislation and improve policy coordination across legislative proposals already underway at EU level, and on the other hand to support the development and coordination of strategies at national and, where applicable, regional levels.

1.2 The monitoring landscape

Since the Forest Focus Regulation[14] expired in 2007 there have been no unified reporting requirements for forests at European level. The need for continuous assessment and monitoring of the status, dynamics and evolution of European forests has been iterated several times, including the review of the Forest Focus and the Green Paper on Forest Protection and Information in the EU[15]. During the past decade, remote sensing methods have been evolving: the technological development of sensors in satellites, aircraft and harvesters, as well as the platforms for accumulating and sharing data illustrate new ways of thinking about how data can be collected, but also how data can be used for multiple purposes.

Forest monitoring is broad and can cover several aspects and sectors. Under the new EU sorest strategy, forest monitoring is to cover issues such as climate change (both mitigation and adaptation), biodiversity, health, damages, invasive alien species, forest management, and biomass use for different socio-economic purposes.

In the EU, there are already numerous efforts towards data collection and reporting operating at national, EU and international levels.

National Forest Inventories (NFIs), for example, are data collection efforts conducted on a regional or national level, while the Land Use and Land Use Survey (LUCAS)[16] is an EU process.

Reporting mechanisms such as the Land Use, Land Use Change and Forestry (LULUCF) and the National Environmental Economic Accounts are regulatory binding commitments for each MS, while the FAO's Global Forest Resource Assessment (FAO-Global FRA)[17] is an international initiative.

Further examples of the current EU systems of forest-related data collection and reporting are summarised in the following figure.

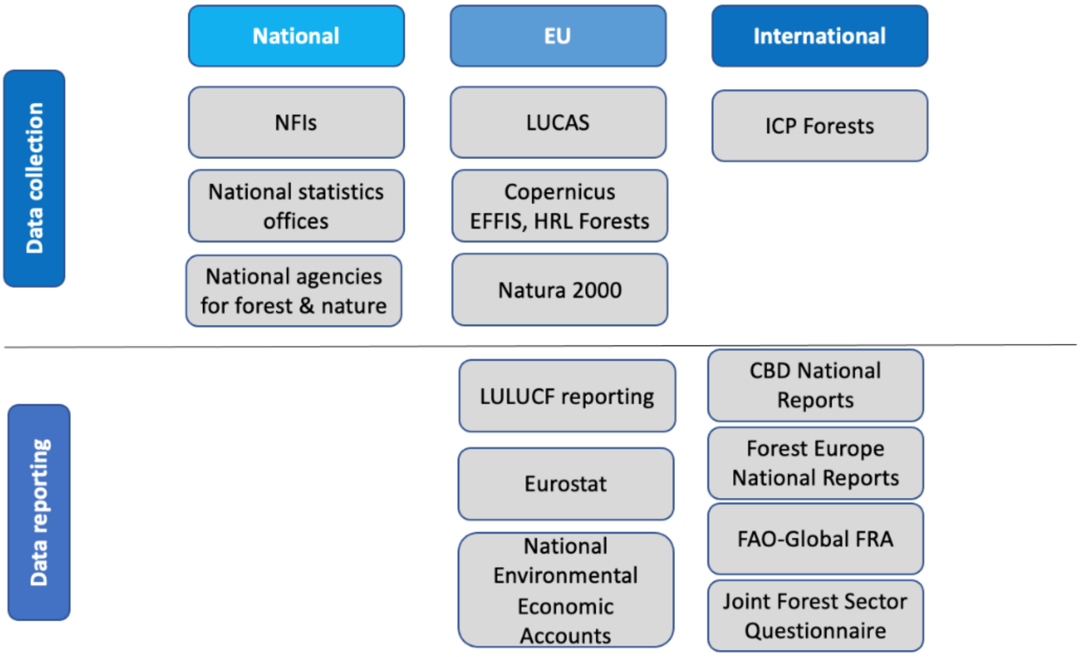
[14] Regulation (EC) No 2152/2003 of the European Parliament and of the Council of 17 November 2003 concerning monitoring of forests and environmental interactions in the Community (Forest Focus). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32003R2152

[15] See: https://www.europarl.europa.eu/meetdocs/2009_2014/documents/com/com_com(2010)0066_/com_com(2010)0066_en.pdf

[16] See for example here: https://ec.europa.eu/eurostat/web/lucas

[17] See for example here: https://www.fao.org/forest-resources-assessment/en/

Figure 1.1 Forest data collecting and reporting systems across the EU



Source: Own illustration

Several problems currently stand in the way of comprehensive forest monitoring in Europe. This is clear from studies that have clarified countries' ability to report to international processes such as Forest Europe[18], and other studies that looked at data availability and the potential for harmonisation or standardisation of forest information at national level[19], or in the context of forest monitoring[20].

Under the new forest strategy, the Commission plans to put forward a new legislative proposal on EU Forest Observation, Reporting and Data Collection to ensure a coordinated EU forest monitoring, data collection and reporting system. As part of this, MS competent authorities would prepare, for forests and the forest-based sector, so-called 'Strategic Plans for Forests', in full adherence to the subsidiarity principle and the Treaty on the Functioning of the European Union.

[18] Linser, S.; Wolfslehner, B. National Implementation of the Forest Europe Indicators for Sustainable Forest Management. Forests 2022, 13, 191, doi:10.3390/f13020191.

Baycheva-Merger, T.; Wolfslehner, B. Evaluating the Implementation of the Pan-European Criteria and Indicators for Sustainable Forest Management – A SWOT Analysis. Ecol Indic 2016, 60, 1192–1199, doi:10.1016/j.ecolind.2015.09.009

[19] Diabolo project Report on the Methodology for Biodiversity Assessment and Forest Conservation Status in Europe. Prospects and Recommendations for European Wide Assessments; 2019

[20] van Brusselen, J. User Needs and Requirements Baseline (D1-URB). Forest Carbon Monitoring Project Deliverable. ESA Contract 4000135015/21/I-NB; Espoo, Finland, 2021;

Gschwantner, T.; Alberdi, I.; Bauwens, S.; Bender, S.; Borota, D.; Bosela, M.; Bouriaud, O.; Breidenbach, J.; Donis, J.; Fischer, C.; et al. Growing Stock Monitoring by European National Forest Inventories: Historical Origins, Current Methods and Harmonisation. For Ecol Manage 2022, 505, 119868, doi:10.1016/j.foreco.2021.119868.

Diabolo project Synthesis Report on Data Demand and Data Provision, Including Data Flows at the Science-Policy Management Interface and the Barriers of Data Flows; 2017

2. Problem definition

2.1 What are the problems?

2.1.1 General problem

The general problem targeted by the legislative proposal on EU Forest Observation, Reporting and Data Collection is defined in the Forest Strategy for 2030 (section 4).

> *" Today the information concerning the status of forests in the EU, their social and economic value, as well as the pressures they face and ecosystem services they provide, is patchy. Since 2007, when the Forest Focus Regulation expired, no comprehensive reporting requirements exist. In addition, there are challenges related to the use of remote sensing data together with ground-based data (i.e. lack of interoperability, common definitions, ambiguity in data interpretation, lack of long and comparable very high resolution time-series, limitations of the current standard forest products from Copernicus). Also, there is insufficient planning for the forests, which would address in a coordinated manner and provide a comprehensive picture of the multifunctionality of forests in the EU, especially regarding climate mitigation and adaptation, ecological condition of forests, forest damage prevention and control, and forest biomass demand and supply for different socio-economic purposes. Combined with the need for more detailed sustainable forest management indicators and thresholds on certain climate and biodiversity aspects, this leads to a situation where, on the one hand, Member States have agreed at EU level to rely to a great extent on forests and forest-based bioeconomy in the EU's transition to a climate-neutral economy.*
>
> *On the other hand, there are several scattered monitoring and reporting mechanisms, but no strategic framework, which would bring these together and make it possible to comprehensively and jointly with Member States demonstrate that the EU is on the right track and that the forests can actually deliver on their multiple demands and functions."*

Forests play a key role in responding to climate change, preserving and restoring biodiversity and developing the bioeconomy. However, information about the status of forests in the EU, their social, ecological and economic value, and the pressures they face and ecosystem services they provide, is fragmented and patchy. Since 2007, when the Forest Focus Regulation was repealed, there have been no harmonised EU forest reporting requirements. Comparable and consistent information on the status of forests in the EU is consequently limited. Climate change is increasingly affecting forests and exacerbating forest disturbances and disasters. The lack of an EU-wide monitoring and reporting system means there is no comprehensive and timely overview of many forest damages, resources, management or trends.

2.1.2 Specific problems

Based on a literature review, five main areas have been identified as specific problems for EU-wide monitoring. These are described further below, including information on the main drivers behind the problems.

2.1.2.1 *Indicator coverage*

Wood resources have historically played an important role for human welfare. Consequently, over recent centuries, many of the efforts towards establishing forest monitoring systems across Europe have focused on accessing timber-related variables. The early forest monitoring and NFI endeavours were implemented due to the necessity of planning wood resources management. Historically these systems have an economic focus, targeting timber-related variables, such as the volume of growing stock.

However, the need for further forest information for resources management and compliance with monitoring and reporting regulations has promoted the expansion in forest monitoring scope over the years. For example, the LULUCF requires data on forest carbon, while REDII[21] requires information on different variables in order to assess sustainable criteria such as conservational values, impacts on soil and biodiversity, regeneration, among others. Despite the expansion in scope over the years, there are still numerous information needs across the EU and MS that are not currently met by the forest monitoring system in place. European forests vary vastly in their characteristics (e.g. ecology, forest management, etc.), presenting country-specific conditions that influence the forest monitoring systems. Data collection and availability vary between countries, depending on purposes, methodological approaches, country-specific conditions and data needs. For instance, some of the indicators covered by Belgium's NFI, such as herb and shrub layers, naturalness, and the presence of red-listed species, are not covered by The Netherlands' NFI. In contrast, the Dutch NFI covers indicators that are not present in the Belgium forest monitoring systems such as noise and reachability, among others.

Even though each MS collects different indicators in their forest monitoring systems, these efforts do not normally deliver sufficiently detailed information for certain topics, such as forest disturbances, socio-economic indicators, biodiversity, agroforestry, bioeconomy, climate change adaptation, mitigation and carbon. A fundamental driver for the scarcity of data on these topics is their complexity; there are technical and methodological challenges that hinder the data collection. The establishment of indicators and data assessments on biodiversity, socio-economic and protective functions is a difficult procedure. For instance, Alberdi et al. (2019)[22] assessed that the main challenges of reporting the conservation status of Natura 2000 forest habitats in Europe are related to the identification of effective indicators, the definition of thresholds, mapping, monitoring design and costs, and keeping the data up to date. Explaining and interpreting information about the value of biodiversity through indicators to decision-makers is also highlighted as an important challenge.

Because of the difficult process of developing indicators for certain topics, and because of the complex nature of data collection involving the assessment of these indicators, problems such as too much reliance on proxy indicators, poor acceptance of qualitative data, excessive simplification of complex systems, or an excessive number of indicators to interpret a theme, are considered a source of concern. Forest monitoring systems such as the countries' NFIs are often relying almost exclusively on tree-dependent variables, although, for example, non-tree vegetation is an important indicator for assessing biodiversity, conservation status and the carbon dynamics of a forest area. However, due to its complexity, ground vegetation surveys are not broadly assessed in NFIs across the EU. Another important theme that currently exhibits poor data collection and use are non-wood forest products, being reported only in a limited number of countries and products. The reason why data on non-wood forest products (NWFP) is considered incomplete and scattered can be attributed to the low perceived importance of their impact on the forests, the difficultly in quantifying these wild products, since most of them are used for self-consumption, and due to different definitions and classifications. Climate change is yet another theme that is difficult to assess, since forest exposure and vulnerability to climate change is a complex, multi-dimensional topic. Many institutes across Europe assess climate change indicators, but there is still heterogeneity regarding the variables assessed, the models used, and the interpretation of the indicators.

Since the demand and scope of forest information needs have increased, the current monitoring efforts do not allow for monitoring of progress towards objectives and do not cover all existing needs.

[21] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32018L2001

[22] Alberdi, I.; Nunes, L.; Kovac, M.; Bonheme, I.; Cañellas, I.; Rego, F.C.; Dias, S.; Duarte, I.; Notarangelo, M.; Rizzo, M.; et al. The Conservation Status Assessment of Natura 2000 Forest Habitats in Europe: Capabilities, Potentials and Challenges of National Forest Inventories Data. Ann For Sci 2019, 76, 34, doi:10.1007/s13595-019-0820-4.

Data availability is not aligned with policy-based information needs for monitoring or compliance. Meanwhile, data collection efforts may be duplicated to serve the interests of different sectors or different purposes.

Table 2.1 Summary description of the problem area "Indicator coverage"

Category	Description
General description	Information systems exist in parallel, either serving operational or strategic goals. Data systems are limited in scope (not sufficiently cross-sectoral, not inclusive of all themes/stakeholders). Data collection efforts do not deliver sufficiently detailed information for certain topics, including forest disturbances, socio-economic indicators, biodiversity too reliant on proxy indicators, agroforestry, bioeconomy, climate change adaptation, mitigation, carbon and qualitative indicators.
Scale	EU-wide, Regional, National or Regional level.
Main drivers	Each NFI in Europe differs due to its unique historical origin, purposes and information needs. Data availability and national concepts vary between countries. Historically, NFIs have had an economic focus. There are technical and methodological struggles that hinder the data collection of certain themes and topics due to their complexity. The establishment of indicators and data assessments on biodiversity, socio-economic and protective functions is a difficult procedure.
Consequences	The data collection effort does not currently allow the monitoring of progress towards objectives and does not cover all existing needs. Data availability is not aligned with policy-based information needs for monitoring or compliance. Meanwhile, data collection efforts may be duplicated to serve the interests of different sectors or different purposes.
No-policy-change scenario, including trends	Indicators with missing or partial data coverage mostly remain as such, with the exception of some bioeconomy indicators for which data will become available midterm, as they are under development, e.g. through the Knowledge Centre for Bioeconomy. Methodologies and data products for forest disturbance indicators are in development in a number of Horizon Europe projects, but as project outputs these will be removed from a proven, operational pan-EU monitoring system. Methods for biodiversity monitoring will mostly develop further for proxy indicators on the basis of Earth Observation-based monitoring of forest structural diversity and tree species – but not operational in a pan-EU monitoring system.
Stakeholders	NFIs and Earth Observation; existing European, EU and regional assessment frameworks.

2.1.2.2 *Accessibility*

Access to official forest data is limited, depending on the user groups. For example, NFI metadata such as plot measurements, and especially their geographical coordinates, are usually not accessible outside the national authority organisations. Thus, it can be considered that the organisations behind the forest information systems are not only providing data but are also participating in its selection and interpretation.

Information-sharing policies and legislation, intellectual property rights (IPRs), inter-organisational arrangements and fragmented data systems represent a significant barrier to the access and exchange of forest information. Additionally, open access to NFI data triggers concerns regarding misuse and misinterpretation due to conflicts of interest, as well as deliberate interferences on the forest plots if exact geographical locations are provided. Moreover, the dissemination of the data also faces issues, while the technical forest information lacks simplicity and easy communicability, and often is not compatible with the information needs of other sectors and non-forest users. For example, forest information does not sufficiently meet the needs of cross- and multi-sectoral policy areas, such as the environment, rural development and bioeconomy. Furthermore, forest information use can be biased due to preferences or perceptions.

Different dissemination preferences are a significant issue in communicating forest information to different user groups. While metadata can be the preferable option for some users, such as researchers, other groups would prefer national reports. It is suggested by the literature that some forest information sources overlook the public interest in forest-related matters, as they adopt a technical/scientific language and exclude non-forest experts and the social dimension. In addition, the dissemination of forest information is weakened by the use of platforms that are not user-friendly and websites that are not fully working.

A study by Baycheva-Merger et al (2018)[23] concluded that one of the major reasons for constraints in the exchange of forest information is the "lack of motivation and willingness due to a lack of political, social and/or economic incentives for data collection, processing, provision, and dissemination". In addition, there can be uncertainties among data providers about what data should be made public. An additional drawback hindering forest data access can be the asserted ownership rights that some of the data collectors retain over the data.

As a consequence, the usefulness of the information, or more precisely the way in which information is delivered, does not meet the needs of the intended users. Therefore, data systems are not serving all existing information needs. Limiting data access can also constrain the exchange and acquisition of, for example, scientific forest information and cross-sectoral connection. Besides, it potentially slows the development of NFI plot data and further monitoring developments.

Table 2.2 Summary description of the problem area "Accessibility"

Category	Description
General description	Access to official forest data is limited, depending on the user's group. Typically, forest data would be published in reports of the NFIs or by uptake of NFI data in other official reporting. Meanwhile, the plot measurements and/or plot coordinates are not accessible to researchers outside the national authorities' organisations. Furthermore, the dissemination of the data faces problems, too, as many times what is shared is not expressed in a form that is usable by the intended users.
Scale	EU-wide, Regional, National or Regional level
Main drivers	Information-sharing policies and legislation, IPRs' inter-organisational arrangements and fragmented data systems represent a significant barrier to access and exchange of forest information. Supporting open NFI data triggers concerns regarding misuse and misinterpretation due to conflicts of interest, as well as purposely interfering on the forest plots if exact geographical locations are provided.
Consequences	Data systems are not serving all existing information needs. Limiting data access can constrain the exchange and acquisition of scientific forest information, for example. Potentially slows the development of NFI plot data and further monitoring developments.
No-policy-change scenario, including trends	Existing limitations remain, particularly preventing the widespread availability of in situ (plot) data. The inaccessibility of official data could promote the creation of, and reliance on, alternative data sources.
Stakeholders	National Forest Inventories and Earth Observation

[23] Baycheva-Merger, T.; Sotirov, M.; Holmgren, S.; Selter, A. Institutional and Actor-Oriented Factors Constraining Expert-Based Forest Information Exchange in Europe: A Policy Analysis from an Actor-Centred Institutionalist Approach. Forests 2018, 9, 129, doi:10.3390/f9030129.

2.1.2.3 *Comparability*

Forest information and data monitoring systems are not comparable across the EU. Since NFIs in Europe present particular origins, purposes, country-specific methodologies and information needs, there is lack of harmonisation and standardisation between different monitoring systems. Even basic concepts and the definition of key forest variables are not yet consistent between countries. For instance, many EU countries use different definitions for forests, forest types, and forests available for wood supply. The manner in which the LULUCF Regulation treats the diversity of forest definitions across the EU is by detailing the minimum values for area size, tree crown cover and tree height parameters for each EU Member State in Annex II to the Regulation.

There is a lack of harmonisation between several indicator sets inside the EU, such as biodiversity, forest management, wood harvesting, among others, which can be adapted to the specific local and forest conditions. In many cases national datasets are not compatible with international definitions, are available only in local languages, or the methodology applied to assess indicators is not commonly agreed or transparent. Growing stock, for example, an indicator that is commonly estimated by NFIs, is dependent on different basic variables and mathematical functions to estimate tree volume across European countries. The lack of harmonisation of some variables and indicators can also be due to the reliance of transfer functions and conversion factors on auxiliary data, which are not always available. In some cases, the presence of long data series can make changes to the dataset harder to be adopted and accepted. Another factor that can hinder the standardisation and comparability of forest information is the change of data requirements from NFIs over time.

Furthermore, the lack of benchmarks, thresholds and targets hinders the comparability of forest resources. The establishment of targets and thresholds is politically sensitive and difficult to homogenise at country level. For instance, establishing EU-wide thresholds may imply lifting, or in some cases lowering, environmental, social or political standards. Even at a national level, the distinct objectives of different sectors can negatively influence the establishment and adaptation of criteria and indicators. Furthermore, according to the literature, in many cases the indicators used are not necessarily the most appropriate information required for the regulation targets. Some of the forest-related definitions can also be a result of the policy process instead of science-based evidence, hindering the correct comparability of forest information.

These incomparability issues result in a lack of clear and integrated EU-wide monitoring results. Data for many indicators cannot be readily compared between countries and does not form a basis for assessment. This could constrain the synergy of policy and international agreements, as well as hindering a holistic view of the status of forest resources in the EU, and their future outlook. Major adjustments would be required to the current indicators used in Europe in order to be able to assess EU forest-related regulation targets.

Table 2.3 Summary description of the problem area "Comparability"

Category	Description
General description	Forest information and data monitoring systems are not comparable across the EU, due to harmonisation and standardisation issues. Furthermore, the lack of benchmarks, thresholds and targets hinders the comparability of forest resources.
Scale	EU-wide, Regional, National or Regional level
Main drivers	NFIs in Europe differ from each other as they each have unique historical origins, purposes and methodologies that vary according to country-specific conditions and information needs. Even concepts and the definition of key forest variables are not consistent between countries. Additionally, there is a lack of harmonisation between several indicator sets inside the EU. The establishment of targets and thresholds is also politically sensitive and difficult to homogenise at country level.

Category	Description
Consequences	Lack of clear and integrated EU-wide monitoring results. Data for many indicators cannot be readily compared between countries and does not form a basis for assessment through targets or benchmarks.
No-policy-change scenario, including trends	Harmonisation of NFI systems remains dependent on cost actions and Horizon Europe projects that bring NFIs together (via ENFIN[24] or other cooperation modalities).
Stakeholders	National Forest Inventories and Earth Observation

2.1.2.4 *Quality*

Accuracy, transparency, timeliness, continuity and duplicity (or competing datasets) are key issues regarding the quality of forest monitoring. The quality of datasets and indicators on some topics varies among the EU MS. In some cases, more attention is given to quantitative information over qualitative, which can cause low precision in some indicators, such as biodiversity indicators, whereas too much reliance on proxy indicators can lead to accuracy problems. Normally, NFI plots and in situ data are collected at large intervals of between 5 and 10 years, creating patchiness and data gaps in reporting.

Generally, in situ based NFIs lack the spatial continuity of remote sensing tools. However, for EO-based data collection, very few EO-based datasets are regularly repeated, and a trade-off still exists between temporal and spatial resolution. Besides that, not all key indicators can be assessed only through EO techniques, while for other indicators or themes, assessment through EO-based data can be insufficiently accurate. For instance, data on land use change cannot be assessed only by the interpretation of EO data; if using only EO resources, it could take years to validate the land use category. There are also some themes that are not yet deeply explored by the by EO techniques, such as the Conservation Status of the Natura 2000 network. Additionally, limitations involving the acquisition of reference data or the lack of correlation between field forest attributes and EO data negatively affect accuracy. The literature raises concerns regarding the interoperability, common definitions, and ambiguity in data interpretation of EO-based monitoring systems. Furthermore, the emerging techniques, plus diverse and evolving data, standards and definitions can pose challenges for assessing the quality of EO-based data collections.

Although generally most data producers seek to provide the most feasible accurate data, it is known that international data of all kinds have substantial errors. Distinct stakeholders can also have different perceptions of forest information credibility and method reliability. Moreover, competing datasets are also an issue, as the assessment of forest indicators by different organisations provides different information. A trade-off between continuation and innovation can also be considered an issue, as emerging techniques can contribute to differences in measurements. Overall, data quality cannot always be quantified or evaluated, causing reliability issues.

Table 2.4 Summary description of the problem area "Quality"

Category	Description
General description	Data quality (accuracy unclear or not sufficient, competing datasets); Data continuity (spatial, temporal, no high resolution-high frequency combined).
Scale	EU-wide, Regional, National or Regional level
Main drivers	The quality of datasets and indicators on some topics varies between MS. More attention is given to quantitative information over qualitative, which can cause low precision in some indicators, such as biodiversity indicators. Too much reliance on proxy indicators can lead to accuracy problems. The assessment of the same forest

[24] See: https://enfin.info/

Category	Description
	indicators by different organisations normally provides different information. Very few EO-based datasets are regularly repeated, while a trade-off still exists between temporal and spatial resolution. Not all key indicators can be assessed only through EO techniques. Limitations involving the acquisition of reference data negatively affect accuracy. In situ data are collected at large intervals of between 5 and 10 years. A trade-off between continuation and innovation.
Consequences	Data quality cannot always be quantified or evaluated, causing reliability issues. Big intervals between measurements create data gaps. EO-based data can be insufficiently accurate for some indicator themes or indicators.
No-policy-change scenario, including trends	Data quality and data continuity would remain, for most indicators, in the current state, with some exceptions, particularly relating to the monitoring of forest-based carbon and several bioeconomy-related indicators.
Stakeholders	National Forest Inventories and Earth Observation

2.1.2.5 ***Strategic planning***

Strategic target-setting, planning, and related monitoring and reporting concerning forests and the forest sector are scattered across policy sectors at regional, national and EU levels. Possible explanations for the status quo can be the complexity of measuring some forest features, such as biodiversity, creating a difficulty for agencies to select relevant indicators for policymaking and forest management. Besides, standardisation is difficult due to country and even region-specific conditions, and the changing information needs over time. There is a lack of cross-sectoral cooperation and a lack of institutional coordination among national and international data providers. There is no consistent language among the policy community, which utilises different terminology and concepts. In addition, there is a lack of synergy with other policy targets, and no consistent monitoring approach for implementation progress.

Motivation and willingness towards more coherent policy development can be low, due to lack of political, social, and/or economic incentives for data collection, processing, provision and dissemination. There is therefore no overview of strategic plans and targets concerning the forests and forest-based sector in the EU, which makes it difficult to harmonise or to avoid counterproductive approaches.

Table 2.1 Summary description of the problem area "Strategic planning"

Category	Description
General description	Strategic target-setting, planning and related monitoring and reporting concerning forests and the forest sector are scattered across policy sectors at regional, national, and EU levels
Scale	National and regional level
Main drivers	Some forest features such as biodiversity are too complex to measure with just a couple of indicators. This makes it hard for agencies to select relevant indicators for policymaking and forest management. Besides, standardisation is difficult due to country- and even region-specific conditions, and changes in information needs over time. Lack of cross-sectoral cooperation and coordination, as well as lack of institutional coordination among national and international data providers. There is a lack of synergy with other policy targets and no consistent monitoring approach for implementation progress. Finally, there is a lack of motivation and willingness due to a lack of political, social and/or economic incentives for data collection, processing, provision and dissemination.

Category	Description
Consequences	Without a holistic overview of strategic plans and targets, it is difficult to harmonise efforts towards forests and the forest-based sector in the EU, or to avoid counterproductive approaches.
No-policy-change scenario, including trends	Lack of oversight and consistency will remain in forest-related strategic planning between complementary policy domains; benchmarking or target-setting will unlikely be achieved; and incentivisation to streamline and improve pan-EU forest monitoring will depend on sectoral legislation addressing only interests in very specific indicators.
Stakeholders	National Forest Inventories and Earth Observation; National and regional public authorities

2.1.3 Consequences - why is it an issue?

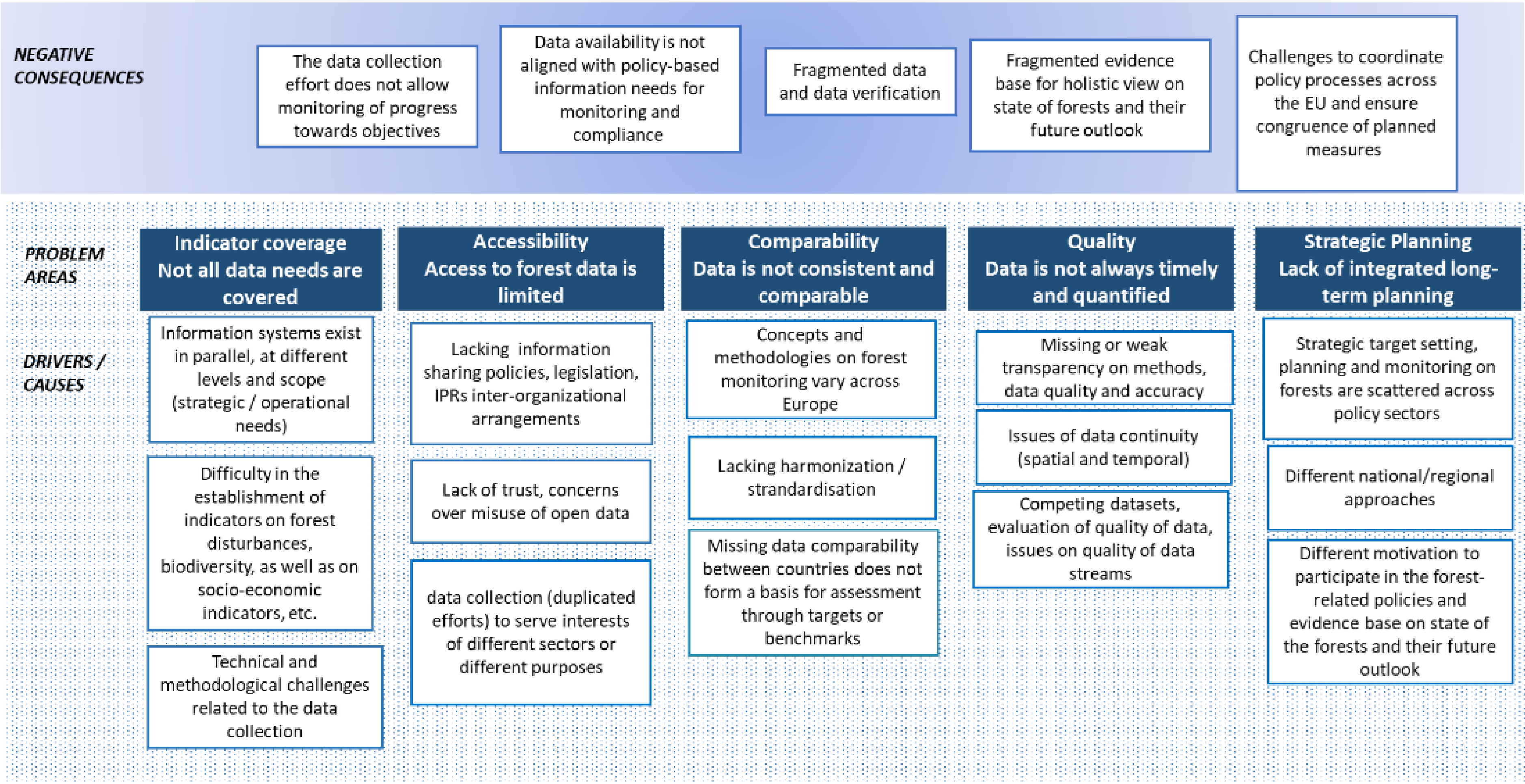
Information on forests in the EU does not currently allow policy responses to be adjusted to actual needs, nor demonstrate that the EU is on the right track and that our forests can deliver on their multiple demands and functions.

The negative consequences from the problems identified concerning forest monitoring and strategic planning are as follows:

- the data collection effort does not allow monitoring of progress towards objectives;
- data availability is not aligned with policy-based information needs for monitoring and compliance;
- fragmented data and data verification;
- fragmented evidence base for a holistic view on the status of forests and their future outlook;
- challenges to coordinating policy processes across the EU and ensuring congruence of planned measures.

The following figure (problem tree) summarises the consequences of the problems. The consequences are described further below the figure.

Figure 2.1 Problem tree of the Framework on Forest Monitoring and Strategic Plans.



Source: Own illustration

The "indicator coverage" problem area describes the current situation where not all data needs are covered: Information systems exist in parallel, either serving operational or strategic goals. Data systems are limited in scope (not sufficiently cross-sectoral, not inclusive of all topics/stakeholders). Data collection efforts do not deliver sufficiently detailed information for certain topics, including:

- forest disturbances (drought, storm damage, near real-time fire monitoring, biotic agents including wildlife damage; prediction, early detection, stock-taking);
- socio-economic indicators;
- bioeconomy; and
- agroforestry.

Furthermore, biodiversity is too reliant on proxy indicators. As a consequence, reporting towards the agreed targets at EU level, but also coordination of the ongoing EU-level policy processes, *ex ante* impact assessments and congruence of planned policies/measures remain scattered.

The "accessibility" problem area describes the situation of limited access to forest data. Access to data is complicated for practical and legal reasons, which especially applies to in situ data, data-sharing and IPR. Not all monitoring schemes provide access to raw and/or processed data and/or information other than to primary or intended users or uses. Connecting with the "indicator coverage" problem area, data availability is not aligned with policy-based information needs for monitoring or compliance at EU level. Meanwhile, data collection efforts may be duplicated to serve the interests of different sectors or different purposes. At EU level, this results in a fragmented information system that is not serving all information needs, thus limiting its use for compliance monitoring but also for the stakeholders, such as the forest-based sector and NGOs, as well as scientific research.

The "comparability" problem area describes the current situation where forest data is not consistent and comparable. This refers to definitions, methods, harmonisation and standardisation issues. Data for many indicators cannot be readily compared between countries and does not form a basis for assessment through targets or benchmarks. Assessment of impacts and the effectiveness of EU-level policies affecting forests remains difficult, but also the evidence base for a holistic view on the status of forests and their future outlook remains fragmented.

The "quality" problem area describes the current situation where forest data is not always timely and quantified. There are concerns about the accuracy of data (unclear or not sufficient), competing datasets, as well as data continuity at spatial and temporal scales (no high resolution-high frequency combined). Moreover, data quality cannot always be quantified or evaluated. Very few EO-based datasets are regularly repeated, while a trade-off still exists between temporal and spatial resolution. In situ data are collected at large intervals of between 5 and 10 years. At EU level, weak or deficient transparency on methods, data quality and accuracy hinder tackling the shortcomings in data systems, but also impact on trust in/reliability of forest monitoring across the EU.

Finally, the "strategic planning" problem area describes the current situation without integrated long-term planning. Strategic target-setting, planning and the related monitoring and reporting concerning forests and the forest sector are scattered across policy sectors at regional, national and EU levels. There is no overview of strategic plans and targets concerning forests and the forest-based sector in the EU. As a consequence, it remains difficult to coordinate long-term planning in a holistic cross-sectoral manner and to avoid counterproductive approaches.

2.2 What are the problem drivers

The descriptions of the specific problems already include details on the drivers that lead to these problems. The key drivers can be summarised as follows.

The monitoring system architecture in Europe has historic origins: MS have developed their NFIs due to their own historical origin, purposes and information needs. There are data and time series accumulated, as well as knowledge bases developed over the decades in MS. The data collected is not consistent across the EU due to diverging indicators in the nationally/regionally important strategy processes, whether it was wood for industrial use, non-wood goods and services for local use, or the multiple benefits provided by forests for rural and/or urban populations. While the socio-economic aspects of forest information, such as roundwood production, have a long history in a number of MS, monitoring environmental aspects, such as the benefits of forests for climate change adaptation and mitigation, for biodiversity and other less economic/market-valued ecosystem benefits is a relatively recent concern. There are technical and methodological challenges. Climate change impact assessments and biodiversity impact assessments are challenging *ex ante*, even though the increasing risks are recognised internationally and, increasingly, also observed locally.

For access to data, the information-sharing policies and legislation, IPRs' inter-organisational arrangements and fragmented data systems are not well developed. There are international processes and collaborations (ICP Forests[25], NFI collaboration in ENFIN, and several international projects) which seek to improve forest monitoring and information, including Europe-wide issues. Missing data comparability between countries does not form a basis for assessment through targets or benchmarks. Comparability of data across national/regional systems, however, remains challenging due to the vested investments in the existing systems: data already accumulated, long time series available on controlled plots, as well as knowledge developed in NFIs and other forest monitoring systems are valuable resources. There are issues of trust (misuse of open data), as well as concern about duplicated efforts to serve data needs for different purposes.

To ensure the quality of data, in situ plots and remote sensing data are both needed, but the building of the infrastructure and necessary methodologies to, for example, utilise the EO data is evolving. Not all key indicators can be assessed through EO techniques alone, and user needs vary by level/scope of and purpose of the data analysis. Considerable research and development are still needed, improving the transparency of methods, data quality and accuracy, as well as evaluating data and issues around the quality of data streams.

While recognition of the numerous benefits of forests (energy and climate, biodiversity, socio-economic benefits, human health and wellbeing) is increasing, lack of cross-sectoral cooperation and coordination in policymaking remains a challenge. Forest monitoring and information not only serves the national forest policies and the demands on forests locally, but also an increasing number of international commitments, not least at EU-level. Green economy targets acknowledge the socio-economic and environmental emphasis placed on them, and the development of the forest monitoring and information system(s) is undoubtedly part of the ongoing political debate, too. Motivation to participate in forest-related policies varies, as does the motivation to develop an evidence base on the status of forests and their future outlook.

Exogenous drivers (those that will affect the size of the problem, but remain outside the scope of the initiative) include:

- Climate change and its implications (extreme weather conditions, biotic and abiotic damage on forests), increasing uncertainties, and a lack of empirical basis available to simulate future changes and their impacts. It remains uncertain how extreme the extreme events will become, and what social, political and economic consequences they will have[26]
- Pressures on natural resources (e.g. the current geopolitical situation, and its impacts on long-term energy supply/energy security)[27] . It remains uncertain how the environmental, social and economic benefits of forests will be valued in the face of increasing scarcities and insecurities.

[25] See: http://icp-forests.net/

[26] Lindner, M.; Verkerk, H. How has climate change affected EU forests and what might happen next? (https://efi.int/forestquestions/q4)

[27] Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319

- Technological development (e.g. the new scale of sensor-based data, early warning strategies, digital twins of natural resources, platform economy solutions, public-private partnerships): digitalisation and the green transition can reinforce each other, but this also necessitates socio-economic changes[28]. It remains uncertain what outcomes the systemic change will have.
- Changing social perceptions (including Urbanisation, also with a direct influence on private forest ownership)[29]. European citizens appreciate forests the most for their environmental benefits[30], while the economic importance of forests, e.g. provisioning forest ecosystem services such as timber and fuelwood, but also berries and mushrooms, is ranked lower. Studies point to regional differences regarding the acceptance of different forest management practices, although there is no systematic overview study at European scale. Traditional forest uses differ considerably across countries, as do their ecological characteristics across Europe. However, benefits can rise in importance quickly, as recognised in the use of recreation opportunities during the COVID-19 pandemic. It remains uncertain how public opinion on forests, forest management and use will change with the ongoing environmental, economic and technological changes. The COVID-19 pandemic and the Russian invasion of Ukraine are examples of 'wild cards' that may have a high impact on long-term developments, including externalities and unpredictable counter impacts on forests and their uses. System management is challenging. Instead, resilience to multiple possible developments should be developed.

The exogenous drivers can drastically influence the problem drivers. An improved knowledge base is a means to mitigate uncertainties, improve preparedness and also prepare for alternative scenarios.

2.3 How likely is the problem to persist?

While forest-related data needs are increasing in several EU policy fields, and indicators are defined for monitoring the status of forests and demands on forests, the challenges related to information systems, common indicator development, technical and methodological challenges are likely to persist. Considering the latest reporting year in the State of Europe's Forests 2020 (Forest Europe), forest data availability differs greatly across Europe. While many international frameworks collect information on forest vitality (ICP Forest), fragmentation (JRC), and the occurrence of common forest birds (PECBMS)[31], data availability for other forest indicators remains scarce. This is the case, for example, for forest land degradation (data available in six countries out of the EU27) or threatened forest species (data available in nine countries out of the EU27). Without a common framework for monitoring, the efforts are likely to remain scattered, and data coverage is not sufficient to cover EU-wide assessments.

The necessity of addressing challenges related to the integration of remote sensing and ground-based data is recognised in MS and in international processes, including ongoing research and development. Among the more relevant challenges are the lack of interoperability, common definitions, ambiguity in data interpretation, a lack of long and comparably very high resolution time series, and the limitations of the current standard forest products from Copernicus. In this context, just a few forest indicators could currently benefit from advanced harmonisation. These are primary forest resources-related indicators (e.g. forest area, growing stock volume and forest carbon) and biodiversity-related indicators (e.g. protected forest areas, deadwood, common forest birds).

[28] Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319

[29] Ranacher, L., Pûlzl, H., Tyrväinen, L., Winkel, G. What do people think about forests in the EU? In: Mauser, H (ed). 2021. Key questions on forests in the EU. Knowledge to Action 4, European Forest Institute, ISBN 978-952-7426-06-7, doi:10.36333/k2a04

[30] European Commission, Directorate-General for Environment, Attitudes of Europeans towards biodiversity, European Commission, 2019, https://data.europa.eu/doi/10.2779/456395

[31] Pan-European Common Bird Monitoring Scheme (PECBMS)

Without a common framework, the development of monitoring, reporting and verification systems can continue, for example, in development projects, but EU-wide data comparability, coverage, quality and timeliness remains a challenge.

Planning on forests (forest strategies at MS level or applicable regional levels) is arranged according to MS/regional strategic goals and the governance structures and institutions in place. An integrated strategic plan considering the role of forests and their contribution to EU-wide goals remains a challenging target, not least due to the cross-sectoral nature of forest-related questions at local, regional, national and international levels. Several scattered monitoring and reporting mechanisms are ongoing. Without an EU framework for forest monitoring, it remains challenging to demonstrate that the EU is on the right track, and that the forests can actually deliver on their multiple demands and functions.

3. Why should the EU act?

The demands placed on forest ecosystems in the EU are increasing, while reliance on bio-based resources in the EU for material and energy use is expected to grow. Meanwhile, the pressures on the forest ecosystems are also increasing due to climate change and an increase in the geographical spread, severity and frequency of damage from forest fires, storms, floods, insects and pests (including alien invasive species) – requiring timely risk detection, intervention and post-calamity support information.

Forest information has been collected by some EU MS for over 100 years, while the monitoring processes in other countries are more recent. The monitoring systems have developed in isolation and while progress has been made in the past 30 years to harmonise definitions and approaches for some basic forest indicators, significant indicators need harmonisation, and differences in the timing of and the varying and relatively long time between in situ assessments also further limits the comparability and usefulness of existing data.

The spatial and temporal resolution of in situ assessments is too coarse and may not capture the status that needs to be monitored. Fast intervention and response mechanisms would need reliable, sometimes near-real-time and more up-to-date data and information than is currently available, e.g. for status and changes in forest biomass, but also in relation to forest disturbances.

The combination of monitoring and strategic plans relates to foresight, based on a multi-stakeholder forest ecosystem and forest sector scenario-based forecasting of ecosystem services, as well as bioeconomy markets – for which current efforts are, however, only voluntary and not equally implemented in MS. This links closely to the topic of strategic plans, bringing together information on past and current status, and which through different policy and societal development scenarios assess the possible future outcomes.

Measures to improve monitoring and strategic planning for forests are needed at EU, MS, and regional/local levels, as well as by the private sector.

Why EU legislation is needed:

- To improve the timeliness and comparability of assessments across the EU, to ensure the targetsset for the EU climate, land use, and biodiversity and bioeconomy goals are being reached, and where different courses of action may be needed.
- To level the varying capacities and the different information needs (linked to the heterogeneity of the forest types) that exist in MS regarding forest monitoring.
- Mechanisms for early warning, intervention and post-calamity support for forest disturbances across MS borders.
- Monitoring of compliance with LULUCF, REDII, and the Sustainable Financing Regulation; the rules of EU funding (e.g. CAP funding for afforestation/reforestation) as well as for implementation of the measures by the private sector (e.g. green financing, third-party SFM certification schemes, CSR and sustainability reporting).

MS, together with international processes and collaborations, such as the ICP Forest, NFI collaboration in ENFIN, and several Horizon Europe projects (such as PathFinder[32], ForestPaths[33], eco2adapt[34]) have valuable resources, infrastructure and accumulated data that are important for the above-mentioned tasks.

While the project should lead to the development of methodology applicable across EU countries and improve the consistency, timeliness and reliability of data provision for several key forest indicators, on their own they do not have the resources to build the necessary indicator coverage and

[32] https://pathfinder-heu.eu/

[33] https://forestpaths.eu/

[34] https://www.eco2adapt.eu/

operational monitoring infrastructure, the information-sharing policies to ensure access to data, and the comparability and quality of data across the entire EU. That would have to be ensured through operational infrastructure such as EFIS, Copernicus and Eurostat. The EC'sresources, including the EO infrastructures and environmental information-sharing policies and platforms, can be mobilised to support the tasks which MS and international collaboration (including Forest Europe) need to accomplish. At the same time, intensifying collaboration on forest information and monitoring can improve the dissemination of new technology across the EU, and adapt emerging tools for the varying conditions and needs of the MS.

4. Objectives: what is to be achieved?

4.1 General objective

This section formulates the requirements for an EU monitoring system and Strategic Plans for forests according to the EU Forest Strategy. As a general objective, the intervention seeks to contribute to the EU commitment to combat climate change, sustainability goals, and a high level of protection and improvement in the quality of the environment, by improving EU Forest Observation, Reporting and Data Collection.

4.2 Specific objectives

Based on the description and definition of the problems and problem drivers regarding forest monitoring and forest planning in the EU, the requirements for an EU monitoring system and Strategic Plans for Forests are defined as follows:

4.2.1 EU priority topics are covered through monitoring

While current national forest monitoring systems and data collection have been developed for national objectives, data collection has historically focused mainly on the economic performance of forests, and less on the monitoring needs for, for example, biodiversity, carbon, forest disturbances, and climate adaptation. Consequently, the indicator coverage does not cover all – or new foreseen – monitoring needs for forests at EU level.

The specific objective for the framework for forest monitoring and strategic plans for forests is to support implementation of EU policy priorities and instruments. These are already foreseen in the EU Forest Strategy for 2030 and include topics such as climate change effects, biodiversity, health, damages, invasive alien species, forest management, and biomass use for different socio-economic purposes.

Means towards this goal are the establishment of key indicators on forests in the EU on the priority topics, and technical/technological and methodological means for data collection, interpretation (concepts, definitions, methods) and data sharing. The contribution of the monitoring system is thus to meet the monitoring needs of existing and upcoming EU regulations as well as to improve coordination of the EU-level policies directly and indirectly affecting forests.

4.2.2 Accessibility to forest data is improved

Ownership, privacy rights and the security of forest data vary across agencies collecting forest data, including both remote sensing and field-collected data. Limited access to existing forest data causes data gaps and possibly slows down the development of monitoring systems. A specific objective of the Framework is to improve public access to forest data. Means towards this goal are the development of information-sharing policies, legislation, IPRs and/or inter-organisational arrangements, and improved open data protocols, platforms and interfaces to ensure the widest possible use of EU-funded datasets, regardless of the level at which they were created. The Framework would thus contribute to data consistency, as well as to cost-efficiency.

4.2.3 Consistency and comparability of data is improved across the EU

While forest monitoring systems are developed and continuously evolving with national, regional and international level efforts, data is not consistent and comparable across the EU. A specific objective of the Framework is to improve the consistency and comparability of data across the EU. Means towards this goal are, on one hand, harmonisation of definitions and methods for long-established indicators, if this can be achieved technically and, on the other hand, standardisation of definitions and methods, particularly for indicators that have little or no data coverage in the EU or where methodological changes are acceptable. The Framework would contribute to forming a basis for assessment through targets or benchmarks, and consequently support a holistic view on the status of the forests and their future outlook.

There are distinct differences between the concepts underlying harmonisation and standardisation, which are explored in the box below.

Box 4.1 Harmonisation and standardisation explained

Harmonisation is based on existing national assessment regimes. Harmonisation utilises available national data and transfers them to meet an internationally agreed system of nomenclature. It can be seen as a 'bottom-up approach' starting from an existing divergence and ending in a state of comparability by simultaneously maintaining the reliability of information. A fundamental goal is to provide harmonisation solutions that allow national authorities to continue their data assessment in a way that aligns with their explicit interests and capacities. That does not mean that new developments in techniques and policy should not be considered and implemented in existing national data assessments as much as possible.

Standardisation is a different concept; it focuses on a common standard and can be seen as a top-down approach that forces national systems to adopt the standard. The implications of standardisation are critical. On the one hand, it requires that an international standard can be found and agreed upon. On the other hand, it forces countries to a) either give up their national systems of nomenclature and adopt the common standard – a decision that will result in the loss of national time series, or b) implement two parallel systems of nomenclature (i.e. their national system and the international standard), which would result in increasing costs and inconsistencies. It is widely accepted that standardisation avoids inconsistencies but can present substantial differences to individual and national approaches. Standardisation is thus rather operational in the context of newly arising information needs and corresponding attributes, or when it aims at finding the smallest common denominator between national systems of nomenclature (i.e. the maximum threshold for diameter at breast height found in national systems).

4.2.4 Quality and continuity of data is achieved

While there are high switching costs for changing the established monitoring systems, at the same time as new technologies in data acquisition, especially those of remote sensing, are developing, there are challenges to coordinate between the national authorities and private initiatives. Data is not always timely, quantified, transparent, or does not always meet user-specific needs. A specific objective of the Framework is to ensure quality and continuity of forest data at EU level. Means towards this goal are measures to require transparency on methods, data quality and accuracy; measures to improve data continuity by achieving higher spatial resolution and shorter time intervals between assessments, as well as measures to improve the quality of existing data streams for topics relating to biodiversity, carbon, bioeconomy or socio-economic aspects. The Framework would contribute to data reliability, and making the forest data trusted, in turn, could increase use of the data that is made open access. Consequently, the Framework could contribute, not only to EU-level policy and decision-making, but also to improved information use at national/regional levels to forest operations, land managers and various stakeholders.

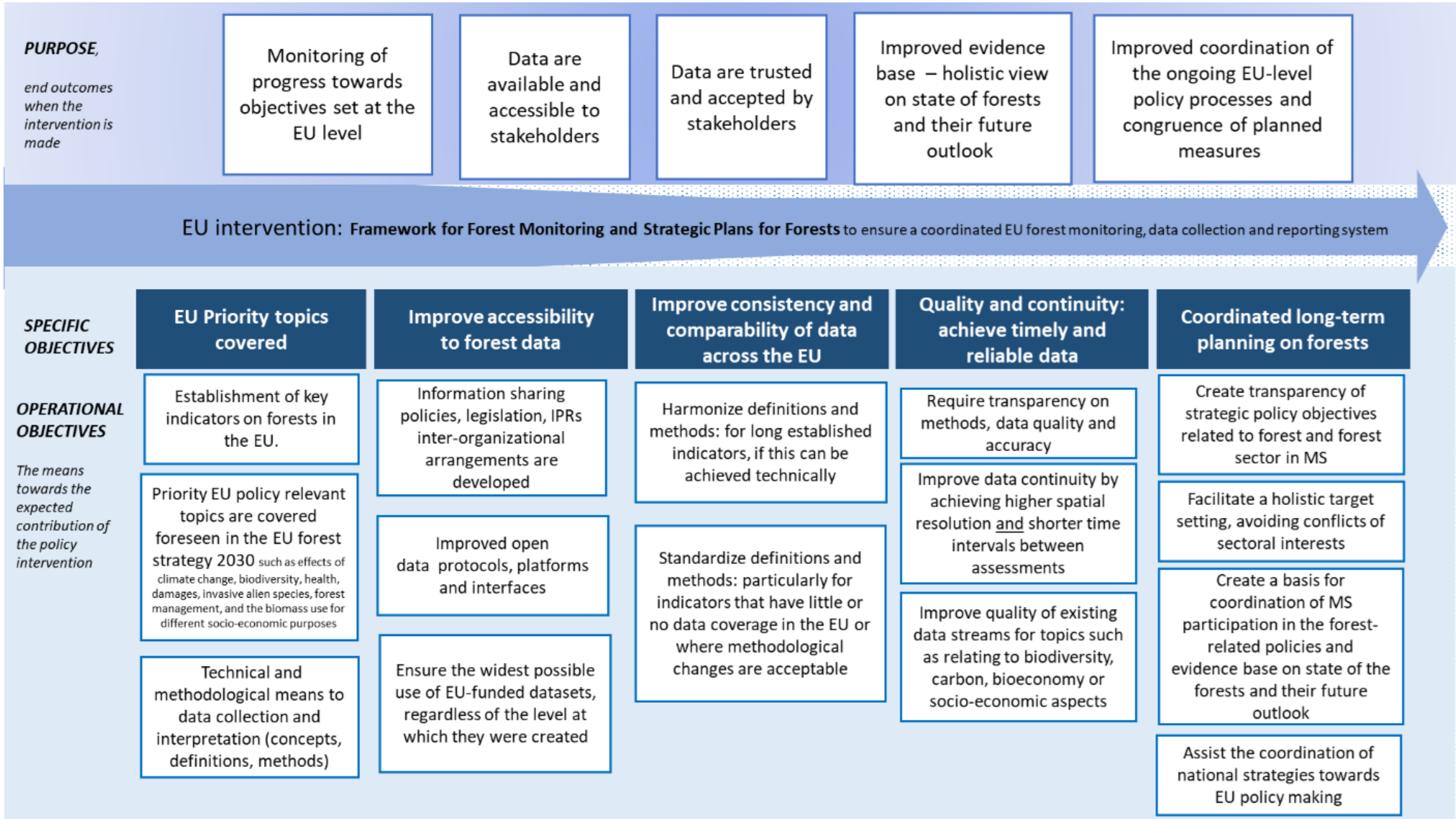
4.2.5 Achieve coordinated long-term planning on forests and the forest sector

While forest planning has evolved for different objectives, based on varying natural conditions and socio-economic and institutional bases across Europe, the forest planning tools have evolved separately, and forest strategies remain different, despite international processes such as Forest Europe. Forecasting and integrated planning for long-term vision on forests at EU level is challenging. A specific goal for the Framework is to improve coordination of long-term planning on forests. Means towards this goal are transparency of strategic policy objectives related to forests and the forest sector in MS; holistic target-setting, avoiding conflicts of sectoral interests; coordination of national strategies towards EU policymaking and active MS participation in the forest-related policies and evidence base on the status of the forests and their future outlook. The Framework would contribute to more coordinated measures in the policy areas directly and indirectly affecting forests and improve coordination across EU-level policies.

4.2.6 Objectives tree

Specific objectives derived from the problem tree, and operational objectives: means towards the expected contribution of the policy intervention summarised in the objectives tree are shown in Figure 4.1 on the following page.

Figure 4.1 Specific objectives derived from the problem tree, operational objectives: means towards the expected contribution of the policy intervention



4.3 What is the baseline?

4.3.1 No-policy-change scenario

The options are assessed vis-à-vis a no-policy-change scenario, which is described here.

4.3.1.1 *EU priority topics are covered*

The baseline scenario – if no policy change was made – of data collection at national (and, where applicable, regional) and EU and international levels continues to evolve in an at best loosely coordinated manner, with harmonisation that is mostly achieved at the level of definitions and less so at the level of data collection design and methods.

Indicators with missing or partial data coverage mostly remain as they are, with the exception of some bioeconomy indicators for which data are expected to become available in the medium term through the Bioeconomy Monitoring Framework developed by the JRC as part of the Commission's Knowledge Centre for Bioeconomy. Among the foreseen indicators are, for example, fellings and increment, forest fragmentation and connectivity, urban green, certified forests, as well as socio-economic indicators, such as indicators on products, consumption, recreational use, employment and the contribution of the forest sector to GDP. The full list of indicators[35] includes indicators where data are already available, as well as indicators currently with no known data.

Methodologies and data products for forest disturbance indicators are in development in a number of Horizon Europe projects, but as project outputs these are not yet necessarily operational, especially for an EU-wide monitoring system. These types of projects present different methods and approaches which means that their operational readiness varies depending on their Technology Readiness Level (TRL). The European Forest Fire Information System (EFFIS), for example, was developed and implemented in two years, but since its creation it has been in constant development, like many others monitoring systems.[36]

Methods for biodiversity monitoring will mostly continue to rely on proxy indicators, with a likely addition of Earth Observation-based monitoring of forest structural diversity and tree species - but not as an operational pan-EU monitoring system. Biodiversity indicators are developed and tested in several national and international research projects, presenting different levels of maturity. Nevertheless, climate-related variables are still the most accurate biodiversity products available.[37]

A selection of key indicators will be made in the context of the Forest Information System for Europe (FISE) during the EEA FISE 2[38] project. Data for these indicators will be sourced from national data and other existing datasets.

4.3.1.2 *Improve accessibility to forest data*

Existing limitations for non-NFI organisations to access NFI plot data and, in particular to access the exact coordinates of plot data, will remain at the discretion of each individual Member State or at sub-national level, depending on the mandate.

[35] Giuntoli, J.; Robert, N.; Ronzon, T.; Sanchez Lopez, J.; Building a Monitoring System for the EU Bioeconomy, EUR 30064 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-15385-6, Doi:10.2760/717782, JRC119056.; 2020;

[36] EFFIS - Brief History Available online: https://effis.jrc.ec.europa.eu/about-effis/brief-history (accessed on 2 December 2022)

[37] Skidmore, A.K.; Coops, N.C.; Neinavaz, E.; Ali, A.; Schaepman, M.E.; Paganini, M.; Kissling, W.D.; Vihervaara, P.; Darvishzadeh, R.; Feilhauer, H.; et al. Priority List of Biodiversity Metrics to Observe from Space. Nat Ecol Evol 2021, 5.

[38] https://forest.eea.europa.eu/

4.3.1.3 *Improve consistency and comparability of data across the EU*

Harmonisation of NFI methods and systems will continue to depend on COST actions and Horizon Europe projects that bring NFIs together (via ENFIN or other cooperation modalities). Comparability would be achieved for some indicators through the development of new EO-based research outputs relating to topics such as forest area, growing stock, forest carbon, forest management approaches and so forth.

4.3.1.4 *Quality and continuity: achieve timely, reliable and trusted data*

Data quality and data continuity would remain in the current state for most indicators (with quality, continuity and transparency of data accuracy varying from MS to MS), with some exceptions, particularly related to the monitoring of forest-based carbon and several bioeconomy-related indicators, which through the impetus of several large EU research projects is edging closer to EU-wide and repeated data production.

4.3.1.5 *Coordinated long-term planning on forests*

The baseline scenario – if no policy change is made – where national and, where applicable, regional programmes and strategies are compiled in the MS and reported within their respective frameworks and (5-yearly) in the Forest Europe State of Europe's Forests reporting process. Information on long-term future forest development is also partly recorded through the National Energy and Climate Plans, and LULUCF reporting by MS, and to a limited extent in the context of UN-ECE/FAO Forest Sector Outlook studies.

Lack of oversight and consistency will continue in forest-related strategic planning between complementary policy domains, benchmarking or the setting of targets and ranges will unlikely be achieved, and incentivisation to streamline and improve pan-EU forest monitoring will depend on sectoral legislation addressing only interests in very specific indicators.

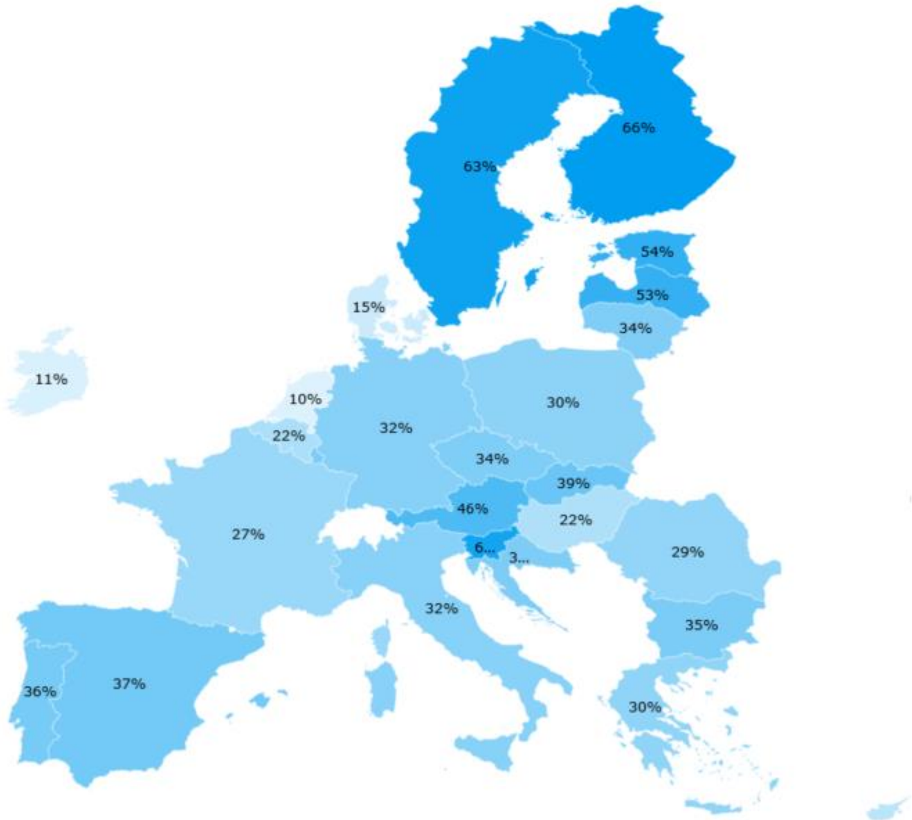
Voluntary approaches to harmonise and develop strategies will continue. Coordination of forest-related policies remains at the initiative of the coordinating ministry/authority/agency.

4.3.2 Other factors affecting the impacts stemming from the policy options

4.3.2.1 *Forest area and share of forest area*

Forest area and share of forest area is an underlying variable that has implications on the benefits and costs of several other variables. The figure below provides an overview of forest area per MS.

Figure 4.2 Respective share of forest areas in the MS of the EU



Source: Own illustration
Not shown: Cyprus (19%), Luxembourg (34%), Malta (1%)

There are large differences regarding the relative share of forest area to the overall area of the respective MS. For example, around 2/3 of the areas of Finland and Sweden are covered by forests. On the other hand, only 1% of Malta is covered in forests, while in Ireland it is 11%.

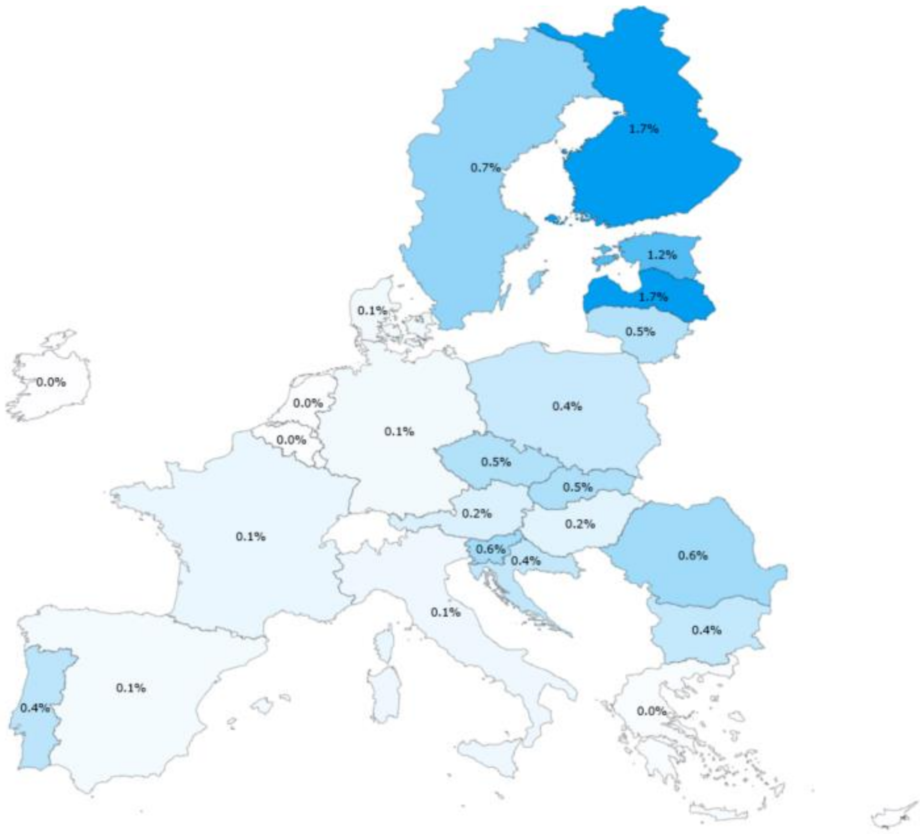
The costs for monitoring depend on the area that needs to be monitored, i.e. the forest area in the respective MS. However, it is not a direct relationship and depends on the extent to which forest monitoring and strategic planning are already conducted in the respective MS. This is further discussed in Section 4.3.2.2.

Regarding the expected long-term benefits from better monitoring and strategic planning, such as reduced biodiversity loss, enhanced resilience and others, it can be expected that these are higher in countries with a larger forest area than in countries with little forest.

4.3.2.2 *Share of gross value added (GVA) of forestry sector to overall GDP*

This variable indicates the economic importance of the forestry sector. The higher the share, the larger the economic importance of the sector. The figure below provides an overview of this variable per MS.

Figure 4.3 Respective shares of GVA of the forestry sector of overall GDP



Source: Own illustration
Not shown: Cyprus (0.0%), Luxembourg (0.0%), Malta (0.0%)

Given that this legislative initiative will lead to better monitoring and strategic planning and, through this, to the increased long-term sustainability of forest resources, it can be expected that those MS in which the sector has greater economic importance will benefit from it to a larger extent.

There is a strong positive correlation ($r = 0.75$) between the share of forest area in an MS and the economic importance of the forestry sector in a MS. This suggests that in general there is a general trend in how forest areas are used in MS; in other words, if a MS has large forest areas, they will usually also use them for economic purposes. However, there are differences between MS. For example, although Spain has a relatively large forest area, the GVA per km^2 of forest area is comparatively low compared with other MS. This suggests that forests in Spain are used less intensively than in other MS like, for example, Denmark, which has a relatively small forest area but a higher GVA per km^2.

4.3.2.3 *Current number of forest monitoring plots*

Monitoring can be purely ground-based, through the means of monitoring plots or the use of Earth observation techniques. However, for the majority of Earth observation techniques ground-based information (collected through plots) is also required for calibrating or validating the data from remote sensing. Thus, plots are an important backbone of forest monitoring.

The table below provides an overview of the overall number of NFI plots per MS.

Table 4.1 Overview of NFI plots

MS	NFI forest plots	MS	NFI forest plots
Austria	11,000	**Italy**	7,000
Belgium	11,000	**Latvia**	No information
Bulgaria	No NFI	**Lithuania**	5,737
Croatia	6,232	**Luxembourg**	1,200
Cyprus	320	**Malta**	No NFI
Czechia	19,727	**Netherlands**	3,190
Denmark	9,558	**Poland**	30,722
Estonia	27,500	**Portugal**	12,000
Finland	60,000	**Romania**	24,000
France	33,500	**Slovakia**	1,486
Germany	78,000	**Slovenia**	761
Greece	2,744	**Spain**	95,327
Hungary	7,425	**Sweden**	No information
Ireland	1,932	/	/

Source: Own compilation

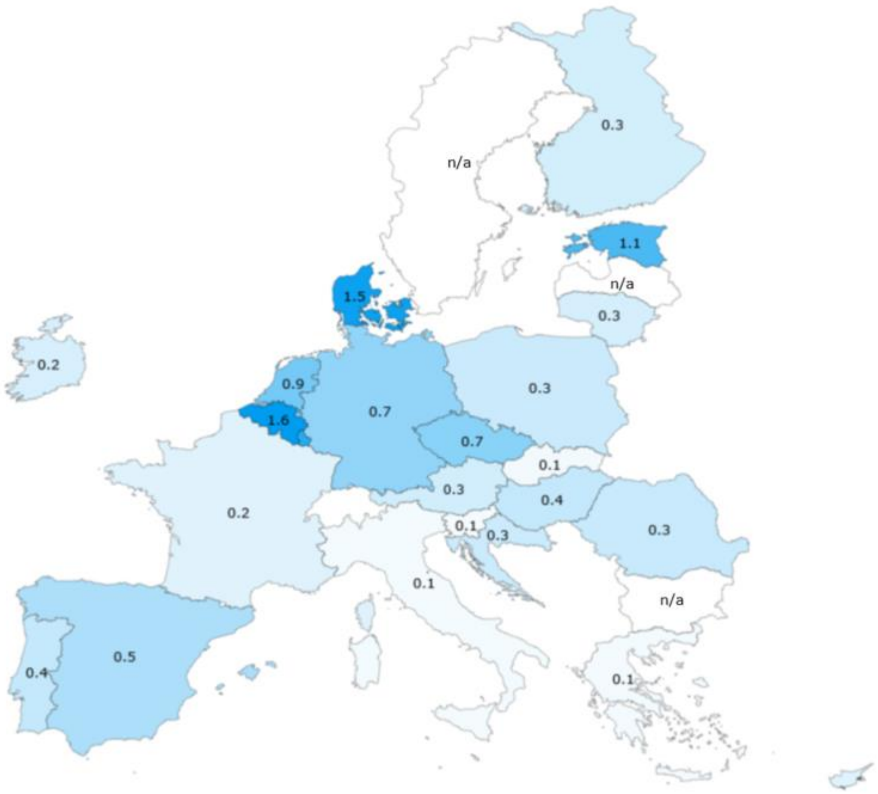
The higher the number of plots, the higher the costs for monitoring per data collection cycle, since data has to be manually collected at each plot by professional staff. A very rough estimate of monitoring cost per plot per monitoring cycle is provided in the literature[39] as EUR 26, based on the assumption that two plots can be surveyed per hour by an expert, and their staff costs.

The table above shows that there are significant differences between the number of NFI monitoring plots in the MS, ranging from 320 in Cyprus to more than 95,000 in Spain. However, this is necessarily linked to the forest area in the respective MS.

Thus, the following figure shows the average number of existing NFI monitoring plots per km^2 of forest area in each MS where data on the number of plots was identified (i.e. excluding Bulgaria, Latvia, Malta and Sweden).

[39] Borgogno-Mondino, Enrico, Samuele De Petris, Filippo Sarvia, Evelyn Joan Momo, Fabio Sussio, and Paolo Pari (2022). "Adoption of Digital Aerial Photogrammetry in Forest Planning: A Case Study of Canavese Forestry Consortium, NW Italy with Technical and Economic Issues" Land 11, no. 8: 1350. https://doi.org/10.3390/land11081350

Figure 4.4 NFI monitoring plots per km² of forest area



Source: Own illustration
Not shown: Cyprus (0.2), Luxembourg (1.4), Malta (n/a)

There are also large differences here, ranging from 0.1 in Greece, Italy, Slovakia and Slovenia, to 1.6 in The Netherlands, 1.5 in Denmark, and 1.4 in Luxembourg. MS with a higher density of monitoring plots face higher costs for the in situ assessments per monitoring cycle.

However, there is another important implication regarding costs. An important objective of this legislative initiative is the harmonisation of forest data at an EU scale. In this context, it is important to consider that the potential for harmonisation could face limitations, e.g. when the quality (collection, validation) of data sources is not sufficiently comparable. An example is presented in Vaukhonen et al. (2019).[40] The paper found that their attempts at harmonising data on future forest resources in Europe faced limitations due to the differences in NFI sampling grid density, the number of NFI plots, and others. Thus, there is the potential that harmonisation attempts would require selected MS to adapt their current data collection framework in order to meet certain quality standards that would allow for comparable data across the EU, although this depends to a large extent on the technical requirements placed on the harmonisation by the final legislative text.

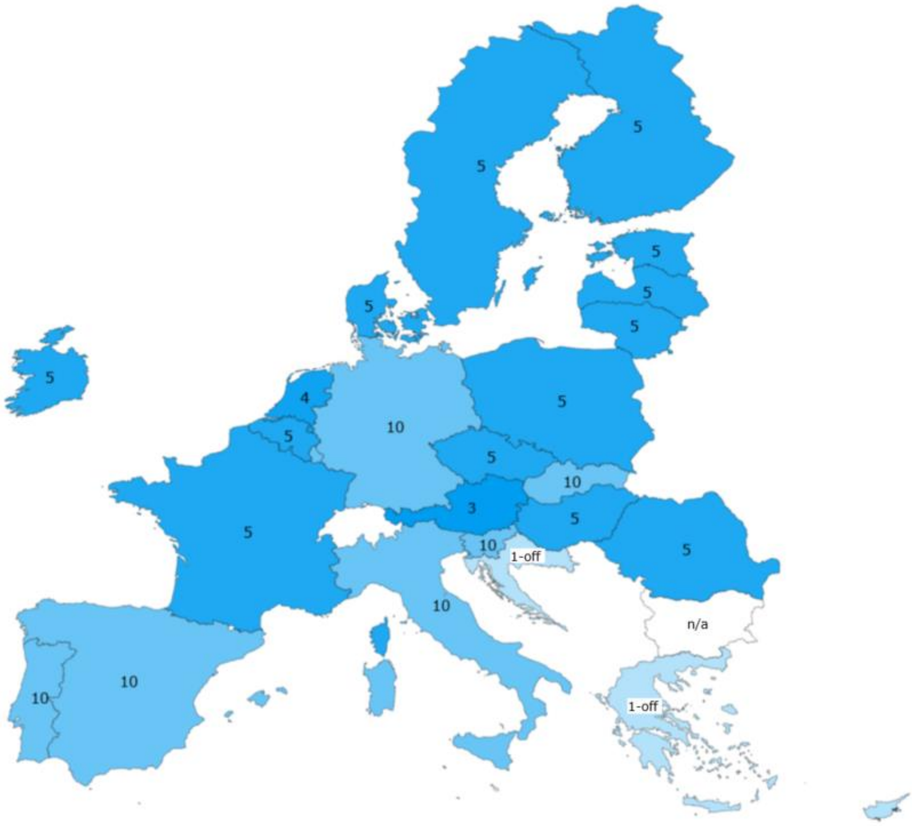
Given the current plot density in the MS, it is possible that such additional one-off costs – if relevant – could be faced by MS currently with a low density such as Greece, Italy, Slovakia and Slovenia. On the other hand, if a generally lower density of plots is planned, this could lead to cost savings in MS currently with a high density, such as The Netherlands, Denmark, or Luxembourg. A mix between the two situations is also possible.

[40] Vaukhonen et al (2019)[40]. Harmonised projections of future forest resources in Europe. Annals of Forest Science. See: https://annforsci.biomedcentral.com/articles/10.1007/s13595-019-0863-6

4.3.2.4 *Current time interval between subsequent plot visits*

Regarding the baseline of costs per MS, in addition to the number of plots, the periodicity of the plot visits is an important factor; i.e. how often each plot gets visited. The figure below provides an overview of the periodicity of the plot visits per MS.

Figure 4.5 Time interval between subsequent plot visits



Source: Own illustration

Not shown: Cyprus (only one assessment to date), Luxembourg (10), Malta (n/a)

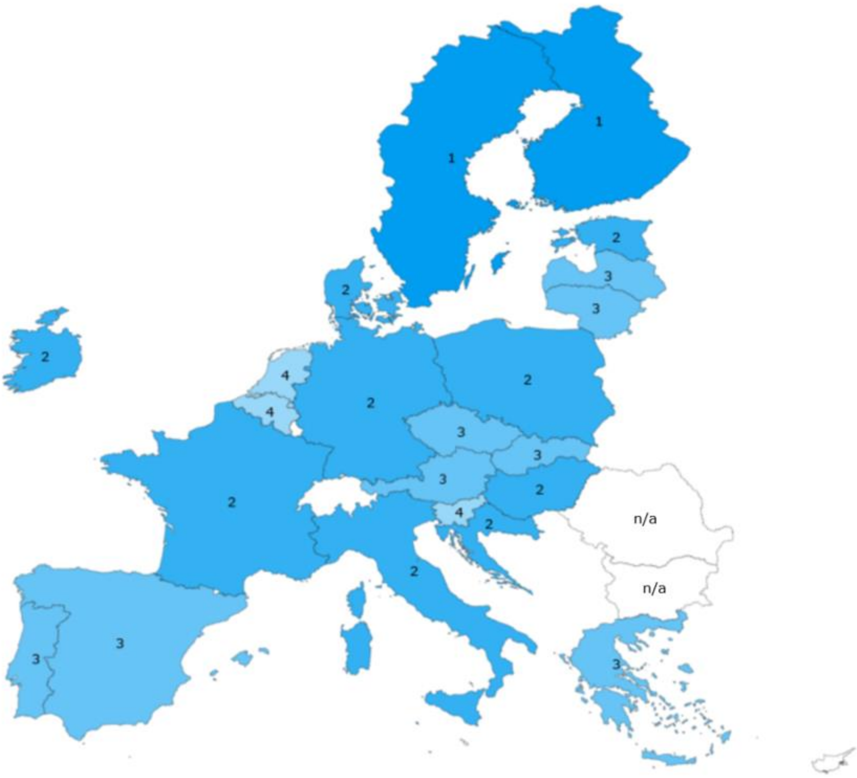
The figure shows that there the majority of MS have intervals of five years. In two MS, Austria and The Netherlands, the plots are assessed more frequently than that, at three- and four-year intervals respectively. Another large group of MS, including Germany, Spain and others, assess their plots every 10 years. In Croatia, Cyprus and Greece, only one assessment has been done to date. No data is available for Bulgaria and Malta. As for the number of plots, the savings or costs of MS will depend on the chosen periodicity in the final legal text of this initiative. MS which currently assess their plots more often than eventually required and which reduce the number of visits will accrue savings compared to the current baseline. Vice versa, MS where the periodicity needs to be increased would face additional costs compared to the current baseline.

The costs will likely be highest for the MS which to date have only done one or no assessments, since it can be expected that they lack crucial infrastructure which the MS already have in place from their periodic assessments, such as trained stuff in the field and for aggregation, technical equipment and others.

4.3.2.5 *Current extent to which EO is integrated into forest monitoring programmes*

Earth observation already has strong application and future potential for making forest monitoring more accurate and more timely, but also more cost-effective. Within the EU, the extent to which EO is already used in the MS differs widely. As part of the impact assessment, a high-level analysis was made of this, which is presented in the following figure.

Figure 4.6 Extent to which EO is currently integrated in forest monitoring programmes



Source: Own illustration
Not shown: Cyprus (no information), Luxembourg (no information), Malta (no information)
Legend: 1 Done; 2 Ready; 3 Almost ready; 4 Not yet ready; n/a No information

The figure shows that in Sweden and Finland the NFI is already fully integrated with multisource remote sensing, a long list of multiple spatial products are available, a full open access policy is adopted, and that there is a long research track. In other countries such as France, Denmark and Italy, research activities in the country are advanced and carried out at national level. Relevant research is already being conducted in countries such as Spain, Portugal and Slovakia. Against this baseline, there are a few considerations relating to costs from this legislative initiative for the indicators which will then eventually have to be assessed through remote sensing:

- In general, remote sensing can be more cost-effective than ground-based assessments. However, ground base assessments are, in the majority of indicators still required for calibration and validation and thus the cost depends on whether ground-based information is already measured in an MS and can be used for calibrating or validating the data from the remote sensing.
  - In MS where ground-based data is not yet available, the MS would thus face costs for this in addition to the Earth observation costs.
  - In MS where this data is already fully collected through ground-based data, it can be assumed that the current costs would be reduced, i.e. that there would be savings.
- If an MS already collects the information through remote sensing and, if yes, if the methodology is similar to the one proposed by the EC, then no – or limited – additional costs would occur.
- In cases where the EC would take over core EO-based monitoring products, this would lead to cost savings in MS where it is already done, and to no additional costs or savings where this

indicator has not yet been measured (while those MS would have the additional benefits of then having the information from this indicator).

Generalising the above considerations for the groups defined in the analysis (see legend of Figure 4.6 above) is challenging. It can be assumed that across all four groups there would be cost savings[41] that would, however, probably be more significant for those MS in groups 3 and 4 than for groups 1 and 2.

4.3.2.6 *Indicators already measured*

An important aspect regarding the benefits and costs of this legislative initiative is the baseline of what is already being done within the MS regarding monitoring. For example, a specific indicator such as canopy height might be fairly costly to monitor; however, the actual overall costs across the EU caused by its inclusion in this initiative will depend strongly on how many MS do already measure it. If it is already measured in the majority of MS, then the overall cost at EU level will be limited since only a few MS would have to start to collect data on it. If it is a new indicator in most MS, then the costs will be considerably higher.

An overview of the situation per MS is provided in Appendix 7.

4.3.2.7 *Strategic planning already in place*

Besides monitoring, improved strategic planning is a key objective of this legislative initiative. A mapping exercise was done as part of the impact assessment to assess which MS already have documents in place (or if they are currently in the process of developing them) that can be considered to be a national forest strategy; or have a central forest law which might, to some extent, have the same function as a strategic plan. The results are shown in Appendix 7.

In MS that do not yet have a strategic plan in place, costs would occur for developing it. The exact costs depend on the conditions in the respective MS. However, as a reference for the magnitude of the costs, the example of Germany can be given, which started developing its 2050 strategy in 2015 and spent approximately EUR 600k for the development (EUR 500k for the preparation of the strategy and EUR 100k for dissemination[42]).

4.4 What are the available policy options?

4.4.1 Considerations regarding the development of policy options

4.4.1.1 *Introduction*

Following the description and definition of problems and problem drivers regarding forest monitoring and forest planning in the EU, and the formulation of requirements for an EU monitoring system and Strategic Plans for Forests, a baseline or ‘no-policy-change’ scenario and a set of policy options are developed which consider as many realistic alternatives as possible.

Three core policy elements can be identified for which policy options can be developed further and in detail, and these concern (1) the standardisation and harmonisation of data collection, (2) the further development of remote sensing-based monitoring systems and (3) the development of strategic plans for forests. The core policy elements partly overlap with the five specific objectives that came forth from the problem analysis as displayed in the following table.

[41] Expect in cases where new indicators have to be measured in a MS. However, also here the cost for establishing those indicators through EO would be lower than establishing it through ground based observations.

[42] See: https://www.bundeshaushalt.de/static/daten/2015/soll/epl10.pdf

Table 4.2 Relation between the specific objectives for improving forest monitoring and the three core policy elements.

Core policy element → Specific objective	Standardise data collection	Operate remote sensing monitoring systems	Develop strategic plans for forests
1. Broaden the scope of forest monitoring to new indicators	X	X	
2. Standardise data collection methodologies	X	X	
3. Improve public access to forest data		X	
4. Ensure timely and cost-efficient information for land managers, policymakers and stakeholders	X	X	
5. Enhance the coherence of forest planning tools			X

4.4.1.2 *Long list of potential policy options*

Introduction

This section sets out to identify elements of policy options that are suitable to address the problems and to achieve the specific and operational objectives. Recommendations on the procedure for this step are provided in the Better Regulation Tool #16, and our approach follows those guidelines. Overall, the aim is to consider as many realistic alternatives as possible and then (in the following step) narrow them down to the most relevant ones for further analysis. The compilation of the range of policy options pays particular attention to a number of issues, as listed below:

- Different levels of intervention e.g. from a new purpose-built information framework to a distributed network that combines new with existing infrastructure.
- Different levels of standardisation/harmonisation of existing datasets and monitoring systems.
- Different levels of integration of monitoring with ground-based and earth observations.
- The role of existing infrastructure at EU level, including e.g. the EEA as service provider and/or data host for monitoring (e.g. under FISE), and the Copernicus Programme.
- Different types of opportunities to enhance integration and mutual learning among MS.
- Different options for the selection of key indicators versus other indicators, differentiation in spatial and temporal resolution, periodicity and other monitoring parameters.
- Different options for the development of technological monitoring infrastructure.
- Different levels of integration between the Monitoring Framework and the Strategic Plans.
- Different options for the framing of the Strategic Plans, including within the DPSIR intervention model, taking into account existing information on strategic planning already performed by MS.
- Respect of the subsidiarity principle
- Respect of the Once-Only Principle,[43] as set out in the Single Digital Gateway regulation.[44]

[43] From 2023, the Once-Only Principle will allow public administrations in Europe to reuse, or share, data and documents that people have already supplied in a transparent and secure way. See: https://ec.europa.eu/digital-building-blocks/wikis/display/DIGITAL/Once+Only+Principle

[44] Regulation (EU) 2018/1724 of the European Parliament and of the Council of 2 October 2018 establishing a single digital gateway to provide access to information, to procedures and to assistance and problem-solving services and amending Regulation (EU) No 1024/2012. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.295.01.0001.01.ENG&toc=OJ:L:2018:295:TOC

EU priority topics are covered

Note that options generally vary by level of legal requirement and number of indicators to be monitored, as well as reliance on existing or new infrastructures. Relating to 'policy-relevant priority EU topics', in practice the choice between keeping the status quo versus further harmonisation or standardisation depends on the existing geographical coverage, resolution, timeliness and quality of the existing datasets. The options for 'Technical and methodological means' represent more generic options/positions towards the collection of different types of data. These options/positions could be further developed if the EC requires.

Operational objectives	Option A	Option B	Option C	Option D
Policy-relevant priority EU topics are covered as foreseen in the EU Forest Strategy for 2030, on topics such as climate change, biodiversity, health, damages, invasive alien species, forest management, and biomass use for different socio-economic purposes	Existing national information systems are improved to cover a wider range of indicators; When relevant and as much as possible in cooperation with key in situ data schemes, data gaps for bio-physical indicators are covered through EO approaches; Data gaps for socio-economic indicators are addressed by strengthening existing data collection frameworks at national and EU statistical agencies.	Existing national information systems are improved to cover a wider range of indicators, with an emphasis on **harmonised approaches** led by MS themselves. When relevant, data gaps for bio-physical indicators are covered through EO approaches, in cooperation with key in situ data schemes; *Improvement of monitoring for some topics will require more directly assessed data (e.g. related to biodiversity, forest disturbances)* Data gaps for socio-economic indicators are addressed by strengthening existing data collection frameworks at national and EU statistical agencies, or if necessary through the development of a new data collection framework.	Existing national information systems are improved to cover a wider range of indicators, with **an emphasis on standardised approaches**; When relevant, data gaps for bio-physical indicators are covered through EO approaches, in cooperation with key in situ data schemes; *Improvement of monitoring for some topics will require more directly assessed data (e.g. related to biodiversity, forest disturbances)* Data gaps for socio-economic indicators are addressed by strengthening existing data collection frameworks at national and EU statistical agencies, or if necessary through the development of a new data collection framework.	
Establishment of key indicators on forests in the EU	- **Key indicators** are identified for each of the EU priority topics; - MS are required to provide data without EU-level standard definition or methodological requirements.	- **Key indicators** are identified for each of the EU priority topics; - The EU requires MS to **harmonise** data collection between MS.	- **Key indicators** are identified for each of the EU priority topics; - The EU invests in the **standardisation** of definitions and data collection across MS.	

Operational objectives	Option A	Option B	Option C	Option D
Technical and methodological means for data collection and interpretation (concepts, definitions, methods) are developed and operational	**In situ data** collection frameworks (including if these would serve as inputs to EO-based information products), for their implementation, fall under the responsibility of the MS, while responsibility for the methodological development lies with the MS or EU, depending on the degree of harmonisation or standardisation that needs to be achieved.	**Satellite data**-based information products: products that require less complex in situ data, and that are thus easier to produce for the pan-EU area, could more justifiably be produced under EU responsibility; when products require complex in situ data inputs, then products are possibly more efficiently produced at MS level. As a rule of thumb, definitions and methodologies for new or relatively recent indicators should be harmonised or even standardised as much as possible – while implementation at MS level will ensure local bio-geographical specificities are better taken into account.	**Airborne Lidar** data. Few countries currently implement nationwide Lidar campaigns regularly. As optimally EU-wide Lidar datasets should be developed to cover (at least) forest areas, the EU could consider supporting such operation.	**Social and economic data**: when data are developed as a more detailed breakdown of existing classifications (e.g. of industrial activities, production, or traded commodities) then data collection could in the first instance be aimed at being an amendment of an information requirement through the EU official classifications, involving Eurostat and MS national statistics agencies. Regular assessments outside the typical scope of MS' statistical agencies, e.g. of public opinion, perceptions or behaviour in relation to forests and the forest sector, may be best coordinated at EU level.

Improve accessibility of forest data

Note that options generally vary by the level of legal requirement to provide transparency and share, and the degree to which data-sharing approaches are technically advanced.

Operational objectives	Option A	Option B	Option C	Option D	Option E
Information-sharing policies, legislation, IPRs' inter-organisational arrangements are developed – "conditions"	- Data access conditions and IPR are resolved and transparent for publicly financed data at MS level; - MS are required to share in situ plot data and exact coordinates with intermediate data aggregators under confidentiality arrangements if and as required by local law.	- Data access conditions and IPR are resolved and transparent for publicly financed data at MS level; - MS are required to share in situ plot data and exact coordinates publicly under open data sharing agreements.	Data access conditions and IPR are resolved and transparent at MS level, for in situ data as well as for EO data (while recognising potential limitations from commercial data providers), from regional to national and EU levels.		

Operational objectives	Option A	Option B	Option C	Option D	Option E
Ensure the widest possible use of EU-funded datasets, regardless of the level at which they were created – "retrieval requirements"	- Require the documentation of datasets with metadata, according to the requirements of the INSPIRE Directive.	- Require the documentation of datasets with metadata, in the spirit of the requirements of the INSPIRE Directive.	- Require the documentation of datasets with metadata, by adding geospatial forest and forest sector indicators to broaden the scope of datasets covered by the (annexes of the) INSPIRE Directive		
Improved open data protocols, platforms and interfaces – "means"	MS are required to create online access to metadata (definitions, methodology) and datasets for forest and forest sector indicators.	Forest and forest sector metadata and data are available through standardised procedures and protocols directly from the data schemes.	A centralised metadata portal allows data to be found in a distributed network and links through to the original datasets through distributed data nodes; data access is resolved through the original data provider	A centralised metadata portal allows data to be found and links through to the original datasets through distributed data nodes; data access is resolved through the centralised portal	Datasets are available directly through a central portal, which stores local copies of regularly synchronised data.

Improve consistency and comparability of data across the EU

Note that options generally vary by indicator scope and level of harmonisation, and consideration of benchmarks/thresholds/targets.

Operational objectives	Option A	Option B	Option C	Option D
Harmonise definitions and methods for long-established indicators, if this can be achieved technically	- **Harmonisation** of indicator definitions is achieved for a set of **key indicators** (particularly those for which strategic policy targets exist or will be required). - Support and help deepen existing ongoing processes of harmonisation (public/private/NGO).	**Harmonisation** of indicator definitions, assessment and evaluation methodology is achieved for a set of **key indicators**, and monitoring considers **benchmarks/thresholds/targets/ranges**.	**Harmonisation** of indicator definitions, assessment and evaluation methodology is achieved for a **broad set of indicators.**	**Harmonisation** of indicator definitions, assessment and evaluation methodology is achieved for a **broad set indicators**, and monitoring considers **benchmarks/thresholds/targets/ranges**.
Standardise definitions and	- Develop definitions and methodology at	- Develop definitions and methodology at EU level;		

Operational objectives	Option A	Option B	Option C	Option D
methods: particularly for indicators that have little or no data coverage in the EU or where methodological changes are acceptable	EU level; - MS to implement collection or to acquire the data collection (in situ and EO) [ref. LUCAS survey (Land Use and Coverage Area frame Survey) 3-yearly operated by Eurostat (integrated with Copernicus), also/ICP Forest/].	- MS to implement collection or to acquire the data (in situ); EU to lead development of pan-EU geo-information (i.e. EU operates the EO component) [ref. Copernicus including CLC, EFFIS, Forest HRL].		

Quality and continuity: achieve timely, reliable and trusted data

Operational objectives	Option A	Option B	Option C	Option D	Option E	Option F
Require transparency on methods, data quality and accuracy	- For a core set of indicators, the EU requires data quality to be assessed and transparently communicated.	- For a core set of indicators, the EU requires data quality to be assessed and transparently communicated, and minimum quality standards are recommended.	- For a core set of indicators, the EU requires data quality to be assessed and transparently communicated and minimum quality standards are required.	- The EU requires data quality to be assessed and transparently communicated, for a full set of indicators ("Forest Europe +").	- The EU requires data quality to be assessed and transparently communicated and minimum quality standards are recommended, for a full set of indicators ("Forest Europe +").	- The EU requires data quality to be assessed and transparently communicated and minimum quality standards are required, for a full set of indicators ("Forest Europe +").
Improve data continuity by achieving higher spatial resolution and shorter time intervals	For relevant spatially explicit indicators: spatial and temporal resolution of data assessments is improved by complementing existing in situ data with EO-based datasets.	For relevant spatially explicit indicators: spatial and temporal resolution of data assessments is improved by complementing existing in situ data with EO-based datasets for which the methodology relies on the best available in situ data.	For relevant spatially explicit indicators: spatial and temporal resolution of data			

Operational objectives	Option A	Option B	Option C	Option D	Option E	Option F
between assessments			assessments is improved by integrating EO-based approaches with in situ monitoring schemes (methods developed and implemented jointly by MS, using own as well as shared infrastructure).			
Improve quality of existing data streams for topics relating to biodiversity	EU to further develop regular geographical information for **proxy indicators** that are valuable to pan-EU biodiversity monitoring, e.g.: - Operationalise pan-EU tree species monitoring as part of Copernicus Forest HRL; - Operationalise pan-EU analysis of forests' structural complexity; - Identify areas that are close to Potential Natural Vegetation (PNV).	Develop pan-EU monitoring of plant and animal diversity data by supporting **citizen science** monitoring (e.g. the Pan-European Common Bird Monitoring Scheme (PECBMS)).	Develop a requirement for the collection of **plant diversity data** in the context of **NFIs**.			
Improve quality of existing data streams for topics relating to carbon, climate mitigation and climate adaptation	EU to support the **development of a standard** that private and public forest owners/managers/certifiers should apply as a minimum threshold to estimate above and below ground carbon stocks and sinks in their forests, and which would also be a basis for nationwide inventories of carbon stocks and sinks at stand level.	**MS required to improve and ease stakeholders' access for mathematical equations and data** related to forest growth, carbon expansion factors, carbon stocks and other data needed to assess legal compliance at the level of the forest management unit.	MS to regularly (1 to 2-yearly) produce a high-resolution map of above-ground carbon in forests, with accuracy sufficient for carbon certification at the level of 0.5 hectares.	EU to regularly (1 to 2-yearly) produce a high resolution map of above-ground carbon in forests, with accuracy sufficient for carbon certification at the level of 0.5 hectares.		

Operational objectives	Option A	Option B	Option C	Option D	Option E	Option F
Improve quality of existing data streams for topics relating to forest disturbances	Develop pan-EU standard approaches to assess insect damage and forest pathogens, storm damage and fire damage. Systems need to be developed to assess vulnerability, early warning detection, the evolution in real time of high-impact disturbances, but also post-calamity impact monitoring. Implement only in areas prone to certain disturbances or where disturbances already occur. **Implementation of the monitoring by MS.**	Develop pan-EU standard approaches to assess insect damage and forest pathogens, storm damage and fire damage. Systems need to be developed to assess vulnerability, early warning detection, the evolution in real time of high-impact disturbances, but also post-calamity impact monitoring. Implement only in areas prone to certain disturbances or where disturbances already occur. **Implementation of the in situ monitoring component by MS, and EO component by EU**.				
Improve quality of existing data streams for topics relating to genetic diversity	Require MS to include the assessment of forest and tree genetic diversity as a standard **component of NFIs, with a harmonised approach** between existing and new methods. **Genetic analysis infrastructure to be organised by MS.**	Require MS to include the assessment of forest and tree genetic diversity as a standard component to be measured at the level of **NFI in situ plots**. **EU facilitates and coordinates** the use of existing or new genetic analysis infrastructure.				
Improve quality of existing data streams for topics relating to bioeconomy-related and socio-economic aspects	Comprehensive pan-EU data need to be developed by Eurostat: - concerning the **re-use and recycling and cascading of wood waste as a raw material**; - concerning the **substitution** of fossil-based with wood-based materials (e.g. basic chemicals, plastics, textile fibres) and therefore the assignment of **unique codes in the PRODCOM and Combined Nomenclature classification systems**.	EU MS need to **monitor the construction of buildings and infrastructure** that can act as long-term carbon storage facilities.	EU to alter the **NACE** and other industrial monitoring systems to distinguish between fossil and **bio-based industrial facilities.**	…		

Coordinated long-term planning on forests

Note that options generally vary by reporting and monitoring frequencies, the geographical reporting unit and the level of legal requirement (voluntary to obligatory).

Operational objectives	Option A	Option B	Option C	Option D
- Create transparency in strategic policy objectives related to forests and the forest sector in MS; **- Facilitate a holistic setting of targets and ranges, recognising the environmental, social and economic differences between regions and MS**	Transparency in strategic forest sector-related planning, goal/target-setting (including any elements of timing), comprehensively for all policy sectors that affect forests and the forest sector at national level; updating the regime 5-yearly, voluntarily.	Transparency in strategic forest sector-related planning, goal/target-setting (including any elements of timing), comprehensively for all policy sectors that affect forests and the forest sector, at the competent geographical level in accordance with subsidiarity principles; updating the regime 5-yearly, voluntarily.	Transparency in strategic forest sector-related planning, goal/target-setting in different policy sectors (including any elements of timing), at the competent geographical level in accordance with subsidiarity principles; including an overview of the baseline and subsequent reporting of progress towards (national/EU) targets – depending on national monitoring cycles; updating the regime 2-yearly.	Transparency in strategic forest sector-related planning, goal/target-setting in different policy sectors (including any elements of timing), at the competent geographical level in accordance with subsidiarity principles (noting that mandates may be at different administrative levels depending on the topic); including an overview of baseline and subsequent reporting of progress towards (national/EU) targets; updating the regime 2-yearly, obligatorily.
Create a basis for the coordination of MS' participation in the forest-related policies and evidence base on state and future development of forests and their social, economic and environmental importance	Complementary to the overview of targets and ranges, MS are **encouraged to provide updated data on the status, progress and outlook** towards achieving or retaining those targets or ranges.	Complementary to the overview of targets and ranges, MS are **obliged to provide updated data on the status, progress and outlook** towards achieving or retaining those targets or ranges.		
Assist the coordination of national strategies and legislation towards EU policymaking	MS are encouraged to share a self-assessment of targets, ranges, state and trends/	- MS are encouraged to share a self-assessment of targets, ranges, state and trends; and - MS are encouraged to identify solutions they will implement in the event of significantly deviating from a trajectory towards reaching stated policy objectives/targets/ranges.	MS are required to share a self-assessment of targets, ranges, statuses and trends	- MS are required to share a self-assessment of targets, ranges, statuses and trends; and - MS are required to identify solutions they will implement in the event of significantly deviating from a trajectory towards reaching stated policy objectives/targets/ranges

4.4.2 Short list of maintained policy options

As mentioned, the specific objectives of this initiative are as follows:

- data collection is harmonised and standardised;
- monitoring by Earth Observation is increased to ensure public access to timely and cost-efficient information for land managers, policymakers, and stakeholders; and
- a coherent governance framework for reporting and planning is established.

Each policy option is designed to meet those three objectives.

Two main policy options are assessed in this chapter:

- **Policy option 1**: Streamlined reporting for forest monitoring and strategic plans – combining legislation and soft instruments.
- **Policy option 2**: EU framework for forest monitoring and strategic plans – legislation only, with sub-options concerning the level of intervention.

Policy option 1 consists of the following elements:

- MS will be required to report the data and information they collect based on forest-related monitoring obligations under existing and upcoming EU legislation through FISE. Harmonisation of data is voluntary and based on EC guidance.
- Where pertinent for the respective mandatory forest data, MS will be required to develop and operate EO-based monitoring, complementary to in situ data collection over their territory.
- Submission of long-term (integrated) plans for forests will be legally required, but the structure and content will be freely chosen according to the Member State's specific needs.
- The EC will set up a dedicated committee/group to facilitate coordination and exchange on forest monitoring, including harmonisation and strategic planning. Building on the work of the committee, the EC will issue voluntary guidance to strengthen consistency and comparability in data collection, to promote EO and to facilitate the drafting of long-term forest plans across MS.

For **policy option 2**, there are two sub-options that are structured around different levels of ambition regarding the number of indicators, level of centralisation of remote sensing-based monitoring, and the level of prescriptiveness for the structure and content of strategic plans.

Common to both sub-options of option 2 are the following aspects:

- MS will be required to report the data and information they collect based on forest-related monitoring obligations under existing and upcoming EU legislation through FISE. Harmonisation (or standardisation for new indicators) is mandatory.
- Where pertinent for the respective mandatory forest data, EO-based monitoring will be mandatory and complementary to in situ data collection over their territory.
- MS will be required to ensure evidence-based, long-term (integrated) strategic forest planning for the coherent delivery of agreed EU objectives and priorities pertaining to forests.
- The EC will set up a dedicated group to facilitate follow-up and implementation of the regulation. The group will, inter alia, deal with data collection needs, propose further indicators and parameters for policy implementation as relevant, and common methods for data harmonisation and standardisation, access rights to data from observations, and share best practices on long-term planning for forests.

Sub-option 2.1 (medium ambition) adds the following to the above:

- Additional indicators (in addition to the ones related to EU legislation) are to be reported, including indicators and parameters related to policy objectives on forests that can be derived from existing EU and relevant international monitoring and reporting systems. These build,

among others, on criteria and indicators used for Forest Europe's State of Europe's Forest reporting, forest condition parameters collected in the ICP Forests network, forest fire monitoring through EFFIS, or the relevant forest information reported through LUCAS.
- The EC will operate EO-based forest monitoring with the possibility for MS to enrich the data with their sources.
- The strategic plans follow a specific structure and include forecasting via available integrated modelling frameworks. Reporting every five years, with a review every 10 years.

Sub-option 2.2 includes the following additions:

- Additional indicators to be reported and harmonised, extending beyond existing EU and relevant international monitoring and reporting systems.
- The EC will develop and operate EO-based forest monitoring complementary to in situ data collection and provide this data and indicators to MS for their reporting.
- The EC will review the strategic plans and issue recommendations.

4.4.3 Discarded "hybrid option"

An additional policy option has been identified. The policy option is called "hybrid option" and reads as follows:

- Obligatory reporting on a set of indicators and parameters related to EU legislation and policy objectives beyond existing EU/international requirements (e.g. tree mortality, storm damage, drought damage, pest outbreaks, silvicultural regimes in EU forests, use of clear-cutting and the location and extent of primary and old-growth forest).
- Data harmonisation for existing indicators; standardisation for the new indicators.
- The Commission will develop and operate EO-based forest monitoring, complementary to in situ data collection, and provide these data and indicators to MS for their reporting.
- Voluntary coordination and exchange on integrated long-term planning via a dedicated expert group.
- Following consultation with this expert group, the Commission would issue voluntary guidance to facilitate the drafting of evidence-based integrated forest planning, for example by offering a common set of basic requirements and core elements for consideration by MS.

The implications of this option are discussed in Appendix 9.

5. What will be the impacts of the different policy options, and who will be affected?

5.1 Introduction

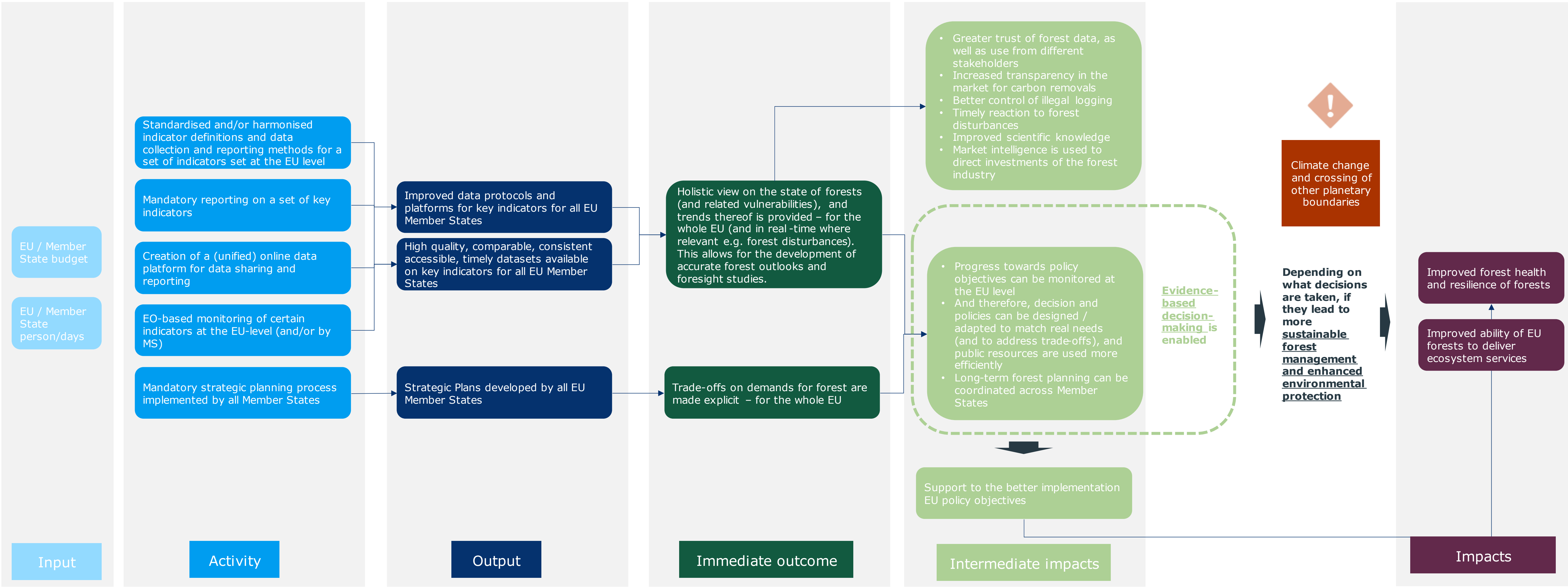
5.1.1 The rationale of the proposal

It is expected that the creation of an EU Framework for forest monitoring and strategic plans ("the Framework") will contribute to wider benefits (i.e. positive impacts) for the whole EU. However, the creation of the Framework will not, in itself, directly lead to environmental, social or macroeconomic benefits for the EU, as it is primarily a framework intended to support evidence-based policy making through a specific set of outputs (data, evidence, analysis, strategies). This is expected to lead to more effective policies and monitoring of policy implementation, to in turn contribute to more long-term, indirect benefits related to forests and nature.

To assess the impacts of the Framework, it is therefore deemed necessary to define the intended intervention logic, i.e. how access to accurate, frequent and robust data will contribute to healthier and more resilient forests, to identify the links between what the framework is proposing with the expected, more indirect, long-term benefits.

Figure 5.1 below presents an overview of the logic chain that leads to identification of the wider benefits of the Framework. It aims to illustrate the logic of the initiative and also highlights the enabling factors (environmental, institutional) that will need to be in place or happen for the proposal to generate the intended long-term benefits.

Figure 5.1 Overview of logic chain of the proposal



5.1.2 The structure of this chapter

This chapter provides an overview of and assesses the most significant impacts of the selected policy options. Impacts include social/environmental/economic, positive/negative, intended/unintended, as well as short/long-term effects. They are assessed in terms of changes relative to the baseline (i.e. incremental changes).

This impact assessment faces the distinct challenge that a large part of the economic costs (or, in instances where costs against the baseline decrease, the direct economic benefits – those can also be referred to as "avoided costs) of the different policy options can be assessed, quantified, and even monetised. Those costs (and avoided costs) are the inputs and activities referred to in Figure 5.1 shown above.

At the same time, the ultimate benefits, which are likely to be several magnitudes larger than the costs, are very challenging to assess in monetary terms. These are intermediate impacts and impacts shown in Figure 5.1 above.

This is because the costs are, to a large extent, administrative costs which can be assessed, while the ultimate benefits are predominantly environmental (such as healthier and more resilient forests) and social benefits (such as health benefits or cultural benefits), which in almost all cases are challenging to assess in monetary terms. In addition, they are fairly indirect, since better monitoring and planning does not, in itself, generate benefits but rather creates the conditions for environmental, economic and social benefits to be addressed through more targeted action, and so on.

Thus, the assessment of impacts is split into two main parts. The first part (Section 5.2) reports on the direct economic costs (and benefits). The second part (Section 5.3) then assesses the wider and more indirect environmental, social and macroeconomic impacts that can be expected from the policy options.

5.1.3 Classification of stakeholders

In the context of the assessment of impacts, a number of the most relevant stakeholder groups have been identified. This was done because impacts need to be identified per stakeholder group, and to allow for better comparability between policy options. The table below summarises the main stakeholder groups that are used throughout this chapter.

Table 5.1 Overview of main stakeholder groups

Group	Description
EU institutions	The EU level institutions develop and coordinate policy and oversee its implementation. They use data for policy monitoring and reviews.
MS public authorities	These include the relevant ministries, agencies, and other public institutions in the MS. They organise and implement (or procure) data collection activities and are in charge of strategic planning. They use data and information to support the monitoring of policy implementation and policymaking (including for forest management purposes) and to fulfil international reporting obligations.
Data providers	These include organisations responsible for the implementation of National Forest Inventories, organisations responsible for preparing and or collecting information on forest management planning, as well as organisations involved in the mid- to down-stream development of forest monitoring services in programmes such as Copernicus.

Group	Description
Other users of forest data	These include a wide range of stakeholders which use forest data, for example: • Forest owners: those who own forests and may or may not use them for economic purposes. • Forest industries: forest industries can use information on forest resources to plan their resourcing strategies and to plan the feasibility of possible investments. • Service providers: forest management services, carbon trade services, environment/green services; financial services/insurances; recreation and health, nature-based tourism, but also other types of service business – data applications on natural sites, non-wood products and services, and any other data-based business. • Non-governmental organisations: accurate and timely information will support transparency and participation by non-governmental organisations.
Society	Users of forest products, beneficiaries of healthy forests, general public

Source: Own compilation

5.2 Assessment of direct economic impacts

5.2.1 Identification of impacts

A screening of the likely direct economic impacts was done to identify the ones expected to have the highest magnitude, and which are then further assessed. To this end, it provides a breakdown of the policy options, implementation, activities and cost elements.

Table 5.2 Identification of direct economic impacts of policy option 1

Policy option elements	Relevant requirements	Cost elements	Key assumptions
Mandatory set of indicators reported in one platform.	• MS will be required to collect data for a mandatory set of indicators required by laws	• /	• MS already have to collect data on those indicators, so no additional costs occur
	• EC to create/adapt an online data platform for MS to report to	• **EU institutions** • One-off costs for human resources for practical adaptation of the system	• FISE will be used for data reporting; no new platform needs to be developed. • Since no standardisation or harmonisation is foreseen, the data cannot be aggregated at EU level and thus the different data sets are uploaded individually by each MS to the FISE data catalogue.[45] • No QA/QC of reported data is done by the EU institutions (EEA) before the data set is published on the platform.
	• MS to report the data to the platform	• **MS public authorities** • One-off human resources for adapting workflows from existing data collection obligations (e.g. LULUCF). • Recurring human resource transmission of data to the platform. • Set-up of national contact points for data transmission within national competent authorities.	• Adapting the workflows from existing data collection activities will be minor. • No additional detail or requirements will be added to the required reported data. • Thus, no additional recurring costs will occur for reporting; the current costs from reporting under existing laws (e.g. LULUCF) will remain the same; the planned costs from upcoming initiatives (e.g. the Nature Restoration Law) will remain the same.
MS to develop and operate remote sensing-based monitoring	• EU institutions to identify and define remote sensing-based indicators where RS is pertinent	• **EU institutions** • One-off costs for identifying and defining the most pertinent indicators; this can be done either through in-house resources or through procurement; some work on this was already done as part of the impact assessment support study. However, more work is needed in order to clearly identify and define the	• This only applies to indicators which are required by law; thus it potentially replaces current (or upcoming) data collection efforts under those laws. • Remote sensing includes both satellite data collection as well as airborne data collection. • "Develop" in the context of the wording of the policy option ("Require MS to develop and operate remote") refers to the national calibration of a methodology developed by the EC; this would be in line with the

[45] See: https://forest.eea.europa.eu/datacatalogue

Policy option elements	Relevant requirements	Cost elements	Key assumptions
		indicators that should be measured by MS through remote sensing	initiative's objective of having more comparable data and would also be the most cost-effective way forward. • MS are either already collecting data through ground-based data for existing legal obligations (or are planning to do so from upcoming legal obligations) OR are already collecting the data through remote sensing.
	• MS to develop remote sensing-based monitoring where RS is pertinent	• **MS authorities** • one-off resources for adapting EC-developed methodology to local context; • potentially recurring resources for further calibration.	• /
	• MS to operate remote sensing-based monitoring where RS is pertinent	• **MS authorities** • MS to operate remote sensing, either through internal resources or through procurement.	• /
MS develop strategic plans according to their own structure and needs.	• MS to develop strategic plans	• **MS authorities** • Recurring cost for drafting the report	• It is assumed that a maximum time interval between different plans is prescribed in the regulation, but that MS are free to choose their own time interval, linked to their existing processes (e.g. linked to data collection cycles) as long as it stays within the maximum. • It is assumed that the maximum period is 10 years. • It is assumed that most MS already have a plan which they consider a strategic plan (since no clear definition or common understanding of what a strategic plan is exists).
Support by an expert group on Forest Monitoring and Strategic Planning to support Policy Coordination, Implementation and Development	• EC will coordinate and facilitate the group; the MS post experts to the group	• **/**	• This is already done outside this legislative initiative (sub-working group of the SFC on forest monitoring and strategic plans) and thus part of the baseline costs

Table 5.3 Identification of direct economic impacts of policy option 2.1 (medium level of intervention)

Policy option elements	Relevant requirements	Cost elements	Key assumptions
Mandatory set of indicators, reported in one platform. Data collection harmonised for existing indicators and standardised for new ones	• Decision-making on which indicators to add	• **EU institutions** • One-off costs (staff costs) for identifying and defining the most pertinent indicators; could also be recurring in case there is a mechanism in the regulation to update the list in certain intervals; • One-off costs (or recurring) for facilitating the expert group. • **MS public authorities** • Posting of experts (one-off or recurring)	• Expert group members represent all EU MS
	• MS to collect data on indicators which so far have not yet been collected in the respective MS	• **MS public authorities** • One-off costs (staff costs) for preparing roll-out of new indicators. • One-off costs for new equipment required for measuring the indicators (if needed).	• Some of the indicators to be covered under this option are not yet mandatory to collect under existing laws. • From those non-mandatory indicators, some are already collected by some MS.
	• EC to create / adapt an online data platform for MS to report to	• **EU institutions** • One-off costs for human resources for developing and implementing platform / platform adaptation; including one-off costs linked to the practical adaptation of the system (e.g. practical accreditation, training of staff). • Recurring human resources for QA/QC of reported data, as well as for following up with MS on identified issues, user support and recurring IT expenses (e.g. software licences).	• FISE will be used for data reporting; no new platform needs to be developed
	• EC to develop standards for data, metadata, data exchange and data-sharing protocols	• **EU institutions** • One-off human resources for development	• /

Policy option elements	Relevant requirements	Cost elements	Key assumptions
	• MS to provide a comprehensive set of metadata, including on data collection methodologies, data results and accuracies	• /	• MS already have this information in place or are preparing it as part of other laws. Adaptations might be needed for fitting the information to the requirements of the platform; these would, however, be minor and not further assessed.
	• MS to report the data to the platform in the standardised format	• **MS public authorities** • One-off human resources for adapting workflows from existing data collection obligations. • One-off human resources for developing workflows for new data collection obligations. • Recurring human resources for the processing and transmission of data in the MS. • Set-up of national contact points for data transmission within national competent authorities.	• Adapting the workflows from existing data collection activities will be minor. • No additional detail or requirements will be added to the required reported data. • Thus, no additional recurring costs will occur for reporting; the current costs from reporting under existing laws (e.g. LULUCF) will remain the same; the planned costs from upcoming initiatives (e.g. the Nature Restoration Law) will remain the same.
	• Harmonisation of data collection for existing indicators	• **EU institutions** • One-off resources (either internal resources or through procurement) for the development of harmonisation methodology. • **MS public authorities** • One-off resources for coordination with EU institutions for the development of harmonisation methodology (provision of information, coordination, feedback throughout the process). • Potential one-off costs for adapting current data collection frameworks to allow for harmonisation. • Recurring costs for harmonisation of data (either internal resources or through procurement).	• EU institutions cover the main costs of developing the methods for harmonisation.[46] • MS cover the costs for implementing the harmonisation from the reported data.

[46] Through dedicated research grants (where required) or otherwise

Policy option elements	Relevant requirements	Cost elements	Key assumptions
	• Standardisation of data collection for new indicators	• **EU institutions** • One-off resources (either internal resources or through procurement) for the development of standardisation methodology.[47] • **MS public authorities** • One-off resources for coordination with EU institutions for the development of standardisation methodology (provision of information, coordination, feedback throughout the process). • *Avoided cost*: No need to develop own national standard.	• EU institutions cover the main costs of developing the methods for standardisation. • There is a need to take into account the diversity of forest types throughout the EU, which might require specific preparation and/or calibration activities throughout the EU forests; it is assumed that those costs are also covered by the EU institutions. • Costs for MS public authorities is minimal.
EU develops and operates remote sensing-based monitoring with opt-in for MS following a documented data processing protocol	• EU institutions to identify and define additional remote sensing-based indicators where RS is pertinent	• **EU institutions** • Same considerations as for this point under policy option 1.	• Remote sensing includes satellite data collection
	• EU institutions to develop and operate remote sensing for those indicators	• **EU institutions** • One-off resources for creating system. • Recurring costs for maintaining system.	• Development and operation of remote sensing-based monitoring implies having control over the development of methodology and protocols for data assessment, processing and interpretation. This approach ensures a standardised assessment of the indicators across the EU. • Where in situ data are not available from MS, EU seeks to develop existing in situ data collection frameworks that it supports.[48]
	• MS can opt-in to produce the	• **MS public authorities (where they opt in)** • One-off resources for creating own system.	• An advantage of a system that is developed centrally but that has the option to be implemented in a

[47] This could e.g. be done through a HORIZON research project or by issuing a standardisation request from the European Commission to the European Standardisation Organisations

[48] This could then potentially entail further costs from the obligations for further collection of in situ data. However, this is hypothetical at this stage and not further assessed

Policy option elements	Relevant requirements	Cost elements	Key assumptions
	remote sensing-based data following the EU protocols	• Recurring costs for maintaining system.	distributed manner is that MS could realise potential synergies and meet requirements at EU-level as well as at national, sub-national to local levels. • An advantage is also that any possible restrictions on the sharing or use of georeferenced in situ plot data – as is currently an issue in several MS – may be circumvented.
MS develop/align strategic plans with a common structure, including forecasting. Reporting every five years, with a review every 10 years. The Commission sets up the means for policy coordination and uses Strategic Plans for future forest strategies and reporting	• EU institutions to develop a common structure for strategic plans	• **EU institutions** • One-off costs for developing the structure.	• Costs are minimal
	• EU institutions to provide the means for policy coordination	• **EU institutions** • One-off costs for organising the workshops.[49] • One-off costs for developing the guidance materials. • **MS public authorities** • Preparation for and participation in workshops.	• It is assumed that this would entail: • Organisation of workshops (e.g. a forum for exchange of information and experiences of multi-sectoral policymakers and stakeholders) with MS for clarifying details on the strategic plans during the first planning circle.[50] • Provision of guidelines (e.g. a study summarising relevant policy obligations from EU policy; the

[49] Potentially recurring in subsequent planning cycles if a need is identified.

[50] In addition to expert group meetings which are already taking place and can be considered part of the baseline.

Policy option elements	Relevant requirements	Cost elements	Key assumptions
			compilation of best practices for different aspects of the strategic plan).
	• MS to prepare reports every 5 years	• **MS authorities** • One-off costs for developing new or adapting existing methodologies for forecasting. This could either be developed within the public sector or procured. • 5-year recurring cost for conducting the forecasting exercise. • One-off costs for developing new or adapting existing multi-sectoral stakeholder dialogue. • 5-year recurring cost for conducting the stakeholder consultation exercise. • 5-year recurring cost for drafting the report.	• A limited number of MS currently have a plan in place which would satisfy the minimum definition of a strategic plan used in this initiative (i.e. setting multi-sectoral targets, modelling of key parameters).[51] • Where an MS did not yet have a comparable strategic plan in place, costs for the first planning cycle would be considerably higher than for subsequent ones in cases where specific methodologies/capacities (modelling) or structures (i.e. multi-sectoral stakeholder dialogues) need to be established.
	• EU institutions to review common structure every 10 years	• **EU institutions** • 10-year recurring cost for reviewing plans and providing recommendations. • MS authorities. • 10-year recurring cost for adapting.	• No major new elements are added which would result in major costs for MS authorities
Support by an expert Group on Forest Monitoring and Strategic Planning to support Policy Coordination, Implementation and Development	• EC will coordinate and facilitate the group; the MS post experts to the group	• **/**	• This is already done outside this legislative initiative (sub-working group of the SFC on forest monitoring and strategic plans) and is thus part of the baseline costs. • If the group also directly works on harmonisation and standardisation then this additional cost would be equal to that assumed above for research projects with this purpose.

[51] Based on research conducted under this project.

Table 5.4 Identification of direct economic impacts of policy option 2.2 (high level of intervention)

Policy option elements	Relevant requirements	Cost elements	Key assumptions
Extended mandatory set of indicators, including for policy development. Data collection harmonised for existing indicators and standardised for new ones.	• Same additional requirements coming from additional indicators as for policy option 2.1	• Same types of costs as for new indicators not yet mandatory under EU law under policy option 2.1	• Same key assumptions as under policy option 2.1
The EU develops and operates remote sensing-based monitoring for indicators where RS is pertinent.	• Same requirements as for policy option 2.1, except that MS cannot opt in	• Same types of costs as for policy option 2.1, except that MS cannot opt in. However, this option does not exclude the purchase of data, data processing, services or infrastructure from MS at national or sub-national level	• /
MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, with a review every 10 years. The Commission will assess Strategic Plans and issue recommendations.	• Same additional requirements as listed under policy option 2.1	• Same costs as policy option 2.1	• Same key assumptions as under policy option 2.1
	• EU institutions to assess Strategic Plans by MS and issue recommendations	• **EU institutions** • 10-year recurring cost for assessing and issuing recommendations. • MS authorities. • 10-year recurring cost for taking recommendations into account.	• Recommendations would not aim at action beyond reaching agreed policy targets
Support by an expert Group on Forest Monitoring and Strategic Planning to support Policy Coordination, Implementation and Development.	• EC will coordinate and facilitate the group; the MS will post experts to the group	• **/**	• This is already done outside this legislative initiative (sub-working group of the SFC on forest monitoring and strategic plans) and is thus part of the baseline costs. • If the group also directly works on harmonisation and standardisation, then this additional cost would be equal to that assumed above for research projects with this purpose.

Costs and benefits for SMEs

It should be noted that no specific impacts on SMEs and competitiveness were identified.[52]

Costs for the forestry sector

Throughout the assessment of all options, no costs for the forestry sector were identified from the legislative proposal, since costs are expected to be fully borne by MS authorities as well as the EU institutions.

However, the forestry sector stands to gain from improved forest monitoring. These benefits may be both direct and indirect.

For example, potential benefits for the forestry sector can stem from improved remote sensing-based monitoring. The magnitude of those benefits (in terms of avoided costs) can be extrapolated from a case study from Sweden that assessed the benefits from a situation in which ground-based data collection has been replaced by satellite-based monitoring.[53] In this specific case, satellite imagery is used by the Swedish Forest Agency to create maps of clear-cut areas to acquire information on forest management in Sweden. The case study found that the use of satellite data collection allows Sweden to save between EUR 16 and 21 m per year for forest management. Breaking this down further, the case study finds that approximately EUR 9 m of those annual benefits accrue for the public authorities (the Swedish Forest Agency), between EUR 6 and 11 m for private forest owners (from increased compliance with forest management obligations, which in the long term led to higher returns), and for citizens approximately EUR 1m. While this example shows that the actual direct economic benefits depend heavily on the respective context, lessons can nevertheless be drawn concerning the magnitude of benefits by extrapolating the results. A simple extrapolation based on forest area (Sweden: 279,800 km^2; EU overall: 1,592,314 km^2) shows that around EUR 50 m of benefits (i.e. avoided costs) per year can accrue for MS public authorities and between EUR 34 m and EUR 63 m for forest owners. Again, it should be emphasised that the extrapolation leaves out a lot of detail and that the results should only be seen as an indicator of the magnitude of benefits. At the same time, it should be emphasised that the case study only looked at one specific indicator, and that benefits from additional indicators are likely to add up.

Another expected long-term benefit could emerge through realistic planning for biomass demand and supply, which also takes into account climate change and uses of forests other than for biomass, and which may lead to better long-term plannability for the forestry sector, as well as the wood and wood-based bioeconomy industry and associated value chains. Direct benefits may thus be gained from an estimate of the growing stock of the forest, number of trees per hectare, and tree species composition, which are examples of basic indicators that are used by forest owners in their management decisions. Forest monitoring using very high-resolution satellite imagery may be used as a deterrent for illegal logging, or increase compliance by forest owners with logging permissions and tax declarations (this was well demonstrated through a Swedish GMES demonstration case in around 2005 and since implemented throughout the country).

Indirect benefits may come from information derivatives. An example could be a private or public forest information platform that provides forest owners with forest management advice on the basis of forest structure information; or, for example, an estimate of the value of the harvestable

[52] See Better Regulation Toolbox TOOL #23. THE 'SME TEST' https://ec.europa.eu/info/sites/default/files/br_toolbox-nov_2021_en_0.pdf

[53] ESA (2016). Copernicus Sentinels' Products Economic Value: A Case Study of Forest Management in Sweden. See: https://issuu.com/earsc/docs/case_report_-_forest_management_in_

components of the growing stock, or guidance concerning the biodiversity value of a forest and advice on how forest owners might improve the forest stand biodiversity features while maintaining their economic incentives. Examples of benefits such as those mentioned here can be found in the Finnish open forest data ecosystem.

The benefits to the forest sector and an increase in the number of potential users would grow with the resolution and accuracy of the pan-EU datasets. Few countries are advanced on this matter and economies of scale in data collection and provision may further justify EU action.

Still, even if the resolution, accuracy and timeliness of the information were not sufficient at stand level, improvements in the data quality at regional and national level will help forest industries' resource planning.

Improved information on forest ecosystems and resources, leading to better management and protection thereof, is ultimately to the benefit of the forest sector.

5.2.2 Direct economic impacts of policy option 1: Streamlined reporting for forest monitoring and strategic plans – combining legislation and soft instruments

This section assesses the direct economic impacts from the different elements within this option, namely:

- a mandatory set of indicators to be reported in one platform;
- MS to develop and operate remote sensing-based monitoring;
- MS develop strategic plans according to their own structure and needs.

5.2.2.1 *Mandatory set of indicators (forest carbon, health, disturbances, deadwood), reported in one platform*

Benefits and costs from the perspective of the EU institutions

The data will be reported to the FISE platform[54] and thus no major (if any) IT development costs would occur. In addition, any costs would be mainly one-off costs at the beginning of the initiative.

Since no standardisation or harmonisation is foreseen, the data cannot be aggregated at EU level and thus it is expected that the different data sets will be uploaded individually by each MS to the FISE data catalogue.

Under this policy option, only indicators which are already obligatory to be measured through other laws are included. As shown in Appendix 1, this could include up to 19 indicators from legislation such as LULUCF, or the upcoming Nature Restoration Law. When assuming annual reporting of each of those indicators (which is not the case, since most of them only have to be reported on every few years), this would lead to an additional 513 datasets[55] per year. There are currently around 2,500 data sets available on FISE. Thus, such an influx of new datasets would add considerably to the current catalogue, which might require some minor additional staff resources for maintaining the platform.

FISE was developed as a follow-up to the 2013 forest strategy and has since then been managed by the EEA. Maintenance and further development of the platform are partly outsourced through a LIFE grant[56] for approximately EUR 240k over two years for all ongoing work, which confirms that the development costs can be considered minor. Within the institutions, it is assumed that the

[54] See: https://forest.eea.europa.eu/

[55] 19 indicators multiplied by 27 MS

[56] See:https://ec.europa.eu/budget/financial-transparency-system/analysis.html, reference SI2.849829.1

integration would take additional person days as a one-off expense, but that this would be limited and within the range of EUR 10k–25k annually.[57] [58]

In terms of benefits, the EC may save costs on accessing and assessing reporting done by MS authorities where current reporting in formats that cannot easily be automated (e.g. reporting in pdf format) is replaced by reporting of the base data to FISE.

Benefits and costs from the perspective of MS public authorities

MS public authorities would overall face limited costs under this policy option. This is due to the already-mentioned fact that only indicators which are already required under other laws are considered under this policy option.

Some one-off costs would occur for MS public authorities for adapting workflows from existing data reporting obligations to the EC under current and upcoming laws. However, given the assumption that the formats already used will largely stay the same, since the datasets are expected to be submitted to the data catalogue, those costs are considered very minor.

Those incremental costs depend, however, on the specifics of the current data reporting of the relevant indicators. The table below demonstrates this for two examples (LULUCF regulation and legislative proposal for the Nature Restoration Law) which are likely to be included.

Table 5.5 Exemplary overview of baseline conditions for existing indicators

	LULUCF regulation	NRL proposal
Relevant data/indicators to be reported on	Indicators include e.g. the following: • Deadwood (specifically listed in Annex I – as a carbon pool, not for biodiversity purposes). • Roundwood (Art 9 – harvested wood products include paper, wood panels and sawn wood. See also Annex V). • Forest damage (Art 10).	All indicators listed in Annex VI of the proposal, including: • standing deadwood • lying deadwood • stock of organic carbon[59] • share of forests with uneven-aged structure • forest connectivity • common forest birds index
Current reporting format		Data will be made public. It is further specified that "*monitoring systems shall operate on the basis of electronic databases and geographic information systems, and shall maximise the access and use of data and services from remote sensing technologies, Earth observation (Copernicus services), in situ sensors and devices, or citizen science data, leveraging the opportunities offered by artificial intelligence, advanced data analysis and processing*".

[57] The upper limit is calculated by multiplying the current annual costs by 0.2 (since an additional 513 datasets would increase the number of datasets by aprox 20%). The lower limit takes economies of scale into account.

[58] Some data on baseline costs for FISE can be found in an early concept paper, see: https://projects.eionet.europa.eu/fise-project/library/1.-initiating-phase/fise-concept-paper. No more recent data could be identified.

[59] The legislative proposal specifies that those first three indicators should be monitored in a manner consistent with the monitoring required under the LULUCF regulation.

	LULUCF regulation	NRL proposal
Reporting frequency	Annual reporting on emissions, removals policies and measures.	At least every three years[60] and, where possible, every year, starting from the entry into force of the regulation.

Source: own compilation

As can be seen, under both legislative frameworks, a wide range of indicators is already required to be monitored. Importantly, under neither framework is the underlying data produced by the MS reported to a central platform such as FISE. Thus, this might create additional costs that are discussed in more detail below. Methodologies are also defined in both frameworks for calculating the indicators. It is assumed that those are maintained and that thus in principle no additional costs should derive for MS from this initiative. It should be noted that the NRL proposal contains a provision on adopting implementing actions to further specify the methods for monitoring the indicators for forest ecosystems. There is thus an opportunity to further specify the method in a way that is also beneficial for the current legislative initiative. However, costs stemming from this would also count under the NRL.

5.2.2.2 *MS to develop and operate remote sensing-based monitoring*

General considerations on benefits and costs regarding remote sensing-based monitoring

Remote sensing is an umbrella term that entails the use of different technologies for observing and analysing objects from a distance. From an operational standpoint (which is relevant for the respective costs of developing and operating such technologies), in the context of forest monitoring, remote sensing technologies could be broadly categorised into two main categories: satellite monitoring and aerial monitoring.

It is planned that, through the legislative initiative, remoting sensing will play a greater role in forest monitoring than is currently the case. To this end, remoting sensing can:

- replace ground-based data collection (however, in those cases initial ground-based calibration as well as recurring accuracy assessments are also typically needed);
- complement ground-based data collection (e.g. remote sensing is used to identify issues which are then assessed in more detail through ground data collection);or
- be used for monitoring new indicators which have not yet been monitored.[61]

All three technology types (ground-based data, aerial data and satellite data) have general benefits and costs that are summarised in the table below, which provides a semi-quantitative assessment of some key attributes. The attributes are rated in relative terms from + (worst, compared to other methods) to +++ (best, compared to other methods).

[60] Except for the common forest birds index, which is to be monitored every 6 years.

[61] However, in those cases ground-based verification or calibration might also be needed.

Table 5.6 Semi-quantitative review of forest monitoring methods

Method	Data timeliness	Resolution	Data accessibility	Costs	Strengths	Weaknesses
Ground-based data collection	+	+ (+++)*	+	+	Direct observation in the field; source of official statistics; long tradition of methods; strong statistical soundness; possibility to complement with remotely sensed information	Lack of harmonisation on definitions and methods; expensive; raw geodata not available; unable to detect quick changes in near real time; without remote sensing they can report estimates only for very large areas
Airborne data collection	++	+++	+ to ++ depending on the project	+ to ++ depending on the project	Airborne Laser Scanning and optical imagery can be used for precise structural and compositional mapping; good biomass/carbon stock monitoring;	Cost; geographical coverage
Satellite data collection	+++	++ to +++ based on the product used	+++	+++	Wall-to-wall information; capable of acquiring changes in near real time (e.g. forest disturbance); large public and open access databases; pan-European monitoring process operational/demonstrated or developed for many forest indicators	Need for processing capacity; limited spatial resolution; data quality related to climatic conditions; need for ground-based data for modelling, calibration and accuracy assessment

** For official NFI statistics, the spatial resolution is very, very low (countries or regions), but plot-level measures refer instead to small areas (a few hundreds of m² in size). Please note that ground observation can be combined with EO from satellite or airborne, producing wall-to-wall high resolution estimates.*

Source: Own compilation

As is shown in the table above, satellite data offers many benefits such as data timeliness, wall-to-wall information, data transparency and many others. It should be noted that satellites are currently already used for EU-wide forest-related monitoring, for example through the EFFIS.[62]

Benefits and costs from the perspective of the EU institutions

Only limited costs would be borne by the EU institutions for this policy option.

These costs would mainly occur as one-off for identifying and defining the most pertinent indicators. Some work on this was already done as part of this impact assessment, but more work is needed in order to clearly identify and define the indicators that should be measured by MS through remote

[62] See: https://effis.jrc.ec.europa.eu/

sensing. Especially where the definition requires detailed attention and, likely, the development of a detailed methodology.

To ensure comparability of data from MS, the EU institutions could also define minimum product requirements for remote sensing in terms of the technical parameters of an indicator, minimum mapping unit, pixel resolution, periodicity between assessments and accuracy. These could then be calibrated to national circumstances to ensure that the data would be comparable across the EU.

It should be noted that the provision of infrastructure for satellite data requires major investments. For example, the European Earth Observation Programme (Copernicus) alone had a budget of around EUR 4 bn for the period 2014 to 2020.[63] However, these are part of the baseline, and no additional cost would accrue from this legislative initiative.

Infrastructure for satellite data is also provided by private providers. However, their expenses are covered through the sale of the data and thus they would benefit from additional use of their data products.[64]

Benefits and costs from the perspective of MS public authorities

It should be noted that this policy option only applies to indicators that are required by law.

Thus, MS authorities are already required to collect the data. In this context, it is therefore important to ensure that the methodologies required in the existing or upcoming laws allow for data collection through remote sensing.

It should be noted, in this context, that the NRL already requires MS to "maximise the access and use of data and services from remote sensing technologies, Earth observation (Copernicus services)" and others. Thus, potentially, the costs for implementing such methodologies could also be seen as being part of the NRL; however, since this obligation is not very concrete, and the specific information on forest-related indicators under the law does not refer to remote sensing, it is assumed that those costs (and benefits) would thus fall under the current initiative.

For the indicators that will then eventually have to be assessed through remote sensing, the actual costs will depend on several factors.

- Firstly, it depends on whether ground-based information is required for calibrating or validating the data from the remote sensing.
- Secondly, it depends on whether the MS already collects the information through remote sensing and, if yes, whether the methodology is similar to the one proposed by the EC. If it is similar, then no additional costs would occur.
- Thirdly, it depends on whether the MS already collects ground-based data on this indicator and to what extent those costs would be replaced through the remote sensing methodology. If the new methodology is less costly, this would lead to benefits through avoided costs.

The magnitude of potential benefits (in terms of avoided costs) can be extrapolated from a case study from Sweden that assessed the benefits of a situation in which ground-based data collection has been replaced by satellite-based monitoring[65].

Specifically in this case, satellite imagery is used by the Swedish Forest Agency to create maps of clear-cut areas to acquire information on forest management in Sweden. The case study found that

[63] See: https://ec.europa.eu/commission/presscorner/api/files/document/print/en/memo_14_251/MEMO_14_251_EN.pdf

[64] A more detailed overview of the forestry value chain can, for example, be found in EUSPA (2022). EUSPA EO and GNSS Market Report. Innovative Solutions for Health. See: https://www.euspa.europa.eu/sites/default/files/uploads/euspa_market_report_2022.pdf

[65] ESA (2016). Copernicus Sentinels' Products Economic Value: A Case Study of Forest Management in Sweden. See: https://issuu.com/earsc/docs/case_report_-_forest_management_in_

the use of satellite data collection allows Sweden to save between EUR 16 and 21 m per year for forest management.

Breaking this down further, the case study finds that approximately EUR 9 m of those annual benefits accrue for the public authorities (the Swedish Forest Agency), between EUR 6 and 11 m for private forests owners (from increased compliance with forest management obligations which in the long term lead to higher return), and for citizens approximately EUR 1 m.

While this example shows that the actual direct economic benefits depend heavily on the respective context, lessons can nevertheless be drawn concerning the magnitude of benefits by extrapolating the results. A simple extrapolation based on forest area (Sweden 279,800 km^2; overall EU 1,592,314 km^2) shows that benefits of around EUR 50 m (i.e. avoided costs) per year can accrue for MS public authorities, and between EUR 34 m and EUR 63 m for forest owners. Again, it should be emphasised that the extrapolation leaves out a lot of detail and that the results should only be seen as an indicator of the magnitude of benefits. At the same time, it should be emphasised that the case study only looked at one specific indicator, and that benefits from additional indicators will likely add up.

A less contextualised study specifically on the benefits of the Copernicus system[66] estimates that the potential of those cumulative benefits[67] between 2017 and 2035 is between EUR 5 and 13 billion across the EU. However, it should be noted that those numbers are subject to major uncertainties and only partly applicable in this context: they are, to a large extent, based on extrapolating findings from the above-mentioned case study across the whole EU; they assume that a lot of the benefits will come from replacing commercial data with free-of-charge Copernicus data; while the ecosystem benefits are based in the assumption that access to Copernicus data will improve the implementation of the Habitats Directive.

No quantified data could be identified on cases where remote sensing through satellites complemented ground-based data collection, or for cases where a new indicator is measured through satellite data which has not been measured before. However, the table below summarises the main benefits of satellite-based data in a qualitative way, highlighting the main arguments.

Table 5.7 Main benefit types arising from different cases in which remote sensing plays a greater role in forest monitoring than is currently the case

Satellite data replace ground-based data collection (while acknowledging the need for ground-based data for calibration and validation)	Satellite data complements existing ground-based data collection	Satellite data is used for monitoring new indicators
• Avoided costs compared to baseline (e.g. for defoliation and crown condition). [68] • Greatly improved timeliness (e.g. important for identification of disturbances).	• Avoided costs where ground-based data collection intervals can be decreased. • At larger scales, greatly improved harmonisation of data. • Wall-to-wall information.	• Benefits from having new data, which might improve management, compliance, strategic planning and others.

[66] PWC (2017). Copernicus ex-ante benefits assessment. Final report. See: https://www.copernicus.eu/sites/default/files/2018-10/Copernicus-Ex-Ante-Final-Report_0_0.pdf

[67] Coming from a) cost reductions in monitoring compliance with forest management best practices; b) improved yields in forest industry thanks to sustainable management; c) improved and preserved forest ecosystems and green infrastructure.

[68] Avoided costs are the baseline costs which are omitted through this legislative initiative

Satellite data replace ground-based data collection (while acknowledging the need for ground-based data for calibration and validation)	Satellite data complements existing ground-based data collection	Satellite data is used for monitoring new indicators
• At larger scales, greatly improved harmonisation of data. • Wall-to-wall information.		

Source: Own compilation

5.2.2.3 *MS develop strategic plans according to their own structures and needs.*

Benefits and costs from the perspective of MS' public authorities

Strategic planning is meant to provide a comprehensive picture of the multifunctionality of forests in the EU, including forest biomass demand and supply, as well as other aspects such as climate mitigation and adaptation or the ecological condition of forests. In terms of direct economic benefits, one effect can be expected; namely that a thorough forecasting exercise on biomass demand and supply, which also takes into account climate change and uses of forests other than for biomass, may lead to better long-term plannability for the wood and wood-based bioeconomy industry and associated value chains (including end users such as the building sector).

Under this sub-option, MS develop strategic plans according to their own structures and needs. Thus, for MS that already have a plan in place, no costs would occur. Since no clear definition or common understanding exists of what a strategic plan is, most MS are to likely already have an adequate plan in place.

A mapping exercise done as part of the impact assessment shows that, in fact, a large number of MS (16) already have documents in place (or they are currently in the process of developing them) that can be considered to be a national forest strategy. Nine additional MS have a central forest law that might, to some extent, have the same function as a strategic plan. Only in two MS could no strategic plan or central law be identified.

Given the above, it can be assumed that costs in most MS are very limited or will not occur.

In MS that do not yet have a strategic plan in place, costs would arise for developing it. The exact costs depend on the conditions in the respective MS. However, as a reference for the magnitude of the costs, the example of Germany can be given. Germany started developing their 2050 strategy in 2015 and spent approximately EUR 600k on the development (EUR 500k for the preparation of the strategy and 100k for dissemination[69]).

An important factor for costs under this sub-option is the maximum time interval for renewal of the strategic plans. It is assumed that a maximum time interval between different plans is prescribed in the regulation, but that MS are free to choose their own time interval, linked to their existing processes (e.g. linked to data collection cycles) as long as this stays within the maximum, which is assumed to be 10 years.

[69] See: https://www.bundeshaushalt.de/static/daten/2015/soll/epl10.pdf

5.2.3 Direct economic impacts of policy option 2.1: EU framework for forest monitoring and strategic plans, legislation only – medium level of intervention

This section assesses the direct economic impacts from the different elements under this sub-option, namely:

- A mandatory set of indicators reported in one platform. Data collection harmonised for existing indicators and standardised for new ones.
- The EU develops and operates remote sensing-based monitoring with opt-in for MS following a documented data processing protocol.
- MS develop/align strategic plans with a common structure, including forecasting. Reporting every five years, with a review every 10 years. The Commission sets up the means for policy coordination and uses Strategic Plans for future forest strategies and reporting.

5.2.3.1 *Mandatory set of indicators, reported in one platform. Data collection harmonised for existing indicators and standardised for new ones.*

Benefits and costs from the perspective of the EU institutions

The data will be reported to the FISE platform.[70]

In contrast to policy option 1, the data to be reported is harmonised or standardised. Thus, the data could be presented in specific maps, graphs, or other means (as is done under the category "Europe's forests"[71] on the platform). The one-off IT development for those additional knowledge products on the website is estimated to be between EUR 50k and EUR 250k, mostly depending on the number of indicators reported to the platform.

In addition, human resources for QA/QC of the reported data can be expected to create costs, although such costs are likely to be minor to medium. However, they are linked to the respective indicators, which are not yet fully clear, but some general takeaways on such costs can be learned from other initiatives. For example, the QA/QC procedure for GHG projections under the governance regulation[72] may provide some pointers.[73] The procedure includes checks for completeness, consistency, accuracy and comparability that are shared between the EEA and contractors and are partly manual and partly automated. For those checks (including QA/QC of other data reported under the regulation), EUR 1m had been allocated for the first reporting period.[74] However, it should be noted that the reported data is highly complex, spanning several sectors. Thus, it is likely that the costs would be considerably lower. However, as mentioned, this also depends on what indicators will be monitored.

Additional costs would occur for the EC for developing IT-related specifications for data, metadata, data exchange and data-sharing protocols. This would, for example, include the development of xml schemas and guidance documents[75] and thus would not cause major costs.

An important factor for this recurrent cost is the reporting frequency for the indicators. The cost for receiving, reviewing, and harmonising data also increases with each additional indicator.

[70] See: https://forest.eea.europa.eu/

[71] See, for example, here: https://forest.eea.europa.eu/topics/forest-basic-data/basic-data

[72] Regulation Governance of the Energy Union and Climate Action (EU) 2018/1999 (Gov. Reg.) and the related Implementing Regulation (EU) 2020/1208

[73] See: https://www.eionet.europa.eu/etcs/etc-cme/products/etc-cme-reports/etc-cme-report-7-2021/@@download/file/ETC-CME_EIONET_report_7-2021.pdf

[74] See Chapter 3.2.2 here: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=COM%3A2016%3A0759%3AFIN

[75] See, for example, the respective files for reporting under the Drinking Water Directive: https://cdr.eionet.europa.eu/help/DWD/dir199883ec/resources/index.html

Major costs can, however, be expected from developing harmonisation methodologies for the different indicators.

It is difficult to provide an exact resource estimate for harmonising forest monitoring data across all EU MS, as this would depend on a number of factors, such as the scope of the monitoring activities and the level of existing data and infrastructure in each country. Thus, the costs are challenging to estimate without extensive research that is beyond the scope of this impact assessment support study. However, some indications can be found from ongoing initiatives with comparable objectives. The table below provides an overview of such initiatives.

Table 5.8 Overview of ongoing and past initiatives aimed at harmonising EU-wide forest data

Name	Type	Overall budget	Estimated share of the overall budget for harmonisation
PathFinder Towards an Integrated Consistent European LULUCF Monitoring and Policy Pathway Assessment Framework	Horizon Europe research project	EUR 6.3 m	5-10 %
ForestPaths Co-designing Holistic Forest-based Policy Pathways for Climate Change Mitigation	Horizon Europe research project	EUR 5.6 m EUR	TBC by project
DIABOLO Distributed, Integrated and Harmonised Forest Information for Bioeconomy Outlooks[76]	Horizon 2020 research project	EUR 5 m	TBC by project
Improving Data and Information on the Potential Supply of Wood Resources – A European Approach from Multisource National Forest Inventories	Cost action	Unknown	Unknown
Harmonisation of National Inventories in Europe: Techniques for Common Reporting[77]	Cost action	EUR 570k	100%

Source: own compilation

In addition, three framework contracts have been tendered by the Joint Research Centre focusing on forest data and harmonisation. The compilation shows that a lot of work was already done or is currently being conducted for facilitating the harmonisation that this legislative proposed could be built on. However, it is unclear to what extent the findings can be used, also since the results from the two first projects are not listed yet. Given the focus of the most recent and ongoing projects (mostly LULUCF/mitigation-focused), it could be assumed that more additional work would be needed for harmonising data from the proposed NRL than for data reported under LULUCF. Even though the cost is mostly a one-off cost, some adaptations and revisions may be required at later stages.

It should also be noted that, outside of EU funding, a lot of work has already been done on the harmonisation of forest indicators in Europe.[78] In addition, harmonisation of geospatial data would

[76] For the first three projects, more information can be found at https://cordis.europa.eu/

[77] See: https://www.cost.eu/actions/E43/

[78] For example through ENFIN, or other research such as :

Gschwantner et al. (2022) on harmonisation of growing stock monitoring. See: https://www.sciencedirect.com/science/article/pii/S0378112721009592

D'Andrimont et al (2020) on the harmonisation of LUCAS in situ data. See : https://www.nature.com/articles/s41597-020-00675-z

Gschwantner et al. (2019) on the harmonisation of stem volume estimates. See: https://www.researchgate.net/publication/331416572_Harmonisation_of_stem_volume_estimates_in_European_National_Forest_Inventories be strongly facilitated by existing obligations under the INSPIRE Directive[79], i.e. the existing harmonising effect of INSPIRE. The Forest Resource Assessment (FRA) programme, which is carried out by the Food and Agriculture Organisation of the United Nations (FAO) in collaboration with the European Forest Institute (EFI), and which, for example, has a total budget of EUR 5.5 million for the period 2020–2025, should also be mentioned. This programme aims to provide policy-relevant information on the state of the world's forests, including on forest biodiversity, carbon stocks, and other ecosystem services.

It is clear that building on those existing efforts can allow for an efficient data harmonisation process. However, to ensure that existing knowledge is used to the extent possible, the EC could consider launching a fact-finding study to produce a detailed overview of the latest status of harmonisation efforts, including information on their success and rollout, to ensure that existing knowledge is used as efficiently as possible within the legislative proposal.

Since it is assumed that the actual harmonisation of the data will be done by the MS (based on findings from workshops organised as part of the impact assessment), no costs would occur for EU institutions.

Finally, costs could occur for EU institutions in cases where standards are to be developed for indicators that have not yet been collected. Given that all indicators considered to be included under this sub-option (see Appendix 2) refer to data already collected, this is not assessed further.

In terms of benefits, the EC may save costs on assessing the reporting done by MS authorities in formats which cannot easily be automated, such as the assessment of written documents (e.g. in pdf format) for compliance and national forestry accounting plans under the LULUCF regulation (see Table 5.5).

It should also be highlighted again that the focus here is on better policy implementation, which can entail a wide range of additional environmental, social and economic benefits, which are discussed in detail in Section 5.3.

Benefits and costs from the perspective of MS public authorities

There are some important differences when compared with policy option 1.

Adding new indicators not yet part of data collection in all MS

Firstly, under this sub-option there are indicators which are not yet part of the data collection in all MS. In those cases, additional costs would therefore accrue for rolling out the indicator in the country (including staff costs and potentially costs for equipment).

It is not possible to predict the exact costs for rolling out new indicators in MS where they are not yet measured. However, an extrapolation can be attempted based on the average current cost of measuring indicators. While the impact assessment in most cases faced major challenges in identifying information on the costs and budgets of conducting NFIs and other forest monitoring activities, such data could be identified in three MS: FI, FR and NL. While this sample is not

Vauhkonen et al. (2019) on harmonising projections of future forest resources. See : https://annforsci.biomedcentral.com/articles/10.1007/s13595-019-0863-6

Winter et al. (2008) on harmonisation of national forest inventory data for use in biodiversity assessments. See: https://academic.oup.com/forestry/article/81/1/33/624417

[79] Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). See: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=CELEX%3A32007L0002

representative for the whole EU, it nevertheless includes a spread of countries of different sizes and different shares of forest areas.

The average annual cost of forest monitoring (NFI) in those countries is EUR 42/km^2 of forest area. Taking into account the number of indicators covered by each of those MS, the average annual cost for measuring one indicator is EUR 2 /km^2 of forest area. This should, however, only be understood as an approximation. Using this value, the average additional cost of measuring one additional indicator would be EUR 3m for the whole forest area of the EU (i.e. in cases where an indicator is not yet measured in any MS).

In general, it must be noted that detailed information on costs for the monitoring of particular indicators is very sparse and is not openly shared, due to various data protection and competitiveness reasons.

In addition, it should be noted that in the field, no indicators are measured, but instead the variables are then used for calculating the indicators.

Thus, depending on the variables that are currently collected, an additional indicator could come with almost no additional cost if all relevant variables are already collected for other indicators and would only need to be calculated based on the existing data. On the other hand, it could create considerable costs if a lot of different information needed to be collected, which also needs additional training of staff, purchasing equipment, or others.

For example, if a new indicator on the structural diversity of forests is to be introduced, this could be done based on the standard deviation of DBHs. This would come at very limited costs because the DBH of trees are already measured, and thus only a new standard deviation would need to be calculated. On the other hand, if a new indicator on spatial horizontal aggregation of the trees as a biodiversity indicator are to be calculated, this would require knowledge on the position of all trees. If this is not information already collected, it might create considerable additional costs per plot of as much as 30 to 50%.[80]

Another example could be the introduction of a Shannon index as a diversity index. This could be calculated based on information on three species, which would create very limited additional costs, since information on those tree species is already collected. But calculating the same indicator (Shannon index) based on a complete list of plant species (including herbs) rather than the cost of one plot would, as a minimum, be double because an additional expert (a botanist) would be needed for the field work.

As a final example, a study found that adding a single new element into the soil's chemical analysis in an indicator in Slovakia increased costs by 10% for laboratory analysis.[81]

Harmonisation of data

As mentioned above, it is assumed that the harmonisation of the data would be done in the MS. The actual costs of harmonising the data, once the method is implemented, is considered less compared to the development of the methodology. However, while most of the process would be automatic, manual quality assurance procedures would need to be implemented, which create recurring costs.

However, it is important to note that that the potential for harmonisation could face limitations, e.g. when the quality (collection, validation) of data sources is not sufficiently comparable. An example

[80] Expert estimate.

[81] Šebeň, V. 2017:Národná inventarizácia a monitoring lesov SR 2015-2016. Informácie, metódy, výsledky. Národné lesnícke centrum Editor: Národné lesnícke centrum 265s., ISBN: 978-80-8093-234-3

is presented in Vaukhonen et al. (2019).[82] The paper found that their attempts at harmonising data on future forest resources in Europe faced limitations due to the differences in NFI sampling grid density, the number of NFI plats, and others. Thus, there is a potential for harmonisation attempts to require selected MS to adapt their current data collection framework in order to meet certain quality standards that would allow for comparable data across the EU. However, this depends to a large extent on the technical requirements placed on harmonisation from the final legislative text. Thus, the assumption remains that no additional costs for data collection are faced by MS.

Standardisation of data

Regarding standardisation and the question of who would bear the costs of developing the standards, there are different approaches. For example, developing standards through CEN/ISO is an industry-driven process which entails costs for the member bodies involved and for business organisations. When the EC wants to develop the standards, this is often done by issuing a standardisation request to the European Standards Organisations and then financing it through action grants. While resources needed for the development of a standard differ, an average estimate can be made. For example, in the latest renewal of the agreement with the European Standards Organisations, a total of EUR 6 m was provided for 22 topics, i.e. around EUR 270k per topic.

The bulk of the costs, however, are borne by MS authorities that have to adapt their current monitoring to the new standards. This can lead to two different situations. On one hand, MS could give up their current national system and only apply the standardised methodology. This could lead to the loss of national time series. On the other hand, MS could decide to implement two parallel systems (i.e. their national system and the international standard), which would result in increasing costs and inconsistencies.

Costs for MS also depend on whether their current collection grid and frequency are meeting the minimum requirements defined in the standards. As noted in Vaukhonen et al. (2019),[83] there is the possibility that selected MS would be required to adapt their current data collection framework in order to meet certain quality standards that would allow for comparable data across the EU.

Costs for the MS for implementing the new methodology therefore also crucially depend on the indicator. For example, for an indicator of forest condition, the cost of standardisation may be close to zero, e.g. for new, easily visually detectable parameters on a tree which require only limited changes in time and skills to detect. Costs of some other indicators can be much higher – e.g. dendrochronological measurements would be extremely expensive.

Standardisation in EU forest monitoring through fully standardised statistical sampling and fully standardised assessment protocols also exhibits differences regarding costs, caused by the variety of the forest ecosystems in Europe. For example, it would be extremely costly to cover all of Europe with the same sample intensity. NFIs have many decades of expertise in organising their work efficiently (e.g. to avoid overly intensive sampling in very homogenous forests like in the far north of Europe, and overly extensive sampling, when forests are very heterogeneous). This is how national forest statistics save a lot of money while maintaining maximum information quality in terms of accuracy. Furthermore, the assessment protocols cannot be fully standardised because of the variety of different forest ecosystems with very different functioning in the development of forests.

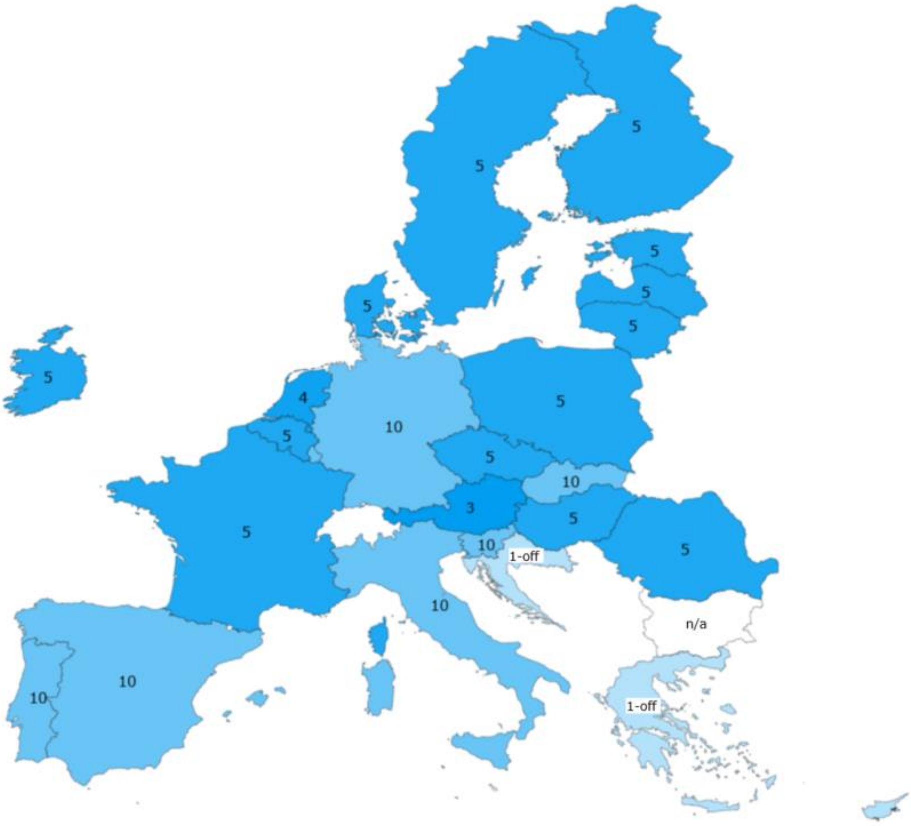
[82] Vaukhonen et al (2019).[82] Harmonised projections of future forest resources in Europe. Annals of Forest Science. See: https://annforsci.biomedcentral.com/articles/10.1007/s13595-019-0863-6

[83] Vaukhonen et al (2019). Harmonised projections of future forest resources in Europe. Annals of Forest Science. See: https://annforsci.biomedcentral.com/articles/10.1007/s13595-019-0863-6

Cost implications of increasing monitoring frequency

The map below shows the current frequency in MS.

Figure 5.2 Time interval between subsequent plot visits



Source: Own illustration

Not shown: Cyprus (only one assessment to date), Luxembourg (10), Malta (n/a)

The figure shows that the majority of MS have intervals of five years. In two MS, Austria and Netherlands, the plots are assessed more frequently than that, at three and four years respectively. Another large group of MS, including Germany, Spain and others, assess their plots every 10 years. In Croatia, Cyprus and Greece, only one assessment has been done to date. No data is available for Bulgaria and Malta.

Based on discussions with experts, it is expected that cost increases due to more frequent data collection would be mostly linear for countries in which frequent plot visits have already been conducted in the past (every 10 years).

For countries which have only conducted one exercise, or none so far, the first NFI would require major investments to put in place new infrastructure, build the expertise, buy equipment, etc. In those cases, the costs would decrease for the subsequent exercises.

5.2.3.2 *The EU develops and operates remote sensing-based monitoring with opt-ins for MS following a documented data processing protocol*

Benefits and costs from the perspective of the EU institutions

It is assumed that the monitoring would rely purely on data from public satellites.

The development and operation of remote sensing-based monitoring implies having control over the development of methodology and protocols for data assessment, processing and interpretation. This approach ensures a standardised assessment of the indicators across the EU. The costs for the EU institutions would predominantly entail costs for creating and maintaining the IT system and an environment for developing and operating the remote sensing-based monitoring of indicators.

It can be assumed that in situ data is needed to calibrate and verify the satellite data. Where in situ data are not available from MS, there is the possibility that the EU could seek to develop existing in situ data collection frameworks that it supports. This could then potentially entail further costs from obligations for further collection of in situ data. However, this is hypothetical at this stage and not assessed further.

Since it is assumed that the monitoring would purely rely on data from public satellites, this implies that there are no costs for data acquisition. However, depending on which indicators are monitored, processing costs can occur.

For accurately assessing the costs stemming from additional remote sensing-based monitoring for indicators, an average price for remote sensing is attempted to be calculated. However, it is challenging to conclude on one average for a number of reasons, including:

- there are free and commercial satellite imagery sources;
- spatial resolution is a major determinant of cost;
- pricing models include volume discounts, a subscription service, pay-per-use, etc.
- studies may or may not consider factors such as processing costs in their calculations.

Some studies exist which can be used for determining an average price for remote sensing data collection. The figure below provides a recent example of such a determination (2018).

Table 5.9 Cost features for satellites sensors

	Minimum order area *ha*	Price per unit *$ ha⁻¹*	Minimum area price* *$*	Computational demand *KB ha⁻¹*
Deimos-2	10 000	0.060	700	50
Dove	10 000	0.012	218	8
GeoEye-1	10 000	0.275	2850	100
Kompsat-2	2 500	0.055	237.5	20
Kompsat-3	2 500	0.110	375	50
Kompsat-3A	2 500	0.160	500	100
Landsat-7/8	3 700 000 (one scene)	0	100	0.5
Pleiades-1A/1B	10 000	0.213	2225	100
Rapideye	10 000	0.012	218	4
Sentinel-2	1 200 000 (one scene)	0	100	0.63
Spot-6/7	10 000	0.045	550	8
WorldView-2/3/4	10 000	0.275	2850	130

*minimum area price is obtained by minimum order area times price per unit plus data processing cost

Source: Sozzi (2018) et al. Benchmark of Satellites Image Services for Precision Agricultural use. See: https://www.researchgate.net/publication/326417596_Benchmark_of_Satellites_Image_Services_for_Precision_Agricultural_use

As can be seen in the table, the averaged minimum area price for the two public satellites covered in that table is approximately EUR 10,000 /km^2. In another example, Sozzi et al. (2021)[84] estimates

[84] Sozzi et al (2021). Economic Comparison of Satellite, Plane and UAV-Acquired NDVI Images for Site-Specific Nitrogen Application: Observations from Italy.

that the price per km^2 of a specific data product[85] that can be used for precision agriculture from satellite data is, on average, EUR 7,600 for medium resolution (spatial resolution >10 m) outputs, while being EUR 250,700 for very high resolution outputs. Another available estimate is based on actual costs in one MS which stated during data collection for this impact assessment that the data processing costs per km^2 are around EUR 100–200. Those average prices then need to be multiplied by the forest area in specific MS or across the whole EU. Due to the large areas of forested land within the EU, this average price of remote sensing data collection is a very important multiplier.

The examples above show that even in cases where costs are only stemming from processing data and not from purchasing it (i.e. for public satellite data such as from Sentinel), costs would still be considerable. It should also be taken into account that resolution plays a crucial role for the price as well as the specific further processing that is needed in order to derive data for a specific indicator.

As can be seen, the estimates of the potential cost for the processing of satellite data have a considerable range. Ultimately, the cost will depend on the specific product or variable that is selected. However, four things should be noted.

First, the data collecting done as part of this impact assessment shows that a majority of MS already use satellite data for forest monitoring. If this was done by the EU institutions and in line with MS needs, it is likely that MS would cease their own operations and thus they would avoid these costs.

Secondly, it should be noted that a wide range of satellite datasets at EU and global scale, relevant for forest monitoring, are already available through open access. The following table provides relevant examples.

Table 5.10 Databases available across Europe regarding forest

Dataset Title	Potential use cases	Resolution	Survey
TERRASAR-X	above-ground biomass, structural characteristics, forest degradation monitoring	1 to 16 m	11 days
RADARSAT-1 & 2	above-ground biomass, structural characteristics, forest degradation and wildfire monitoring	10 to 100 m	24 days
SENTINEL 1	above-ground biomass, structural characteristics, forest degradation and wildfire monitoring	5 to 100 m	12 days
Landsat MSS, TM, ETM+	vegetation indices (e.g. NDVI)	30 m (15 m panchromatic, 60 m thermal)	16 days
Landsat OLI	vegetation indices (e.g. NDVI)	30 m (15 m panchromatic, 100 m thermal infrared)	16 days
MODIS Aqua and Terra	Land products: land cover transformation; vegetation chlorophyll; leaf, canopy and green differences; forest fires	250 m to 1000 m	daily, monthly, composite
MODIS Vegetation Indices	NDVI (normalised difference vegetation index) and EVI (enhanced vegetation index)	250 m to 1000 m	16 days
MODIS Thermal anomalies (Fire)	Fire occurrence (day/night), location, criteria used, detection confidence, fire radiative power	1000 m	1 to 8 days
MODIS Leaf area index/FPAR	LAI (one-sided green leaf area per unit ground area in broadleaf canopies, and as half the total needle surface area per unit ground area in coniferous canopies) and fPAR (fraction of photosynthetically active radiation (400–700 nm) absorbed by green vegetation)	500 m	4 to 8 days

[85] A Normalised Difference Vegetation Index (NDVI). Although not directly on the topic of forest observation, the agricultural topic of the paper can nevertheless be considered closely related enough to be able to transfer findings, including costs for the development and processing of data.

Dataset Title	Potential use cases	Resolution	Survey
MODIS GPP/NPP	GPP (gross primary production) and NPP (Net primary production)	1000 m	8-day to yearly
MODIS Burned area	Burn area	500 m	monthly
Rapideye	High spatial resolution data for e.g. calculation of vegetation indices	5 m	average 5 days
SPOT 6,7	High spatial resolution data for e.g. calculation of vegetation indices	6 m (1.5 m panchromatic)	26 days
ASTER	Visible/NIR bands to e.g. calculation of vegetation indices, main product is Global Digital Elevation Model (GDEM)	15 m (VNIR), 30 m (SWIR), 90 m (TIR)	16 days
ENVISAT MERIS	Visible/NIR reflective bands to calculate e.g. vegetation indices, chlorophyll fluorescence and absorption. Higher spectral resolution than MODIS.	300 m	yearly
SENTINEL-2 MSI	High spatial resolution data for e.g. calculation of vegetation indices, water and crop monitoring	10 to 60 m	5 days (2 satellites)
MERIS - Vegetation index	NDVI	300 m	daily, weekly, monthly
NOAA AVHRR - Vegetation index	NDVI	1 km	daily, weekly, monthly

Based on information in Ruiz-Benito et al. (2020). See: https://www.sciencedirect.com/science/article/pii/S0304380019303783?via%3Dihub

Most of the examples in the table (except for the last two) refer to raw satellite data and thus require data treatment with additional costs. However, given that the data sets already exist (also taking into account the existing investments made for developing the infrastructure) and the benefits that can be expected from better forest monitoring, those additional costs can be considered an efficient investment.

Thirdly, it should also be noted that, when developing more forest data services, e.g. through Copernicus, there will be common data streams (e.g. in situ data compilation and validation), which will lead to efficiency gains.

Finally, economies of scale (i.e. efficiency gains) can be expected for larger areas such as entire EU forest areas, as compared to smaller ones such as at national or local scale, as provided in the examples above.

Benefits and costs from the perspective of MS public authorities

MS can opt in to produce the remote sensing-based data following the EU protocols. An advantage of a system that is developed centrally but that has the option to be implemented in a distributed manner is that MS could realise potential synergies and meet requirements both at EU-level as well as at national, sub-national to local levels. Another advantage is also that any possible restrictions on the sharing or use of georeferenced in situ plot data – as is currently an issue in several MS – may be circumvented. Finally, as mentioned above, it can be assumed that MS will cease their own satellite-based data sets if the ones headed by the EU are fit for their purposes, and thus that the costs for these would be avoided.

5.2.3.3 *MS develop/align strategic plans with a common structure including forecasting. Reporting every five years and reviewing every 10 years. The Commission sets up means for policy coordination and uses Strategic Plans for future forest strategies and reporting.*

General considerations on strategic planning

It is assumed that strategic plans should, as a minimum, entail the following elements:

- Target-setting for different uses, including for key thematic areas: forest resources; productive functions; ecosystem services; forest biodiversity; forest health and vitality; climate change adaptation and mitigation; the bioeconomy.
- Long-term modelling (forecasting) of key parameters (e.g. production of wood resources, environmental parameters such as GHG balances or bark beetle risk).

Beyond this, there are still some uncertainties which affect the assessment of impacts, including the following main points:

- Based on research conducted in the project, no existing "strategic plan" could be identified which would fully satisfy the above points. The conducted research allows for some conclusions on the extent to which the different topics mentioned above (forest resources; productive functions; ecosystem services; forest biodiversity; forest health and vitality; climate change adaptation and mitigation; bioeconomy) are already covered in existing plans, such as sectoral plans; however, the detail in the research conducted is not sufficient to draw conclusions on the extent to which MS could transfer the existing information from existing plans into a new strategic plan, due to differences in approach, scope, timeline, etc.
- The required level of detail of the different topics to be contained in the strategic plans is not yet known.
- The modelling is not yet closely defined; in addition, data collection activities in the MS as part of this project did not cover the question of the extent to which comparable modelling approaches already exist in the MS.
- It is not clear whether the data needs required to fill the respective section of the strategic plan outline would go beyond:
- a) what is required under the policy option eventually picked under objective A.
- b) other information which is already collected in MS.

Benefits and costs from the perspective of the EU institutions

EU institutions would face minor costs under this policy option.

This includes:

- Costs for developing the final structure of the strategic plans, in case this is done as part of a future delegated action and not already included in the current preparation activity.
- Costs for providing the means of policy coordination between EU MS, such as costs for organising the workshops, or costs for developing the guidance materials (depending on the chosen form of policy coordination).
- 10-year recurring costs for reviewing the structure of the strategic plans.

Under this policy option, no activities are foreseen for the EU institutions regarding assessment of the plans submitted by the MS, which would be likely to create the main bulk of the costs.

Benefits and costs from the perspective of MS public authorities

MS authorities would cover the main costs under this policy option.

The actual costs per MS would, to some extent, depend on the existing information, structures and expertise in the MS. However, it is challenging to build this baseline, due to the points discussed at the beginning of this chapter.

Throughout all MS, public authorities would face minor costs for participation in policy coordination activities.

The main costs would arise from the preparation of the reports. This would include the following items:

- one-off costs for developing new or adapting existing methodologies for forecasting;
- recurring costs for conducting the forecasting exercise;
- recurring costs for target-setting (including internal coordination between authorities and conducting stakeholder consultations);
- recurring costs for drafting the report.

The recurring costs depend on the frequency with which the reports are due; it is currently assumed that this will occur every five years.

The costs of development or adaptation of existing methodologies and capacities for forecasting depend, to a large extent, on the status quo in the MS as well as on the indicators to be included.

Regarding the costs of drafting the reports, it is not possible to foresee how MS would work to conduct this, since this would be likely to depend on the national context, capacity, economic situation, etc. Since there are a multitude of options available on how the structure of the strategic plans could eventually be designed, it is not possible to estimate the direct costs for MS. It is not possible to estimate the costs precisely, but an indication can be derived from the example of the Renewable Energy Directive (RED). The Fitness Check of Reporting, Planning and Monitoring Obligations in the EU energy *acquis*[86] surveyed MS about their policy planning and reporting costs in relation to several obligations, including those of the RED. The results presented in the study include median costs of EUR 4,407 per Member State per year (resulting in a total of EUR 118,989) for the biennial progress report provided for in Article 22 of the RED. The biennial nature of the report needs to be borne in mind, meaning the costs would be approximately half for a five-year reporting frequency. Those relatively low costs have been found to be largely driven by a standardised template provided by the Commission, which was also found to increase MS compliance with the reporting obligations.[87]

A direct potential benefit could be achieved if the strategic plans were coherent or connected to other relevant reporting processes, such as under CAP, LULUCF, Natura2000 or others.

Benefits and costs from the perspective of forest owners

It is expected that some long-term benefits could emerge through realistic planning for biomass demand and supply, which also takes into account climate change and uses of forests other than for biomass, and which may also lead to better long-term plannability for the wood and wood-based bioeconomy industry and associated value chains.

[86] Trinomics (2016). Fitness Check of the Reporting, Planning and Monitoring Obligations in the EU energy acquis. See: https://energy.ec.europa.eu/preparatory-study-fitness-check-evaluation-planning-and-reporting-obligations-eu-energy-acquis-and_en

[87] European Commission. (2016). SWD(2016) 416 final. REFIT evaluation of the Directive 2009/28/EC of the European Parliament and of the Council. See: https://eur-lex.europa.eu/LexUriServ/LexUriServ.do?uri=SWD:2016:0416:FIN:EN:PDF

5.2.4 Direct economic impacts of policy option 2.2: EU framework for forest monitoring and strategic plans, legislation only – high level of intervention

This section assesses the direct economic impacts from the different elements under this sub-option, namely:

- An extended mandatory set of indicators, including for policy development. Data collection harmonised for existing indicators and standardised for new ones.
- The EU develops and operates remote sensing-based monitoring for indicators where RS is pertinent.
- MS develop/align strategic plans with a common structure, including forecasting. Reporting every five years, with a review every 10 years. The EC will assess Strategic Plans and issue recommendations.

5.2.4.1 *Extended mandatory set of indicators, including for policy development. Data collection harmonised for existing indicators and standardised for new ones.*

The cost structure is comparable to the one in the option, but takes into consideration that additional indicators would have to be measured.

5.2.4.2 *The EU develops and operates remote sensing-based monitoring for indicators where RS is pertinent*

The same costs as for policy option 2.1 are expected, except that MS cannot opt in. However, this option does not exclude the purchase of data, data processing, services or infrastructure from MS national or sub-national level.

5.2.4.3 *MS develop/align strategic plans with a common structure, including forecasting. Reporting every five years, with a review every 10 years. The Commission will assess Strategic Plans and issue recommendations.*

The European Institutions will face costs for assessing the strategic plans and for issuing recommendations.

It is assumed that those recommendations would be targeted at helping MS to reach agreed policy targets faster and more effectively, i.e. with policy compliance, which is not considered a cost in the impact assessment.

5.3 Assessment of environmental, social, and macroeconomic impacts

As was shown in Figure 5.1 above, the following section is structured by separating impacts into intermediate impacts and long-term impacts. Intermediate impacts are those which would come into effect relatively soon after the above assumptions about more effective policies and monitoring of policy implementation have come to fruition, and they generally represent a midway point between the immediate outcomes and the higher level or more long-term benefits. Long-term impacts are more general assumptions enabled by the immediate outcomes and intermediate impacts, facilitating more sustainable forest management and enhanced environmental protection.

Some impacts, particularly long-term benefits which may be more abstract or indirect, are difficult to directly quantify as they are high-level, 'knock-on' benefits of the initiative. Therefore, general estimations are given in quantitative terms where possible, and where numerical estimates are difficult to conclude, qualitative statements based on existing literature are used to illustrate the impact. The long-term impacts are further separated into environmental impacts and socio-economic impacts. However, it is also important to bear in mind that this is a simplification of the complex interlinkages between environmental, social and economic impacts.

Following this same qualification and the difficulties in quantifying many of these impacts, it was decided not to assess each impact per policy option. There would be too much uncertainty in terms of assigning exact impacts to each option based on existing literature and the evidence we have collected, particularly for the long-term benefits. To this end, a more high-level assessment approach was taken, where the baseline is considered in comparison to the potential changes that can arise from the impacts of the initiative.

5.3.1 Intermediate impacts

Facilitation of evidence-based decision-making

The availability of high-quality, accurate and continuous datasets that provide a holistic picture of the state of forests can facilitate the monitoring of progress towards the achievement of policy objectives set either at EU or national level. More importantly, monitoring is a means to improving policymaking across various future and already foreseen, and potentially conflicting, demands on forests. Increasing uncertainties include threats as well as opportunities, such as the impacts from climate change or those of novel methods and technological advancements, for example for carbon capture, nature restoration, or precision forestry. Data monitoring is needed for EU-wide outlooks, scenario-building and impact assessments. The ability of the framework to deliver on this is, of course, highly dependent on the type of indicators that are selected for inclusion, and their adequacy in capturing the broad range of policy goals and objectives.

Assuming that the set of indicators selected allows for progress to be monitored, this could in turn facilitate the development of the necessary evidence base to evaluate the implementation of these objectives, identify gaps or barriers, negative or positive side effects, and eventually adapt existing policy objectives to match current needs and proactively mitigate possible trade-offs. This could also facilitate the design of additional measures or policy objectives that address newly identified needs.

The availability of strategic plans that offer trade-offs between different policy objectives at national level can also contribute to identifying inefficiencies and needs that could require a policy review. In addition to this, processes can be implemented to ensure that long-term forest planning can be coordinated across MS, on the basis of an assessment of the strategic plans (if this is included as a policy option).

Overall, the framework will enable evidence-based decision-making concerning forests at EU level, and potentially also at national and sub-national level. Evidence-based decision-making is one of the pillars of EU policy.[88] It is also strongly recommended in the field of natural resource management and, in particular, forest management and planning where variation in forest types across the continent, as well as differences in the intensity and scale of natural disturbance regimes necessitate approaches adapted to local/regional conditions. Indeed, "forest management is characterised by long decision horizons, inflexible systems and multiple objectives, and is subject to deeply uncertain climate change".[89] "Issues in forest policymaking are subject to differing interpretations, and agreed policies are the result of compromises among many different and sometimes opposing and changing positions and interests related to forests".[90] As a result, the monitoring framework enables more informed decision-making in the face of increasing uncertainties: the decisions cannot be made on past evidence alone, but instead should be made

[88] Communication from the Commission to the European Parliament, the Council, the European Economic and Social Committee and the Committee of the Regions (2021) Better regulation: Joining forces to make better laws. COM(2021) 219 final. See: https://eur-lex.europa.eu/legal-content/EN/ALL/?uri=COM:2021:219:FIN

[89] See: https://annforsci.biomedcentral.com/articles/10.1007/s13595-017-0641-2

[90] See: https://www.fao.org/3/mk788e/mk788e.pdf

on the evidence base accrued through collective learning, experimentation, and research on forests and their contribution to multiple demands.

Greater trust in forest data and use from different stakeholders

More accurate and trustworthy forest information is identified as a key need of stakeholders in the public consultation. The adoption of modern technology, common definitions of indicators and harmonisation/standardisation of data collection methodologies, as well as increased transparency relating to data, could improve trust in forest data across the EU. Depending on the level of accessibility granted to the data collected in the context of the monitoring and planning framework, this could potentially stimulate the additional use of forest data by different stakeholders, beyond traditional users and industries, e.g. the scientific community, policymakers, certain actors within the forest industries, data-based services, the financial sector, etc.

Increased transparency in the market for nature-based carbon removals

Carbon removals will play a key role in the achievement of carbon neutrality by 2050 in the EU, and will be increasingly needed when negative emissions are pursued to stabilise the world's increase in temperature.[91] EU forests and wood products remove approximately 380 MtCO2 eq yr−1.[92] This removal could be a crucial measure within the Fit for 55 legislative package, which has set a target of net greenhouse gas removals in the EU's LULUCF sector of 310 million tonnes of CO_2 in 2030.

In 2022, the European Commission adopted a proposal for a first EU-wide voluntary framework to reliably certify high-quality carbon removals.[93] Forest restoration and carbon storage in long-lasting wood-based products are among the types of removals that will be certified under this framework. Only carbon removal activities that can be measured accurately, that demonstrate additionality and provide long-term storage can be certified, and monitoring of the removals constitutes a key element of the framework. In this context, the monitoring and strategic planning framework, supported by EO-based monitoring, could provide a substantial contribution to the enhancement of transparency regarding forest-based removals. In fact, the proposal specifies that "all land managers should have access to verified emissions and removal data to measure carbon farming practices, and all CO_2 captured, transported, used and stored through industrial activities should be reported and accounted".[94] The availability of this data could support the overall functioning of the EU-wide certification mechanism, but also a broad range of voluntary schemes, and therefore stimulate the adoption of sustainable carbon farming practices across the EU.

Timely reaction to disturbances

Forest disturbances disrupt the composition of forests and compromise the provision of ecosystem services. Disturbances are becoming more frequent and intense, and this is altering forest health at a pace that will increasingly compromise natural adaptation to them.[95] Significant costs are associated with the response to such disturbances, as well as with restoration from disturbances. Where the monitoring and planning framework supports the provision of (near) real-time data on a number of disturbances (e.g. pests), via the more widespread use of EO-based monitoring, this

[91] See: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021DC0800&from=EN

[92] See: https://efi.int/forestquestions/climate

[93] See: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7156

[94] See: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7156

[95] See: https://reader.elsevier.com/reader/sd/pii/S2666719321000625?token=67AB108258B27D4320C19DC6B3692B0113D0E3B574E035D5F3C87D0DA45E40ECB0B186D002C39E2140F668E9962C58F3&originRegion=eu-west-1&originCreation=20221202171419

could result in a faster reaction to disturbances across MS. This could therefore reduce forest degradation related to the disturbances (see Section 5.3.2.1).

Improved scientific knowledge

The availability of high-quality, accessible, comparable and consistent forest data is likely to stimulate advancements in scientific research relating to forests and their management, as well as potentially helping to address existing research gaps.[96]

Market intelligence, and innovative solutions based on forest resources

Monitoring bioeconomy indicators is crucial to ensuring that investments in the forest industry are pursued in a sustainable way, to highlighting potential trade-offs between different demands, as well as identifying areas in need of policy intervention. It is also crucial to assess the coherence and impacts of existing legislation on the sector,[97] including the unintended consequences and trade-offs between competing biomass uses as stocks of natural capital (supporting biodiversity and ecosystem services) and the various extractive uses of biomass for materials and energy.

Data availability is a key obstacle to the assessment of forest stocks and the potential capacity to supply biomass resources for different socio-economic purposes today. Data gaps for forest bioeconomy indicators today mainly relate to geographical coverage, the period covered and disaggregated sectoral information, beyond the unavailability of data for quantifying some of the main bioeconomy indicators.[98]

It is estimated that there is a considerable gap between biomass supply and demand for materials and energy in the EU,[99] and accurate assessments of this gap are crucial to making informed decisions on how to move forward. A report assessing biomass demand and supply in the EU[100] informs us that data availability, for the time periods required and at the appropriate scale, is one of the key obstacles to an accurate assessment, both for current times and for the future. When trying to provide an historical overview of biomass production and consumption in Europe, the study team noted that, for several indicators, data sets were incomplete, were at an incorrect scale, or covered an inappropriate time span. Data uncertainties in this field mean that not all changes are captured, and this can have negative economic consequences in the future.

Data availability and the lack of common definitions and data collection methods are also a problem in the case of non-wood forest products.[101] This leads to the under-representation of these products in "national statistics, development plans, forest policies and land use planning", despite the fact that these products can be an important source of revenue or cultural identity and belonging for consumers and collectors. Furthermore, innovations in novel solutions for health and wellbeing, green infrastructure and urban green spaces, illustrate opportunities beyond traditional wood-based industries and their markets.

[96] See overview: https://link.springer.com/content/pdf/10.1007/s10668-022-02478-1.pdf?pdf=button%20sticky

[97] JRC (2019) Building a monitoring system for the EU bioeconomy.

[98] A complete overview of data gaps for bioeconomy is presented in Biomonitor (2022): Data and data gaps for bioeconomy drivers and indicators and their implications.

[99] Material Economics (2021) EU biomass use in a net-zero economy.

[100] CE Delft (forthcoming) Support to the EEA Biomass Assessment.

[101] Lovric et al. (2021) Collection and consumption of non-wood forest products in Europe.

Recent policy initiatives on sustainable finance, such as the SFDR[102] and CSRD[103], supported by the EU taxonomy, aim to redirect financial flows towards positive outcomes. However, this redirection cannot be achieved using policy measures alone, as there is a need to also discuss the use of the data with the private sectors. Data is required in order to support and comply with SFDR and CSRD reporting, to enable a double materiality approach and to effect positive change. The improved evidence base upon which policy decisions could be made under an EU-wide data reporting and monitoring framework could assist in the accuracy, transparency, and engagement with which sustainable financial reporting is carried out.

Natural capital accounting is a crucial exercise, to ensure that natural capital is considered in decision-making (both policy and business-related). This also helps ensure that ecosystems' contribution to the economy is considered, and that better decisions can be made to preserve them. The MAES report on valuing ecosystem services in the EU[104] informs us that "ecosystem accounting depends on the availability of geospatial reference data that accurately describe the distribution and condition of ecosystems and the services they deliver with sufficient resolution to capture both large and small ecosystems".[105] The report informs us that the current data is not fit for purpose for supporting regular monitoring and accounting of the trends in and status of ecosystems, their condition and the services they provide.

Accurate forest data is needed for forest outlook and foresight studies. Such studies are key to assessing forest resources, their availability and their sustainable future supply. Natural resources, developments related to environmental factors, and the policies affecting the use of natural resources are one factor analysed in corporate foresight studies and the scenarios used for business strategies. Where the monitoring and planning framework provides the necessary data to develop accurate outlook and foresight studies, this market intelligence could support informed investments, but also innovation in bioeconomy activities.

5.3.2 Long-term impacts

Assuming that the framework facilitates evidence-based decision-making at EU level, and supports the implementation (and achievement) of EU policy objectives relating to forests, as well as generally more sustainable forest management and enhanced environmental protection of forests, this could lead to the generation of wider, long-term (indirect) benefits for society. It is acknowledged that the extent to which the availability of a good evidence base will lead different stakeholders, from policymakers to forest owners, to take decisions that ensure healthy and resilient forests in future remains to be seen. In addition to this, a number of external factors, such as climate change and the crossing of other planetary boundaries, will also affect the resilience of forest systems, no matter what decisions are taken. However, it seems important, in the context of this impact assessment, to acknowledge the broader context in which the initiative is being developed, and the ultimate vision to which this is expected to contribute, i.e. indirect environmental and socio-economic benefits.

If the framework facilitates evidence-based decision-making, a mitigation of trade-offs between the demands on forests, and more informed proactive action on emerging disturbances that in fact result in the more sustainable management of forests and enhanced environmental protection, this

[102] Regulation (EU) 2019/2088 of the European Parliament and of the Council of 27 November 2019 on sustainability-related disclosures in the financial services sector (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32019R2088

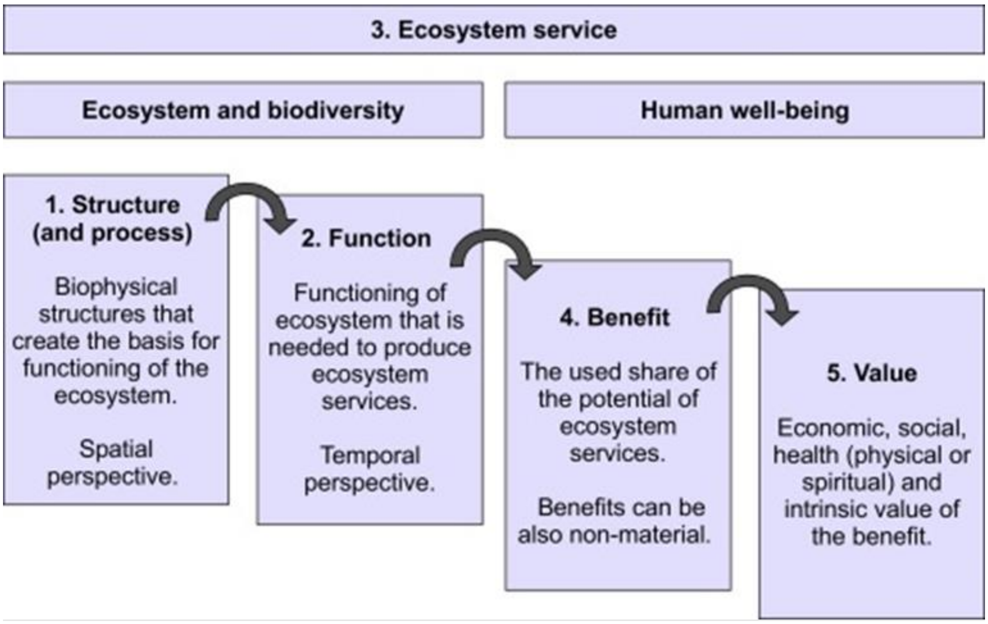
[103] Directive (EU) 2022/2464 of the European Parliament and of the Council of 14 December 2022 amending Regulation (EU) No 537/2014, Directive 2004/109/EC, Directive 2006/43/EC and Directive 2013/34/EU, as regards corporate sustainability reporting (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX%3A32022L2464

[104] See: https://publications.jrc.ec.europa.eu/repository/handle/JRC120383

[105] MAES 2019.

could lead to an overall improvement in the health and resilience of EU forests. This will in turn enable EU forests to continue to deliver on a set of ecosystem services which provide economic, social and health benefits to EU citizens (as outlined in the figure below).

Figure 5.3 Overview of the "functioning" of ecosystem services



The indirect environmental and socio-economic impacts of the policy option(s) are articulated, where possible/relevant, through the lenses of forest ecosystem services. This approach follows the rationale used in the impact assessment of the proposal for a Nature Restoration Law.[106] We assume here that evidence-based decision-making in relation to forests, facilitated by the newly available monitoring and planning framework, would enhance forest health and resilience, and therefore improve ecosystem services in the EU – compared to a no-policy-change scenario where this evidence would not be available.

Worldwide, the loss of ecosystem services is estimated at about 10 trillion euros per year, more than five times the entire value of agriculture in the market economy. Forests provide a wide range of ecosystem services, including timber provisions, non-wood goods, carbon sequestration, flood control, water purification and nature-based recreation. Combined, these forest services are estimated to have a total economic value of EUR 81,413 million for the year 2012 (EU28), with nature-based recreation providing the highest value, at EUR 30,723 million, followed by water purification and timber provision, at EUR 15,374 million and EUR 14,739 million respectively.[107] However, the quantity of the ecosystem services provided, and by association their value, depends both on what ecosystems can deliver and on what is demanded of them. For example, the value of forest ecosystems for flood control and nature-based recreation depends on people's need and demand for these services. Therefore, for example, higher flood risk from further climatic stress and subsequent extreme weather events will require increased flood control power from forests, which must be sufficiently resilient to provide this. In any case, nature's value goes beyond

[106] Impact Assessment accompanying the proposal for a Nature Restoration Law (2022). See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12596-Protecting-biodiversity-nature-restoration-targets-under-EU-biodiversity-strategy_en

[107] Eurostat (2021) Accounting for ecosystems and their services in the European Union (INCA) — 2021 edition. See: https://ec.europa.eu/eurostat/web/products-statistical-reports/-/ks-ft-20-002

economic goods and services: most EU citizens highly value its very existence and recognise its intrinsic worth, consistently identifying ecological degradation as an urgent concern.[108]

Different classification approaches for forest ecosystem services exist. MAES, according to the Common International Classification of Ecosystem Services[109], classifies ecosystem services into three groups: Provisioning, Regulating/Maintenance and Cultural services.[110] However, there are also two other international classifications of ecosystem services applied, according to MA and TEEB initiatives[111]. As MAES is the main framework used at EU level, this is the preferred classification for the report.

Table 5.11 Overview of main forest ecosystem services[112]

Category of ecosystem service	Forest-related ecosystem service
Provisioning services	Provision of biomass, biomass-based energy sources, non-biomass forest products, genetic resources
Regulation and maintenance services	Pest and disease control, liquid and air flows, water conditions, atmospheric composition and climate regulation, mass flow, soil formation and composition, lifecycle maintenance, habitat and gene pool protection
Cultural services	Spiritual and/or emblematic, intellectual and representative interactions, physical and experiential interactions, other cultural outputs. This includes (eco)tourism, hunting, environmental education,

Environmental, social and economic impacts are complex and interlinked. A monitoring framework could contribute improved data and information, preparedness (evidence accumulation and action readiness) and processes (better outlooks and foresight across policy areas and across sectors).

5.3.2.1 *Assessment of environmental impacts*

Better control of illegal logging

Illegal logging primarily impacts regions that are most at risk of large-scale deforestation (e.g. the Amazon, Borneo, the Congo Basin, the Greater Mekong, New Guinea and Sumatra), although it is also a threat within the EU itself, including for some of Europe's last remaining old-growth forests.[113] Specifically, illegal logging affects the ancient forests of central and South-East Europe, in countries such as Bulgaria, Romania, Hungary, Latvia and Lithuania. [114] In Bulgaria, illegal operations made up around a quarter of all logging in 2006–2013, generating hidden revenue of over EUR 50 million

[108] Impact Assessment accompanying the proposal for a Nature Restoration Law (2022). See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12596-Protecting-biodiversity-nature-restoration-targets-under-EU-biodiversity-strategy_en

[109] See: https://cices.eu/

[110] See: https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

[111] See: https://teebweb.org/

[112] See: https://ec.europa.eu/environment/nature/knowledge/ecosystem_assessment/pdf/2ndMAESWorkingPaper.pdf

[113] WWF, 2015. Illegal timber in the EU: Why the EU Timber Regulation should be improved.

[114] European Commission, 2020. Commission staff working document – Evaluation of the Directive 2008/99/EC of the European Parliament and of the Council of 19 November 2008 on the protection of the environment through. Available at: https://ec.europa.eu/info/sites/info/files/evaluation_-_swd2020259_-_part_1_0.pdf

per year.[115] According to a study by the Romanian Government, focused only on a limited set of illegal harvesting methods, an estimated volume of 80 million m^3 of timber was cut illegally in Romania between 1990 and 2011. This represents 24% of the total volume of wood cut during this period – worth at least EUR 5 billion. Another study based on a more detailed approach revealed that "8.8 million m^3 of timber was cut illegally each year between 2008 and 2014, equivalent to 49% of the timber cut during this period". None of these studies took into account all typologies of illegal logging, suggesting the issue has a wider magnitude.[116]

In order to combat illegal logging, a proper monitoring system is essential for quantifying and evaluating the extent of the problem, as a first step towards any further tackling of the issue.[117] Where the creation of an EU-wide forest monitoring framework includes monitoring, across the EU, of key variables that allow for the identification of illegal logging (such as tree cover), this could enable EU- and national level-authorities to take action to stop the criminal practice from happening. If successful, this may result in a reduction of illegal logging within the EU, protecting forest stocks and reducing biodiversity loss, while also allowing MS to reappropriate revenues lost to illegal logging. It is difficult to estimate the value of this reappropriation, as EU-level estimates on the value of illegal logging are not available (beyond some country-level values, as presented above). A comprehensive overview of illegal logging within the EU's forests is unsurprisingly difficult to source, due to the global nature of the issue (with the majority of the EU's connection to the illegal timber trade thought to be from imported wood), the complex interlinkages between sectors, and the associated economic losses and gains. Moreover, a substantial part of the economic losses associated with illegal logging, which would be avoided by improved evidence-based action on this matter, relate to the loss of the ecosystem services supported by those forest stocks, which are not currently priced by the market,[118] but have potentially material societal disbenefits (e.g. loss of natural hazard mitigation, such as floods or landslides; air quality regulation or carbon sequestration).

Reduced deforestation or area of forest cover loss

Deforestation remains one of the largest threats to forests in the EU, despite evidence of stable forest cover since 2000.[119] While overall forest stock may have remained steady, the trends for several important indicators have shown that the quality and health of forests are in decline. As an essential ecosystem, forests provide value across many sectors and for many stakeholder groups. However, many of the less tangible benefits of forests, such as biodiversity or cultural value, require maintained and stable forest ecosystems, which are not conducive to the cyclical nature of deforestation and afforestation commonly seen in forests managed for the industrial sector. The total forest ecosystem extent turnover (the sum of forest cover loss and forest cover gain) in the EU was 285,348 km^2 between 2000 and 2018, despite a 572km^2 net gain in forest cover.[120] Eighteen percent of the initial forest ecosystem extent in 2000 was replaced by 2018, compared to 5.5% in the 2000–2006 period.[121] While this increase is not necessarily exponential, it shows that existing forest ecosystems are not being maintained and that the proportion of original forest area present in 2000 that has been turned over continues to increase. Under the European Green Deal and the

[115] WWF, 2015. Illegal timber in the EU: Why the EU Timber Regulation should be improved.

[116] https://www.europarl.europa.eu/RegData/etudes/STUD/2021/700009/IPOL_STU(2021)700009_EN.pdf

[117] https://lup.lub.lu.se/luur/download?func=downloadFile&recordOId=8986632&fileOId=8986644

[118] See: World Bank, 2019 in https://ec.europa.eu/info/sites/default/files/study_final_report_en.pdf

[119] See: https://www.eea.europa.eu/ims/ecosystem-coverage-in-europe

[120] Maes, J. *et al*. Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN. Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17833-0, doi:10.2760/757183, JRC120383.

[121] Maes, J. *et al*. Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN. Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17833-0, doi:10.2760/757183, JRC120383.

Biodiversity Strategy for 2030, old-growth and primary forests are recognised for their superior ability to sequester carbon, regulate the climate, and act as important habitats, and should be protected. However, old-growth forests only cover 3% of the EU's total forest area.[122] This, along with the trend seen for increasingly high forest extent turnover, shows the potential effect of forest management decisions on important forest services. The practices of clear-cutting and the removal of woody debris from forest floors, while necessary in some capacities, reduce the overall benefit potential of forests.

Old-growth forests are historically less well monitored than other forests and tend to be fragmented and small in plot size.[123] More timely and more accurate monitoring across all of the EU's forests, especially for old-growth forests with high potential for improving environmental health, would reduce mapping inequalities and facilitate the current EU efforts concerning their mapping and subsequent protection. Similarly, increased mapping of all forest area, in terms of extent and health indicators, can enable MS to track patterns of deforestation and identify areas which are most at risk, or aptly named deforestation fronts. This would allow for more informed forest planning and management decisions, particularly concerning the management of protected areas, which are often under national jurisdiction. Similarly, risks to forests (biotic and abiotic disturbances) could be assessed and mitigated across MS. The role of forest ecosystems for soil and water are also factors which impact forest cover – as well as having socio-economic impacts – across Member State borders.

Reduced biodiversity loss

Forests are a key part of the Biodiversity Strategy for 2030, which aims to increase forest cover and improve forest health and resilience. Currently, the global trend for biodiversity loss and biosphere integrity as a planetary boundary is far exceeding the safe operating zone and poses a high risk for irreversible environmental changes.[124]

Biodiversity is an essential pillar of forests ecosystems, as a diverse array of species complete different necessary functions to maintain overall ecosystem health. Forests with higher levels of biodiversity are more resilient, more productive, and have improved ecosystem service performance.[125] However, biodiversity in the EU's forests faces a number of threats, primarily habitat fragmentation, natural and anthropogenic disturbances, pests and diseases, and climate change, which also acts as a major driver of other threats.

As a result of the few indicators related to biodiversity present in the primary European forest assessment reports, there are clear gaps in current knowledge on the state of biodiversity in the EU's forests.[126] [127] EU assessments of forest ecosystems typically include only a limited number of indicators to monitor biodiversity. If the EU is to fulfil the Biodiversity Strategy for 2030, data

[122] Barredo, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. Janouskova, K, Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN. Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76 34230-4, doi:10.2760/797591, JRC124671.

[123] Barredo, J.I., Brailescu, C., Teller, A., Sabatini, F.M., Mauri, A. Janouskova, K, Mapping and assessment of primary and old-growth forests in Europe, EUR 30661 EN. Publications Office of the European Union, Luxembourg, 2021, ISBN 978-92-76-34230-4, doi:10.2760/797591, JRC124671.

[124] Steffen, W., K. Richardson, J. Rockström, S.E. Cornell, et.al. 2015. Planetary boundaries: Guiding human development on a changing planet. Science 347: 736, 1259855.

[125] Sophia Ratcliffe et al., Biodiversity and ecosystem functioning relations in European forests depend on environmental context. Ecology Letters (2017). DOI: 10.1111/ele.12849.

[126] Maes, J. et al. Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN. Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17833-0, doi:10.2760/757183, JRC120383.

[127] FOREST EUROPE, 2020: State of Europe's Forests 2020.

collection and monitoring of other important indicators for biodiversity within forests, for example on other plant and animal species, must be undertaken.

An improved EU-wide monitoring framework would allow for better understanding of the impact of forest management decisions on biodiversity and ecosystem service provision, and the detection of biodiversity hotspots, and therefore protection could be more accurately and efficiently afforded to the most essential areas. Equally, this would better inform strategic planning for those with authority over these areas, and management practices could be streamlined to efficiently make use of resources. A large contributor to the potential of forests to foster biodiversity are the management practices carried out. Clear-cutting, for example, while often a necessary forest management technique, can hinder biodiversity in forests. More concrete links between management practices and biodiversity effects can be assessed once a clearer overview of forest biodiversity is accessible to different forestry stakeholders in the EU through a monitoring and reporting framework.

Reduced forest disturbances and enhanced resilience of forests

There are many disturbances, both anthropogenic and natural, affecting forests in the EU. However, it is clear that climate change plays a role in almost all primary disturbances and will continue to alter current and predicted trends. It is important to improve and maintain forest health and vitality as a measure of protection against the pressures faced. Healthier forests exhibit high resilience against both abiotic and biotic stressors, and as these disturbances will continue to be exacerbated by climate change, the need to enhance forest resilience will increase.

Forests also play a bio-physical role in cyclically reducing their exposure to disturbances by increasing forest carbon stock and reducing the impacts of climate change. Managing forests specifically to increase their resilience to climate change requires specific management decisions which can be informed by well-managed monitoring and the accessible and timely nature of reported data.

Forest fires and extreme droughts

The long-term trend for forest area burned by fires shows a decline of 19.5% (compared to the 2010 baseline value of 331,000 ha/yr). However, the number of fires per year is predicted to increase by 5.3%. In the short-term, extreme drought events will increase by 67.5%, while long-term trends show events will increase by 8.98%. There is a general lack of economic assessments of forest fires and the costs associated with them,[128] yet some estimates have valued economic damage from forest fires in Europe at approximately EUR 1.5 billion per year in the 1998–2009 period.[129]

Without an accurate picture of the areas most at risk of forest fires, sufficient forest management measures cannot be taken to plan for and prevent them. Management strategies such as the use of fire lanes and mosaic landscapes, for example, can be utilised for early detection to minimise the damage and spread, but only if accurate and timely information is provided to inform their implementation.

[128] COACCH, 2018. The Economic Cost of Climate Change in Europe: Synthesis Report on State of Knowledge and Key Research Gaps. Policy brief by the COACCH project. Editors: Paul Watkiss, Jenny Troeltzsch, Katriona McGlade. Published May, 2018.

[129] EEA, 2010. Mapping the impacts of natural hazards and technological accidents in Europe: An overview of the last decade.

Pests and disease outbreaks

The 2020 MAES report found that trends for the pressure from pests, parasites, and insect infestations on forests are unknown, most likely due to a lack of available data. Indeed, a 2018 study which provided an assessment of the economic costs of climate change in Europe found that there was low coverage of the forest sector, and that there was a particularly limited number of studies on the valuation of losses from pests and diseases.[130] Quantitative estimates of the impacts of invasive insects are often incomparable, cover variable time periods, or are at regional level, making it difficult to extrapolate to a national or EU scale.[131] As pest outbreaks are often closely linked to climatic changes (season length, precipitation, food availability, related species population),[132] it will be important to consider both in tandem, particularly regarding how the current rapidly declining trends for climatic indicators will exacerbate the trends for pests.[133] Similarly, the effects of pollutants and excessive nutrient loading on forests can increase their susceptibility to attacks from pests. The bark beetle is currently causing severe damage to the EU's forests, particularly in central Europe. The effects of climate change, mainly the increasingly extended periods of warm and dry weather in the spring and summer have allowed bark beetles to adapt shorter development periods between generations, and thus increase their populations at a rapid rate.[134]

One of the most affected EU MS has been Czechia, where the amount of wood infected by insects has increased rapidly year-on-year since 2015 with further increases expected.[135] Czechia suffered dramatic decreases in the market value of its wood products due to severe bark beetle attacks, necessitating large numbers of infected trees to be cut and sold. Following a severe outbreak in 2018, timber prices decreased from EUR 56-€64 per m^3 (2011–2017) to EUR 14-€16 per m^3.[136]

As climate change continues to affect forests in predicted and unforeseen ways, the specific monitoring needs of forests will continue to change alongside it. A better monitoring framework can assist with creating a solid basis for further monitoring on forest pests and disease outbreaks. For example, remote sensing can be used with high levels of accuracy to detect forest damage caused by bark beetle infestations.[137] Earlier detection of the "green" stage within the outbreak cycle can improve the reaction time and allow forest management decisions to be more informed and effective. Targeted forest management interventions, such as salvage logging, using more timely data, could greatly reduce the incidence and severity of forest damage and improve forest resilience in the short to long-term.

[130] COACCH, 2018. The Economic Cost of Climate Change in Europe: Synthesis Report on State of Knowledge and Key Research Gaps. Policy brief by the COACCH project. Editors: Paul Watkiss, Jenny Troeltzsch, Katriona McGlade. Published May, 2018.

[131] Bradshaw, C., Leroy, B., Bellard, C. et al., 2016. Massive yet grossly underestimated global costs of invasive insects. Nat Commun 7, 12986. https://doi.org/10.1038/ncomms12986

[132] Netherer, S. and Schopf, A., 2010, Potential effects of climate change on insect herbivores in European forests—General aspects and the pine processionary moth as specific example. Forest Ecology and Management (259) 831–838.

[133] Netherer, S. and Schopf, A., 2010, Potential effects of climate change on insect herbivores in European forests—General aspects and the pine processionary moth as specific example. Forest Ecology and Management (259) 831–838.

[134] Baier, P., Pennerstorfer, J. and Schopf, A., 2007, 'PHENIPS — A comprehensive phenology model of Ips typographus (L.) (Col., Scolytinae) as a tool for hazard rating of bark beetle infestation'. Forest Ecology and Management, 249(3) 171–186

[135] Fernandez-Carrillo, A., Patočka, Z., Dobrovolný, L., Franco-Nieto, A., Revilla-Romero, B. Monitoring Bark Beetle Forest Damage in Central Europe. A Remote Sensing Approach Validated with Field Data. Remote Sensing. 2020; 12(21):3634. https://doi.org/10.3390/rs12213634

[136] Hlásny, T., Krokene, P., Liebhold, A., Montagné-Huck, C., Müller, J., Qin, H., Raffa, K., Schelhaas, M-J., Seidl, R., Svoboda, M., Viiri, H. 2019. Living with bark beetles: impacts, outlook and management options. From Science to Policy 8. European Forest Institute.

[137] Hlásny, T., Krokene, P., Liebhold, A., Montagné-Huck, C., Müller, J., Qin, H., Raffa, K., Schelhaas, M-J., Seidl, R., Svoboda, M., Viiri, H. 2019. Living with bark beetles: impacts, outlook and management options. From Science to Policy 8. European Forest Institute.

Introduction of invasive alien species (IAS)

The trends for the percentage of forest area under pressure from IAS are generally unknown, due to a lack of information available for monitoring these species.[138] As stated above, economic losses from IAS in EU forests are not widely reported, especially for invasive insect species that have large damage potential for EU forests. However, a 2021 study estimated that the cumulative cost of the impact of biological invasions on the forest sector in Europe between 1960 and 2020 was EUR 20.9 billion.[139]

In order to accurately plan for potential degradation from IAS, as well as to facilitate optimal forest management if IAS are present, a solid framework for reporting and monitoring the relevant indicators is essential, particularly for enabling early detection and rapid eradication. The uncontrolled spread of IAS is often a transboundary issue that requires cooperation across various levels and regions of governance. The existence of an EU-wide framework for reporting and monitoring spatially explicit information on the species type, extent and density, among other things, could greatly reduce this as a threat in the EU.

5.3.2.2 *Assessment of socio-economic impacts*

The following section, which deals with the long-term socio-economic impacts of the initiative, is structured through the lens of forest ecosystem services, since they generally represent the intersection between social and economic interests in the form of anthropogenic-derived value from nature for social benefit.

The socio-economic impacts and ecosystem services provided by forests that are detailed below are certainly not exhaustive and are not indicative of the full capabilities of the EU's forests, or the long-term impacts that improved sustainable forest management and enhanced environmental protection can have. However, these were prioritised and deemed to be the most prominent and important to highlight, based on the extent to which they are discussed in the literature and the importance placed on them in prominent forest assessment reports. Other impacts besides those discussed here include supporting pollination services for agriculture and so on, water purification, flood and soil erosion mitigation.

Regulation and maintenance services: enhancement of carbon storage and sequestration

"Forests currently sequester around 10% of the EU's annual emissions. While the EU forest sink is currently declining, there is a vast potential to enhance this forest function for climate change mitigation. Forests are considered to play an increasing role to the EU's climate targets for 2030 and 2050. Forests' ability to sequester carbon from the atmosphere is projected to decline further towards 2030 and beyond, under a baseline scenario".[140]

Forest land in the EU currently stores about 360 Mt CO2eq yr−1 of carbon, and this must increase to 450 Mt CO2eq yr−1 by 2050 in order to reach the EU target for carbon neutrality by 2050.[141]

[138] Maes, J. et al. Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment, EUR 30161 EN. Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-17833-0, doi:10.2760/757183, JRC120383.

[139] Haubrock PJ, et al., 2021. Economic costs of invasive alien species across Europe In: Zenni RD, McDermott S, García-Berthou E, Essl F (Eds) The economic costs of biological invasions around the world. NeoBiota 67: 153–190. https://doi.org/10.3897/neobiota.67.58196

[140] Impact Assessment accompanying the proposal for a Nature Restoration Law (2022). See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12596-Protecting-biodiversity-nature-restoration-targets-under-EU-biodiversity-strategy_en

[141] Pilli, R., Alkama, R., Cescatti, A., Kurz, W. A., and Grassi, G. 2022. The European forest carbon budget under future climate conditions and current management practices, Biogeosciences, 19, 3263–3284, https://doi.org/10.5194/bg-19-3263-2022.

There has been a steady decline in the amount of carbon stores, with levels of about 410 Mt CO2eq in the 2010–2012 period, decreasing to 360 Mt CO2eq in the 2016–2018 period.[142] Therefore, the current estimated economic value of the net carbon sink of EU forests is EUR 32.8 billion.[143] Better planning among MS can contribute to the protection of forests for carbon storage into the future and to maintaining the high value of forests for this purpose.

Forests have the potential to greatly contribute to the EU's carbon storage needs for climate mitigation. By improving EU-wide monitoring capabilities, forests can be more accurately managed specifically for carbon storage, including through the promotion of carbon farming practices such as ecologically respectful principles for afforestation and reforestation, enhanced sustainable forest management, and combining agroforestry with other agricultural systems on the same land.[144] The recent European Commission proposal to introduce an EU-wide framework to certify high-quality carbon removals[145] could also be complemented through this initiative where forest owners are encouraged to report and monitor the carbon stored in their forests. Not only would this provide social and environmental benefits through the regulation and maintenance services, but would also provide an economic incentive for those making forest management decisions.

Sustainable provision of forest resources

"Forestry and logging employs almost 500 000 people in the EU27 and the wider sector around 4.5 million people in the EU28".[146] "More than 16 million private forest owners depend directly on the income generated by forests, and forest activities have a turnover of almost €500 billion, employing approximately 3.5 million people".[147]

Timber provision as an ecosystem service is defined as the contribution of ecosystems to the growth of wood harvested as raw material for different purposes (i.e. construction, energy). The value of timber provision as an ecosystem service was estimated at EUR 14,739 million in 2012, for the EU28. For 2019, this value was estimated at EUR 16,379 million.[148] On the other hand, the reported value of marketed non-wood goods in Europe was approximately EUR 4,000 million in 2015.[149]

Where the monitoring and planning framework leads to the adoption of decisions that ensure a more sustainable management of forest resources, this could potentially ensure long-term provision of forest resources in the future, and the ability of forest resources to satisfy the many competing demands (e.g. solid wood for construction, furniture and other wood products, from the paper and packaging industry as well as new bio-based materials for several industrial uses,and for energy).

Monitoring can support the understanding of the current supply for the various competing extractive and non-extractive uses of forests. It is also needed for providing a means to develop alternative scenarios for forest uses and assess the impacts of such scenarios. Alternative scenarios, in turn,

[142] Pilli, R., Alkama, R., Cescatti, A., Kurz, W. A., and Grassi, G. 2022. The European forest carbon budget under future climate conditions and current management practices, Biogeosciences, 19, 3263–3284, https://doi.org/10.5194/bg-19-3263-2022.

[143] Calculated based on the current figure of 360 Mt CO2eq referenced above and the EIB 2022 shadow cost of carbon. See here: https://eur-lex.europa.eu/legal-content/EN/TXT/PDF/?uri=CELEX:52021XC0916(03)&from=EN

[144] See: https://climate.ec.europa.eu/eu-action/sustainable-carbon-cycles/carbon-farming_en

[145] See: https://ec.europa.eu/commission/presscorner/detail/en/ip_22_7156

[146] Impact Assessment accompanying the proposal for a Nature Restoration Law (2022). See: https://ec.europa.eu/info/law/better-regulation/have-your-say/initiatives/12596-Protecting-biodiversity-nature-restoration-targets-under-EU-biodiversity-strategy_en

[147] See: https://sincereforests.eu/forests/forest-ecosystem-services/

[148] Eurostat (2021) Accounting for ecosystems and their services in the European Union (INCA) — 2021 edition. See: https://ec.europa.eu/eurostat/web/products-statistical-reports/-/ks-ft-20-002

[149] See: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

can support the development of new bioeconomic activities, innovative solutions based on wood biomass, as well as non-wood forest goods and services. Multiple demands on forests exceed supply and we must understand the gap between supply and demand to inform policy. Furthermore, policy goals incentivise new approaches to be developed for nature restoration, for climate-smart forestry and precision forestry methods, for example for water protection or agroforestry. Thus, monitoring is needed to collect evidence on the adjusting means to support the sustainable provision of forest resources.

Increased social and cultural services from forests

Forests provide aesthetic experiences and an environment for different outdoor activities. Experiences that are typically sought after are, predominantly, enjoying the natural scenery, peace and quietness, as well as getting physical exercise. Forest-based recreation and tourism are, in themselves, direct benefits for people, as well as also contributing to human health because they reduce stress and enhance both psychological and physiological recovery.[150]

Ninety percent of forest and other wooded land is reported by the European countries as being available for recreational purposes, and more than 1.25 million cultural sites are located in European forests.[151] The use of nature-base recreation is slowly increasing in the EU (17% per decade – from 2000 to 2010), because of an increase in suitable areas for daily recreation, together with an increase in the population in the need of recreation.[152]

The economic value of forest-based recreation was evaluated at EUR 30,723 million in 2012, for the EU28.[153] Forests were the main contributor to the total value of nature-based recreation in the EU, which was estimated at EUR 50,393 million in 2012 for all ecosystems. This total value was estimated at EUR 80,262 million.[154] This represents daily recreation opportunities available for people in ecosystems with high natural quality within 4 km from human settlements.

Recreational users and the tourism and recreation sector, particularly in rural economies, will benefit from healthier and more resilient forests. Enhanced provision of recreational services could also lead to positive impacts on the economy, providing employment opportunities and income for the tourism/recreation sectors and conservation organisations, especially in rural economies. Furthermore, there is green infrastructure that is already tested and developed for new types of solutions in urban environments. Innovations in non-wood goods and services, as well as new types of bioeconomic solutions, could also create opportunities in urban economies.

Increased health benefits from forests

Access to healthy forests, in urban and rural areas alike, brings multiple benefits for mental and physical health. Key health benefits include reduced rates of deaths and diseases (e.g. obesity), reduced stress levels and improvements in mental health, as well as improvements in hospital recovery times.[155] This is because forests reduce air pollution and noise (caused by traffic or other sources, mostly in urban environments) and contribute to the regulation of temperature (e.g.

[150] EFI (2014) The Provision of Forest Ecosystem Services-Volume I: Quantifying and valuing non-marketed ecosystem services.

[151] See: https://sincereforests.eu/forests/forest-ecosystem-services/

[152] JRC (2020) Mapping and Assessment of Ecosystems and their Services: An EU ecosystem assessment.

[153] Eurostat (2021) Accounting for ecosystems and their services in the European Union (INCA) — 2021 edition. See: https://ec.europa.eu/eurostat/web/products-statistical-reports/-/ks-ft-20-002

[154] Eurostat (2021) Accounting for ecosystems and their services in the European Union (INCA) — 2021 edition. See: https://ec.europa.eu/eurostat/web/products-statistical-reports/-/ks-ft-20-002

[155] See: https://www.eea.europa.eu/articles/forests-health-and-climate-change

reduction of heat islands in urban environments). Visits to forest and viewing forest landscapes have direct positive effects on health and wellbeing, explained by the restoration of attention as a result of escaping daily routines and the constant need for concentration, or by innately triggering positive emotions. Urban forests and forested recreation also provide opportunities for physical activity, which is a key factor for the prevention of cardiovascular disease and depression.[156] Not only do forests protect people from natural hazards, but they also provide food, water and medicinal plants.[157]

While it is not possible to quantify the current contribution of forests to health, it is possible to infer that healthier and more resilient forests will maximise their value for health and wellbeing in the EU. For instance, this could help reduce the number of premature deaths related to air pollution, which in 2019 amounted to 307,000 due to chronic exposure to fine particulate matter, and 40,400 due to chronic nitrogen dioxide exposure.[158]

5.3.3 Summary of benefits

- The facilitation of evidence-based decision-making.
- Greater trust in forest data and use by different stakeholders.
- Increased transparency in the market for nature-based carbon removals: EU forests and wood products currently remove approximately 380 MtCO2 eq per year. Enhanced transparency for forest-based removals through this initiative could stimulate further adoption of sustainable carbon farming practices across the EU.
- Better control of illegal logging: a solid evidence base for illegal logging activities across the EU through the improved reporting and monitoring of relevant indicators could help MS and forest owners to reappropriate losses experienced from the practice as revenue elsewhere. Further long-term benefits to ecosystem services and wider societal and biodiversity benefits can also be gained from better control of illegal logging and reduced losses, both economic and biotic.
- More timely reaction to disturbances.
- Improved scientific knowledge.
- Supporting market intelligence and innovative solutions based on forest resources: A comprehensive monitoring and planning framework which improves the data availability on forest stocks and the natural capital of the forest sector could facilitate and improve investment decisions, resource allocation and sustainable finance reporting.
- Reduced deforestation or area of forest cover loss: improved coverage and monitoring of indicators related to EU forest extent can facilitate advancements in the mapping of deforestation and, by extension, enable better-informed planning for forests, which is particularly important in the case of primary forests and the decision-making regarding their protection.
- Reduced biodiversity loss: an improved knowledge base on forest biodiversity indicators could assist with detecting key areas in need of protection, which could better inform strategic planning for forests and contribute to reduced biodiversity loss in the long-term.
- Reduced forest disturbances and enhanced resilience of forests: forest damage from disturbances can have major economic consequences. For example, forest fires caused damages worth approximately EUR 1.5 billion per year in Europe in the 1998 to 2009 period, while biological invasions in European forests were estimated to cost EUR 20.9 billion over a 60-year period. The existence of an EU-wide framework for reporting and monitoring spatially

[156] See: https://foresteurope.org/wp-content/uploads/2017/08/Forest_book_final_WEBpdf.pdf

[157] See: https://files.worldwildlife.org/wwfcmsprod/files/Publication/file/3peoo4s5i3_VoF.8.14.22.pdf?_ga=2.58908143.313529225.1669995518-2043658886.1669995512

[158] See: https://www.eea.europa.eu/publications/air-quality-in-europe-2021/health-impacts-of-air-pollution

explicit information to allow early and rapid detection of forest disturbances could reduce the costs associated with controlling and compensating for the losses.
- Enhancement of carbon storage and sequestration: the economic value of the EU forest area's net carbon sink can be estimated at EUR 32.8 billion.
- More sustainable provision of forest resources.
- Increased social and cultural services.
- Increased health benefits for people.

6. How do the options compare?

The tables below provide a high-level summary of the different options and sub-options. Each table contains the options and sub-options related to one specific objective. As a reminder, the specific objectives are as follows:

- data collection is harmonised and standardised;
- monitoring by Earth Observation is increased to ensure public access to timely and cost-efficient information for land managers, policymakers and stakeholders; and
- establish a coherent governance framework for reporting and planning.

This high-level overview structured around the specific objectives then allows the options and sub-options to be compared.

Table 6.1 Comparison of options and sub-options addressing specific objective 1: Data collection is harmonised and standardised

	Policy option 1: Mandatory set of indicators (forest carbon, health, disturbances, deadwood), reported in one platform	**Sub-option 2.1: Mandatory set of indicators, reported in one platform. Data collection harmonised for existing indicators and standardised for new ones**	**Sub-option 2.2: Extended mandatory set of indicators including for policy development. Data collection harmonised for existing indicators and standardised for new ones**
Impacts			
European institutions	**-** *Limited additional costs for the platform (10k – 25k annually)* **+** *Potential cost savings on accessing and assessing reporting done by MS*	**-- to ---** (depending on number of indicators, reporting frequency) *Several data/IT-related costs including:* • *IT development for additional knowledge products on the website (EUR 50k-250k);* • *QA/QC (relatively large recurring cost).* *Costs from the development of harmonisation methodologies through research projects* **+** *Potential cost savings on accessing and assessing reporting done by MS*	*Same considerations as for sub-option 2.1; additional cost only depending on the number of indicators and reporting frequency*
MS national authorities	**-** *Limited one-off costs for adapting workflows from existing data reporting obligations*	**- to ---** (depending on indicators already measured in MS, forest area in MS, adequacy of existing sampling grid, number of indicators, reporting frequency) *Average annual cost for measuring one indicator is EUR 2 /km^2 of forest area* *Harmonisation of data would create some limited recurring costs* *Substantial one-off costs could occur if an MS has to adapt their current data collection framework in order to meet certain quality standards that would allow for comparable data across the EU*	*Same considerations as for sub-option 2.1; additional cost only depending on indicators already measured in MS, forest area in MS, adequacy of existing sampling grid, number of indicators, reporting frequency*
Other stakeholders	/	/	/
Other criteria			
Effectiveness	**+ to –** *There would be value in making the data available through one platform which thus far*	**+++** *The objective would be fully achieved.*	*Same considerations as for sub-option 2.1*

	Policy option 1: Mandatory set of indicators (forest carbon, health, disturbances, deadwood), reported in one platform	Sub-option 2.1: Mandatory set of indicators, reported in one platform. Data collection harmonised for existing indicators and standardised for new ones	Sub-option 2.2: Extended mandatory set of indicators including for policy development. Data collection harmonised for existing indicators and standardised for new ones
Coverage of identified requirements	*is very scattered and not easily available. However, no harmonisation is achieved.*	*However, this would only be reached in the near future, since time is needed for the development of harmonisation methods, rolling them out, and then the first data collection.*	
Efficiency	**/** *Costs are very limited; however, so is effectiveness*	**++ to –** *If only indicators are selected for reporting and harmonisation under this sub-option which already need to be reported on under other legislation, the objective would be reached efficiently, since the main cost would stem from harmonisation.* *In cases where other indicators are added, those need to be carefully selected based on the number of MS they are already measured in, and the potential need within MS to adapt their system.*	*Same considerations as for sub-option 2.1*
Distribution of advantages and disadvantages between different stakeholders	No observations.	Both, EU institutions and MS would have an equal distribution of costs and benefits.	Same considerations, as for *sub-option 2.1*

/: no impact
Costs, burdens or negative performance on indicators: signalled with between 1 and 3 minus signs, between low costs or burdens (-) and high (---).
Benefits, savings and positive performance on indicators: signalled with between 1 and 3 plus signs in the same way (+; ++; or +++).
():brackets if costs, benefits, etc. are only potential.
If there is uncertainty as to the range of costs, benefits, etc., a range is indicated: e.g. ++ to +++ or – to +.

Table 6.2 Comparison of options and sub-options addressing specific objective 2: Monitoring by Earth Observation is increased to ensure public access to timely and cost-efficient information for land managers, policymakers and stakeholders

	Policy option 1: MS to develop and operate remote sensing-based monitoring	Sub-option 2.1: EU develops and operates remote sensing-based monitoring with opt-in for MS following a documented data processing protocol		Sub-option 2.2: The EU develops and operates remote sensing-based monitoring
Impacts				
European institutions	**-** *Minor costs for identifying indicators, defining minimum product requirements.*	- to --- *Costs are very uncertain and depend on the number of type of indicator. Available examples range from EUR 100 to more than EUR 200 k per km^2 for data processing. However, the lower boundary can still be expected to decrease to economies of scale as well as other efficiency gains.*		*Same considerations as for sub-option 2.1*
MS national authorities	**/ to ++** (depending on extent to which selected indicators are already monitored though remote sensing in specific MS) *Benefits from (partly) replacing ground-based data collection with remote sensing (taking into account that some in situ data collection is still needed)* *Case study on one specific indicator shows potential benefits of EUR 50 m across all MS.*	**/ to ++** *Depending on whether the current satellite data activities at MS level are ceased.*		*Same considerations as for sub-option 2.1*
Other stakeholders	*Case study on one specific indicator shows potential benefits EUR 34 m and EUR 63 m across EU forest owners.*	/		*Same considerations as for sub-option 2.1*
Other criteria				

	Policy option 1: MS to develop and operate remote sensing-based monitoring	Sub-option 2.1: EU develops and operates remote sensing-based monitoring with opt-in for MS following a documented data processing protocol		Sub-option 2.2: The EU develops and operates remote sensing-based monitoring
Effectiveness **Coverage of identified requirements**	+++ *Objective would be achieved.*	+++ *Objective would be achieved.*		*Same considerations as for sub-option 2.1*
Efficiency	+++	*This depends to a major extent on the selected indicators and related costs.*		*Same considerations as for sub-option 2.1*
Distribution of advantages and disadvantages between different stakeholders	No observations.	Costs could be shifted from MS to EU institutions, thus creating financial benefits for the MS.		*Same considerations as for sub-option 2.1*

/: no impact
Costs, burden, or negative performance on indicators: signalled with between 1 and 3 minus signs, between low costs or burdens (-) and high (---).
Benefits, savings and positive performance on indicators: signalled with between 1 and 3 plus signs in the same way (+; ++; or +++).
():brackets if costs, benefits, etc. are only potential.
If there is uncertainty as to the range of costs, benefits, etc., a range is indicated: e.g. ++ to +++ or – to +.

Table 6.3 Comparison of options and sub-options addressing specific objective 3: A coherent governance framework for reporting and planning is established

	Policy option 1: MS develop strategic plans according to their own structure and needs.	**Sub-option 2.1: MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, review every 10 years**	**Sub-option 2.2: MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, with a review every 10 years. The Commission will assess Strategic Plans and issue recommendations.**
Impacts			
European institutions	**/**	**-**	**-** *Compared to sub-option 2.1, some additional costs for issuing recommendations, albeit also minor.*
MS national authorities	**/ to –** (depending on whether MS already have a plan in place) *Development of a plan estimated to cost up to EUR 500k.*	**/ to --** *Actual costs per MS would depend on existing information, structures and expertise in the MS*	Same considerations as for *sub-option 2.1*
Other stakeholders	/	/	/
Other criteria			
Effectiveness **Coverage of identified requirements**	Almost no change since most MS already have some kind of strategic plan in place.	**++**	**++** Potential increase over time if recommendations lead to a gradual improvement throughout the iterations.
Efficiency	/	**+++**	Same considerations as for sub-option 2.1
Distribution of advantages and disadvantages between different stakeholders	No observations.	No observations.	No observations.

/: no impact

Costs, burdens or negative performance on indicators: signalled with between 1 and 3 minus signs, between low costs or burdens (-) and high (---).

Benefits, savings and positive performance on indicators: signalled with between 1 and 3 plus signs in the same way (+; ++; or +++).

():brackets if costs, benefits, etc. are only potential.

If there is uncertainty as to the range of costs, benefits, etc., a range is indicated: e.g. ++ to +++ or – to +.

Annex 1. Procedural information

Not relevant.

Annex 2. Stakeholder consultation synopsis report

This Annex was published by the EC.

Annex 3. Who is affected and how

Practical implications of the initiative

This section reports potential costs and benefits from this initiative for the most pertinent actors: European institutions, national authorities, and other stakeholders such as forest owners and data providers.

Summary of costs and benefits

I. Overview of Benefits (total for all provisions) – Preferred Option		
Description	***Amount***	***Comments***
	Direct benefits	
Harmonisation/ standardisation of forest monitoring	**European institutions** Potential cost savings on accessing and assessing reporting done by MS **MS national authorities** n/a **Other stakeholders** n/a	Benefits are to a large extent indirect
Development of enhanced remote sensing for forest monitoring	**European institutions** n/a **MS national authorities** No to medium cost savings, depending on if the current satellite data activities at MS level are ceased and replaced by EU level monitoring. In those cases there could also be benefits from (partly) replacing ground-based data collection with remote sensing (taking into account that some in-situ data collection is still needed). Extrapolated results from a case study on one specific indicator shows potential benefits of 50m EUR across all MS **Other stakeholders** n/a	Benefits are to a large extent indirect
Strategic planning	**European institutions** n/a **MS national authorities** n/a **Other stakeholders** n/a	Benefits are to a large extent indirect
	Indirect benefits	
	• The facilitation of evidence-based decision-making • Greater trust in forest data and use from different stakeholders • Increased transparency in the market for nature-based carbon removals: EU forests and wood products currently remove approximately 380 MtCO2 eq per year. Enhanced transparency for forest-based removals through this initiative could stimulate further adoption of sustainable carbon farming practices across the EU. • Better control of illegal logging: A solid evidence base for illegal logging activities across the EU through the improved reporting and monitoring of relevant indicators could help MS and forest owners to reappropriate losses felt from the practice as revenue elsewhere. Further long-term benefits to ecosystem services and larger societal and biodiversity benefits can also be felt from the better control of illegal logging and reduced losses, both economic and biotic.	Most benefits of the initiative are fairly indirect since better monitoring and planning in itself does not generate benefits but rather creates the conditions for environmental, economic and social benefits to be addressed through more

I. Overview of Benefits (total for all provisions) – Preferred Option		
Description	***Amount***	***Comments***
	• More timely reaction to disturbances • Improved scientific knowledge • Supporting market intelligence and innovative solutions based on forest resources: A comprehensive monitoring and planning framework which improves the data availability on forest stocks and natural capital of the forest sector could facilitate and improve investment decisions, resource allocation, and sustainable finance reporting. • Reduced deforestation or area of forest cover loss: Improved coverage and monitoring of indicators related to EU forest extent can facilitate advancements in the mapping of deforestation and related better-informed planning for forests, which is particularly important in the case of primary forests and the decision-making regarding their protection. • Reduced biodiversity loss: An improved knowledge base on forest biodiversity indicators could assist in detecting key areas in need of protection which could better inform strategic planning for forests and contribute to reduced biodiversity loss in the long-term. • Reduced forest disturbances and enhanced resilience of forests: Forest damage from disturbances can have large economic consequences. For example, forest fires caused damages worth approximately €1.5 billion per year in Europe in the 1998 to 2009 period and biological invasions in European forests were estimated to cost €20.9 billion over a 60-year period. The existence of an EU-wide framework for reporting and monitoring spatially explicit information to allow early and rapid detection of forest disturbances could reduce the costs associated with controlling and compensating the losses. • Enhancement of carbon storage and sequestration: The economic value of the EU forest area's net carbon sink can be estimated at €32.8 billion. • More sustainable provision of forest resources • Increased social and cultural services • Increased health benefits for people	targeted action etc. Also, those indirect benefits cannot be attributed to one aspect of this legislative proposal, but rather to all parts of it working together towards the overall intended general objective.
Administrative cost savings related to the 'one in, one out' approach*		
(direct/indirect)	n/a since no direct effects on businesses	

*(1) Estimates are gross values relative to the baseline for the preferred option as a whole (i.e. the impact of individual actions/obligations of the preferred option are aggregated together); (2) Please indicate which stakeholder group is the main recipient of the benefit in the comment section;(3) For reductions in regulatory costs, please describe details as to how the saving arises (e.g. reductions in adjustment costs, administrative costs, regulatory charges, enforcement costs, etc.;); (4) Cost savings related to the 'one in, one out' approach are detailed in Tool #58 and #59 of the 'better regulation' toolbox. * if relevant*

The most relevant and quantifiable costs additional to baseline are indicated in Table II. The baseline is built on data collection in all MS to assess the extent to which relevant activities are already conducted in MS. Based on this baseline, cost in MS can vary widely, depending on the extent to which they already collect data on relevant indicators, already use earth observation, or already develop strategic plans.

On the costs related to the 'one in, one out' approach, the initiative is expected to have no effects since no impacts are expected on businesses.

II. Overview of costs – Preferred option							
		Citizens/Consumers		**Businesses**		**Administrations**	
		One-off	**Recurrent**	**One-off**	**Recurrent**	**One-off**	**Recurrent**
Harmonisation/ standardisation of forest monitoring	Direct adjustment costs	n/a	n/a	n/a	n/a	**EU institutions** • One-off costs (staff costs) for identifying and defining the most pertinent indicators; could also be recurring in case there is a mechanism in the regulation to update the list in certain intervals • IT development for additional knowledge products on the website (50k - 250k EUR) • Costs from development of harmonisation methodologies through research projects; to ensure efficiency, it is considered to conduct a fact finding study with an overview of existing harmonisation approaches and their respective success **MS national authorities**	**EU institutions** • Medium to considerable costs, depending on the number of indicators and reporting frequency • Costs are challenging to asses; however, by example of QA/QC procedure for GHG projections under the governance regulation, the required QA/QC procedure cost 1 MEUR for the first reporting period **MS national authorities** • Some to considerable cost, depending on indicators already measured in MS, forest area in MS, adequateness of existing sampling grid, number of indicators, reporting frequency) • Average annual cost for measuring one indicator is 2 EUR/km2 of forest area; thus, average additional cost

II. Overview of costs – Preferred option							
		Citizens/Consumers		Businesses		Administrations	
		One-off	Recurrent	One-off	Recurrent	One-off	Recurrent
						• Substantial one-off costs could occur if a MS has to adapt their current data collection framework in order to meet certain quality standards that would allow for comparable data across the EU • One-off costs (staff costs) for preparing roll-out of new indicators • One-off costs for new equipment required for measuring the indicators (if needed) • One-off human resources for adapting workflows from existing data collection obligations • One-off human resources for developing workflows for new data collection obligations	of measuring one additional indicator would be 3m EUR for the whole forest area of the EU (i.e. in cases where an indicator is not measured yet in any MS) • Harmonisation of data would create some limited recurring costs • Recurring limited costs for human resources for processing and transmission of data in the MS
	Direct administrative costs	n/a	n/a	n/a	n/a	**EU institutions** • n/a	**EU institutions** • n/a

II. Overview of costs – Preferred option							
		Citizens/Consumers		**Businesses**		**Administrations**	
		One-off	**Recurrent**	**One-off**	**Recurrent**	**One-off**	**Recurrent**
						MS national authorities • n/a	**MS national authorities** • n/a
Development of enhanced remote sensing for forest monitoring	Direct adjustment costs	n/a	n/a	n/a	n/a	**EU institutions** • Cost for setting up data infrastructure • One-off costs for identifying and defining the most pertinent indicators; this can be done either through in-house resources or through procurement **MS national authorities** • n/a	**EU institutions** • Costs are very uncertain and depend on the number of type of indicators. Available examples range from 100 EUR to more than 200 KEUR per km2 for data processing. Lower boundary can be expected to still be decreased to economies of scale as well as other efficiency gains. **MS national authorities** • n/a
	Direct administrative costs	n/a	n/a	n/a	n/a	**EU institutions** • n/a **MS national authorities** • n/a	**EU institutions** • n/a **MS national authorities** • n/a
Strategic planning	Direct adjustment costs	n/a	n/a	n/a	n/a	**EU institutions** • n/a **MS national authorities** • Very limited to medium costs • Actual costs per MS would depend on already existing information,	**EU institutions** • Limited costs for issuing recommendations **MS national authorities** • Costs for reporting; again, depends on the baseline of the extent to which the MS already have something

II. Overview of costs – Preferred option							
		Citizens/Consumers		**Businesses**		**Administrations**	
		One-off	**Recurrent**	**One-off**	**Recurrent**	**One-off**	**Recurrent**
						structures and expertise in the MS • Where no comparable information, structures and expertise is in place yet, there are one-off costs for developing new or adaption existing multisectoral stakeholder dialogue; one-off costs for developing new or adapting existing methodologies for forecasting	comparable in place • 5-year recurring cost for conducting the forecasting exercise • 5-year recurring cost for conducting the stakeholder consultation exercise • 5-year recurring cost for drafting the report
	Direct administrative costs	n/a	n/a	n/a	n/a	**EU institutions** • n/a **MS national authorities** • n/a	**EU institutions** • n/a **MS national authorities** • n/a
Costs related to the 'one in, one out' approach							
Total	Direct adjustment costs	n/a	n/a	n/a	n/a		
	Indirect adjustment costs	n/a	n/a	n/a	n/a		
	Administrative costs (for offsetting)	n/a	n/a	n/a	n/a		

Relevant sustainable development goals

III. Overview of relevant Sustainable Development Goals – Preferred Option(s)		
Relevant SDG	**Expected progress towards the Goal**	**Comments (possible synergies and trade-offs between specific SDGs)**
SDG no. 3 – Good health and well-being	The physical and mental health benefits associated with healthier forests could contribute to SDG 3 through targets 3.4[159] (e.g. as mental health improvements from forest visitation and recreation, or from reduced obesity) and 3.9[160] (as reduced mortalities from the reduction of air pollution).	
SDG no. 6 – Clean water and sanitation	The potential of this initiative to restore forests (which are important water-related ecosystems) and improve their health, could contribute to water purification and water availability through the filtration of sediments and harmful pollutants, as well by maintaining the physical structure and integrity of water sources such as rivers and lakes. Overall, these services alleviate additional pressures on water treatment facilities and can reduce costs for suppliers and consumers. Therefore, this initiative could contribute to targets 6.1[161], 6.3[162], and 6.6[163].	
SDG no. 7 – Affordable and clean energy	Under the assumption that this initiative can facilitate more sustainable management of forest resources, there is potential for a greater or more long-term provision of biomass for bioenergy into the future. As a renewable energy source,	A potential trade-off of an increased use of biomass for bioenergy is the over-harvesting of forests resulting in ecosystem degradation, which could conflict with SDGs 13 and 15.

[159] By 2030, reduce by one third premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being

[160] Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all

[161] By 2030, achieve universal and equitable access to safe and affordable drinking water for all

[162] By 2030, improve water quality by reducing pollution, eliminating dumping and minimizing release of hazardous chemicals and materials, halving the proportion of untreated wastewater and substantially increasing recycling and safe reuse globally

[163] By 2020, protect and restore water-related ecosystems, including mountains, forests, wetlands, rivers, aquifers and lakes

III. Overview of relevant Sustainable Development Goals – Preferred Option(s)		
Relevant SDG	**Expected progress towards the Goal**	**Comments (possible synergies and trade-offs between specific SDGs)**
	this would contribute towards target 7.2[164].	
SDG no. 8 – Decent work and economic growth	A monitoring and planning framework which contributes to the sustainable long-term provision of forest resources and also supports the development of new bioeconomic activities and employment opportunities around forest ecosystems (e.g. eco-tourism) can contribute to SDG 8, specifically target 8.9[165].	Important trade-offs may be the shift in employment from traditionally unsustainable forest sectors to emerging or existing sustainable forest industries, or the natural decline of some forest sectors. This may have trade-off effects on SDG 8 target 8.1 on sustaining economic growth if typically more profitable industries are in decline.
SDG no. 12 – Responsible consumption and production	The facilitation of evidence-based decision making, and more informed forest management decisions can contribute to more sustainable consumption and production of forests resources, as is specified under SDG 12. As a natural resource with high natural capital value, the sustainable management and efficient use of forest resources could greatly contribute to target 12.2[166]. Sustainable management within agroforestry could lead to reduced food losses in the production chain as specified under target 12.3[167].	
SDG no. 13 – Climate action	Healthier forests as a potential benefit of this initiative can contribute to combatting climate change and its impacts. Forest ecosystems can act as sinks to store carbon, as well as remove carbon from the atmosphere through sequestration. Healthier forests are more resilient to climate-related or exacerbated	

[164] By 2030, increase substantially the share of renewable energy in the global energy mix

[165] By 2030, devise and implement policies to promote sustainable tourism that creates jobs and promotes local culture and products

[166] By 2030, achieve the sustainable management and efficient use of natural resources

[167] By 2030, halve per capita global food waste at the retail and consumer levels and reduce food losses along production and supply chains, including post-harvest losses

III. Overview of relevant Sustainable Development Goals – Preferred Option(s)		
Relevant SDG	**Expected progress towards the Goal**	**Comments (possible synergies and trade-offs between specific SDGs)**
	disturbances such as fires, flooding, droughts, and pest and disease outbreaks. Therefore, this can contribute to target 13.1[168] to strengthen resilience to climate-related hazards and natural disasters.	
SDG no. 15 – Life on land	An EU-wide framework for forest monitoring and strategic planning could facilitate better management decisions and policymaking to ensure forest ecosystems are protected, restored, and sustainably managed, all important factors of SDG 15. Better sustainable forest management and improved monitoring of the state of forests can contribute to healthier forests in the EU through reduced biodiversity loss, reduced forest disturbances and enhanced resilience to climate change. Equally the initiative could lead to reduced deforestation; reduced land and soil degradation; control of invasive species; and could inform planning for reforestation and afforestation, as a part of targets 15.1[169] 15.2[170], 15.3[171], 15.4[172], 15.8[173], and 15.9[174].	

[168] Strengthen resilience and adaptive capacity to climate-related hazards and natural disasters in all countries

[169] By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

[170] By 2020, promote the implementation of sustainable management of all types of forests, halt deforestation, restore degraded forests and substantially increase afforestation and reforestation globally

[171] By 2030, combat desertification, restore degraded land and soil, including land affected by desertification, drought and floods, and strive to achieve a land degradation-neutral world

[172] By 2020, ensure the conservation, restoration and sustainable use of terrestrial and inland freshwater ecosystems and their services, in particular forests, wetlands, mountains and drylands, in line with obligations under international agreements

[173] By 2020, introduce measures to prevent the introduction and significantly reduce the impact of invasive alien species on land and water ecosystems and control or eradicate the priority species

[174] By 2020, integrate ecosystem and biodiversity values into national and local planning, development processes, poverty reduction strategies and accounts

Annex 4. Analytical methods

Introduction

This Annex describes the analytical methods used in the impact assessment. It is structured around different steps of the impact assessment, namely

- Identification of problems and objectives
- Identification and analysis of impacts

In addition, it explains the method for developing the country fiches developed as part of the impact assessment.

Identification of problems and objectives

The purpose was to clearly identify the problems and drivers that constitute the starting point (and raison d'être) for the new Legislative proposal for an EU Framework on Forest Monitoring and Strategic Plans, as well as to defining the general and specific objectives that the proposed policy options could aim to deliver on. The work was organised along the following stages:

- 1.1 where problems and problem drivers regarding forest monitoring and forest planning in the EU were described;
- 1.2 where requirements for an EU monitoring system and Strategic Plans were formulated; and
- 1.3 where a set of preliminary policy options for consideration were developed.

Stage 1.1: Describe and define problems and problem drivers regarding forest monitoring and forest planning in the EU.

Step 1: Gather information

Subtask 1.1 target was to gather information and conducted a detailed overview of problems and their drivers concerning the forest monitoring systems and forest planning in the EU. The overview is preliminarily based on literature review and expert knowledge as well as to some extent stakeholder views. At the stage of the Task 1 report, the stakeholder views were collected by participating in recent forums discussing the forest monitoring in Europe.

Furthermore, it is worth noting that Tasks 3 and 4 analyses were ongoing in parallel, including the verification of country fiches with necessary detail, for example, for defining the scale of the problem areas described in the Task 1 report.

For the literature review, around 60 sources such as books, scientific papers, projects reports, EU support documents were reviewed. The review focused on screening relevant sources, which covered a critical assessments of monitoring options and related topics, for mentions of problems and drawback of the current forest monitoring system in EU. All references are listed at the end of this Annex.

Step 2: Draft the problem descriptions

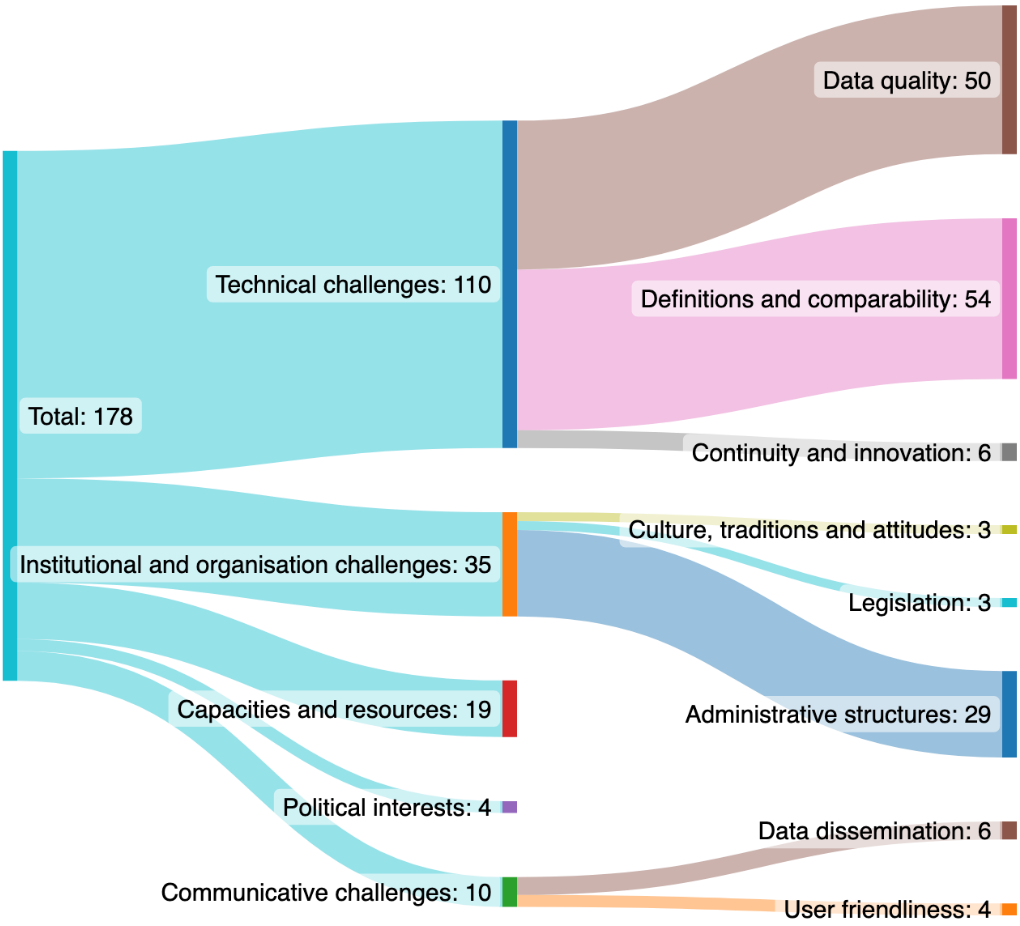
From the 60 references that were reviewed, altogether 178 problems were identified as key obstacles on the roadmap towards forest monitoring in the European Union. Aiming to have a clear understanding of the collected data, two consecutive categorisation approaches were performed.

In a first categorisation approach, two category levels were developed. Based on the description of the identified problems, five different categories were created, and the problems were distributed among these categories according to their scope.

After this step, the problems inside each one of the five categories were further divided into a secondary category level to provide additional information and obtain a better overview of the identified problems.

The results of this exercise are presented in the following Figure.

Problem categorisation

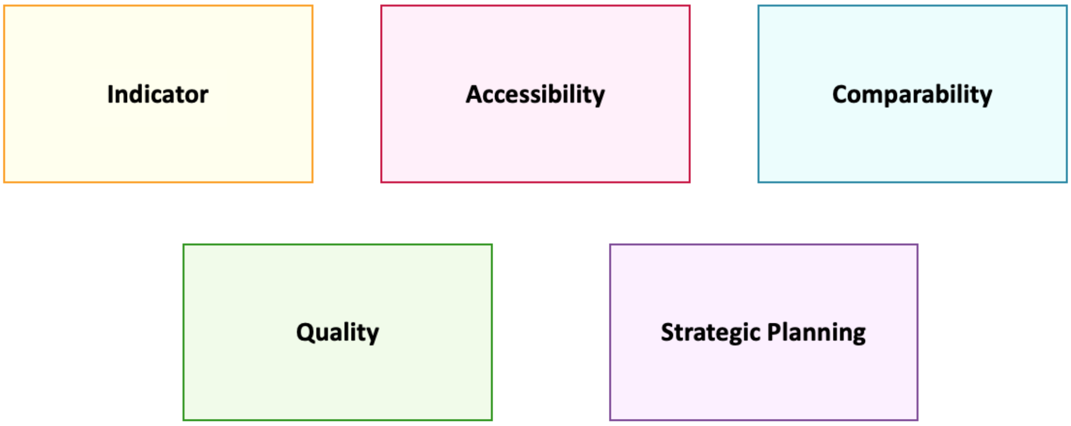


Source: Own illustration

The results made it possible to recognise that part of the identified problems shared, to some degree, the same main drivers and consequences.

Therefore, a second categorisation approach was performed, where not only the main subject of the problems was considered, but also the roots and consequences of the problems. This approach allowed the identified problems and drawbacks of the current forest monitoring system in the EU to be summarised into five main areas which are shown in the next Figure.

Five main problem areas



Source: Own illustration

Conforming to the five main identified areas, upon (i) identifying the problems, the problem analysis was further refined by (ii) estimating the scale of the problem; (iii) analysing its causes/drivers; (iv) identifying stakeholders in a sense of who own and/or can solve a problem and; (vi) assessing the likelihood that the problem may persist.

According to the Better Regulation Tool #14 guidelines, a detailed formulation of the main problems elements, outlined in the Table below was carried out. The tables for each main problem areas are presented below.

Overview of main problem elements

Category	Function	Description
General description	Indicating nature	Qualitative overall description of the problem.
Scale	Indicating relevance	Quantification and, were feasible, monetisation of the extent to which the defined problem affects the attainment of the Regulation´s goals.
Main drivers	Indicating causes	Indicating which factors have caused the problem and influence the identified trends.
Consequences	Indicating consequences	Main health, environmental, economic, political and social effects which are likely to occur under no-policy change scenario.
No-policy change scenario including trends	Indicating baseline scenario	Description of the policy measures currently in place. Possible paths of development of the problem, bearing in mind its drivers and consequences.
Stakeholders	Indicating actors (to be) involved	Political, economic and societal actors which are affected by/concerned with the identified problem.

Step 3: Development of problem trees

As a next step of the analysis the problem descriptions were illustrated in problem trees of the main problems areas, including their underlying drivers and impacts. As already pointed out, the drivers as well as impacts of the problem areas are interlinked. Data was condensed into one problem tree for structuring the legislative initiative as a whole: establishing what the problem is, what its negative consequences are, and identifying the issues that might have to be addressed by an EU intervention.

At this step also the problem drivers were further scrutinised – including additional material for describing the *exogenous* drivers, e.g., the EU Strategic foresight reports (most recent, incl. STEEP analysis: Muench, S., Stoermer, E., Jensen, K., Asikainen, T., Salvi, M. and Scapolo, F., Towards a green and digital future, EUR 31075 EN, Publications Office of the European Union, Luxembourg, 2022, ISBN 978-92-76-52451-9, doi:10.2760/977331, JRC129319) and the trends in key questions about forests in the EU (summarily Lindner, M.; Verkerk, H. How has climate change affected EU forests and what might happen next? Ranacher, L., Pûlzl, H., Tyrväinen, L., Winkel, G. What do people think about forests in the EU? In: Mauser, H (ed). 2021. Key questions on forests in the EU. Knowledge to Action 4, European Forest Institute, ISBN 978-952-7426-06-7, doi:10.36333/k2a04).

Step 4: Assessment of subsidiarity and EU added value

While Step 4 was part of the proposed project activities, it was indicated by the EC to the project team that subsidiarity and EU added value will be assessed internally by Commission Services, and thus the assessment is not included in this report.

Stage 1.2: Formulate requirements for an EU monitoring system and Strategic Plans for Forests according to the EU Forest Strategy. This includes defining the scope of parameters and information products that will be part of the monitoring system, defining the characteristics of the monitoring system, as well as the characteristics of the Strategic Plans.

Based on the description and definition of the problems and problem drivers regarding forest monitoring and forest planning in the EU, requirements for an EU monitoring system and Strategic Plans for Forests are defined. In addition to those requirements outlined by the forest strategy, problems and needs identified in the first step (stage 1.1, with inputs from Task 3 and Task 4) will be translated into possible requirements towards the monitoring system. This includes defining the scope of parameters and information products that will be part of the monitoring system, defining the characteristics of the monitoring system, as well as the characteristics of the Strategic Plans. Purpose, specific and operational objectives for an EU monitoring system and strategic plans for forests are described.

Stage 1.3 - Develop preliminary policy options

Step 1: Construct a baseline "no-policy-change" scenario

A draft "no-policy-change" scenario was developed, in line with the Better Regulation Tool #16. Currently no legislative framework on forest monitoring exists in Europe and the "no-policy-change" scenario builds on the assumption that no proposal on the EU Framework on Forest Monitoring and Strategic Plans is adopted (i.e. "no action" scenario).

The "no-policy-change" scenario is the counterfactual against which the impact of the different policy options are compared. This scenario covers the evolution of the legal framework considering relevant external factors and elements, such as EU-level and international policies which are assumed to remain in force, and the foreseen policy and socio-economic development that will influence the problem drivers and solution drivers.

The no-policy-change scenarios are described in view of the specific objectives.

Step 2: Compile a wide range of alternative policy options

Development of the policy options has been an iterative process with the Commission representatives. In a first draft of the Task 1 report, a long-list of policy options was provided by the consortium.

In reviewing the long-list of options, the European Commission developed three thematical strands, and the more detailed policy options are developed along these core policy elements: (1) the Standardisation of data collection, (2) the further development of remote sensing-based monitoring systems and (3) the development of strategic plans for forests. A set of policy options will consider as many realistic alternatives as possible. Also this step is iterative, including information feeding in from the Tasks 3 and 4.

Step 3: Identify most viable policy options and measures

With the set of policy options produced, the next step is to reduce the number of policy options that will be subjected to a more in-depth analysis of impacts. The aim of the screening of policy options is to arrive at a shortlist of the most promising options.

Identification and analysis of impacts

Identification of impacts

The assessment of impacts followed the methodology lined out in the Better Regulation Toolbox.

First, the most significant impacts from the selected policy options were identified. Impacts include social/environmental/economic, positive/negative, intended/unintended as well as short/long-term effects. They have been assessed the based on the expected significance in terms of changes relative to the baseline (i.e., the incremental changes). To this end, data collected from the country fiches were an important input.

Then, the most important impacts were identified and further assessed.

Assessment of impacts

Direct economic impacts

Direct economic impacts are direct costs or savings stemming from provisions. Policy implementation, enforcement and compliance necessarily involve costs that stakeholders must face, which can be summarised under the term "regulatory burden". Those are the costs from the part of the process which is done solely because of a legal obligation and are compared to the "business as usual costs" which correspond to the costs resulting from collecting and processing information that would even be done in the absence of new legislation[175]. To assess the direct economic impacts (i.e., the regulatory burden as well as the savings), the Standard Cost Model (SCM) methodology was used. It should be noted that administrative costs consist of two elements: business-as-usual costs (i.e. the baseline) and administrative burdens.

Macroeconomic, environmental and social impacts

It should be reminded again that the specific objectives of the initiative are as follows:

- Data collection is harmonised and standardised;

[175] See Better Regulation Toolbox TOOL #58. EU STANDARD COST MODEL https://ec.europa.eu/info/sites/default/files/br_toolbox-nov_2021_en_0.pdf

- Monitoring by Earth Observation is increased to ensure public access to timely and cost-efficient information for land managers, policy makers, and stakeholders; and
- A coherent governance framework for reporting and planning is established.

Ultimately, the further effect of those would be improved health of forests. However, those effects are indirect and also impacted by a wide range of external factors. Thus, it is very challenging to quantitatively assesses the effects and trends and establish a clear link between the extent of those effects within the framework of external impacts.

To challenge was tackled by separating impacts into intermediate impacts and long-term impacts. Intermediate impacts are those which would come into effect relatively soon after the aforementioned assumptions of more effective policies and monitoring of policy implementation have come to fruition, and they generally represent a mid-way point between the immediate outcomes and the higher level or more long-term benefits. Long-term impacts are more general assumptions enabled by the immediate outcomes and intermediate impacts facilitating more sustainable forest management and enhanced environmental protection.

Some impacts, particularly the long-term benefits which may be more abstract or indirect, are difficult to directly quantify as they are high-level, 'knock-on' benefits of the initiative. Therefore, general estimations are given in quantitative terms where possible, but where numerical estimates are difficult to conclude, qualitative statements based on existing literature are used to illustrate the impact. The long-term impacts are further separated into environmental impacts and socioeconomic impacts. However, it is also important to consider that this is a simplification of the complex interlinkages between environmental, social and economic impacts.

Following this same qualification and the difficulties in quantifying many of these impacts, it was decided not to assess each impact per policy option. There would be too much uncertainty in terms of assigning exact impacts to each option based on existing literature and evidence we have collected, particularly for the long-term benefits. To this end, a more high-level assessment approach was taken where the baseline is considered in comparison to the potential changes which can result due to the impacts of the initiative.

Comparison of policy options

Once the impacts of each of the policy options have been identified and analysed, they were compared based on their relative strengths and weaknesses. This was done by listing and summarising the impact of each option in tabular form. The Table below presents a list of relevant criteria (compared to baseline scenario so that so that their added value can be clearly identified) to compare the options.

Overview of criteria for comparison

Criterion	Definition	Data source
Impacts per stakeholder group	An overview of the extent to which differ stakeholder groups are affected and how.	• Outcome of assessment of environmental, social and economic impacts.
Effectiveness (coverage of identified requirements)	The extent to which different options would achieve the general objective of the initiative.	• Outcome of assessment of environmental, social and economic impacts.
Efficiency	An analysis of the net benefits of the impacts, i.e. comparing the benefits and the costs	• Outcome of assessment of economic impacts, as well as the estimates of administrative burden.

Criterion	Definition	Data source
Distribution of advantages and disadvantages between different stakeholders	An analysis of the extent to which specific stakeholder groups have disproportionate advantages or disadvantages	• Outcome of assessment of environmental, social and economic impacts.

Using those criteria, the policy options were compared in a comparison table. Since the data is a mix of quantitative and qualitative data, a Multi-Criteria Analysis (MCA) framework was used to aid coherent decision-making. To this end, a use a simple sign framework was used as outlined the following Table.

Legend of signs to be used in the comparison table

Sign	Legend
- / --/ ---	Low to high negative impact expected
+ / ++ / +++	Low to high benefits or savings
0	No measurable or significant impact expected
()	Brackets, in combination with the above, to show if impacts are potential
From / to	If there is uncertainty as to the range of impacts, a range (of the first two above) is indicated

Method for developing the country fiches

After agreeing on templates for the country fiches on the existing monitoring frameworks as well as strategic planning frameworks, the fiches were filled for each MS, based on an extensive literature review.

This resulted in a set of draft fiches for each MS. Those draft fiches were then shared with relevant stakeholders in each MS for feedback and revisions.

Based on the feedback, the fiches were revised, and a final version was created for each.

Sources for identifying problems

Aggestam, F.; Giurca, A. The Art of the “Green” Deal: Policy Pathways for the EU Forest Strategy. For Policy Econ 2021, 128.

Alberdi, I.; Condés, S.; Martínez-Millán, J. Review of Monitoring and Assessing Ground Vegetation Biodiversity in National Forest Inventories. Environ Monit Assess 2010, 164.

Alberdi, I.; Michalak, R.; Fischer, C.; Gasparini, P.; Brändli, U.-B.; Tomter, S.M.; Kuliesis, A.; Snorrason, A.; Redmond, J.; Hernández, L.; et al. Towards Harmonised Assessment of European Forest Availability for Wood Supply in Europe. For Policy Econ 2016, 70, 20–29, doi:10.1016/j.forpol.2016.05.014.

Alberdi, I.; Nunes, L.; Kovac, M.; Bonheme, I.; Cañellas, I.; Rego, F.C.; Dias, S.; Duarte, I.; Notarangelo, M.; Rizzo, M.; et al. The Conservation Status Assessment of Natura 2000 Forest Habitats in Europe: Capabilities, Potentials and Challenges of National Forest Inventories Data. Ann For Sci 2019, 76, 34, doi:10.1007/s13595-019-0820-4.

Anderegg, W.R.L.; Trugman, A.T.; Badgley, G.; Anderson, C.M.; Bartuska, A.; Ciais, P.; Cullenward, D.; Field, C.B.; Freeman, J.; Goetz, S.J.; et al. Climate-Driven Risks to the Climate Mitigation Potential of Forests. Science (1979) 2020, 368, doi:10.1126/science.aaz7005.

Atzberger, C.; Zeug, G.; Defourny, P.; Aragão, L.; Hammarström, L.; Immitzer, M. Study on Monitoring of Forests through Remote Sensing. Scope on Monitoring of Phenology, Illegal Logging, Pests and Diseases, Wildfires, Storm Damages and Forest Drought and Water Content Forests.; 2018;

Avitabile, V.; Camia, A. An Assessment of Forest Biomass Maps in Europe Using Harmonised National Statistics and Inventory Plots. For Ecol Manage 2018, 409, 489–498, doi:10.1016/j.foreco.2017.11.047.

Baycheva-Merger, T.; Sotirov, M.; Holmgren, S.; Selter, A. Institutional and Actor-Oriented Factors Constraining Expert-Based Forest Information Exchange in Europe: A Policy Analysis from an Actor-Centred Institutionalist Approach. Forests 2018, 9, 129, doi:10.3390/f9030129.

Baycheva-Merger, T.; Wolfslehner, B. Evaluating the Implementation of the Pan-European Criteria and Indicators for Sustainable Forest Management – A SWOT Analysis. Ecol Indic 2016, 60, 1192–1199, doi:10.1016/j.ecolind.2015.09.009.

Biomonitor Data and Data Gaps for Bioeconomy Drivers and Indicators and Their Implications; 2019;

Bontemps, J.-D.; Bouriaud, O.; Vega, C.; Bouriaud, L. Offering the Appetite for the Monitoring of European Forests a Diversified Diet. Ann For Sci 2022, 79, 19, doi:10.1186/s13595-022-01139-7.

Buongiorno, J. On the Accuracy of International Forest Product Statistics. Forestry: An International Journal of Forest Research 2018, 91, 541–551, doi:10.1093/forestry/cpy025.

Curtis, P.G.; Slay, C.M.; Harris, N.L.; Tyukavina, A.; Hansen, M.C. Classifying Drivers of Global Forest Loss. Science (1979) 2018, 361, doi:10.1126/science.aau3445.

Diabolo project Report on the Harmonisation Concept, Identified and Evaluated Harmonisation Options, and the Methodology to Bridge the Gap between Each National Definition and the Reference Definition; 2016;

Diabolo project Report on the Methodology for Biodiversity Assessment and Forest Conservation Status in Europe. Prospects and Recommendations for European Wide Assessments; 2019;

Diabolo project Synthesis Report on Data Demand and Data Provision, Including Data Flows at the Science-Policy Management Interface and the Barriers of Data Flows; 2017;

EC. A Clean Planet for All: A European Strategic Long-Term Vision for a Prosperous, Modern, Competitive and Climate Neutral Economy. COM(2018) 773 Final. 2018.

EC. A New Circular Economy Action Plan For a Cleaner and More Competitive Europe EN. Official Journal of the European Union 2020, COM(2020).

EC. Action Plan: Financing Sustainable Growth. EUR-Lex 2018.

EC. DIRECTIVE 2003/4/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 28 January 2003 on Public Access to Environmental Information and Repealing Council Directive 90/313/EEC. 2003.

EC. Directive 2007/2/EC of the European Parliament and of the Council of 14 March 2007 Establishing an Infrastructure for Spatial Information in the European Community (INSPIRE). Official Journal of the European Union 2007, 50.

EC. EU Biodiversity Strategy for 2030. Bringing Nature Back into Our Lives.; 2020; Vol. 53;.

EC. European Court of Auditors, EU Funding for Biodiversity and Climate Change in EU Forests : Positive but Limited Results. Special Report No 21, 2021, Publications Office of the European Union, 2021, Https://Data.Europa.Eu/Doi/10.2865/897243. 2021.

EC. Forging a Climate-Resilient Europe - the New EU Strategy on Adaptation to Climate Change. European Commission 2021, 6.

EC. Regulation, 2018. 2018/841. Inclusion of Greenhouse Gas Emissions and Removals from Land Use, Land Use Change and Forestry in the 2030 Climate and Energy Framework, and Amending Regulation (EU) No 525/2013 and Decision No 529/ 2013/EU. L 156/1. ; 2018;

EC. Soil Strategy Available online: https://environment.ec.europa.eu/topics/soil-and-land/soil-strategy_en (accessed on 2 December 2022).

EC. Sustainable Bioeconomy for Europe: Strengthening the Connection . 2018.

EC. The EU Nature Restoration Law Available online: https://environment.ec.europa.eu/topics/nature-and-biodiversity/nature-restoration-law_en (accessed on 2 December 2022).

EC. The European Green Deal (COM (2019) 640 Final); 2019;

EC; Commission, E. New EU Forest Strategy for 2030. European Commission 2021, 25.

EFFIS EFFIS - Brief History Available online: https://effis.jrc.ec.europa.eu/about-effis/brief-history (accessed on 2 December 2022).

EFINET European Forest Information Network: Review of Potential Contributors, Forest Information Systems & Recommendations. ; 2022;

EU Directive (EU) 2018/2001 on the Promotion of the Use of Energy from Renewable Sources; 2018;

European Environment Agency European Ecosystem Assessment – Concept, Data and Implementation; 2015;

European Parliament and the Council 2020/852 Taxonomy Regulation (EU) of 18 June 2020 on the Establishment of a Framework to Facilitate Sustainable Investment, and Amending Regulation (EU) 2019/2088. Official Journal of the European Union 2020, 2019.

Fischer, C.; Gasparini, P.; Nylander, M.; Redmond, J.; Hernandez, L.; Brändli, U.-B.; Pastor, A.; Rizzo, M.; Alberdi, I. Joining Criteria for Harmonizing European Forest Available for Wood Supply Estimates. Case Studies from National Forest Inventories. Forests 2016, 7, 104, doi:10.3390/f7050104.

Forest Europe State of Europe’s Forests 2020. Inisterial Conference on the Roection of Forests in Europe – FOREST EUROPE; Bratislava, 2020;

Giuntoli, J.; Robert, N.; Ronzon, T.; Sanchez Lopez, J.; ... Building a Monitoring System for the EU Bioeconomy, EUR 30064 EN, Publications Office of the European Union, Luxembourg, 2020, ISBN 978-92-76-15385-6, Doi:10.2760/717782, JRC119056.; 2020;

Global Forest Observations Initiative (GFOI) Integration of Remote-Sensing and Ground-Based Observations for Estimation of Emissions and Removals of Greenhouse Gases in Forests Methods and Guidance from the Global Forest Observations Initiative. Food and Agriculture Organization 2016, Edition 2.

Gschwantner, T.; Alberdi, I.; Bauwens, S.; Bender, S.; Borota, D.; Bosela, M.; Bouriaud, O.; Breidenbach, J.; Donis, J.; Fischer, C.; et al. Growing Stock Monitoring by European National Forest Inventories: Historical Origins, Current Methods and Harmonisation. For Ecol Manage 2022, 505, 119868, doi:10.1016/j.foreco.2021.119868.

Illes, A.; Russi, D.; Kettunen, M.; Robertson M. Innovative Mechanisms for Financing Biodiversity Conservation: Experiences from Europe, Final Report in the Context of the Project "Innovative Financing Mechanisms for Biodiversity in Mexico / N°2015/368378". ; 2017;

Janse, G. Characteristics and Challenges of Forest Sector Communication in the EU. Silva Fennica 2007, 41, doi:10.14214/sf.279.

Janse, G. Communication between Forest Scientists and Forest Policy-Makers in Europe - A Survey on Both Sides of the Science/Policy Interface. For Policy Econ 2008, 10, doi:10.1016/j.forpol.2007.10.001.

Janse, G. Information Search Behaviour of European Forest Policy Decision-Makers. For Policy Econ 2006, 8, doi:10.1016/j.forpol.2004.10.001.

Kallio, A.; Solberg, B. On the Reliability of International Forest Sector Statistics: Problems and Needs for Improvements. Forests 2018, 9, 407, doi:10.3390/f9070407.

Köhl, M.; Traub, B.; Päivinen, R. Harmonisation and Standardisation in Multi-National Environmental Statistics - Mission Impossible? Environ Monit Assess 2000, 63, doi:10.1023/A:1006257630216.

Lier, M.; Köhl, M.; Korhonen, K.T.; Linser, S.; Prins, K. Forest Relevant Targets in EU Policy Instruments - Can Progress Be Measured by the Pan-European Criteria and Indicators for Sustainable Forest Management? For Policy Econ 2021, 128, 102481, doi:10.1016/j.forpol.2021.102481.

Linser, S.; Wolfslehner, B. National Implementation of the Forest Europe Indicators for Sustainable Forest Management. Forests 2022, 13, 191, doi:10.3390/f13020191.

Lovrić, M.; da Re, R.; Vidale, E.; Prokofieva, I.; Wong, J.; Pettenella, D.; Verkerk, P.J.; Mavsar, R. Non-Wood Forest Products in Europe – A Quantitative Overview. For Policy Econ 2020, 116, 102175, doi:10.1016/j.forpol.2020.102175.

Lovrić, M.; da Re, R.; Vidale, E.; Prokofieva, I.; Wong, J.; Pettenella, D.; Verkerk, P.J.; Mavsar, R. Collection and Consumption of Non-Wood Forest Products in Europe. Forestry: An International Journal of Forest Research 2021, 94, 757–770, doi:10.1093/forestry/cpab018.

Milheiras, S.G.; Sallu, S.M.; Marshall, A.R.; Shirima, D.D.; Kioko, E.N.; Loveridge, R.; Moore, E.; Olivier, P.; Teh, Y.A.; Rushton, S.; et al. A Framework to Assess Forest-Agricultural Landscape Management for Socioecological Well-Being Outcomes. Frontiers in Forests and Global Change 2022, 5, doi:10.3389/ffgc.2022.709971.

Nabuurs, G.-J.; Harris, N.; Sheil, D.; Palahi, M.; Chirici, G.; Boissière, M.; Fay, C.; Reiche, J.; Valbuena, R. Glasgow Forest Declaration Needs New Modes of Data Ownership. Nat Clim Chang 2022, 12, 415–417, doi:10.1038/s41558-022-01343-3.

Nilsson, S.B. Ten Things the Legislative Proposal on EU Forest Observation, Reporting and Data Collection Needs to Consider.; 2022;

Requardt, A. Pan-European Criteria and Indicators for Sustainable Forest Management : Networking Structures and Data Potentials of International Data Sources. Forest Science 2007.

Requardt, A.; Siwe, R.; Riedel, T.; Köhl, M.; Tröltzsch, K.; Varis, S.; Travaglini, D.; Corona, . P.; Sanchez, A.; Vayreda, J.; et al. Pilot Study on Harmonising National Forest Inventories in Europe. JRC Scientific and Technical Reports.; Publications Office of the European Union: Luxembourg, 2010;

Roshani; Sajjad, H.; Kumar, P.; Masroor, M.; Rahaman, M.H.; Rehman, S.; Ahmed, R.; Sahana, M. Forest Vulnerability to Climate Change: A Review for Future Research Framework. Forests 2022, 13, 917, doi:10.3390/f13060917.

Schueler, S.; Cavalli, R.; Kleinschmit von Lengefeld, A. A Real-Time European Forest Monitoring System RT-EFMS for Green-Growth and Prospective; 2020;

Skidmore, A.K.; Coops, N.C.; Neinavaz, E.; Ali, A.; Schaepman, M.E.; Paganini, M.; Kissling, W.D.; Vihervaara, P.; Darvishzadeh, R.; Feilhauer, H.; et al. Priority List of Biodiversity Metrics to Observe from Space. Nat Ecol Evol 2021, 5.

Ståhl, G.; Cienciala, E.; Chirici, G.; Lanz, A.; Vidal, C.; Winter, S.; McRoberts, R.E.; Rondeux, J.; Schadauer, K.; Tomppo, E. Bridging National and Reference Definitions for Harmonizing Forest Statistics. Forest Science 2012, 58, doi:10.5849/forsci.10-067.

Tomppo, E.; Gschwantner, T.; Lawrence, M.; McRoberts, R.E. National Forest Inventories: Pathways for Common Reporting; 2010;

Tomter, S.M.; Gasparini, P.; Gschwantner, T.; Hennig, P.; Kulbokas, G.; Kuliešis, A.; Polley, H.; Robert, N.; Rondeux, J.; Tabacchi, G.; et al. Establishing Bridging Functions for Harmonizing Growing Stock Estimates: Examples from European National Forest Inventories. Forest Science 2012, 58, 224–235, doi:10.5849/forsci.10-068.

Valbuena, R.; O'Connor, B.; Zellweger, F.; Simonson, W.; Vihervaara, P.; Maltamo, M.; Silva, C.A.; Almeida, D.R.A.; Danks, F.; Morsdorf, F.; et al. Standardizing Ecosystem Morphological Traits from 3D Information Sources. Trends Ecol Evol 2020, 35, 656–667, doi:10.1016/j.tree.2020.03.006.

van Brusselen, J. User Needs and Requirements Baseline (D1-URB). Forest Carbon Monitoring Project Deliverable. ESA Contract 4000135015/21/I-NB; Espoo, Finland, 2021;

Wardle, P.; Narayan, C.; Requardt, A.; Pesonen, E.; Schuck, A. International Information on European Forest Sector. State—Challenges—Opportunities; Joensuu, Finland, 2008;

Wolfslehner, B.; Pülzl, H.; Kleinschmit, D.; Aggestam, F.; Winkel, G.; Candel, J.; Eckerberg, K.; Feindt, P.; McDermott, C.; Secco, L.; et al. European Forest Governance Post-2020; 2020;

Wulder, M.A.; Coops, N.C. Satellites: Make Earth Observations Open Access. Nature 2014, 513, 30–31, doi:10.1038/513030a.

Annex 5. Initiative specific appendices

Appendix 1 NON-EXHAUSTIVE LIST OF INDICATORS THAT COULD BE CONSIDERED FOR OPTION 1

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
Forest area (and annual changes)	Option 1	biomass resources and management	x	7	27	AT BE BG CY CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK	Copernicus-HRL/CLC/Forest Europe/CBD/MAES	Yes	Operational
Forest Area available/not available for Wood supply	Option 1	biomass resources and management	(x)		25		ESTAT JRC FAWS mapping		
Growing stock	Option 1	biomass resources and management	(x)	4	21	AT BE BG CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PT RO SE SI SK	SoEF	Yes	Demonstrated
Structure (even-aged/un-evenaged)	Option 1	biomass resources and management	(x)	4	18	AT BE BG CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK	SoEF	-	
Forest biomass and carbon	Option 1	biomass resources	x	4	21	AT BE BG CZ DE DK	LULUCF	Yes	Development

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
(aboveground biomass, belowground, deadwood, litter, soil (organic vs mineral) - stocks and fluxes		and management				EE EL FI FR HR HU IE IT LT LU LV PT RO SE SI			
Net annual increment of growing stock volume (on all forest; on FAWS)	Option 1	biomass resources and management	(x)	4	17	AT BE BG CZ DE EE ES FI FR HU IE IT LT LU LV NL PT SE	SoEF	-	Development
Annual roundwood removals	Option 1	biomass resources and management	(x)	4	26	EE AT BG CZ DE ES FI IE LT LV NL PT SE SI RO SK HU FR	EUROSTAT/JFSQ	-	
Tree cover density	Option 1	biomass resources and management	x			DK EE EL AT BE BG CY CZ DE ES FI HR IE IT LT LU LV NL PL PT SE SI RO SK HU FR	Copernicus - HRL		Operational
Share of renewable energy from biomass	Option 1	Forest bioeconomy	?	2	N.A.			-	

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
Deposition and concentration of air pollutants	Option 1	Forest health and resilience	x	2	ICP Forests	AT BE BG CY CZ DE DK EE EL ES FI FR HR IE IT LT LU LV MT NL PL PT SE SI SK	ICP Forest	-	
Soil condition (pH, CEC, N, C, ...) -C/N ratio, nitrate, nitrate leaching	Option 1	Forest health and resilience	x	4	ICP Forests	BE BG CY CZ DE DK EE EL ES FI FR IE LT LU LV MT NL PL PT RO SI SK	ICP Forest	-	
Defoliation and Crown Condition (by forest area)	Option 1	Forest health and resilience	x	2	ICP Forests	BE BG CY CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV MT NL PL PT SI SK	ICP Forest	-	Operational
Area of habitat types in good/not good condition (ref. Directive 92/43/EEC and Directive 2009/147/EC)	Option 1	Forest protection and biodiversity	x	2	N.A.			-	
Diversity of tree species	Option 1	Forest protection	x	2	20	AT BE BG CY CZ DE	SoEF	-	Demonstrated

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
		and biodiversity				DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK			
Common forest bird species	Option 1	Forest protection and biodiversity	x	4	PECBMS	BE BG CZ ES FI IT LU LV NL PT SE FR	PECBM/Birds Directive Reporting	Yes	
Deadwood - volume and type (standing/lying)	Option 1	Forest protection and biodiversity	(x)	5	18	DK EE EL AT BE BG CZ DE ES FI HR IE IT LT LU LV NL PL PT SE SI RO SK HU FR	CBD, partially SoEF	Yes	Achievable
Forest connectivity /fragmentation	Option 1	Forest protection and biodiversity	(x)	3	JRC		JRC, SoEF	-	Operational
Threatened forest species (including non-tree species)	Option 1	Forest protection and biodiversity	x	3	9	BE BG ES FI LU LV PT SE SK FR	SoEF	-	
Protected forests	Option 1	Forest protection and biodiversity	x	3	17	EE AT BE BG CZ DE ES FI IT LT LU LV PT SE SI MT HU	EUROSTAT/Natura 2000/Habitat Directive Reporting/EEA GIS Map	Yes	Operational

Appendix 2 NON-EXHAUSTIVE LIST OF INDICATORS THAT COULD BE CONSIDERED FOR OPTION 2.1

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
Agroforestry (Share of utilised agricultural area (UAA) under supported commitments for managing landscape features, including hedgerows and trees)	Option 2.1	biomass resources and management		1	N.A.			-	Achievable
Forest area by dominant tree species/forest type	Option 2.1	biomass resources and management			22	AT BE BG CY CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK	Forest Europe/Copernicus - CLMS (HRL Forests)/ICP Forests Level I/ Corine Land Cover		Operational
Main management objective	Option 2.1 (partly: forest protective categories ; FAWS)	biomass resources and management				AT BE BG CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK			
Forest management	Option 2.1	biomass resources and				AT BE BG CZ DE EE EL ES HR			

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
plan (share of forest area)		management				HU IT LU LV PL PT SE SI SK			
Carbon in harvested wood products	Option 2.1	Forest bioeconomy		*2*	N.A.			-	
EU uses of woody biomass	Option 2.1	Forest bioeconomy					EUROSTAT/JFSQ		
Protective forests – soil, water and other ecosystem functions – infrastructure	Option 2.1	Forest ecosystem functions		1	15		SoEF	-	
"Forest disturbance recorded in terms of area size and volume distinguished by **1 human disturbances: regular harvest/salvage loggging,** **2. natural disturbances: damage types (storm, drought, burnt**	Option 2.1 (some 2.2)	Forest health and resilience		3	16	AT BE BG CY CZ DE DK ES FI FR HR HU IE IT LT LU LV NL PT SE SI SK	EFFIS (for wildfires)	-	Operational & Development

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
area, pests and diseases, sea level rise) and with sub-category on irretrievable loss (windthrow, fires)"									
Tree mortality	Option 2.1	Forest health and resilience			14	AT BE BG CZ DE EE ES FI FR HU IE IT LT LU LV NL PT SE			
Regeneration type	Option 2.1	Forest protection and biodiversity		2	20	BG HU RO NL LV	SoEF	-	Demonstrated
Naturalness	Option 2.1	Forest protection and biodiversity		1	22	BE CZ LT RO	SoEF	Yes	Achievable
Introduced tree species	Option 2.1	Forest protection and biodiversity		1	21	ES FI RO	SoEF	-	
Invasive tree/forest species	Option 2.1	Forest protection and biodiversity		3	N.A.	ES FI RO		-	
Habitat condition	Option 2.1	Forest protection							

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
(structure and function)		and biodiversity							
Diversity of non-tree plant species	Option 2.1	Forest protection and biodiversity				AT BE ES IE LT			
Old growth and primary forest area	Option 2.1	Forest protection and biodiversity				BE BG CZ DE FI HR LU LV PT SE FR			

Appendix 3 NON-EXHAUSTIVE LIST OF INDICATORS THAT COULD BE CONSIDERED FOR OPTION 2.2

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
urban green space	Option 2.2	biomass resources and management		3	N.A.			-	Operational
urban tree canopy cover	Option 2.2	biomass resources and management		1	N.A.			-	Operational
Forest area available for non-wood products	Option 2.2	biomass resources and management					SEEA/FRA SoEF		
Forest management/silvicultural regime (Clear-cutting/ continuous cover)	Option 2.2	biomass resources and management				AT BE BG CZ DE DK EE EL ES FI FR HR HU IE IT LT LU LV NL PL PT RO SE SI SK			
Net primary productivity	Option 2.2	biomass resources and management							
Wood energy - feedstock sources (primary/secondary biomass)	Option 2.2	Forest bioeconomy		2	14	DK LV	EUROSTAT/JFSQ	-	

EC list - indicators	Policy options	Indicator category	Existing legal obligations	Policy information requirements	Data availability	Data availability	Data availability	Data harmonization	Earth Observation
Degraded forest	Option 2.2	Forest health and resilience		3	6			-	Development

Appendix 4 NON-EXHAUSTIVE LIST OF INDICATORS FOR WHICH THE APPLICATION OF REMOTE SENSING IS PERTINENT

Legend:

- EO: Earth Observation: pan-EU Earth Observation operational (O) or developed (D) demonstrated (DD) or achievable (A)
- System: Reference to already established monitoring system in the EU

Indicators	EO	System
Forest area (and annual changes)	O	Copernicus-HRL/CLC/Forest Europe/CBD/MAES
Growing stock	DD	SoEF
Structure (even-aged/un-evenaged)	DD	MAES
Dominant tree species/forest type	DD	Forest Europe/Copernicus - CLMS (HRL Forests)
Tree cover density	O	Copernicus - HRL/MAES/LUCAS
Forest biomass and carbon **(aboveground biomass, belowground, deadwood, litter, soil (organic vs mineral) - stocks and fluxes**	D	LULUCF, MAES
Defoliation and Crown Condition (by forest area)	O	ICP Forest
Forest disturbance **recorded in terms of area size and volume distinguished by** **- 1. human disturbances: regular harvest/salvage loggging,** **-2. natural disturbances: damage types (storm, drought, burnt area, pests and diseases, sea level rise) and with sub-category on irretrievable loss (windthrow, fires)**	O & D	
Burnt areas (size)	O	EFFIS
Actives fires (number)	O	EFFIS
Wildfire risk	O	EFFIS
Other types of risks: storms, droughts, pests	A	Drought: European Drought Observatory
Forest management/silvicultural regime (Clear-cutting/ continuous cover)	DD	
Tree mortality	D	
Regeneration (+ natural vs assisted (seeding or planting))		
Forest connectivity /fragmentation	O	JRC/MAES
Old growth and primary forest area	D	
urban tree canopy cover	O	Copernicus - HRL
Agroforestry (Share of utilised agricultural area (UAA) under supported commitments for managing landscape features, including hedgerows and trees)	A	
Net primary productivity and increment	O	

Appendix 5 USE OF EO TOOLS FOR MONITORING FORESTS IN EU MEMBER STATES

Introduction

This report is intended to give an updated and, as far as possible, completed vision of the use of EO tools for monitoring forests in the different EU member States. In all the States (with a few minor exceptions) official statistics on forests are provided by the NFIs, therefore this report is mainly focused on the use of EO in the framework of the NFIs. Even if in some Countries EO is used to produce other forest-related products (mainly as maps) outside the framework of the NFI programs.

For a better comprehension of this quite complex situation, it is important to spend a few lines to reconstruct in a very condensed way the historical development of these forest monitoring frameworks.

For monitoring EU forests there is only one very simple approach that can produce true values of the parameters (such as average, minimum, maximum, standard deviation, etc.) of the variables we have to report (such as basal area, growing stock volume, biomass, etc.): measuring every single tree. If we want updated statistics every, let's say, three years, we should repeat the census every three years. To have information on the spatial coverage of forests the geographical position of the trees should also be recorded.

Since the number of trees in EU forests can be roughly estimated at around 200 billion trees[176], reporting statistics every three years requires approximately 1 million people working full time[177]. Since this census approach is not feasible, in the past two alternatives were developed to produce forest information at a reasonable cost:

- **stand-wise forest inventories** dividing the forests in stands and acquiring ground information in each stand with a variety of differing methods
- **sampling-based (or statistical) forest inventories** where only a very small statistical sample[178] of the total forest is measured in the field and the data are then used to infer the estimates of the population parameters.

The first method was widely used in Eastern Europe, and it is still in many of these countries an important component of forest monitoring systems; the second method determined the origin of the modern NFI programs in the early 20th century, first in the Nordic regions, where wood production is a very relevant economic resource and its estimation is essential for planning purposes, and then later in the other Countries.

The NFIs are still carried out following the traditional idea at their origin. Since the precision of the estimates strictly depends on the number of sampling units measured in the field, the NFIs were oriented to carry out many sampling units. To keep the cost of the inventory as low as possible it was important to limit the time for a team to complete one sampling unit. So these sampling units are small circular plots (the dimension is around 10 m radius) where all trees (or all the largest trees) are measured. In the end, a good inventory is that one is able to produce precise estimations at a lower cost.

The use of remote sensing was a central issue in NFIs because this technology was considered since its very beginning a good tool to limit the cost of the inventory. To improve accuracy, a method called two-phase sampling design was used. First, a large number of sampling units were classified based on the land cover using manual classification of aerial photos. This allowed for precise

[176] On the basis of FAO statistics 2022 and a density of 1000 trees per hectare.

[177] Considering a crew of two people working 365 days per year and measuring 300 trees per day.

[178] We intend here that the sample must be extracted using a random approach, units cannot be chosen but must be extracted on the basis of a formal sampling design.

estimation of forest area. Then, only a sub-sample of the units classified as forest were surveyed in the second phase.

The advent of satellite imagery opened the advent of new integrated approaches to complement the two worlds (field and EO data). Here the line dividing research activities and operational implementation is subtle. With the Nordic countries clearly investing more resources in the NFI programs and achieving important results in such direction. Following their example in many other EU Countries the use of satellite EO entered in the NFI programs, but with different purposes; all of them are based on the same idea: that the quantitative information retrieved by satellite imagery is correlated with the forest variables to be estimated. For example, the spectral response of an optical image can be used to separate forest from non-forest pixels or pixels belonging to different forest species or groups of species; or for example to model the amount of carbon stocked in the biomass of a forest pixel.

Based on the combination of field data and EO data it is possible to predict the forest variable for all the pixels belonging to forest areas. Thus, creating maps. Even if they are very useful for supporting decision-making, maps are frequently not considered the result of the combination of field and EO data, but pixel-level values generated by the models, are aggregated on larger areas generating small area estimations. Thus, overcoming one of the main limitations of traditional design-based estimation produced by the NFIs which can report estimates only at the country level or for very large sub-country regions.

More recent operative use of EO is for mapping forest disturbances due to insect outbreaks, adverse meteorological conditions (windstorms, spring low temperatures, extreme summer heat waves, floodings, drought), loggings, and fires. These disturbances alter in a rapid way the forest variables and their monitoring cannot be based on the NFIs because they are not designed for near real-time reporting (NFIs are in fact most frequently carried out in cycles of 5 or 10 years). EO is instead able to provide very fast responses with imageries acquired a few hours or a few days after the event. The advent of new cloud-based computing systems based on artificial intelligence algorithms can elaborate in a very efficient way a large amount of data and can provide accurate maps of the disturbed areas. These maps can also be integrated into the NFI systems, but these approaches are still very close to research activities.

What kind of EO data?

For the NFIs, and in general for forest monitoring, the most useful type of remotely sensed data is **Airborne Laser Scanning** (ALS). Based on LiDAR point data, it is in fact possible to develop very accurate models for estimating many forest variables, not just those based on species composition, or volume/biomass/carbon, but also those related to structural diversity, under canopy vegetation, etc. The problem with ALS is mainly twofold: i) they are expensive, and ii) the raw point clouds over large areas are still very large datasets that cannot be easily manipulated in a fast way. As a result, ALS cannot be acquired with the same frequency as satellite data. ALS is in general acquired not specifically for forest applications and thus the moment and characteristics of the acquisition are frequently not optimised for forest applications.

Under this point of view the GEDI data, acquired by LiDAR on board the International Space Agency could be a very interesting source of information but, also considering the fact that GEDI data were not available in Nordic EU Countries, their use is still related to research activities. Future possible Satellite Laser Scanning missions could become a relevant source of information for forest applications.

In the second position, we have a more traditional source of information provided by **optical sensors**, with multiple bands acquired in the visible and infrared wavelengths. The most used satellite for such applications was Landsat. With a 30 m resolution, a 16-day revisit time, 7 bands, and an uninterrupted time series dating back to 1972, Landsat images were the most common source of information for estimating forest variables until the advent in 2015 of Sentinel-2 images. Operated by ESA in the framework of the Copernicus system, the EU EO program, Sentinel-2 satellites have more bands, a higher frequency (5 days), and a smaller pixel (10 m). Sentinel-2 images can be considered the most important satellite source of information for monitoring EU forests. The main limiting issues for optical imagery are related to cloud coverage and to the so-called "saturation effect". When the top canopy cover is full, additional changes in the amount of wood volume/biomass cannot be easily detected. A long list of other optical data was used as an alternative or in conjunction with Landsat imagery, especially before the advent of Sentinel-2, including but not limited to SPOT and ASTER imagery.

In the third position, **microwave** data was acquired by Synthetic Aperture Radar (SAR) satellites. They have the major advantage of being able to operate in adverse meteorological conditions. Different applications exist for L, C, and X bands but most usually this data complements ALS or optical imagery.

Results

The result of our analysis is the description of how EO is integrated into forest monitoring programs in the different EU countries. The extensive analysis is presented in the following chapters, one for each of the EU countries, with a SWOT analysis for each Country. The information was collected by analyzing available literature, websites, and reports provided for the different countries, and we were helped by national reference contact points directly involved in such programs.

Here below we tried to summarize our results.

Finland and Sweden are the two EU countries with the most advanced systems for the integration of EO in forest monitoring, mainly based on NFI programs. Both countries invest relevant resources in the NFIs with multiple cycles of field observations and country-level multitemporal ALS data available. Finland was the first country to implement technologies for producing wall-to-wall maps as products of the NFIs, followed a few years later by Sweden. Both publish online open-access maps based on the integration between field and remotely sensed data for a long list of variables and for multiple years. Remote sensing in these inventories is also used for optimizing sampling efficiency. What is relatively less integrated is the link between the NFIs and forest disturbance monitoring, especially for forest logging mapping. This activity is apparently carried out by other national agencies, but such data is not integrated into the NFI. The Finnish maps from the NFI are more difficult to access and are mainly available in the local language only.

In a second class, we grouped Denmark and France, they both provide official NFI maps based on remote sensing for the whole country. In both countries, these maps are available online, even if in French then comes together with the vast array of maps produced by the IGN. In Denmark, the number of variables mapped is higher (with approaches similar to those presented in Finland and Sweden) than in France where a very detailed map of forest composition based on aerial manual delineation is available. In France, recent research activities demonstrated that a wider integration of EO products is ready.

In a third class, we aggregated Italy, Germany, Ireland and Poland. In these countries, the NFI does not produce official maps based on EO, but scientific papers demonstrated this potentiality with experiments at the country level for estimating several forest variables.

In a fourth class a quite large group of countries (Spain, Portugal, Slovakia, Czech Republic, Austria, Lithuania, Latvia, Greece) where the NFI provides maps only for species composition but where research activities still do not demonstrate examples of country-level wall-to-wall spatial estimation of forest variables.

In fifth-class Belgium, Slovenia, and Netherlands where the NFI does not provide official maps and research activities still do not demonstrate examples of country-level wall-to-wall spatial estimation of forest variables. It is important to note that in Slovenia maps of forest variables are available but are based on stand-wise inventory data (forest management information) not from the NFI.

Finally Luxemburg, Malta, Cyprus, Romania, Bulgaria where we are not able to retrieve examples of this kind of EO integration.

Classes	Countries	Integration NFI - EO
The NFI is fully integrated with multisource remote sensing, a long list of multiple spatial products is available, a full open access policy adopted, long research track	Sweden, Finland	done
The NFI provides maps, usually only visible in GIS online, research activities in the country are advanced and carried out at the national level	France, Denmark	ready
The NFI does not provide maps but research activities in the country are advanced and carried out at the national level	Italy, Germany, Ireland, Poland	
The NFI provides maps (mainly for species composition), research is mainly in test areas	Spain, Portugal, Slovakia, Czech Republic, Austria, Lithuania, Latvia, Greece	almost ready
The NFI does not provide maps, research is mainly in test areas	Belgium, Slovenia, Netherlands	not yet ready
No information available	Luxemburg, Malta, Cyprus, Romania, Bulgaria	

Conclusions

As a conclusion of this review, we can report that currently, the NFIs are taking advantage of satellite EO to increase the accuracy of large area inventory estimates, often via stratified or weighted estimation, and for producing forest maps of several forest variables that can be used for purposes for different activities.

This is more frequently successfully implemented if ALS data are available at the country level and updated regularly.

This level of integration, even in the Nordic countries that implemented advanced systems to produce spatial estimates and a large number of maps based on EO but without altering the main characteristics of their statistical framework. There is a very solid motivation for this choice, altering the sampling design would determine a drop in the reported variables and potential inconsistency of the time series of the NFI records. For this reason, the sampling units of the NFIs remain the same as they developed at the beginning of the 20^{th} century. In our opinion, this is probably the main limitation to the advancement of EO integration for forest monitoring. A clear and univocal connection between the pixels of remotely sensed data and the plot-level information acquired in the field should be created. But this is not possible in the current conditions: i) because the plots are smaller than Landsat or even Sentinel-2 pixels, ii) because the position of the plots is frequently not registered with sufficient precision. An extreme condition is when angle-count systems are used for defining the trees to be measured in a plot, in this condition the dimension of the plot is unknown, and the connection with remotely sensed data is almost impossible.

For the future development of the integration of EO for forest monitoring in Europe, we recommend the **ground component**:

i) a more open policy for accessing geocoded raw field data of the NFIs, at least for research activities;
ii) the revision of sampling schemes to be based on remotely sensed data for stratification purposes;
iii) the abandonment of angle-count systems and the adoption of a minimum DBH threshold of 0 in callipering;
iv) the adoption of systems for recording the positioning of the measured trees, this is essential for the implementation of more advanced and precise models based on ALS data;
v) the adoption of larger plots (at least for a subsample of the NFI plots) to be able to create a univocal relationship with pixels of satellite images;
vi) highly precise positioning of the plots in the field (at least for a subsample of the NFI plots), for the same reason at the previous point;
vii) the integration of forest disturbance mapping in the NFI wall-to-wall spatial products should be implemented, examples exist already in Norway and Canada.

For the future in the EU, a standardised system for the acquisition of forest information in the field as a basis for the development of pan-European EO maps of forest variables could be established.

The system could be intended as a proposal for a reference in-situ ground component of the Copernicus program specifically designed for spatial modeling of forest variables. The system is not intended to replace NFIs but to complement them. The system could be aimed at creating a large dataset of field observations based on large plots distributed across Europe with a sampling design guided by remotely sensed data. The system could be based on large plots (approx. 1 ha each) to be able to study the exact relationship between spectral, radar, and lidar responses across a variety of forest conditions in Europe. The information, updated regularly every 3-5 years with a permanent revisiting approach (a certain number of plots measured every year), could be collected in the field with a standard pan-European protocol specifically optimised for the combination with RS data (e.g.: geocoding each tree). The information could be used for producing pan-European wall-to-wall estimations with model-based and model-assisted inferential algorithms.

The plots could have limited numerosity (approx. 5000) because estimations will be based on a modeling approach. Plots can be located as subsamples of existing grids, such as the pan-European ICP level I plots, or the national NFI plots.

Finally, more resources should be invested in large projects (especially in activities similar to those of COST actions E43 and FP1001 to continue the integration and harmonization/standardization between the NFIs in the EU.

Our recommendation for the **EO component** is instead of a general remarkable appreciative evaluation of the data available from the Copernicus platforms, especially for Sentinel-2 imagery. Since LiDAR data seems the best remotely sensed information for producing spatial estimates of many forest variables, we can propose to invest EU resources for the development of next-generation LiDAR satellites (following the good results of the GEDI mission) and, meanwhile, in the acquisition of EU ALS data. Since ALS data can be used in a modeling approach even if they are not available wall-to-wall, long transnational ALS strips could be acquired at the EU level to create pan-European modeling approaches for the standardised production of forest variables maps.

Appendix 6 IDENTIFICATION AND ANALYSYS OF GAPS IN CURRENT FOREST MONITORING SYSTEMS

Introduction

The main objective of this section is to identify and analyze gaps between current forest monitoring systems adopted by the MS and the optimal potential condition for achieving the result of providing complete, accurate, and updated, information on European forests.

The first point to clarify is that multiple alternative solutions can be considered "optimal" for such an aim. Here to restrict the analysis we consider "optimal" all the solutions able to provide reliable and statistically sound estimates of the main forest variables at the European level. Higher is the spatial resolution (the grain expressed as the minimum mapping unit or pixel dimension), the thematic resolution (number harmonised or standardised forest variables), and temporal resolution (minimum time between two consecutive revisits), and smaller the gap between national forest monitoring frameworks and the optimal pan-European condition will be.

The most common forest monitoring framework adopted by MS is based on National Forest Inventories (NFIs). Each NFI in the MS has specific characteristics, with different degrees of international standardization/harmonization and integration with remote sensing. Additionally, the NFIs in Europe have different temporal cycles independent from the others. In such a framework the main gaps are the following.

Data accessibility

One of the possibilities to create pan-European estimates of forest variables is to re-elaborate raw plot level (or even tree level) data acquired by the NFIs, in conjunction with remotely sensed data. Many such hybrid systems exist in literature. To do so the NFI data should be accessible. The traditional way the NFIs produce their results is with design-based estimates for large, aggregated regions published on the national websites in the form of reports. Nowadays, some MSs upload plot and tree-level information surveyed during NFIs in an openly accessible form. This is the case in Germany, Italy, and the Netherlands. For research purposes, MSs could provide plot-level information (as in Pucher, Neumann, and Hasenauer, 2022). On the other hand, public access to aggregated NFI data exists in most MSs. For more information on the availability of plot-level and tree-level information, see the table below.

MS	Plot-level data availability	Tree-level data availability	Language
AT	Upon request		
BE	Upon request	-	
BG	-	-	
CY	-	-	
CZ	-	-	
DE	Public	Public	Local
DK	-	-	
EE	Upon request	-	
ES	Public	-	Local
FI	Upon request		
FR	Upon request		
GR	-	-	
HR	Upon request		
HU	-	-	
IE	-		
IT	Public	Public	Local - EN
LT			
LU	-	-	
LV			
MT	-	-	
NL	Public	Public	Local
PL	Upon request	-	

MS	Plot-level data availability	Tree-level data availability	Language
PT			
RO	Upon request	-	
SE	Public (for temporary plots)	-	
SK	Public	-	Local
SL	-	-	

None of the MSs publish open access to the real coordinates of all the plots, but for scientific purposes, these data can be obtained upon request, as in Sweden, Finland, and Germany. Moreover, Sweden provides an openly accessible database where the coordinates of temporary sample plots - along with the forest information surveyed in them - are reported from 2007 to 2021. Indeed, these temporary plots were only surveyed once within each Swedish NFI campaign.

The availability of publicly accessible NFI data is not reported for Greece, Denmark, Latvia, and the Netherlands (SoEF, 2020).

This specific gap could be easily solved by publishing in an open-access framework the coordinates of all the NFI plots, or at least a subsample of them, for example following the Swedish example of the coordinates of temporary plots. This could lead to a very straightforward and efficient way for creating pan-European consistent and updated estimates of many forest variables through the integration with remote sensing, at least for those variables already standardised or that can be more easily harmonised. Unfortunately, this simple solution to this gap cannot be easily implemented because NFIs of the MS are strongly against the distribution of real plot coordinates. As possible alternative more complex solutions can be identified, such as the ENFIESTA system under development in the framework of the PATHFINDER EU project where the raw NFI data remain stored in the MS and only the aggregated statistics (eventually also resulting in the integration with remote sensing) are distributed through an on-line platform. This solution is a good alternative but requires the setup and maintenance of a complex online infrastructure for large data storage and cloud computing.

Data standardisation and harmonisation

To ensure the specific objective of data comparability, forest variables across the EU should be based on common definitions. For some variables also the standardization of methods is needed, especially for biodiversity indicators that are sensible to the size of the sampling unit. In Europe, NFIs adopted different basic definitions and methodologies, leading to inconsistencies and a lack of comparable data for pan-European reporting. In this context, the need for harmonization among MSs reporting, especially regarding the definition of forests, is pivotal. Even if all countries based their national definition on the extent, percentage of tree crown cover, and tree height, a difference exists between member states on these criteria (when reporting is available). According to the FAO – FRA standard definition, the **forest** is defined as "land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent, or trees able to reach these thresholds in situ. It does not include land that is predominantly under agricultural or urban land use."

A minimum height of 5 meters is used in the majority of MSs. Indeed, 20 MSs use this threshold (74%), while 6 MSs (22%) use a minimum height of 2 meters, and just one MS uses a minimum height of 3 meters (4%). On the other hand, the criteria used for minimum size area is further diverse. Indeed, 10 MSs (37%) use the same criterion as FAO – i.e., 0.5 ha - while 7 MSs (26%) use a minimum size of 0.1 ha. The remaining MS uses a minimum size of 0.3 ha (11%), 1 ha (11%), 0.25 ha (7%) or 0.05 ha (4%) respectively. Finland uses both 0.25 ha and 0.5 ha. Lastly, approximately half of MSs use a minimum crown cover of 10% as a criterion (48% - 13 MSs), while the rest use a higher percentage, namely 20% (26% - 7 MSs), 30% (22% - 6 MSs), and 25 (4% - 1 MS), of crown coverage. In total, 6 MSs use the same forest definition as FAO – FRA (22%), namely Denmark, Finland, France, Italy, Lithuania, and Sweden. In particular, Finland and Sweden adopted a second national definition of forest. Here, forest is also defined as "a land capable of producing an annual increment of volume growing stock of at least 1 m^3 per ha per year over the rotation under the most favorable tree species composition, and not used for any other purpose than forestry or forestry related purposes". For further details on MSs' forest definition criteria, see the table below.

MS	Crown cover (%)	Height (m)	Area (ha)	FAO-FRA harmonization
FAO - FRA	*10*	*5*	*0.5*	-
AT	30	2	0.05	
BE	20	5	0.5	
BG	10	5	0.1	
CY	10	5	0.3	
CZ	20	5	0.5	
DE	10	5	0.1	
DK	10	5	0.5	X
EE	30	2	0.5	
ES	20	3	1	
FI	10	5	0.25/0.5	X
FR	10	5	0.5	X
GR	25	2	0.3	
HR	10	2	0.1	
HU	30	5	0.5	
IE	20	5	0.1	
IT	10	5	0.5	X
LT	30	5	0.1	
LU	10	5	0.5	X
LV	20	5	0.1	
MT	30	5	1	
NL	20	5	0.5	
PL	10	2	0.1	
PT	10	5	1	
RO	10	5	0.25	
SE	10	5	0.5	X
SK	20	5	0.3	
SL	30	2	0.25	

Currently, the only variable that could achieve a good level of harmonization at the European level is forest area. For other forest variables, such as growing stock volume, biomass, deadwood, or carbon content, much work is still necessary to clarify definitions so that estimates can be directly compared or aggregated for international reporting (Rondeux et al., 2012, Gschwantner et al., 2019, Gschwantner et al., 2022). Hence, while the FAO had some success in harmonizing definitions for their reports, only MS-level totals were published.

To eliminate this gap standardization or harmonization procedures can be applied, both are based on commonly agreed definitions at the international level. If common definitions are not agreed upon, then the only solution is to acquire the data with multiple definitions. A typical example is Finland where the NFI uses both a national forest definition and the FAO standard definition. In this way, the NFI can provide estimates based on both definitions. The same should be implemented in all the MS.

For harmonizing the estimation of wood-related variables (growing stock, biomass, carbon) a minimum DBH for tree callipering equal to zero should be adopted and the position of each tree should be also recorded. The use of angle-count methods (those based on relascopes) should be avoided.

Integration of remote sensing

Differences among MSs forest monitoring frameworks also regard the implementation of EO within NFIs. Indeed, while most countries currently implement remote sensing within their forest monitoring frameworks, along with fieldwork, eight MSs haven't implemented it yet. This is the case for Bulgaria, Croatia, Cyprus, Estonia, Germany, Malta, Romania and Slovakia.

On the other hand, these countries could benefit from external research combining earth observation with ground data acquisition, mostly occurring at test sites. Here, the earth observation methods used are related to the analysis of satellite imagery, aerial photogrammetry, and ALS data. In this context, Sweden and Finland provide virtuous examples of efficient integration between NFI and EO, where the databases are openly accessible, and up-to-date maps and results are provided. Thus, in Finland, two forest inventory systems are used, the NFI - conducted by the Natural Resources Institute Finland (LUKE) every 5-10 years, collects information on national and regional forest resources - and the remote-sensing-based inventory carried out by the Finnish Forest Centre (Metsäkeskus) that implement laser scanning to assess forest stock and management activities. On the other hand, many MS currently cannot benefit from this integration, even if progress has been made. This is the case in France and Denmark. Here, NFI provides maps that are usually only visible in GIS online, and countries could benefit from national research activities frameworks, which are much more advanced than in other countries. Similar situations occurred in Italy, Poland, Germany, and Ireland, where research activities are currently carried out to develop maps based on NFI data at the national level. Many other MS – Spain, Portugal, Slovakia, Czech Republic, Austria, Lithuania, Latvia, Greece, Belgium, Slovenia, and the Netherlands – are currently conducting research at test areas, developing maps mostly related to species composition. On the other hand, no further information on the integration of EO and NFI, or related research activities, has been available for Luxemburg, Malta, Cyprus, Romania, and Bulgaria.

Time frame

The time interval between two subsequent field revisits varies within different NFIs. Across Europe, most MSs adopt a five-year revisit cycle (i.e., Belgium, Czech Republic, Denmark, Estonia, Finland, France, Hungary, Ireland, Latvia, Lithuania, Poland, Romania, and Sweden), while a 10-year cycle occurred in Germany, Spain, Italy, Luxembourg, Portugal, Slovenia, and Slovakia. Other MS either does not have a planned NFI (i.e., Malta, Bulgaria) or only happened once (i.e., Croatia, Cyprus, Greece). Lastly, Austria and the Netherlands adopted a specific period between the measurement of subsequent NFI, the first every three years (where one-third of the sampling plots were surveyed every year) while the latter has a planned cycle of four years.

For gap filling the solution is to have annual estimates produced by the NFI based on a permanent monitoring system where every year a proportion of 1/n plots (where n = years of the NFI rotation, most frequently 5 years) are visited in the field.

References

Gschwantner, T., Alberdi, I., Balázs, A. et al. Harmonization of stem volume estimates in European National Forest Inventories. Annals of Forest Science 76, 24 (2019). https://doi.org/10.1007/s13595-019-0800-8

Gschwantner, T., Alberdi, I., Bauwens, S., Bender, S., Borota, D., Bosela, M., ... & Tomter, S. M. (2022). Growing stock monitoring by European National Forest Inventories: Historical origins, current methods, and harmonisation. *Forest Ecology and Management*, *505*, 119868. https://doi.org/10.1016/j.foreco.2021.119868

Rondeux, J., Bertini, R., Bastrup-Birk, A., Corona, P., Latte, N., McRoberts, R. E., ... & Chirici, G. (2012). Assessing deadwood using harmonised national forest inventory data. Forest science, 58(3), 269-283.

SoEF - State of European Forests, 2020. https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

Appendix 7 GROUPING OF MS DEPENDING ON IMPACTS

	MS			Monitoring plots			Extent to which EO is currently integrated in forest monitoring programs	Overall number of indicators NOT monitored yet	Extent to which MS already have forest strategic planning in place
		Forest area	Share of GVA of forestry sector overall GDP	Number of NFI forest monitoring plots	NFI monitoring plots per km2 of forest area	Current time interval between subsequent plot visits			
Group 1	Bulgaria	38,930 km2	0.40%	No NFI	n/a	n/a	No info	5	2
	Croatia	19,391 km2	0.40%	6,232	0.3	only 1 assessment	2	6	2
	Cyprus	1,725 km2	0.01%	320	0.2	only 1 assessment	No info	12	3
	Greece	39,018 km2	0.03%	2,744	0.1	only 1 assessment	3	9	2
	Malta	5 km2	0.00%	No NFI	n/a	n/a	No info	18	2
Group 2	Austria	38,992 km2	0.24%	11,000	0.3	3	3	5	2
	Belgium	6,893 km2	0.02%	11,000	1.6	5	4	4	2
	Czechia	26,771 km2	0.52%	19,727	0.7	5	3	5	3
	Denmark	6,284 km2	0.09%	9,558	1.5	5	2	6	3
	France	172,530 km2	0.14%	33,500	0.2	5	2	5	3
	Germany	114,190 km2	0.08%	78,000	0.7	10	2	5	2
	Hungary	20,530 km2	0.19%	7,425	0.4	5	2	6	2
	Ireland	7,820 km2	0.01%	1,932	0.2	5	2	6	2
	Italy	95,661 km2	0.11%	7,000	0.1	10	2	4	2
	Lithuania	22,010 km2	0.50%	5,737	0.3	5	3	4	2
	Luxembourg	887 km2	0.03%	1,200	1.4	10	No info	6	3
	Netherlands	3,695 km2	0.02%	3,190	0.9	4	4	7	2
	Poland	94,830 km2	0.36%	30,722	0.3	5	2	9	3
	Portugal	33,120 km2	0.44%	12,000	0.4	10	3	5	2
	Romania	69,291 km2	0.63%	24,000	0.3	5	No info	7	2
	Slovakia	19,259 km2	0.54%	1,486	0.1	10	3	6	3
	Slovenia	12,378 km2	0.60%	761	0.1	10	4	6	3
	Spain	185,722 km2	0.08%	95,327	0.5	10	3	4	2
Group 3	Estonia	24,384 km2	1.16%	27,500	1.1	5	2	6	2
	Finland	224,090 km2	1.70%	60,000	0.3	5	1	3	2
	Latvia	34,108 km2	1.70%	No info	n/a	5	3	5	3
	Sweden	279,800 km2	0.73%	No info	n/a	5	1	5	2
	Total	1,592,314 km2	n/a	450,361	n/a	n/a	n/a	n/a	n/a
	Median	26,771 km2	0.24%	9,558	0.3	5.0	n/a	6	n/a
	Average	58,975 km2	0.40%	19,581	0.5	6.5	n/a	6	n/a

Legend	*Judgement criterion: From lowest to highest Red = highest cost increasing effect of this variable Yellow = lowest cost increasing effect of this variable*	*Judgement criterion: From lowest to highest Red = lowest benefit increasing effect of this variable Green = highest benefit increasing effect of this variable*	*Judgement criterion: From lowest to highest Red = highest cost increasing effect of this variable Green = lowest cost increasing effect of this variable*	*Judgement criterion: Compared to median Red = Costs expected Yellow = median; no cost or savings expected Green = Savings expected*	*Judgement criterion: Compared to median Red = Costs expected Yellow = median; no cost or savings expected Green = Savings expected*	*Judgement criterion: nominal Yellow = No or minimal savings expected Green = high savings expected*	*Judgement criterion: From lowest to highest Red = highest cost increasing effect of this variable Green = lowest cost increasing effect of this variable*	*Judgement criterion: nominal Red = highest cost Green = No cost*

Group 1- Facing high costs

This group includes countries for which high costs can be expected. The main driver of this is, that so far no, or no regular NFI has been conducted. Thus, if this assessment becomes obligatory, there are high one-off costs to be expected from developing and putting in place the system, such as training of staff, purchase of equipment, and others.

Within this category are also those countries which have the lowest numbers of the planned indicators already monitored before – or, in other words, which have the highest number of indicators for which no assessment has been done before. However, this is not the case for all countries in this category.

This category also entails two of the countries which the smallest forest size. While in theory this means that they thus face less overall cost for monitoring, on the other hand this also means that their costs per area for monitoring and strategic planning would likely be much higher than for other countries, since the overheads for the organisation, planning, training etc. are spread over a smaller area.

Group 2 – Medium cost

This is the largest group of countries. The group entails countries which all already have frequent NFIs in place, but where forestry does not play a very strong role.

Group 3 – High economic interest and lower expected costs

Those are the countries in which forestry plays a big role. They thus typically already have a well-functioning monitoring and planning in place, and all organise their assessments every 5 years and would thus face no additional costs from the planned 5 year frequency.

Appendix 8 ASSESSMENT OF EU FUNDING RECEIVED BY MS RELATED TO FOREST MONITORING

Methodology

The following project databases were consulted to identify projects relating to forest monitoring: Kohesio database for regional funding, LIFE public database for LIFE funding and Cordis database for Horizon funding. The following keywords were used to identify relevant projects: "forest" and "monitoring". The "project" category was looked at. All data available was included, namely from 2014 to 2023 for Kohesio, from 1997 to 2023 for LIFE and from 1986 to 2023 for Cordis.

A list of than 1159 projects was obtained. The list of projects included all information that could be downloaded, e.g. name, budget, description, dates of implementation, beneficiary countries etc. For the Horizon projects, it was not possible to download the budget, nor the beneficiary country. For this reason these projects are not included in the final assessment of EU funding (see paragraphs below).

The list of projects was then manually screened to estimate the share of total EU funding allocated to forest monitoring. The estimation was conducted based on a reading of the project description and the project title. The projects were divided between projects where high, medium or low level of funding was allocated to forest monitoring. For some projects, monitoring was not mentioned in the project description, but it was considered likely that some level of monitoring was nevertheless carried out (e.g. in the case of conservation measures). For these projects, the level of funding was identified as "unknown". Following manual screening, some projects were deleted from the table as they were not relevant for forest monitoring.

Each category of project (High, Medium, Low, Unknown) was assigned a specific share, as outlined in the table below. The shares were assigned to allow for a quantification of the actual share of the total EU funding allocated to forest monitoring.

Level of funding	Share of EU funding estimated to be allocated to forest monitoring	Definition
High	75%	Forest monitoring is the main objective of the project, Forest monitoring is explicitly mentioned in the title of the project
Medium	50%	Forest monitoring is one of the main components / objectives of the project
Low	25%	Forest monitoring is a minor component of the project
Unknown	10%	Monitoring is not explicitly mentioned in the project description but it can be assumed some level of monitoring was performed to conduct the activities of the project
Not relevant	0%	The project is not relevant for forest monitoring.

The share of funding allocated to forest monitoring for each of the projects, and to each of the beneficiary countries was then calculated, and it is presented in the submitted Excel file.

Database

See separate file.

Appendix 9 ASSESSMENT OF DISCARDED "HYBRID OPTION"

Introduction

The policy option called "hybrid option" reads as follows:

- Obligatory reporting on a set of indicators and parameters related to EU legislation and policy objectives beyond existing EU/international requirements (e.g. tree mortality, storm damage, drought damage, pest outbreaks, silvicultural regimes in EU forests, use of clear-cutting and the location and extent of primary and old-growth forest).
- Data harmonisation for existing indicators, standardisation for the new indicators
- The Commission will develop and operate EO-based forest monitoring, complementary to in-situ data collection, and provide these data and indicators to MS for their reporting
- Voluntary coordination and exchange on integrated long-term planning via dedicated expert group.
- Following consultation with this expert group, the Commission would issue voluntary guidance to facilitate the drafting of evidence-based integrated forest planning for example by offering a common set of basic requirements and core elements for consideration by MS.

The provisions regarding monitoring (the first three bullet points) are the same as for the existing policy option 2.2. and are thus not assessed in a stand-alone manner again in this report. However, the coherence of those provisions with the remainder of the policy option are discussed.

The provisions on strategic planning (the last two bullet points) differ, since they make the strategic planning part optional which was not yet part of a policy option and is thus assessed more in depth in this report.

Lessons learned from existing legislation

Comparable planning or reporting provisions

There are several planning or reporting provisions in the EU environmental acquis as well as other legislation which could be seen as comparable in terms of mechanism to the strategic plans discussed in this legislative initiative.

However, no comparable provision could be identified which is voluntary. However, some lessons can nevertheless be learned from those by assessing the extent to which the obligatory nature of the planning or reporting provisions has been identified as being relevant.

To this end, the Table below lists planning or reporting provisions from existing EU legislation together with a short summary of relevant findings from evaluations or other documents, where available.

Table 6.4 Overview and assessment of existing reporting or planning provisions

Legislation	Relevant reporting / planning instrument	Summary of relevant findings
Sustainable Use of Pesticides Directive (SUD)[179]	National Action Plans (NAPs); report on implementation of measures as	• Regarding the additional value of the SUD compared to possible national or regional initiatives, the most crucial added value identified was the creation of a harmonised EU framework (including the NAPs) as compared to the situation before; it was found that this helped avoid unbalanced competition in the single market (a race to the

[179] Directive 2009/128/EC of the European Parliament and of the Council of 21 October 2009 establishing a framework for Community action to achieve the sustainable use of pesticides (Text with EEA relevance). See: https://eur-lex.europa.eu/eli/dir/2009/128/2009-11-25

Legislation	Relevant reporting / planning instrument	Summary of relevant findings
	well as on level of ambition in terms of reduction	bottom situation); also, it was found that many MS were not pushing for ambitious measures themselves and that therefore, the SUD could be seen as essential to harmonising the national approaches to create a sustainable use of pesticides[180]
Marine Strategy Framework Directive[181] (MSFD)	Setting of national targets, monitoring progress	• Defining a coherent level of ambition (i.e. good environmental status, GES) is an ongoing challenge • "The MSFD assessments, monitoring networks and programmes of measures do not only channel efforts into new fields of research, but also into improving management and policy coherence" and the MSFD "plays an important role in ensuring that actions across EU MS are more coherent"[182]
Water Framework Directive (WFD)	Setting environmental objectives and coherent ambitions	• "Contrary to traditional command-and-control approaches, the Water Framework Directive's innovation was to put the needs of a healthy ecosystem as the objective to be reached and requires doing what is necessary cost-effectively across all sectors and pressures to reach this objective"; in other words, setting strategic environmental objectives was an effective management tool[183] • "Action by one Member State that affects the water of a lake or river shared with another Member State therefore directly affects the status of that water body in both MS. […]. A harmonised approach in terms of water management principles and water quality parameters secures an EU-wide level playing field and contributes to the functioning of the internal market
CAP strategic plans[184]	CAP strategic plans	• "In the proposed future CAP, MS will address potential difficulties in the choices which they make (within CAP strategic plans) about how to allocate funding on their territory to achieve objectives […]. Significant involvement and oversight from the Commission will ensure a level-playing field with common requirements, for instance on conditionality, indicators and minimum target setting and accountability […]. In the areas of the environment and climate it emerged that, although voluntary tools have a very large role to play, they need to be complemented by a certain level of "mandatory" standards, especially (but not only) regarding domains in which there is no EU legislation but nevertheless commitments for action, such as that of soil"[185]

[180] Findings taken from recent evaluation report. See: https://food.ec.europa.eu/system/files/2022-06/pesticides_sud_eval_2022_eval_report.pdf

[181] Directive 2008/56/EC of the European Parliament and of the Council of 17 June 2008 establishing a framework for community action in the field of marine environmental policy (Marine Strategy Framework Directive) (Text with EEA relevance). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:32008L0056

[182] An evaluation of the MSFD will only be available later in 2023. The findings were taken from the 2020 implementation report. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1593613439738&uri=CELEX:52020DC0259

[183] Findings taken from the 2019 fitness check. See: https://ec.europa.eu/environment/water/fitness_check_of_the_eu_water_legislation/documents/Water%20Fitness%20Check%20-%20SWD(2019)439%20-%20web.pdf

[184] Regulation (EU) 2021/2115 of the European Parliament and of the Council of 2 December 2021 establishing rules on support for strategic plans to be drawn up by MS under the common agricultural policy (CAP Strategic Plans) and financed by the European Agricultural Guarantee Fund (EAGF) and by the European Agricultural Fund for Rural Development (EAFRD) and repealing Regulations (EU) No 1305/2013 and (EU) No 1307/2013. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2021.435.01.0001.01.ENG

[185] An evaluation is not yet available since this is a relatively new instrument and thus the findings were taken from the impact assessment. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=SWD%3A2018%3A0301%3AFIN

The key lessons from the above examples could be distilled as follows:

- Mandatory targets / strategic targets / environmental objectives help raising the ambition, especially in MS with thus far low ambition;
- Harmonised strategic targets help avoid unbalanced competition (a race to the bottom situation) and the functioning of the single market
- The cross-border nature of the environment calls for coherent setting of standards since actions in on MS affect the environmental assets in the other MS

Legislation that combines obligatory and voluntary measures

It was attempted to assess if general lessons could be learned regarding legislation which combines obligatory and voluntary measures. This was attempted for the following:

- The regulation on reporting, analysis and follow-up of occurrences in civil aviation[186] which combines obligatory and voluntary reporting provisions
- The renewable energy directive[187] which sets a mandatory EU target but no mandatory national targets
- The proposal for a regulation towards for deforestation-free products[188]

However, no transferable lessons could be identified.

Overview of benefits and costs of the hybrid option

The provisions regarding strategic planning of this policy options are comparable to the policy option 2.1. in terms of governance and allocation of responsibilities, benefits and costs. Albeit the key difference is that this would be voluntary instead of mandatory, those responsibilities, benefits and costs would be comparable for those which do participate while benefits and costs would be reversed for those which will not participate.

Thus, the Table below repeats the findings from the original impact assessment report regarding benefits and costs for the different stakeholder groups for option 2.1. and based on this adds a comparative analysis for the hybrid option assess in the current report.

[186] Regulation (EU) No 376/2014 on the reporting, analysis and follow-up of occurrences in civil aviation. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A32014R0376

[187] Directive (EU) 2018/2001 of the European Parliament and of the Council of 11 December 2018 on the promotion of the use of energy from renewable sources (recast) (Text with EEA relevance.). See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=uriserv:OJ.L_.2018.328.01.0082.01.ENG

[188] Proposal for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL on the making available on the Union market as well as export from the Union of certain commodities and products associated with deforestation and forest degradation and repealing Regulation (EU) No 995/2010. See: https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=celex%3A52021PC0706

Provisions		Findings for option 2.1		Findings for the hybrid option
Policy option elements	**Relevant requirements**	**Cost elements**	**Key assumptions**	**Comparative analysis**
MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, review every 10 years. The Commission sets up means for policy coordination and uses Strategic Plans for future forest strategies and reporting	• EU institutions to develop a common structure for strategic plans	• **EU institutions** • One-off costs for developing the structure	• Costs are minimal	• The same would apply
	• EU institutions to provide means for policy coordination	• **EU institutions** • One-off costs for organising the workshops[189] • One-off costs for developing the guidance materials • **MS public authorities** • Preparation for and participation in workshops	• It is assumed that this would entail • Organisation of workshops (e.g. a forum for exchange of information and experience of multi-sectoral policy makers and stakeholders) with MS for clarifying details on the strategic plans during the first planning circle[190] • Provision of guidelines (e.g. a study summarising relevant policy obligations from EU policy; compilation of best practice for different aspects of the strategic plan)	• Mostly the same would apply • MS public authorities not participating would face no costs; however, those costs have been assessed as being minimal • See section 1.2.3.3 of the final task 2 report submitted on 12 January 2023 for detailed information on benefits and costs
	• MS to prepare reports every 5 years	• **MS authorities** • One-off developing new or adapting existing methodologies for forecasting. This could be either developed within in the public sector or procured.	• A limited number of MS currently has a plan in place which would satisfy the minimum definition of a strategic plan used in this initiative (i.e. setting multi-sectoral targets, modelling of key parameters)[191] • Where a MS did not have a comparable strategic plan in place yet, costs for first planning cycle would be considerably higher than for subsequent ones in cases where specific methodologies/capacities (modelling)	• Those costs would only apply for participating MS • See section 1.2.3.3 of the final task 2 report submitted on 12 January 2023 for detailed information on benefits and costs for the participating MS

[189] Potentially recurring in subsequent planning cycles if a need is identified.

[190] In addition to expert group meetings which are already taking place and can be considered part of the baseline.

[191] Based on research conducted under this project.

Provisions		Findings for option 2.1		Findings for the hybrid option
Policy option elements	**Relevant requirements**	**Cost elements**	**Key assumptions**	**Comparative analysis**
		• 5-year recurring cost for conducting the forecasting exercise • One-off costs for developing new or adaption existing multisectoral stakeholder dialogue • 5-year recurring cost for conducting the stakeholder consultation exercise • 5-year recurring cost for drafting the report	or structures (i.e. multisectoral stakeholder dialogues) need to be established	
	• EU institutions to review common structure every 10 years	• **EU institutions** • 10-year recurring cost for reviewing plans and providing recommendations • MS authorities • 10-year recurring cost for adapting	• No major new elements are added which would result in major costs for MS authorities	• The same would apply
Support by an expert Group on Forest Monitoring and Strategic Planning to support Policy Coordination, Implementation and Development	• EC will coordinate and facilitate the group; the MS post experts to the group	• /	• This is already done outside this legislative initiative (sub-working group of the SFC on forest monitoring and strategic plans) and thus part of the baseline costs • If the group also directly works on harmonisation and standardisation then this additional cost would be equal to that assumed above for research projects with this purpose	• The same would apply

As can be seen, in terms of benefits and costs per stakeholder group there are no signification differences. However, there are implications regarding other impacts as well as other comparative criteria. Those are discussed in the next chapter.

How does the option compare

The following table provides an overview assessment of the hybrid option, following the same format as the assessment of the other options in the final impact assessment report.

As in the last chapter, option 2.1 is added as comparison.

Comparison of the relevant options addressing specific objective 3: A coherent governance framework for reporting and planning is established

	Sub-option 2.1: MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, review every 10 years	**Hybrid option**
Impacts		
European institutions	**-**	-
MS national authorities	**/ to --** *Actual costs per MS would depend on already existing information, structures and expertise in the MS*	**/ to --** *Actual costs per MS will depend on if they will participate in the voluntary action, and if yes, on the already existing information, structures and expertise in the MS*
Other stakeholders	/	/
Other criteria		
Effectiveness Coverage of identified requirements	++	/ *It is assumed that this option would not or little effective. Based on lessons learned from other EU legislation with obligatory reporting and strategic planning provisions, the following can be assumed:* • *Predominantly MS with already high ambition in terms of strategic planning would join; thus, overall ambition in the EU would not be raised* • *Thus, the objective of a coherent governance framework would not be achieved* • *Through this, other crucial benefits which have been identified by other initiatives would not be realised such as avoiding unbalanced competition (a race to the bottom situation), better functioning of the single market, and accounting for the cross-border nature of the environment*
Efficiency	+++	+++

	Sub-option 2.1: MS develop/align strategic plans with a common structure including forecasting. Reporting every five years, review every 10 years	**Hybrid option**
Distribution of advantages and disadvantages between different stakeholders	No observations.	*The MS which participate would face the costs for the strategic planning.* *The MS would then also enjoy the wider socio-economic and environmental benefits which are discussed in chapter 1.4 the final task 2 report submitted on 12 January 2023 and which have been further amended in the resubmission of this chapter from 09 March 2023.* *However, many of those wider benefits (especially environmental benefits) are of cross-border nature and thus the MS not implementing strategic planning would be "free-riders", i.e. they would receive the benefits without contributing to the costs.*

The main takeaway from the above would be that it can be assumed that the objective that this legislative initiative seeks to achieve, i.e. "A coherent governance framework for reporting and planning is established", would likely not be achieved through this option.

An additional criterion to be discussed as part of the hybrid option is the internal coherence of the option which had not been identified as an issue for the other policy options.

In the hybrid option, the monitoring obligations would produce a wide range of high-quality datapoints regarding forests for all MS. However, data collection in itself is not an end goal but rather means for a range of goals which have been discussed in the original impact assessment report such as better policy making and improvement, better management, and others.

The strategic planning would fall under those potential uses of the available data and would also, compared to the obligatory monitoring part of the legislative initiative, cause significantly lower costs, even in MS which thus far do not have a strategic plan. Thus, not using this data to the best extent possible would not reach the full potential of the legislative proposal. In addition, it could actually undermine the assessed effectiveness of the monitoring, given, that the collected data would be used to a lesser extent.

Appendix 10 REFLECTIONS ON NON-WOOD FOREST PRODUCT INDICATORS

Non-wood forest products

Introduction: NWFP in the EU

Forests provide many ecosystem services that are essential to maintain sustainable bioeconomy and society functions. Besides timber, forests are capable of producing a range of non-wood forest products (NWFP) that are considered economically and socially important, such as berries, mushrooms, aromatic, medicinal, and decorative plant material, saps and resins, nuts, honey, fibers, game, and animal products. Most households in the EU consume NWFP and nearly a quarter collects them (Lovrić, 2020). In 2015 the worth of market NWFP achieved around 4 billion Euros, even though in the EU the majority of these products are self-consumed and not marketed (Lovrić, 2020; FOREST EUROPE, 2020).

Problems with assessment of NWFP

Despite the importance of NWFP, many aspects pose difficulties to obtain an overview and comparable data on the topic across Europe. The EU's monitoring lacks systematics and harmonised data on NWFP, the available information is mostly incomplete, scattered, or not comparable among countries (Vantomme, 2003). National statistical and scientific data on this topic are reported only for a limited number of countries, products, and case-study areas (Lovrić, 2021). According to Vantomme (2003), the most reliable data on NWFP comes from international trading statistics, however, as around 86% are self-consumed and are also usually traded in informal markets, it is evident that available data is incomplete (Lovrić, 2020). The heterogeneity of the NWFP markets and the diverse local-level importance of many products is also a limiting factor to the harmonization and comparison of data across Europe (Wahlén, 2017) since there are at least 600 mushroom and plant species that are collected in Europe and that are even commonly known by different names in the same country (Schulp et al., 2014; Lovrić, 2021). The heterogeneity of the product categories and data collection processes also results in the use of different quantitative (e.g., kilograms, pieces) and qualitative (e.g., bags, baskets, handfuls among others) reported units (Lovrić, 2020).

Main NWFP data sources

NWFP are covered by the Combined Nomenclature (CN), the EU's classification system for externally traded goods covers NWFP, which is based on the Harmonised Commodity Description and Coding System (HS). Each CN subheading has an eight-digit code – the first six relate to the headings and subheadings of the HS nomenclature, while the seventh and eighth identify the CN subheadings. Some NWFPs (mostly food products) can be identified through the additional two digits (Sorrenti, 2017). NWFP is also covered by forest monitoring and reporting initiatives such as Forest Europe's SoEF and FAO's FRA, although usually the data originate from the national statistical offices and can be the same or are subject to the same problems.

All the EU countries, except three, report information on NWFP to the SoEF and FRA databases. The data availability varies among countries, as not all report both total harvested goods, market value for the same products. Due to the high variability of forest ecosystems across the EU countries, the non-wood products reported are diverse, however, most of them are classified under food and ornamental plants.

NWFP indicators

- **Forest Europe**
  - Indicator 3.3a: Harvested quantity and market value of non-wood forest goods: **plant product/raw material** [Product types: Food; Fodder; Raw material for medicine and aromatic products; Raw material for colorants and dyes; Raw material for utensils, handicrafts & construction; Ornamental plants; Exudates; Other plant products] ; [Unit: Marketed value (EUR); Quantity (metric tonnes / pieces)]

- Indicator 3.3b: Harvested quantity and market value of non-wood forest goods: animal product/raw material [Product types: Living animals; Hides, skins and trophies; Wild honey and bee-wax; Wild meat] ; [Unit: Marketed value (EUR); Quantity (pieces / metric tonnes]
- Indicator 3.4: Value of marketed services on forest and other wooded land [Types: Ecological services; Biospheric services; Social services; Amenity services; Other services] ; [Units: Value (EUR) ; Amount of service/product (area / pieces / licenses / value/ha / visit etc.)]

References

- FOREST EUROPE, 2020: State of Europe's Forests 2020.
- Lovrić, Marko & Da Re, Riccardo & Vidale, Enrico & Prokofieva, Irina & Wong, Jennifer & Pettenella, Davide & Verkerk, Hans & Mavsar, Robert. (2020). Non-wood forest products in Europe – A quantitative overview. Forest Policy and Economics. 116. 10.1016/j.forpol.2020.102175.
- Schulp, C.J., Thuiller, W. and Verburg, P.H. 2014 Wild food in Europe: a synthesis of knowledge and data of terrestrial wild food as an ecosystem service. Ecol. Econ. 105, 292–305
- Sorrenti, S. 2017. Non-wood forest products in international statistical systems. Non-wood Forest
  Products Series no. 22. Rome, FAO.
- Vantomme, P. 2003 Compiling statistics on non-wood forest products as policy and decision-making tools at the national level. Int. For. Rev. 5, 156–160.
- Wahlén, C.B. 2017 Opportunities for making the invisible visible: towards an improved understanding of the economic contributions of NTFPs. Forest Policy Econ. 84, 11–19.

Recreation

Introduction

Forest across Europe provides important services such as ecotourism and recreation. However, since most of these recreational activities are not exchanged via market transactions, these services values are difficult to obtain and therefore not reported, even though this represents a significant amount. Information in the EU countries regarding forest services are still scarce, most of the information available regarding recreational services originates from hunting and fishing licenses, the renting of huts and houses, forest-based recreation, sports, and outdoor activities, and educational activities that are not free of charge to the users.

Data availability

SoEF contemplates these recreational services in their database, however only few EU countries reports to this indicator category. However, through a pan-European questionnaire Atkinson et al. 2020 found that 31 countries reported on thxceir national reporting systems at least one social or recreational service, being the most frequently recorded variables: ownership, general transport infrastructure and recreation-specific infrastructure.

Recreation Indicators:

- **Forest Europe**
  - Indicator 3.4: Market value [Service provision: Amount of service/product; Service provision: Value (1000 national currency)]
  - Indicator 6.10a: Forest area available for public recreation and area managed for recreational use; [Unit: Total (1000ha); Percentage of total]
  - Indicator 6.10b: Intensity of use; [annual number of visits (million)]

- Indicator 6.10c: Recreation facilities; [Forest roads and paths available for public recreation (length in 1000km); Forest roads which designated for hiking, biking, cross country skiing, etc. (length in 1000km)]

Reference:

▫ Atkinson, M.A., Edwards, D.M., Jensen, F.S. et al. Harmonising, improving and using social and recreational data in National Forest Inventories across Europe. Annals of Forest Science 77, 76 (2020). https://doi.org/10.1007/s13595-020-00952-2

Bioeconomy indicators

The following table presents indicators on the topic of "Dependence on non-renewable resources" based on BioMonitor project assessment of Bioeconomy indicators, data requirements and relevant data sources.

These indicators focus on product substitution – more forest relevant indicators are covered in the referred report, mostly covered already in the indicator overview in the forest monitoring and strategic plans impact assessment study.

Table: Indicators concerning "Dependence on non-renewable resources"; Overview of BioMonitor indicators, data requirements and relevant data sources [source: Zhu et al. (2019)]

Bioenergy replacing non-renewable energy	Data on biofuel, biogas production, import, export and use	EUROSTAT (EUROSTAT 2018)
Biomaterials replacing non-renewable resources	Wood based constructions, bio- based textiles, bio-based pharmaceuticals, bio-based chemicals and bio-based plastics expressed as quantity and share in total consumption including fossil-based counterparts.	
Biomass self-sufficiency rate	Domestic biomass production, domestic biomass use, exports of biomass, imports of biomass	S2BIOM; Dees et al. (2017)
Material use efficiency	Greenhouse gas and energy balance of bio-based products, review of LCA of bio-based products	EC JRC - Bioeconomy Knowledge Centre, Bioeconomy Data Catalogue https://biobs.jrc.ec.europa.eu/
• Material and waste recycling		
• Recycling bio-based products	waste statistics, material flow accounts	EUROSTAT (EUROSTAT 2018)
• Cascaded use of biomass		
Certified bio-based products		

References

▫ Zhu et al. (2019) Biomonitor Project Deliverable: Data and data gaps for bioeconomy drivers and indicators and their implications. Date of document – 08/2019 (M15). EU Grant Agreement N° 773297

Appendix 11 SWOT ANALYSIS OF CURRENT STRATEGIC PLANNING FRAMEWORK IN THE MS

Background and methodology

This section provides an EU-wide SWOT analysis to synthesise the main existing, missing or contradicting elements of forest planning and strategic documents; it is based on the information in the country fiches from the 27 EU MS which are presented in Appendix 15.

A SWOT provides a structure for a systematic analysis of factors relating to a new product, technology, management, or planning; and includes both, internal factors (strength and weakness) and external factors (opportunities and threats). The influence of an internal factor entirely derives from the study object, whereas external factors originate from the outside the object and can either be positive (opportunities) or negative (threats). In the context of this analysis, 'internal' is defined as national level, while 'external' refers to interplay between EU and MS.

'Internal' factors are synthesised from the country fiches, and ranked by consortium experts to narrow down the factors to a reasonable level.

'External factors' are synthesised from country fiches and other political documents addressing or touching the issue of strategic plans.

To operationalise the general SWOT structure, for each of the four elements (strengths, weaknesses, opportunities, and threats) a number of factors are defined along which the analysis is then structured).

Table Overview of the SWOT factors for strategic plans

	Positive	Negative
Internal Environment	**Strengths** Comprehensive national policies and instruments that can create synergies and help further develop strategic plans	**Weaknesses** National policies and instruments that are missing or likely to hamper synergies and the further development of strategic plans
External environment	**Opportunities** Political, institutional, social, economic, technological and/or sectoral and cross-sectoral features which create positive potential for further uptake of Strategic Plans	**Threats** Political, institutional, social, economic, technological and/or sectoral and cross-sectoral features which create negative potential for further uptake of Strategic Plans

SWOT analysis

The SWOT analysis is to identify a list of key issues that are relevant for the development of Strategic Plans (SPs) from national and EU's perspectives. As this relates to all 27 EU MS in summary, not every element is valid for each country, but tries to identify certain patterns, that might be considered for the set-up of SPs.

Table SWOT analysis

	Positive	Negative
Internal Environment	**Strengths** • Comprehensiveness of planning documents • Existing national expertise as key for forest planning • Established stakeholder networks • National Forest Programmes	**Weaknesses** • Lacking strategies responding to major forest-related EU topics • Incoherence of planning instruments • Missing coordination and communication • Too many emerging issues
External environment	**Opportunities** • Further develop monitoring schemes • Harmonise funding schemes • Guidance for connecting different objectives • Improve clarity on impacts of new EU instruments	**Threats** • Planning as part of the subsidiarity • Lack of trust in new EU instruments • Uncertainty for forest owners • Unclarity on impacts of strategic plans

Description of factors

Strengths

- **Comprehensiveness of planning documents**
  In most countries, there is long history of planning of forest management and other forest-related issues (e.g. water, biodiversity). These instruments have been constantly modernised, yet they are not always intertwined. For SPs these sources provide a good starting point in many countries as regards data, objectives, and implementation instruments.
- **National expertise as key forest planning**
  National forest expertise is widely perceived as key asset for forest planning. There are long-lasting structures, proven interrelations between administration and forest owners/managers, and function control mechanisms in place. SPs will require involvement of national experts and making use of national governance and communication structures as well as bottom-up initiatives.
- **Established stakeholder networks**
  Stakeholder organisations and associations are set up in most countries and build an essential backbone in forest governance and in connection policy and practice. Participatory stakeholder involvement is one of the key success factors for strategic processes, and SPs bear the opportunity to broaden the gathering beyond sectoral boundaries.

- **National forest programmes**
  National forest programmes exist in many countries and are proven tools for a multi-stakeholder dialogue. Ideally, they are also adaptive to bringing new strategic issues together. SPs could build on such processes where existent, and demonstrate good practices on how strategic planning can be performed combining both EU goals and national competences.

Weaknesses

- **Lacking strategies responding to major forest-related EU topics**
  Currently, the forest policy arena is developing dynamically. Since forest-related policies are a cross-cutting matter it is difficult to find comprehensive and long-term collection for implementation of EU instruments, even on national levels. This phenomenon might also be referred to as policy fragmentation. SPs might be an instrument to overcome this fragmentation.
- **Incoherence of planning instruments**
  Forests are directly or indirectly subject to a variety of planning instruments, also on national level. This can lead to horizontal incoherence among instruments both in terms of goals, content, competences, terminology and planning horizon, and may hamper their implementation in actual forest management.
- **Missing coordination and communication**
  Missing coordination happens often if both there is a split/partial overlap in national competences, and if there is no cross-sectoral exchange or conflict between forest stakeholders and others. SPs might be platform that stipulates such exchange between authorities, administrations, and stakeholders.
- **Too many emerging issues**
  In recent years, things around forests and forestry changed quickly. For both forests and administration, this makes it difficult to move due too economic and capacity constraints. SPs would need to lift such issues that first require tactical response to a strategic and prospective level.

Opportunities

- **Further develop monitoring schemes**
  An EU-wide forest monitoring instrument can build on a variety of national monitoring instruments as a solid ground for further development. In addition, synergies should be sought with other reporting schemes (e.g. global forest reporting). Currently, there are a lot of activities and funding ongoing for further developing forest monitoring, which will give new impetus and grounding to SPs.
- **Harmonise funding schemes**
  EU forest funding is often less prioritised compared to other sectors. It is an opportunity to harmonise and substantiate funding on the basis of Strategic Plans. This entails aspects such as, conservation, carbon sequestration, and provision of other ecosystem services.
- **Guidance for connecting different objectives**
  The EU Forest Strategy contains a certain level of complexity, as does forest-related policy in general. Guidance in wake of Strategic Plans on how to balance the different objectives, create synergies in forest management and handle trade-offs would make the outcome of the process more tangible.
- **Improve clarity on impacts of new EU instruments**
  Creating clarity on the wealth of new instruments that have a connection to forests (e.g. taxonomy, zero deforestation) and how they are interrelated or should incorporated in Strategic plans might be an asset.

Threats

- **Planning as part of the subsidiarity**
  Forest Planning is widely seen as clear competence of the Member States according to their national priorities, and especially forest-rich countries with a highly developed forest sector either don’t see the need for a new instrument or are in opposition. The success of SPs will depend on untangling this situation.
- **Lack of trust in new EU instruments**

There is a certain level of mistrust by many countries on turning things upside down in forestry domain with a wealth of new instruments, especially legal ones. Lack of trust is a clear threat to the uptake and implementation of SPs.

- **Uncertainty for forest owners**
  Additional legal frameworks may increase the uncertainty of forest owners about the background of a new instrument on monitoring and strategic plans and the interference with their management practices (e.g., is it used to control their actual management?) I It requires strong communication to explain the objectives and non-objectives of SPs, and the system boundaries of their application**.**
- **Unclarity on impacts of strategic plans**
  Unclarity about the instrument of Strategic Plans and its potential impact on forest management might hamper its acceptance and implementation, and create dynamics that undermine the instrument. Incoherence between EU- and national instruments, or parallel forest policy systems might threaten acceptance of SPs.

While having a heterogeneous forest landscape across the EU with also different forest governance systems we can see some certain patterns in the SWOT analysis. This synthesis is to support the identification of supporting and critical factors for the implementation of SPs.

Essential assets are to use the stock-taking of existing national instruments, expertise, networks, and processes and further build on them. Uncertainty, lack of trust, communication deficits are the key issues to overcome for a successful implementation of SPs.

Appendix 12 GAP ANALYSIS OF CURRENT STRATEGIC PLANNING FRAMEWORK IN THE MS

GAP Analysis

The Gap Analysis was conducted based on the country fiches in Appendix 15, and tackles a conglomerate of key forestry issues as regards:

- Governance aspects
- Status of forests
- Development goals
- Bioeconomy aspects
- Supply and demand, import and export of goods
- Potential of ecosystem services

A Strategic Plan should serve as an instrument that is able to cover a heterogeneity of different planning aspects. In this exercise, we consider a gap not only an issue that is missing. We address issues that are open, unclear or where new challenges are arising.

While it is difficult to summarise EU-27 countries, some patterns of gap issues can be summarised:

- There is no homogeneous approach towards National Forest Programmes (NFP) in the countries. NFP can be seen as a potent starting base for Strategic Plans, as they are designed as major strategic and participatory process on forest topics. It might be an idea to look into good practice examples for NFPs, and how they stand in relation to Strategic Plans. For instance, in Austria has been a continuous process on a dialogue on forests, generating a forest programme and a set of national indicators with target values.
- There have been good efforts in further developing and harmonising monitoring instruments in the past decades, but the status still varies. This has also historical reasons, because e.g. Eastern European countries had to set-up completely new systems. Monitoring efforts by the EC and in numerous research projects are likely to improve this gap.
- A big issue is still lacking cross-sectoral coordination beyond the forestry sector. This might lead to non-harmonised and diverging planning and incentives. Umbrella strategies (e.g. a biodiversity strategy) need more specific implementation strategies for the forestry sector.
- Creating planning instruments while having to reach out to forest owners depends a lot on the forest governance regime in countries. For instance, in Eastern European countries forest management planning is strongly tied to state administration, while in most Western European countries state administration is mostly checking legality of management and providing advisory services. Strategic Plans thus have to reflect this dichotomy between strategic elements and practical implementation in different set-ups.
- A variety of new emerging issues in forests (e.g. climate change – large scale disturbances, markets) brought new dynamic and particular new uncertainties into strategic planning of forests. Clearly, many countries are at a stage of responsiveness rather than strategic planning. It will need a balanced consideration in the strategic plans on how to deal with uncertainties, risks, and to implement the mid- to long-term political goals for forests in times where there is a lot of concerns about the future of forests and forestry.
- In many country, disturbances are the elemental driver for the future of forests (e.g. forest fires in Southern Europe). So, it requires safeguarding fundamental basics in forest management and planning before enlarging the strategic scope. A first strategic element might be how to maintain the existence of forests in such areas, and support this respectively e.g. via a priority plan.
- Little evidence was found on how the inherent trade-offs are dealt with that origin from the dichotomy between fostering a bio-economy in parallel with conservation and carbon sequestration. Strategic Plans have the potential to address and guide this, because this remains a major gap so far.
- Ecosystem services and how to make them contribute to a viable forest management is often mentioned by countries, while instruments to do so are mostly not fully developed. Strategic

Plans can hence bring together elements from other EU policy processes that address this issue (e.g. taxonomy).

The following table gives an overview on the major forest-related issues in EU-27 as identified in the analysis of current strategies and instruments. Not all countries have sent feedback on the country fiches, so the evidence from the is strongly built on national planning documents and country reports to different processes[192].

Table 6.5 Overview per MS

Country	Major issues observed
Austria	• Resolution of interest conflicts arising out of an increasingly urbanised society with shifting demands on forests • The dialogue between foresters and hunters on minimizing browsing is still ongoing, but didn't solve the problems sufficiently yet • The recent calamities had big impact on forest owners and the value development of their forests, which is particular difficult for small-scale owners to handle. There is the danger that forest owners lose motivation, which would lead larger areas of unmanaged forests
Belgium	• Forest management plans are compulsory in Brussels, but only partially in Flanders and Wallonia • High forest fragmentation • Neither National Forest Programme or Strategy, or similar instrument, could be found
Bulgaria	• Insufficient finance and institutional capacities to implement the new policies
Croatia	• Maintaining stable and sustainable financing for FES • Large forested areas are still contaminated by landmines from the Homeland war. This makes the areas inaccessible for SFM • Additional efforts (such as further digitalisation) is needed to improve the traceability of wood/timber • Only a National Forestry Policy and Strategy from 2003, no later version, nor National Forest Programme or similar instrument could be found
Cyprus	• Forest fires (prevention and management of) • 19,54 % of state forests is found in the area of Cyprus beyond the control of the Government • High dependence on fossil fuels (and thus imports thereof). Need and urgency to develop renewable energy sources • We could only find a Draft Integrated National Energy and Climate Plan for the period 2021-2030 • We could not find a National Forest Programme, nor Forest Strategy or similar instrument • Forest certification, since no forests are under third party certification scheme
Czech Republic	• Strategies need to be developed to mitigate the increasing demands on forests from society and climate change pressures • The economic situation of the forest owners needs to be considerably improved
Denmark	• Reliance on imports to satisfy wood and wood-based products demand. Challenge to create the obligation to ensure that such imports are produced sustainably • Grant schemes prioritize only a few services, which might hinder incentives for multifunctional services • A National Forest Programme 2018 and Forest Act 2018 were found. No Forest Strategy could be found • An Energy Political Agreement 2018 and Promotion of Renewable Energy Act 2018 exist, but no National Bioeconomy Strategy was found
Estonia	• No National Forest Programme/Plan nor forest Strategy could be found More efforts should be made to use wood in construction and for bio-based energy • The continuing fragmentation and loss of characteristic habitat types and populations of important species and their habitats is problematic • Private forest owners need support, also from forest experts
Finland	• Balancing the various aspects of SFM, including climate change mitigation

[192] E.g. FOREST EUROPE, FAO FRA, Natura 2000 reports

Country	Major issues observed
	• Work still remains to be done on boosting the production and profitable commercialisation of non-timber forest products. This is emphasised in the revised National Forest Strategy 2025
France	• Easy access to on-line platforms providing mapping data and designing new monitoring indicators is needed • No National Forest Programme could be found, however French National Forest Strategy, Bioeconomy and Biodiversity strategies were found
Germany	• Transformation from coniferous to stable deciduous and mixed forest is needed to make the forests more resilient against climate change and less prone to calamities, such as bark beetle invasions or draughts • There is still high uncertainty about the magnitude of climate change impacts on regional and local scale which is needed for optimizing decisions on active adaptation measures. Efforts are needed to make projections more reliable
Greece	• Certification of forests is not developed in Greece • Completion of forest maps
Hungary	• Shared common ownership of forest area is a challenge for management • High proportion of forestry area covered with non-native tree species (36%) requires regulation
Ireland	• Certification of private forests • Increase efforts at biodiversity conservation • Increase the forest area through sustainable afforestation • Improve forest adaptation to climate change
Italy	• Better adaptation of sustainable forest management practices, particularly for the Mediterranean area • Promoting communication actions and awareness of the public opinion on the role of forest and forest products
Latvia	• No national forest strategy could be found • No national biodiversity strategy and action plan • Integration of biodiversity targets into the national forest strategy • Increasing competitiveness of Latvian forest industry • Increasing the level of skill among people working in the forest sector
Lithuania	• Improvement of forest management regimes, as the current system does not completely ensure the protection important forest habitats and is not adjusted to the small-scale private forest holdings • Competing needs of society for forests – there is a need to find a new balance • Growing demand for non-timber forest services needs to be accounted for • The conflict between the aspirations of better nature conservation and more rational forest use needs to be addressed
Luxembourg	• Spruce monocultures representing 10% of the forest cover are severely endangered by climate change and need to be restored to mixed forest stands over the next 2-3 decades
Malta	• Safeguard existing habitat areas and explore the possibility of extending the network of green areas through tree planting initiatives
Netherlands	• Transformation from coniferous to stable deciduous and mixed forest is a key action. This has partly been pushed by the major drought damage to Norwegian Spruce and bark beetle attacks on Larch • The trade-offs in values and interests related to forest use needs to be addressed. e.g., through zoning • No National Forest Programme could be found, but National Forest strategy 2020 addresses most crucial aspects
Poland	• Enhancing expertise & capacities of private forest owners • Research on expected changes in forests due to climate change & their mitigation through forests • Promotion and support regarding carbon storage in forest products and substitution of non-renewable materials need to be intensified • More detailed regulations and removing legal gaps concerning forests in urban areas in order to promote their protection and maintenance • Drafting and implementation of a future National Forest Programme
Portugal	• Promote forest environmental and social services among the population • Engage stakeholders to contribute to sustainable forest management and participation & prevent forest risks, mainly fire and pests
Romania	• Forest restitution process in Romania is problematic which results in large areas of disputed and mismanaged forestlands

Country	Major issues observed
	• No national forest strategy could be found
Slovakia	• Optimizing legislation on Sustainable Forest Management • Optimizing financing of Sustainable Forest Management • Generally improving Forest Management
Slovenia	• Ownership structure (large number of owners - 431,000 and co-owners) hinders intensification of forest management. Some owners are not interested in income from forests because of small properties, which results in low cutting rates. The level of technology applied in harvesting in private sector is relatively low. Marketing of timber of small quantities is not optimal • Difficult regeneration of forests due to an overabundance of wild animals (deer, roe deer) in the forests • Increased frequency and intensity of natural disasters: ○ droughts and ice break following by bark beetle gradations; ○ blowdown of trees; ○ forest fires
Spain	• Improve measures to prevent forest fires • Forest abandonment and depopulation of rural areas is a challenge • Promotion of the use of timber and non-wood forest products among the population • Contribute to a rise in the added value of forest products
Sweden	• To maintain and develop a skilled and diverse work force and forest owners in an urbanised society • Developing a better understanding of ecosystem services, as seven ecosystem services have been identified as having an inadequate status. Ecosystem services with an inadequate status were primarily found among the regulating and supporting services, but also among some of the provisioning services.

Appendix 13 OVERVIEW OF EXISTING PLANNING INSTRUMENTS

Planning instrument	Forest-related dimension	Reporting/reviewing interval	Commission action (approval, recommendation, acknowledgement)	MS that have submitted the plans (latest applicable round)
National Forestry Accounting Plans	Forest Reference Level in the context of LULUCF	Once for the period from 2021 to 2025	Technical assessment	All EU MS
National or regional adaptation strategies	Forestry (sector)	5-year compliance check: comprehensive review process in 2027 and 2032	Comprehensive review by EEA	All EU MS
National Energy and Climate Plans	Decarbonisation, renewable energy and energy efficiency	10-year long cycle, update at 5-year and progress reports on a biennial basis	Assessment and country-specific recommendations	All EU MS
Long-Term Strategies	Decarbonisation, renewable energy and energy efficiency	Every 10 years; update every 5 years, where necessary. At least 30 years perspective	Assessment	All EU MS ex. IE, PL, RO
CAP Strategic Plans	Financial instrument to support investments (afforestation, agroforestry, prevention and restoration of damage, provision of ecosystem services etc), management commitments and horizontal measures (advisory services, cooperation etc)	From 2023 to 2027. One yearly amendment possibility	Formal approval	All EU MS have submitted the CAP SP (FI, IE, LU, NL, SE foresee no forestry measures with CAP funds); BE has two regional plans
Environmental Implementation Reviews	Circular economy and waste management; biodiversity and natural capital; climate action	First in 2016, previous EIR in 2019, latest review by COM in 2022	review/recommendation	All EU MS ex. HR, LU
Prioritised Action Frameworks for Natura 2000	overview of the measures and financing that are needed to implement the EU-wide Natura 2000 network – including for significant area covered by forest habitats	Financing programmes, the present one 2021-2027 was due by end of 2021 (previous 2014-2020); as deemed appropriate by MS	Assessment	All EU MS except DK (Jan.2022 situation)
National Biodiversity Strategies or Action Plans	Variable forest-related dimension depending on country circumstances	Reporting intervals varying between 5 and 10 years, depending on MS and consecutive submissions (ref. EU Biodiversity Strategy	N.A.	All EU MS, except LT (chapter in env.l policy guidelines) and SE

Planning instrument	Forest-related dimension	Reporting/reviewing interval	Commission action (approval, recommendation, acknowledgement)	MS that have submitted the plans (latest applicable round)
		2030: revised NBSAP by end of 2021, or as min. submit nat. commitments for the most important targets + there should be regular review cycle)		(integrated env.l policy); 2030-strategies in NL and PT, Updates ongoing (AT, BG, DE, FI, FR, HU, IE, IT, SK)
National Ecosystem Assessments	Ecosystem services (state and trends)	Irregular at country initiative	N.A.	BG, CZ, DE, ES, IT, NL, PL, PT, FI,
Management plans of Natura 2000 sites [193]	Forest management plans, integration of conservation objectives and measures (such as deadwood, old trees, old-growth forests and a diverse structure), Habitats Directive and Birds Directive	Planning obligation depends on MS and can be also varying by region	N.A.	Countries where national obligation are in place: CZ, DK, EE, ES, FR, IE, LT, LU, NL, PL, SE, SI Countries where sub-national obligations are in place: AT, BE, DE
N2K – Article 17 reporting	conservation status and trends in forest habitats, restoration needs, status and trends in forest bird species; pressures for habitats and species	Every 6 years (2001, 2007, 2013, 2019, next planned for 2026)	Assessment (EEA)	ES, EE, DK, DE, CZ, CY, BG, BE, AT, SK, SI, SE, RO, PT, PL, NL, MT, LV, LU, LT, IT, IE, HU, HR, GR, FR, FI
National Bioeconomy Strategies and Action Plans	biomass production, bioresources, bioproducts, bioenergy (emphasis given to sustainability dimensions, ecosystem services or, for example, biodiversity varies); innovation RTDI,	N.A.	N.A.	All EU MS have Bioeconomy Strategy at national level, ex. EE, DE, BE, SL, GR, BG, RO which have other policy initiatives dedicated to bioeconomy

[193] https://ec.europa.eu/environment/nature/natura2000/management/docs/conservation%20measures-Annex%202.pdf

Planning instrument	Forest-related dimension	Reporting/reviewing interval	Commission action (approval, recommendation, acknowledgement)	MS that have submitted the plans (latest applicable round)
	biotechnological solutions			
Disaster-risk reduction strategies (Sendai Framework 2015-2030 UNDRR.org)	Variable attention to forest depending on the significance of forest related risks	yearly	N.A.	Variable number by criterion
National Forest Risk assessment Plans	identify and evaluate risks to forests, including natural (biotic and abiotic) disturbances, and detrimental impacts from climate change or human activities	N.A.	N.A.	No EU-level requirement
National reports to Forest Europe	6 criteria and 35 quantitative indicators (describing the forest status and changes) as well as 17 qualitative indicators (describing the national forest policies, institutions and instruments towards SFM)	Approx. 5 yearly	Not Applicable	All EU MS

Appendix 14 OVERVIEW INDICATOR COVERAGE OF POLICY OPTION 2.1

Note: this Table shows the coverage of indicators which are already monitored in MS from the ones considered ate the time of writing for option 2.1. This selection of indicators might still be subject to change and thus the coverage as well.

	Biomass resources and management	Forest bioeconomy	Forest health and resilience	Forest protection and biodiversity
Austria	92%	100%	50%	57%
Belgium	92%	78%	100%	71%
Bulgaria	92%	78%	83%	57%
Cyprus	33%	100%	67%	14%
Czechia	92%	89%	83%	64%
Germany	92%	89%	83%	43%
Denmark	75%	89%	100%	50%
Estonia	92%	89%	67%	50%
Greece	83%	56%	50%	21%
Spain	83%	56%	83%	71%
Finland	83%	100%	100%	71%
France	83%	100%	83%	57%
Croatia	83%	100%	83%	57%
Hungary	92%	67%	50%	50%
Ireland	83%	56%	100%	43%
Italy	92%	67%	67%	57%
Lithuania	83%	89%	83%	57%
Luxembourg	83%	56%	83%	50%
Latvia	92%	89%	83%	64%
Malta	0%	33%	50%	7%
Netherlands	75%	67%	83%	50%
Poland	67%	89%	50%	50%
Portugal	92%	89%	83%	50%
Romania	75%	78%	33%	57%
Sweden	92%	100%	67%	64%
Slovenia	83%	100%	67%	50%
Slovakia	75%	100%	83%	57%

Appendix 15 COUNTRY FICHES ON FOREST MONITORING AND PLANNING

European Commission

SUPPORT FOR THE IMPACT ASSESSMENT OF THE LEGISLATIVE PROPOSAL FOR A MONITORING FRAMEWORK FOR RESILIENT EUROPEAN FORESTS

Country fiches on forest monitoring and planning

Written by Ramboll, European Forest Institute,
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November – 2023

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SUPPORT FOR THE IMPACT ASSESSMENT OF THE LEGISLATIVE PROPOSAL FOR A MONITORING FRAMEWORK FOR RESILIENT EUROPEAN FORESTS

Country fiches on forest monitoring and planning

List of abbreviations

Abbreviation	Definition
CBD	Convention on Biological Diversity
FAO	Food and Agriculture Organization
FRA	Forest Resource Assessment
ICP-Forests	International Cooperative Programme on Assessment and Monitoring of Air Pollution Effects on Forests
LULUCF	Land Use, Land-Use Change and Forestry
MCPFE	Ministerial Conference on the Protection of Forests in Europe
NFI	National Forest inventory
OECD	Organization for Economic Co-operation and Development

Note on data collection

The Member States fiches on forest monitoring and on planning tools are based on a combination of data collected through desk research and consultation with Member States representatives. In particular, once compiled by the desk research, the fiches were sent to various Member State representatives involved in either forest monitoring or planning at the national level to validate or complete the information. The data presented here reflect the best available information.

1. AUSTRIA

1.1. Country overview: major forest facts

1.1.1. Key forest data

Austria is a country rich in forests, with almost 48% of its area covered by forests. Against this background, forests play a fundamental role for rural development, for the forest-based sector, and cross-sectoral cooperations such as tourism. Forests are fundamental elements for Austrian cultural landscapes and provide – beyond timber – a variety of welfare functions, most notably protection and water provision functions. Although small, Austria covers a range of different forest types, from the Alps to the summer-warm forests in the Eastern part. The catalogue of biotope types contains 93 different forest biotope types. Spruce is the dominating tree species (>50%), but more and more reduced to mixed forests in the wake of climate change adaptation. In total, around 70 tree species have been identified in Austria. 21.5% of Austrian forests fall under some protection regulations, which is more than 800.000 ha. 20.5% are protection forests, for soil, water and other ecosystem services. Around 470.000 ha are covered by the Natura 2000 network. Nearly 120 thousand ha of forest and other wooded land are considered “undisturbed by man”.

1.1.2. Institutional setup and legal framework

The Austrian forest law is built on the principles of sustainable forest management, stressing the importance of balancing economic, ecological and social functions.

There are different national strategies with direct context in Austria, most notable the bioeconomy strategy, the biodiversity strategy and the climate strategy.

A major strategic instrument for balancing these objectives is the Austrian Forest Dialogue (launched in 2003), which is a platform of exchange for all forest-related and interested stakeholders, leading to regular Austrian Forest Reports, which both contain a revisit of the past period and a strategic outlook for things to come.

Its tangible outcomes were the Austrian Forest Programme 2005 (defining strategic fields of activity and 70 indicators for measuring against targets), and in the Austrian Forest Strategy 2020.

Austrian forests are monitored by the National Forest Inventory, which has recently been changed from periodic to a continuous system, i.e. every year a certain portion of forests fixed plots are measured. In addition, annual surveys of removals and various special surveys on forest health, biological diversity, protective effects of forests, the production and the market of timber products are conducted and other socio-economic data are collected.

An important instrument to support the integrated long-term planning is the Austrian forest fund (*Waldfond*) launched in 2020, provides thematic and financial support with regards to current key issues for Austrian forestry and the value-chain.

A central strategic activity alongside the funds is the Austrian Wood Initiative, which aims at giving impulse to the use of wood in a circular bioeconomy and contributing to a shift in resource and energy use.

1.1.3. Key actors and stakeholder organisations

Federal Ministry of Agriculture, Forestry, regions and Water Management.

1.1.4. Forest ownership

Austrian forests are managed by around 145.000 forest owners, of which 85% are private owners, and 50% small-scale owners (<200 ha).

1.1.5. Forest industry

Austria’s forests contain around 1.2 billion cubic metres of wood. Currently, around 89% of the increment per year are harvested (many of which are salvage loggings due to calamities). The largest portion (75%) is used for material use in sawmills and forest-based industries, 25% are used for energetic purposes (firewood and bioenergy). The forest-based sector is comparatively large in Austria, provides 300.000 jobs, generates 5.7% of the GDP along the value chain, and among the largest producers and exporters of sawn timber worldwide.

1.1.6. Key forestry issues

Climate change adaptation & resolution of interest conflicts.

1.2. Forest monitoring

1.2.1. National Forest Inventory

The first evaluation of Austrian forest resources, after the World War II, was conducted during 1952–1956. It covered the entire area of Austria and was based on aerial photographs and terrestrial assessments (Braun, 1960). From the experiences in this forest survey, the first sample-based National Forest Inventory (NFI) was conducted during the years 1961–1970. The field assessments were based on a temporary systematic sampling grid.

The second NFI (1971–1980) was designed as a temporary inventory. The importance of monitoring changes in the forest resulted in the establishment of a permanent sampling grid, with the third NFI (1981–1985). All subsequent NFIs were based on this permanent sampling grid.

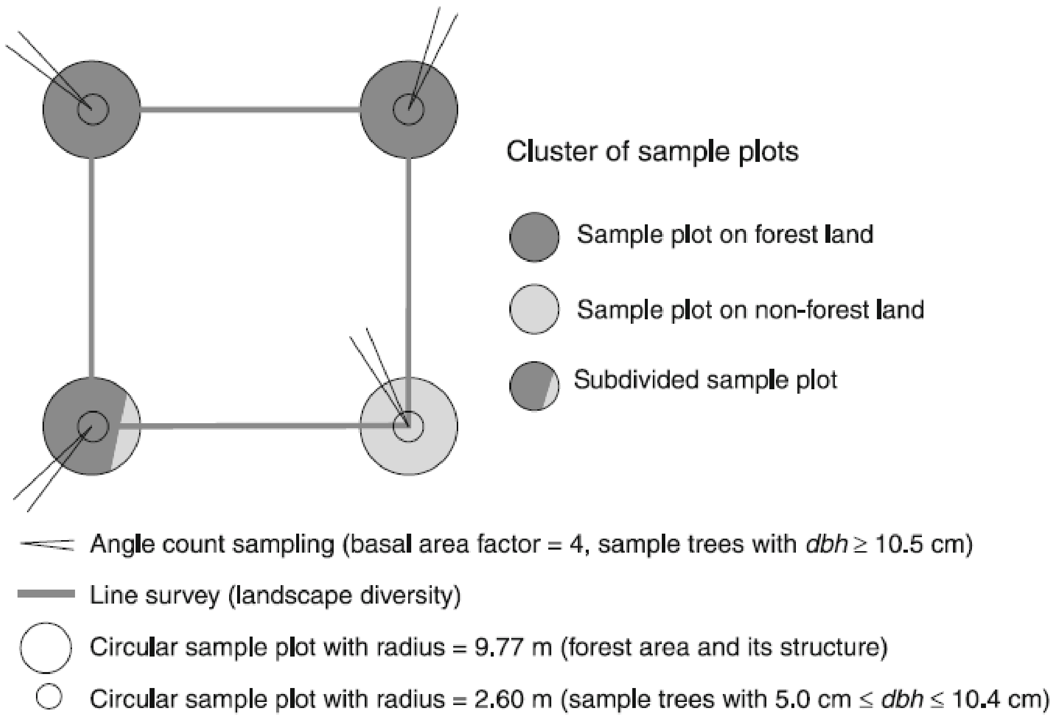
The first re-measurement of the permanent plots was done in the fourth NFI (1986–1990) which also included assessments on an additional temporary grid. In the fifth NFI (1992-1996) the continuous assessment changed to a discontinuous scheme, and several new and mainly ecological variables were integrated in the inventory (Schieler and Schadauer, 1991). The assessment of these new variables was continued and extended in the sixth NFI from 2000–2002 which was accompanied by a reduction of the field assessment period to 3 years. The seventh NFI (2007–2009) introduced further assessments including the topics of sustainability, biomass availability, biodiversity, protective function of forests, and provided data to fulfil the reporting obligations of the Kyoto Protocol. The harmonization efforts at the European level (Tomppo et al., 2010) led to the implementation of field assessments according to commonly agreed definitions in COST Action E43 (2010).

In parallel with the national definitions, the forest and Other Wooded Land definitions of the Food and Agriculture Organization of the United Nations (FAO, 2004) were also applied in the field assessments and trees below the national dbh-threshold of 5.0 cm were recorded as stem counts in two diameter classes. From 2011 to 2013 a special survey to satisfy carbon reporting requirements (under Article 3.3 of the Kyoto Protocol) was implemented, and included a remote sensing as well as a field assessment component. The most recent Austrian NFI (8th) plot data are recorded in 2016–2021.

The field measurement period lasted for 3 years. The sampling grid is systematically divided into three parts so that each year one third of the grid (covering the whole country) is inventoried.

The time span between the measurements of the two latest inventories is seven years. The Austrian NFI uses a sampling grid which has a size of 3.889 x 3.889 km. Clusters of four sample plots are located on the intersections of the grid. The clusters are square-shaped and have a side length of 200 m. The sample plots are located at the corners of the clusters. The shape and size of the grid and clusters are uniform all over Austria. In total, there are approximately 22,300 sample plots, of which about 11,000 are located on forest land. The sample plots consist of a large circular plot of 300 m2 (9.77 m as radius), a small circular plot of 21.2 m2 and an angle count plot.

Figure 1 Cluster with sample plots (according to Gabler and Schadauer 2008)



Austrian NFI implements remote-sensing technologies in data elaboration. In fact, the data gained from Aerial and Satellite Imagery is evaluated together with data collected in-situ during fieldwork. 3D point clouds are operationally created for the whole country, with Image Matching techniques, using aerial images. After combination with LIDAR data, digital height models are generated.

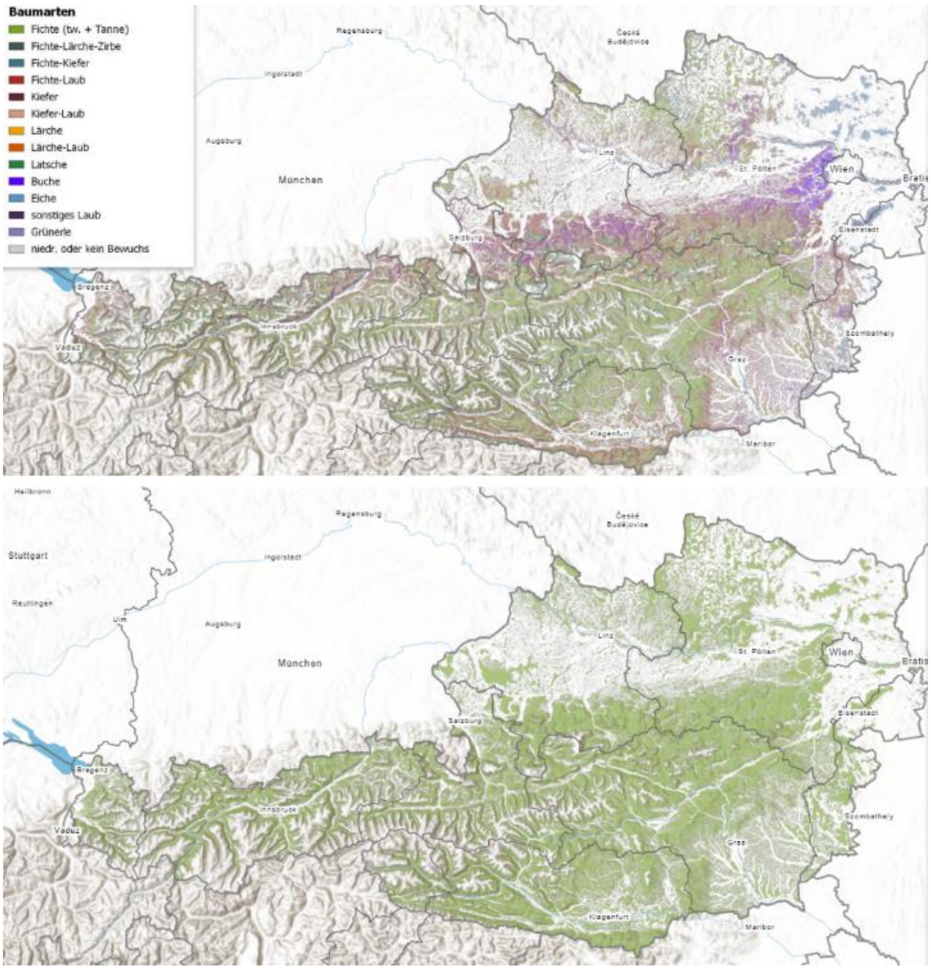
Digital height models are used to assess various forest parameters like forest area, timber volume, biomass, gain and use. Furthermore, satellite images like Sentinal-1 and Sentinel-2 are used to detect forest damage and to enhance information about soil moisture in forests.

High accurate forest maps, a nationwide net of forest roads and forest type maps are produced and updated continuously by using the combination of all available Remote Sensing data.

1.2.2. Forest mapping

Maps on specific forest topics are generated from satellite and aerial photographs, along with other remote sensing methods. Forest map (*Waldkarte*) of the forest inventory and a tree species map (*Baumartenkarte*) are available at https://www.waldinventur.at/#/ENG. The latter was created by aggregating a very detailed map with 30 classes of tree species and species mixtures to a map with 14 classes to increase clarity.

Figure 2 Austrian tree species map and forest mask (https://www.waldinventur.at/#/ENG)



Moreover, external research explored the potential use of remote sensing techniques and Earth Observation to monitor vegetation characteristics in Austria. Hollaus *et al.* (2009) estimated the forest growing stock volume using airborne laser scanning and national forest inventory data in the Austrian state of Vorarlberg. Hasenauer *et al.* (2012) developed for the whole Austria a "space-based" net primary production (NPP) map, determined by the MODIS (moderate resolution imaging spectroradiometer) satellite, comparing it with estimates of "terrestrial" productivity, with forest increment data from 151 research plots. More recently, Low and Koukal (2020) exploited the potential of Sentinel-2 satellites to map Austrian forest disturbances.

1.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Austria.

Table 1 Austria: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	complete	6y	yes	yes		x		
Forest biomass	NFI	National	complete	6y	yes	yes		x		
Forest carbon	NFI	National	complete	6y	yes			x		
Tree age	NFI	National	complete	6y	yes	yes		x		
Canopy height	NFI	National	complete	6y		yes		x		
Forest structural diversity	NFI	National	complete	6y		yes		x		
Forest soil properties	NFI	National	complete	6y		yes		x		
Forest/tree cover change	NFI							x		
Tree age diversity	NFI	National	complete	6y				x		
Tree species/composition	NFI	National	complete	6y		yes		x		
Tree species diversity	NFI	National	complete	6y		yes		x		
Forest type	NFI	National	complete	6y	yes	yes		x		
Deadwood	NFI	National	complete	6y	yes	yes		x		
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns	NFI		complete					x		
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	MA	National	complete			yes				
Silvicultural system	NFI	National	complete	6y		yes		x		
Main management objectives	MA	National	complete	10y		yes				
Forest area covered by a management plan	MA	National	complete			yes				
Volume of wood harvested	MA, NFI	National	complete		yes	-/yes				
Ratio of annual fellings to	NFI	National	complete	6y		yes		x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	**Aggregated**	**Processed**	***Note***
annual increments										
Forest revenue	MA					yes				
Roundwood prices	LKO	National	complete	1m		yes				
Forest products trade	MA	National	complete			yes				
Employment in the forest sector	MA	National	complete			yes				
Forest area with 3rd party certification	PEFC/FSC	National	complete	1y		yes				
Forest visitor statistics										
Forest ground vegetation Biomass	ICP forests	International	partial	5y	yes	no	x			upon request
Deposition	ICP forests	International	partial	continuously	yes	no	x			upon request
Growth and yield	ICP forests	International	partial	5y	yes	no	x			upon request
Foliage	ICP forests	International	partial	1y	yes	yes	x			upon request
Litterfall	ICP forests	International	partial	1y	yes	yes	x			upon request
Single tree diameter growth	ICP forests	International	partial	continuously	yes	no		x		upon request
Leaf Area Index	ICP forests								x	
Stand climate (temperature, relative humidity, soil moisture, soil temperature)	ICP forests	International	partial	continuously	yes	yes			x	upon request
Soil solution	ICP forests	International	partial	continuously	yes	no	x			upon request
Tree health	mixed									
Forest growth	NFI	National	complete	6y		yes		x		
Occurrence of forest fires	BOKU									
Occurrence of storms						no				
Forest disturbance	NFI, DWF	National	complete	annual				x		upon request
Number of forest fires	BOKU									
Number of storms										

1.2.4. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in Austria.

Table 2 Austria: SWOT analysis

Strengths	Weaknesses
Austria has a well-established NFI that is able to report robust statistics for a large number of forest variables.	NFI produces a forest category map only.
Opportunities	**Threats**
The frequent updating of the Austrian inventory allows for continuous improvement of methodologies, including the use of remotely sensed data	No wall-to-wall estimates (maps) of forest variables (growing stock volume, biomass, etc.) have been produced so far.

1.3. Main planning tools at national or, where appropriate, regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 3 Austria: Overview of planning and reporting instruments

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	BML Forest Report, 2015	Sustainable forestry as central element
	Forest Inventory	Current data on forests (ANFI 2016-21)
Biodiversity	BML Forest Report, 2015	Sustainable forest management and protected areas as means to ensure a rich biodiversity
	Forest Strategy	Several measures: Waldstrategie 2020+ (bfw.ac.at)
	Forest Programme, 2007	A variety of measures to protect biodiversity & reference to EU Biodiversity Strategy
	Forest Inventory - Report	Provision of information on forest reserves, description of ecosystems and their growth regions, functions of deadwood
Bioeconomy	Forest Strategy	Several measures: Waldstrategie 2020+ (bfw.ac.at)
	National Bioeconomy Strategy	Optimised tree species
	Forest Europe Report 2020	Image campaign: Promoting social acceptance for the economic use of the Austrian forest Broad-based

Thematic area	Main Strategic reference	Summary of planning elements
		campaign aimed at the general public and showing the importance of wood use and forest management for all the effects of the forest in a simple and understandable way. http://www.proholz.at/holzistgenial/
Ecosystem services	BML Forest Report, 2015	Acknowledgement of lack of adequate financing of ecosystem functions; Indicators and monitoring; protection of forests and enhancement of their ecosystem functions as Austria`s international obligation
	Austrian Forest Inventory	Austrian Forest Inventory (AFI): The objective of the AFI is to provide information on the resources of the raw material wood and on the state and change of the forest ecosystem. http://bfw.ac.at/rz/wi.home
	Austrian Forest Strategy	The Austrian Forest Strategy defines 7 fields of action. The objectives are addressed by a variety of measures, partly by institutional, financial, legal or informational means. All measures are laid out in the Working Programme of the Forest Strategy.
Climate change	Austrian Forest Strategy	Several measures: https://bfw.ac.at/ws/strat2020public.main?seite=1
	BML Forest Report, 2015	Several measures & reference to United Nations Framework Convention on Climate Change
	National Forestry Accounting Plan for Austria	Several references throughout the plan on (1) projects related to climate change and (2) climate data in accounting
	Integrated National Energy and Climate Plan for Austria 2021-2030	Goal for 2030: A corresponding quantitative GHG sector contribution will be enshrined in the Climate Protection Act

1.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 4 Austria: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Measures for climate change adaptation are very high on the agenda, incl. considerations on tree species choice, non-native tree species, adaptive genotypes, and new forest management schemes
Ecosystem services	A wide range of forest ecosystem services which are still not market-based.
Interest conflicts	An increasingly urbanised society has shifting demands on forests that can differ quite strongly from the views of forest owners and hunters. The pandemic showed an increase of recreation activities in Austria. New methods for balancing and mediation of conflicts but also for informing the society on forests are needed. The dialogue between foresters and hunters on minimizing browsing is still ongoing but didn't solve the problems sufficiently yet.
Private forest owners	The recent calamities had big impact on forest owners and on the value of their forests, which is particularly difficult to manage by small-scale owners. There is a risk that forest owners lose motivation, which would lead to larger areas of unmanaged forests.
Biodiversity conservation	Loss of ash due to the ash dieback
Bioeconomy	Increase efficiency in use of wood & acceptance by the public
Forest fires	Like all over Europe, forest fires increase in frequency and scale.
Desertification	Insufficient funding
Population-related challenges	A too high population of ungulates puts additional pressure on forest regeneration, which is harmful for reforested areas and protection of over-aged forests.
Financing	No information
Governance	No information

1.4. References

Braun (1960) Österreichische Waldstandsaufnahme 1952/56 - Gesamtergebnis.Bundesministerium für Land- und Forstwirtschaft und Forstliche Bundesversuchsanstalt Wien

COST Action E43 (2010) Harmonisation of National Forest Inventories in Europe: Techniques for Common Reporting. www.metla.fi/eu/cost/e43/; Accessed 15 Dec 2014

FAO (2004) Global Forest Resources Assessment Update 2005: Terms and definitions (final version). Forest Resources Assessment Programme Working Paper 83/E, FAO Forestry Department, Rome

Gabler K, Schadauer K (2008) Methods of the Austrian Forest Inventory 2000/02 – Origins, approaches, design, sampling, data models, evaluation and calculation of standard error. BFWBerichte 142, 121 p

Hasenauer, H., Petritsch, R., Zhao, M., Boisvenue, C., & Running, S. W. (2012). Reconciling satellite with ground data to estimate forest productivity at national scales. *Forest ecology and management*, *276*, 196-208. https://doi.org/10.1016/j.foreco.2012.03.022

Hollaus, M., Dorigo, W., Wagner, W., Schadauer, K., Höfle, B., & Maier, B. (2009). Operational wide-area stem volume estimation based on airborne laser scanning and national forest inventory data. *International Journal of Remote Sensing*, *30*(19), 5159-5175. https://doi.org/10.1080/01431160903022894

Löw, M., & Koukal, T. (2020). Phenology Modelling and Forest Disturbance Mapping with Sentinel-2 Time Series in Austria. Remote Sens. 12, 4191. https://doi.org/10.3390/rs12244191

Schieler K, Schadauer K (1991) ÖFI—Ein Großprojekt wird neu überdacht. Österreichische Forstzeitung 10:59

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2010). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

2. BELGIUM

2.1. Country overview: major forest facts

2.1.1. Key forest data

Belgium is a country in western Europe with nearly 23% forest cover. The main types of forests are mixed deciduous, scots pine plantations and poplar plantations. 47% of forests inn Flanders are under a management plan. Forest management plans are compulsory in Brussels, but only partially in Flanders and Wallonia. 47% of forests in Belgium are certified under third party certification schemes. Forest area has been stable for many years within the margins of statistical reliability, while growing stock and above ground biomass have been increasing. Growing stock/ha was expected to reach 262 m3/ha in 2020. 7.7% of Belgian forests are designated for conservation of biodiversity. Nearly a quarter of forests in Belgium are designated as having protection functions. There are no forests undisturbed by man.

2.1.2. Institutional setup and legal framework

The regional (sub-national) governments (Brussels, Flanders, Wallonia) have full authority and competence with respect to forests and nature policy, so policies and institutions vary within the country. Regional forest inventories take place regularly, based on continuing data collection. A new long-term vision for the forest of Flanders, based on a process with stakeholder participation, was completed in 2017 and published in 2018. Similar processes are under way in Brussels and Wallonia. 47% of forests inn Flanders are under a management plan. Forest management plans are compulsory in Brussels, but only partially in Flanders and Wallonia.

2.1.3. Key actors and stakeholder organisations

Belgian Nature and Forest Agency (Flanders); Operational Directorate-General for Agriculture, Natural Resources and Environment (Wallonia); Forest Owners Associations, e.g. Flemish Forest Group; Research Institute for Nature and Forest; Key NGO e.g. Natuurpunt vzw.

2.1.4. Forest ownership

65% of forests are privately owned forests with small properties (not larger than 1ha on average).

2.1.5. Forest industry

Total wood removals since 2010 have fluctuated around 4 Mio m3 over bark, well below reported net annual increment of 4.6 Mio m3 o.b. However, data before and after 2010 not strictly comparable due to methodology changes in Flanders. About 31 thousand people are employed in the forest sector, mostly in wood processing and pulp and paper industries. This total fell by nearly 20% between 2010 and 2015.

2.1.6. Key forestry issues

No NFS, high forest fragmentation.

2.2. Forest monitoring

2.2.1. Regional Forest Inventory of Wallonia (RFI)

The permanent regional forest inventory of Wallonia (http://iprfw.spw.wallonie.be/) started its first cycle in February 1994 and ended in 2008. The second was launched as soon as the first was completed and is currently still ongoing (expected conclusion 2028). The ongoing inventory (RFI2) is a single-phase, non-stratified inventory using a systematic sampling design based on concentric circular plots located at the intersections of a 1000 (east-west) x 500 m (north-south) grid. This grid is covering the entire region with 33,000 sample plots of which 11,000 are in the forest. Each year 10% of all plots are assessed. They are scattered throughout the region but always selected on a systematic basis, on a grid 10 times larger than the previous one. Data is collected only in productive forest land. According to the current sampling design, half of the plots visited annually are re-measured after 5 years to assess increments; the remaining plots are re-measured after 15 years.

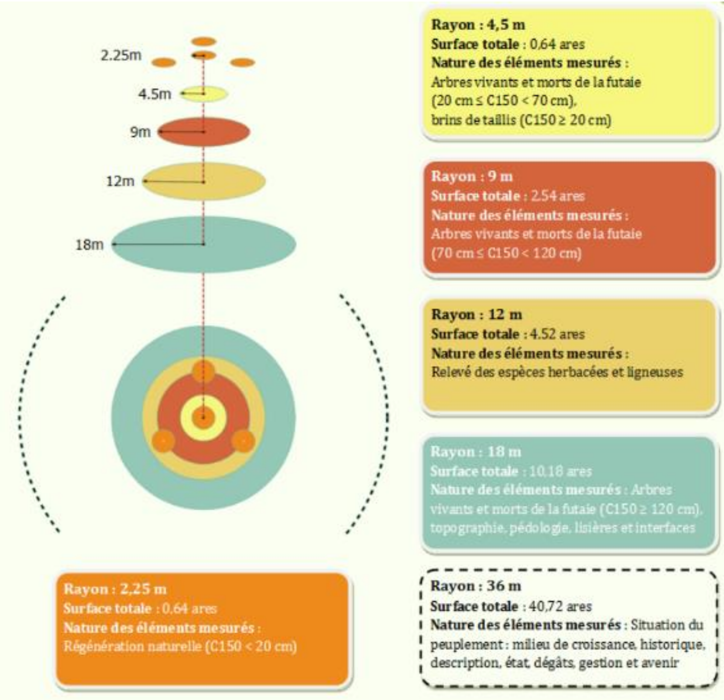
Remote sensing techniques are currently only used as a complementary source of information before visiting the sample point, i.e., to determine land use.

The minimum area (0.1 ha) used in Walloon's forest definition is smaller than that established by FAO (2004).

The information collected by the regional forest inventory of Wallonia are used in international statistical reports as FRA, ICP Forests, MCPFE and OECD in the frame of the Convention on Biological Diversity. It is also used to produce information on forest health, biodiversity and carbon pools for the LULUCF reports.

Along with information on forest evolution, the RFI has been used for game damage assessment (Lecomte *et al.*, 1992), soil fertility assessment, Kyoto reporting at the national level, biodiversity quality assessment and Natura2000 site classification (Rondeaux, 2010).

Figure 3 General structure of an RFI sampling unit, source http://iprfw.spw.wallonie.be



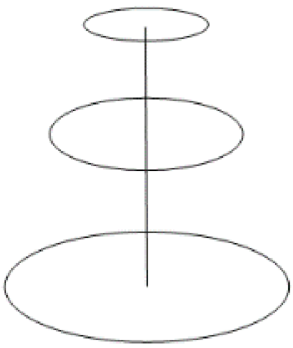
2.2.2. Regional Forest Inventory of Flanders (VBI)

The first Flemish regional forest inventory took place in the period 1997-1999, when a network of sampling plot – located on a rectangular grid of 1 x 0.5 km – was measured through fieldwork. In 2009, the Agency for Nature and Forests started the second inventory campaign, re-measuring 10% of the plot every year. The third inventory campaign was launched in 2019 and it is still ongoing. Currently, 26,730 sampling points are located over Flanders.

Aerial photos (orthophotos) are used to check whether points are in forests or not. Every forest sampling point is visited twice, during summer for the vegetation inventory, and during winter for tree mensuration.

Both the sampling design and the number of variables measured in the second and third VBI has changed compared to the first VBI. The most recent VBI includes information on habitat types, while the socio-recreational use of forest is not evaluated.

Figure 4 General structure of an VBI sampling unit, source https://www.natuurenbos.be/beleid-wetgeving/natuurbeheer/bosinventaris/hoe-gebeuren-de-metingen



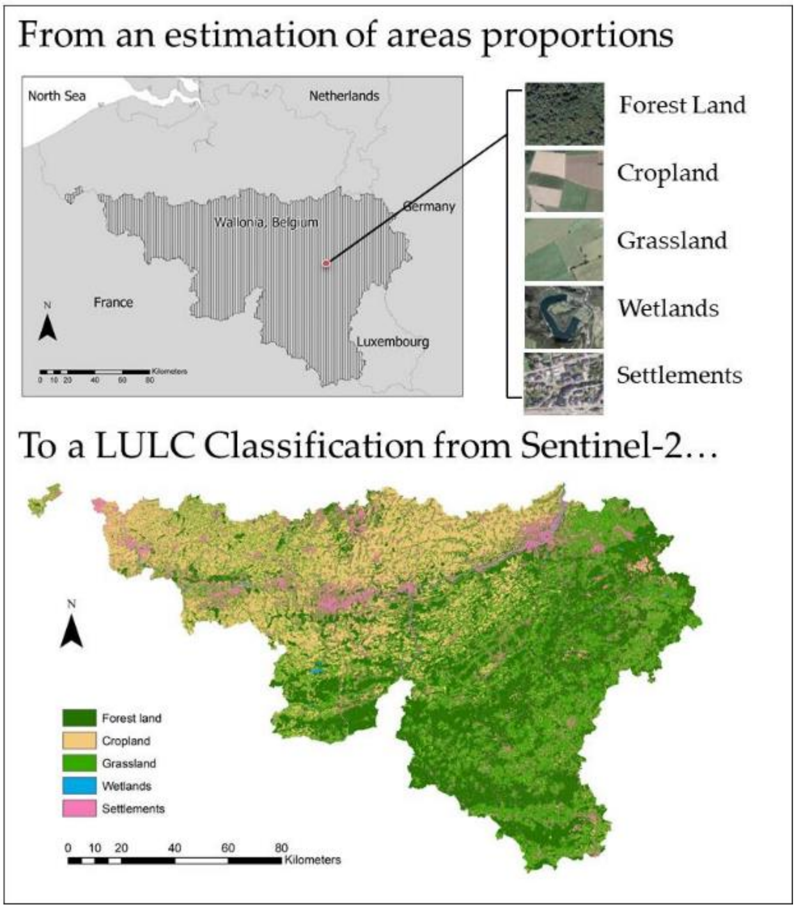
A2	- R_2 = 4,5 m - bomen met omtrek < 22cm en totale hoogte ≥ 2m
A3	- R_3 = 9 m - bomen met 22 cm ≤ omtrek < 122 cm - hakhoutspillen met 22 cm ≤ omtrek < 122 cm
A4	- R_4 = 18 m
	- bomen met omtrek ≥ 122 cm
	- hakhoutspillen met omtrek ≥ 122 cm

2.2.3. Forest mapping

Currently, regional forest inventories carried out in Belgium (both Flanders and Wallonia) do not contribute directly to the creation of a national forest mapping system. On the other hand, research activities explored the potential use of remote sensing techniques and Earth Observation to monitor vegetation characteristics in Belgium.

For instance, the angular hyperspectral CHRIS (Compact High Resolution Imaging Spectrometer) imagery was tested for mapping Natura 2000 heathland site located in the northern part of the nation (Chan et al., 2012). Furthermore, in a study from Close et al. (2018), Sentinel-2 imagery from 2016 was used for mapping greenhouse gas emission and removals associated with the LULUCF sector in Wallonia region. In this study, LUCAS (Land Use/Cover Area frame statistical Survey) of 2015 was used as training data to validate the map produced.

Figure 5 LULUCF 2016 Classification in Wallonia region, Belgium, with Sentinel-2 bands (Close et al., 2018)



Sentinel-2 imagery was also used to create a forest map at the regional scale, to discriminate the main forest classes in the Belgian Ardenne ecoregion (Bolyn et al., 2018). Here, the study also incorporates LiDAR data acquired during the survey flights realized by the Public Service of Wallonia from December 2012 - April 2013 and December 2013 - March 2014 (1 m ground sampling distance).

Along with the potential use of remote sensing in forestry, Earth Observation was also implemented in agriculture, where Sentinel-1 radar and Sentinel-2 optical imagery were used to create a crop map for Belgium (Van Tricht et al., 2018).

2.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Belgium.

Table 5 Belgium: Overview of criteria and indicators monitored. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	RFI/VBI	Regional	Complete	5-15y (RFI)/10 y (VBI)	reported to FRA (1a-1b and 1f) et FOREST EUROPE (1.1)	Yes				yes - upon request
Forest biomass	RFI/VBI	Regional	Complete	5-15y (RFI)/10 y (VBI)	reported to FRA (2c) and LULUCF	Yes				yes - upon request
Forest carbon	RFI/VBI	Regional	Complete	5-15y	reported to FRA (2d), FOREST EUROPE (1.4) and LULUCF	Yes				yes - upon request
Tree age	RFI/VBI	Regional	Complete	5-15y (RFI)/10 y (VBI)	reported to FOREST EUROPE (1.3)	Yes				yes - upon request
Canopy height	RFI/VBI	Regional	Complete	5-15y (RFI)/10 y (VBI)		Yes				yes - upon request
Forest structural diversity	RFI/VBI	Regional	Complete	5-15y (RFI)/10 y (VBI)		Yes				yes - upon request
Forest soil properties	RFI	Regional	complete for physical characteristics and partial for chemical soil properties	5-15y	not reported to FOREST EUROPE (2.2)	Yes				yes - upon request
Forest/tree cover change	RFI	Regional	complete	5-15y	reported to FRA (1.c et 1.d) et FOREST EUROPE (4.2a and 4.2b)	Yes				yes - upon request
Tree age diversity	RFI	Regional	complete	5-15y		Yes				yes - upon request
Tree species/composition	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FRA (2.b) et FOREST EUROPE (4.1)	Yes				yes - upon request
Tree species diversity	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FRA (2.b) et FOREST EUROPE (4.1)	Yes				yes - upon request
Forest type	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FRA (2.a) et FOREST	Yes				yes - upon request

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
					EUROPE (1.1)					
Deadwood	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FRA (2.a) et FOREST EUROPE (4.5)	Yes				yes - upon request
Presence of Red-list species	DEMNA	Regional			FOREST EUROPE (4.8)					
Abundance of common forest birds	DEMNA	Regional			FOREST EUROPE (4.10)					
Forest spatial patterns	FANF				FOREST EUROPE (4.7)					
Areas of primary and old-growth forests	RFI/DEMNA	Regional	complete	5-15y (RFI)	reported to FRA (1.b) et FOREST EUROPE (4.3)	Yes				yes - upon request
Forest ancientness	DEMNA	Regional								
Forest area under protection	DNF/DEMNA	Regional			reported to FRA (3.b) et FOREST EUROPE (4.3 and 5.1)					
Silvicultural system	RFI	Regional	complete	5-15y (RFI)	reported to FRA (1.b) et FOREST EUROPE (4.3)	Yes				yes - upon request
Main management objectives	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FRA (3.a)	Yes				yes - upon request
Forest area covered by a management plan	DNF	Regional	complete [public and private parties]	annual	reported to FRA (3.b)	Yes				yes - upon request
Volume of wood harvested	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FOREST EUROPE (3.1)	Yes				yes - upon request
Ratio of annual fellings to annual increments	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FOREST EUROPE (3.1)	Yes				yes - upon request
Forest revenue	FANF				FOREST EUROPE(6.3/ 6.4 from a to c)					
Roundwood prices	FANF				FOREST EUROPE(3.2)					
Forest products trade	FANF				FOREST EUROPE(6.7/ 6.8/6.9)					
Employment in the forest sector	FANF				FRA (7a and 7b) - FOREST EUROPE(6.5 to 6.6)					
Forest area with 3rd party certification	FANF				reported to FRA (3.b)					
Forest visitor statistics	FANF				FOREST EUROPE(6.10 from a to d)					

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest foliage/phenology/anomalies	FANF				FOREST EUROPE(2.3)					
Tree health	RFI	Regional	complete	5-15y	FOREST EUROPE(2.4)	Yes				yes - upon request
Forest growth	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	reported to FOREST EUROPE (3.1)	Yes				yes - upon request
Occurrence of forest fires	RFI	Regional	complete	5-15y	FOREST EUROPE(2.4)	Yes				yes - upon request
Occurrence of storms	RFI	Regional	complete	5-15y	FOREST EUROPE(2.4)	Yes				yes - upon request
Forest disturbance	RFI	Regional	complete	5-15y	Reported to FRA (5a and 5b) - FOREST EUROPE(2.4)	Yes				yes - upon request
Number of forest fires	FANF				FOREST EUROPE(2.4)					
Number of storms	FANF				FOREST EUROPE(2.4)					
Microhabitats	RFI	Regional		5-15y						yes - upon request
Infrastructures	RFI	Regional		5-15y						yes - upon request
Seedlings	RFI	Regional		5-15y	FOREST EUROPE(4.2b)					yes - upon request
Stand quality	RFI	Regional		5-15y						yes - upon request
Functional diversity	VBI	Regional		10y						yes - upon request
Naturalness	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	FOREST EUROPE(4.3a et 4.3b)	Yes				yes - upon request
Native species	RFI/VBI	Regional	complete	5-15y (RFI)/10 y (VBI)	FOREST EUROPE(4.4a, 4.4b et 4.4c)	Yes				yes - upon request
Herb and shrub layers	DEMNA/VBI/RFI	Regional		10y						yes - upon request

2.2.5. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in the country.

Table 6 Belgium: SWOT analysis

Strengths	**Weaknesses**
Wallonia and Flanders's regional forest inventories provide continuous forest measurements in both regions	Wall-to-wall maps of forest variables do not exist.
Opportunities	**Threats**
Integration between regional forest inventories could be auspicable.	Due to regional differences, a common National Forest Map does not exist yet.

2.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 7 Belgium: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	SoEF, 2020	Country file
	National Forestry Accounting Plan	Summary of forest-related data
	Forest inventory of Wallonia	Current data on forests
	Forest inventory of Flanders	Current data on forests
Biodiversity	National Strategy for Nature Conservation and Biodiversity	In situ conservation, SFM as major instrument, forest certification
	National Forestry Accounting Plan	Reference to Wallonian Forest Code, the Forest Decree in Flanders and the Sonian forest in the Brussels region with measures directly or indirectly related to biodiversity preservation
Bioeconomy	Bioeconomy Factsheet - Belgium	Summary of bieocnomy-related policies and actions

Thematic area	Main Strategic reference	Summary of planning elements
Ecosystem services	Bioeconomy Factsheet - Belgium	Summary of bieocnomy-related policies and actions
Climate change	National Climate Adaptation Strategy	Description of climate change impacts; description of measures taken by the regions
	National Forestry Accounting Plan	Reference to measures included in the Wallonian Forest Code and the Forest Decree in Flanders as well as to the modelling approach
	National Energy and Climate Plan 2021-2030	Among others, afforestation is seen as an important instrument with regard to carbon storage

2.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 8 Belgium: Forest-related challenges that influence integrated long-term plans

Major challenge	Summary description
Climate change	Forests in Belgium are usually fragmented, at landscape level and in ownership structure. That has a negative effect on resilience. Make forests thus more resilient at the landscape level; Work to do on emergency plans for heavy damages in forests in case of storms; Revisit the policy guidance on use of exotic tree species which are non-invasive; Strengthen quick reaction to crisis such as bark beetle and other pests
Ecosystem services	Making the ecosystem services more visible and accountable. Financial flows do not follow in the overall economic and accounting systems with which governments work.
Interest conflicts	Progress should be made by strengthening the dialogue between the society and forest professional while respecting the various ethical models in place. Beside economics and scientific criteria, ethical and symbolical ones should also be taken into account in the decision-making process
Private forest owners	Structural low financial profitability of forestry in Flanders is a major challenge. Possibilities for forest owners to influence to pricing of the timber in a global market are limited.
Biodiversity conservation	Limiting deforestation of most valuable and ‘old’ forest on sites with long-term historic documented forest use; Pressure on forest biodiversity is still high, due to fragmentation of forests and general environmental condition; Upscaling efforts on planned increase of N2000 forest habitats in and outside N2000-protected sites (afforestation; reconversion of not-N2000 forest habitat types into N2000 forest habitat types); Reach to control the excess of big game (deer and wild boar)
Bioeconomy	Be even more innovative in timber auctioning; Increase local capacity for processing the timber and increase value chains; Practical solutions for implementing the cascading principle for use of timber; Upscaling actions in promoting use of timber with long life cycles (in construction; promoting re-use of timber); Increase domestic use and local transformation of wood; Stimulating short chain economy.

Forest fires	No information
Desertification	Questions from private forest owners are not (yet) recognised in relation to access to disaster funds for compensation of damage in forest regeneration in case of extreme drought (see existing systems for agricultural crops).
Population-related challenges	Social representations of forest by urbanized society which are increasingly endorsing trends towards sacralising/untouched forest, should become a priority and should be addressed in an appropriate way; Upscaling efforts on the use and integration of forests and green and blue areas for climate buffering in urbanised areas
Financing	Turn the balance of the compensation scheme for deforestation positively and to catch up on the targets for afforestation; Make more and better use of possibilities within the EU rural development schemes.
Governance	No single reference document that oversees all aspects of policy related to forests. No explicit one single 'forest programme' document.

2.4. References

Forest inventory of Wallonia: http://iprfw.spw.wallonie.be/summary.php

Forest inventory of Flanders: https://www.natuurenbos.be/beleid-wetgeving/natuurbeheer/bosinventaris

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_BEL_5-4-2019 (foresteurope.org)

National Biodiversity Strategy 2020: https://www.health.belgium.be/sites/default/files/uploads/fields/fpshealth_theme_file/19104339/Strat%C3%A9gie%20nationale%20biodiversit%C3%A9%202013_EN.pdf

Bioeconomy Factsheet - Belgium: https://www.nnfcc.co.uk/files/mydocs/Bioeconomy%20Factsheet%20Belgium.pdf

National Climate Adaptation Strategy: https://www.cnc-nkc.be/sites/default/files/report/file/be_nas_2010_1.pdf

National Forestry Accounting Plan: https://www.cnc-nkc.be/sites/default/files/report/file/national_forest_accounting_plan_-_belgium.pdf

Rondeux, J., et al., (2010,) 2.1 : Development of the Regional Forest Inventory in Wallonia, National Forest Inventories online available under: https://www.researchgate.net/profile/Nicolas-Latte/publication/310826083_National_Forest_Inventories_Assessment_of_Wood_Availability_and_Use_-_Chapter_8_-_Belgium_Wallonia/links/5a3a2744458515889d2bd8a0/National-Forest-Inventories-Assessment-of-Wood-Availability-and-Use-Chapter-8-Belgium-Wallonia.pdf

CAP Strategic Plans: https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans/approved-csp-0_en?f%5B0%5D=document_country_document_country%3Ahttp%3A//publications.europa.eu/resource/authority/country/BEL

National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-09/be_final_necp_parta_en_0.pdf

Bolyn, C., Michez, A., Gaucher, P., Lejeune, P., & Bonnet, S. (2018). Forest mapping and species composition using supervised per pixel classification of Sentinel-2 imagery. Biotechnologie, Agronomie, Société et Environnement, 22(3). https://dx.doi.org/10.25518/1780-4507.16524

Chan, J. C. W., Beckers, P., Spanhove, T., & Borre, J. V. (2012). An evaluation of ensemble classifiers for mapping Natura 2000 heathland in Belgium using spaceborne angular hyperspectral (CHRIS/Proba) imagery. International Journal of Applied Earth Observation and Geoinformation, 18, 13-22. https://doi.org/10.1016/j.jag.2012.01.002

Close, O., Benjamin, B., Petit, S., Fripiat, X., & Hallot, E. (2018). Use of Sentinel-2 and LUCAS database for the inventory of land use, land use change, and forestry in Wallonia, Belgium. Land, 7(4), 154. https://doi.org/10.3390/land7040154

FAO (2004) Global Forest Resources Assessment Update 2005: Terms and definitions (final version). Forest Resources Assessment Programme Working Paper 83/E, FAO Forestry Department, Rome

Lecomte H, Hebert J, Rondeux J (1992) Estimation des de´gaˆts de chablis a`partir d'un inventaireforestier permanent. Estimation of wind damage from a permanent forest inventory. Annalesde Gembloux 98:49–62 (in French)

Rondeux J, Sanchez C, Latte N (2010) Belgium (Walloon Region). In: Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) National Forest inventories—pathways for common reporting. Springer, Heidelberg, pp 73–86

Van Tricht, K., Gobin, A., Gilliams, S., & Piccard, I. (2018). Synergistic use of radar Sentinel-1 and optical Sentinel-2 imagery for crop mapping: A case study for Belgium. Remote Sensing, 10(10), 1642. https://doi.org/10.3390/rs10101642

3. BULGARIA

3.1. Country overview – major forest facts

3.1.1. Key forest data

Forests cover 35.9% of the land area of Bulgaria and the trend is positive since 2000. Bulgaria is in a transition zone between continental and Mediterranean climate, around 75% are broadleaved trees, in the mountain region coniferous trees can be found, mostly fir, pine and spruce. The forest area has been growing steadily and increased by about 60% since 1990. All forests in Bulgaria are subject to a management plan. Nearly 34% of forests are certified under third party certification schemes, essentially FSC. Over 18% of forest and other wooded land is protected for conservation of biodiversity, nearly 11% is designated “protection forest”. The area of forest reported as “undisturbed by man” was 704 thousand ha in 2015.

3.1.2. Institutional setup and legal framework

Responsible for forestry issues in Bulgaria is the Ministry of Agriculture (former Ministry of Agriculture, Food and Forestry. Implementation is done by the Executive Forest Agency (EFA) and Regional Forest Directorates. State owned forests are managed by 6 State Forest Companies with a central administration each. Municipal forest is managed by municipal forest enterprises spread over the country. Forest management planning is performed by private companies after public tender with the biggest one being state owned. Research is performed by the University of Forestry and the Forest Institute of the Bulgarian Academy of Science. Forest inventories have a 10-year cycle. Within the cycle, data on area and harvest are reported annually and all other data are actualised every fifth year.

3.1.3. Key actors and stakeholder organisations

Ministry of Agriculture, food and forestry; Executive Forest Agency (EFA); Regional Forest Directorates; 6 State Forest Companies; Municipal forest enterprises; University of Forestry; Bulgarian Academy of Science.

3.1.4. Forest ownership

Former socialist country - high percentage of publicly owned forest, private owners through privatization & restitution. Result are small and fragmented properties and low degree of proficiency of forest owners. Around 25% of forests are privately owned, rest in public hand.

3.1.5. Forest industry

Wood removals are reported at 6.2 Mio m3 for 2017 and their quantity depends on a number of factors in the different years. Fellings are 60% of net annual increment. About 54 thousand people are employed in the forest sector of Bulgaria, more than half of these in forestry itself.

3.1.6. Key forestry issues

Insufficient finance and institutional capacities to implement the new policies.

3.2. Forest monitoring

3.2.1. Forest Management Planning

The first State Service on Measuring and Organization of Bulgarian Forests was created in 1901, when the first of three Forest Management Plans (FMP) were established. During the period from 1901 to 1919, 225,000 ha were inventoried and described during the FMP process (Raykov 2006). Prior to 1944 only 28 % of forest areas were monitored using FMP's. After the end of the Second World War, the forest sector and the Forest Management Organization in Bulgaria developed quickly.

From 1950 to 1954, 2,890,000 ha of forests were inventoried and described in FMP's. During this period, FMP's were completed for all forest areas. Forest management plans and programs specified the allowable amount of forest resources to be used, and defined guidelines to achieve the objectives of forest management in a 10-year period. In the period 1955–1980 the original basis of the FMP process was improved and based on forest types. During more recent years, new technologies such as GPS, was introduced into the FMP process. The country completed GIS maps of the forest estate and attribute data can be captured in real time. Combined with the use of precise satellite images and remote analysis, the FMP data provides a comprehensive forest inventory. After 1997, with the restoration of forest property to former owners, private companies began to implement FMP in competitive conditions. According to Bulgarian forest Law (The Forest Act 2011 and 2019) it is necessary to establish the state of resources by undertaking an inventory of the forest areas. In addition, data from FMPs are public as determined by the Forest Act (2011).

3.2.2. National Forest Inventory

Since 2011, it has been mandatory to carry out a National Forest Inventory (NFI) due to the implementation of forest legislation (Forest Act 2011) for the purposes of developing state forest policy and the forestry sector. However, due to lack of financial resources Bulgaria postponed the start of the NFI process. The classification and evaluation of NFI indicators should be consistent with the previous measurements (stand wise inventory) and Forest Management Plans, as well as with other European NFI's. General statistical information concerning forests from the NFI should also be consistent with current forestry statistics in the Republic of Bulgaria. To do this, quantitative and qualitative parameters with an accuracy of estimates between 5 and 10 percent, acquired with FMPs, has been used. Permanent sample plots are used to monitor forests according to a methodology approved by the Executive Forest Agency. The boundaries of separate parts of the forests, assessed by the FMP, are then used for stratification purposes to implement a statistical NFI.

According to FAO FRA2020, data on Bulgarian forests are acquired from the annual report of the National Forest Fund, which is an official report and database of the Executive Forestry Agency for Forest Resources in Bulgaria. It is presented in the form of a database and is not an exact publication.

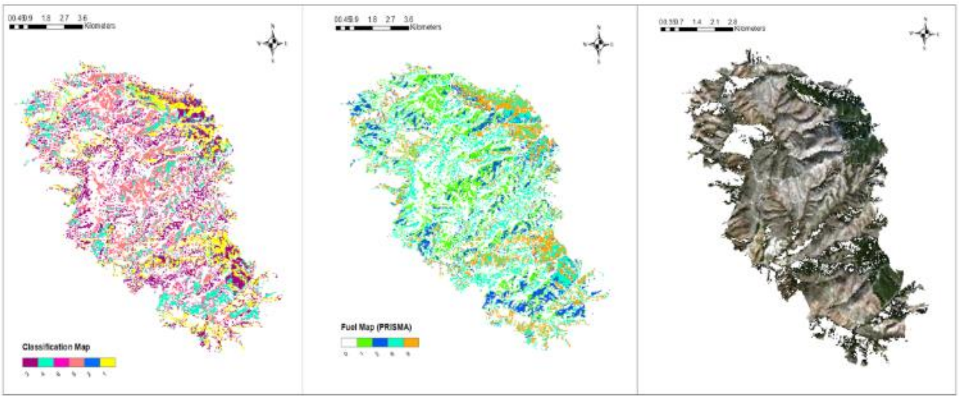
3.2.3. Forest mapping

No official forest mapping has been developed in Bulgaria as part of the national forest inventory.

On the other hand, external research explored the potential use of remote sensing techniques and Earth Observation to monitor national vegetation characteristics. For instance, Stoyanova *et al.* (2018), tested a multispectral camera near the town of Kalofer, Bulgaria, in August 2017. This work showed the good capabilities of UAV for observing and mapping large areas, to monitor and prevent the rapid spread of the bark beetle that results in the complete destruction of some conifers.

While Shaik *et al.* (2022), exploited the new hyperspectral PRISMA satellite for the classification of wildfire fuel mapping in Bulgaria, by reproducing an algorithm developed in Sardinia, Italy.

Figure 6 Classification, fuel and RGB map from PRISMA (Shaik et al., 2022)



3.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Bulgaria.

Table 9 Bulgaria: Overview of criteria and indicators monitored. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	FMP	National	complete	10y	FAO, Forest Europe, Eurostat	yes		x		yes - through EFA
Forest biomass	EFA (data calculated through IPCC methodology used for FRA/FAO)	National	complete	5y	FAO, IPCC				x	yes - through EFA (IPCC methodology used for FRA/FAO)
Forest carbon	EFA (data calculated through IPCC methodology used for FRA/FAO)	National	complete	5y	FAO, IPCC				x	yes - through EFA (IPCC methodology used for FRA)
Tree age	EFA	National	complete	5y	FAO, Forest Europe	yes		x		yes - through EFA

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Canopy height	FMP	National		10y		yes		x		yes - through EFA
Forest structural diversity	FMP	National		10y		yes		x		yes - through EFA
Forest soil properties	EEA									EEA
Forest/tree cover change	EFA	National	complete	5y		yes		x		yes - through EFA
Tree age diversity	EFA	National		5y		yes		x		yes - through EFA
Tree species/composition	EFA	National	complete	5y	Forest Europe	yes		x		yes - through EFA
Tree species diversity	EFA	National	complete	5y		yes		x		yes - through EFA
Forest type	EFA	National	complete	5y	Forest Europe	yes		x		yes - through EFA
Deadwood	EFA	National	partial	10y		yes				yes - through EFA
Presence of Red-list species	Red book of the Republic of BUlgaria	National	complete			yes				
Abundance of common forest birds	MOEW	National								
Forest spatial patterns										
Areas of primary and old-growth forests	EFA	National	complete		FAO, Forest Europe	yes				yes - through EFA
Forest ancientness										
Forest area under protection	EFA, MOEW	National	complete	5y	FAO, Forest Europe	yes		x		yes - through EFA
Silvicultural system										
Main management objectives	FMP	National	complete	10y	FAO, Forest Europe	yes		x		yes - through EFA
Forest area covered by a management plan	FMP	National	complete	10y	FAO, Forest Europe	yes		x		yes - through EFA
Volume of wood harvested	EFA	National	complete	1y	FAO, Forest Europe, Eurostat	yes		x		yes - through EFA
Ratio of annual fellings to annual increments	EFA	National		1y		yes		x		yes - through EFA
Forest revenue	NSI	National		1y						
Roundwood prices	MA	National (only state forest)	partial	1y	Eurostat	yes		x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest products trade	NSI	National		1y	Eurostat			x		
Employment in the forest sector	NSI	National		1y	Eurostat			x		
Forest area with 3rd party certification	FSC	National	complete	1y	FAO, Forest Europe					
Forest visitor statistics										
Forest foliage/phenology/anomalies	EEA	National								
Tree health	EEA	National								
Forest growth										
Occurrence of forest fires	EFA	National		1y	FAO, Forest Europe, EFFIS	yes		x		yes - through EFA
Occurrence of storms	EFA	National		1y		yes		x		yes - through EFA
Forest disturbance	EFA	National		1y	FAO, Forest Europe	yes		x		yes - through EFA
Number of forest fires	EFA	National		1y	FAO, Forest Europe, EFFIS	yes		x		yes - through EFA
Number of storms										
Non wood forest products	EFA	National (only state forests)	partial	1y	FAO, Forest Europe	yes		x		yes - through EFA
Forest erosion	EFA	National	partial	1y				x		
Forest regeneration	EFA	National (afforestation data only state forests)	partial	1y	FAO, Forest Europe	yes		x		yes - through EFA

3.2.5. SWOT analysis

Table 10 Bulgaria: SWOT analysis

Strengths	Weaknesses
The Executive Forestry Agency for Forest Resources in Bulgaria produces a report on the state of forests. Forest monitoring through forest management plans has a long history that began in 1901.	The start of the NFI process has been delayed due to financial deficiencies.
Opportunities	**Threats**
Preliminary inventory decisions may allow the selection of indicators consistent with previous forest measurements and management plans, as well as with other European NFIs.	According to Bulgarian forest Law (The Forest Act 2011) it is necessary to establish the state of resources by undertaking an inventory of the forest areas. In more than a decade this did not happen. There is also a lack of forest geographic layers including an official forest mask.

3.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 11 Bulgaria: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	SoEF, 2020	Current data on forests, reference to the national forest inventory
	National forest inventory	Current data on forests
Biodiversity	National Forest Strategy	More effective governance to preserve biodiversity and acknowledgement of its importance
	Strategic plan for biodiversity 2011-2022	5 key areas ranging from identification of causes for biodiversity loss to implementation of biodiversity goals
Bioeconomy	Strategy for the development of bioeconomy in the Stara Sagora region	Information about the use of forest for purposes of bioeconomy and overall goal to sustainably manage forests
Ecosystem services	National forestry accounting plan for Bulgaria	Bulgarian forestry keeps pace on global ideas and concepts for an ecosystem approach in forestry.
	National Forest Strategy	Reference to Ecosystem Services Act adopted in 2011. Public benefits from forest ecosystem services, also in economic terms. Scientific experience and research beneficial for sustainable and socially acceptable management of ecosystem services; Key areas are identified: air & soil quality, deforestation, damage to forests caused by biotic, abiotic and anthropogenic factors
Climate change	National forestry accounting plan for Bulgaria	Climate change as a parameter for forestry accounting
	National Forest Strategy	Adaptation of forests to climate change
	Integrated energy and climate plan of the Republic of Bulgaria 2021–2030	National target for the Land use, land use change and forestry (LULUCF) sector in accordance with Regulation (EU) 2018/841 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework.

3.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 12 Forest-related challenges that influence integrated long-term plans

Major challenge	Summary description
Climate change	EFA has developed a programme document related to the adaptation the climate changes and limitation of their negative effect. The challenges in the implementation of this document is not only the lack of sufficient financial resources, but also a reliable monitoring system, controlling and standing body/commission/working group is missing. Forthcoming is the adoption of National Strategy and Action Plan for adaptation to climate changes. EFA took part in the discussions and elaboration of the draft documents. A challenge will be the implementation of the strategic and operational goals as a substantial financial resources and political will is needed to that end.
Ecosystem services	In terms of the economic functions of the forests, the goal and the challenge is to shape an economically viable forest sector that will use the potential of the Bulgarian forests with no harm to their environmental functions , e.g satisfying the social and cultural demands of the society - providing employment and source of income together with aesthetic and cultural services.
Interest conflicts	Recognition of the major importance of the forest sector for the social-economic development of the country, as well as for improved conditions in rural regions.
Private forest owners	No information
Biodiversity conservation	Overall challenge for the performance of the foreseen activities is the insufficient amount of finances.
Bioeconomy	The implementation of measures and activities of the National Action plan for energy development from forest wood biomass 2018-2027 will require strong political support and adequate financing, part of which can be assured through EU investment funds. Elaboration of methodologies for assessment of FES and the Regulation for their payment. The development and implementation of such documents could diversify the income of the forestry sector and could assure additional financial resources for the sustainable governance and management of forests.
Forest fires	The establishment of a system for monitoring, early warning and reporting of forest fires will take time and long term commitment.
Desertification	No information
Population-related challenges	No information
Financing	Overall challenge for the implementation of the activities foreseen in the strategic documents is the insufficient amount of finances. This is linked to the existing priorities in the state budget and their respective financing and the underestimation of the forest sector.

Major challenge	Summary description
Governance	Optimization of the legislation and the organization in terms of control and management of forests. Analysis on the impact of the division of functions and implementation of new regulations from 2011 till now need to be performed. Minimized state support for research in the forest sector.

3.4. References

FAO FRA2020, Bulgaria. https://www.fao.org/3/ca9971en/ca9971en.pdf

Forests Act, in force from 09.04.2011, Prom. SG. No. 19 of 8 Mar 2011

Forests Act, in force from 01.01.2019, Prom. SG. No. 1/3.01.2019

Raykov R (2006) 105 years forest management in Bulgaria, Highly qualified, experience and reputation. Forest Magazine 3

Shaik, R. U., Laneve, G., & Fusilli, L. (2022). An automatic procedure for forest fire fuel mapping using hyperspectral (PRISMA) imagery: A semi-supervised classification approach. Remote Sensing, 14(5), 1264. https://doi.org/10.3390/rs14051264

Stoyanova, M., Kandilarov, A., Koutev, V., Nitcheva, O., & Dobreva, P. (2018). Potential of multispectral imaging technology for assessment coniferous forests bitten by a bark beetle in Central Bulgaria. In MATEC Web of Conferences (Vol. 145, p. 01005). EDP Sciences. https://doi.org/10.1051/matecconf/201814501005

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2010). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

National Forest Strategy: https://www.mzh.government.bg/bg/politiki-i-programi/politiki-i-strategii/nacionalna-strategiya-za-razvitie-na-gorskiya-sektor-v-republika/

National forest inventory: http://www.iag.bg/docs/lang/1/cat/3/index

Forestry Act, Ministry of Finance, available at: https://www.minfin.bg

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_BGR_22-10-2019 (foresteurope.org)

National forestry accounting plan for Bulgaria: https://www.researchgate.net/publication/330542262_National_Forestry_Accounting_Plan_of_Bulgaria_including_Forest_Reference_Levels_for_the_period_2021-2025

Strategic plan for biodiversity 2011-2022: https://www.moew.government.bg/bg/priroda/strategicheski-dokumenti/

Strategy for the development of bioeconomy in the Stara Sagora region: https://be-rural.eu/wp-content/uploads/2021/12/Strategy_Stara_Zagora_BG.pdf

Weiss, G. et al., 2019, Forest Ownership changes in Europe: State of knowledge ad conceptual foundations, Forest Policy and Economics 99: 9-20

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-12/csp-at-a-glance-bulgaria_en.pdf

Integrated energy and climate plan of the Republic of Bulgaria 2021–2030: https://energy.ec.europa.eu/system/files/2020-06/bg_final_necp_main_en_0.pdf

4. CROATIA

4.1. Country overview – major forest facts

4.1.1. Key forest data

The Republic of Croatia is situated in the south-eastern part of Europe. It is the only EU Member State faced with the War and post-War circumstances in the recent past, which also heavily impacts on forest management. Forested land in Croatia covers about 1.92 million ha (equivalent to 34.3% of the total land area). The most common tree species is beech (37%), followed by oak (Quercus robur and Q. petrea) (21%), hornbeam (8%), fir (8%), narrow-leaved ash (3%) and spruce (2%). Forests and other wooded land in Croatia are managed in line with the Forest Management Plans, adopted for the period of 10 years, which are compulsory and registered with an official body (Ministry of Agriculture). Currently, the Forest Management Plan of the Republic of Croatia 2016- 2025 is in force. 96% of state-owned forests are certified under third party certification schemes, all FSC. Privately owned forests are still under the process of certification. 3.5% of forest and other wooded land showed damage, due to abiotic and biotic causes, although this percentage fluctuates quite strongly. Forest area has expanded slightly and now stands at 34.7% of total land area. Growing stock and above ground biomass have been increasing faster than forest area: average growing stock is now 220 m3 o.b./ ha. No information was supplied on carbon stock in harvested wood products. 16.3% of forest and other wooded land are protected for the conservation of biodiversity, and this share has been rising (percentage amount does not include forests and other wooded land in Natura 2000, and it will be expressed in next SoEF report). 12.5% of forest and other wooded land are designated protection forests. Nearly 7 thousand ha of forest are considered undisturbed by man.

4.1.2. Institutional setup and legal framework

Sustainable forest management in Croatia has a tradition of more than 250 years and is regulated by several laws and other legal acts. The Ministry of Agriculture is the administrative body responsible for the implementation of national forestry policy. The Ministry of Agriculture is the administrative body responsible for the implementation of national forestry policy. The latest Forest Law was passed in 2018.

4.1.3. Key actors and stakeholder organisations

Ministry of Agriculture; Ministry of Economy and Sustainable Development; Croatian Forests Ltd.; Croatian Union of Private Forest Owners' Associations (CUPFOA); Croatian Chamber of Forestry and Wood Technology Engineers; Academy of Forestry Sciences; Croatian Forestry Society; Faculty of Forestry and Wood Technology, University of Zagreb; Croatian Forest Research Institute; State Institute for Nature Protection; Society for the Nature Protection of Croatia (Natura).

4.1.4. Forest ownership

Forests in Croatia are made up of 24% private forest, 73% state forests, 3% other state owners.

4.1.5. Forestry industry

Wood removals have been rising steadily to 5.7 million m3 in 2017. The share of wood fuel has been rising and reached 47% in 2017. Fellings were 71% of net annual increment on forest available for wood supply.

Over 36 thousand people are employed in the forest sector in Croatia. Employment in forestry itself has been rising. In 2015, 11% of Croatia's primary energy supply was derived from wood.

4.1.6. Key forestry issues

Maintaining stable and sustainable financing of forestry works and activities in the circumstances of reducing accumulated funds from the Fee for FES; large forested areas are still contaminated by landmines from the Homeland war. This makes the areas inaccessible for SFM. (project NATURAVITA - Demining, restoration and protection of forests and forest land in protected and Natura 2000 areas in the Danube-Drava region). Additional efforts (such as further digitalisation) is needed to improve the traceability of wood/timber. Devastating negative impact of the new disease (*Hymenoscyphus fraxineus*) in pure and mixed forests of narrow-leaved ash (*Fraxinus angustifolia*).

4.2. Forest monitoring

4.2.1. State General Forest Management Plan (GFMP)

Since the foundation of the Republic of Croatia in 1990, the state of national forest resources has been assessed with a bottom-up approach, using stand-wise management plans for all-management units. The state General Forest Management Plans are compiled every 10 years, i.e., 1996-2005 (GFMP, 1996), 2006-2015 (GFMP, 2006), and 2016-2025 (ongoing). The GFMPs represent the basis of national reporting for FAO-FRA (FAO, 2005). "*Hrvatske šume*", the Croatian State Forest Enterprise, which is responsible for forest and woodland management, has been also the holder of the FSC certificate for forest management since 2002.

4.2.2. National Forest Inventory (CRONFI)

First early forest inventories in Croatia date back to the eighteenth and nineteenth century, when local-level surveys were carried out in some region for the preparation of management plans. After the World War II, a large-scale forest survey on the entire area was conducted, to assess the state of forests after the conflict. The first Croatian National Forest Inventory (CRONFI) was conducted from 2006 to 2009 (Vedriš *et al*., 2010), and was based on a permanent, systematic sampling grid of 4 x 4 km. The sampling grid consists of 1932 squares located in forest areas (4376 in total), where a quadratic cluster (area 2.25 ha) of concentric sample plots are located at the corners of each square. During the first CRONFI, a total of 6232 permanent forest plots were established. The sample plots consist of (i) a large circular plot of radius 25 m, (ii) four concentric circular plots with radii 3.5, 7, 13 and 20 m respectively, and (iii) a smaller plot of radius 2 m (Čavlović *et al*., 2016).

The definition of forest used in CRONFI (minimum area of 0.5 ha, a minimum crown cover of woody plants of 10%, and a minimum width of 20 m) is in line with the forest definition provided by FAO (2004).

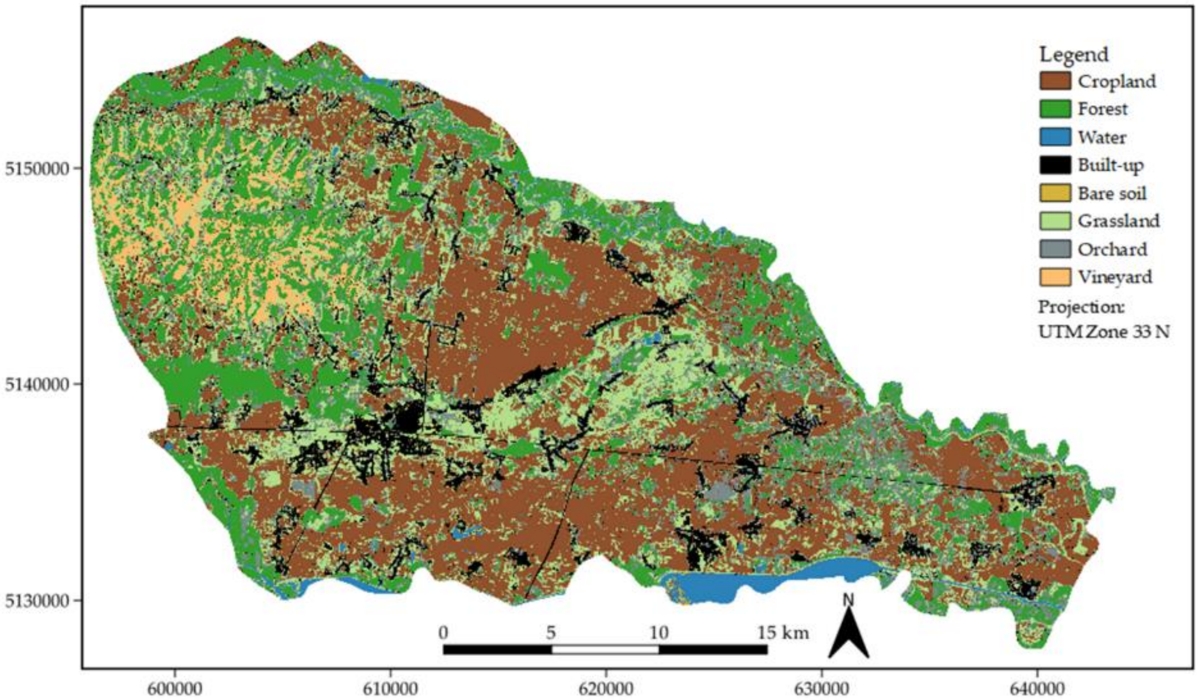
The planned time span between the first and second CRONFI is 10 years. However, no information is available for a second CRONFI.

The first CRONFI provides information of forest resources (forest area, tree species composition, tree-level characteristics, stand structure, growing stock, management practices, deadwood, forest carbon, stand regeneration and vitality) at the national level and different regional scales (5 bioclimatic zones, 16 forest types, 16 Forest Administrations, 21 counties) and represents the main forest information source for reporting obligations and international statistics as the FRA-FAO, the MCPFE, and the LULUCF report.

4.2.3. Forest mapping

Remote sensing and Earth Observation in Croatia are mainly related to external research, rather than a national forest monitoring plan. Indeed, while orthophotos were used to distinguish forest to non-forest areas during the first CRONFI, a national forest map still does not exist. However, a recent study addressed the possibility to use remotely sensed optical imagery to create a vegetation map of Međimurje County, in the northernmost part of Croatia (Dobrinić *et al.*, 2021), using Sentinel-1 and Sentinel-2 time series.

Figure 7 Classification map of the Međimurje County produced using Sentinel-1 and Sentinel-2 (Dobrinić et al., 2021)



Moreover, while Landsat-8 optical imagery was used to map forest damage that occurred during the winter of 2014 (Milas et al., 2015), a remote-sensing based national forest damage monitoring framework is still missing in Croatia.

4.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Croatia.

Table 13 Croatia: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	CRON FI, NFAP	National		10y						
Forest biomass	GGI	National								
Forest carbon	GGI	National								
Tree age	NFAP									
Canopy height										
Forest structural diversity										
Forest soil properties	ICP									
Forest/tree cover change										
Tree age diversity	NFAP									
Tree species/composition	NFAP									
Tree species diversity										
Forest type	NFAP									
Deadwood	CRON FI	National		10y						
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system	NFAP									
Main management objectives	NFAP, FMP_HR									
Forest area covered by a management plan	NFAP, FMP_HR									
Volume of wood harvested	NFAP									
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies	ICP									
Tree health	ICP									

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest growth	NFAP									
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance	GGI, NFAP	National								
Number of forest fires										
Number of storms										

4.2.5. SWOT analysis

Table 14 Croatia: SWOT analysis

Strengths	Weaknesses
Long tradition and data availability of stand-wise forest inventories.	Only one cycle of the NFI available. No integration of the NFI with EO for producing maps.
Opportunities	**Threats**
Research activities available for developing future integration with EO.	It is not sure when a new cycle of the inventory will be available.

4.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 15 Croatia: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Forest Policy and Strategy 2003, Section A.	Information on forest resources.
	National Forest Inventory 2010	Data on forests
	Forest Management Plan of the Republic of Croatia	Data on forests
Biodiversity	Forestry Act, 2018	Has the aim, a.o., to protect forests as natural habitats and maintain biodiversity. Contain regulations that contribute to biodiversity conservation, such as the designation of forests with special purpose which include forests in protected areas and the most valuable forest sites. It prescribes the obligation to forest

Thematic area	Main Strategic reference	Summary of planning elements
		owners to maintain the natural tree species composition of forests as well as support local composition of forests.
	National Forestry Policy and Strategy, 2003	Emphasises the link between biodiversity and SFM; References the National Strategy and Action Plan for the Protection of Biological and Landscape Diversity – the two policies will greatly affect the protection of forests and nature.
	The Strategy and Action Plan for the Protection of Biological and Landscape Diversity	Laying down long-term objectives and guidelines for the conservation of biological and landscape diversity and protected natural values, and methods for implementation thereof, in accordance with the overall economic, social and cultural development of the Republic of Croatia.
Bioeconomy	Forest Europe Report, p. 9	Short rotation coppices Law (OG 15/18) aims to create conditions for the production of biomass from forest species short rotation coppices as a legitimate renewable and environmentally acceptable energy source on the principles of economic sustainability, social responsibility and ecological acceptance; The Law on Timbered Crops (NN 15/2018), which aims to create conditions for the production of biomass from culture as a renewable and environmentally acceptable energy source on the principles of economic sustainability, social responsibility and ecological acceptance
	National Forestry Policy and Strategy, 2003	Sustainable climate-neutral development; Using bioneric raw-material for sustainable, circular economy
	Positioning the Croatian Linear Bioeconomy towards Sustainable and Circular Bioeconomy, 2019	Describes the political position and steps being taken for the development of a Croatian Bioeconomy and Action Plan.
Ecosystem services	Forestry Act, 2018	Acknowledges the multiple services forests provide. The Act is dedicated to accomplish the objective of multi-forest functions and enhancing the lasting provision of goods and services. It lists several services (e.g. protection of soil, water quality, climate mitigation, recreational, biodiversity, wood production). A Fee for FES is established, and activities financed by the Fee for FES is stipulated.
	National Forestry Policy and Strategy, 2003, Section C.	Acknowledges the rise in interest in forest values other than wood, e.g. eco-tourism, and also the importance of services such as hunting. Croatia has a long and rich tradition of hunting, which is part of its national cultural heritage. Non-timber forest products, such as mushrooms, forest fruits, honey, medicinal plants, leaves and wildflowers, can be a valuable source of income for local communities and populations.

Thematic area	Main Strategic reference	Summary of planning elements
Climate change	Climate Change Adjustment Strategy in Croatia for the period up to 2040	Maintenance of forests as CO2 sink and as producers of renewable energy
	National Forestry Policy and Strategy, 2003	Acknowledges that the forestry sector has one of the priority roles in reducing greenhouse gases
	Forestry Act 2018	Acknowledges the role forest play in the climate and mitigation of climate change.
	National Forestry Accounting Plan for the Republic of Croatia	Climate change parameters indirectly included in in the Croatian Forest reference level
	Integrated National Energy and Climate Plan for the Republic of Croatia 2021-2030, p.30	Preparation of cost-benefit analysis of afforestation on new areas and natural regeneration of forests as a measure of increasing the sinks in the LULUCF sector

4.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 16 Croatia: Forest-related challenges that influence integrated long-term plans

Major challenge	Summary description
Climate change	Preparation of detailed climate projections and appropriate medium and long-term models related to the possibilities and frequencies of extreme climatic events and general climate parameters. Capacity building for systematic monitoring of the state of forest ecosystems as a prerequisite for informed planning and implementation of climate change adaptation. Preparation of the model of effects of climate change on forest ecological systems and developing the possibilities of their mitigation and adaptation of forest ecological systems; Incorporating of adaptation measures into key forest sector documents. Forest vitality and health (Forest pests, diseases and disorders): Monitoring and analysing native and non-native invasive and potentially harmful organisms, the causal agents of outbreaks and decreased forest ecosystems stability and biodiversity, under the climate change or influence of negative abiotic and/or biotic factors. Developing and strengthening the preventive and ecological friendly (acceptable) controlling measurements.
Ecosystem services	raising awareness and development of the policies based on full recognizing of importance of the forests, multiple benefits related to the forests, wood and non-wood forest products and services

Major challenge	Summary description
Interest conflicts	Afforestation The Republic of Croatia in the past has invested considerable efforts to increase its forest areas through afforestation activities, due to which it increased its forest areas by 2.5% (around 60,000 hectares) since 1990 onwards. However, the areas that had been planned for a long-term future afforestation (around 200,000 hectares) are mostly blocked pursuant to the Regulation on the Ecological Network (NATURA 2000) of 2013, Ordinance on the list of habitat types, habitats map, and threatened and rare habitat types of 2014 and the Nature Protection Act of 2014, which expressly prohibit the conversion of land from the category of grassland to the category of forest land. The total area available for afforestation is thus reduced from approximately 200 00 ha to the area of 4700 ha, which would amount to only 313 ha per year for the period 2016-2030.
Private forest owners	Strengthening awareness and sensibility of all the stakeholders in the forest sector on climate change and necessary adaptation measures with priority to private forests. The aim of these activities is in order to support sustainable forest management as a prerequisite for adapting to climate change.
Biodiversity conservation	No information
Bioeconomy	Valorisation of forestry and multiple forest ecosystem services as a one of the main pillars of bioeconomy as well as guarantee of survival and sustainable development of rural areas; Transformation of the national economy in terms of switching to the use of biomass /renewable resources (sugar, fibre, oil, etc.) for conversion to energy, chemical products, animal feed, etc. through: - development of new technologies and processes for bioeconomy, - market and competitiveness development in bioeconomy sector.
Forest fires	Strengthening of fire-fighting prevention/protection capacity; Additional efficiency and higher quality fire-fighting protection based to the fact of increase of financial allocations for this purpose (Ordinance on the procedure, manner of exercising the right and manner of using the funds from the fee for utilization of forest functions of general benefit 107/21).
Desertification	No information
Population-related challenges	Maintaining a qualitative level of control and conservation of forest ecosystems in the context of the significant depopulation of rural areas.
Financing	Maintaining and increasing activities and investments related to sustainable forest management as a necessary balance in the context of the reduction of funding accumulated by the Fee for FES. frame of the reduction of accumulated funds through the Fee for FES.
Governance	No information

4.4. References

Čavlović J, Božić M, Teslak K, Vedriš M (2016). Chapter 15 - Croatia. In: “National Forest Inventories - Assessment of Wood Availability and Use” (Vidal C, Alberdi I, Hernandez L, Redmond J eds). Springer, Cham, Switzerland, pp. 281- 305.

Dobrinić, D., Gašparović, M., & Medak, D. (2021). Sentinel-1 and 2 time-series for vegetation mapping using random forest classification: A case study of Northern Croatia. Remote Sensing, 13(12), 2321. https://doi.org/10.3390/rs13122321

FAO (2004) Global Forest Resources Assessment Update 2005: Terms and definitions (final version). Forest Resources Assessment Programme Working Paper 83/E, FAO Forestry Department, Rome

GFMP (1996) General forest management plan of entire region of Republic of Croatia for period1996–2005. Ministry of Agriculture and Forestry, Zagreb

GFMP (2006) General forest management plan of entire region of Republic of Croatia for period 2006–2015. Ministry of Agriculture Water management and Forestry, Zagreb

Šimić Milas, A., Rupasinghe, P., Balenović, I., & Grosevski, P. (2015). Assessment of forest damage in Croatia using Landsat-8 OLI Images. South-east European forestry: SEEFOR, 6(2), 159-169. https://doi.org/10.15177/seefor.15-14

Vedriš M,Čavlović J, Božić M (2010) Chapter 6—Croatia. In: Tomppo E, Gschwantner T,Lawrence M, McRoberts RE (eds) National forest inventories pathways for common reporting.Springer, Netherlands, pp 131–138

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory, 2010 : https://www.sumari.hr/biblio/pdf/11405.pdf

Forest Europe Report 2020: https://foresteurope.org/wp-content/uploads/2017/08/QL_questions-responses_DEU_16-11-2018.pdf
https://foresteurope.org/wp-content/uploads/2017/08/QL_questions-responses_HRV_16-11-2018_v2.pdf

EUFORGEN : https://www.euforgen.org/member-countries/croatia/

National Forest Policy and Strategy 2020: https://narodne-novine.nn.hr/clanci/sluzbeni/2003_07_120_1663.html

National Forestry Accounting Plan for the Republic of Croatia, 2018: https://mingor.gov.hr/UserDocsImages//KLIMA/SZKAIZOS//NFAP_Croatia.pdf

Forestry Act 2018: http://extwprlegs1.fao.org/docs/pdf/cro71624.pdf

The Strategy and Action Plan for the Protection of Biological and Landscape Diversity of the Republic of Croatia, 2008: https://geoheritage-iugs.mnhn.fr/international/Croatia/hr6-2008-Protection%20of%20Biological%20and%20Landscape%20Diversity%20of%20the%20Republic%20of%20Croatia.pdf

Positioning the Croatian Linear Bioeconomy towards Sustainable and Circular Bioeconomy, 2019: https://ec.europa.eu/programmes/erasmus-plus/project-result-content/a06e1f76-3688-4547-9835-0b889403a518/POSITIONING%20THE%20CROATIAN%20LINEAR%20BIOECONOMY%20TOWARDS%20SUSTAINABLE%20AND%20CIRCULAR%20BIOECONOMY.pdf

Forest Management Plan of the Republic of Croatia https://poljoprivreda.gov.hr/istaknute-teme/sume-112/sumarstvo/sumskogospodarska-osnova-2016-2025/250

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-10/csp-at-a-glance-croatia_en.pdf

Integrated National Energy and Climate Plan for the Republic of Croatia 2021-2030: https://energy.ec.europa.eu/system/files/2020-01/hr_final_necp_main_en_0.pdf

5. CYPRUS

5.1. Country overview – major forest facts

5.1.1. Key forest data

The Republic of Cyprus is an island country in the eastern Mediterranean, with nearly a fifth forest cover. Forest management plans are obligatory and registered with an official body. Forest area has been stable since 2000 and stands at 18.7% of total land area (including the occupied areas in the northern part of the island). Cypriot forests mostly consist of Calabrian pine and Black pine. Other tree species include Cedar, Plane tree, Cypress, Alder and Juniper. Forest inventories cover only the area of state forests. Growing stock and above ground biomass have both been increasing. In 2015, growing stock was on average 64 m3 o.b./ha, 40% more than in 1990. No information was supplied on carbon stock in harvested wood products.

1.4% of forest and other wooded land was reported. as with damage in 2010, chiefly because of insects/ diseases and fire.

In 2010, 6.8% of forest and other wooded land were protected for conservation of biodiversity. No forests are specifically designated as protection forests. 13 thousand ha of forest are considered undisturbed by man. No forests in Cyprus are under third party certification schemes. Most of the managed forest is state forest, thus managed primarily for conservation and protection of the forest ecosystems, emphasizing in biodiversity and ecosystem services.

5.1.2. Institutional setup and legal framework

The political situation (including forest governance) is difficult to assess in Cyprus due to the ongoing peaceful, yet unresolved conflict. De jure, the whole of the island forms part of the sovereign Republic of Cyprus. De facto the country is divided into 2 parts, the northern part being occupied and administered by the self-declared Turkish Republic of Northern Cyprus. The occupation is viewed by the international community as illegal occupation of EU territory. The United Nations Peacekeeping Forces are in Cyprus since 1974 and effectively controls the Buffer Zone until today.

The new Forest Law was enacted in 2012. There is a platform for stakeholder participation in forest policy making, the Forest Consultation Board, but no formal NFP process. A new forest policy statement was published in 2013.

5.1.3. Key actors and stakeholder organisations

Department of Forests; Minister of Agriculture, Natural Resources and Environment; Terra Cypria (A non-governmental organization that aims to promote environmental awareness and sustainability).

5.1.4. Forest ownership

80.46% of the total State forest area is situated in the area under the control of the Government whilst the remaining 19.54 % is found in the area of Cyprus beyond the control of the Government. Private forests and other forested State land cover 24.74 % of the total area of Cyprus.

5.1.5. Forest industry

In 2016, wood removals were 16 thousand m u.b., almost all woodfuel. Fellings are reported to have fallen over the 30 year period, from 51 to 9 thousand m3 o.b. The ratio of fellings to net annual increment also fell, from 110% in 1990 to 23% in 2015.

In 2010, about 4 thousand people were employed in the forest sector, of which over 60% in the wood processing industries.

In 2015, wood provided 0.6% of Cyprus' total primary energy supply.

Any wood products, i.e. fire wood and timber are extracted as side products resulting from silviculture or forest fire protection activities. The main silviculture method applied is the single selection system, based on national guidelines for forest silviculture. The annual felling rate is around 9-10 % of the annual growing stock in state forests, ensuring the sustainable management. The annual increment is calculated through National Forest Inventory projects which are conducted by the Department of Forests every ten years.

5.1.6. Key forestry issues

In 2013, a new legislation was voted for the control of timber and timber products trade in order to control illegal logging ang illegal timber trade. Since then, the implementation of the new law has been a key priority for the Department of Forests.

Forest fires (prevention and management of) is a major issue.

5.2. Forest monitoring

5.2.1. National Forest Inventory

Cyprus has a long forestry tradition. In 1897, the first inventory was designed and carried out based on sample plots, which were established in various areas of the forests (Polycarpou, 1959). The main objective was to obtain estimates on the growing stock volume, volume increment and diameter and height growth through stem analysis. The second forest inventory was performed during 1922–1924. In 1936, the Department of Forests carried out an inventory of State Forests using systematic sampling (Peonides, 1978). In 1953, a new inventory method for State Forests featuring 2.7 ha, randomly located, permanent circular sample plots were introduced.

The plots were measured every 10 years. A new method of "Continuous Forest Inventory" based on sampling was introduced in 1980. It also included the use of aerial photographs to classify state forests (with Calabrian pine, Pinus brutia) into productive and non-productive classes and areas of artificial regeneration. Productive area was inventoried three times using randomly selected circular units of 0.2 ha: 1981–1982, 1991–1992 and 2001–2002. While in 2011-2012, the fourth Forest Inventory covered Productive Forests, Non-Productive Forests and Reforestations.

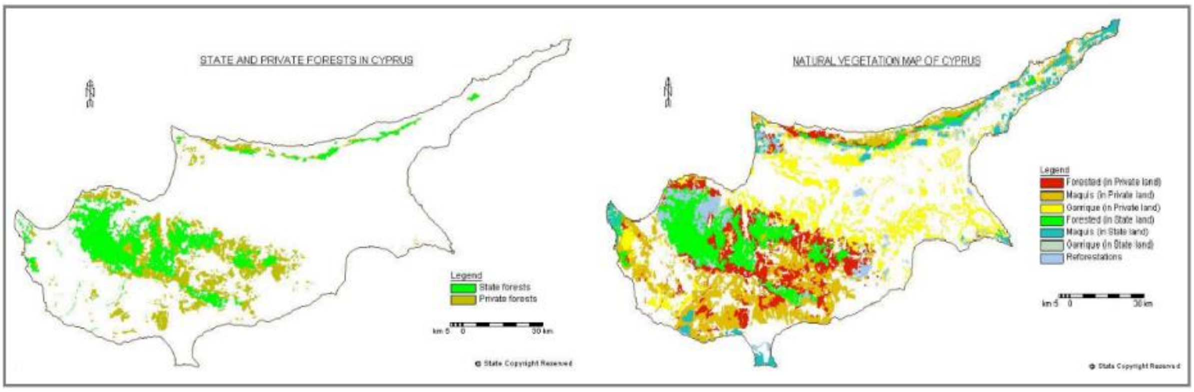
The forest area estimate can be given based on the reference definition of COST Action E43.

5.2.2. Forest mapping

The Cyprus National Forestry Accounting Plan (CNFAP, 2019) reported the national forests map figures of owners and the natural vegetation map. These mappings are not available in vector or raster format.

However, external research explored the potential use of remote sensing techniques and Earth Observation to monitor national vegetation characteristics. For instance, Andronis et al. (2022), investigated the relationship between land surface temperature and forest changes in Paphos forest, through Landsat 5 and 8 satellites.

Figure 8 State and private forest in Cyprus (Department of Forests) and Natural vegetation map of Cyprus (Natural resources information and remote sensing center, Ministry of agriculture, natural resources and environment)



5.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Cyprus.

Table 17 Cyprus: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	DF	National						x		yes-public
Forest biomass	DF	National						x		yes-public
Forest carbon										
Tree age										
Canopy height										
Forest structural diversity	DF	National						x		yes-public
Forest soil properties										
Forest/tree cover change										
Tree age diversity										
Tree species/composition	DF	National						x		yes-public
Tree species diversity	DF	National						x		yes-public
Forest type	DF	National						x		yes-public
Deadwood										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested										
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth										
Occurrence of forest fires	DF	National		1y				x		yes-public
Occurrence of storms										
Forest disturbance	DF	National		1y				x		yes-public
Number of forest fires	DF	National		1y				x		yes-public
Number of storms										

5.2.4. SWOT analysis

Table 18 Cyprus: SWOT analysis

Strengths	Weaknesses
Cyprus has a well-established NFI that is able to report robust statistics.	The NFI in Cyprus is performed only once every 10 years, so it is not possible to have reliable statistics on variables with short periods such as forest disturbances. A dedicated forest inventory site is missing. The NFI does not produce wall-to-wall estimates (maps).
Opportunities	**Threats**
In anticipation of the next cycle of surveys, a new methodology based on the use of remotely sensed data can be implemented.	Lack of access to raw NFI data limits forestry analysis to support new EU forestry strategy

5.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 19 Cyprus: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Forestry Accounting Plan 2021-2025	Some information on forest resource status and trends.
Biodiversity	Forest Europe Report 2020, p.18	The Department of Forests implemented a comprehensive project aiming particularly on the conservation of biodiversity during the restoration and management of Amiantos Asbestos Mine - one of the most degraded ex-forest areas of the island.
	Strategy and Action Plan for Biodiversity in Cyprus	It includes 13 Strategic Objectives for the conservation and protection of biodiversity, for the decade 2020 - 2030. The strategic plan for the adaptation of the forests of Cyprus to climate change includes the implementation of measures to addressing the increased risk of forest fires, the establishment of a framework for monitoring the pest population and strengthening research, data collection and systematic monitoring of the impacts of climate change on forests, as well as the selection and use of appropriate forest species.
Bioeconomy	No planning tool could be identified	
Ecosystem services	No planning tool could be identified	

Thematic area	Main Strategic reference	Summary of planning elements
Climate change	National Strategy for Adaptation and Climate Change	Climate change is putting pressure on Cypriot forests due to higher average annual temperatures, lower rainfall and unusual distribution of extreme weather events leading to desertification, higher risks of forest fires, serious diseases and insect infestation. The Department of Forests is focusing on three measures to reduce the impact of climate change on forests. These relate to forest fire prevention and suppression, forest expansion through afforestation and reforestation of degraded and burnt forest land, and effective control of grazing on forest land to prevent forest degradation.
	National Forestry Accounting Plan 2021-2025	Trends on the Forest Reference Level, GHG emissions and carbon storage.
	Cyprus' Integrated National Energy and Climate Plan 2021-2030	Emissions from land use, land use change or forestry are offset by at least an equivalent removal of CO_2 from the atmosphere

5.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 20 Cyprus: Forest-related challenges that influence integrated long-term plans

Major challenge	Summary description Challenges are mostly unknown as country report was not submitted
Climate change	No information
Ecosystem services	No information
Interest conflicts	No information
Private forest owners	No information
Biodiversity conservation	No information
Bioeconomy	No information
Forest fires	No information
Desertification	No information
Population-related challenges	No information

Major challenge	Summary description Challenges are mostly unknown as country report was not submitted
Financing	In 2015, an internal process for a broad restructure of the Department was attempted, but it was only by mid-2018 that final decisions were taken. Since June 2018, a full re-structuring has been in progress, although with limited human resources
Governance	The political situation in Cyprus is difficult and unique as a a peaceful, yet unresolved conflict continues to exist.

5.4. References

Andronis, V., Karathanassi, V., Tsalapati, V., Kolokoussis, P., Miltiadou, M., & Danezis, C. (2022). Time Series Analysis of Landsat Data for Investigating the Relationship between Land Surface Temperature and Forest Changes in Paphos Forest, Cyprus. Remote Sensing, 14(4), 1010. https://doi.org/10.3390/rs14041010

Cyprus National forestry accounting plan, Ministry of Agriculture, Rural Development and Environment (2019)

Peonides L (1978) The Forest Inventory in Cyprus. Nicosia, Cyprus

Polycarpou A (1959) Inventory investigation in Pinus brutia forests of Cyprus, Department of forests. Nicosia, Cyprus

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_CYP (foresteurope.org)

https://unficyp.unmissions.org/about-buffer-zone

National Forestry Accounting Plan 2021-2025, 2019: http://www.moa.gov.cy/moa/fd/fd.nsf/447F6A84B70700B2C2257D1C0040CB63/$file/NFAP_FRL_CYPRUS_REVISED_31DEC2019.pdf

National Forest Inventory, 2021

Forest Act, 2006

Cyprus' Integrated National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-01/cy_final_necp_main_en_0.pdf

6. CZECHIA

6.1. Country overview – major forest facts

6.1.1. Key forest data

Czechia is a mountainous landlocked country in Central Europe, with forest cover nearly 35%. Coniferous trees (70%) significantly exceed deciduous trees (29%). The most frequently represented tree is the Norway spruce (48%), pine (16%), beech (9%), oak (8%), larch (4%), birch (3%) and fir (1%) (1). Forest area has expanded very slightly, but growing stock has increased, with slight decline in recent years as a result of large scale bark-beetle outbreak, reaching 268 m3/ha in 2021. Likewise, above ground biomass has also been increasing, by 0.5% a year with slight decline in the most recent years. All forests in Czechia are under a management plan, which is compulsory. Seventy per cent of the forests are certified, mostly by PEFC. Over 29% of forests are protected for conservation of biodiversity, while over 10% have designated protection functions. Nearly ten thousand hectares of forest are considered “undisturbed by man”.

6.1.2. Institutional setup and legal framework

The current Forest Act was enacted in 1995 and amended most recently in 2021. A National Forest Programme for the period to 2013, was issued in 2008 and, despite its name, is still under implementation. It is accompanied by National Forest Policy up to 2035 with its Implementation document.

A forest monitoring system is in place, and a report on the state of sustainable forest management in Czechia is being issued annually.

6.1.3. Key actors and stakeholder organisations

Ministry of Agriculture of Czechia; Forest Management Institute; Forestry Game and Management Research Institute; Association of Municipal and Private Forest Owners (SVOL); Forests of the Czech Republic – state enterprise; Ministry of Environment of Czechia.

6.1.4. Forest ownership

The ownership structure underwent many changes in the 20th century caused by several revolutionary social-political episodes. The last substantial change occurred in relation to the process of returning property to former owners, restitution process, which was in progress in the 90s of the 20th century. On its basis an ownership structure was established which has not altered much since 2000 except for restitution of forests belonging to churches which was mainly finished only recently. In 2021, the ownership structure was as follows: 53.8% state forests; 19.1% forests owned by individuals, 17.2 communal and municipal forests, 5.3 % churches and religious communities, 3.4% legal persons and 1.2% by forest cooperatives.

6.1.5. Forest industry

Wood removals have recently risen due to bark-beetle outbreak, with peak value of 35,8 million m3 in 2020 and slightly lower 30.3 million m3 in 2021. The ratio of fellings to net annual increment, reaching 84% in 2015 rised to 160% in 2020 and 136% in 2021. However, a significant part of the fellings (varying from 20% to 95% according to the years) consists of fellings of natural losses. If fellings of natural losses are deducted from the fellings data, the ratio is much lower, about 45% in 2015 for forests available for wood supply. Employment in the forest sector of Czechia fell between 2000 and 2015, from 120 thousand people (FTE – full time equivalent) to 80 thousand people. Over half of the employment is in the wood processing industries.

6.1.6. Key forestry issues

Forest owners and managers face increasing demands from society related to forests and forest management as well as challenges related to climate change, but simultaneously the economic situation of the forest owner is deteriorating (less incentives and support).

6.2. Forest monitoring

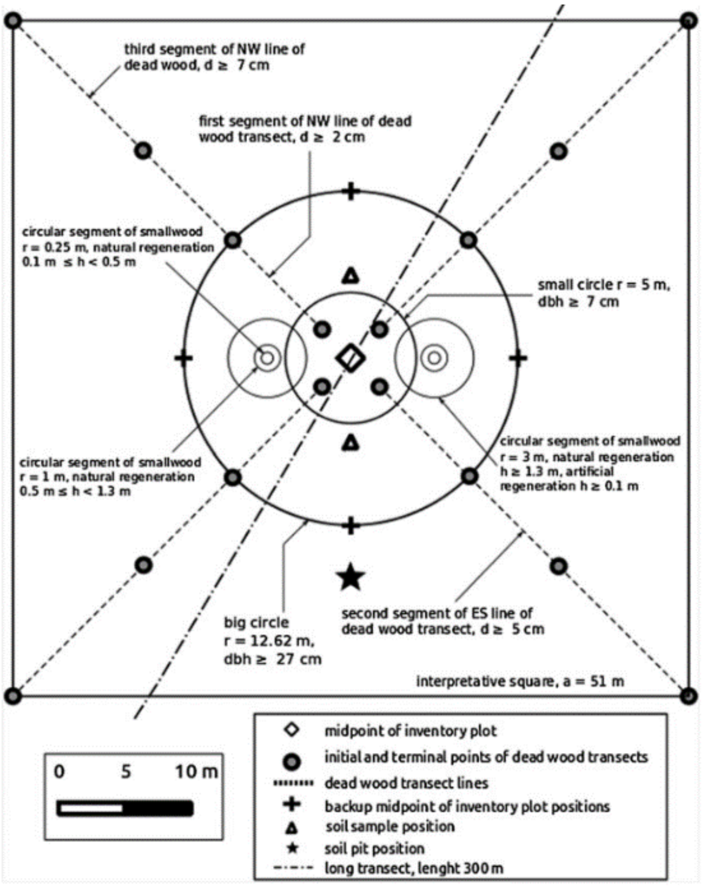
6.2.1. National Forest Inventory

In Czechia, the National Forest Inventory is carried out by the Institute for Forest Management Brandýs nad Labem (https://nil.uhul.cz/), which is a government organization established by the Ministry of Agriculture.

The first National Forest Inventory (NFI1), methodologically based on sample surveys carried out in the field, started in 2001 and the field measurements were completed in 2004. Results were published in 2005, and two years later, a monograph on the results and methodology of NFI1 was published (ÚHÚL, 2007). NFI1 divided land into two main categories, forest and non-forests, that were defined by national definitions and were not compatible with the FAO's ones (FAO, 2004).

Government Regulation No 247/2009 Coll. of 20 July 2009 launched the second NFI cycle (NFI2). Starting NFI2 the COST E43 definitions (Tomppo et al., 2010) have been used for forest, other wooded land, other land with tree cover and other land. Following the methodological and technological preparations in 2009–2010, a pilot survey was conducted in Central Moravian Carpathians. Indeed, many differences occurred between NFI1 and NFI2 in Czechia, mainly related to the sampling design. While a repeated field survey was carried out on sample plots of NFI1 (two sample plots in a square of 2 x 2 km), a new denser grid (one sample point on a 0.5 x 0.5 km) was analyzed through photointerpretation. Inside every 0.5 x 0.5 km grid, a single circular inventory plot is randomly located. The field survey of NFI2 was carried out on 23199 sample plots, most of which were categorized as forest land. The NFI2 inventory grid comprised five sampling frames, with different data collection and measurement details. In detail, (i) a 0.5 x 0.5 km grid, where land category was undertaken along with stand characteristics assessment; (ii) 1 x 1 km, in comparison to the previous grid, a photogrammetry assessment was conducted to monitor landscape characteristics; (iii) 2 x 2 km grid, in comparison with the previous 1 x 1 km grid, field measurements were carried out on all plots classified as forest and OWL. Within these plots, tree measurement, site and stand descriptions occurred; (iv) 4 x 4 km grid, in comparison with previous 2 x 2 km grid, the field measurements included additional variables such as deadwood, tree health condition and forest soil; (v) 16 x 16 km grid, in comparison with previous grid, land category and IPCC land use is assessed in the field in all plots (Kučera, 2016).

Figure 9 Extended survey inventory plot located in the 4x4km grid (Adolt et al., 2013)



Since NFI2, both field and photogrammetric surveys have been carried out in spring and autumn throughout the whole country. The results from NFI2 were published in 2015. The two-step tessellation stratified sampling introduced with NFI2 aimed to a new continuous inventory and to incorporate new remote sensing methods.

Since the beginning of the third NFI cycle (2016–2020, NFI3), the survey has been conducted using plots of NFI2 sampling grid only. In addition to the sub-grid prescribed for the field survey in the NFI2, additional plots were selected for NFI3 field survey. These were obtained by selecting one additional plot out of the 1 x 1 km NFI2 sub-grid in each of the 2 x 2 km blocks (groupings of four plots). The resulting density of the field sub-grid is 0.5 plots per km2, and it corresponds to the density of NFI1 sampling grid.

NFI results, along with Forest Management Plans, are used as the main sources of information for both national and international reporting requirements in Czechia. However, NFIs supply additional information that are not available in FMPs, such as volume of deadwood (Kučera, 2016).

6.2.2. Forest Mapping

The Forest Management Institute (FMI), Remote Sensing Department, is responsible for the use of remote sensing for forest mapping in Czechia. FMI is a government organization established by the Ministry of the Agriculture in 1935.

The main tasks of the FMI – Remote Sensing Department are (i) the stereoscopic interpretation of NFI plots and transects, (ii) the processing and production of CIR orthophotos and normalized digital surface models (used to detect clearcuts) from aerial images, (iii) the creation of periodic mosaic of satellite data. In this context, different sources of information are used, such as Sentinel-2, PlanetScope, Landsat (2,5,8,9) and airborne data, to create forest health and leaf area index maps (and monitor trends). Indeed, Landsat satellites, offering approximately 40 years of imagery, are used to assess forest NIR (near Infrared) reflectance annually (30 m resolution), during summer period since 1977. Furthermore, since 2015, Sentinel-2 data is used to monitor forest health status. 3 mosaics were produced per year, in different seasons (spring, summer and autumn) using different bands compositions (VIS – visible infrared, NIR and SWIR – short-wave infrared, with 20 m resolution). Similarly, PlanetScope imagery is used to produce 3 mosaics per year, using VIS and NIR bands (6-8 m resolution) since 2018.

Figure 10 Sentinel-2 mosaic in July-August 2022 (Marek et al., 2022)

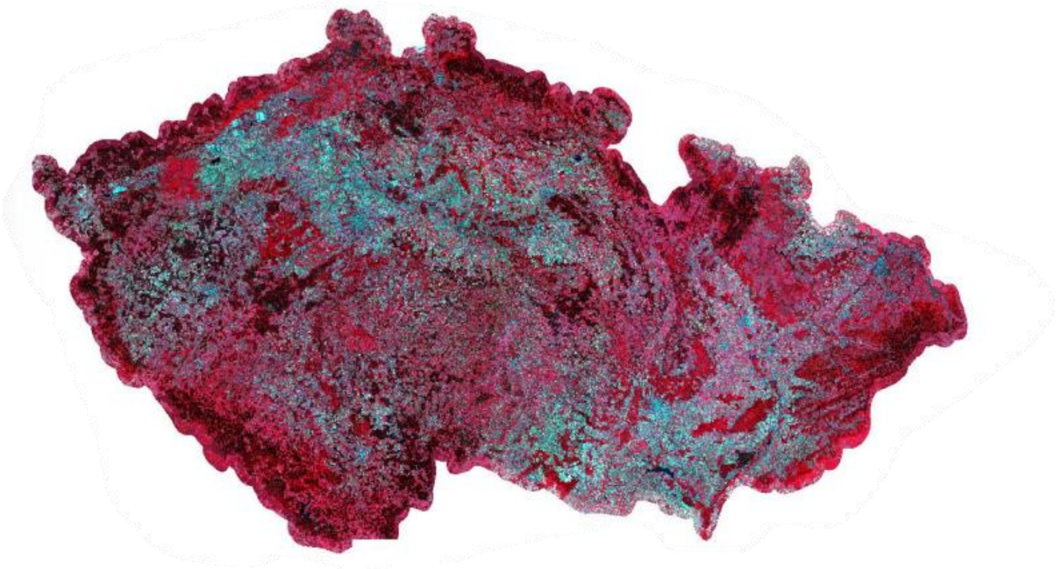
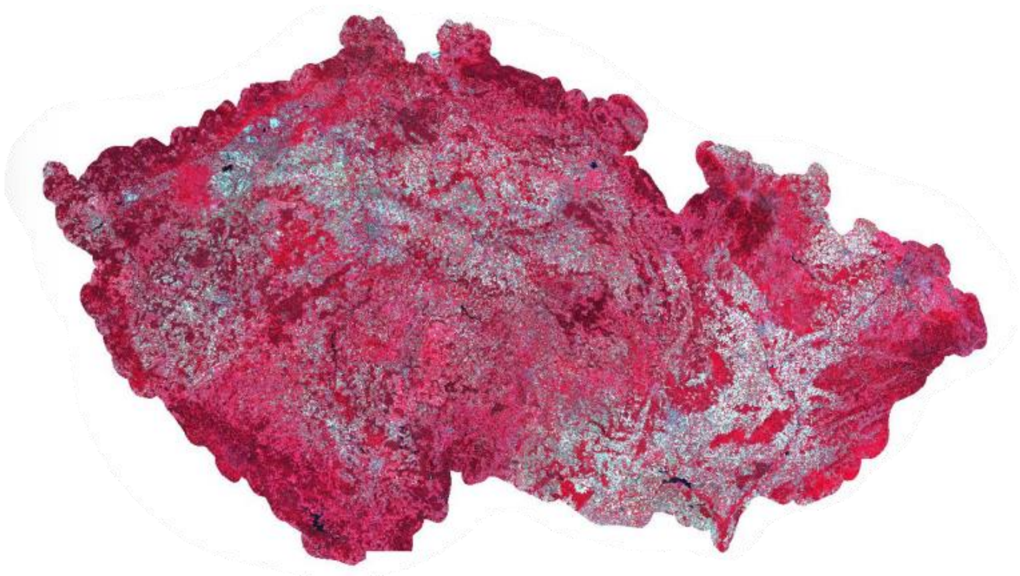


Figure 11 PlanetScope mosaic in July 2022 (Marek et al., 2022)



Moreover, the ground data provided by the NFI is used as training data for image analysis aimed at creating the national map of the main forest tree species.

Figure 12 Training database for tree species classification based on approximately 10000 NFI ground survey points (Marek et al., 2022)

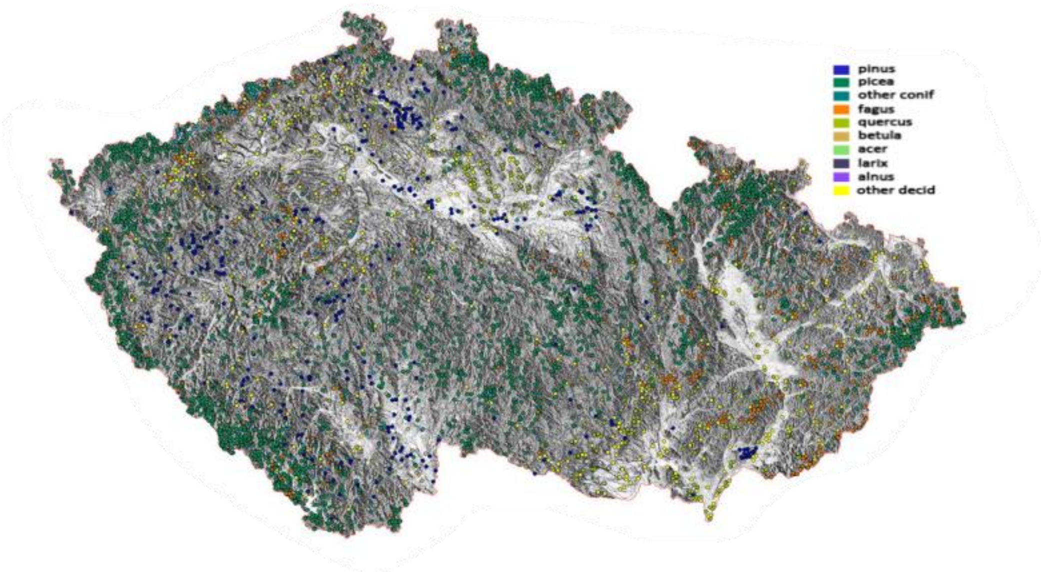
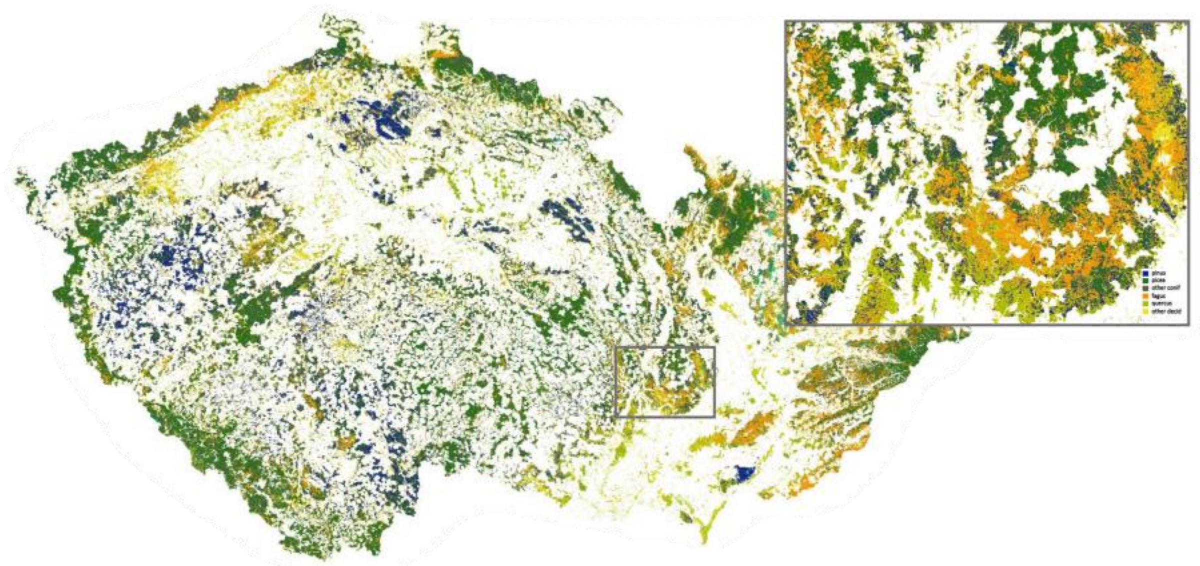


Figure 13 Map of forest tree species classification 2019-2021, overall accuracy over 85% (Marek et *al., 2022)*



PlanetScope imagery is also used to monitor the bark beetle outbreak, with a spatial resolution of 6-8 m. The bark map is based on the automatic evaluation of vegetation indices for the forest areas characterized mainly by coniferous trees (https://geoportal.uhul.cz/).

6.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Czechia.

Table 21 Czechia: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Forest biomass	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Forest carbon	NFI/FMP	National	complete	5y/10y				x		yes public
Tree age	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Canopy height	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Forest structural diversity	NFI	National	complete	5y		yes		x		yes public
Forest soil properties	NFI	National	complete	5y		yes		x		yes public
Forest/tree cover change	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Tree age diversity	NFI	National	complete	5y		yes		x		yes public
Tree species/composition	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Tree species diversity	NFI	National	complete	5y		yes		x		yes public
Forest type	NFI/FMP	National	complete	5y/10y		yes		x		yes public
Deadwood	NFI	National	complete	5y		yes		x		yes public
Presence of Red-list species										
Abundance of common forest birds	PECBMS	National	complete	1y				x		yes public
Forest spatial patterns	NFI	National	complete	5y		yes		x		yes public
Areas of primary and old-growth forests	PrimFor	National	complete					x		yes public
Forest ancientness										
Forest area under protection	FMI			upon request				x		yes - upon request

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Silvicultural system	NFI/FMP	National	complete	5y/10y		yes		x		yes - public
Main management objectives	FMP	National	complete	10y				x		yes - public
Forest area covered by a management plan	FMI	National	complete	10y					x	Yes - public
Volume of wood harvested	CSO/NFI	National	complete	1y				x		yes - public
Ratio of annual fellings to annual increments	NFI/FMP							x		yes - public
Forest revenue	CMA	National	complete	1y				x		yes - public
Roundwood prices	CSO	National	complete	1y				x		yes - public
Forest products trade	CSO	National	complete	1y				x		yes - public
Employment in the forest sector	CSO	National	complete	1y				x		yes - public
Forest area with 3rd party certification	FMI	National	complete	1y				x		yes - public
Forest visitor statistics	VisFor	National	complete	1y				x		yes - public
Forest foliage/phenology/anomalies	NFI/ForHealth/ICP	National	complete	5y/1y		yes		x		yes - public
Tree health	NFI/ForHealth/FPS	National	complete	5y/1y/1y		yes		x		
Forest growth	NFI	National	complete	5y		yes		x		
Occurrence of forest fires	CMA	National	complete	1y				x		yes - public
Occurrence of storms	FPS	National	Survey - approx. 70% of forest	1y				x		yes - public
Forest disturbance	FPS	National	Survey - approx. 70% of forest	1y				x		yes - public
Number of forest fires	ForFir	National	complete	1y				x		yes - public
Number of storms	FPS	National	Survey - approx. 70% of forest	1y				x		yes - public
Naturalness	NFI	National	complete	5y		yes		x		
Habitats of value biota										
Forest roads	NFI	National	complete	5y		yes		x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
State services supporting forest management	CMA	National	complete	1y					x	yes - public
Timber import/export	CMA	National	complete	1y					x	yes - public

6.2.4. SWOT analysis

Table 22 Czechia: SWOT analysis

Strengths	Weaknesses
Wide portfolio of data on forest state and development is available. Forest maps are open access, in GIS visualization. NFI raw data is available upon request (without precise plot coordinates)	Adapting to new information demands is in some cases longer term activity as new parameters has to be surveyed on site. Two available sources of forest related information (FMP and NFI) provide slightly different information, which can be explained, but still is confusing. Transition to NFI needs to estimate methodologically coherent information for years prior to NFI (2001). Forest maps are only available in local language
Opportunities	**Threats**
Better integration of different data sources. Possible extension of NFI with socio-economic parameters	Lack of financing, changes to definitions of international indicators

6.3. Main planning tools at national or, where appropriate, regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 23 Czechia: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Ministry of Agriculture, Forest Report 2020	Key information on forests, collected from several providers
	National Forest Policy up to 2035	Four long-term targets: A: to ensure balanced fulfilment of forest functions for next generations B: To increase biodiversity and ecological stability in light of ongoing climate change C: To ensure competitiveness of forestry and related sectors and their importance D: To strengthen the importance of consulting, education, research and innovation in forestry

Thematic area	Main Strategic reference	Summary of planning elements
	National Forest Inventory	Current data on forests – including biodiversity
Biodiversity	National Forest Policy up to 2035	Recognition of environmental forest functions & reference to international commitments; sustainable forest management as means to preserve biodiversity & assessments to identify value of sites. With regards to ongoing climate change enhance biodiversity and ecological stability of forest ecosystems while preserving the productive function of forests. Several measures within long-term target B of implementation document.
	National Biodiversity Strategy of the Czech Republic 2016-2025	Various objectives, incl. planning and policy elements
Bioeconomy	Ministry of Agriculture, Bioeconomy Concept	Agroforestry & bioeconomy as a tool to reinsure the sustainable use of natural resources, incl. forestry
	National Forest Policy up to 2035	Proper recognition to wood as a renewable strategic material and its use in bioeconomy – C.5.1 p. 42
	Bioeconomy Platform of the Czech Republic	Objectives of the Platform are to deepen knowledge in the respective fields of bioeconomy by means of research and education and to promote their use in practice at the level of enterprises and public administration while respecting principles of sustainable development.
Ecosystem services	National Forest Policy up to 2035,	Ecosystem services are integrated in majority of measures of Implementation document (13) Payments for ecosystem services are covered by measure C.4.2. - Ensuring payments for ecosystem services resulting from non-production forest functions (p. 41).
	National Biodiversity Strategy of the Czech Republic 2016-2025, pp. 93-95	Definition of objectives upon an evaluation of threats and respective countermeasures
Climate change	National Forest Policy up to 2035, pp. 8-10	Identification and estimation of current and future climate change threats
	Climate Protection Policy of the Czech Republic, executive summary, p. 13	Increase CO2 storage through measures, e.g. afforestation
	National Energy and Climate Plan of the Czech Republic	Multiple references to forestry throughout the text, particularly in relation to LULUCF

6.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 24 Czechia: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Adaptation of forests to climate change. Accelerating impacts of the climate change - droughts, bark beetle outbreak. Inconsistencies in the international processes obligations (more emphasis on the mitigation than adaptation).
Ecosystem services	No information
Interest conflicts	necessity to find balanced compromise between different uses of wood, also between wood production and nature protection
Private forest owners	Deteriorated economic situation of forest owner
Biodiversity conservation	Rising awareness of forest owners and nature protection. Rigidness of nature protection authorities and policies, which are based on establishing protected areas instead of integrative approaches.
Bioeconomy	Low added value in wood products produced in the country. Recognition of advantages of wood as a renewable material by policy makers (in comparison to other materials).
Forest fires	Accelerating impacts of the climate change - droughts, bark beetle outbreak
Desertification	Accelerating impacts of the climate change - droughts, bark beetle outbreak
Population-related challenges	Decrease in rural population caused by other impacts outside forestry sector.
Financing	No information
Governance	Increasing demands of society on provision of forest functions and services

6.4. References

Adolt R, Kučera M, Zapadlo J, AndrlíkM,Čech Z, Coufal J (2013) Pracovnípostupy pozemníhošetřeníNIL2 (Workflows offield measurement NFI2). Brandýs nad Labem:Ústav prohospodářskouúpravu lesů

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

Mlčoušek Marek, Lukeš Petr and Filip Hájek (2022). Towards harmonized forest observation, reporting and dara collection framework. Workshop 14-16 September 2022, Kutna Hora, Czech Republic

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories—pathways for common reporting. Springer-Verlag, Heidelberg, Dordrecht, London, NewYork

ÚHÚL (2007): Národní inventarizace lesů v České republice 2001–2004; Úvod, metody, výsledky. Brandýs nad Labem: Ústav pro hospodářskou úpravu lesů Brandýs nad Labem (ÚHÚL), 224 pp., ISBN 978-80-7084-578-5.

Ministry of Agriculture, Forest Report 2020: https://eagri.cz/public/web/file/712363/ZZ2021_vladni.pdf

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Land Ownership Change in Czech Republic, COST Action FP1201 FACEMAP country report 2015, EFI: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_CZECH%20REPUBLIC.pdf

National Forest Inventory: http://www.uhul.cz/what-we-do/national-forest-inventory

National Forest Strategy 2013: http://www.uhul.cz/images/NLP/1Podklady/1_Cizojazycne_verze_NLP/6_NLP_II_EN.pdf

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_CZE_8-2-2019 (foresteurope.org)

National Biodiversity Strategy of the Czech Republic 2016-2025: https://www.cbd.int/doc/world/cz/cz-nbsap-v2-en.pdf

Ministry of Agriculture, Bioeconomy Concept: Leaflet_Bioeconomy_concept_in_the_Czech_Republic.pdf (eagri.cz)

Bioeconomy Platform of the Czech Republic: https://bioeconomy.czu.cz/en/r-14282-about-us

Climate Protection Policy of the Czech Republic, executive summary: https://unfccc.int/sites/default/files/resource/CZE_Climate_Protection_Policy_Summary.pdf

Forest Europe country report: https://foresteurope.org/wp-content/uploads/2017/08/QL_questions-responses_CZE_8-2-2019.pdf

National forest policy concept up to 2035 https://eagri.cz/public/web/file/646382/Koncepce_statni_lesnicke_politiky_do_roku_2035.pdf

National forest policy up to 2035 implementation document: https://eagri.cz/public/web/file/669446/Aplikacni_dokument_ke_Koncepci_statni_lesnicke_politiky_do_roku_2035.pdf

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-czechia_en.pdf

National Energy and Climate Plan of the Czech Republic: https://energy.ec.europa.eu/system/files/2020-03/cs_final_necp_main_en_0.pdf

7. DENMARK

7.1. Country overview – major forest facts

7.1.1. Key forest data

Denmark is a Nordic country. It has a forest cover of approximately 15% (equal to about 0.665 mil ha). The forest area is increasing at an average annual rate of 0.6%. Growing stock per hectare is also rising; it was 211 m3/ha in 2015 and was last recorded at 216 m3/ha in 2018. There are about 41 million tonnes of carbon stored in living biomass in Danish forests. Conifers are the most common tree species (covering 53% of total forest area), of which Norway spruce is the main species, growing on 19% of the forest area. Other coniferous species include Pine and Sitka Spruce. Deciduous tree species (oak and beech) cover 43% of forest area. The exact forest area covered by a management plan is not known, as forest management plans are not required in Denmark. Nearly 30 % of Danish forests are under third party certification schemes, such as FSC or PEFC. More than 20% of Danish forest cover is protected for biodiversity conservation. In 2016, biodiversity protection was enhanced through a political decision to designate more forest, in particular state forest, primarily for biodiversity protection purposes.

7.1.2. Institutional setup and legal framework

The Ministry of Environment of Denmark is responsible for forestry, particularly two agencies. The Danish Nature Agency and the Danish Environmental Protection Agency.

A key role of the new Nature Agency is to manage the Ministry's approximately 200,000 hectares of forests and natural areas. Responsibility for law administration, including the National Forest Act, is nowadays primarily covered by the Agency for Environmental Protection, while advise and support on forest policy Development, including developing the new NFP, falls under the responsibility of the Department of the Ministry for Environment and Food.

The current Danish Forest Act forms the legal basis for forestry in Denmark. It was enacted by Parliament in 2004 and amended most recently in 2019. In 2018, a new National Forest Programme was published, replacing the former NFP of 2002. The new NFP sets out long term goals for an increasing forest cover as well as designating a share of forest primarily managed for biodiversity purposes. It covers all Forest Europe SFM criteria and describes strategic orientation lines and concrete implementing actions. Grant schemes for afforestation since 2016 have been primarily designed to pursue water protection purposes. The Nature Packages of 2016 and the Biodiversity Strategy set out targets for the preservation of biodiversity.

In 2012 a Political Agreement on Energy gave a major lift to the use of wood for energy. Amongst other elements it included a decision to speed up the transition from coal-based heat and power to biomass-based platforms. The Political Agreement was updated in 2018. However, to date Denmark does not yet have a dedicated national bioeconomy strategy.

7.1.3. Key actors and stakeholder organisations

Ministry of Environment of Denmark (Including Danish Nature Agency and Danish Environmental Protection Agency); Nature Agency's local units; Danish Forest Association; Danish Forest Owners Associations; Confederation of European Forest Owners; Danish

Society for Nature Conservation; Danish Sawmilling Industries Organisation; Danish Timber Trade Federation.

7.1.4. Forest ownership

30% public owners (state forests equals 18% of total forest area, other public bodies own 12-13%), 69-70% private ownership (of which 88% are owners with less than 20ha areas).

7.1.5. Forest industry

Removals from Danish forests have been increasing since 2001, reaching 3.6 mil cubic meters in 2017. Fellings lie at approximately 67% of net annual increment. The share of wood in total primary energy supply has been rising. National production of chipped wood has also increased. The Danish Forest industry employs about 23 thousand people. A rise in employment in forestry can be observed until 2016 after which it stabilised, while the employment in the wood processing and pulp and paper sector has been steadily decreasing during the last 30 years.

7.1.6. Key forestry issues

Denmark is a densely populated country, with a relatively low forest cover, in comparison to some other European countries. It has made a political decision to transfer from coal-based energy to renewable energy, which provides opportunities also for biomass-based platforms. In order to satisfy its wood and wood-based products demand, it relies on imports. This creates the obligation to ensure that such imports are produced sustainably.

Grant schemes prioritize only a few services, which might hinder incentives for multifunctional services.

7.2. Forest monitoring

7.2.1. National Forest Inventory

Since 1881, a Forest Census (based on forest owner responses to questionnaires and not to field observation) has been carried out approximately every 10 years (Larsen and Johannsen 2002).

The Forest Act of 1989 established the census as the responsibility of the Forest and Nature Agency of the Danish Ministry of Environment and requested national forest statistics every 10 years. In 1990 and 2000 two censuses were carried out. Here, the basic definition of forest included a criterion of a minimum area of 0.5 ha but no criteria for crown cover or tree height. Open woodland and open areas within forest areas were not included.

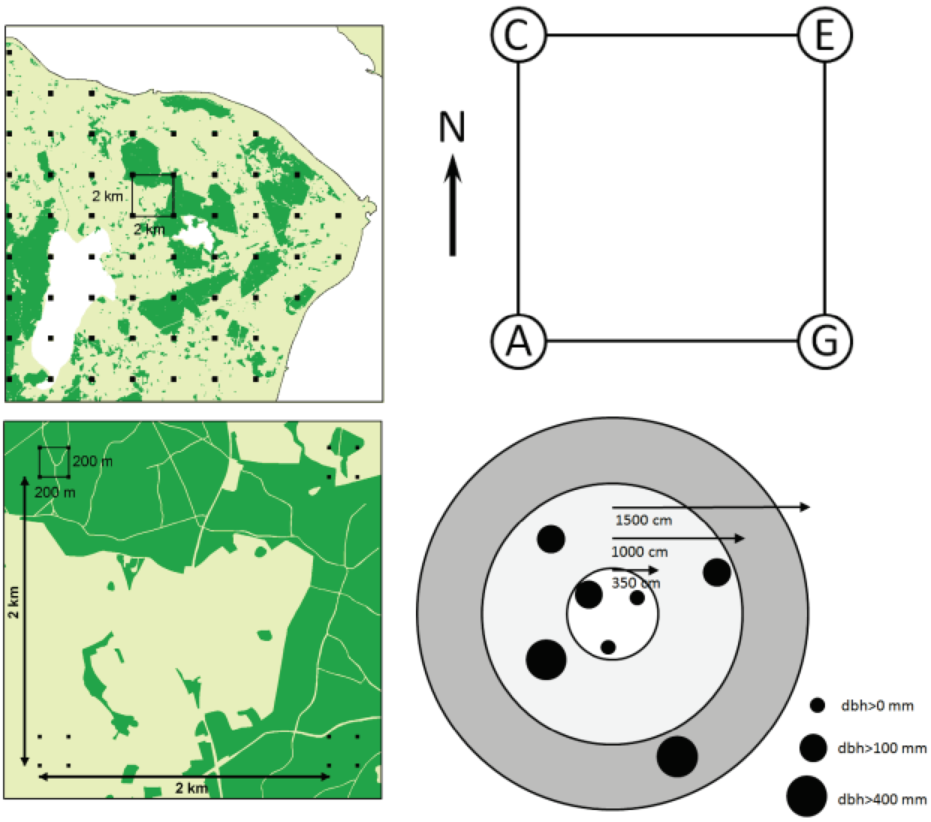
With the increased needs for new and more comprehensive information on forestry and forest-related issues, the first sample-based national forest inventory (NFI) was launched in 2002 (Johanssen 2003).

During the 5-year cycle, information on traditional forest resources such as growing stock, variations in stand structure, tree species mixtures, and indicators of biodiversity are collected. The definition of forest was also reformulated in accordance with the FAO definition (FAO 2000). The Danish NFI completed its first (2002–2006), second (2009-2013) and third (2012-2016) 5-year cycle. Currently, ground measurements of the fourth cycle (2016-2020) are completed (Nord-Larse et al., 2021).

The NFI covers all forests for all ownership groups and is intended to be a major information source and tool for forestry and forest-related issues. The Danish NFI is a continuous, sample-based inventory, with partial replacement of sample plots based on a 2 x 2-km grid covering the country land surface. Approximately one-third of the plots are permanent and are re-measured in every 5-years cycle, whereas two-thirds are temporary and are moved randomly within the particular 2 x 2 km grid cells in subsequent cycles. The sample of permanent and temporary field plots has been systematically divided into five non-overlapping, interpenetrating panels that are each measured in a single year and constitute a systematic sample of the entire country.

In each square grid cell, a cluster of four circular plots is placed at the corners of a square with 200-m side length. Each plot is composed of three concentric circles with radii of 3.5, 10 and 15m.

Figure 14 Design of the Danish National Forest Inventory. Cluster of sample plots are placed in a 2x2 km grid. Each cluster contains four sample plots placed in the corners of a 200x200 m square. The sample plot is divided into three concentric circles with radius 15, 10 and 3.5 m. Black circles illustrate trees measured on the sample plot (Nord-Larsen and Johannsen, 2016).

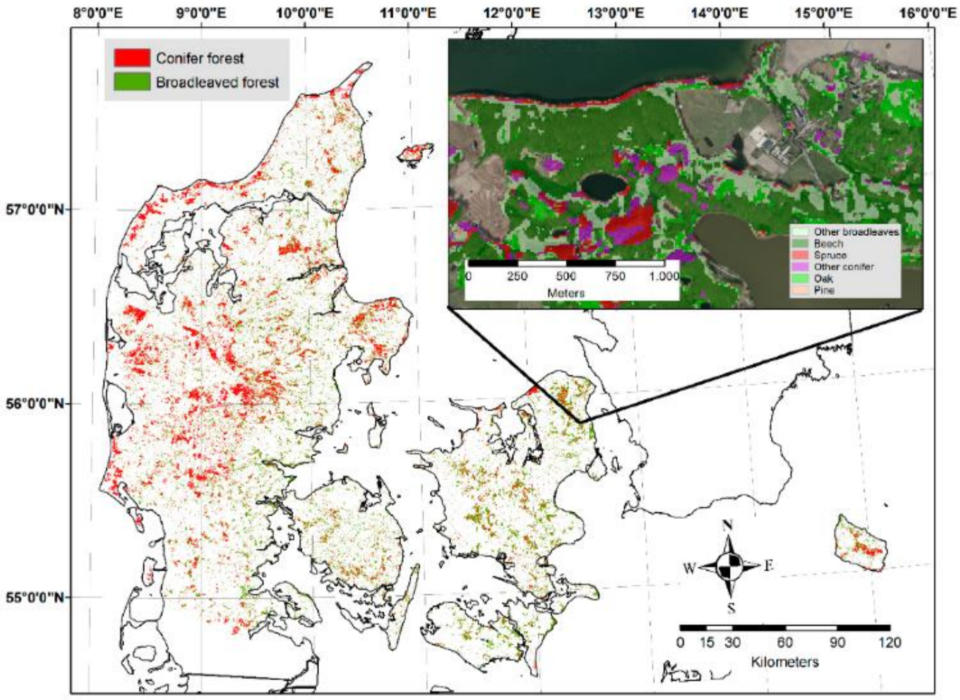


7.2.2. Forest mapping

The data from the first NFI have been used for training and validation purposes in the development of the European Joint Research Centre (JRC) Forest Map 2000 and for development of a Danish land cover map, under the Global Service Element on Forest Monitoring project (GSE-FM).

Data from the last NFI were also used by Magnussen et al. (2018), to estimate forest volume and biomass at the national scale, with ALS data and a national land-use map. While, using multitemporal Sentinel-1 and 2 satellite data, Bjerreskov et al. (2021), classified the Danish landscape into forest/non-forest and then into forest types (broadleaf/coniferous) and species groups, using a cloud-based approach and a random forest classifier trained with data from the NFI.

Figure 15 Forest cover map of Denmark 2018 (Bjerreskov et al., 2021).

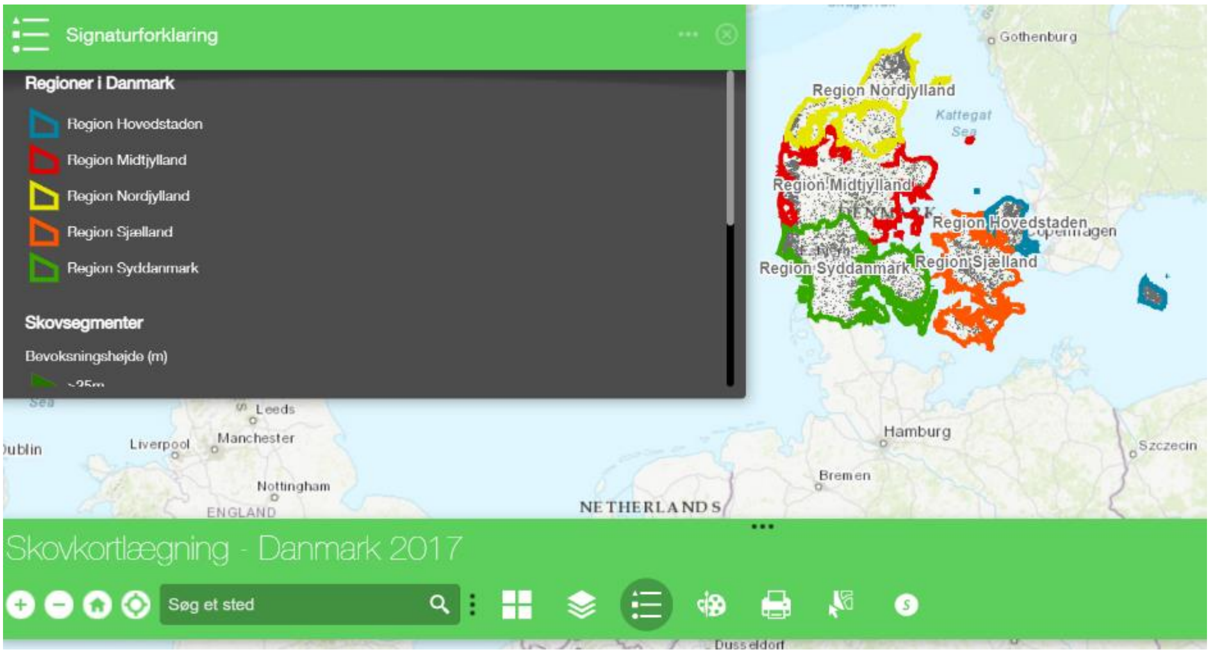


7.2.3. Map of forest resources

Since the beginning of Danish NFI in 2002, a regular combination of ground truth data form the NFI and remote sensing for provision of updated mapping of forest resources in Denmark was developed. Ad-hoc mappings are publicly available in online GIS-visualization, and for download.

The map of forest resources was created based on a nationwide ALS that was carried out for the Agency for Data Supply and Efficiency in 2014-15. The mapping includes estimates for stand height, standing wood mass, above-ground live biomass and total live biomass, estimated for forest in fields of 25 x 25 m. The map is made based on models that describe the connection between the laser scanning and data collected on Denmark's forest statistics sample areas.

Figure 16 Map of canopy height per Danish regions (Map of forest resources, web-gis visualization)



The applicability of the map in practice has been tested at Frederiksdal Forest District. The test showed a good correlation for both stand height and wood mass. The strength of the forest resource map is that it is based on an actual measurement. It must be compared with the previous practice, where the wood mass is determined at best by measuring the height of a few trees and entering a growth overview.

Until now it has not been prioritized by the funding authorities to secure regular mapping.

7.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Denmark.

Table 25 Denmark: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	Complete	5y		yes				
Forest biomass	NFI	National	Complete	5y		yes				
Forest carbon	NFI	National	Complete	5y		yes				
Tree age	NFI	National	Complete	5y		yes				
Canopy height	NFI	National	Complete	5y		yes				
Forest structural diversity	NFI	National	Complete	5y		yes				
Forest soil properties										
Forest/tree cover change										
Tree age diversity										
Tree species/composition	NFI	National	Complete	5y		yes				
Tree species diversity										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest type	NFI	National	Complete	5y		yes				
Deadwood	NFI	National	Complete	5y		yes				
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested										
Ratio of annual fellings to annual increments										
Forest revenue	SD	National	Complete	1y					x	yes - public
Roundwood prices										
Forest products trade	SD	National	Complete	1y					x	yes - public
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health	NFI	National	Complete	5y		yes				
Forest growth										
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										
Consumption of energy by source	DEA	National	Complete	1y					x	yes - public
Production of energy by source	DEA	National	Complete	1y					x	yes - public

7.2.5. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in Denmark.

Table 26 Denmark: SWOT analysis

Strengths	**Weaknesses**
Denmark has a well-established NFI that is able to report robust statistics for a large number of forest variables. The availability of ALS data throughout the country allowed the development of wall-to-wall maps of numerous forest variables	The web-gis in which the official forest maps are implemented is only available in Danish.
Opportunities	Threats
Improved integration of different remote sensing data sources. Possible extension of NFI with socioeconomic parameters. Provision of additional mapping of forest interest such as disturbances, biodiversity, etc.	Along with the next rounds of NFI, ALS surveys on which the forest maps are based should also be planned; No priority to secure regular mapping by funding authority

7.3. Main planning tools at national or, where appropriate, regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 27 Overview of planning and reporting instruments

Thematic area	**Main Strategic reference**	**Summary of planning elements**
Forest resource status and trends	National Forest Programme 2018	Increase forest cover; Convert to more natural form of forest management based on permanent forest cover with tree species adapted to local conditions, specifically native tree species.
	National Forest Inventory	Current data on forests
	National Forest Act 2018	Increase forest cover; Prohibit the conversion of most forests to other land uses; monitor of forests and data collection.
Biodiversity	National Forest Programme 2018	Long-term conversion to near-to-nature forest management principles and 10% of the national forest area having biodiversity as the most important management objective by 2040.
	National Forest Act, 2017	Preserve and increase biodiversity of forests; establishment and management of protected areas

Thematic area	Main Strategic reference	Summary of planning elements
	Nature Packages (Naturpakken) 2016	Set a target for set-aside areas at 20% of state forests with the aim of biodiversity protection. Create a grant scheme for private owners to incentivise set-aside areas. Improved environmental monitoring.
	Biodiversity Strategy 2014-2020, 2014	Aim to halt biodiversity loss. Establish a Green Map of Denmark depicting both the existing nature, and where municipalities have planned for new nature. It includes biodiversity layers showing most important habitats for threatened species (also outside Natura2000 areas). Focus areas include: more and better interconnected nature, strengthened initiatives for fauna and flora, importance of societiy's nature experiences and outdoor activities.
Bioeconomy	Energy Political Agreement 2018	Speed up the transition from coal-based heat and power to biomass-based platforms allows for grants to be provided for biomass-based production of electricity. The Political Agreement was updated in 2018.
	Promotion of Renewable Energy Act 2018	Promote the use of renewable energy sources, which includes, a.o., biomass energy sources.
Ecosystem services	National Forest Act 2018	The act promotes SFM and acknowledges that SFM should have the aim to, a.o., ensure that landscape, natural and cultural history, environmental protection and outdoor recreation are taken into account.
	Hunting and Game Management Act 2018	Balancing the need for recreational activities while ensuring the protection of wildlife (includes regulations related to hunting, but also protection of the wildlife habitat such as prohibition of felling of certain trees).
	National Forest Programme 2018	Sets out a range of strategic orientation lines and concrete actions to underpin a multifunctional and sustainable development of Danish forest; Maintain and develop the forests as a benefit for public welfare through opportunities for outdoor recreation and nature experience in the forests (e.g. everyman's right).
Climate change	National Forest Act 2018	Promote the development of robust forests.
	National Forest Programme 2018	Increase the uptake and stocks of carbon in forests and wood products through sustainable management; Strengthen the forests' contribution to climate adaptation; mitigate climate change; subsidies for private forests that are robust with high proportion of native tree species that are considered to be adaptable to climate change.
	Promotion of Renewable Energy Act 2018	promote the production of energy using renewable energy sources in accordance with climate and environmental as well as socio-economic considerations with a view to reducing dependence on

Thematic area	Main Strategic reference	Summary of planning elements
		fossil fuels, ensuring security of supply and reducing the emission of CO_2 and other greenhouse gases.
	National Forestry Accounting Plan 2021-2030, 2019	Climate change parameters indirectly included in in the Danish forest reference level
	Denmark's Integrated National Energy and Climate Plan 2021-2030	Ensure that emissions do not exceed removals as accounted in the LULUCF sector

7.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 28 Denmark: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	No information
Ecosystem services	Finding balance between use and conservation; Grant schemes prioritize only a few services, which might hinder incentives for multifunctional services. No specific reference found to “ecosystem services” in policy documents.
Interest conflicts	Balancing afforestion and the expansion of the Danish forest cover targets with several competing interests for land use, such as agriculture.
Private forest owners	No information
Biodiversity conservation	No information
Bioeconomy	Although renewable energy, including biomass, is high on the political agenda, it is not clear to what extent wood-based energy is included. No National Bioenergy Strategy could be found.
Forest fires	No information
Desertification	No information
Population-related challenges	Densely populated country, with not enough forest resources to satisfy all the demands (causing trade-offs, but also the need to import)
Financing	Grant schemes and other incentives tend to focus on only one or a few key criteria for prioritization. Multifunctionality as such can be harder to provide incentives for; Implementation in practise of public procurement policies of timber remains an ongoing challenge, in spite of binding obligations for central government and voluntary guidance to facilitate implementation.
Governance	No information

7.4. References

Bjerreskov, K. S., Nord-Larsen, T., & Fensholt, R. (2021). Classification of nemoral forests with fusion of multi-temporal sentinel-1 and 2 data. Remote Sensing, 13(5), 950. https://doi.org/10.3390/rs13050950

FAO (2000) Forest Resources of Europe, CIS, North America, Australia, Japan and New Zealand (industrialized temperate/boreal countries. UN-ECE/FAO contribution to the Global Forest Resources Assessment 2000. Main report. Geneva Timber and Forest Study Papers, 17. United Nations. 445 p

Johansen VK (2003) Designing a sample-based National Forest Inventory for Denmark – data handling and analysis. Life Environment project: demonstration of methods to monitor sustainable forestry EU/LIFE project 1998–2001 (LIFE98ENV/S/000478)

Larsen PH, Johannsen VK (eds) (2002) Forests and plantations 2000. Danmarks Statistik, Skov & Landskab, Skov- og Naturstyrelsen, Copenhagen, 171 p (in Danish)

Magnussen, S., Nord-Larsen, T., & Riis-Nielsen, T. (2018). Lidar supported estimators of wood volume and aboveground biomass from the Danish national forest inventory (2012–2016). Remote Sensing of Environment, 211, 146-153. https://doi.org/10.1016/j.rse.2018.04.015

Nord-Larsen, T., & Schumacher, J. (2012). Estimation of forest resources from a country wide laser scanning survey and national forest inventory data. Remote Sensing of Environment, 119, 148-157. https://doi.org/10.1016/j.rse.2011.12.022

Nord-Larsen, T., & Johansen, V. K. (2016). Danish national Forest inventory. Design and calculations.(Management DoGaNR, trans.) IGN report, 33.

Nord-Larsen, T., Johannsen, VK., Riis-Nielsen, T., Thomsen, I. M., & Jørgensen, B. B. (2021). Skovstatistik 2020. Institut for Geovidenskab og Naturforvaltning, Københavns Universitet.

Nord-Larsen, T., Riis-Nielsen, T., & Ottosen, M. B. (2017). Forest resource map of Denmark. Mapping of Danish forest resources using ALS from 2014, 15. Department of Geosciences and Natural Resource Management, University of Copenhagen, Frederiksberg.

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report, 2020: Microsoft Word - QL_questions-responses_DNK (foresteurope.org)

Danish National Forest Programme, 2018: https://mfvm.dk/fileadmin/user_upload/MFVM/Nyheder/Danmarks_nationale_skovprogram_2018.pdf

National Forest Act, 2017 : https://www.retsinformation.dk/eli/lta/2017/122

Nature Package (Naturpakken), 2016: https://mst.dk/media/114023/natturpakke-2016.pdf

Biodiversity Strategy : https://mst.dk/media/115610/naturplan-danmark-vores-faelles-natur.pdf

Energy Political Agreement, 2018: https://en.kefm.dk/Media/C/5/Energy%20Agreement%202018%20a-webtilg%C3%A6ngelig.pdf

Promotion of Renewable Energy Act, 2018: https://www.retsinformation.dk/eli/lta/2018/1194

Hunting and Game Management Act, 2018: https://www.retsinformation.dk/eli/lta/2018/270

Danish National Forest Accounting Plan 2021-2030, 2019: https://kefm.dk/media/7113/dnfap_revised_2019_web20191219.pdf

National Forest Inventory: https://ign.ku.dk/english/employees/forest-nature-biomass/?pure=en%2Fpublications%2Fdanish-national-forest-inventory(1b6fa271-2ca6-4eac-8bb3-666c7edacecc).html

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-09/csp-at-a-glance-denmark_en.pdf

Denmark's Integrated National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-01/dk_final_necp_main_en_0.pdf

8. ESTONIA

8.1. Country overview – major forest facts

8.1.1. Key forest data

Estonia, a Baltic country, has a forest cover of almost 49% (i.e. stocked forest land). The first large-scale stand-wise forest inventory for Estonia was started 100 years ago. Now there is a continuous sample-plot based national forest inventory, with methodological revisions at five-year intervals, which provides most of the data for policy makers and international reporting. Almost all managed forests are covered by a forest management plan or equivalent. Management plans are required for state forests. In private forests up-to-date inventory data are considered to be equal to the management plan. The up-to-date stand-wise inventory data of all state forests and 70% of private forests is available in digital, publicly available on-line Forest Registry for planning purposes to provide wood and other forest products and ecosystem services in the long run. Nearly 2/3 of Estonia forests (including most state owned and ca 300 thousand ha of private forests) are under a third part certification scheme (e.g. FSC and PEFC). The most common tree species in Estonian forests include, in different mixtures, Norway spruce, birch, Scots pine and grey alder. The forest area has been expanding steadily since the 1950s, and the growing stock has also been growing, reaching 203 m3/ha in 2020. Above ground biomass stock has been decreasing at about 2% in last year. The carbon stock in harvested wood products is estimated at 9 million tons of carbon. In 2020, 26.8% of the forested area were protected under different protection regimes for biodiversity conservation, 14.9% of the forested area is under strict protection and 11.9% under protection with limited management options.

8.1.2. Institutional setup and legal framework

The Ministry of Environment is responsible for forests in Estonia, specifically the Forest Department. The Forest Act was approved in 2006 by Parliament. There is a Forest Policy (adopted in 1997). The Act was amended in 2013, in order to implement the Estonian National Forest Programme 2020. The implementation plan of the Estonian National Forest Programme for 2016-2020 was approved by the Estonian Government in 2015. Estonian Forestry Development plans have been compiled for 2001-2010 and 2011-2020. The process to develop a forest strategy to 2030 was launched in 2019.

8.1.3. Key actors and stakeholder organisations

Forest Department of the Ministry of the Environment; Estonian Environment Agency; State Forest Management Centre (RMK); Private Forest Centre (PFC); Eesti Erametsaliit (Estonian Private Forest Union); Estonian Forest and Wood Industries Association; Estonian Chamber of Agriculture and Commerce; Estonian Fund for Nature (ELF); Erametsakeskus (Local forest owners associations); NaTourEst.

8.1.4. Forest ownership

46% State forests, 5% other state land, 27% Privately owned (individuals); 21% Privately owned (companies/legal persons).

8.1.5. Forest industry

Removals were low after the recovery of independence, but rapidly reached 9 million m3 u.b. in 2000, even 10.5 million m3 u.b. in 2001. Since then they have fluctuated according to market conditions and nearly reached 10 million m3 u.b. in 2016. The ratio of fellings to net annual increment in the most recent period is 83%. Employment in the forest sector was 27 thousand people in 2016, of which about two thirds in the wood processing industries. In 2015, nearly 20% of Estonian primary energy supply came from wood.

8.1.6. Key forestry issues

More efforts should be made to use wood in construction and for bio-based energy.

The continuing fragmentation and loss of Estonia's characteristic habitat types and populations of important species and their habitats is problematic.

Private forest owners need support, also from forest experts.

8.2. Forest monitoring

8.2.1. National Forest Inventory

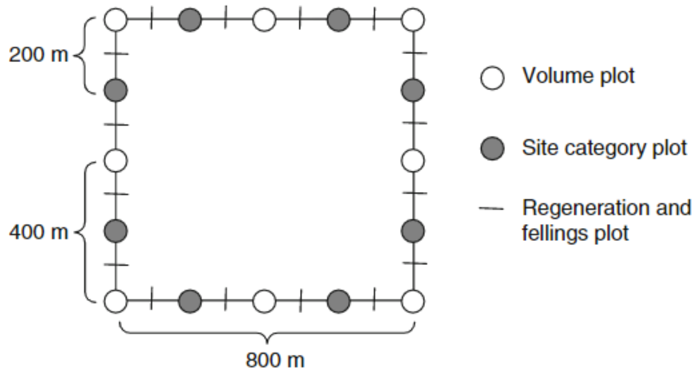
Half of the Estonian territory is covered by forests, and large-scale, regular (every 10 years) forest management inventories were conducted until the 1990s. However, even if forest management inventories would give a complete overview of the national forests, results were updated occasionally (Lang et al., 2021).

After Estonia re-gained independence in 1991, a need for new, consistent forest inventory methods intensified. The first Estonian National Forest Inventory started in 1999, covering the whole country (Adermann, 2010). The Estonian Forest Survey Centre conducted the NFI in 1999–2002. After its liquidation in 2003, the Department of NFI continued its work as a sub-unit of the administrative institution the Centre of Forest Protection and Silviculture. It was responsible for the inventories, planning of the design and estimation methods, field assessments, as well as calculation and publication of the results.

The last NFI campaign took place between 2014 and 2018.

The NFI is based on a grid of sample plots, covering the entire country, a quarter of which is permanent and re-measured every five years. The sample distribution is based on a national 5 x 5 km quadrangular grid, and the sampling intensity is the same throughout the country. The method of sampling with partial replacement is used. Plots are divided into permanent and temporary clusters, that form 800 x 800 m squares. Three types of circular sample plots are used: volume sample plots (divided into permanent and temporary, with radii 10 m and 7 m respectively), site category plots (radius 20 m), and regeneration and felling plots (radius 1-7 m, less than 10 m).

Figure 17 Cluster and location of Estonian sample pots in NFI2 (Adermann, 2010)



Since 2014, forest sampling has been conducted with increasing frequency, to ensure the re-measurement of permanent plots every 5 years (Lang et al., 2021).

The Estonian NFI is designed as a systematic sample without pre-stratification (Adermann, 2010). It covers all land uses classes, including protected forests.

The information collected during NFI represents the basis for national and international statistics in the country, such as FRA, MCPFE, and LULUCF reports. Since 2005, the data measured and recorded by the NFI includes land that satisfies the UNECE/FAO and FRA 2005 definition for forest land, also that which does not necessarily qualify as forest land in Estonia due to the Forest Act. This dual forest area calculation using definitions simultaneously enables the submission of better estimates for international reports.

8.2.2. Forest mapping

The remote-sensing support system of the Estonian NFI is based on data from the European Union Copernicus programme, from the NASA/USGS Landsat programme, and from the airborne photography and laser scanning programme of the Estonian Land Board (Lang, 2021). Sentinel-2 and Landsat images (resolution 10 m and 30 m, respectively) are used for the prediction of tree species composition and for the detection of changes in forests. Data are available through the data center ESThub (2016).

Aerial photography and ALS are conducted by the Estonian Land Board under a repetition schema that provides either summer or springtime data in each second year. It additionally produces measurements from each similar growth season after every four years (Maa-amet, 2020). The point density of the archived ALS data ranges from 0.15 to 2 points m^{-2}. The ALS pulse footprint diameter at canopy level is about 0.5 m, with a scanning angle that does not exceed 30° from nadir. Data are distributed according to a 1 km^2 map sheet system (Maa-amet, 2019).

In the Estonian NFI, orthophotos are currently used only for visual interpretation for the estimation of land cover type, during the preparation of the fieldwork agenda.

A recent paper explored the potential use in NFI of ALS data, for the prediction of forest height and volume for Estonian forests (Lang et al., 2021). Ancillary data sources were a 1:10,000 base map and soil map of Estonia, the forest management inventory database with its stand-level forest-management inventory data, and a digital terrain model provided by the Estonian Land Board.

8.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Estonia.

Table 29 Estonia: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	NFI	National	Complete	5y		yes				
Forest biomass	NFI	National	Complete	5y		yes				
Forest carbon	StatEE	National	Complete	1y						
Tree age	NFI	National	Complete	5y		yes				
Canopy height										
Forest structural diversity										
Forest soil properties										
Forest/tree cover change	NFI	National	Complete	5y	LULUCF	yes				
Tree age diversity	NFI	National	Complete	5y		yes				
Tree species/composition	NFI	National	Complete	5y		yes				
Tree species diversity	NFI			5y						
Forest type	NFI			5y						
Deadwood	NFI	National	Complete	5y		yes				
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	NFI	National	Complete	5y	Natura2000	yes				
Silvicultural system	NFI	National	Complete	5y		yes				
Main management objectives	NFI	National	Complete	5y		yes				
Forest area covered by a management plan	NFI	National	Complete	5y		yes				
Volume of wood harvested	NFI	National	Complete	5y						
Ratio of annual fellings to annual increments	StatEE	National	Complete	1y						
Forest revenue										
Roundwood prices	LUKE	National		1m						
Forest products trade	LUKE	National		1m						
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	StatEE	National	Complete	1y						
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										

8.2.4. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in Estonia.

Table 30 Estonia: SWOT analysis

Strengths	Weaknesses
A well-established NFI.	NFI-based statistics are presented at country level only; Estonian NFI lacks of the integration of remote sensing and earth observation.
Opportunities	**Threats**
Current national forest monitoring plan could be implemented using Remote Sensing techniques at national level.	Lack of sufficient field observation to provide forest information at smaller land units (i.e., municipalities).

8.3. Main planning tools at national or, where appropriate, regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 31 Estonia: Overview of planning and reporting instruments

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Forest Act 2006	Sets minimal rotation ages for tree species (based on a balance between economic and ecologic goals). Sets restrictions to final felling maximum areas that are site specific.
	Estonian Forestry Development Programme until 2020	Overview of forest resources and forest use planning

Thematic area	Main Strategic reference	Summary of planning elements
	National Forest Inventory 2021	Current data on forests
	National Register of Forest Resource Accounting	Forest register is to collect and store data on the location, area, stock, use and condition of the forest
Biodiversity	Estonian Environmental Strategy 2030	Acknowledges the role forests play in biodiversity. Several references to the potential trade-offs with biodiversity that needs to be taken into consideration (eg. Economic)
	Forest Act 2006	Purpose of the act is to ensure SFM also to enhance and protect biodiversity. Regulates the protection of woodland key habitats. Allows to restrict or prohibit economic activities in a key habitat on the basis of the key habitat protection objective.
	Estonian Forestry Development Programme until 2020	Sets the objective to have at least 10% of forest area under strict protection to maintain a good status of endangered species and populations inherent to Estonia.
	Climate Change Adaptation Development Plan until 2030	Acknowledges the impact of climate changes on biodiversity. Attention to the protection of biodiversity must be paid at the local, regional as well as the global level. It is essential to prevent (also monitor) the spread of invasive alien species. Highlights development and innovation trends that help increase carbon sequestration and find alternative ways of using wood.
Bioeconomy	General Principles of Climate Policy until 2050	Promotes SFM and the positive effect it has on the carbon stock.
	Climate Change Adaptation Development Plan until 2030	The use of wood is continuously promoted and the carbon stock in wood products and buildings is increased, thereby replacing the use of non-renewable natural resources.
	Estonian Forestry Development Programme until 2020	Sets the objectives to use wood as a renewable resource in industry and energy sector up to the amount of annual increment. Wood industry is inclining towards long term-wood products incl wooden houses. Proportion of wood fuels as resource of primary energy has been ca 16% annually. Transformation of fossil fuel boiler houses into wood fuel ones has been publicly supported.
Ecosystem services	Environmental Development Plan 2030	Acknowledges that functioning and diverse ecosystem services are needed for the provisioning of diverse ecosystem services. Emphasise is placed on clean water, air, food, good soil quality, adaptation to climate change. Acknowledges the value society attaches to forests and its ecosystem services, including cultural services.

Thematic area	Main Strategic reference	Summary of planning elements
	Forest Europe Report, 2020	Multiple forest functions are ensured and lasting provision of goods and services is enhanced by the implementation of Estonian National Forest Programme 2020, approved by the Parliament. The Programme includes target indicators and measures on wood and non-wood products and services.
	Climate Change Adaptation Development Plan until 2030	Healthy and recoverable ecosystems offer considerable protection against the effects of climate change. Acknowledges the impact of climate changes on ecosystem services. Emphasizes the following services: carbon capture and storage, protection from storms, floods and soil erosion (which are directly linked to climate change), hunting, eco-tourism. There is a need to review the concept of ecosystem services and to reassess the monetary value of at least some of the services
Climate change	Climate Change Adaptation Development Plan until 2030	National strategy on climate change adaptation. Acknowledges the dangers of climate change to forests, as well as the role forests play in climate change adaptation and mitigation.
	General Principles of Climate Policy until 2050	A low carbon strategy. Acknowledges the role of forests in climate adaptation and mitigation (including in bioeconomy), and the importance of SFM in this regard. Promotes SFM and the positive effect it has on the carbon stock.
	National Forestry Accounting Plan 2021-2025	Trends on the Forest Reference Level, GHG emissions and carbon storage.
	Estonia 2035 Action Plan of the Government of the Republic	According to the strategy, by 2050 Estonia is a climate-neutral country with a knowledge-based society and economy ensuring a high-quality and diverse living environment as well as readiness and capacity to reduce unfavourable effects of climate change and make the best possible use of the positive effects. The precondition for implementing the objectives of sustainable development is consistent development of the cultural, social, environmental and economic aspects.
	Estonia's 2030 National Energy and Climate Plan 2021-2030	Key objective: Achieve a 13% reduction of GHG emissions by 2030 compared to 2005 levels in the sectors falling under the scope of the Shared Effort Regulation (transport, small-scale power, agriculture, waste management, forestry, industry)

8.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 32 Estonia: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Further research/scientific knowledge is needed about the climate change implications to silviculture to provide answers about best management practices and forest reproductive material.
Ecosystem services	Collection of data of multiple use of forests and balancing different functions as well as goods and services remains a challenge also for the future.
Interest conflicts	Collection of data of multiple use of forests and balancing different functions as well as goods and services remains a challenge also for the future.
Private forest owners	Encourage assistance from forest experts (or capacity building) for private forest owners to conduct SFM, particularly focusing on nature protection but also the economic benefits of forest (including its multiple services)
Biodiversity conservation	The protection of a representative and balanced selection of different forest site types; protection of primary and old-gowth forests
Bioeconomy	The potential of low-value broad-leaved wood suitable for energy production and chemical processing has not been fully used. As a result, an opportunity of creating additional green jobs and using renewable material remains to be unleashed.
Forest fires	No information
Desertification	No information
Population-related challenges	Promote communication actions and awareness of the public opinion on the role of forest and forest products
Financing	No information
Governance	No information

8.4. References

Adermann in: Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

ESTHub. 2016. Smart infrastructure development plan for year 2016. (2016. a nutika teenuste taristu arendamise toetamise investeeringute kava nr 5). Majandus- ja Kommunikatsiooniministeerium. – Käskkiri 22.11.16 nr 16-0334. (In Estonian).

Lang, M., Sims, A., Pärna, K., Kangro, R., Möls, M., Mõistus, M., ... & Rennel, M. (2021). Remote-sensing support for the Estonian National Forest Inventory, facilitating the construction of maps for forest height, standing-wood volume, and tree species composition. Forestry Studies, 73(1), 77-97. https://doi.org/10.2478/fsmu-2020-0016

Maa-amet (2019). Map sheet indexes and coordinates systems. Site: https://geoportaal.maaamet.ee/eng/Spatial-Data/Map-Sheet-Indexes-and-Coordinate-Systems-p359.html. Accessed on 02/01/2023

Maa-amet (2020). Orthophoto metadata by year.

https://geoportaal.maaamet.ee/eng/Spatial-Data/Orthophotos/Orthophoto-metadata-by-year-p350.html. Accessed on 02/01/2023

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_EST (foresteurope.org)

National Forest Inventory, 2021 : https://keskkonnaportaal.ee/sites/default/files/Teemad/Mets/SMI2021_tulemused.pdf

Lang et al., 2018: https://www.researchgate.net/publication/329655291_Construction_of_tree_species_composition_map_of_Estonia_using_multispectral_satellite_images_soil_map_and_a_random_forest_algorithm/link/5c13b27fa6fdcc494ff3cd6d/download

Yearbook Forests, 2020: https://keskkonnaportaal.ee/sites/default/files/Teemad/Mets/Mets2020.pdf

Forest Act, 2006 : https://www.riigiteataja.ee/en/eli/521032019004/consolide

Estonian forestry development plan until 2020, 2022: https://envir.ee/media/7243/download

National Forestry Accounting Plan 2021-2025, 2019: https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwiz8pX5oJH6AhUCksMKHQnwDPIQFnoECAQQAQ&url=https%3A%2F%2Fenvir.ee%2Fmedia%2F1032%2Fdownload&usg=AOvVaw1p62JZVnCV-gtcz_fGZkyR

Estonian Environmental Strategy 2030; https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjkg4eQvZH6AhX_AxAIHdDNDOcQFnoECAwQAQ&url=https%3A%2F%2Fenvir.ee%2Fen%2Fmedia%2F2042%2Fdownload&usg=AOvVaw1wx3HjVkofR2NUzEPLHICB

Climate Change Adaptation Development Plan until 2030, https://www.google.com/url?sa=t&rct=j&q=&esrc=s&source=web&cd=&cad=rja&uact=8&ved=2ahUKEwjk7Jmq45H6AhXvh4sKHepnDJgQFnoECA0QAQ&url=https%3A%2F%2Fenvir.ee%2Fmedia%2F912%2Fdownload&usg=AOvVaw0TRNNZeOtDy6bbLfl7AP32

General Principles of Climate Policy until 2050: https://www.riigiteataja.ee/akt/307042017001

National Register of Forest Resource Accounting, 2017: https://www.riigiteataja.ee/akt/129082017002

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-estonia_en.pdf

Estonia’s 2030 National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2022-08/ee_final_necp_main_en.pdf

9. FINLAND

9.1. Country overview – major forest facts

9.1.1. Key forest data

Finland is a Nordic country, the large majority of Finland is in the boreal vegetation zone. Forests cover more than 75% of Finland`s land area, which makes Finland the most forested country in Europe if measured by proportional share. In total, 20,3 Mio ha of land is available for wood production in Finland. There has been little change in forest area, although growing stock has steadily increased. Four tree species naturally dominate the Finnish forests: Norway spruce, Scots pine, Downy birch and silver birch. Forest growth exceeds harvesting, which leaves Finland with a positive increment balance. All Finnish forests are covered under the equivalent of a management plan. This is an official website that provides access to forest data of private forest properties, with silvicultural recommendations that are not compulsory. Nearly 90% of Finnish forests are under third party certification schemes, mostly PEFC. Over 18% of forest and other wooded land is protected for biodiversity. Just over 200 thousand ha of forest are considered undisturbed by man.

9.1.2. Institutional setup and legal framework

The major principle of the Finnish forestry legislation is sustainability. Forest legislation covers among many other law and regulations: the Forest Act, Act on the Financing of Sustainable Forestry, the Forest Management Associations Act, the Act on Metsähallitus and the Act on the Finnish Forestry Centre. The Forest Act is the main law regulating the use of managed forests. Its implementation is monitored by the Finnish Forestry Centre. Finland has a regularly revised, national level NFP, as well as regional ones. There is a continuous forest inventory in place.

9.1.3. Key actors and stakeholder organisations

Ministry of Agriculture and Forestry of Finland.

9.1.4. Forest owners

Finnish Forest Centre / Metsäkeskus (MKK); Metsähallitus (Finnish State Forest Enterprise); Finnish Forest Association / Suomen Metsäyhdistys; The Central Union of Agricultural Producers and Forest Owners / metsätaloustuottajain Keskusliitto (MTK); Metsäteollisuus – Finnish Forest Industries; Finnish Association for Nature Conservation (FANC) / Suomen luonnonsuojeluliitto (SLL); The Finnish Society for Nature and Environment; Sahateollisuus – Finnish Sawmills Association.

9.1.5. Forest ownership

Private forest owners own 60%, the state – 26%, companies (incl. forest industry) own 9% and other entities own 5% of productive forest land. Most of the Finnish forests are owned by family forest owners.

9.1.6. Forest industry

Finland is a major player on international forest product markets. Finland`s annual increment of growing stock is 103 Mio cubic metres each year. In 2021, roundwood removals totalled around 76,3 Mio cubic metres. In 2021, about 74% of the annual increment of the growing stock was harvested. The growing stock has increased over the last 50 years. In 2013-2017, fellings were on average 80% of net annual increment on forest available for wood supply. Wood production is an important objective for many private forest owners; forest industry purchases 80% of its domestic wood from private forest owners. 64 thousand people are employed in the forest sector, about half the number of 1990.

9.1.7. Key forestry issues

Balancing the various aspects of SFM, including climate change mitigation; maintaining good health status of forests and preventing forest damages; work still remains to be done on boosting the production and profitable commercialisation of non-timber forest products.

9.2. Forest monitoring

9.2.1. National Forest Inventory

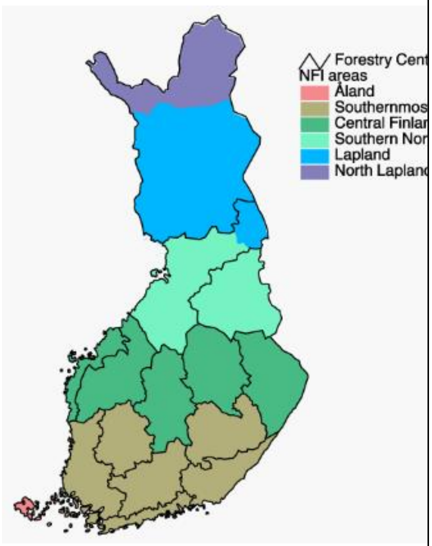
The first National Forest Inventory (NFI) of Finland was undertaken during the period 1921–1924. Since then, NFI's have been repeated on a cycle of approximately 10 years. From the very beginning, NFI's have been based on statistical sampling. The first four inventories applied a line survey method with plot measurements.

Since the 5th NFI (in early 1960s) cluster sampling has been applied. The first inventories were completed in three to four years for the whole country. Since the 1960s NFI's have been done district by district over a longer period as part of a permanent structure within the organization.

The new inventory cycle starts immediately after finishing the previous cycle. Starting from the 10th NFI (2004–2008) a five-year rolling system, so called "panel system" has been used, meaning that one fifth of NFI plots are measured each year over the whole country, and the whole sample is measured in five years. Traditionally, temporary plots have been used, but in the 9th NFI (1996–2003) one fourth of the plot clusters were established as permanent. In 11th NFI (2009-2013) the number of temporary clusters was increased by 25 %, while the number of plots in a cluster was decreased so that the total number of plots remained the same. In the 12th NFI (2014-2018), the field plot type was changed. A fixed radius plot is used, where all trees with diameter ≥ 95 mm are measured up to distance of 9 meters. In addition to this, trees with diameter ≥ 45 mm are measured up to distance of 5.64 meters. Small trees with diameter < 45 mm are measured using a relascope plot with relascope factor 1.5. The new inventory cycle began in 2020. Monitoring of forest resources will be carried out between 2021-2026.

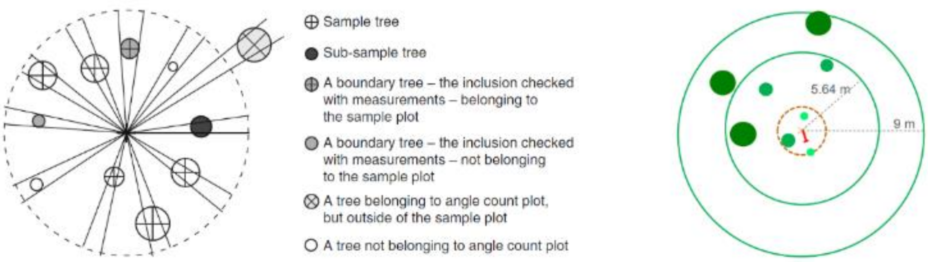
The Finnish NFI is primarily based on a systematic cluster sampling system. Stratified sampling is only applied in Northern Lapland. The distance between clusters, shape of the cluster, number of field plots in a cluster, and distance between plots within a cluster varies in different parts of the country according to spatial variation of forests and the density of roads. The sampling design consists of permanent and temporary clusters. Further information on regional NFI differences are reported below (Luke, 2019).

Area	Distance between temporary clusters	Shape of a cluster	Distance between plots within a cluster	No. of plots in a temporary (permanent) cluster
Åland	To be decided	-	-	- (10)
Southernmost Finland	6 x 6 km	L-shaped	300 m (250 m)	9 (10)S
Central Finland	7 x 7 km	L-shaped (Rectangular)	300 m	11 (14)
Southern North Finland	7 x 7 km	L-shaped	300 m	9 (11)
Lapland and Kuusamo	10 x 10 km	L-shaped	300 m	12 (11)
Nothern Lapland	To be decided	-	-	- (9)



The NFI field data consists of three main categories: stand description (e.g., land use class or forest stand), tree data, and dead tree data

Figure 18 Left: Sample plot as used in NFI10 NFI11. The maximum radius for trees to be counted was 12.52 m in Southern Finland (q = 2) (regions 1–3) and 12.45 m in Northern Finland (q = 1.5) (regions 4–6). Every seventh tree is measured as a sub-sample tree. The trees are counted by crews, starting at the beginning of the field season. Right NFI12: fixed area plot radius 9m: (d≥95mm), radiud 5.64: 45 mm ≤ d ≤ 95 mm (Luke, 2019).



9.2.2. Forest mapping

The Finnish NFI represent the first European example of “Multi-source NFI”, where field data was combined with satellite imagery. Indeed, as - in addition to statistics - Finland was the first country to present NFI results in the form of thematic maps. Hence, the development of MS-NFI began in the Research Forest Institute of Finland (Metla) in 1989, and the first results were calculated in 1990.

The availability of satellite data has changed from the 12th NFI, as Sentinel-2A was launched in 2015. The maps from the Finnish NFI are publicly available.

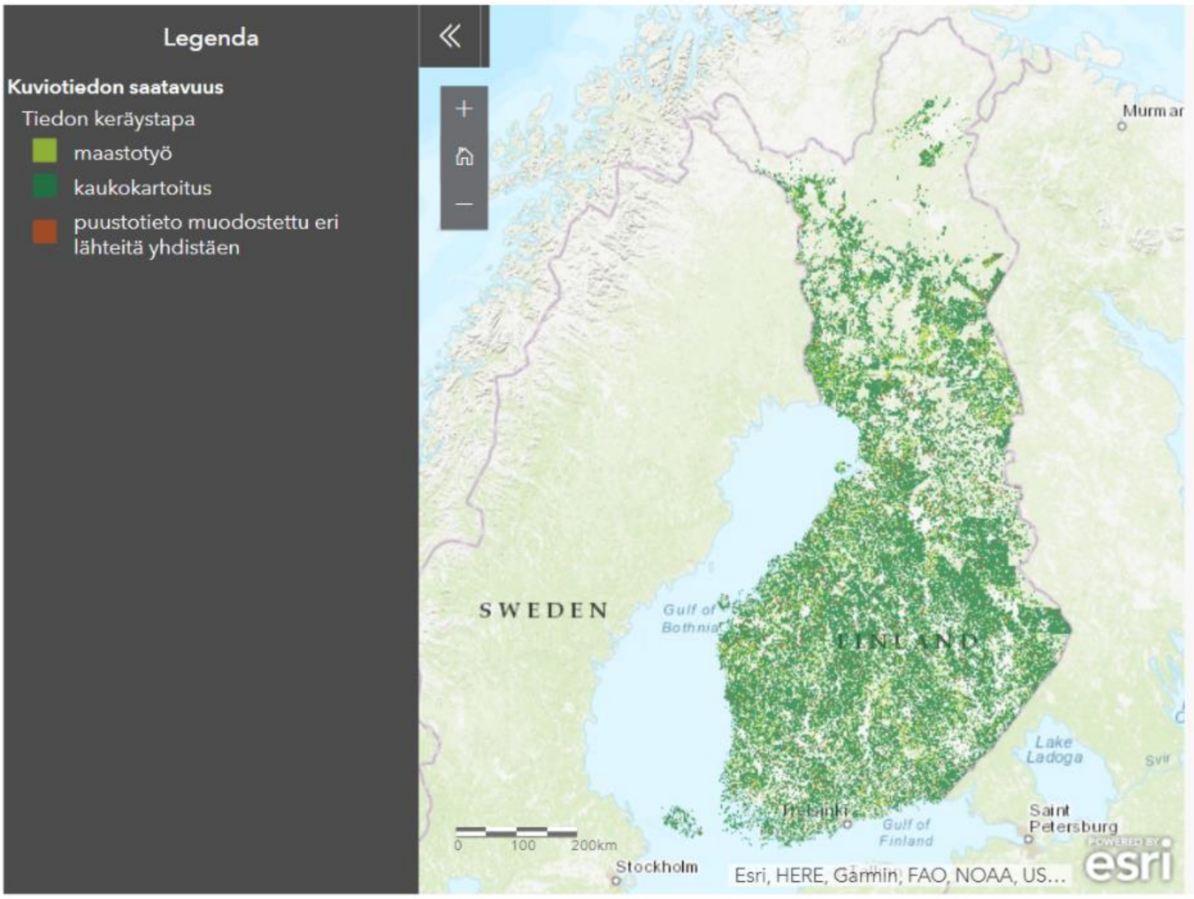
Digital thematic maps can be easily incorporated to a modern GIS system and combined with other geo-referenced data and used for various purposes in forestry (https://kartta.luke.fi/index-en.html). The system allows to download for the years 2006, 2009, 2011, 2013, 2015, 2017, 2019 several forest variables, such as stand height, diameter, basal area, site fertility, biomass (divided into the different components and among forest species), growing stock volume, etc. per map sheet mainly at 16 m resolution.

For the year 2019, the NFI maps (file available as a GeoTIFF) reported information on various themes, as pixel values. For instance, biomass (10kg/ha) for (i) spruce, (ii) broad leaved trees, and (iii) pine are reported, including living branches, stem residuals, roots, stumps, dead branches, stem, barks and foliage. For these species, volume is also represented as a pixel value. Lastly, map includes information also on site-specific characteristics and stand values (age, mean diameter and height).

Moreover, Suomen metsäkeskus (Forestry Centre of Finland - https://www.metsakeskus.fi/) also provides forest resource data, spatially in grid and polygon formats (in Finnish language). The temporal range of this data is more diverse than with MS-NFI, since it is based mainly on laser scanning, which has longer rotation than satellite-based MS-NFI. Hence, the oldest data available is from 2012.

Even if the map does not cover Finland wall-to-wall, since it covers mainly private-owned forests, it could provide very accurate measurements at stand level, especially for height and volume.

Figure 19 Availability of forest resource information from Suomen metsäkeskus across Finland, divided into data collection method (from top: fieldwork, light green; remote sensing, dark green; combination of methods, brown)



The many mapping products available in Finland are the result of a long tradition of research and innovation also related to remote sensing data. As a matter of fact, as noted by Tomppo *et al.* (2008), estimates based on satellite imagery are the most efficient way to obtain estimates of national forest resources in a timely manner.

9.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Finland.

Table 33 Finland: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Notes
Forest/ tree cover	NFI	National	complete	5y	FAO	yes		x		Plot level data available for scientific research on agreement
Forest biomass	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Forest carbon	NFI	National	complete	5y				x		Plot level data available for scientific research on agreement
Tree age	NFI	National	complete	5y		yes		x		Plot level data ava available for scientific research on agreement
Canopy height	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Forest structural diversity	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Forest soil properties	NFi	National	complete	5y		yes		x		Plot level data

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Notes
										available for scientific research on agreement
Forest/tree cover change	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Tree age diversity	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Tree species/composition	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Tree species diversity	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Forest type	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Deadwood	NFI	National	complete	5y		yes		x		Plot level data available for scientific research on agreement
Forest spatial patterns	NFI	16mx16m	complete	2-3y						based on satellite image classification with NFI data
Areas of primary and old-growth forests	NFI	National	complete	5y				x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Notes
Tree health	NFI	National	complete	5y				x		
Forest disturbance	NFI	National	complete	5y						

9.2.4. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in Finland.

Table 34 Finland: SWOT analysis

Strengths	Weaknesses
Finland has a well-established NFI that is able to report robust statistics for a large number of forest variables. Thematic maps are available for any user-defined area in Finland.	Numerous changes in survey procedures between successive cycles. Distribution of plots in the country differentiated and largely related to clusters.
Opportunities	**Threats**
Integration of additional remote sensing data sources at higher spatial or temporal resolution. Integration with forest disturbance mapping.	NFI process requires numerous and specialized personal involved.

9.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 35 Finland: Overview of planning and reporting instruments

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Ministry of Agriculture and Forestry of Finland, Report 2022	Sustainable forestry as central element, multifunctional use of forests
	National Forest Inventory	Current data on forests
Biodiversity	National Forest Strategy 2025	Forest Management and good administration as means to safeguard biodiversity; special attention is paid to southern Finland where there are not many protected territories. In addition to increasing the land area of protected areas their quality needs to be improved.
	Forest biodiversity programme for Southern Finland (METSO)	Voluntary forest protection by forest owners in Southern Finland where the network of protected territories is not as developed as in other parts of Finland. METSO offers various tools for forest owners to do so.
	Strategy for the Conservation and Sustainable Use of Biodiversity, 'Saving Nature for People'	Main objective to halt the loss of biodiversity in Finland by 2020. Places focus on the decision-making concerning the use of natural resources in the economic and cultural values of biodiversity. The strategy also outlined ways to link the traditional knowledge of the Sámi people to the protection of biodiversity. A new National Biodiversity Strategy and Action Plan to 2030 is in the process of being completed.
Bioeconomy	National Forest Strategy 2025	The role of forests, sustainable forest management and forest-based bioeconomy
	The Finnish Bioeconomy Strategy	Forest Strategy as foundation for the Bioeconomy Strategy, from which the marginal conditions related to the availability and growth of Finnish forest biomass can be determined
Ecosystem services	National Forest Strategy 2025	Opportunities for forest owners to engage in gainful activities increase through commercialisation of ecosystem services; Healthy, abundant and biologically diverse forests are a precondition for the maintenance of ecosystem services and the growing and diverse use of forests
	The Finnish Bioeconomy Strategy	Ecosystem services are part of the bioeconomy

Thematic area	Main Strategic reference	Summary of planning elements
Climate change	National Forest Strategy 2025	Climate change mitigation and adaptation are part of ecological sustainability; climate sustainable forestry
	Climate Plan for the land use sector	The Climate Change Plan for the Land Use Sector covers measures targeted at carbon dioxide emissions from agricultural land, forests, land use changes and climate wetland.
	Finland's Integrated Energy and Climate Plan	Multiple references, particularly in relation to LULUCF

9.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 36 Finland: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Balancing the various aspects of SFM, including climate change mitigation, is a challenge. Common knowledge and understanding on the substitution effects of wood products is somewhat lacking and creates challenges when balancing the various aspects of SFM.
Ecosystem services	No information
Interest conflicts	Recent statistics show that urbanisation advances on a rapid pace in Finland, and the average age of rural dwellers gets higher. This is creating challenges for the forestry sector.
Private forest owners	No information
Biodiversity conservation	The forest damages are likely to be a challenge in the future. A balance has to be struck between safeguarding biodiversity and forest protection. The Forest Act and Forest Damages Prevention Act are being evaluated (2019) and thus this balance is currently under scrutiny. Another challenge is to increase the demand for new nature management techniques in commercial forests and also to increase the related know-how of forestry professionals.
Bioeconomy	Work still remains to be done on boosting the production and profitable commercialisation of non-timber forest products. This is emphasized in the revised National Forest Strategy 2025.
Forest fires	No information
Desertification	No information

Major challenge	Summary description
Population-related challenges	No information
Financing	Adequate budget resources for implementing the NFS is a challenge.
Governance	No information

9.4. References

Tomppo, E., Olsson, H., Ståhl, G., Nilsson, M., Hagner, O., & Katila, M. (2008). Combining national forest inventory field plots and remote sensing data for forest databases. *Remote Sensing of Environment*, *112*(5), 1982-1999. https://doi.org/10.1016/j.rse.2007.03.032

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

Ministry of Agriculture an Forestry of Finland, Report 2022: https://mmm.fi/documents/1410837/12877048/Forestry+and+use+of+wood+in+Finland.pdf/2598dc7e-6992-9b97-1773-da94a1e903bd/Forestry+and+use+of+wood+in+Finland.pdf/Forestry+and+use+of+wood+in+Finland.pdf?t=1656487105602

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory: http://www.metla.fi/ohjelma/vmi/info-en.htm

National Forest Strategy: https://www.e-julkaisu.fi/mmm/national-forest-strategy_of_finland-2025/mobile.html#pid=2

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_FIN (foresteurope.org)

Forest biodiversity programme for southern Finland (METSO): https://mmm.fi/en/forests/biodiversity-and-protection/metso-programme

Finland's biodiversity policy: https://ym.fi/en/national-biodiversity-policy

The Finnish Bioeconomy Strategy: https://www.biotalous.fi/wp-content/uploads/2022/05/The-Finnish-Bioeconomy-Strategy-Sustainably-towards-higher-value-added-VN_2022_5.pdf

Climate Plan for the land use sector: https://mmm.fi/en/climate-plan-for-the-land-use-sector#:~:text=Climate%20Change%20Plan%20for%20the%20Land%20Use%20Sector,-This%20year%2C%20a&text=The%20plan%20will%20specify%20the,achieving%20carbon%20neutrality%20by%202035.

National Forest Strategy 2035 (recently adopted): https://mmm.fi/en/nfs2035

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-09/csp-a-a-glance-finland_en.pdf

Finland's Integrated Energy and Climate Plan: https://energy.ec.europa.eu/system/files/2020-01/fi_final_necp_main_en_0.pdf

10. FRANCE

10.1. Country overview – major forest facts

10.1.1. Key forest data

France is a country in western Europe, with 31% forest cover. Most of the forest is covered by deciduous species, coniferous forests can be found mainly in the mountains. The sub-temperate or Mediterranean forests of France are composed of mixtures of coniferous and evergreen trees, with low formations: scrub or scrubland. Tropical forests can be found in France's overseas territories particularly in French Guiana. Over the last quarter century, the area of forest has grown steadily and is now at 31.5% of land area. Growing stock has also expanded, and is now at 177 m3/ha. Above ground biomass increased at 1.4%/ year between 2010 and 2020. 45% of French forests are subject to a management plan or equivalent instrument, which is compulsory for certain categories of forest. 47% of French forests are under third party certification schemes, mostly PEFC. 37% of French forests are reported as protected for conservation of biodiversity, while nearly 7% are designated as protective forests. Most forests in France are considered "semi-natural".

10.1.2. Institutional setup and legal framework

The formal authority for forests is the Forest Code, first promulgated in 1827, and continuously revised since, and *Loi d'avenir pour l'alimentation, l'agriculture et la forêt* (Law for the future of food, agriculture and forests) enacted in 2016. There is an ongoing National Forest and Wood Program (PNFB) (2016-2026). There has been a continuous national forest inventory process since 1958.

10.1.3. Key actors and stakeholder organisations

Ministry of Agriculture; Ministry of Ecological Transition and Territorial Cohesion; National Forestry Office; French Forestry Cooperative Association; Forestry Groups (civil partnership status to encourage reforestation, the improvement and conservation of forested areas, and to drive a healthy forest economy); Private Forest Owners Associations, e.g. La Fédération nationale des Communes forestières; National Institute of Geographic and Forestry Information (IGN) in charge of the NFI.

10.1.4. Forest ownership

French forest is mainly privately owned (74%), with 3.8 million owners, 200,000 of whom own more than 10 ha (representing 68% of the surface area). The public forests, of the State (10%) or of the territorial communities (16%), are managed by the National Forestry Office, a public establishment of an industrial and commercial nature, in accordance with the forestry regime. All public forests (without any threshold) and private forests above 25 ha must present a management document approved by the State.

10.1.5. Forest industry

Over recent decades, French removals have fluctuated between 50 and 65 million m3 u.b. In 2015, on forest available for wood supply, felling was 60% of net annual increment. In 2015, 172 thousand people were employed in the forest sector, a third less than in 1990. Less than a fifth of these work in forestry itself.

10.1.6. Key forestry issues

Addressing challenges such as: forest health, mortality, impacts of climate change, impact of game on forests, etc.

Easy access to on-line platforms providing mapping data and designing new monitoring indicators is needed.

10.2. Forest monitoring

10.2.1. National Forest Inventory

The decision to set the first permanent National Forest Inventory dates back in 1959, when was launched by the Ministry of Agriculture. In 2012, the NFI merged with the National Geographic Institute, forming the "*Institut national de l'information géographique et forestière*" (IGN). The first NFI took place in 1980, and two ten-year cycles followed it.

Until 2004, the NFI was based on a two-phased stratified sampling design of temporary plots, covering one administrative region (NUT3). Each year, approximately eight NUT3 were sampled each year. First phase used a systematic grid, where points were analyzed on aerial photos (0.5 m resolution) to determine land use and the type of vegetation. The second phase sample was a stratified sub-sample of the first phase, which was assessed in the field. The first two cycles were focused on the assessment of wood resources, while additional observations (i.e., botanical and ecological) were introduced in the late 1990s.

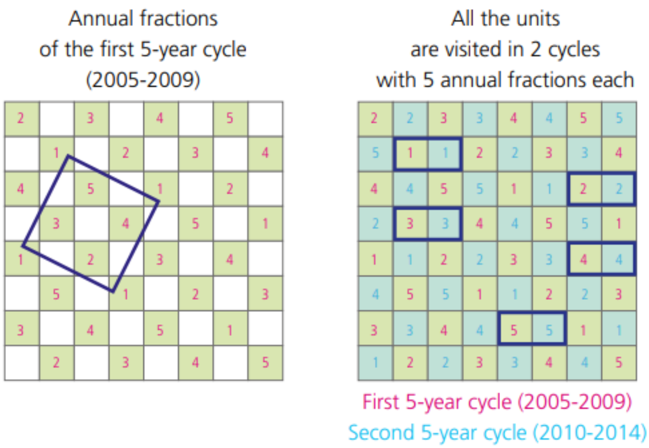
In 2004, the sampling plan was revised into a 5-year cycle (2005-2009). Since 2005, additional assessment were added to enhance the evaluation of sustainability, biomass availability and biodiversity (e.g., sampling deadwood). Furthermore, the data necessary to fulfill reporting obligations of LULUCF were provided.

Since 2007, forest definition adopted by the French NFI was in line with the commonly agreed definitions in COST action E43 (2010).

During the period 2010-2014, the forest field sampled during the 2005-2009 cycle were revised to assess forest cuttings. The last 5-year cycle (2015-2019) assessed both the preceding sample and new plots, to improve the state and change estimates (Hervé, 2016).

Since 2005, the sampling design of the French NFI is continuous in time, with a systematic sample covering the whole country next year. It was designated as a regular square grid of 1 km^{-2} to cover two 5-years periods. Each year, a representative sample of the national forests is visited. It is combinable with the one of the previous years, to produce results on annual samples according to the principle of sliding windows. However, since 2010, the sampling strategy is composed of point systematically revisited 5 years after the first visit.

Figure 20 French National Forest Inventory grid (source: https://inventaire-forestier.ign.fr/)



To limit the costs of fieldwork and data collection, the national territory has been divided into different areas where the sampling density was optimized according to specific characteristics.

Field information is collected on four concentric circular plots of radius 6, 9, 15 and 25 m, respectively. The largest plot is used to assess land cover, stand structure and forest composition. Tree measurements occurred in the three smaller plots, according to the tree circumference at breast height, e.g., smaller trees measured in the smaller plot. Information about tree species, vegetation state, increments and circumference at breast height are collected for all the trees. Attributes such as volume and volume increment are computed from field measurements using NFI's species-specific allometric models (Sagar et al., 2022).

Lying deadwood data are collected on a 12 m transect, centered on the plot. The name of the species (when possible), the diameter of the piece and the decomposition rate are collected.

Figure 21 French NFI circular plots and examples of data inventoried. Source: https://inventaire-forestier.ign.fr/

Results from the French NFI are published, and their consultation is open access.

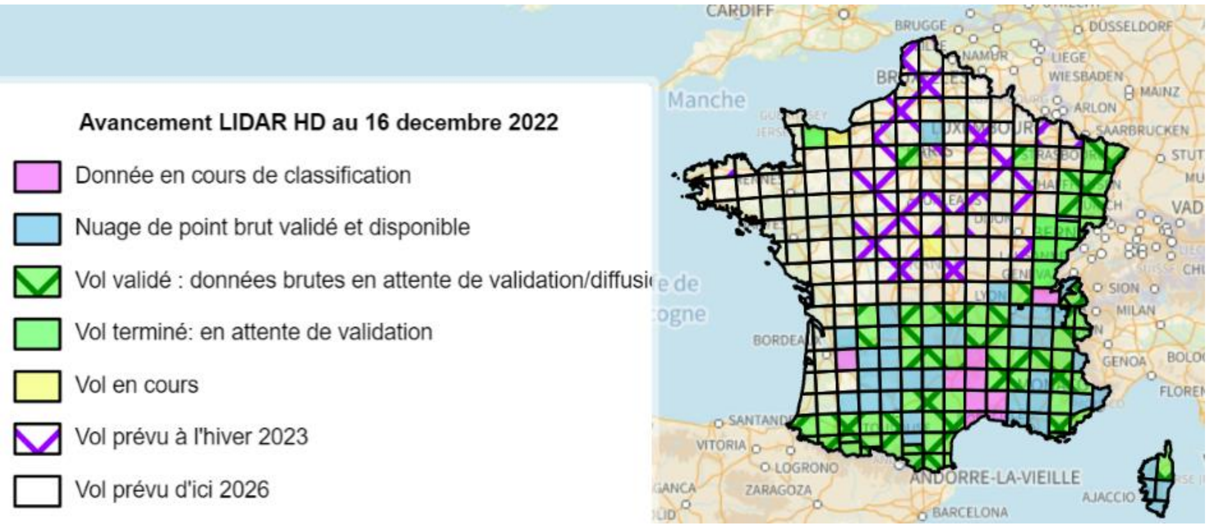
The IGN have been working on the development of a multisource NFI, as a tool to provide reliable estimates of forest resources combining fieldwork and auxiliary information (remote sensing and thematic maps). The data used includes (i) the NFI sampling points, (ii) Landsat imagery (30 m spatial resolution), (iii) structural measurements derived from ALS (1 m resolution), (iv) and the Forest Map (BD Forêt® v2).

10.2.2. Airborne laser scanning (ALS) availability

The IGN oversees the national LiDAR HD program, that provides tridimensional information on the whole country (10 points per square meter, on average). Sequenced over five years, the program aims to provide open-access data: classified point clouds, digital terrain models, digital surface models, and digital height models. The initiative is part of the France Recovery plan deployed by the Franch Government, and the estimated budget for its implementation is 60 mln euros (https://www.ign.fr/institut/lidar-hd-vers-une-nouvelle-cartographie-3d-du-territoire). A period of 5 years (2021 - 2026) is indicated for the achievement of national LiDAR HD coverage and the provision of 3D data relating to the ground and above ground.

All the data acquired and processed within the frameworks (raw and classified point clouds) is available in open access.

Figure 22 Current status of LiDAR HD project coverage at national level. Source: https://macarte.ign.fr

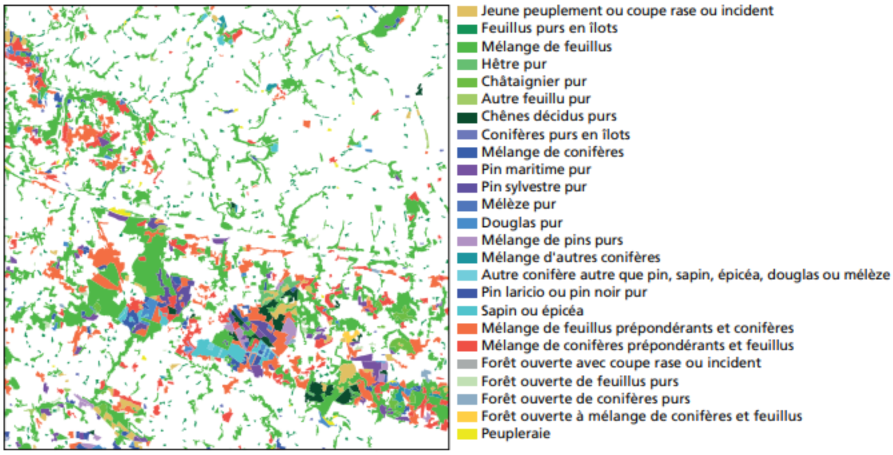


10.2.3. Forest mapping

The BD Forêt® is a vector reference database for forest areas developed by the IGN. Indeed, the French NFI creates high resolution forest maps by administrative county (NUT3) through the manual interpretation of aerial photographs. The first version (BD Forêt® v1) presented the ground cover based on a departmental nomenclature, with a minimum mapping unit of 2.25 ha.

Since 2007, a second version of the BD Forêt® is available. The Forest Types map (BD Forêt® v2) is a vector layer created by photointepretation of near-infrared aerial photographs. This map includes a total of 32 forest classes, with a minimum polygon size of 0.5 ha. The nomenclature reported in the map includes the description of the vegetation type with dominant species.

Figure 23 Detail of the BD Forêt® v2 forest type map (source: https://inventaire-forestier.ign.fr/)



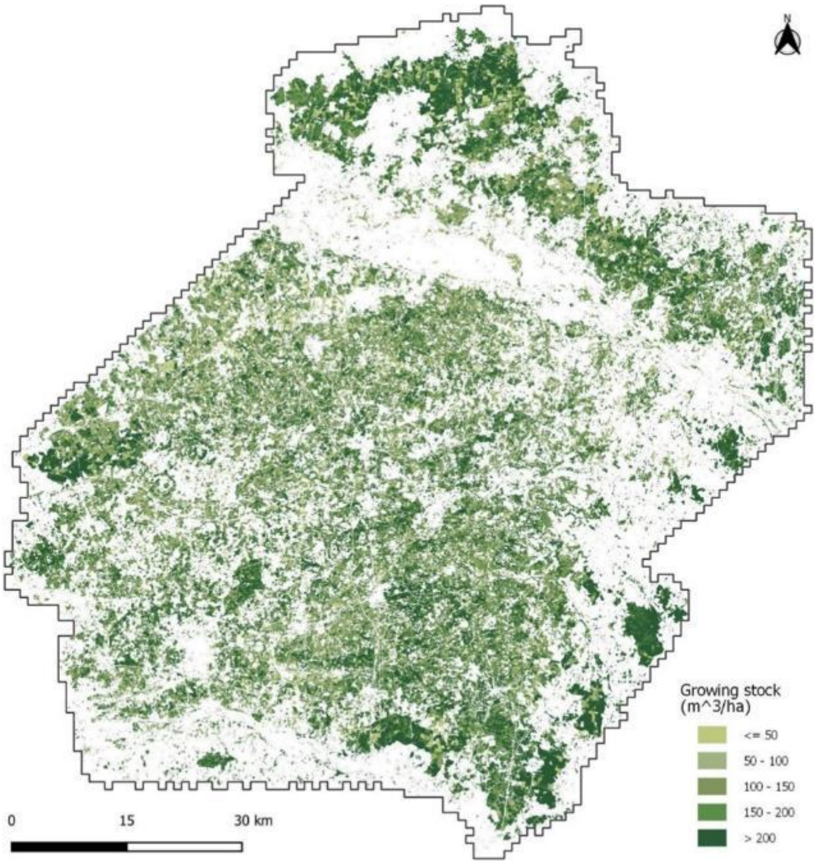
The Forest Type map intervenes at several levels in the French NFI process. Firstly, it makes possible to optimize the sampling stratification according to forest types and their economic value. Secondly, the auxiliary information reported in the BD Forêt v2 improves the statistical precision of the results produced. Without this step, the NFI would have collect information on four times more points to obtain the same precision.

French forest maps developed by the IGN are freely available on GIS online visualization. Since the beginning of 2021, the Forest Types map has been released and it can be downloaded from the website *https://geoservices.ign.fr/foret.*

Recently, external research (Sagar *et al.,* 2022) proposed a method to produce high resolution forest attribute and reliability maps at pixel level, in the forest of Sologne and Orléans, using (among the others) the forest map produced by IGN. Other auxiliary data included Landsat 8 images, ALS 3D point cloud and the Digital Aerial Photogrammetry.

The main forest variables assessed were the forest growing stock and volume increment, along with basal area, at 30 m spatial resolution.

Figure 24 Map of ALS growing stock volume prediction at 30 m spatial resolution, in the forest of Sologne and Orléans (Sagar et al., 2022)



10.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in France.

Table 37 France: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	**Leading data provider**	**Geographical reporting unit**	**Geographical coverage**	**Assessment periodicity**	**Data harmonization**	**Data accuracy**	**Data availability**			
							Raw	**Aggregated**	**Processed**	***Note***
Forest/ tree cover	NFI	National	complete	5y	FAO	yes	x	x	x	yes - public
Forest biomass	NFI	National	complete	5y		yes		x	x	yes - public
Forest carbon	NFI/citepa	National	complete	5y		yes		x		yes - public
Tree age	NFI	National	complete	5y		yes	x	x	x	yes - public
Canopy height	NFI	National	complete	5y		yes	x	x	x	yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest structural diversity	NFI	National	complete	5y		yes		x	x	yes - public
Forest soil properties	NFI	National	complete	5y		yes	x	x	x	yes - public
Forest/tree cover change	NFI	National	complete	5y		yes		x	x	yes - public
Tree age diversity	NFI	National	complete	5y		yes		x	x	yes - public
Tree species/composition	NFI	National	complete	5y		yes	x	x	x	yes - public
Tree species diversity	NFI	National	complete	5y		yes	x	x	x	yes - public
Forest type	NFI	National	complete	5y		yes		x	x	
Deadwood	NFI	National	complete	5y		yes	x	x	x	yes - public
Presence of Red-list species	NFI	National	complete	5y		yes	x			
Abundance of common forest birds	MNHN	National		1y						
Forest spatial patterns	NFI	National	complete	5y		yes	x			yes - public
Areas of primary and old-growth forests	NFI	National	incomplete	5y		yes				
Forest ancientness	IGN	National	incomplete			yes				
Forest area under protection										
Silvicultural system	NFI	National	complete	5y		yes		x	x	yes - public
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NFI	National	complete	5y		yes		x	x	yes - public
Ratio of annual fellings to annual increments	NFI	National	complete	5y		yes		x	x	yes - public
Forest revenue										
Roundwood prices	INSEE	National	complete	1m				x		yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest products trade	INSEE	National	complete	1m				x		yes - public
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies	NFI	National	complete	5y		yes	x	x	x	yes - public
Tree health	NFI and DSF	National	complete	5y		yes	x	x	x	yes - public
Forest growth	NFI	National	complete	5y		yes	x	x	x	yes - public
Occurrence of forest fires	BDIFF									
Occurrence of storms										
Forest disturbance	DSF	National	Complete, only significative events	1y		yes		x		yes - public
Number of forest fires	BDIFF									
Number of storms										
Forest habitats	NFI	National	complete	5y		yes	x	x	x	yes - public
Harvestability	NFI	National	complete	5y		yes		x	x	yes - public

10.2.5. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in France.

Table 38 France: SWOT analysis

Strengths	Weaknesses
The continuous NFI allows yearly updated national forest statistics; Availability of remote sensing-based forest composition maps; Efficient assessment of major disturbance events.	Forest maps and information are available in local language only. Forest maps with species composition only, wall-to-wall maps of other variables produced for research purposes only.
Opportunities	**Threats**
Multisource forest inventory offers the opportunity to produce wall-to-wall mapping of forest attributes at	Lack of effective communication and accessibility to non-local stakeholders.

high spatial resolution, through the statistical combination of NFI and remote-sensing data.	Absence of wall-to-wall for other forest variables apart from composition.

10.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 39 France: Overview of planning and reporting instruments

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Forestry Office	Informative summary on state of the public forests
	National Forest Inventory	Current data on forests
Biodiversity	National low carbon strategy	The National Biomass Mobilization Strategy (NBMS) encourages forest mobilization through a management adapted to each situation and respectful of biodiversity.
	National Biodiversity Strategy	References to EU and international Biodiversity Strategy targets & acknowledges importance of forests as habitats & means to reduce pressure on biodiversity.
Bioeconomy	National Forest and Wood Program	Reference to the National Bioeconomy Strategy and to the uses of wood
	National low carbon strategy	
	The National Bioeconomy Strategy	Several references about variety of uses of biomass and new materials
Ecosystem services	National low carbon strategy	Reference to ability to store CO2
	The National Bioeconomy Strategy	Sustainable bioeconomy
	National Forest and Wood Program	Promotes multifunctionality. Aims to: - Create value in France by mobilising resources in a sustainable manner; - Respond to citizens' expectations and integrating into territorial projects; - Combine mitigation and adaptation of forests to climate change; - Develop synergies between forest and industry. Refers to many UE policies, including EU Forest Strategy, and international policies
	The National Bioeconomy Strategy	Preservation and restoration of ecosystems and their functioning

Thematic area	Main Strategic reference	Summary of planning elements
Climate change	National Forest and Wood Program (PNFB)	Promotes sustainable management of the resource by taking into account climate change and developing synergies with industry.
	Climate Change Adaptation Strategy	Forests as CO2 sinks & need to model possible scenarios of forest development under climate change
	French Climate Plan	
	Roadmap for forest adaptation to climate change	Roadmap written by stakeholders and public institutions on adaptation of forests to climate change
	Forests Fires Data Base (BDIFF)	National Database on forests fires in France
	Integrated national energy and climate plan	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

10.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 40 France: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Adaptation to climate change; potentially increased impact of pathogens
Ecosystem services	Protection of soils and water quality
Interest conflicts	Promotion of multifunctional management; hunters' interests versus forests' owners interests (big population of game in forests who can jeopardize the forest renewal process)
Private forest owners	Formation of groups of forest owners
Biodiversity conservation	Diversification of tree species
Bioeconomy	Exploitation of wood; developing markets for hardwood products and reduce production costs of hardwood products
Forest fires	Prevention of fires and protection against its destruction

Major challenge	Summary description
Desertification	Afforestation. Protection of soil. Dune fixation.
Population-related challenges	Regional development
Financing	No information
Governance	Creation of jobs and value-added; Settle Regional Forest and Wood Programs (PRFB) and involve local authorities

10.4. References

French NFI website https://inventaire-forestier.ign.fr/spip.php?rubrique74

IGN Institute https://www.ign.fr/institut

Hervé J.C. in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

Sagar, A., Vega, C., Bouriaud, O., Piedallu, C., & Renaud, J. P. (2022). Multisource forest inventories: A model-based approach using k-NN to reconcile forest attributes statistics and map products. ISPRS Journal of Photogrammetry and Remote Sensing, 192, 175-188. https://doi.org/10.1016/j.isprsjprs.2022.08.016

a) The summary in English can be downloaded here: https://agriculture.gouv.fr/le-programme-national-de-la-foret-et-du-bois-2016-2026

Ministry of Agriculture of France, Information page: https://agriculture.gouv.fr/foret-bois

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory: https://inventaire-forestier.ign.fr/ *

Indicators of sustainable forest management: https://foret.ign.fr/IGD/en/ and https://foret.ign.fr/IGD/en/indicateurs/critere1

National Forestry Office: https://www.onf.fr/onf/forets-et-espaces-naturels/+/20::les-forets-de-nos-territoires.html

Forest part of the National Low Carbon Strategy (summary): https://www.ecologie.gouv.fr/sites/default/files/SNBC%20Fiche%20For%C3%AAt.pdf

Forest Europe Report 2020: QL_questions-responses_FRA_2-4-2019_updated2-8-2019.pdf (foresteurope.org)

National Biodiversity Strategy 2011-2020: https://www.cbd.int/doc/world/fr/fr-nbsap-v2-en.pdf

The National Biomass Mobilization Strategy: https://www.ecologie.gouv.fr/sites/default/files/Strat%C3%A9gie%20Nationale%20de%20Mobilisation%20de%20la%20Biomasse.pdf

The National Bioeconomy Strategy, downloaded from Ministry of Agriculture website: https://agriculture.gouv.fr/english-contents

Climate Change Adaptation Strategy: https://www.ecologie.gouv.fr/sites/default/files/ONERC_Rapport_2006_Strategie_Nationale_WEB.pdf

French Climate Plan: https://ec.europa.eu/environment/archives/networks/greenspider/doc/climate_change_campaigns/ccc_france.pdf

Roadmap for forest adaptation to climate change: https://agriculture.gouv.fr/francerelance-adapter-les-forets-au-changement-climatique

BDIFF :

https://bdiff.agriculture.gouv.fr/

CAP Strategic Plan:https://agriculture.ec.europa.eu/system/files/2022-09/csp-at-a-glance-france_en_0.pdf

Integrated national energy and climate plan: https://energy.ec.europa.eu/system/files/2022-08/fr_final_necp_main_en.pdf

11. GERMANY

11.1. Country overview – major forest facts

11.1.1. Key forest data

Germany is a country in west Europe, with nearly 33% forest cover, which equivalents to 11,4 Mio ha. With a growing stock of 3.9 billion cubic metres, Germany's forests have the highest growing stock in the European Union. Growing stock and above ground biomass have been growing at a faster rate than forest area. Overall, 117 million cubic metres of wood grow in Germany every year. The most common tree species are: spruce (25%); pine (22%); beech (15%); oak (10%). 66% of forests are under a management plan which is obligatory for all forest enterprises over 100 ha, and is registered with an official body. 78% of German forests are under a third party certification scheme, mostly PEFC. 81.1% of Germany's forests are protected.

11.1.2. Institutional setup and legal framework

Germany is a federal State. On the national level the Federal Ministry of Food and Agriculture is responsible for forestry; at the state level it is the Ministries of the Länder. The Federal Forest Law and state forest legislation provide the legal basis for German forestry. Forest policy is mostly implemented at the sub-national level. There is a national level NFP, which has led to the Forest Strategy 2020 and the Charter for Wood 2.0. The Forest Strategy 2020 addresses all forest-related stakeholder issues, while the Charter for Wood 2.0 provides a stakeholder platform. There are regular forest inventories. Federal and state governments manage financial aid provided to communal and privately owned forests jointly. In addition, several Länder have developed their own funding schemes. Other relevant policies are: National Strategy on Biological Diversity; Climate Action Programme 2050, Climate Change Act & Climate Action Plan 2050; National Bioeconomy Strategy.

11.1.3. Key actors and stakeholder organisations

Federal Ministry of Food and Agriculture; Ministries of the Länder; German Forestry Council (*Deutscher Forstwirtschaftsrat*); Confederation of European Forest Owners; *Deutscher Forstverein*; *Bund deutscher Forstleute*; *Industriegewerkschaft Bauen-Agrar-Umwelt*; Schutzgemeinschaft deutscher Wald; Deutscher Naturschutzring; *Bund für Umwelt und Naturschutz in Deutschland*; *Naturschutzbund Deutschland*; *Deutsche Umwelthilfe*

11.1.4. Forest ownership

48% private forest owners (differences East/West), 29% states; 19% municipalities; 4% Federal Government.

11.1.5. Forest industry

Removals average of the last 10 years from German forests was about 74.mio. m³. The last few years have been characterized by storms, drought and damage from bark beetles. The result was an increasing of the removals from forest.

The average removals corresponds to about 64% of the net annual increment. For 2019, the round wood production amounted to 74 million m3. The obtained market value was EUR 3990 million. Just over 1 million people are employed in the German forest-based sector. About 45 thousand people are employed in forestry itself.

11.1.6. Key forestry issues

Transformation from coniferous to structure-rich mixed forests with predominantly native tree species is a core element of German forestry. The aim is to make the forests more resilient against climate change and less prone to calamities, such as bark beetle invasions or draughts.

There is still high uncertainty about the magnitude of climate change impacts on regional and local scale which is needed for optimizing decisions on active adaptation measures. Efforts are needed to make projections more reliable.

11.2. Forest monitoring

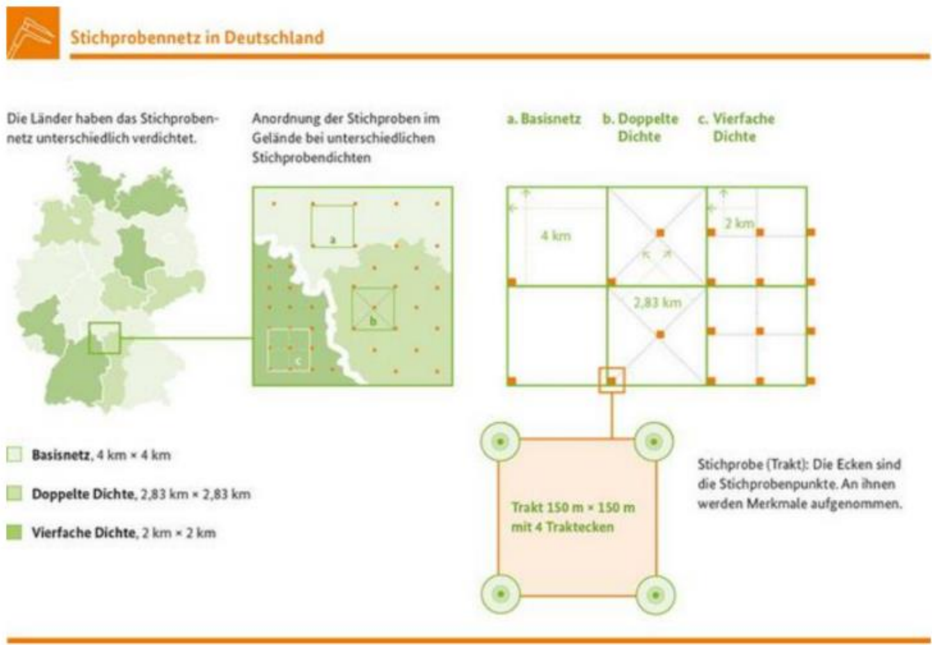
11.2.1. National Forest Inventory

Forest statistics and forest inventories have a long tradition in Germany, originating in the nineteenth century (Tomppo et al. 2010). The first German National Forest Inventory (NFI) with a nationwide sample-based data survey based on mathematical and statistical methods was implemented in the old German Laender within the years 1986–1990 (NFI1987). The NFI measured large-scale forest condition and the forest production potential. After Germany reunification, the second NFI (2002) was conducted expanding the methods used in the first NFI to the new German Laender. In the spring of 2011, the field assessment for the Third NFI was started. This NFI is referred to as NFI 2012, with measurements completed in February 2013. NFI 2012 is the first consecutive inventory for the entire Federal Republic since German reunification.

The German NFI is currently in its fourth inventory cycle with reference date in 2022 (NFI 2022). For the NFI 2022, the largest sample size of all previous inventories is planned. The inventory methods have changed only marginally to maintain the comparability of previous data. For the first time, DNA samples were collected for the investigation of genetic diversity. In addition, remote sensing data were integrated to obtain a higher spatial resolution of the result.

To collect the data, inventory teams of the federal states travel to the permanent sampling points. These are located in a systematic sampling network, that covers the whole of Germany, in a 4 x 4 km grid. More and more federal states are additionally densifying the network to 2.83 or 2 km, so that the significance of the results can be increased even for smaller evaluation units.

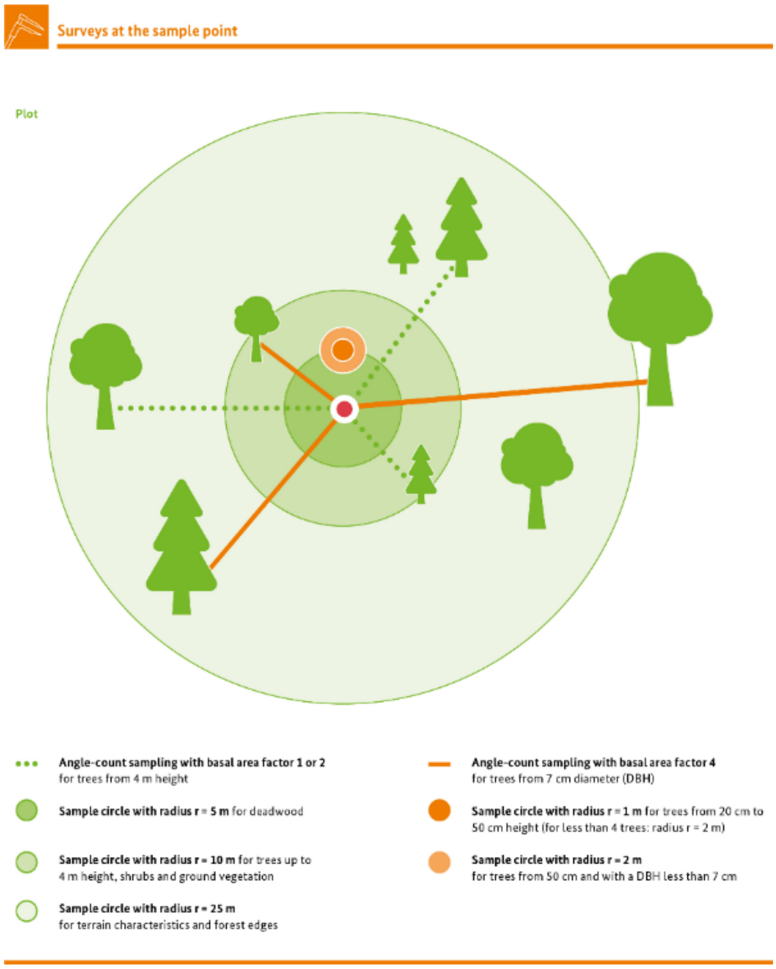
Figure 25 NFI sampling grid (Federal Ministry of Food and Agriculture, 2015)



To describe the forest stand characteristics, data from the angle count sampling with basal area factor 1 or 2 and from the 10 m radius circle were used. The 1 and 2 m circles were used to derive estimates of regeneration: abundance, stem number, species composition and biomass. The typical forest parameters of volume, growth and drain were estimated based on the angle count sampling with a basal area factor 4.

The following parameters were assessed: tree number, tree species, azimuth, horizontal distance, canopy class, diameter at breast height (dbh), social position according to Kraft, damage, special habitat tree attributes and pruning. The age of the trees is taken from the preliminary data of the cluster established before the actual survey.

Figure 26 Surveys at the sample point (Federal Ministry of Food and Agriculture, 2015)

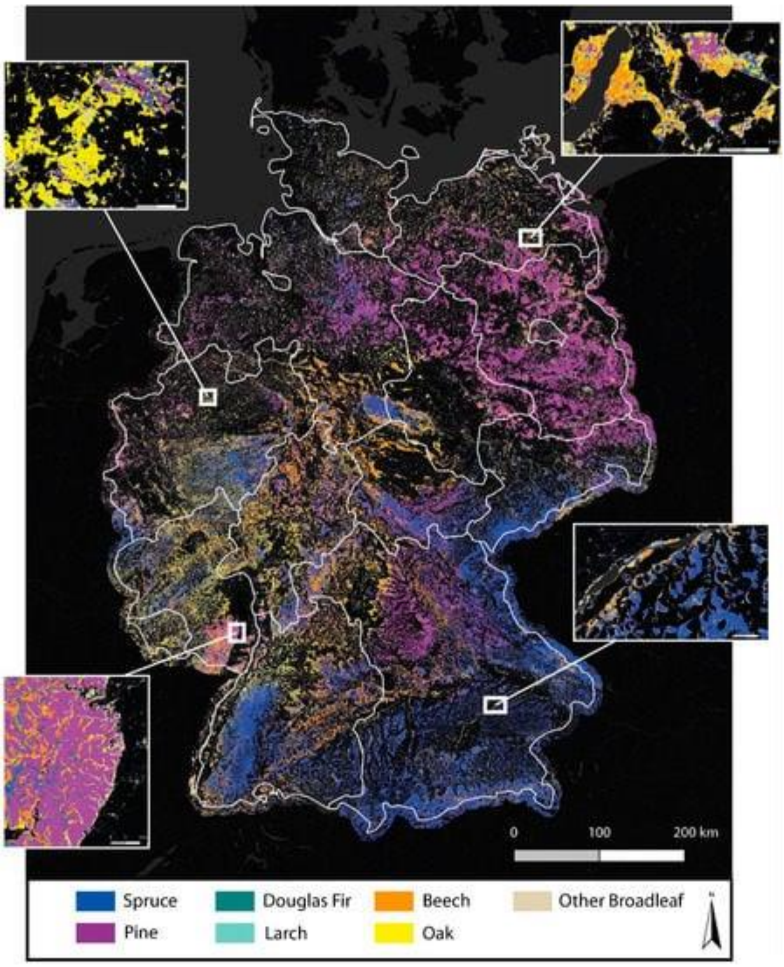


11.2.2. Forest mapping

Under the NFI, data are disseminated in aggregate form or as point maps of forest conditions. Thus, there is a lack of wall-to-wall maps based on forest data collected in sample plots.

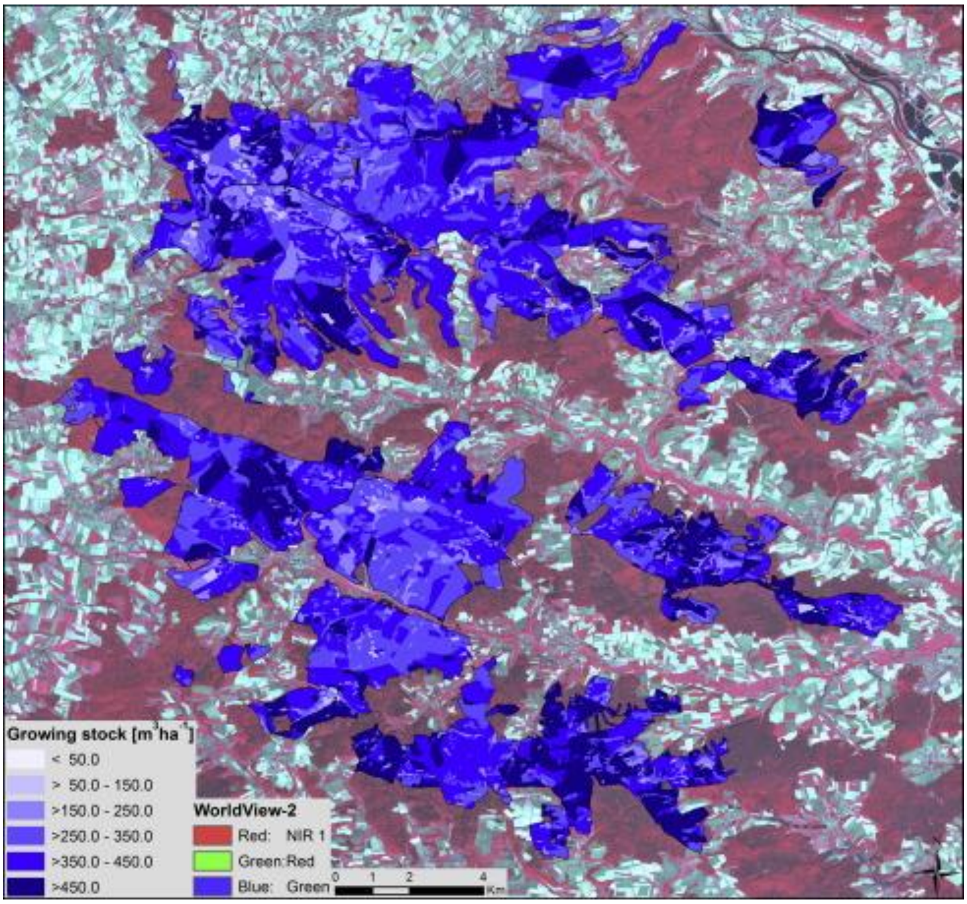
On the other hand, some research has used NFI samples and remotely sensed data to produce maps of forest variables. For instance, Welle et al. (2022), used NFI data of tree forest species to train and test a machine learning approach that classifies a dense Sentinel-2 time series resulting in a map of dominant tree species in German forests with seven major tree species classes.

Figure 27 Dominant tree species map of Germany for the year 2017 (Welle et al., 2022)



Due to the lack of fixed reference areas for NFI angle-count sampling plots, the German NFI data are rarely used as training data for forest enterprise-level wall-to-wall mapping applications. However, Immitzet et al. (2016) developed an approach to overcome this shortcoming in a study area in northern Bavaria, Germany. ACS-based NFI data were used for model training to generate wall-to-wall growth maps for deciduous, coniferous, and mixed forest stands. Spectral and elevation information from the very high-resolution WorldView-2 (WV2) satellite was used as auxiliary information, and the nonparametric Random Forests (RF) algorithm was chosen as the modeling approach.

Figure 28 Map of the growing stock estimates aggregated at the stand level for the state-owned land (Immitzer et al., 2016)



11.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Germany.

Table 41 Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	NFI	National	Complete	10y		yes			x	yes - public
Forest biomass	NFI	National	Complete	10y		yes			x	yes - public
Forest carbon	NFI	National	Complete	10y		yes			x	yes - public
Tree age	NFI	National	Complete	10y		yes			x	yes - public
Canopy height	NFI	National	Complete	10y		yes			x	yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest structural diversity		National	Complete	10y		yes			x	yes - public
Forest soil properties										
Forest/tree cover change	NFI	National	Complete	10y		yes			x	yes - public
Tree age diversity	NFI	National	Complete	10y		yes			x	yes - public
Tree species/composition	NFI	National	Complete	10y		yes			x	yes - public
Tree species diversity	NFI	National	Complete	10y		yes			x	yes - public
Forest type										
Deadwood	NFI	National	Complete	10y		yes			x	yes - public
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests	NFI	National	Complete	10y		yes			x	yes - public
Forest ancientness										
Forest area under protection										
Silvicultural system	NFI	National	Complete	10y		yes			x	yes - public
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NFI	National	Complete	10y		yes			x	yes - public
Ratio of annual fellings to annual increments	NFI	National	Complete	10y		yes			x	yes - public
Forest revenue										
Roundwood prices	Destatis	National	Complete	1m					x	yes - public
Forest products trade										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	NFI	National	Complete	10y		yes			x	yes - public
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										

11.2.4. SWOT analysis

The table below presents a SWOT analysis on the forest monitoring framework implemented in Germany.

Table 42 Germany: SWOT analysis

Strengths	**Weaknesses**
Germany has a well-established NFI that is able to report robust statistics for a large number of forest variables.	The NFI is run only once every 10 years, thus it is not possible to have reliable statistics on variables with short periods such as forest disturbances. The NFI does not produce wall-to-wall estimates (maps). Forest maps were produced only for research activities.
Opportunities	**Threats**
NFI 2022 plans to use remote sensing data for regional assessments.	Lack of fixed reference areas for NFI angle-count sampling plots, has limited their use to produce wall-to-wall mapping.

11.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 43 Germany: Overview of planning and reporting instruments

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	BMEL Forest Report, 2021	Transformation from coniferous to stable deciduous and mixed forest
	National Forest Inventory	Current data on forests
Biodiversity	BMEL Forest Report 2021	Sustainable forest management and conservation, protection and adequate enhancement of biodiversity in forest ecosystems
	Forest Strategy 2020 (with reference to the National Biodiversity Strategy)	Defuse tension between the use of biological resources and maintaining biodiversity
	Forest Strategy 2050	Information and goals until 2030: improving biodiversity; establishing and implementing a concept for efficient forest nature conservation and systematic planning; establishing better monitoring; increase the usage of INTEGRA network; improve cooperation between biodiversity nature protection; rewarding biodiversity protection measures by forest owners; limitation of external factors of the endangerment of biological diversity in the forest
Bioeconomy	BMEL Forest Report, 2021	Long-lasting wood products, cascading use of wood, substitution of non-renewable materials
	Forest Strategy 2050	Information and goals until 2030: The cultivation of site-appropriate tree species is further supported; The Charter for Wood 2.0 dialogue process is strengthened; The wood construction rate is increased; Resource policy with wood is expanded; The knowledge about wood production and use is strengthened; Regional value-added and supply chains of the resource wood are strengthened; Resource-efficient wood utilization is strengthened
	National Bioeconomy Strategy	Sustainable climate-neutral development; Using bioneric raw-material for sustainable, circular economy
Ecosystem services	BMEL Forest Report, 2021	Acknowledgement of importance; Special attention is paid to: development of forest soils, tree-crown condition as indicator of forest health, biotic & abiotic influences and impacts of climate change
	Forest Strategy 2050	Information and elaboration of goals as one of the central elements of the Strategy
	Forest Europe Report 2020	Monitoring and research; multiple forest functions as permanent task Two reports have specifically addressed values of forest ecosystem services: “Natural Capital and Climate Policy” (2015) and “Ecosystem Services in Rural Areas” (2016). The latter contains an overview of

Thematic area	Main Strategic reference	Summary of planning elements
		those monetary valuation studies on forest ecosystem services, which have been available for Germany at the time of publication
Climate change	Forest Strategy 2020	Maintenance of forests as CO2 sink & as producers of renewable energy
	Forest Strategy 2050	Information and goals until 2030: The climate protection contribution of forest and wood is to be preserved and expanded; The use of wood from domestic forestry is expanded; A model for rewarding climate protection services is established; Wind turbines in the forest contribute to energy supply; Plans of measures for the adaptation of forests are implemented; The forest conversion is strengthened; Measures for the adaptation of forests and increased support for forest conversion; Climate change monitoring is established
	BMEL Forest Report, 2021	Acknowledgement of role of climate mitigation
	National Forestry Accounting Plan for Germany	Climate change parameters indirectly included in in the German Forest reference level
	Integrated National Energy and Climate Plan	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

11.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 44 Germany: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Strengthen forests against impacts of climate change. There is still high uncertainty about the magnitude of climate change impacts on regional and local scale which is needed for optimizing decisions on active adaptation measures. Still efforts are needed to make projections more reliable.
Ecosystem services	Finding balance between use and conservation; there is a need to intensify the support being provided to small private forest owners by offering them targeted information and advisory services, and adapted forest management concepts.
Interest conflicts	Finding balance between private and public interests.
Private forest owners	Providing support in form of targeted information and advisory services, and adapted forest management concepts.

Major challenge	Summary description
Biodiversity conservation	Improved monitoring, evaluation and research.
Bioeconomy	Continuing to develop wood as an industrial and construction material and trying to create new marketable products for the future bioeconomy; Education and training of workers in the forestry sector.
Forest fires	Need for more reliable projections on effects of climate change; there is still the need for further developing and implementing the ideas of Adaptive Forest Management (AFM) on different political levels.
Desertification	No information
Population-related challenges	No information
Financing	No information
Governance	No information

11.4. References

Federal Ministry of Food and Agriculture (2015) The Forests in Germany. Selected results of the third national forest inventory

Immitzer, M., Stepper, C., Böck, S., Straub, C., & Atzberger, C. (2016). Use of WorldView-2 stereo imagery and National Forest Inventory data for wall-to-wall mapping of growing stock. Forest Ecology and Management, 359, 232-246. https://doi.org/10.1016/j.foreco.2015.10.018

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

Welle, T., Aschenbrenner, L., Kuonath, K., Kirmaier, S., & Franke, J. (2022). Mapping Dominant Tree Species of German Forests. Remote Sensing, 14(14), 3330. https://doi.org/10.3390/rs14143330

BMEL Forest Report, 2021: https://www.bmel.de/SharedDocs/Downloads/EN/Publications/german-forests.html

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory, 2022 : https://www.bundeswaldinventur.de/

Forest Strategy 2020: https://www.bmel.de/SharedDocs/Downloads/EN/Publications/ForestStrategy2020.pdf?__blob=publicationFile&v=4

Biodiversity Strategy: https://biologischevielfalt.bfn.de/fileadmin/NBS/documents/Veroeffentlichungen/BMU_Natio_Strategie_en_bf.pdf

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_DEU (foresteurope.org)

National Bioeconomy Strategy : https://www.bmel.de/SharedDocs/Downloads/EN/Publications/national-bioeconomy-strategy.pdf?__blob=publicationFile&v=2

Ecosystem Services in Rural Areas, 2016: https://www.ufz.de/export/data/global/190551_TEEB_DE_Landbericht_Kurzfassung_engl_web_bf.pdf

National Forestry Accounting Plan for Germany: https://www.bmuv.de/fileadmin/Daten_BMU/Download_PDF/Klimaschutz/nfap_germany_bf.pdf

https://blumwald.thuenen.de/

https://www.thuenen.de/media/institute/wf/HM_div._Statistik_Dateien/Dateien_-_Bilanzen_-_Tabellen/Wald/Einschlagrueckrechnung/de_tab_Einschlagrueckrechnung_Einschlag_und_Verwendung.pdf

National Forest Strategy 2050: https://www.bmel.de/SharedDocs/Downloads/DE/Broschueren/Waldstrategie2050.pdf?__blob=publicationFile&v=9

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-germany_en_1.pdf

Integrated National Energy and Climate Plan: https://energy.ec.europa.eu/system/files/2022-08/de_final_necp_main_en.pdf

12. GREECE

12.1. Country overview – major forest facts

12.1.1. Key forest data

Greece is a country in the eastern Mediterranean, with nearly a third of forest cover. Among the most common tree species are fir and pine. Forest area has expanded considerably since 1990 and stands at 30.3% of total land area. The main reason for this increase is the adoption and implementation of forestry measures in agriculture. Growing stock and above ground biomass have risen at about the same rate. Growing stock per hectare has remained stable at 47m3 o.b./ha. Forests and forested areas are sustainably managed by Forest Services, through the application of “Forest Management Plans” (FMPs). The technical specifications of FMPs were revised in 2018. For the period 2009-2018, 39.5% of forests and forested areas are sustainably managed though the application of FMPs.

12.1.2. Institutional setup and legal framework

All Greek forests and forested areas are protected by the Greek Constitution. Law No. 998/1979 protects and enhances the country's forest resources while harmonizing its multiple functions with the basic needs of the social life of citizens and the demands of modern civilization. Provisions for sustainable forest management are included in Law 3208/2003, which stresses the principles of sustainability, conservation of biodiversity and multiple uses of forest lands. The NFS defines the principles and guidelines of forest policy for the period 2018-2038, identifies specific objectives of this policy as well as the necessary resources and the means of its implementation. A national forest inventory was carried out in 1992. Forest maps have already been completed for 54% of the country’s territory. The rest is under way and expected to cover the whole country by the end of 2020.

12.1.3. Key actors and stakeholder organisations

Forest Services; Ministry of Environment, Energy & Climate Change; Institute of Mediterranean and Forest Ecosystems

12.1.4. Forest ownership

63.5% of the forests are state owned, 12% are owned by local communities and the rest (22.5%) are privately owned by monasteries, or individuals, groups, various organizations and foundations.

12.1.5. Forest industry

Wood removals, of which three quarters are woodfuel, have been trending slowly downwards, from around 2.5 million m3 u.b. around 1990 to 1.4 million m3 u.b. in 2016. In 1990, fellings were 81.5% of net annual increment. 23 thousand people were employed in the forest sector in 2015, half the figure of 1990. Half the employment is in the wood processing industries.

12.1.6. Key forestry issues

Certification of forests and completion of forest maps.

12.2. Forest monitoring

12.2.1. National Forest Inventory

The first forest inventory conducted in Greece dates back to 1836, even if it was not based on scientific or statistical methods. The first official National Forest Inventory was initiated in 1963 and covered more than the 80% of the country; the uncovered areas were mostly agricultural lands (Ministry of Agriculture, 1992). This first NFI based on a scientific method, was conducted as a joint project between the Hellenic Forest Service and the FAO, and it was completed in 1992.

After the admission of Greece into the European Union, the main objective of the NFI was to define and report on common definitions, to create comparable results at the EU level (Tsitsoni, 2016).

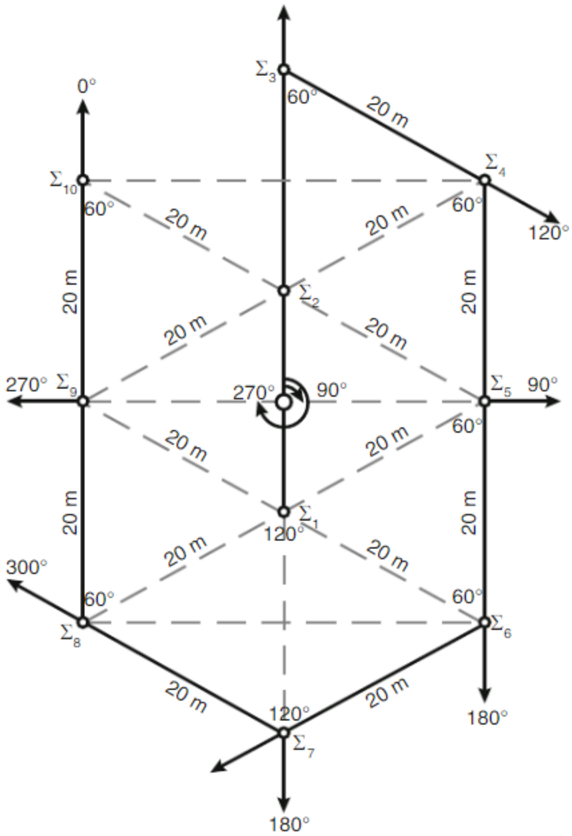
Considering the last available NFI (1992), it was based on a two-phased sampling scheme. The first phase of the inventory was related to photointerpretation of panchromatic black and white aerial photographs, where photo-plots were classified according to their land use, forest type and canopy closure. These were used as the basis for the stratification into three strata (non forest, forest with volume, forest without volume). A random sample of photo-plots was verified in the field.

For each plot, ten trees were measured using a systematic orientation scheme (Meliadis *et al*., 2010). These ten sample points were separated by a distance of 20 m, covering an area of 0.5 ha. In each sample point, trees were selected using a metric angle corresponding to 10 m2ha-1.

For each tree, measured variables were basal area, diameter at breast height, total height, merchantable height, non-merchantable height, Pressler's height, radial increment and bark thickness. Also, the tree species were identified, and the tree quality, degree of damage, and percentage of the healthy merchantable volume were estimated (Tsitsoni, 2016).

No further NFI campaigns were carried out in Greece after 1992.

Table 45 Location of the ten sample points of the Greek NFI, 1992 (Meliadis et al., 2010)



12.2.2. Forest mapping

No information on remote-sensing based forest mapping is available from the Greek NFI. However, remote sensing is used to monitor forest fire damage. The National Observatory of Forest Fires (NOFFI) is a research project aiming at developing a pilot operation of a forest fire observatory for Greece and the Balkan region. Specifically, NOFFI provides three fire-related products and services: (i) a remote sensing-based fuel type mapping methodology, (ii) a semi-automatic burned area mapping service and (iii) a dynamically updatable fire danger index providing mid-term predictions. The main products used to produce these outputs are freely available satellite data, such as Sentinel-2, Landsat-8 and MODIS imagery. Statistic collected by NOFFI are crucial for reporting to international institutions (e.g., LULUCF).

Maps (in vector format) are accessible as online visualization (http://epadap.web.auth.gr/?page_id=2175&lang=en) or through QGIS plugin implementation.

12.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Greece.

Table 46 Greece: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	incomplete		FAO	yes				
Forest biomass	NFI	National	incomplete			yes				
Forest carbon	FutMon									
Tree age										
Canopy height										
Forest structural diversity	NFI	National	incomplete			yes				
Forest soil properties	NFI	National	incomplete			yes				
Forest/tree cover change	NFI	National	incomplete			yes				
Tree age diversity										
Tree species/composition	NFI	National	incomplete			yes				
Tree species diversity	NFI	National	incomplete			yes				
Forest type	NFI	National	incomplete			yes				
Deadwood	NFI	National	incomplete			yes				
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system	NFI	National	incomplete			yes				
Main management objectives	NFI	National	incomplete			yes				
Forest area covered by a management plan	NFI	National	incomplete			yes				
Volume of wood harvested	NFI	National	incomplete			yes				
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade	DGF	National		1y						
Employment in the forest sector										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest area with 3rd party certification	DGF (FLEGT)	National		1y						
Forest visitor statistics										
Forest foliage/phenology/anomalies	FutMon									
Tree health	FutMon									
Forest growth	NFI	National	incomplete			yes				
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										
Production of resin	DGF								x	Yes - public

12.2.4. SWOT analysis

Table 47 Greece: SWOT analysis

Strengths	Weaknesses
The use of freely available satellite data supports an updated forest fire monitoring system.	Lack of updated NFI and forest monitoring.
Opportunities	**Threats**
Future NFIs could benefit from remote sensing technique to produce cost-effective sampling scheme, as demonstrated in other European countries.	No further NFI campaign available.

12.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 48 Greece: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource	Nature and biodiversity information website Greece	Current forest-related information

status and trends	National Forest Inventory	Current data on forests
Biodiversity	National Forest Strategy	Several mentions, incl. Sustainable Forest Management as means to preserve biodiversity*
	National Biodiversity Strategy Action Plan	Section on Forest Ecosystems
Bioeconomy	National Forest Strategy	Recognition of the value and enhancement of the contribution of forest ecosystems to the bio-economy and the circular economy.
	Bio-economy in Greece: Current trends and the road ahead	The exploitation of agricultural and forest residues could compensate for the consumption of 3-4 million tons of petroleum per year
Ecosystem services	National Forest Strategy	Several mentions*
Climate change	National Forest Strategy	Several mentions*
	National Strategy for Adaptation to Climate Change	Several measures*
	Integrated National Energy and Climate Plan	Several mentions of forestry, particularly in the context of GHG storage and in relation to LULUCF

**National Forest Strategy and National Strategy for Adaptation to Climate Change available only in Greek; Member State did not revise the country fiche. Therefore, no concrete information on the tasks can be provided*

12.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness. The challenges are unknown as the country report was not completed and the Member State did not revise the fiche.

Table 49 Greece: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	No information
Ecosystem services	No information
Interest conflicts	No information
Private forest owners	No information

Major challenge	Summary description
Biodiversity conservation	No information
Bioeconomy	No information
Forest fires	No information
Desertification	No information
Population-related challenges	No information
Financing	No information
Governance	No information

12.4. References

Meliadis I., Zagkas T., and Tsitsoni T. in: Tomppo, E., Gschwantner, T., Lawrence, M., McRoberts, R. E., Gabler, K., Schadauer, K., ... & Cienciala, E. (2010). National forest inventories. Pathways for Common Reporting. European Science Foundation, 1, 541-553. http://dx.doi.org/10.1007/978-90-481-3233-1_15

Tsitsoni I. in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

Hellenic Ministry of Environment and Energy information portal: https://ypen.gov.gr/perivallon/dasi/prostasia-dason/

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Strategy: https://www.peproe.gr/images/diavouleusi_2021-2027/stratigikes-ee-keimena/10-ethniki-stratigiki-gia-ta-dasi.pdf

National Forest Inventory (report by Aristotle University of Thessaloniki): http://users.auth.gr/tsitsoni/files/gr/28%20National%20Forest%20Inventory_Greece.pdf

National Biodiversity Strategy Action Plan: https://www.cbd.int/doc/world/gr/gr-nbsap-01-en.pdf

Bio-economy in Greece: Current trends and the road ahead, Euro-Biotech Journal 2018: https://sciendo.com/pdf/10.2478/ebtj-2018-0018

National Strategy for Adaptation to Climate Change: https://ypen.gov.gr/wp-content/uploads/legacy/Files/Klimatiki%20Allagi/Prosarmogi/20160406_ESPKA_teliko.pdf

Forest Land Ownership Change in Greece, COST Action FP1201 FACEMAP country report 2015, EFI: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_GREECE.pdf

Konstantinos A. Spanos et al., (2021), Forests of Greece, Their Multiple Functions and Uses, Sustainable Management and Biodiversity Conservation in the Face of Climate Change, Open Journal of Ecology, 11, 374-406: https://www.scirp.org/pdf/oje_2021042615200934.pdf

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-greece_en.pdf

Integrated National Energy and Climate Plan: https://energy.ec.europa.eu/system/files/2020-03/el_final_necp_main_en_0.pdf

13. HUNGARY

13.1. Country overview – major forest facts

13.1.1. Key forest data

Hungary is a central European country with nearly 23% forest cover. The major tree species in Hungary are Oak (21%), black locust (24%), conifers (10%), beech (6%) and poplars and willows (12%). All forests are under a management plan, which is compulsory. 11% of forests are under a third party certification scheme, exclusively FSC. Forest area has been growing slowly and reached 22.9% of land area in 2020. Growing stock and above ground biomass have also been expanding, faster than forest area. Growing stock average is now 215 m3/ ha. Nearly 42% of forest is protected for conservation of biodiversity. This share more than doubled between 2000 and 2010. About 11% of forest is designated protective forest.

13.1.2. Institutional setup and legal framework

The second National Forest programme resulted in the National Forest Strategy 2016-2030, approved in 2016. Parliament enacted a Law to regulate forests in 2009. There is a national forest inventory as well as a stand-wise national forest database.

13.1.3. Key actors and stakeholder organisations

Ministry of Agriculture; National Land Centre.

13.1.4. Forest ownership

Around 56% of Hungarian forests are in state ownership; 36% are owned by individuals; 7% by local communities and the rest by other owners (municipality, church, mixed). Local community forests are regarded by the forest administration as private forests (already excluded in this report), which is a theoretical mistake, as this form`s several features are similar to state ownership. Mixed form of ownership with both state and private owner within the same parcel imposes management problems and difficulties with statistics, even though the share of this form of ownership is rather small (around 1%).

13.1.5. Forest industry

Wood removals have fluctuated around 5.5 million m3 u.b. since 2000. Fellings were about 66% of net annual increment in 2015. Over 57 thousand people were employed in the forest sector in 2015, rather more than in 2010, but less than in earlier years.

13.1.6. Key forestry issues

Shared common ownership of forest area is a challenge for management, while a high proportion of forestry area covered with non-native tree species (36%) requires regulation.

13.2. Forest monitoring

13.2.1. National Forest Inventory

Forest management planning, using a stand wise forest inventory, began in 1879. From this date a lot of progress has been made in developing a methodology for forest inventory. The basis of the current stand-wise inventory (SWI) was initiated in 1970 and the basic methodology of SWI remains unchanged. Forest management plans based on the SWI are prepared in 10-year cycles. Nowadays the planning and regulatory activities are coordinated by the Forest Directorate of the National Food-chain Safety Office (successor of the former State Forest Service). In Hungary a systematic inventory began in 1993 with the Growth Monitoring System (GMS). A 2.8 x 2.8 km grid was used, and the survey was accomplished on a five-year cycle. This survey was closely related to the SWI including scope and definition applied and basic inventory parameters (surveyed species, age, origin and social status all the trees height and max-min DBH) were assessed or measured.

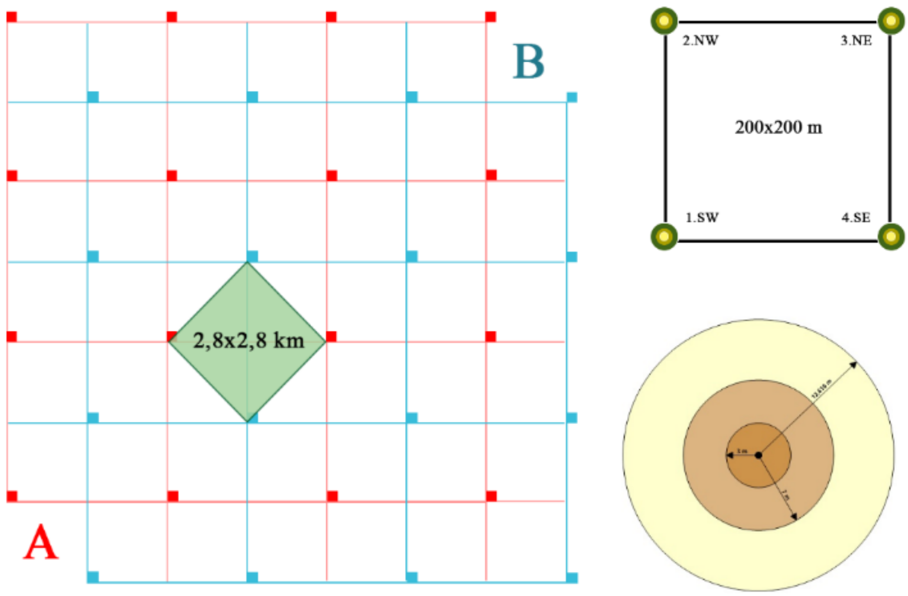
In 2010, a new harmonized National Forest Inventory (NFI) was developed with a cycle of 5 years, with the aim to survey the forest ecosystem with a special focus on forest resource assessment and the requirement to satisfy information needs on the resources of Hungarian forests.

Sampling during Hungarian NFI occurs at the intersection points of a national grid with a 4 x 4 km mesh. The establishment of the sampling grid relied on our previous Forest Protection Network (FPN), which was set up in 1988. Sampling intensity was doubled by shifting grid nodes in two directions (SE-NE) and yielded a basic mesh (marked “A”) and an offset mesh (marked “B”). Both comprise 4 x 4 squares and grid lines intersect each other at midpoint. Meshes “A” and “B” are rotated at 45 degrees to yield a 2.828 x 2.828 grid.

Several rounds of sampling have been performed at the nodes that happen to be located on forest land of this systematic set of points. In the 2010-2014 forest inventory cycle, sampling was performed at the nodes of mesh “B”. Four sampling plots are developed at each node, which are basically independent of each other in terms of sampling. The four corner points of a tract are also the center points of sample circles of equal radiuses, whilst the area covered by a sampling circle is known as a sampling plot.

To increase the efficiency of field work, additional concentric circles (segments) have been delineated in each sampling plot with the latter associated with different diameter limits to determine whether a sample tree is to be included in a sample. This way, work can be performed efficiently without reducing the statistical reliability of recorded parameters. The full cycle was completed by sampling 1/5 of the nodes of mesh “A” each year in a cycle of 5 years.

Figure 29 Left: Nodes. Right-top: A schematic drawing of a tract with sampling circles at the corner points. Right-bottom: sample plot.

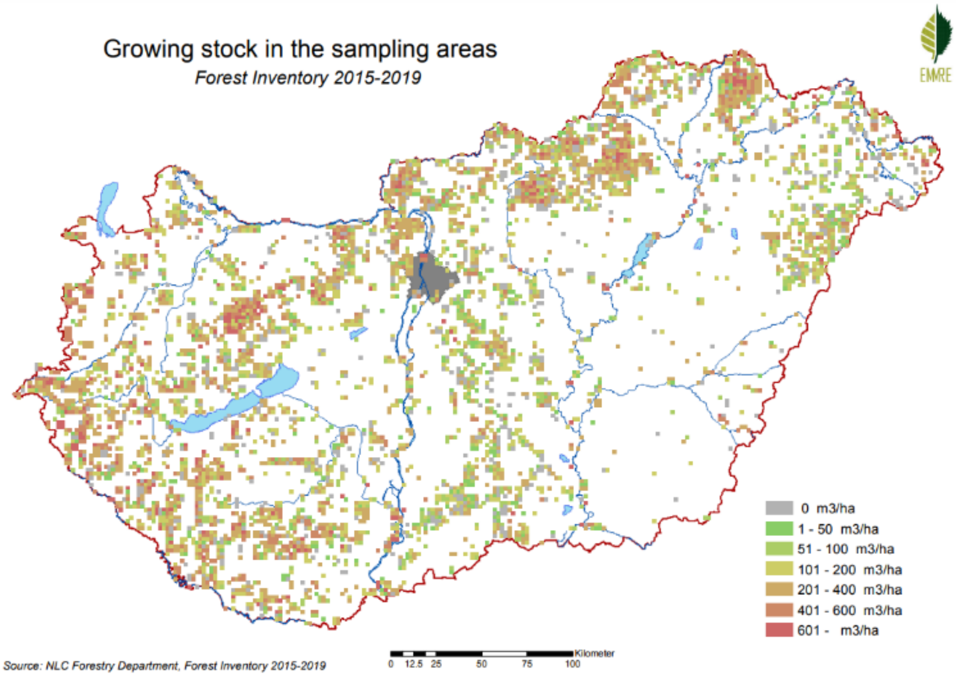


The results of two consecutive five-year survey cycles of the Hungarian NFI, launched in 2010, are available on the website in the form of detailed statistical data (https://nfi.nfk.gov.hu/).

13.2.2. Forest Mapping

Hungarian NFI's Data downloader (https://nfi.nfk.gov.hu/document_downloader) provides access to data in tabular form, graphs and maps to support interpretation, as maps of the sampling area provided in pdf format.

Figure 30 Growing stock in the sampling areas of II NFI cycle



The official web-GIS service of National Land Center (https://erdoterkep.nebih.gov.hu/) provides information layers also related to forests.

In a recent published study by Dostálová *et al.* (2021), the Hungarian forest type map (with 10 m resolution for the 2020 reference year) was used for a European-scale forest classification with Sentinel-1 data.

13.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Hungary.

Table 50 Hungary: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI/NFD	National	complete	5y/1y	NFI: International FAO/COST-E43 definitions	NFI: yes		x		yes - public
Forest biomass	NFI/NFD	National	complete	5y/1y	-	NFI: yes		x		NFD: yes - public NFI: yes - upon request/payment
Forest carbon	NFI/NFD		complete	5y/1y	-	NFI: yes				NFD: yes - public
Tree age	NFI/NFD	National	complete	5y/1y	-	NFI: yes		x		NFI: yes - public
Canopy height	NFI/NFD	National	complete	5y/1y	-	NFI: yes		x		NFI: yes - upon

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
										request/payment
Forest structural diversity	NFI/NFD	National	complete	5y/1y	-	NFI: yes		x		NFI: yes - upon request/payment
Forest soil properties	NFD		complete	1y						
Forest/tree cover change	NFD/ (NFI)	National	complete	10y/1y		NFI: yes		x		NFI: will be available in 2025
Tree age diversity	NFI/NFD	National	complete	5y/1y		NFI: yes		x		NFI: yes - upon request/payment
Tree species/composition	NFI/NFD	National	complete	5y/1y		NFI: yes		x		NFI: yes - upon request/payment
Tree species diversity	NFI/NFD	National	complete	5y/1y		NFI: yes		x		NFI: yes - upon request/payment
Forest type	NFI/NFD	National	complete	5y/1y		NFI: yes		x		yes - public
Deadwood	NFI	National	complete	5y		yes		x		yes - public
Presence of Red-list species										no
Abundance of common forest birds										no
Forest spatial patterns	NFD		complete	1y		no		x		
Areas of primary and old-growth forests										no
Forest ancientness										no
Forest area under protection	NFD		complete	1y		no		x		yes - public
Silvicultural system	NFD		complete	1y		no		x		yes - public
Main management objectives	NFD		complete	1y		no		x		yes - public
Forest area covered by a management plan	NFD		complete	1y		no		x		yes - public
Volume of wood harvested	NFD/ (NFI)	National	complete	1y/10y		no		x		NFD: yes - public NFI: will be available in 2025
Ratio of annual fellings to annual increments	NFD/ (NFI)	National	complete	1y/10y		no		x		NFD: yes - public NFI: will be available in 2025
Forest revenue	HCSO	National	complete	1y		NO		X		yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Roundwood prices	SDCP		complete	1y		no		x		yes - public
Forest products trade	HCSO			1y		no		x		yes - public
Employment in the forest sector	HCSO		complete			no		x		
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies	FPN	National	complete	1y		yes			x	yes - upon request
Tree health	FPN	National	complete	1y		yes			x	yes - public
Forest growth	NFD/ (NFI)	National	complete	1y/10y		yes		x		NFI: will be available in 2025
Occurrence of forest fires	NFFD	National	complete	1y		yes			x	yes - public
Occurrence of storms	FDRS	National		1y		no			x	yes - public
Forest disturbance	FPN	National		1y		yes			x	yes - public
Number of forest fires	NFFD	National	complete	1y				x		
Number of storms										no
Monthly precipitation in vegetaion period	CCM	Forest stand	partial	1d	-	no			x	yes - upon request
Forest damage per agent (biotic/abiotic)	FDRS	National	complete	1y	-	no			x	yes - public
Area of forest-related land use conversions	NFD	National	complete	1y		no		x		yes - public
Area under regeneration	NFD/ NFI	National	complete	1y/ 5y		no NFI: yes		x		yes - public

13.2.4. SWOT analysis

Table 51 Hungary: SWOT analysis

Strengths	Weaknesses
Hungary has a well-established NFI that can report robust statistics for a large number of forest variables.	Maps of forest variables are missing. If available in official web-GIS, the language barrier does not make them usable at a supranational scale
Opportunities	**Threats**
The large amount of data acquired in the two rounds of inventories started in 2010, may allow, if properly integrated with remote sensing data the development of wall-to-wall maps of forest variables	Limited accessibility and usability due to language barriers

13.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 52 Hungary: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Land Centre	Links to information websites on forest topics
	National Forest Inventory	Current data on forests
Biodiversity	National Forest Strategy	References to international documents and several mentions in the text
	National Strategy for the Conservation of Biodiversity	Several references, incl. protected areas; sections on forest management and game management
Bioeconomy	National Forest Strategy	Role of forests in bioenergy is emphasized
	Presentation on bioeconomy "Power4Bio"	Overview and objectives of the Hungarian bioeconomy strategy
Ecosystem services	National Forest Strategy	Enhancement of ecosystem services as part of sustainable forest management (task 4)
Climate change	National Forest Strategy	Climate change adaptation part of sustainable forest management (task 3)
	National Climate Change Strategy 2008-2025	Several mentions of forestry*
	National Energy and Climate Plan	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

**Document available only in Hungarian; therefore no concrete information on the tasks can be provided*

13.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 53 Hungary: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Negative effects of climate change are unpredictable. Serious forest damages as well as significant reduction of the forest area is also possible as large areas of Hungary are already dry and close to the forest limit. Especially native species may not be able to survive. To maintain or preferably increase forest cover and growing stock - carbon sequestration in forests and trees. Find and test climate tolerant propagative materials.
Ecosystem services	Payment of ecosystem services should be considered in the future to motivate forest owners and managers to improve forest welfare services.
Interest conflicts	No information
Private forest owners	Shared common ownership of forest area is a challenge for management and no satisfactory solution has been found yet. Around 130 000 hectares forests area is not managed properly, therefore we have to seek for long term solutions. Proposals are elaborated, implementation is foreseen in 2020
Biodiversity conservation	High proportion of forestry area covered with non-native tree species (36%) – need for regulation, esp. invasive tree species.
Bioeconomy	To increase the use of wood products for long term carbon storage and substitution of materials with high GHG emission.
Forest fires	
Desertification	Improve water management and retention of water.
Population-related challenges	No information
Financing	No information
Governance	To connect the information system of state administration and the recently developed system of the state-owned forestry companies.

13.4. References

Dostálová, A., Lang, M., Ivanovs, J., Waser, L. T., & Wagner, W. (2021). European Wide Forest Classification Based on Sentinel-1 Data. Remote Sensing, 13(3), 337. https://doi.org/10.3390/rs13030337

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

National Land Centre: https://nfk.gov.hu/Adatbazisok_linkjei___Erdeszet_news_305

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Strategy: http://erdo-mezo.hu/wp-content/uploads/2016/10/nemzeti_erdostrategia_2016.pdf

National Forest Inventory: https://nfi.nfk.gov.hu/

Forest Europe Report 2020: https://foresteurope.org/wp-content/uploads/2017/08/QL_questions-responses_HUN_22-4-2019.pdf

National Strategy for the Conservation of Biodiversity in 2015-2020: https://www.cbd.int/doc/world/hu/hu-nbsap-v2-en.pdf

Presentation on bioeconomy "Power4Bio": https://power4bio.eu/wp-content/uploads/2021/03/BIW_session1_4_Juhasz.pdf

National Climate Change Strategy 2008-2025: http://www.pestmegye.hu/images/2014/agazati_strategiak/Nemzeti_eghajlatvaltozasi_Strategia_2008_2025.pdf

Forest Land Ownership Change in Hungary, COST Action FP1201 FACEMAP country report 2015, EFI: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_HUNGARY.pdf

Statista, Distribution of man native tree species in Hungary in 2020: https://www.statista.com/statistics/1284415/hungary-distribution-of-native-tree-species/

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-hungary_en_0.pdf

National Energy and Climate Plan: https://energy.ec.europa.eu/system/files/2022-08/hu_final_necp_main_en.pdf

14. IRELAND

14.1. Country overview – major forest facts

14.1.1. Key forest data

Ireland is a country in western Europe, with forest cover of approximately 11.6%. Of the total forest area, 88.2% comprises areas occupied by trees or potentially occupied by trees. Sitka spruce is the most common species, occupying 44.6% of the forest area. Over one quarter of the forest contains broadleaves. Nearly one-third (34.3%) of the broadleaves are ‘Other broadleaf species’ (both long living and short living), of which over half are willow. The next largest broadleaf species group was birch (26.6%), followed by ash (11.1%) and oak (9.3%). Conifers occupy 495,100 ha while broadleaved species cover 218,100 ha. Forest area has been growing steadily, as a result of a long standing policy goal to raise forest cover in Ireland, which now stands at 11.6% of total land area. In fact there has been an unbroken programme of afforestation since 1923. As a result, the forest estate is young with the majority (70%) of Ireland’s forests consisting of trees of 30 years old or less. In 2017, the total growing stock volume of Irish forests is estimated to be over 116 million m^3, an increase of over 19 million m^3 on 2012. Mean Growing stock volume per hectare is now 155 m3. Conifer species represent 71% of the stocked forest area. Above-ground biomass has also been increasing. About 70% of forests are covered by a forest management plan, although these plans are not compulsory, and not officially registered. 56% of forests are under a third party certification scheme. Forests of the State forest agency, Coillte, which accounts for 49.1% of all forests, are certified by both FSC and PEFC, and account for most of the certified area. Less than 1% of forests are protected for conservation of biodiversity and no information is available on the area of protective forests. No forest undisturbed by man is reported.

14.1.2. Institutional setup and legal framework

A new Forest Act was passed in 2014, emerging from an NFP process, which generated a forestry strategy for 2014-2020. A new forestry strategy and implementation plan is currently being prepared. The forest strategy is scheduled for launch in late 2022 and its implementation plan in 2023. There have been four national forest inventories, and data for this study are also based on administration records.

14.1.3. Key actors and stakeholder organisations

Forest Service, Department of Agriculture, Food and the Marine; National Parks and Wildlife Service, Department of Housing, Local Government and Heritage; Department of the Environment, Climate and Communications.

14.1.4. Forest ownership

In 2022, 49.1% of forests were in State ownership, a reduction from 50.8% in 2017. The expansion of the private sector forest cover is a result of afforestation and natural expansion of semi-natural forests. Of the privately owned forests 35.7% are grant-aided and 15.2% non-grant aided.

14.1.5. Forest industry

The total roundwood harvest in 2021 (excluding firewood) was 4.33 million m3. The share of private sector roundwood available for processing has increased from 8.2% in 2006 to 48.4% in 2021, reflecting the maturing private forest estate. The All Ireland Roundwood Production Forecast 2021-2040 estimates that annual potential supply of roundwood on the island of Ireland is predicted to increase from 4.7 million cubic metres in 2021 to close to 8 million cubic metres in 2035. Exports of wood and paper products were valued at €751 million in 2020 compared with a value of €1.8 billion for imports of wood and paper products in 2020. In 2020 total employment generated by activities in the forest and wood products sector was estimated to be 9,500 full time equivalents.

14.1.6. Key forestry issues

Certification of private forests; increasing efforts at biodiversity conservation; increasing the forest area through sustainable afforestation; forest adaptation to climate change.

14.2. Forest monitoring

14.2.1. National Forest Inventory

The first statistical, multi-resource National Forest Inventory of Ireland was carried out between 2004-2006, to provide information to domestic policymakers, support forest research and fulfill national and international reporting requirement (Redmond, 2016). Results from the first Ireland's NFI were published in 2007.

A second NFI started in 2009 and was completed three years later. Forest information collected during Irish NFIs included (i) forest area and species composition, (ii) growing stock volume, (iii) biodiversity (including deadwood), (iv) forest health and vitality, (v) forest carbon content and (vi) soil characteristics. With the second NFI, the assessment of new parameters such as forest area change, volume increment and harvesting volume allow, for the first time in Ireland, to monitor Sustainable Forest Management practices. Ireland NFI occurs on a cyclical 5-years basis, between the starting date of cycles. Data collection for the third NFI began in 2015 and was completed in 2017.

The Irish NFI is carried out by Forest Service under the Department of Agriculture, Food and the Marine. The analysis and results generation for the third NFI cycle were undertaken by the Forestry Inspectorate, in close collaboration with the Institute of Forest Ecosystem Research.

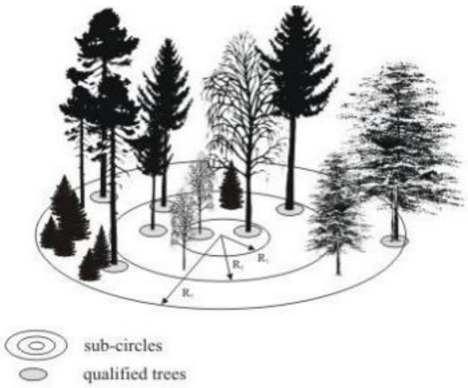
The forest definition adopted by the Ireland's NFI (land with a minimum area of 0.1 ha, a minimum width of 20 m, trees higher than 5 m and a canopy cover of more than 20% within the forest boundary, or trees able to reach these thresholds in situ) slightly differs from FAO's one.

Information collected by the Irish NFI has been used to report on several international frameworks such as FAO FRA, Forest Europe, and greenhouse gas monitoring reports. Indeed, the NFI in Ireland has been used to estimate national forest carbon stock, and the data is a crucial component of the national forest reporting system, which submit annual estimates to the UNFCCC.

The Irish NFI is based on a systematic 2 x 2 km grid sample design, with approximately 17,423 points covering the whole country. The first phase of NFI is related to photointerpretation of the most recently available aerial photos, to identify plots that are potentially forest; during the second NFI cycle in 2012, 1827 permanent forest plots were established.

Each circular plot measures 25.24 m in diameter (comprising 500 square meters) and consists of three concentric circles with different radii used for tree assessment.

Figure 31 Tree mapping concentric NFI plot design. Source: Irish Forest Service, 2018



	R_1	R_2	R_3
Sub-circle radius (m)	4	7	12.62
Sub-circle area (m^2)	50.3	153.9	500
Threshold Dbh (mm)	70	120	200

14.2.2. Forest mapping

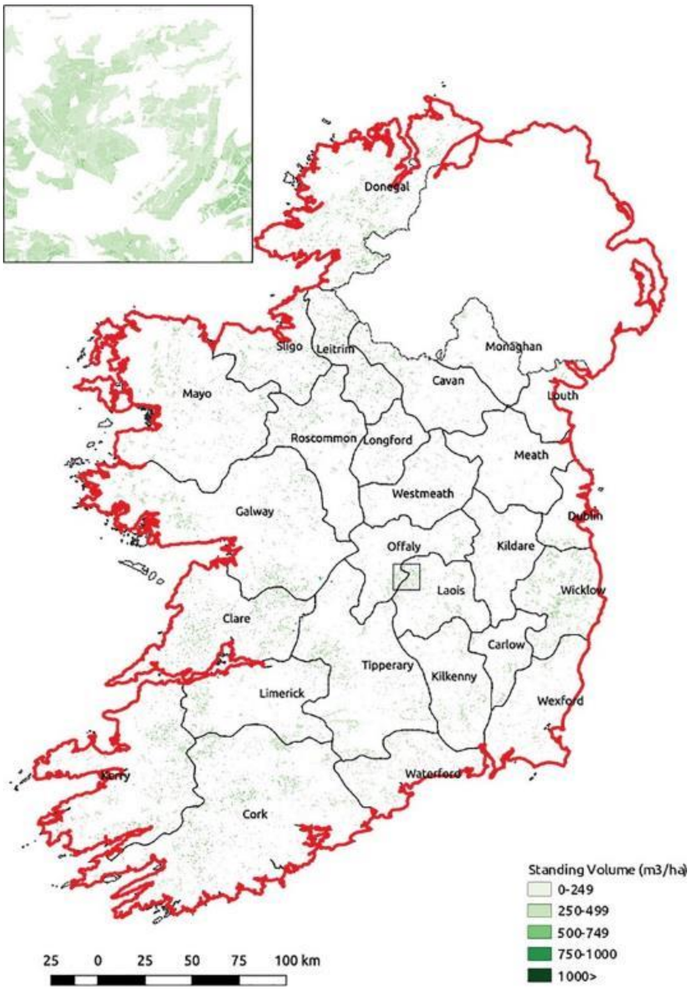
Since 1995, the Irish Forest Service has produced spatial datasets detailing the national forest estate extent (Gallagher et al., 2001). Initially known as the Forest Inventory and Planning System (FIPS), the spatial dataset was derived from automatic classification and manual photointerpretation of Landsat imagery (1993-1997), panchromatic orthophotos (1995) and Ordnance Survey Ireland (OSI – the official national mapping agency) map series. This national forest map has since been updated for newly planted areas on an annual basis using digital orthophotos available to the Irish Forest Service. The resulting inventory database includes all forest areas of more than 0.2 ha with a classification accuracy of 88% for the forest species and age classes comprising the database (DAFM, 2018). In 2014, the Forest Service began working towards an update of the FIPS forest cover layer for the private estate. This new forest cover layer is referred to as PrivateForests2016 and it is accessible upon request.

Prime2, released in late 2014, is an object-based spatial data storage model, created by OSi. It provides a highly detailed database of all topological features on the landscape and is derived from digitization of OSi orthophotography and existing boundaries datasets. All objects in Prime2 are classified by form and function attributes, and they are grouped into five complementary layers including “vegetation”, from which forest classes could be extracted (Devaney et al., 2015). The type of geometry associated to “vegetation” layer object is polygon geometry.

A collection of forest cover maps, published by the Department of Agriculture, Food and the Marine is available in PDF format. The information reported in each document is related to the ownership, public or private, of forest areas in each Irish county for the year 2017.

However, neither of those maps are directly related to the Irish NFI. Conversely, a recently published paper (McInerney et al., 2018) presents a nationwide application of k-nearest neighbors to estimate growing stock volume per ha for the Irish National Forest Estate, combining optical satellite imagery (SPOT-4 and Indian Resource Satellite) and field data collected during the second NFI.

Figure 32 Irish map of forest growing stock volume per hectare, with focus on Laois-Offaly counties' forest (upper left panel) (McInerney et al., 2018)



14.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Ireland.

Table 54 Ireland: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Note
Forest/ tree cover	NFI	National	complete	5y		yes		x		yes - public
Forest biomass	NFI	National	complete	5y		yes		x		yes - public
Forest carbon	NFI	National	complete	5y		yes		x		yes - public
Tree age	NFI	National	complete	5y		yes		x		yes -

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Note
										public
Canopy height	NFI	National	complete	5y		yes		x		yes - public
Forest structural diversity	NFI	National	complete	5y		yes		x		yes - public
Forest soil properties	NFI	National	complete	5y		yes		x		yes - public
Forest/tree cover change	NFI	National	complete	5y		yes		x		yes - public
Tree age diversity	NFI	National	complete	5y		yes		x		yes - public
Tree species/composition	NFI	National	complete	5y		yes		x		yes - public
Tree species diversity	NFI	National	complete	5y		yes		x		yes - public
Forest type	NFI	National	complete	5y		yes		x		yes - public
Deadwood	NFI	National	complete	5y		yes		x		yes - public
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NFI	National	complete	5y		yes		x		yes - public
Ratio of annual fellings to annual increments	NFI	National	complete	5y		yes		x		yes -

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	Note
										public
Forest revenue										
Roundwood prices	ITGA	National	complete	1y		yes		x		yes - public
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies	NFI/FutMon	National	complete	5y		yes		x		yes - public
Tree health	NFI	National	complete	5y		yes		x		yes - public
Forest growth	NFI	National	complete	5y		yes		x		yes - public
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance	NFI	National	complete	5y		yes		x		yes - public
Number of forest fires										
Number of storms										
Lichens	NFI	National	complete	5y		yes		x		yes - public
Phenology	FutMon	National	complete	1w		yes				
Ground Vegetation	FutMon	National	complete	3y		yes				

14.2.4. SWOT analysis

Table 55 Ireland: SWOT analysis

Strengths	Weaknesses
Multisource NFI that collect information frequently	NFI's forest definition differs from FAO; Lack of official remote-sensing based forest mapping related to Irish NFI.
Opportunities	**Threats**

The operational use of Earth observation data in combination with Irish NFI field plot data can promote more efficient use of financial resources while increasing the accuracy and precision of Forest Estate estimates at different geographic scales. Furthermore, the results of this type of analysis are required for the development of up-to-date timber supply forecasts and regional management plans as they provide accurate data on the spatial distribution of timber volume.	Frequent and extensive cloud cover in Ireland has historically been a barrier to national-scale remote-sensing survey.

14.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 56 Ireland: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Forest Statistics Ireland 2022	Current forest-related information
	National Forest Inventory	Current data on forests
	Central Statistics Office (CSO)	Roundwood harvest, wood removals, wood exports and imports
Biodiversity	National Forest Programme	Biodiversity and Nature Conservation
	National Biodiversity Action Plan	Objective 4: Conserve and restore biodiversity and ecosystem services in the wider countryside
	National Forestry Accounting Plan for Ireland	Several references to biodiversity-related policies, e.g. the EU Biodiversity Strategy or the LULUCF
	Prioritised Action Framework for Natura 2000 in Ireland	A strategic multiannual planning tool, aimed at providing a comprehensive overview of the measures needed to implement the EU-wide Natura 2000 network and its associated green infrastructure (including Annex I forest habitats, their supporting habitats and associated species), specifying the financing needs for these measures and linking them to the corresponding EU funding programmes.
	Sustainable Development and Conservation of Forest Genetic Resources 2020-2030	Addresses key challenges, including climate change, and how forest genetic resources can be mobilised to increase the adaptive capacity of our forests. The strategy also includes recommendations on how to ensure the sustainable supply and use of seeds and other reproductive material, and steps required for the genetic conservation of tree species.

Thematic area	Main Strategic reference	Summary of planning elements
Bioeconomy	National Forest Programme	Priority 5c: Facilitating the supply and use of renewable sources of energy, of by products, wastes, residues and other non-food raw material for purposes of the bio-economy
	National Policy Statement on the Bioeconomy	Several mentions of forestry as one of the sources for the bioeconomy, e.g. on p. 7 of the Statement it says: “Approximately 10.7% of Ireland is under forests which produce 3.2 million cubic metres of material each year and this is forecasted to increase to 8 million by 2035.”
Ecosystem services	National Forest Programme	Reference to the Forest Research Ireland FORI report and listing of measures to improve the delivery of ecosystem services
	National Forestry Accounting Plan for Ireland	Ecosystem services covered by the Forest Policy Review Group
Climate change	National Forest Programme	Climate Change Mitigation an National Policy Objectives
	Climate Change Action Plan	Land Use, Land Use Change, Forestry and the Marine
	Agriculture, Forest and Seafood - Climate Change Sectoral Adaptation Plan	Adaptation goals and objectives for forest sector.
	National Forestry Accounting Plan for Ireland	Several references to climate change-related policies
	Forests and wood products, and their importance in climate change mitigation	The COFORD Working Group on Forests, Climate Change Mitigation and Adaption, which has as its aim to highlight and promote the role that forests, and forest products play in climate change mitigation and to raise awareness of the impacts of climate change on forests and forestry practice.
	National Energy & Climate Plan 2021-2030, p. 19	One of the key policies and measures for decarbonization: Deliver expansion of forestry planting and soil management to ensure that carbon abatement from land-use is delivered in 2021-30 and in the years beyond.

14.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 57 Ireland: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Achieving the balance between climate mitigation and the sustainable use of natural resources including the protection of biodiversity. Increasing the use of wood products that store carbon over the long-term, and avoid emissions by substituting emissions-intensive materials. Supporting the adaptation of forests to a changing climate and related knowledge to forest owners and managers.
Ecosystem services	Forests and undisturbed water setbacks can be used in combination to deliver meaningful ecosystem services that protect and enhance water quality and aquatic ecosystems (Link). A key challenge is deliver a greater range of ecosystem services and also to increase opportunities for paid ecosystem services, tourism and recreation, providing additional opportunities to support local communities.
Interest conflicts	The Department and stakeholders are working together to deliver Project Woodland with a view to resolve the current difficulties in the forestry sector and revitalise the creation of forests in Ireland. Project Woodland is developing a new Forest Strategy to 2030, which will underpin a new Forestry Programme for the period 2023-2027.
Licensing	Low afforestation rates in recent years, together with reduced rates of other licensed activities such as felling and road construction, have been attributed to the complexity of the regulatory environment and the associated licensing system. A regulatory review has been caried out actions proposed. In addition significant investment has been made by the Department which has resulted a increase in licensing output.
Private forest owners	The challenge is to provide further opportunities for income and enterprise diversification, particularly in rural areas and for farmers. Presently total employment generated by activities in the forest and wood products sector is estimated at 9,500 full-time equivalents, while since 1980, nearly 23,500 private landowners have received grant aid to establish forests, the majority of which were farmers. A greater expansion of forests can reward farmers and landowners and can underpin increased demand for sustainably sourced timber from local sources. Such changes can also increase opportunities for tourism and recreation, providing additional opportunities to support local communities. The lack of certification for these private forests is a cause for concern. The Coford Wood Mobilisation Group are working to resolve this issue and are currently in the process of preparing a business plan for the establishment of a national group forest certification scheme. Supporting the adaptation of forests to a changing climate and related knowledge to forest owners and managers.
Biodiversity conservation	The EU Biodiversity Strategy and the proposed Nature Restoration Law will require very substantial efforts to protect, restore and expand Annex I forests and their supporting habitats, and to address legacy environmental issues associated with past forestry practices. A National Restoration Plan will be prepared. Supporting nature and biodiversity will be a key driver in forest expansion and forest management, delivering a greater range of ecosystem services and protecting our natural heritage. Challenge to increase the diversity of species planted within the national estate, particularly native broadleaves. During the Mid-Term Review of the forest programme in 2018, the minimum mandatory requirement per site was increased from 10% to 15% broadleaves. In the next forestry programme due to commence in 2023, it is proposed that this minimum requirement is increased to 20%. Other changes included; a 5% increase in all broadleaves & diverse conifer premium categories and a 7% increase in all broadleaves & diverse conifer grant categories.

Major challenge	Summary description
	Building resilience in our existing forests through diversification of species and management practices. The Native Woodland Conservation Scheme enhances the protection of Ireland's native woodlands and biodiversity. It supports the restoration of existing native woodlands and the conversion of existing non-native forests to native woodland. There is also a Native Woodland Establishment Scheme supporting the establishment of new native woodlands on 'green field' sites. Its focus is on native species, minimal site disturbance and long-term 'close-to-nature' management. Both schemes support a wide range of other benefits and functions arising from native woodlands, relating to reversing wider habitat fragmentation, the protection and enhancement of water quality, landscape, cultural heritage, wood and non-wood products and services, the practice of traditional woodland management techniques, environmental education, and carbon sequestration. Forest genetic resources are integral to the success of the forest sector. Quality seed and other reproductive material suited to their environment are the building blocks for expanding the forest estate and are essential to drive the economic, environment, scientific and societal benefits that forests provide. Conservation of the forest genetic resource is essential to protect the genetic diversity of our forest resource and thus ensure that our forests are more resilient to the challenges posed by climate change.
Bioeconomy	Challenge is for forestry to be at the centre of the circular and green economy; supporting a thriving forest sector; and, providing long term quality employment, ecosystem services, and public, educational and recreational amenities. Specific challenges include promoting the use of wood products, including combating misconceptions about fire risk and lack of durability, communicating to the general public on multiple benefits of wood products in terms of reducing pollution, and reducing the carbon footprint of our future building stock Increase supply of forest-based biomass to bridge expected supply gap by 2020 and beyond. Assessing the contribution of forests to the green economy. Promote the greater use of wood products in house building.
Forest fires	A forest fire risk warning system is in place and danger notices issue during those times where there is a risk of a fire which is typically from February to September. Further information is available here: https://www.teagasc.ie/media/website/crops/forestry/advice/Forest-Fire-Risk-Warning-System.pdf
Desertification	No information
Population-related challenges	The population of Ireland has grown from approximately 3.8 million at the turn of the millennium to over 5 million today and is forecasted to reach 6 million by 2050. The Shared National Vision for Trees and Forests in Ireland until 2050 was published in 2021. It anticipates by 2050 that Ireland's forests will be seen as a key solution to the climate, biodiversity, housing and health emergencies of the 2020s. The vision has been informed by a series of consultation methods with the public, including: a public attitudes survey, an online survey, a study of the attitudes of rural communities, a citizens' assembly style deliberative dialogue, a youth forum, and a series of bilateral meetings with key stakeholders
Financing	A new Forestry Programme will launch in 2023 focussing on the importance of forests for climate change, biodiversity and the production of wood. Actions to support carbon farming and upscale this green business model to better reward land managers for carbon sequestration and biodiversity protection will be important in the future. The EU Commission is working on a regulatory framework for the certification of carbon removals, with the intention of publishing a proposal by the end of 2022 and expected entry into force by the end of 2023. Initiatives similar to the existing Woodland Environment Fund, which includes a mix of private finance and state funding to pay farmers to establish native woodlands.

Major challenge	Summary description
Governance	Good governance and oversight will be essential to enhancing coherence across the policy domains for forestry-related objectives as forest products and services are increasingly integrated into many other sectors such as energy, conservation, public health and industry. In alignment with the EU Forest Strategy 2030 and the EU forest governance framework, the new Forest Strategy for Ireland recognises the necessity for a multidisciplinary exchange with a variety of stakeholders and for transparency that shows how the goals and objectives are being delivered.
Education, skills & careers	To meet future demands we need to address the skills development requirements of the existing workforce, as well as attract a diverse range of talented people to work in the sector and ensure that appropriate qualifications and training opportunities are available. Support for training, education and continued professional career path development, to increase the capacity and capability of the workforce available to the forestry sector.
Forest Health	Ireland's forest health status overall remains relatively good and remains free from a range of harmful organisms present throughout the EU. There have been outbreaks of Ash Dieback (Chalara), Dothistroma Needle Blight, Brown Spot Needle Blight and Phytophthora ramorum. Ireland is a Protected Zone within EU for 14 forestry harmful organisms and monitoring is undertaken each year to ensure this status is maintained. Forest pests of potential concern include: pests to Sitka spruce (European Bark Beetles), European priority pests (Emerald Ash Borer & Bronze Birch Borer) and the Oak Processionary Moth. Import controls at our ports, annual forest health surveys including monitoring of bait log and phermone traps, Export certification and plant passporting, National ISPM No.15 Scheme are all important elements of Irelands approach to maintain a good health status. Forest research is a key element in our preparedness and capacity approach.

14.4. References

DAFM. Department of Agriculture, Food and the Marine (DAFM). 2018b. Forest cover datasets [online - https://wayback.archive-it.org/org-1444/20201125201230/https://www.agriculture.gov.ie/forestservice/forestservicegeneralinformation/foreststatisticsandmapping/forestcoverdatasets/] accessed on 29 Dic 2022

Devaney, J., Barrett, B., Barrett, F., Redmond, J., & OHalloran, J. (2015). Forest cover estimation in Ireland using radar remote sensing: a comparative analysis of forest cover assessment methodologies. Plos one, 10(8), e0133583. https://doi.org/10.1371/journal.pone.0133583

Gallagher, G., Dunne, S., Jordan, P., & Stanley, B. (2001). Ireland's forestry and planning system. Unpublished report, Department of Marine and Natural Resources, Wexford.

Irish National Forest Inventory website http://www.agriculture.gov.ie/nfi/

McInerney, D., Barrett, F., McRoberts, R. E., & Tomppo, E. (2018). Enhancing the Irish NFI using k-nearest neighbors and a genetic algorithm. Canadian Journal of Forest Research, 48(12), 1482-1494. https://doi.org/10.1139/cjfr-2018-0011

Redmond J. in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

Forest Statistics Ireland 2022: https://www.gov.ie/en/collection/15b56-forest-statistics-and-mapping/#annual-forest-sector-statistics

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Overview of government forest policies, incl. Forestry Programme 2014-2020 (extended to 2022): https://www.gov.ie/en/publication/forestry-policy-and-strategy/#forestry-programme-2014-2020

National Forest Inventory: https://www.gov.ie/en/publication/823b8-irelands-national-forest-inventory/

Forest Europe Report 2020: https://foresteurope.org/wp-content/uploads/2017/08/QL_questions-responses_IRL_20-2-2019.pdf

National Biodiversity Strategy Action Plan: https://www.npws.ie/sites/default/files/publications/pdf/National%20Biodiversity%20Action%20Plan%20English.pdf

National Policy Statement on the Bioeconomy: https://assets.gov.ie/2244/241018115730-41d795e366bf4000a6bc0b69a136bda4.pdf

Climate Action Plan: https://www.gov.ie/en/publication/6223e-climate-action-plan-2021/#:~:text=The%20Climate%20Action%20Plan%202021,in%20the%20Climate%20Act%202021.

National Forestry Accounting Plan for Ireland: download from government website: https://www.gov.ie/en/

Central Statistics Office (CSO): https://www.cso.ie/en/statistics/environmentstatistics/forestwoodremovals/

COFORD. 2022. Forests and wood products, and their importance in climate change mitigation: A series of COFORD statements. COFORD, Dublin

COFORD, 2021. All Ireland Roundwood Production Forecast 2021-2040. COFORD, Kildare St. Dublin 2. http://www.coford.ie/media/coford/content/CofordAllIrelandRoundwoodBookREVISED150721.pdf

COFORD, 2020. Sustainable Development and Conservation of Forest Genetic Resources 2020-2030. COFORD, Kildare St., Dublin 2. http://www.coford.ie/media/coford/content/publications/2020/35769COFORDbodyreportweb211220.pdf

Prioritised Action Framework for Natura 2000 in Ireland https://www.npws.ie/sites/default/files/files/Prioritised-Action-Framework-(PAF)-for-Natura%20-2000-in-Ireland.pdf

National Energy & Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-08/ie_final_necp_main_en_0.pdf

15. ITALY

15.1. Country overview – major forest facts

15.1.1. Key forest data

Italy is a country in southern Europe, with about a third forest cover (36.7%, INFC, 2015) . The third Italian national forest inventory INFC2015 estimated the Total wooded area to be more than 11 million hectares, which is 36.7% of the country area. It includes the so-called Tall trees forest and Temporarily unstocked areas, Plantations for timber and wood production and Other wooded land (short trees forests, sparse forests, scrubland and shrubs) (INFC, 2015). In Italy, the Forest area consists mainly of pure broadleaved forests; pure conifers and mixed forests account for just over 10% of the total each, except for the Alpine regions where pure coniferous forests are predominant. The prevalence of broadleaves is even more marked in Other wooded land. . INFC2015 has measured woody individuals of near 180 species, for a total volume of 1.5 billion cubic metres. Four species make 50% of the wood in forests, three broadleaves and one conifer: beech (*Fagus sylvatica L*.), spruce (*Picea abies K*.), chestnut (*Castanea sativa Mill*.) and Turkey oak (*Quercus cerris L.*) . Coppices and high forests occupy approximately the same area of the Italian forests, as their percentage is 42.3 and 41.9% of total, respectively . The growing stock volume estimated in all Italian Forests exceeds 1.5 billion cubic metres, with an average value per hectare of 165.4 cubic metres. 3.5 million hectares of wooded area being in protected areas, 31.8% of the total at the national level, 2.8 million hectares of which are Forest and almost 700 000-ha Other wooded land .

About 11% of Italian forests are under a third party certification scheme, mostly PEFC. Forests on terrains with slope over 60% are often considered protective. In the Alpine regions, from 27.3% to 41.6% of the Forest area is on terrains with slope higher than 60%, while in the Central and Southern regions the percentage generally ranges between 5.5% and 17.6%. Due to its role in protecting water resources, the 86.6% of the Forest area is subject to hydrogeological constraint regulations.

15.1.2. Institutional setup and legal framework

Regional authorities have major forest policy responsibilities. The national forest law of 2001 was revised in 2018 (D.lgs. 34/2018) to provide a reference base for the definition of regional laws. The national NFP expired in 2019, and was replaced by a new NFP with a validity of 20 years. Management plans are used, but are not compulsory for private forest owners. No data were supplied on the area covered by management plans. Detailed plans for forests falling under a single ownership, known as economic, settlement or company plans, regulate the 15.3% of the Forest area at the national level. The percentage is rather variable among the regions and the Northern ones are generally marked by higher rates of regulated areas.

15.1.3. Key actors and stakeholder organisations

Ministry of Agriculture, Food and Forestry, General Directorate for Forests.

15.1.4. Forest ownership

63.5% of Italian forests are privately owned, 24% are owned by communes, about 6% by the state and 6% by other forms of public ownership.

15.1.5. Forest industry

Removals are in the range of 6 to 9 million m3 u.b. (9,566,257 m3, INFC2015). Two thirds of removals are of woodfuel. In 2010, fellings were 39.2% of net annual increment, lower than in previous years. In 2015, 252 thousand people were employed in the forest sector, nearly 100 thousand less than in 1990. The biggest fall was for employment in the wood processing industries, while employment in forestry itself has been rising since 2000.

15.1.6. Key forestry issues

Better adaptation of sustainable forest management practices, particularly for the Mediterranean area.

Promoting communication actions and awareness of the public opinion on the role of forest and forest products.

15.2. Forest monitoring

15.2.1. National Forest Inventory

Nowadays in Italy the only official source of statistical information on forests is the NFI, designed specifically for satisfying the reporting needs defined in the framework of the United Nations Framework Convention on Climate Change (IPCC, 2003). NFI statistics (https://doi.org/10.1007/978-3-030-98678-0) are used for compiling several national and international reporting processes: (i) the national report on forests and forestry sector (RaF Italia), (ii) the annual inventory of greenhouse gas emissions for UNFCCC, (iii) the Kyoto Protocol, done by the Italian Institute for Environmental Protection and Research (ISPRA, 2021), (iv) the national report on natural capital (Comitato Capitale Naturale, 2021), (v) the European report on sustainable forest management (SoEF Europe), and (vi) the UNECE-FAO Global FRA.

The NFI in Italy is under responsibility of *Arma dei Carabinieri - Comando unità forestali, ambientali e agroalimentari* (CUFAA) since 2016, when the former *Corpo Forestale dello Stato* (the Italian forest service under the Ministry of Agriculture) was merged with *Arma dei Carabinieri* (a police corp under Ministry of Defense). While the operative implementation of the NFI is done with Carabinieri personnel, the technical and scientific implementation, including the statistical design, database management and reporting activities, are carried out by Carabinieri with the support of CREA - *Consiglio per la Ricerca in Agricoltura e l'Analisi dell'Economia Agraria* (CREA is a research institution under the Ministry of Agriculture https://www.crea.gov.it/en/web/foreste-e-legno).

The last NFI was carried out in 2015, the previous one was from 2005. Both carried out with the same procedure. Based on an unaligned systematic sampling design of 1km x 1km national grid and a three-phases.

During the first phase, systematic unaligned sampling is used to select sample points to be observed on orthophotos. Approximately 301,000 sample points are randomly distributed on a 1km x 1km square grid covering the whole nation. Through photo interpretation, sample points are classified by land use/land cover classes consistent with the first level of the CORINE Land Cover nomenclature system and with the FAO forest definition, with a single class including both forest and other wooded lands. In the second phase, a subsample of the other wooded land strata of approximately 30,000 sample points is selected, where forest types and other qualitative information is collected. Lastly, a third-phase sample of approximately 7,000 plots with 13 meters radius is selected from the second-phase subsample and measured on the ground to acquire quantitative data. Finally, statistically rigorous procedures and unbiased estimators are implemented and exploited to estimate (i) the areal extents of the different land use and cover categories and (ii) the total and density values of the quantities measured during the third phase of the survey campaign.

The NFI reports estimates over 50 qualitative and quantitative forest variables and produces statistics aggregated at National (NUT1) and Regional level (NUT2).

These variables include those relating to the composition of the vegetation, origin, and stage of development, characteristics of forest sites, ownership, accessibility, management methods, availability of wood supply, presence of planning tools and constraints, protected forests, health status, and terrain instability.

Plot and tree level raw data are also available with a geolocation to the systematic 1 km grid, not the real plot location.

The first Italian NFI was carried out in 1985 with a systematic sampling scheme based on a regular 3km x 3km grid of observation points, with a single survey phase on the ground. The remote sensing component was limited to the pre-classification in forest/non-forest. The forest definition adopted at that time was different from the FAO standard, so statistically are no more compatible with the latest inventories carried out in 2005 and 2015.

For the future a new cycle of the NFI is planned for 2025.

It is important to note that since the forest planning activities in Italy are under responsibility of Regional Governments several Regions carried out local forest inventories, most of them before the new cycle of the NFI started in 2005. But some Regions started local inventories adopting the NFI sampling but augmenting the number of sampling units also after 2005. Anyhow these data are not used to compile official statistics.

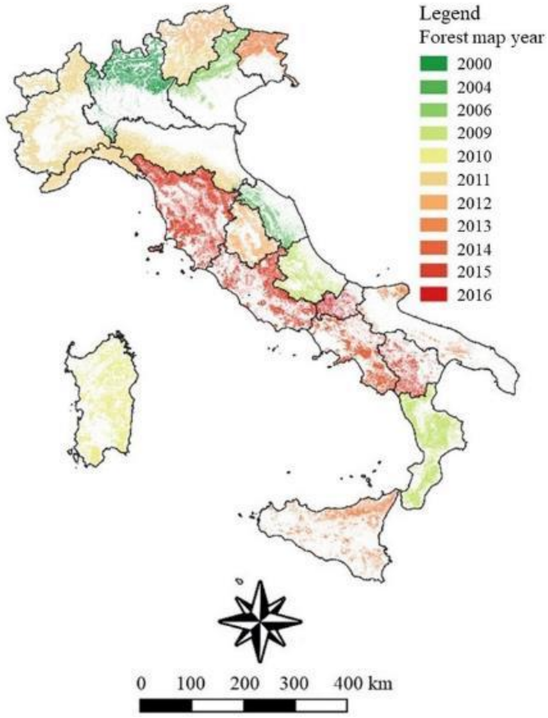
Currently Carabinieri are working in cooperation with CREA and other scientific institutions to set up the future NFI cycle that will start in 2025. Some modifications are expected such as passing from a decadal assessment to a permanent infrastructure able to measure a certain percentage of the plots every year in order to create yearly statistics and a more relevant role of remote sensing for the production of wall-to-wall maps of forest variables. Some research activities were carried out already (Chirici et al., 2020).

Here below we describe other relevant forest monitoring activities in Italy.

15.2.2. Forest mapping

High resolution forest maps are available in most of the Italian Regions, all of them where created on the manual delineation of aerial orthophotos. In most of the cases the definition used is compatible with the standard FAO forest definition (minimum mapping unit of 0.5 hectares). Since the maps are acquired in different years and are only partially compatible (Figure 1) the Italian Ministry of Agriculture funded an important project for mosaicking, harmonizing and updating regional maps to create a final national forest map. The system of nomenclature selected for the national map is based on the European standard set up by the EEA (2006) and is compatible (relationship 1:1) with the forest categories used for stratification by the NFI.

Figure 33 Regional high resolution Forest maps in Italy on the basis of the year of production (from D'Amico et al., 2021)



The project of the national forest map is expected to be completed within the year 2023.

15.2.3. National land use inventory – IUTI

IUTI is the inventory of land uses carried out by routinely by ISPRA – Istituto Superiore per la Protezione e la Ricerca Ambientale (Higher Institute for Environmental Protection and Research, the former Agency for the Environmental Protection), an Italian public research body established by law no. 133/2008, and subject to the supervision of the Ministry of Environment (https://www.isprambiente.gov.it/en/activities?set_language=en).

IUTI is carried out my manual photointerpretation of sampling points of aerial orthophotos. The points are defined on the basis of the same systematic grid used for the NFI but intensified to 500 m from the original 1 km for a total of 1.205.983 points. So 1 point on 4 of the IUTI grid is part of the NFI grid.

The first year of implementation of IUTI was based on historical photos from the period 1988-1989, and then updated with photos from 2008, and 2018 (Di Cristofaro, 2022).

The system of nomenclature is based on the IPCC GPG LULUCF, similar to a first level Corine Land Cover.

All the data are available open access.

15.2.4. National Land use/land cover mapping

ISPRA as National Focal Point (NFP) of the Eionet network of the European Environment Agency (EEA) and in accordance with the modernization process initiated by the EEA of the Eionet network, coordinates through the thematic group Eionet Support to Copernicus land monitoring the flow of data at national level of the Land component for monitoring the territory of the Copernicus program (CLMS) and as such it creates data and cartography of land use and land cover with high spatial and thematic resolution that can be a national reference for analysing the state of the territory and the landscape and for the study of natural and anthropogenic processes. All products are periodically updated based on the availability of new data and services from the Copernicus programme.

Three types of products are available: land cover, land use and land use and land cover, the latter for the description of ecosystem typologies. All the cartographic production is in raster format with a spatial resolution of 10 meters and a classification system of use and coverage in line with the European indications of the EAGLE Group and with the MAES classification system (only for the map referring to the types of ecosystems).

All the maps are available open access on line.

Figure 34 national Land Cover map of Italy for the year 2021, 10 m resolution (from https://groupware.sinanet.isprambiente.it/uso-copertura-e-consumo-di-suolo)

15.2.5. UNFCCC reporting system

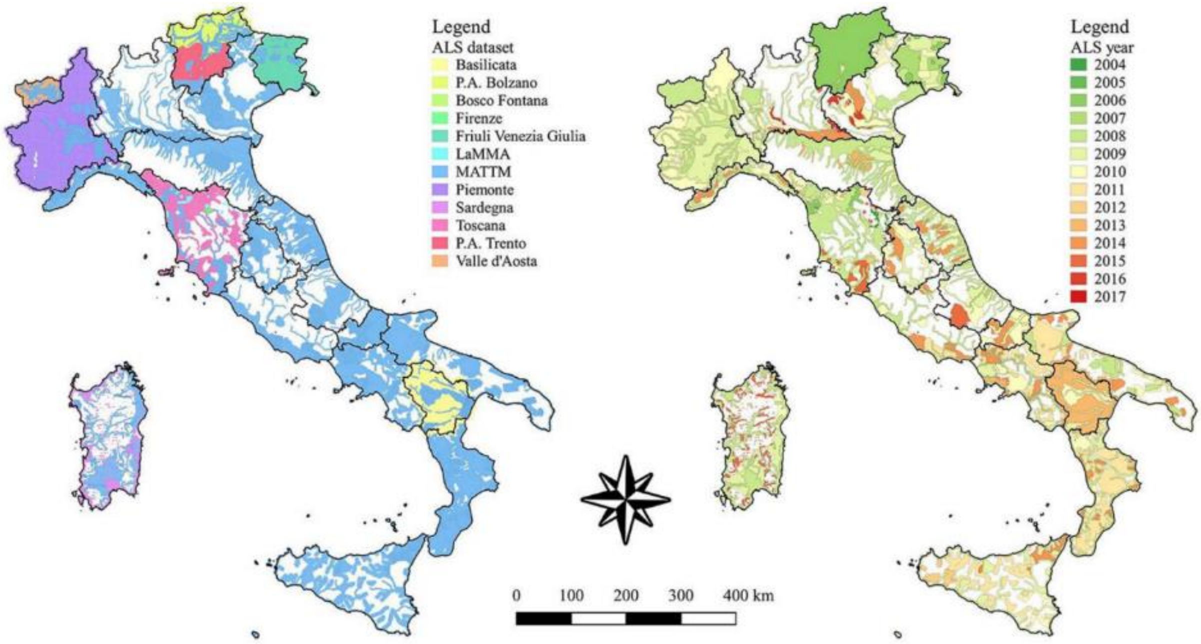
As required by the United Nations Framework Convention on Climate Change (UNFCCC) for all industrialized countries and in line with the commitments of the Kyoto Protocol, Italy must compile, publish and annually review the national greenhouse gas inventory. To that end it was established the National System for the inventory of greenhouse gas emissions. ISPRA processes and transmits the Common Reporting Format (CRF), tables of greenhouse gases with historical series, since 1990, of activity data, emission factors and emissions/absorptions, for the sectors productive and LULUCF, and documents in a specific report, the National Inventory Report (NIR), the estimation methodologies used, together with an explanation of the observed trends.

Since reporting is expected every two years, the NFI is not able to provide updated regular figures. In this framework ISPRA developed an interpolation system to create biannual statistics on the basis of official decadal estimates from the NFI (Federici et al., 2008). Recently the use of remote sensing was demonstrated as a possible valuable source of information for revising such an approach for producing yearly spatially explicit information (Vangi et al., 2023).

15.2.6. The availability of Airborne Laser Scanning data

In Italy a national wall-to-wall coverage with ALS is not yet available Figure 3). The most important acquisition was carried out by the Ministry of Environment with the "*Piano Straordinario di Telerilevamento Ambientale*". After that a number of local acquisitions carried out by Regions or other local bodies created an overall coverage that is approximately the 63% of the total Country (D'Amico et al., 2021).

Figure 35 Spatial distribution of ALS data in Italy. On the left on the basis of the body responsible for the acquisition and on the right on the basis of the year of acquisition (from D'Amico et al., 2021).



15.2.7. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Italy.

Table 58 Italy: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Forest variables monitored/products provided	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	Complete	10y	FAO forest definition	Yes	x	x	x	Yes-Public
Forest biomass	NFI	National	Complete	10y		Yes	x	x	x	Yes-Public
Forest carbon	NFI			10y						
Tree age										
Canopy height	MATTM							x		Yes-upon request
Forest structural diversity	NFI	National	Complete	10y			x	x	x	Yes-Public
Forest soil properties	NFI	National	Complete	10y			x	x	x	Yes-Public
Forest/tree cover change	ISPRA	National	Complete		FAO forest definition	Yes		x		Yes-Public
Tree age diversity										
Tree species/composition	NFI	National	Complete	10y			x	x	x	Yes-Public
Tree species diversity	NFI	National	Complete	10y			x	x	x	Yes-Public
Forest type	NFI	National	Complete	10y			x	x	x	Yes-Public
Deadwood	NFI	National	Complete	10y			x	x	x	Yes-Public
Presence of Red-list species										
Abundance of common forest birds	MITO2000	Plot	Complete	2y		Yes				
Forest spatial patterns	NFI	National	Complete	10y				x		Yes-Public
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	NFI	National	Complete	10y	Natura2000	yes		x		
Silvicultural system	NFI	National	Complete	10y				x		Yes-Public
Main management objectives	NFI	National	Complete	10y				x		Yes-Public
Forest area covered by a management plan	NFI	National	Complete	10y				x		Yes-Public

Forest variables monitored/products provided	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Volume of wood harvested	ISTAT	Regional	Complete	1y				x	x	Yes-Public
Ratio of annual fellings to annual increments	NFI	National	Complete	10y						
Forest revenue	ISTAT	National	Complete	1y				x	x	Yes-Public
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification	PEFC	National	Complete					x		Yes-Public
Forest visitor statistics	ISPRA	National						x		Yes-Public
Forest foliage/phenology/anomalies	NFI	National	Complete		10y			x		Yes-Public
Tree health	CONECOFOR						x	x	x	Yes-Upon request
Forest growth	NFI	National	Complete		10y		x	x	x	Yes-Public
Occurrence of forest fires	MiTE	National Parks	Complete					x	x	Yes-Public
Occurrence of storms	CREA	National	Complete					x	x	Yes-Public
Forest disturbance										
Number of forest fires	MITE (Arma dei Carabinieri)	National	Complete					x	x	Yes-Public

15.2.8. SWOT analysis

Table 59 Italy: SWOT analysis

Strengths	Weaknesses
Italy has a well-established NFI that is able to report robust statistics for a large number of forest variables.	The NFI in Italy is run only once every 10 years (and data are released several years after the completion of the assessment), thus it is not possible to have reliable statistics on variables with short periods such as forest disturbances. For example, Italy is not able to assess the yearly estimates of forest loggings. The NFI does not produce wall-to-wall estimates (maps). Forest maps were produced by independent authorities thus creating potentially contrasting figures on the estimation and reporting of some important variables (such as forest area). Under this point of view the NFI is currently not taking advantage of modern remote sensing technologies. Only of aerial orthophotos for the pre-classification of sampling units.
Opportunities	**Threats**
The new NFI cycle for the 2025 is under planning. It is therefore possible that the new methodology will be based on the use of remotely sensed data. A new forest map in under preparation that is planned to be consistent with the NFI. A large project on the implementation of a national forest information system is currently under development in order to bring all the forest data in a unique and consistent framework.	Several bodies in Italy are responsible for the production of forest related spatial information. NFI produces official statistics that are available only every 10 years (in theory, for example 2015 data were published in 2022). In this situation the need for more frequently updated information activates parallel processes for the creation of alternative information. Examples are IUTI and Land Cover mapping both carried out by ISPRA. It is essential that all the bodies cooperate for the future forest information system. A wall-to-wall coverage of ALS is urgently needed but for the moment it is not planned.

15.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 60 Italy: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Ministry of Agriculture, Food and Forestry	Summary of the newest forest inventory data
	National Forest Inventory	Current data on forests
Biodiversity	National Forest Strategy	Several references throughout the document Main Objective: Forests rich in biodiversity
	National Biodiversity Strategy, pp.63-72	Section dedicated to forests
Bioeconomy	National Forest Strategy, p.32	Objective B: Improve resource use efficiency by optimizing the multifunctional contribution of forests to the development of the bioeconomy and forest economies and rural and inland areas interior of the country, also promoting the expansion and enhancement of forests in urban and suburban settings to improve well-being and environmental quality
	National Bioeconomy Strategy, p.15	Forestry as part of the biodiversity strategy
Ecosystem services	National Forest Strategy, p. 32	Objective A: Promote SFM and the multifunctional role of forests to ensure, at the national scale, ecoregional, regional, and local scales, the balanced, steady, and continuous provision of ecosystem services.
Climate change	National Forest Strategy	NFS to contribute to the actions of mitigation and adaptation to the climate crisis
	Strategy on the reduction of greenhouse gas emissions	Several references to forestry
	Integrated national energy and climate plan	Several mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

15.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 61 Italy: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Promote a European action plan with dedicated funding to improve forest adaptation and resistance to climate change, particularly for the Mediterranean area (south of

Major challenge	Summary description
	Europe); promote and support the use of wood and cork as an alternative to synthetic products; increase wood arboriculture and sustainable forest management for the production of wood-based materials and products; increase the management and growth of urban and peri-urban forests
Ecosystem services	Recognizing a European voluntary market for ecosystem services generated by sustainable forest management
Interest conflicts	
Private forest owners	Interventions aimed at increasing the association between forest owners (public and private) in order to increase sustainable forest management over large areas and make effective actions
Biodiversity conservation	No information
Bioeconomy	Interventions aimed at increasing the cascade use of wood forest products by promoting the development of local supply chains, in particular for the Mediterranean area (south of Europe); Interventions aimed at promoting the social, cultural and tourist recreational role of forests by encouraging integrated projects involving forest owners, the forest sector and the local entrepreneurial fabric, particularly for the Mediterranean area (south of Europe)
Forest fires	General aim of NFS: action A forest fire coordination, fighting and prevention. It is composed of different sub-actions. The main objectives of these sub actions aim to improve the forest fires prevention system, to improve the coordination between land management strategies, to promote the post-fire reconstruction and to improve the collection and analysis of data and to create an open access database on forest fires (Source: National Forest Strategy, *Allegato 1, "Schede delle Azioni Operative, Specifiche e Strumentali*").
Desertification	
Population-related challenges	Promote communication actions and awareness of the public opinion on the role of forest and forest products
Financing	No information
Governance	No information

15.4. References

Chirici, G., Giannetti, F., McRoberts, R.E., Travaglini, D., Pecchi, M., Maselli, F., Chiesi, M., & Corona, P. (2020). Wall-to-wall spatial prediction of growing stock volume based on Italian National Forest Inventory plots and remotely sensed data. International Journal of Applied Earth Observation and Geoinformation, 84

CONECOFOR - https://agris.fao.org/agris-search/search.do?recordID=AV2012091189

D'Amico, G., Vangi, E., Francini, S., Giannetti, F., Nicolaci, A., Travaglini, D., Massai, L., Giambastiani, Y., Terranova, C., & Chirici, G. (2021). Are we ready for a National Forest Information System? State of the art of forest maps and airborne laser scanning data availability in Italy. iForest - Biogeosciences and Forestry, 14, 144-154

di Cristofaro, M., Di Pirro, E., Ottaviano, M., Marchetti, M., Lasserre, B., & Sallustio, L. (2022). Greener or Greyer? Exploring the Trends of Sealed and Permeable Spaces Availability in Italian Built-Up Areas during the Last Three Decades. Forests, 13, 1983

EEA (2006). European forest types. Categories and types for sustainable forest management reporting and policy. In, Technical report 9/2006 (p. 111): European Environmental Agency

Federici, S., Vitullo, M., Tulipano, S., De Lauretis, R., Seufert, G., 2008. An approach to estimate carbon stocks changes in forest carbon pools under the UNFCCC: the Italian case. iForest 1, 86–95 [online: 2008-05-19] URL: http://www.sisef.it/iforest/.

Vangi, E., D'Amico, G., Francini, S., Borghi, C., Giannetti, F., Corona, P., Marchetti, M., Travaglini, D., Pellis, G., Vitullo, M., & Chirici, G. (2023). Large-scale high-resolution yearly modeling of forest growing stock volume and above-ground carbon pool. Environmental Modelling & Software, 159, 105580

Ministry of Agriculture, Food and Forestry report: https://www.crea.gov.it/-/ambiente-foreste-per-il-clima-dati-nuovo-inventario-nazionale-forestale-e-dei-serbatoi-di-carbonio-carabinieri-all4climate-milano-29-30-settembre#:~:text=L'Inventario%20Nazionale%20delle%20Foreste,a%20livello%20nazionale%20e%20regionale.

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory – INFC 2015: https://www.inventarioforestale.org/

Gasparini P., Di Cosmo L., Floris A., De Laurentis D.- 2022 - Italian National Forest Inventory—Methods and Results of the Third Survey - Springer Cham

Le foreste italiane - Sintesi dei risultati del terzo Inventario Forestale Nazionale INFC2015 - Arma dei Carabinieri Comando Unità Forestali, Ambientali e Agroalimentari e CREA https://www.inventarioforestale.org/sites/default/files/datiinventario/pubb/Sintesi_INFC2015.pdf

National Forest Strategy: https://www.crea.gov.it/web/politiche-e-bioeconomia/-/la-strategia-forestale-nazionale-il-futuro-delle-foreste-e-del-settore-forestale#:~:text=La%20sua%20missione%20%C3%A8%20quella,domani%2C%20ponendo%20cos%C3%AC%20i%20nostri

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_ITA (foresteurope.org)

National Biodiversity Strategy: http://extwprlegs1.fao.org/docs/pdf/ita169210.pdf

National Bioeconomy Strategy: https://www.agenziacoesione.gov.it/wp-content/uploads/2019/06/bioeconomia_eng.pdf

Strategy on the reduction of greenhouse gas emissions: https://ec.europa.eu/clima/sites/lts/lts_it_it.pdf

COST Action E30, country report: https://www.isprambiente.gov.it/files/atmosfera/italy-report.pdf

Integrated national energy and climate plan: https://energy.ec.europa.eu/system/files/2020-02/it_final_necp_main_en_0.pdf

16. LATVIA

16.1. Country overview – major forest facts

16.1.1. Key forest data

Latvia is a country on the Baltic Sea. The forest covers 3.403 million hectares of land in Latvia, or 55% of the country's territory. Latvia is the fourth highest forest cover among all EU countries. Both conifers and deciduous trees grow in Latvian forests. Main tree species: Scots pine (33.1%%), Norway spruce (19,8%), silver birch (23,3%). The rest of the forest areas are occupied by stands of grey alder, aspen, common alder, European ash and oak and other hardwood trees (23,8%). Forest area has been growing steadily, from 51% forest cover as proportion of total land area in 1990, to 54.9% in 2020. Growing stock and above ground biomass stock have been increasing faster than forest area. Growing stock is 197 m3 ob./ha in 2020. Over 16% of forest is protected for conservation of biodiversity. In 2020, areas designated as protection forest accounted for 6.4% of forest area. Nearly 17 thousand ha of forest are reported as being undisturbed by man.

16.1.2. Institutional setup and legal framework

There is National Forest Policy as a formal process. The Latvian Forest Policy was adopted in 1998 at national level. The prerequisites for sustainable forest management in Latvia are the goals and principles defined in Latvia's forest policy, the implementation of which is ensured by industry policy planning documents and regulatory acts: guidelines for the development of forestry and related industries, as well as the regulation contained in the Forest Law and other regulatory acts related to forest management and nature protection. Last analyses about Latvia's forest sector sustainable development done in 2013.

Forest and Related Sectors Development Guidelines amendment - Objectives, directions of action, policy, and operational results and their planned and achieved performance indicators.

Forest management and use in Latvia is regulated by the Law on Forests. The purpose of the Law on Forests is to promote economically, ecologically, and socially sustainable management and use of the forest by ensuring equal rights, inviolability of the ownership rights, and independence of economic activity of all owners or lawful possessors of the forest and determining equal obligations.

The Law on Forests states that Latvian State Forest Research Institute Silava shall perform national forest monitoring (National Forest inventory) in the whole territory of the State, obtaining statistical information regarding the situation with forest resources and forest health, as well as the interaction of the forest and environmental factors (biotic, abiotic, anthropogenic factors). National forest monitoring is a system for the observation, analysis, and forecasting of forest resources and environmental situation in which scientific methods are employed.

The other important producer of official forestry statistics is the State Forest Service. The State Forest Service is a state administration civil institution with the Ministry of Agriculture, which is responsible for pursuing a unified forest policy in all the Latvia`s forests, controlling observance of the provisions of statutory acts, and implementing support programmes, in the long term aimed at ensuring sustainable forest management.

The State Forestry Service carries out forest inventory on the scale of forest land parcels. The Law on Forests states a forest owner shall ensure the forest inventory in its ownership or lawful possession and submit the data thereof to the State Forest Service. Forest inventories that are conducted at the level of forest districts make it possible to plan and implement forest management plans in each specific area.

The most important producers of official forestry statistics, in Latvia are the State Forest Service, the NFI, State Land Service and Central Statistical Bureau.

The main data source for estimates of forest resource parameters since 2008 is the NFI.

Until 2008 the main producer of official forestry statistics was the State Forest Service.

16.1.3. Key actors and stakeholder organisations

Ministry of Agriculture; State Forest Service; National Forest Inventory (Latvian State Forest Research Institute "*Silava*"); State Land Service; Central Statistical Bureau; Ministry of Environmental Protection and Regional Development; Nature Conservation Agency; Latvian Forest Industry Federation; Latvian Forest Owner's Association; Joint Stock Company "Latvia's State Forests"

16.1.4. Forest ownership

In Latvia 51% of area of all forests are owned and managed by the state and local governments and 49% by about 135 private forest owners, The distribution of private forests by the property size classes, 22% are managed by forest owners whose forest area is 10 hectares or less, 55% are managed by forest owners whose forest area is 11-500 hectares, while 23% of the private forest area belongs to forest owners whose forest area is larger than 500 hectares.

16.1.5. Forest industry

Forest sector – forestry and wood processing industry, is one of biggest sectors in Latvia's national economy and contribute 5,3% in national GDP, 2020. Forest sector turnover in 2019 was 4096 Mio. EUR. Forest sector is the biggest employ in rural areas and cities outside capital Riga.

Wood removals rose rapidly in the 1990s but have now stabilized around 13-15 million m3 (under bark) in last five years.

In 2020, fellings were nearly 70% of net annual increment, according to monitoring data of National Forest Inventory.

Forestry and wood products production is one of the most important economic sectors in Latvia. In the removals statistic about 50% consist of sawlogs and veneer logs, 26% pulpwood, 18% fuelwood and 6% other industrial roundwood. In recent years, there has been a tendency to increase the intensity of forest use, which is explained by the accumulation of old- growth forest stands.

In Latvia, employment in forestry and the wood processing industries (no data available for pulp and paper) have fluctuated around 40 thousand people, although there was a temporary spike in 2005, to 63 thousand people.

16.1.6. Key forestry issues

The Latvian Forest and Related Sectors Development Guidelines include -

Policy objective 1 - Latvia's forest management is sustainable and internationally recognized

Main direction of action to achieve the goal are:

- Effective and sustainable management of forest and forest land.
- Forest management risk reduction.

Policy objective 2 - The production of the Latvian forest industry is competitive with high added value and meets the customer's needs

Main direction of action to achieve the goal are:

- Development of the competitiveness of the forest sector.
- Development of new wood products and companies.

Policy objective 3 - Educational and scientific potential and skill level of human resources corresponding to the development of the forest sector

Main direction of action to achieve the goal are:

- Development of forest science.
- Development of forest sector education.
- Informing and educating the public and forest owners.

Developing a national biodiversity strategy and integration of biodiversity targets into the national forest strategy.

16.2. Forest monitoring

16.2.1. National Forest Inventory

Latvia has the fourth biggest forest cover among the EU countries, with 3.8 million of hectares (Silava, 2018).

Latvian State Forest Research Institute (LSFRI) "Silava" carries out the National Forest Inventory according with The Regulation of the Cabinet of Ministers, No.238 and LSFRI Silava Medium term development strategy. Latvia counts three completed NFI cycles, which results were published in 2011, 2014, 2018. The fourth NFI is still ongoing.

The NFI plots, located on a 4x4 km grid, were revisited every five years, to re-measure (and compare) forest characteristic such as average tree height, deadwood and growing stock, according to the methodology of the National Forest Monitoring plan.

The information collected during the NFI sampling were also used as in reporting for LULUCF sector to the EU and the UNFCCC, along with the Latvian forestry accounting plans. Forest definition adopted in Latvia’s national forest accounting plan, national land register and in the national greenhouse gas inventory is harmonized.

The NFI database is maintained by the Latvian State Forest Research institute “Silava”, and includes complete information related to Latvian forest stand parameters such as tree species, density, growing stock, stand height, biomass and deadwood.

16.2.2. Forest mapping

Silava carried out a regional cooperation project for remote sensing forest monitoring (Lūkins, 2015). Satellite images (SPOT-%, Landsat, DMCII, IRS-P6 LISS-III, and IRS-P6 AWiFS) and

NFI information were used for data interpolation and spatial planning, along with monitoring land use changes.

Moreover, the use of LiDAR-based Canopy Height Model was compared to NFI tree information.

Currently, a national project aimed at monitoring forest risk factors through remote sensing is active in Latvia. Started in 2022, the estimated end date is 30 November 2023 and the expected output will be the development of software tools for assessment, monitoring and alerting of forest risk factors using satellite and unmanned aerial vehicle (UAV) based techniques. The leading partner of the project is the Institute of Elecrontics and Computers Science, in cooperation with the Latvian State Forest Research Institute “Silava”. The estimated cost for the project is 431 726 € and is based on the European Regional Development Fund project (No 1.1.1.1/21/A/040), Specific Objective 1.1.1 "Improve research and innovation capacity and the ability of Latvian research institutions to attract external funding, by investing in human capital and infrastructure", 1.1.1.1. measure "Industry-Driven Research" Project application selection round No 5.

External research in Latvia assessed the large-format digital surface model (DSM) performance for canopy height estimation in primarily mature, closed-canopy Hemiboreal forests (Taurkalne forests), using geosynchronous satellites (GeoEye1 and Pleiades1B) and aircraft (UltraCam) imagery acquired in 2020. Airborne LiDAR and forest inventory data were used as reference data for the study. LiDAR open access data were acquired over the study area by MGGP Aero (Poland) at the end of May 2017 and provided by the Latvian Geospatial Information Agency (Goldbergs, 2021).

16.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Latvia.

Table 62 Latvia: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest biomass	NFI, SILAVA	National	Complete	5y	*FAO, Forest Europe, LULUCF*	yes			x	*yes - public*
Forest carbon	NFI, SILAVA	National	Complete	*5y*	*LULUCF*				x	yes - public
Tree age	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Canopy height	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Forest structural diversity	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Forest soil properties	*SILAVA*	*National*								
Forest/tree cover change	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Tree age diversity	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Tree species/composition	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Tree species diversity	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Forest type	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - upon request
Deadwood	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes-public
Presence of Red-list species	NCA	National								
Abundance of common forest birds	NCA	National								
Forest spatial patterns	NFI, SILAVA	National	Complete	5y	???					
Areas of primary and old-growth forests	NFI, SILAVA	National			*FAO, Forest Europe*					
Forest ancientness	NFI, SILAVA	National								
Forest area under protection	OZOLS/ SFS	National			*FAO, Forest Europe*					
Silvicultural system	CSB	National	Complete	1y					x	yes-public
Main management objectives	SFS	National	Complete		*FAO, Forest Europe*			x	x	yes - upon request
Forest area covered by a management plan	SFS	National	Complete	1y	*FAO, Forest Europe*			x	x	yes - upon request
Volume of wood harvested	NFI, SFS	National	Complete	1y	JFSQ, FAO, Forest Europe	yes		x	x	yes - upon request
Ratio of annual fellings to annual increments	NFI	National	Complete		*FAO, Forest Europe*	yes		x	x	yes - upon request
Forest revenue	CSB	National	Complete	1y	JFSQ	yes			x	yes - public
Roundwood prices	CSB	National	Complete	1y		yes			x	yes - public
Forest products trade	CSB	National	Complete	1y		yes			x	yes - public
Employment in the forest sector	CSB	National	Complete	1y	*FAO, Forest Europe*	yes			x	yes - public
Forest area with 3rd party certification	Forest certification organizations	National	Complete	no	*FAO, Forest Europe*	yes			x	yes - public

Indicator	**Leading data provider**	**Geographical reporting unit**	**Geographical coverage**	**Assessment periodicity**	**Data harmonization**	**Data accuracy**	**Data availability**			
							Raw	**Aggregated**	**Processed**	***note***
Forest visitor statistics	no data available									
Forest foliage/phenology/anomalies	NFI	National	Complete	1y	???	yes			x	yes - public
Tree health	NFI/SFS	National	Complete	1y	*FAO, Forest Europe*	yes			x	yes - public/upon request
Forest growth	NFI	National	Complete	5y	*FAO, Forest Europe*	yes			x	yes - public/upon request
Occurrence of forest fires	SFS	National	Complete	1y	*FAO, Forest Europe*				x	yes - public
Occurrence of storms	SFS, NFI	National	Complete	1y	*FAO, Forest Europe*				x	yes - public
Forest disturbance	SFS, NFI	National	Complete	1y	*FAO, Forest Europe*				x	yes - public
Number of forest fires	SFS	National	Complete	1y	*FAO, Forest Europe*					
Number of storms	no data available									
Import/export	CSB	National	Complete	1y	JFSQ	Yes			x	yes - public
Forest regeneration	SFS	National	Complete	1y	*FAO, Forest Europe*	Yes			x	yes - public
Type of energy wood	CSB	National	Complete	1y	JFSQ	Yes			x	yes - public
Total consumption of energy resources	CSB	National	Complete	1y	JFSQ	Yes			x	yes - public
Output per worker	CSB	National	Complete	1y		Yes			x	yes - public
Profit of Forest sector companies	CSB	National	Complete	1y		Yes			x	yes - public
Net turnover of Forest sector	CSB	National	Complete	1y		Yes			x	yes - public

16.2.4. SWOT analysis

Table 63 Latvia: SWOT analysis

Strengths	**Weaknesses**
A well-established NFI exist	Poor information reported for Latvian NFI and forest monitoring in general
Opportunities	**Threats**
Many projects related to forest monitoring are currently active in Latvia	Insufficient communication among researcher and institution led to limitation of research project for remote sensing applied in forestry

16.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 64 Latvia: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Forest and Related Sectors Development Guidelines	Policy objective: Latvian forest management is sustainable and internationally recognized. Policy action: Effective and sustainable management of forest and forest land. Policy result: Ensuring availability of forest resources now and for future generations Forest resource status and trends are published at Latvian Forest Sector in Facts & Figures 2022
	National Forest Inventory	Current data on forests
Biodiversity	Environment Policy Guidelines	Policy objective: To preserve and restore ecosystems and biological diversity Sub-objective 1: Preservation of biological diversity, including specially protected species and habitats, and valuable landscapes. Sub-objective 2: Conservation and management of natural capital. Policy result: Biodiversity conservation ensured
	Biodiversity monitoring program Policy objectives, actions and results included in Environment Policy Guidelines.	Biodiversity monitoring program obtaining information about species and habitats of EU importance and specially protected species and habitats of Latvia. EU requirements in the implementation of biodiversity monitoring have been fulfilled.
	National Forest monitoring (NFI)	According to National Forest monitoring methodology that obtains information on biologically significant structural elements in the forest (such as the amount of dead wood, forest species, forest structure, forest genetics etc.)
Bioeconomy	National Bioeconomy Strategy	The vision of the Latvian bioeconomy development strategy – the bioeconomy industries in Latvia are innovation leaders in maintaining, increase, effective and sustainable use of natural capital value in the Baltic States. The goal of the strategy is to keep employment in the traditional sectors of the bioeconomy in 2030 at the level of 2015, i.e., 128 thousand. human beings. Forest sector as important part of Latvia's bioeconomy can contribute with potential to increase the economic value of the forest and higher added value product production in wood working sector.

Thematic area	Main Strategic reference	Summary of planning elements
Ecosystem services	Environment Policy Guidelines	Policy objective: To preserve and restore ecosystems and biological diversity. Policy Result: Transition to natural capital management and ecosystem services in biodiversity conservation initiated.
	Law on Forests	Natural persons have the right of access to and free movement in a State and local government forest if laws and regulations do not provide for otherwise. Owners of private forests often do not restrict the movement of persons in the forest. Forest non-wood material values - wild berries, fruit, nuts, mushrooms, and medicinal plants - may be gathered by persons at their discretion, if the forest owner or the lawful possessor has not set restrictions accordance with the provisions of this Law.
	Medium-term strategy of the JSC	Strategic goal 10: Provide nature diversity and recreation services from the forest ecosystem
Climate change	National Energy and Climate Plan of Latvia from 2021-2030	The following action have been defined to achieve the objectives of the plan: 9. Sustainable use of resources and reduction of GHG emissions and increasing carbon sequestration in the sectors of land use, land-use change and forestry.
	Medium-term strategy of the JSC	Strategic goal 9: To increase the contribution of forests to be managed to mitigate global climate change and increase the use of renewable resources

16.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 65 Latvia: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Climate extremes are increasing in frequency and intensity, causing losses to agriculture and forestry, affecting crop yields, and increasing crop failure risks. Farmers and foresters lack understanding of the impact of their economic activity on climate change, incl. soil management, opportunities to mitigate and adapt to climate change. Inappropriate forest management can reduce the potential for CO2 capture.
Ecosystem services	Not all ecosystem services are valued, especially those freely available in the forest sector.

Major challenge	Summary description
Interest conflicts	The interests of landowners are in conflict with strict limitations for the protection of biodiversity.
Private small forest owners	Insufficient compensations for economic activity restrictions.
Biodiversity conservation	Land use, land use change and fragmentation of ecosystems has an impact to biodiversity.
Bioeconomy	Shortages in biomass availability for production due to different unharmonized regulations at EU and national level.
Forest fires	Forest fires can lead to catastrophic changes in the ecosystem, causing the deaths of most biocenosis-making populations. Great losses are being done to the country's economy. Natural disasters caused by climate change also contribute to the threat of forest fires in recent years. The total costs of forest fires are often undetectable, as they are comprised of forest fire relief costs, timber losses, tourism-related losses as well as impacts on human health and damages to the ecosystem.
Desertification	Desertification is not relevant in Latvian forests.
Population density	Population in rural regions is decreasing.
Financing	Due to different regulations, the economic viability of forest management is decreasing.
Governance	Increase of administrative burden to landowners, and forest sector operators due to EU policies un regulations.

16.4. References

Goldbergs, G. (2021). Impact of Base-to-Height Ratio on Canopy Height Estimation Accuracy of Hemiboreal Forest Tree Species by Using Satellite and Airborne Stereo Imagery. Remote Sensing, 13(15), 2941. https://doi.org/10.3390/rs13152941

Latvia National Forest Inventory http://www.silava.lv/69/section.aspx/View/13

Lūkins M. (2015) Regional cooperation for space success.

https://www.eesc.europa.eu/sites/default/files/resources/docs/mr-lukins.pdf accessed on 29/12/2022

SoEF, 2020: https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

Latvian Forest Policy: https://www.zm.gov.lv/mezi/statiskas-lapas/nozares-strategijas-politikas-dokumenti/latvijas-meza-politika?nid=328 (in Latvian)

Medium-term strategy of the JSC: medium-term-strategy-of-the-joint-stock-company-latvijas-valsts-mezi_en_gb.pdf (lvm.lv)

Informative Report on the Importance of Forests: http://polsis.mk.gov.lv/documents/7162 (in Latvian).

Law on Forests: https://likumi.lv/ta/en/en/id/2825-law-on-forests

National Forest Inventory: http://www.silava.lv/petijumi/nacionlais-mea-monitorings.aspx (in Latvian).

State Forest Service: https://www.vmd.gov.lv/en/valsts-meza-dienests/statiskas-lapas/about-us?nid=631#jump

Forest and Related Sectors Development Guidelines 2015-2020: http://polsis.mk.gov.lv/documents/5331 (in Latvian).

Latvian Forest Sector in Facts & Figures 2022: https://www.zm.gov.lv/public/ck/files/ZM/mezhi/buklets/Latvian_Forest_Sector_in_facts_figures_2022.pdf

Environment Policy Guidelines: https://likumi.lv/ta/id/335137-par-vides-politikas-pamatnostadnem-20212027-gadam (in Latvian).

National Bioeconomy Strategy: https://www.zm.gov.lv/public/files/CMS_Static_Page_Doc/00/00/01/46/58/E2758-LatvianBioeconomyStrategy2030.pdf

National Energy and Climate Plan of Latvia from 2021-2030: https://energy.ec.europa.eu/system/files/2020-04/lv_final_necp_main_en_0.pdf ;https://ec.europa.eu/eurostat/databrowser/view/FOR_REMOV__custom_3567871/settings_1/table?lang=en

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-latvia_en_0.pdf

17. LITHUANIA

17.1. Country overview – major forest facts

17.1.1. Key forest data

Lithuania is a country on the Baltic Sea with about a third forest cover. Among the most common tree species in Lithuania are: pine (34%), spruce (21%), birch (22%) other species (23%). Almost 100 % of Lithuanian forests are under a forest management plan. These plans are obligatory in certain circumstances and registered with an official body. 58% of forests are under third party certification, exclusively by FSC . Over the last 30 years, forest area has expanded from 31% to 35.2% of total land area. Growing stock and above-ground biomass have expanded faster than forest area. Growing stock per hectare in 2022 was on average 259 m3.All forests in Lithuania are divided into 4 different forest groups, according to the level of protection and its main functional purpose: I – forest reserves (1% of forests). These are forests in state natural reserves, natural reserves in national parks and biosphere monitoring areas. The most protected areas, where no human activities are allowed. II – forests of special purpose (11%), further divided into a) ecosystem protection forests, which are established to protect, preserve and restore various ecosystems and b) recreational forests which are established to preserve and restore recreational environment. Strict regulations for human activities, no clear fellings are allowed. III – protective forests (12%), with the aim to form productive stands, able to provide ecosystem services – protection of soil, air and water. Management restrictions consist of maximum clear-felling area; clear-felling is not allowed in National parks. IV – commercial forests (75%), with the main aim to form productive stands, providing wood resources, taking into account sustainable forest management. Management restrictions consist of maximum clear-felling area, rotation lengths. About 28 thousand ha of forest are considered undisturbed by man.

17.1.2. Institutional setup and legal framework

The Law on Forest was enacted in 1995 and was most recently amended in 2018. Current forest-related information at state level is from the NFI. Amendment of the Law on Forest and new National Forest Sector Strategic document is under preparation now.

17.1.3. Key actors and stakeholder organisations

Ministry of Environment; State Forest Service; The Department of Environmental Protection controls the implementation of the Forest Law; State Forest Enterprise; Private forest owners' associations.

17.1.4. Forest ownership

During the Soviet period, the state ownership of forestland and centralized planned management have been characteristic of forestry as well as the entire economy. The emergence of private forest ownership has occurred after Independence in 1990. All private forest owners can be assigned to the 'new forest owners' group, which represents 'individuals or organizations that previously have not owned forest land, and transformed public ownership categories through restitution'. Currently, the private forest sector constitutes around 42% of the total forest area. Small-sized private forest properties are common in Lithuania. The average size of a forest estate remains unchanged from 2001 and is 3.3– 3.4ha.

17.1.5. Forest industry

Removals are about 7 million m3 according to market conditions. Fellings were 76% of net annual increment in 2021. If this ratio is adjusted to take account of felling of natural losses, it is 69%. Nearly 35 thousand people were employed in the forest sector in 2020, of which 20 thousand were in the wood processing sector.

17.1.6. Key forestry issues

Improvement of forest management regimes, as the current system does not completely ensure the protection important forest habitats and is not adjusted to the small-scale private forest holdings.

Competing needs of society for forests - the need to find a new balance.

Growing demand for non-timber forest services.

Climate change is a threat to the forests.

The conflict between the aspirations of better nature conservation and more rational forest use.

17.2. Forest monitoring

17.2.1. National Forest Inventory

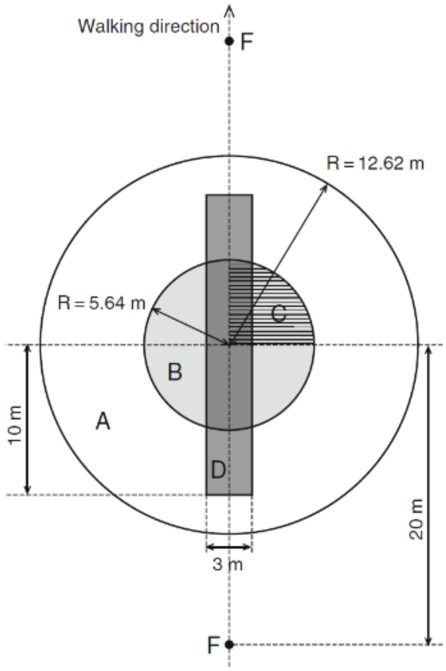
Forest inventory in Lithuania consists of two national inventories: a stand level forest inventory (SFI), with the main objective to obtain data about every forest compartment, which can be used for the purpose of forest planning and organization and a national forest inventory (NFI) using statistical sampling methods, to thoroughly monitor all Lithuanian forests, with a note and estimate the main forest parameters and their variation at the national or local level. Both inventories cover the entire national forest estate on a regular basis.

In 1969 all Lithuanian state forests (75% of all forests) were inventoried first time using the NFI based on temporary plots, allowing the estimation of growing stock volume changes in post-war Lithuanian forests. After preliminary studies, in 1998 a regular NFI was launched in Lithuania (Nacionalinė 1998). It is a continuous multistage sampling inventory based on a combination of permanent and temporary plots (Kuliešis *et al.* 2009). Since 2012, the field work was expanded from forest land to include all other land use categories by visiting every plot in field with the goal to assess all land use, land use changes, soil and biomass characteristics on the entire network of NFI permanent plots.

The Lithuanian NFI is based on a systematic sampling, conducted using a 4 x 4 km grid with a random starting point. The systematic grid assures a uniform distribution of plots over the entire country and regular management of conversion amongst land use categories. The sample plots are arranged into clusters and include permanent, regularly measured, and temporary plots. On the whole territory, permanent plots are 16,325 (Kuliešis et al. 2010). The ratio of permanent and temporary plots is three to one. Since the beginning in 1998 (1998-2002) the NFI has been implemented on a continuous basis with an interval of 5 years remeasurement cycle, repeated three times (2003–2007, 2008–2012, and 2013–2017). The NFI data consists of three main data categories: (i) area characteristics, (ii) state and (iii) dimensions of trees. After the fieldworks check, data are permanently stored in the NFI databases. This dataset is used to estimate forest statistics, as no further correction of the data is allowed. The data are published in yearly statistical reports.

The principal sample unit is a permanent or temporary plot of 12.62 m radius and area of 500 m^2, where all trees with dbh > 14.0 cm are measured. In the center of the plot, another 100 m^2 circular plot is used to measure all trees with dbh > 6.0 cm. In the first quarter of the 100 m^2 plot, i.e. on 25 m^2 area, naturally growing saplings, shoots over 2.0 cm in diameter at 1.3 m height as well as all planted trees, regardless of their dimensions, are measured and mapped.

Figure 36 Construction of the sample plot. A, B – circular plots, C quarter of a circular plot, respectively 500, 100, and 25 m^2 in size, D – 60 m^2 strip and F – angle count plots



17.2.2. Forest Mapping

The Lithuanian geoportal (https://www.geoportal.lt/geoportal/en/web/en) provides information layers also related to forests (Bikuvienė and Tiškutė-Memgaudienė, 2016).

Among the research with remote sensing data from outside the NFI project, Gozdowski *et al.* (2020), assessed land cover changes in southwestern Lithuania from 1984 to 2018, based on Landsat 5, Landsat 8, and Sentinel-2 multispectral imagery. However, there is a lack of mapping of inventory variables derived from the use of remote sensing data and NFI samples.

17.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Lithuania.

Table 66 Lithuania: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	NFI	National, Regional	Complete	5y		yes		x		
Forest biomass	NFI	National, Regional	Complete	5y		yes		x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest carbon	NFI	National, Regional	Complete	5y		yes		x		
Tree age	NFI	National, Regional	Complete	5y		yes		x		
Canopy height	NFI	National, Regional	Complete	5y		yes		x		
Forest structural diversity	NFI	National, Regional	Complete	5y		yes		x		
Forest soil properties	NFI	National, Regional	Complete	5y		yes		x		
Forest/tree cover change	NFI	National, Regional	Complete	5y		yes		x		
Tree age diversity	NFI	National, Regional	Complete	5y		yes		x		
Tree species/composition	NFI	National, Regional	Complete	5y		yes		x		
Tree species diversity	NFI	National, Regional	Complete	5y		yes		x		
Forest type	NFI	National, Regional	Complete	5y		yes		x		
Deadwood	NFI	National, Regional	Complete	5y		yes		x		
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	NFI	National, Regional	Complete	5y		yes		x		
Silvicultural system	NFI	National, Regional	Complete	5y		yes		x		
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NFI	National, Regional	Complete	5y		yes		x		
Ratio of annual fellings to annual increments	NFI	National, Regional	Complete	5y		yes		x		
Forest revenue	State Forest Enterprise	National	Partial	1y				x		
Roundwood prices	State Forest Enterprise	National	Partial	1m				x		
Forest products trade	Statistics Lithuania	National	Complete	1m				x		
Employment in the forest sector	Statistics Lithuania	National	Complete	1y				x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies	NFI, SHM	National, Regional	Complete	5y, 1y		yes		x		
Tree health	NFI, SHM	National, Regional	Complete	5y, 1y		yes		x		
Forest growth	NFI	National, Regional	Complete	5y		yes		x		
Occurrence of forest fires	State Forest Enterprise	National	Complete	1y				x		
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										
Vegetation species (occurrence and abundance)	NFI	National	Complete	5y		yes				
Naturalness	NFI	National	Complete	5y		yes				

17.2.4. SWOT analysis

Table 67 Lithuania: SWOT analysis

Strengths	**Weaknesses**
Well established NFI that is able to report robust statistics for a large number of forest variables.	The NFI does not produce wall-to-wall estimates (maps).
Opportunities	**Threats**
The production of forest maps in the context of NFI would ensure the consistency of the estimates. In the new NFI cycles update the new methodology to take advantage of the use of remotely sensed data.	NFI is not currently taking advantage of modern remote sensing technologies.

17.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 68 Lithuania: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	State Forest Service	Current forest-related information
	National Forest Inventory	Current data on forests
Biodiversity	National Environment Protection Strategy	Determines the priority areas of environmental protection policy, long-term goals until 2030 and Lithuania's environmental vision until 2050
	Landscape and Biodiversity Conservation Action Plan 2015-2020	Summary of actions for the period of 2015-2020; national level conservation objectives for habitats of Community importance
	2021-2030 National Progress Plan	Identifies the key changes that ensure progress in the social, economic, environmental and security fields
	2022-2030 Environmental Protection and Climate Change Management Progress Programme	Summary of environmental conservation and climate actions for the period 2022-2030, including forests and biodiversity
	Comprehensive Plan of the Territory of the Republic of Lithuania	Defines spatial development aims and functional priorities for the use of territories
	Forestry Sector Development Programme for 2012-2020	Acknowledgement of importance of forests for maintenance of biodiveristy
	State Forest Enterprise operational strategy for 2022-2026	Strategic orientation A2: Improve condition of biodiversity in the areas managed by the State Forest Enterprise
Bioeconomy	Lithuanian Bioeconomy Strategy	Exploration of the potential of the forest and forest-based sector
	Forestry Sector Development Programme for 2012-2020	Task 13 – forest as source for biofuels
Ecosystem services	Forestry Sector Development Programme for 2012-2020	Task 20: Enhancing the ecological and landscape stability of forest ecosystems
	State Forest Enterprise operational strategy for 2022-2026	Strategic orientation A: Increase forest ecosystems sustainability
Climate change	National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030	Several mentions of forestry as a means to achieve climate-related goals
	Forestry Sector Development Programme for 2012-2020	The objective is to preserve and enhance the sustainability of forest ecosystems, taking into account their ecological and social role and the impact of climate change

17.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 69 Lithuania: Forest-related challenges that influence integrated long-term planning

Major challenge	**Summary description**
Climate change	Additional actions and measures needed for better adaptation of the forests to the climate change.
Ecosystem services	With the strengthening of the private forest sector, the conflict between the public function of forests and the owner's direct benefit from the property (the issue of payment for forest ecosystem services) is becoming apparent.
Interest conflicts	The conflict between the aspirations of better nature conservation and use of forest resources, competing needs of society for forests, growing demand for non-timber forest services - the need for new forestry measures and the search for a new balance.
Private small forest owners	Small private forest holdings, weak cooperation of forest owners and lack of forestry knowledge hinder the development of private forestry
Biodiversity conservation	Finding and applying of new silvicultural and forest management system is needed in order to better respond to the biodiversity protection targets in the protected forest habitats, especially in those, where clear-cut systems are applied nowadays. Conservation of localities of endangered species in forests across all forest groups.
Bioeconomy	About 7% of Lithuanian forests are "reserved for restitution of property rights" and eliminated from the forest management and timber supply. The integration of those forests into the management system would bring respective value added to the green economy.
Forest fires	Adapt forest fire protection to climate change by introducing advanced forest fire detection and rapid response tools and technologies[1]
Desertification	No information
Population-related challenges	Rising emigration and aging of the society leads to the workforce deficits also in the forest sector. Mechanisation of the processes are not always the way out. Especially forest planting, maintenance and thinning of young stands, forest cuttings in FOREST EUROPE/UNECE/FAO pan-European questionnaire on the qualitative Indicators for SFM ecologically sensitive areas, also nature management measures needs a lot of forest workers.
Financing	Money for compensations for economic activity restrictions in private forests
Governance	Harmonization of competing forest ecosystem services at the national level

[1] 2021-2030 National Progress Plan

17.4. References

Bikuvienė, I., Tiškutė-Memgaudienė, D. (2016). GIS in Lithuanian forest inventory–20 years' experience. In Sinteza 2016-International Scientific Conference on ICT and E-Business Related Research (pp. 208-212). Singidunum University.

Kuliešis A, Kasperavičius A, Kulbokas G, Kvalkauskienė M (2009) Lietuvos nacionalinė miškų inventorizacija 2003–2007. Miškų ištekliai ir jų kaita [Lithuanian national forest inventory 2003–2007. Forest resources and their dynamic]. Aplinkos ministerija, Valstybinė miškotvarkos tarnyba, Kaunas: Lututė

Gozdowski, D., Žukovskis, J., Kaziukonytė, K., & Razinkovas-Baziukas, A. (2020). Evaluation of land cover changes in Southwestern Lithuania from 1984 to 2018 using medium spatial resolution satellite imagery. Polish Journal of Environmental Studies, 29(6). 10.15244/pjoes/118745

Tiškutė-Memgaudienė, D., Mozgeris, G., & Gaižutis, A. (2020). Open geo-spatial data for sustainable forest management: Lithuanian case. RESEARCH FOR RURAL DEVELOPMENT, 35. 10.22616/rrd.26.2020.005

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

State Forest Enterprise: 2021-I-PUSMECIO-ATASKAITA_galutine.pdf (governance.lt)/

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forestry Sector Development Programme for 2012-2020: 569 Dėl Nacionalinės miškų ūkio sektoriaus plėtros 2012–2020 metų programos patvirtinimo (lrs.lt)

National Forest Inventory: Nacionalinė miškų inventorizacija Lietuvoje (pmsa.lt)

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_LTU (foresteurope.org)

State Forest Enterprise operational strategy for 2022-2026: VI-VMU-2022-2026-m.-strategija.pdf

Biodiversity Strategy and Action Plan for Lithuania, 1996: https://www.cbd.int/doc/world/lt/lt-nbsap-01-en.pdf

Lithuanian Bioeconomy Strategy: https://scar-europe.org/images/CASA/Events/Batltic_Riga_4-5April2019/presentations/3-2_Dalia-Miniataite_Bioeconomy%20_Lithuanian.pdf

National Energy and Climate Action Plan of the Republic of Lithuania for 2021-2030: https://ec.europa.eu/energy/sites/default/files/documents/lt_final_necp_main_en.pdf#page=26

Forest Land Ownership Change in Lithuania, COST Action FP1201 FACEMAP country report 2015, EFI: Forest Land Ownership Change in Lithuania (boku.ac.at)

Lithuanian statistical yearbook of forestry, 2021: https://amvmt.lrv.lt/lt/atviri-duomenys-1/misku-statistikos-leidiniai/misku-ukio-statistika/2021-m-1

State forest statstics: https://amvmt.lrv.lt/lt/atviri-duomenys-1/misku-statistikos-leidiniai/valstybine-misku-apskaita/2022-01-01

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-lithuania_en_1.pdf

18. LUXEMBOURG

18.1. Country overview – major forest facts

18.1.1. Key forest data

Luxembourg is a landlocked country in central-west Europe, with 36% forest cover. Forest area has been stable over the last 30 years and is at 35.7% of total land area. Growing stock has been increasing, and in 2015 was nearly 300 m3 o.b./ha. There has been a national forest inventory since 2000. Half the forests of Luxembourg are under a forest management plan: all public forests have one, while small private forest owners have the possibility of filing a simpler planning document. Nearly 50% of the forests are certified under a third party scheme (the state forests are certified under both FSC and PEFC). 40% of forest area in Luxembourg is protected for conservation of biodiversity, and at least 5% is designated as protection forest (water protection). 1.4% of forest are total forest reserves (no intervention). No forests are considered primary forest.

18.1.2. Institutional setup and legal framework

In 2014, the Government started to revise laws and regulations in order to draw up a new Forest Code, which would modernise the legal instruments in the light of recent developments. Consultations have taken place within the frame-work of the national forest programme, including stakeholders of the sector. A draft law was placed before Parliament in January 2018.

18.1.3. Key actors and stakeholder organisations

Ministry of the Environment, Climate and sustainable Development; National Nature and Forest Agency (Administration de la Nature et des Forêts; Family Forestry Luxembourg; Prosilva Luxembourg.

18.1.4. Forest ownership

54% of forests are privately owned. About one third of the area is owned by municipalities and only one tenth of the forest area is owned by the state. In terms of area, private forests are by far the most important form of ownership, with around 49,000 ha.

18.1.5. Forest industry

Removals of about 500 thousand m3 o.b in 2010 have dropped to 300.000 m3 in 2021 by promoting and applying permanent forest cover silviculture in order to foster forest resilience. Considering a natural wood increment of about 800.000 m3 o.b. per year, wood removals in the forest represented less than 65% in 2010. In 2010, about 400 people were employed in the forest sector, mostly in forestry and the wood processing industry. In 2019, about 1,100 people are employed in the forest sector, 400 in the public administration (Administration de la nature et des forêts) and 600 for the private forest sector (silviculture and exploitation) and 100 in sawmills and first transformation). (Data not comparable as based on different methodologies).

18.1.6. Key forestry issues

Spruce monocultures representing 10% of forest cover are severely endangered by climate change and need to be restored to mixed forest stands over the next 2 to 3 decades.

18.2. Forest monitoring

18.2.1. National Forest Inventory

A permanent National Forest Inventory was implemented in 1990 in the context of the resolutions of the MCPFE. The general aim of the NFI was to report on the state and evolution of forests, assessing characteristics as the forest area, stand composition, growing stock, regeneration, biodiversity and forest health. Satellite imagery and maps were also used to provide estimates for small forest areas.

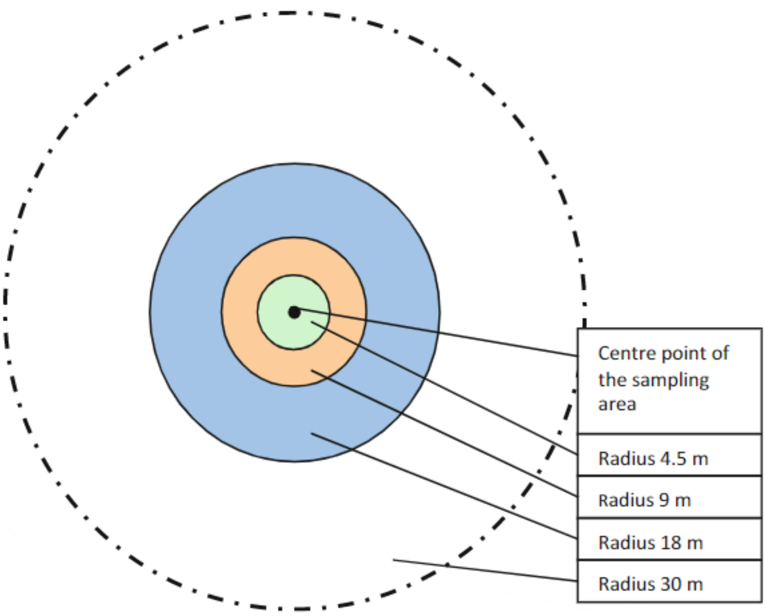
Field data collection started in 1998 and the results of the first NFI cycle were published in 2003. A second inventory cycle was launched in 2009, and the results were published in 2014. The programmed interval between two successive cycles is 10 years.

Luxembourg's NFI adopt the forest definition as in FAO (2004).

The Luxembourg's NFI sampling scheme is single-phased, non-stratified, based on plots systematically distributed at the intersection of a rectangular grid (1 x 0.5 km). Nearly 1800 permanent plots were established during the first NFI cycle and were remeasured during the second (Kugener, 2016).

Each sampling units consists of five concentric circular plots (radii 2, 4.5, 9, 18 and 30 m). All living and standing dead trees were measured (minimum diameter at breast height 7 cm). Aerial photographs and cartography were used to pre-classify the land use of the sampling points, to support the organization of the field operations (e.g., plots location).

Figure 37 Sampling area design in Luxembourg's NFI (Kugener, 2016)



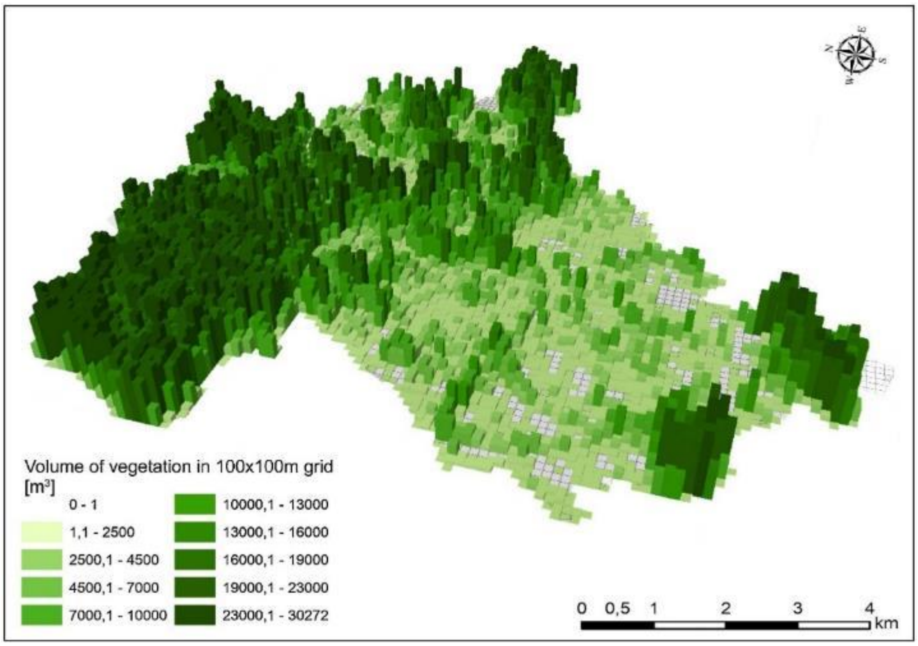
18.2.2. Forest mapping

In Luxembourg, the information collected during the NFI is used to delimitate the municipal, state and public national forests. This layer, openly access in GIS visualization, is updated every six months.

Moreover, the Forest Biotope Cadastre map offers information on the forest biotopes and habitats protected in Luxembourg. This layer, freely downloadable as a vector format, have been assessed by botanist experts and has a temporal coverage starting from 2014 to 2020 (annual revision).

Recently published external research (Zięba-Kulawik *et al*., 2021) also investigates the volume of urban forests in Luxembourg City, using LiDAR point cloud provided by the national programme, and the cadastral map to describe the spatial and volumetric distribution of urban vegetation.

Figure 38 Map of 3D spatial distribution of volume of vegetation in Luxembourg City (100 m raster) (Zięba-Kulawik et al., 2021)



18.2.3. Land cover map

The Grand Duchy of Luxembourg produced an up-to-date land cover map with 0.2 m spatial resolution, for the year 2018. For this purpose, data obtained by LiDAR (DEM and DSM, 1 m spatial resolution) and Sentinel-2A time series (10 m spatial resolution), along with infrared aerial images (NIR, 0.2 m spatial resolution), were used. The project was a follow-up of Land Information System Luxembourg (LIS-L) aimed at mapping land cover and land use for 2015 (1 m spatial resolution). While Sentinel images are collected with a 5-day interval for the same region, aerial image campaigns for the Grand Duchy of Luxembourg are arranged once a year. As a result, there is a new set of extremely high-resolution RGB and color infrared data released once a year.

Only one nationwide LiDAR campaign has been conducted so far. The LiDAR data has a time stamp that only goes up to October 2017. As ancillary data, the building census, the transport network, the water surfaces, and the agriculture data were used.

Figure 39 Workflow for 2018 Land Cover mapping in the Grand Duchy of Luxembourg (source: Source: space4environment, 2019)

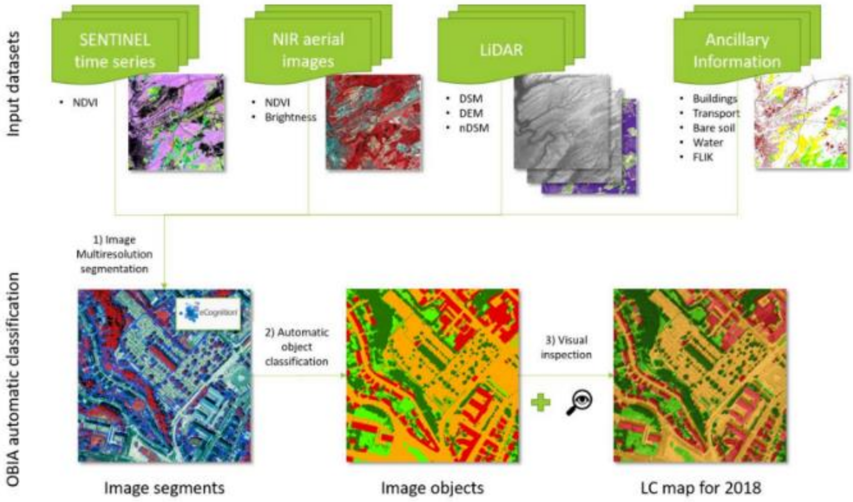
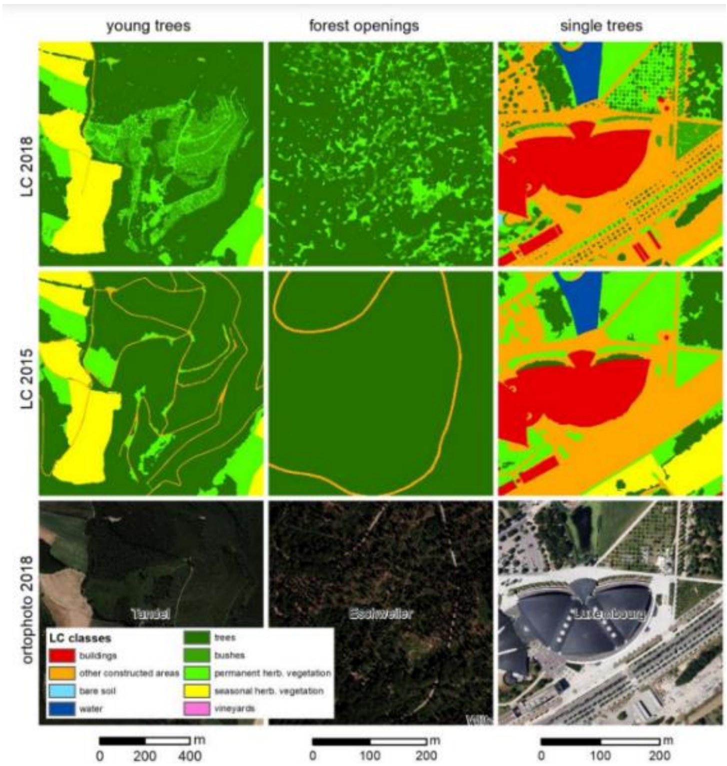


Figure 40 Visual comparison of forest land cover classification in 2018 (0.2 m spatial resolution) and 2015 (1 m spatial resolution) (source: space4environment, 2019)



18.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Luxembourg.

Table 70 Luxembourg: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	Complete	10y	FAO	yes		x		yes - public
Forest biomass	NFI	National	Complete	10y		yes		x		yes - public
Forest carbon	NFI	National	Complete	10y		yes		x		yes - public
Tree age										
Canopy height	NFI	National	Complete	10y		yes		x		yes - public
Forest structural diversity	NFI	National	Complete	10y		yes		x		yes - public
Forest soil properties	NFI	National	Complete	10y		yes		x		yes - public
Forest/tree cover change	NFI	National	Complete	10y		yes		x		yes - public
Tree age diversity										
Tree species/composition	NFI	National	Complete	10y		yes		x		yes - public
Tree species diversity	NFI	National	Complete	10y		yes		x		yes - public
Forest type										
Deadwood	NFI	National	Complete	10y		yes		x		yes - public
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Silvicultural system	NFI	National	Complete	10y		yes		x		yes - public
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested										
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth										
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										
Presence of veteran trees	NFI	National	Complete	10y		yes		x		yes - public
Key biotopes	NFI	National	Complete	10y		yes		x		yes - public

18.2.5. SWOT analysis

Table 71 Luxembourg: SWOT analysis

Strengths	**Weaknesses**
A well-established NFI exists.	To date, only one national LiDAR campaign has been conducted.
Opportunities	**Threats**

The methodology applied in the Luxemburg City to map vegetation volume through LiDAR data could be implemented in future NFIs.	Scarce availability of information on forest disturbances and naturalness.

18.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 72 Luxembourg: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Government website (forests & ecosystem services)	Summarized information on forests and links to related programmes and documents
	Forest Information System for Europe	Basic data on forests
	National Inventory	Information on forest management
Biodiversity	National Forest Programme	Biodiversity as part of Sustainable Frest Management – strategic goals and measures
	Government website (biodiversity)	Summarized information on biodiversity issues and links to related programmes
	National Plan for the Protection of Nature	Objective 4ii: By 2020, forest management plans, consistent with sustainable forest management, will be put in place for all public forests, as well as for private forest estates larger than 10ha, in order to maintain or measurably improve the conservation status of forest-dependent and forest-impacted species and habitats, as well as the provision of ecosystem services, compared to the conservation status assessed in 2013
	National Forestry Accounting plan for Luxembourg	Additional Biodiversity enhancement measures
Bioeconomy	Green Growth in the Benelux: Indicators of Local Transition to a LowCarbon Economy in CrossBorder Regions (OECD paper)	Forests as “renewable stock”
	National Forest Programme	Wood Production and Carbon Storage
Ecosystem services	Government website (forests & ecosystem services)	Summarized information on forest ecosystem functions and links to related programmes and documents
	National Forest Programme	Maintaining the health of forest ecosystems
	National Forest Programme	Wood Production and Carbon Storage

Thematic area	Main Strategic reference	Summary of planning elements
Climate change	Government website climate protection	Information on climate protection/adaptation
	Strategy and Action Plan for Adaptation to the Effects of Climate Change in Luxembourg	Sylvicultural sector as one of the measures to adapt to climate change
	Luxembourg`s integrated national energy and climate plan for 2021-2030	One of the climate support measures: The support schemes for improving the protection and sustainable management of forest ecosystems ensure sustainable timber production, improve the condition of forests and help our forests adapt to climate change. In this way, the state, society and forest owners together ensure that we will continue to have stable, healthy, climate-tolerant and species-rich forests in Luxembourg in the future.

18.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 73 Luxembourg: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Resilience fostering measures were identified at national level in 2021 and are supported by government subsidies. Application on the ground in private forest is a major challenge due to high fragmentation and lack of capacity building.
Ecosystem services	Provision of ES will depend on the success of climate change adaption measures. Forest ES payments exist in Luxembourg since 2021.
Interest conflicts	Deficiencies in game management put climate change adaption measures (diversity of natural regeneration) at risk due to high game densities.
Private forest owners	Lack of capacity building.
Biodiversity conservation	The identification process of the forest biotopes is finalized.
Bioeconomy	A national location for selling and buying quality wood is currently developed.
Forest fires	Might become a major challenge over the next decades due to increasing extreme weather events. To be discussed in the update of the National Forest Programme.
Desertification	No information

Population-related challenges	A research project has been finalized to create a tool that helps public and private forest owners to select the tree species adapted to the situations and climate change.
Financing	No information
Governance	New forest act is about to be adopted by the Parliament.

18.4. References

Kugener G. in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

LISL Landcover 2018 https://data.public.lu/fr/datasets/lis-l-land-cover-2018/

Space4environment (2019). Project deliverable D1.1 – Object-based image analysis (OBIA) for mapping Land Cover 2018 in Luxembourg: an approach based on aerial images, LiDAR and intra-annual SENTINEL time series (https://download.data.public.lu/resources/landcover-landuse-2018/20200504-135251/lisl-landcover-2018-documentation.pdf, last access: 29/12/2022)

Zięba-Kulawik, K., Skoczylas, K., Wężyk, P., Teller, J., Mustafa, A., & Omrani, H. (2021). Monitoring of urban forests using 3D spatial indices based on LiDAR point clouds and voxel approach. Urban Forestry & Urban Greening, 65, 127324. https://doi.org/10.1016/j.ufug.2021.127324

Government website (forests & ecosystem services): https://environnement.public.lu/fr/natur/forets.html

Government website biodiversity: https://environnement.public.lu/fr/natur/biodiversite.html

Government website climate protection: https://environnement.public.lu/fr/klima-an-energie/changement-climatique.html

Forest Information System for Europe: https://forest.eea.europa.eu/countries/luxembourg/luxembourg-basic-data

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Programme: https://environnement.public.lu/dam-assets/documents/for%C3%AAt/pfntxtfin.pdf

National Inventory: https://unfccc.int/documents/461887

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_LUX (foresteurope.org)

National Plan for the Protection of Nature: https://legilux.public.lu/eli/etat/leg/dgc/2017/01/13/a194/jo

Martinez-Fernandez, C., et al., (2013), Green Growth in the Benelux: Indicators of Local Transition to a LowCarbon Economy in CrossBorder Regions, OECD Local Economic Development and Employment papers: https://www.oecd-ilibrary.org/docserver/5k453xgh72ls-en.pdf?expires=1663075514&id=id&accname=guest&checksum=87E23593CB6453FBC8E524ED28B7AD88

Strategy and Action Plan for Adaptation to the Effects of Climate Change in Luxembourg: https://environnement.public.lu/content/dam/environnement/documents/klima_an_energie/Strategie-Adaptation-Changement-climatique-Clean.pdf

Evaluierung der ökologischen, ökonomischen und sozialen Effekte der Waldflurneuordnung in Luxemburg: https://agriculture.public.lu/content/dam/agriculture/publications/onr/brochures/2017-11-22-wfno-lux-final.pdf

National Forestry Accounting Plan for Luxembourg: https://environnement.public.lu/dam-assets/documents/for%C3%AAt/nfap/NFAP-2018.pdf

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-09/csp-at-a-glance-luxembourg-en.pdf

Luxembourg`s integrated national energy and climate plan for 2021-2030: https://energy.ec.europa.eu/system/files/2020-07/lu_final_necp_main_en_0.pdf

19. MALTA

19.1. Counry overview – major forest facts

19.1.1. Key forest data

Malta is an island in the southern Mediterranean, with very low forest cover. Forest area is stable, and forest cover is 1.1% of total land area. Average growing stock is 231 m3 o.b./ha. As there are only 350 ha of forest on Malta, and there is no wood supply, it is not surprising that it was not possible to provide much of the information requested.

19.1.2. Institutional setup and legal framework

No information was supplied for SoEF 2020 on policies and institutions.

19.1.3. Key actors and stakeholder organisations

Ministry for the Environment, Climate Change and Planning.

19.1.4. Forest ownership

All Maltese forests are publicly owned.

19.1.5. Forest industry

There are no reported wood removals.

19.1.6. Key forestry issues

Safeguard existing habitat areas and explore the possibility of extending the network of green areas through tree planting initiatives.

19.2. Forest monitoring

Malta is an island in the southern Mediterranean, with a very sparce forest cover. In Malta there are only about 460 hectares of forests and no timber supply (FAO FRA, 2020). Forest area is stable, and forest cover is 1.1% of total land area. Average growing stock is about 230 m^3 ha^{-1} (Forest Europe, 2020). There are no reported wood removals, no further information is available.

19.2.1. Criteria and indicators

No information on forests is currently available for Malta, and the country fiche was not validated or returned by the Member State.

The table below aims to provide an overview of criteria and indicators monitored in Malta. However, an overview cannot be provided due to a lack of available data, and due to the fact that the Member State did not provide feedback on the fiches.

Table 74 Malta: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover										
Forest biomass										
Forest carbon										
Tree age										
Canopy height										
Forest structural diversity										
Forest soil properties										
Forest/tree cover change										
Tree age diversity										
Tree species/composition										
Tree species diversity										
Forest type										
Deadwood										
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested										
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest growth										
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										

19.2.2. SWOT analysis

Table 75 Malta: SWOT analysis

Strengths	Weaknesses
No information on forests available	No information on forests available
Opportunities	**Threats**
No information on forests available	No information on forests available

19.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 76 Malta: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Outline strategy for implementation of a national restoration and afforestation project	Forest-related information
	National Trees and Woodlands Strategy and Action Plan 2022-2030 (Consultation process)	Objective 2: promote and improve streamlined environmental data collection and status assessment related to trees and woodland
Biodiversity	Outline strategy for implementation of a national restoration and afforestation project	Reference to the National Biodiversity Strategy & relevance of afforestation and restoration
	National Trees and Woodlands Strategy and Action Plan 2022-2030 (Consultation process)	Biodiversity listed among objectives

Thematic area	Main Strategic reference	Summary of planning elements
	Malta`s national biodiversity strategy and action plan 2012-2020	Targets 1-11 aimes at: (1) Addressing the underlying causes of biodiversity loss; (2) Reducing the direct pressures of biodiversity; (3) Improving the status of biodiversity
Bioeconomy	No planning tool could be identified	
Ecosystem services	Outline strategy for implementation of a national restoration and afforestation project, p.33-34	Chapter on ecosystem services
Climate change	Outline strategy for implementation of a national restoration and afforestation project	Reference to national biodiversity strategy and other mentions throughout document
	Malta's 2030 National Energy and Climate Plan	Rhetorical reference as Malta has almost no forest
	Integrated National Energy and Climate Plan	Several mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF (specifically with reference to afforestation)

19.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness. Unfortunately the challenges are unknown as the country report was not completed and the Member State did not revise the fiche.

Table 77 Malta: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	No information
Ecosystem services	No information
Interest conflicts	No information
Private forest owners	No information
Biodiversity conservation	No information

Major challenge	Summary description
Bioeconomy	No information
Forest fires	No information
Desertification	No information
Population-related challenges	No information
Financing	No information
Governance	No information

19.4. References

FAO FRA (2020), Malta. https://www.fao.org/3/cb0028en/cb0028en.pdf

FOREST EUROPE, 2020: State of Europe’s Forests 2020.

Outline strategy for implementation of a national restoration and afforestation project: https://environment.gov.mt/en/Documents/Downloads/afforestationRestorationEcologyCassar.pdf

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Mongabay (nonprofit environmental science and conservation news platform): https://rainforests.mongabay.com/deforestation/2000/Malta.htm

National Trees and Woodlands Strategy and Action Plan 2022-2030 (Consultation process): https://meae.gov.mt/en/Public_Consultations/MECP/Pages/Consultations/IntentandObjectivesNationalTreesandWoodlandsStrategyandActionPlan20222030.aspx

Malta’s 2030 National Energy and Climate Plan: https://ec.europa.eu/energy/sites/ener/files/documents/mt_final_necp_main_en.pdf

Malta`s national biodiversity strategy and action plan 2012-2020: https://era.org.mt/wp-content/uploads/2019/05/MaltaNBSAP_2012-2020.pdf

CAP Strategic Plan 2021 Report for Malta: https://agriculture.ec.europa.eu/cap-my-country/cap-strategic-plans-country_en

Malta’s 2030 National Energy and Climate Plan December 2019 https://energy.ec.europa.eu/system/files/2020-01/mt_final_necp_main_en_0.pdf

20. NETHERLANDS

20.1. Country overview – major forest facts

20.1.1. Key forest data

The Netherlands lies in north-west Europe. It has 11% forest cover, which remains fairly stable, with some fluctuations. Trends indicate that Dutch forests are getting older, more mixed and uneven-aged. The amount of deadwood is also increasing. The expanding growing stock stands at 224 cubic meters o.b/ha. Above ground biomass has also been growing, at an average rate of 1.6%/year over the 30 year period. Carbon stock in harvested wood products is estimated at 2 million tons. The transformation from coniferous to deciduous and mixed forests are continuing. Currently, for the first time, deciduous forests occupy more than half of the forested area. The most common tree species in Dutch forests is Scots

Pine, followed by oak and Birch. Although forest management plans are not required by law, it is generally presumed that the most forest areas are included in a long-term management plan. 47% of total forest area (equivalent to 171 thousand ha) of forest is under third party certification schemes, such as FSC and PEFC.

20.1.2. Institutional setup and legal framework

The Netherlands is a decentralized unitary state. Dutch forests fall under domain of the Ministry of Agriculture, Nature and Food Quality at national level, at provincial level, the Provincial Executive is responsible for forests. Central government is responsible for setting the framework for and defining the goals of nature policy. The provincial authorities are responsible for filling in the details and implementing the policy. National forest inventories are carried out regularly, with 7th completed in 2022. Since 2017 the protection of forests is covered through the Nature Conservation Act. The Dutch Forest Strategy for 2030 was launched in 2020 by the Minister of Agriculture, Nature and Food Quality and the 12 provinces. In 2014 the Government Vision 2014 “The Natural way forward” was published to form the foundation for future biodiversity policy. Furthermore, the Dutch government has set up the Programme ‘Reinforcement Biodiversity’ in response to the EU Biodiversity Strategy and regularly publishes reports on the status of biodiversity and nature, such as the Progress Report nature (the Sixth was published in 2020).

20.1.3. Key actors and stakeholder organisations

Ministry of Agriculture, Nature and Food Quality; Interprovincial council; *Staatsbosbeheer* (State Forest Service); The Royal Dutch Forestry Association (*Koninklijke Nederlandse Bosbouwvereniging*); The Royal Association of Dutch Timber Companies (*Koninklijke Vereniging van Nderlandse Houtondernemingen*); *De Bosgroepen*; The Dutch Forest and Nature Reserve Owners Association (VBNE); Dutch Federation for Private Landownership (FPG); Dutch Society for Nature Conservation (*Natuurmonumenten*); *LandschappenNL;* The Association of Municipal Forest Owners (NNG); PBL Netherlands Environmental Assessment Agency; International Union for Nature Conservation (IUCN) Netherlands.

20.1.4. Forest ownership

32% private ownership (including companies, estates, individuals), 26% State Forest Service, 5% other national-level/state ownership (e.g. Ministry of Defence); 1% provinces; 14% municipalities, 19% nature conservation organisations.

20.1.5. Forest industry

Wood removals are quite stable in the Netherlands. The reported data indicate a sharp increase in wood removals, but this is the consequence of a methodology change for the estimation of the fuelwood consumption by households. In addition, energy wood derived from landscape care wood and municipal waste streams has also been included in the wood removal figure since 2015. For this reason, the reported removals of over 3.1 million m3 u.b. represents wood derived from forests and outside forests and consists of both roundwood as well as chips, shreds and particles. Roundwood removals (both industrial and fuelwood) account for about 50% of net annual increment.

Employment in the forest sector, at 32.5 thousand people is a third less than in 1990. Employment in the wood processing and pulp/paper sectors has declined, while employment in forestry has remained roughly stable, at around 2 thousand people.

In 2015, wood accounted for 1.3% of the Netherlands' total primary energy supply.

20.1.6. Key forestry issues

Transformation from coniferous to stable deciduous and mixed forest is a key action. This has partly been pushed by the major drought damage and bark beetle attacks to Norwegian Spruce and Larch. Other pests and diseases have also severely impacted other native trees, such as Elm and Ash. Felling trees causes a rise in emotions; however, it is unavoidable. The trade-offs in values and interests need to be addressed but are a constant debate. More transparency about the goals of the forest and greater involvement of local residents in its management is necessary, as is the case when (plantation) forests are converted to other forms of nature for biodiversity goals. Also trade-offs and clashing interests arise through the increasing number of visitors to the forests for recreational purposes. This should be addressed e.g., through zoning.

20.2. Forest monitoring

20.2.1. National Forest Inventory

In the Netherland, regular forest assessment began in 1938, but since 1968 the NFI was restricted to the forest area only. Information on Dutch forests (growing stock, growth and removals) were collected in the "Houtoogststatistiek en prognose oogstbaar hout" (HOSP) survey, during the period 1985-1997 (FRA, 2015).

The fifth NFI (NFI5 – 2001-2005), known as the Meetnet Functievervulling (MFV forests), was defined as a permanent, policy-oriented, GIS-based forest monitoring framework. Thus, it was designated to provide the government with forest information. The main forest attributes assessed during NFI5 were (i) growing stock, (ii) forest ownership, (iii) management and stand age, (iv) biodiversity, (v) forest status, (vi) forest carbon stock, and (vii) recreational activities. The NFI5 used permanent and temporary sampling points. The exact locations of the temporary sampling points were not determined, and the coordinates of the individual trees were not registered. Samples were taken at a density of one point per 100 hectares. A nationwide grid with potential sampling points was created in the NFI5. A point was selected at random within cells of 1 km^2. The same grid was used for NFI6 (Oldenburger and Schoonderwoerd, 2016).

The sixth Dutch NFI (NFI6) was conducted between 2012 and 2014, when the results were published. During NFI6, most of the NFI5 permanent plots were re-measured (1235), to obtain the increment, fellings and removals in national forests. Most variables from the NFI5 were assessed, apart from the biodiversity and recreational ones. NFI6, for the first time, registered information on forest regeneration.

Within NFI6, the Dutch forest area was derived from LULUCF2009 land use database (Basiskaart Natuur 2009 - BKN), by the Dutch LULUCF team. The LULUCF-derived forest map was checked with aerial photos, to determine whether plots were located in forests. The BKN is a 25 x 25 m grid map which divides the surface area of the Netherlands into cells (Kramer et al., 2016). Each square is assigned a type of land use. In compliance with the customary definition of a forest (see below) a distinction is drawn between areas that are larger or smaller than 0.5 hectares. Areas are designated as larger than 0.5 hectares if they consist of at least eight consecutive cells of forest on BKN 2009.

In total, during NFI6 3393 forest plots (110 ha) were sampled.

The seventh Dutch NFI, commissioned by the Ministry of Agriculture, Nature and Food Safety, was carried out between 2017 and 2022. The results have been published in the form of a report, and the database containing the data is freely accessible (https://www.probos.nl/publicaties/overige/1094-bosinventarisaties). Measurements were carried out on 3197 plots, of which 1413 were re-measurements made in NFI6. On almost 10% of the total NFI7 forest plots, measurements were (i) denied by the forest owners, or (ii) made impossible by physical obstacles (Schelhaas et al., 2022). For cost reasons, re-measurement of floristic characteristics was carried out in NFI5 only.

The eight Dutch NFI cycle started in 2022 and will be concluded in 2026.

Results from the Dutch NFIs, supplied approximately every 5 years, provide information for international reporting obligations for carbon sequestration (UNFCCC) and international reports (e.g., FRA, Forest Europe).

The Netherlands' NFIs definition of forest (land with tree crown cover of more than 10 percent and an area of more than 0.5 hectares. The trees should be able to reach a minimum height of 5 m at maturity in situ) has been derived from FAO's definition (FAO, 2004) and adapted to meet national characteristics.

20.2.2. Forest mapping

Currently, there are no information about official remote sensing-based forest attribute maps in the Netherlands. However, a wall-to-wall Dutch forest structure map based on remote sensing data is under development by the Wageningen University.

20.2.3. Nature Base Map (BKN)

The Nature Base Map (*Basiskaart Natuur*) is a geodatabase of natural areas in the Netherlands. It is a raster database with a cell size of 25 x 25 m, where classes are determined using orthophotos.

The series of BKN include: BKN1990rev (Hazeu et al., 2011), BKN2004 (Kramer et al., 2007), BKN2006, BKN2009 and BKN2013 (Kramer and Clemens, 2015, 2016).

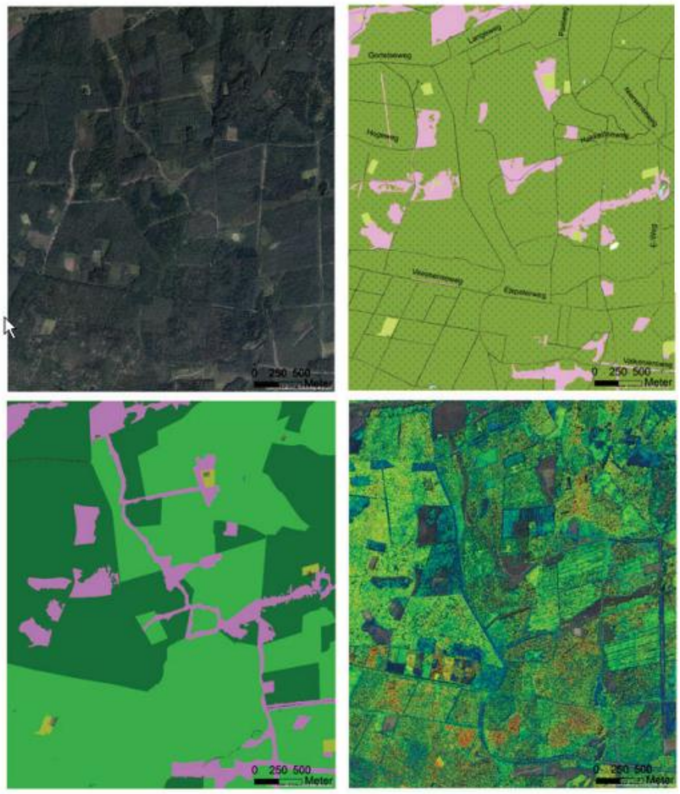
The database includes 13 land use classes, each with its own code and descriptor. The most important part of the database is the natural area; according to the definition used in BKN2009, the total area is 650,374 ha. This area includes the following land use classes: natural grassland (code 11), heath (30), forest (40), reed marsh (80), drift sand (90) and dune, beach and sand banks (91). BKN2013 has not yet been validated for use in monitoring (Kramer and Clemens., 2016).

20.2.4. GeoDatabase of Nature and Landscape

In its work for studies by the Netherlands Environmental Assessment Agency (PBL), such as the Assessment of the Dutch Human Environment, the Environmental Data Compendium, the Natuurpact reflexive evaluation and the Nature Outlook, the Statutory Research Tasks Unit for Nature & the Environment (WOt N&M) makes use of various base maps of natural and semi-natural habitats, such as the Nature Base Map (BKN), the Land Use Database of the Netherlands (LGN database) and the map of habitat management types (Beheertypenkaart). The problem is that information derived from these maps can influence the indicators and model results used in the PBL studies and lead to inconsistencies between them.

The standardized procedure for compiling a Geodatabase of Nature and Landscape (*Basisbestand Natuur en Landschap* – BNL) is described in Sanders and Meeuwsen (2019). The BNL is a raster database with a resolution of 2.5 metres. It consists of several layers and is generated using a GIS script. The geometric basis of the map is Top10NL, which is considered to be a reflection of the true situation in the field. The management type map produced by the provincial governments (IMNaB) was used as a source database for the areas and types of natural and semi-natural habitats. This map is a key resource in Dutch nature policy for the allocation of subsidies for conservation management and for determining ecological quality.

Figure 41 Example of the map produced in the geodatabase of Nature and Landscape. Upper left: orthophoto; upper left: Top10NL; lower left: management type map; lower right: objects height, from blue (low) to red (high). Sanders et al., 2019



20.2.5. Current Height File Netherlands (AHN)

The Netherlands is fully covered by 3D LiDAR imagery collected by aircraft or helicopter, which compile the Current Height File map (AHN - *Astueel Hoogtebestand Nederland*). AHN is a multi-year program and a collaboration between the Water Boards, Provinces and Rijkswaterstaat with the aim of producing a digital height file of the Netherlands.

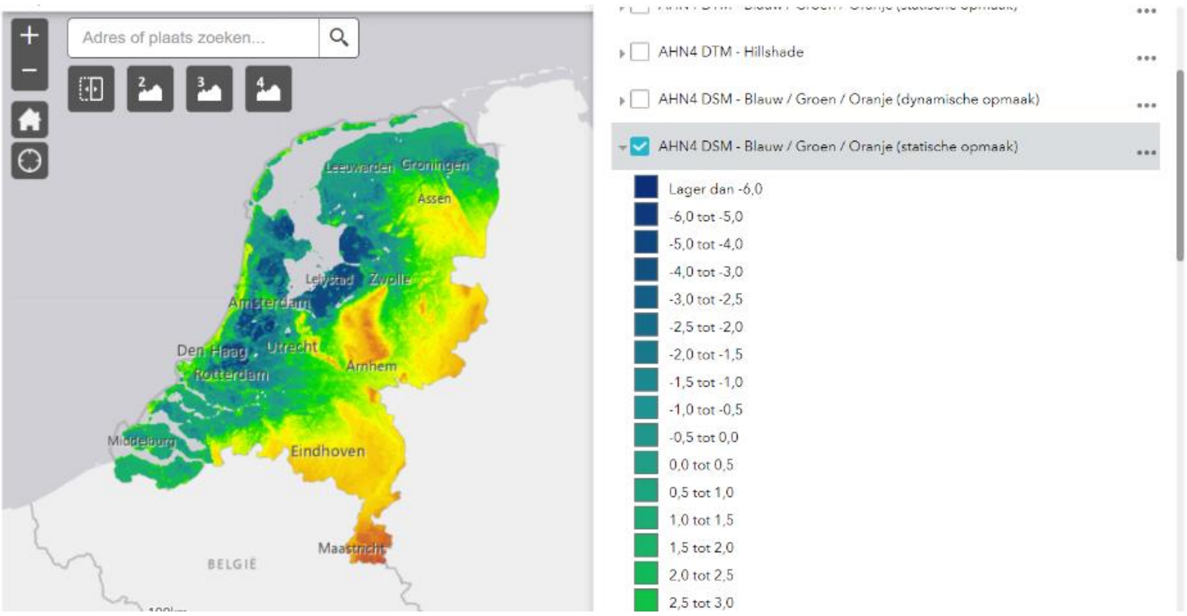
Four different AHN are available. The collection of AHN1 started in 1997 and ended in 2004. Initially, a point density of one point per 16 m^2 was used even if a point per square meter was reached in certain areas.

After completing AHN1, the second cycle AHN2 begin in 2007 and ended in 2012. The average point density in AHN2 was between 6-10 points per m^2.

AHN3 (2014-2019) was followed by the last collection AHN4, which data collection started in 2020 and it is still ongoing. Differences between the AHN3 and the AHN4 occurred. Specifically, in AHN4 national data collection is planned in three years instead of six, while the point density, spread and accuracy has been different between the two AHN, but comparable.

DTM (Digital Terrain Model) and DSM (Digital Surface Model) are created, with a spatial resolution of 0.05 m. A 5 m grid is produced through the aggregation of the finer grid.

Figure 42 AHN4 GIS online visualization. The map shows, from blue (low) to red (high) DSM values in The Netherlands (source: https://www.ahn.nl/ahn-viewer)



Information about structures and vegetation is also available. The Dutch Government has shared the AHN map in the form of open data (https://www.ahn.nl/).

20.2.6. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in the Netherlands.

Table 78 Netherlands: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Forest biomass	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Forest carbon				4y-cyclic						
Tree age	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Canopy height	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Forest structural diversity	NFI	National	Complete	4y-cyclic		yes		x		yes - public
Forest soil properties	NFI	National	Complete	4y-cyclic		yes		x		yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/tree cover change	NFI	National	Complete	4y-cyclic		yes		x		yes - public
Tree age diversity				4y-cyclic						
Tree species/composition	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Tree species diversity	NFI	National	Complete	4y-cyclic		yes		x		yes - public
Forest type	NFI	National	Complete	4y-cyclic		yes		x		yes - public
Deadwood	NFI	National	Complete	4y-cyclic		yes	x	x		yes - public
Presence of Red-list species										
Abundance of common forest birds	Dutch Centre for Field Ornithology (Sovon)	National	Complete	yearly						yes - public
Forest spatial patterns	NFI									
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	NFI (derived from)									
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NFI; Probos	National	Complete	4y-cyclic; yearly				x		yes - public
Ratio of annual fellings to annual increments	NFI	National	Complete	4y-cyclic		yes				
Forest revenue	Probos									
Roundwood prices	Probos									
Forest products trade	Probos	National	Complete	yearly				x		yes - public
Employment in the forest sector	National statistics office	National	Complete	yearly				x		
Forest area with 3rd party certification	PEFC, FSC									
Forest visitor statistics										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	NFI (derived from)	National								
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance	NFI	National	Complete	4y-cyclic		yes				
Number of forest fires										
Number of storms										
(Accessibility/)Reachability	NFI	National	Complete	4y-cyclic		yes				
Noise	NFI	National	Complete	4y-cyclic		yes				
Regeneration method	NFI	National	Complete	4y-cyclic		yes		x		yes - public

20.2.7. SWOT analysis

Table 79 Netherlands: SWOT analysis

Strengths	Weaknesses
NFI is a stable, long running information source with a broad look at forest indicators.	Information is mainly based on statistical analysis of plots, which cover 1% of forests (3600 plots of 1 hectare, for a total of 363k ha). Land-use information is based on satellite pictures and maps. Standard error of 3%.
Opportunites	**Threats**
Satellite info that looks at more than just pictures, could be very useful for various indicators, such as forest health or tree growth. This data is so far not able to improve on what we currently use. EU-wide use of such technology could greatly decrease costs.	EU-wide monitoring could lead to less adequate information for the specific Dutch situation. For instance, we monitor on a smaller scale (0.1 hectare) than the FAO definition of forests (0.5 hectare), as our law classifies forest from 0.1 hectare upwards.

20.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 80 Netherlands: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	State Forest Service Report 2021	Transformation from coniferous to stable deciduous and mixed forest
	National Forest Inventory 2017-2021	Current data on forests; Continued transformation from coniferous to deciduous and mixed forest
	Forest Strategy 2020	Revitalisation of existing forests and a targeted 37 000 ha for afforestation of new forests; Aim to have resilient forests consisting of more diversity in species.
Biodiversity	State Forest Service Report 2021	Dominance of invasive species (which could also be worsened through climate change), poses a risk to biodiversity
	Nature Conservation Act, 2015	The Act aims to protect and develop nature, and preserve and restore biological diversity;
	Forest Strategy 2020	Increase forest cover and forest species diversity with the aim to improve biodiversity and increase the area of forests where management is focused on biodiversity by 10% (from 140k ha to 155k ha).
	Nature Vision 2014	Setting out the major strands of government nature policy; decentralization of nature management. Aim for robust and diverse nature.
Bioeconomy	National Forest Strategy	Aim to stimulate high-quality use of wood and reduce its use for energy, in line with efforts to stimulate bio-based construction in the context of the circular economy and the sustainable sequestration of carbon in materials.
	Climate Agreement 2019	Stimulate the use of wood and other natural products for construction and renewable energy. Balance emission of GHG on the one hand and the sequestration of greenhouse gases and production of renewable energy and biomass on the other hand
	The Transition Agenda	Five roadmaps for different industries (including construction and biomass and food) setting out the agenda for these industries to become circular by 2050. Promoting the use of bio-based material such as wood.
Ecosystem services	Forest Strategy 2020	Acknowledgement of importance; Balancing different demands for different services (including recreational and other social services). Special attention is paid to: development of forest soils, water and air purification, carbon sequestration, biodiversity, social functions. Also acknowledges the economic benefits (alternative forms of income) through ecosystem services.
	Forest Strategy 2020	Acknowledges the importance of resilient forests in climate adaptation and also the effect of climate

Thematic area	Main Strategic reference	Summary of planning elements
Climate change		change on forests; Natural, self-regulating forests is the long-term aim. Acknowledges the importance of urban forests in the adaptation and mitigation of climate change.
	State Forest Service Report	A Foundation in the form of carbon certificates for new forests has been established through the National Carbon Market Foundation; establishment of Climate Smart forestry demo-sites; Importance of resilient forests for climate adaptation and mitigation.
	Dutch Climate Agreement 2019	Acknowledges that trees contribute to CO2 capture and storage. Investing in the prevention of deforestation, expanding and protecting nature conservation areas and stimulate the use of wood and other nature products for construction. Reduce GHG emissions. Increasingly capture carbon in soils, forests and materials, produce biomass and generate renewable energy.
	Dutch National Forestry Accounting Plan 2019	Climate change parameters indirectly included in in the Dutch Forest reference level
	Dutch Integrated National Energy and Climate Plan 2021-2030	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF, eg. In the context of agriculture and land use: acknowledging forests as carbon sinks and consequently the importance of afforestation, reducing deforestation and managing forests in a climate-smart manner.

20.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 81 Netherlands: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Drought severely impacts forest health and growth. Certain species are expected to gradually move out of the country as their distribution range moves further north. Native species such as oak and beech experience difficulties, but also productive non-native species such as Norway Spruce and (Japanese) Larch.
Ecosystem services	No information
Interest conflicts	Logging has come under increased scrutiny by local residents and NGO's. This is primarily caused not by forestry operations, but the large-scale conversion of forested

	land to other types of nature, which was necessary to prevent further deterioration of such habitats.
Private forest owners	No information
Biodiversity conservation	Nitrogen deposition continues to be too high, acidifying soils and limiting growth in certain tree species. This, in combination with drought, endangers forest health and (soil) biodiversity.
Bioeconomy	No information
Forest fires	Longer periods of drought increase the probability of forest fires.
Desertification	No information
Population-related challenges	Population growth and infrastructural needs require some deforestation. This has to be compensated elsewhere, but parties have been slow to follow up on this requirement.
Financing	No information
Governance	No information

20.4. References

Basiskaart Natuur 2009 - https://library.wur.nl/WebQuery/wurpubs/508611

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

FRA 2015 – Country Report, Netherlands (https://www.fao.org/3/az287e/az287e.pdf, accessed on 29/12/2022)

Hazeu, G.W., Kramer H., Clement J en Daamen, W.P. (2011). Basiskaart Natuur 1990rev. Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu. WOt-werkdocument 218.

Kramer H., Hazeu, G.W. en Clement J. (2007). Basiskaart Natuur 2004; Vervaardiging van een landsdekkend basisbestand terrestrische natuur in Nederland. Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu, WOt-werkdocument 40.

Kramer, H. & J. Clement (2015). Basiskaart Natuur 2013; een landsdekkend basisbestand voor de terrestrische natuur in Nederland. Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu, WOt-technical report 41. 78 blz.; 4 fig.; 17 tab.; 6 ref.; 9 bijl. https://edepot.wur.nl/356218 accessed on 29/12/2022

Kramer, H. & J. Clement (2016). Basiskaart Natuur 2009; een landsdekkend basisbestand voor de terrestrische natuur in Nederland. Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu, WOt-technical report 72. 80 blz.; 4 fig.; 17 tab.; 8 ref.; 10 bijl.

Oldenburger J, Schoonderwoerd H in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

Sanders, M.E. & H.A.M. Meeuwsen (2019). Basisbestand Natuur en Landschap. Wageningen, Wettelijke Onderzoekstaken Natuur & Milieu, WUR. WOt-technical report 158. 100 blz.; 28 fig.; 7 tab.; 13 ref; 14 Bijlagen. https://edepot.wur.nl/507994

Schelhaas, M. J., Teeuwen, S., Oldenburger, J., Beerkens, G., Velema, G., Kremers, J., Lerink, B., Paulo, M. J., Schoonderwoerd, H., Daamen, W., Dolstra, F., Lusink, M., van Tongeren, K., Scholten, T., Pruijsten, I., Voncken, F., & Clerkx, A. P. P. M. (2022). Zevende Nederlandse Bosinventarisatie: Methoden en resultaten. (WOt-rapport; No. 142). Wettelijke Onderzoekstaken Natuur & Milieu. https://doi.org/10.18174/571720

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

State Forest Service Report, 2021: https://www.staatsbosbeheer.nl/-/media/14-over-staatsbosbeheer/jaarverslag/jaarverslag-2021.pdf

Forest Strategy 2020: https://nl.chm-cbd.net/sites/nl/files/2021-05/Bos%2Bvoor%2Bde%2Btoekomst_Uitwerking%2Bambities%2Ben%2Bdoelen%2Blandelijke%2BBossenstrategie%2Ben%2Bbeleidsagenda%2B2030.pdf

Nature Conservation Act, 2015 https://wetten.overheid.nl/BWBR0037552/2021-07-01

National Forest Inventory, 2022 : https://edepot.wur.nl/571720

Nature Vision (The Natural Way Forward : Government Vision), 2014 : https://nl.chm-cbd.net/sites/nl/files/2021-05/thenaturalwayforward-webversion.pdf

National Climate Agreement, 2019 : https://www.klimaatakkoord.nl/binaries/klimaatakkoord/documenten/publicaties/2019/06/28/national-climate-agreement-the-netherlands/20190628+National+Climate+Agreement+The+Netherlands.pdf

The Transition Agenda, 2018: Construction https://hollandcircularhotspot.nl/wp-content/uploads/2019/09/Circular-Construction-Economy.pdf ; Biomass & Food: https://hollandcircularhotspot.nl/wp-content/uploads/2019/09/Transition-Agenda-Biomass-and-Food.pdf

Dutch National Forestry Accounting Plan 2019: https://english.rvo.nl/sites/default/files/2019/12/National%20Forestry%20Accounting%20Plan.pdf

Dutch Integrated National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-03/nl_final_necp_main_en_0.pdf

21. POLAND

21.1. Country overview – major forest facts

21.1.1. Key forest data

Poland is a country in central Europe, with 30.9% forest cover. Coniferous (the share of coniferous dominant species area) trees are predominant as they account for 68.3% of the forest area, while the broadleaved trees account for 31.7% of Poland`s forest area. 95% of forests are under valid management plan or equivalent, which are mandatory and approved by an official authority . The area certified under third party certification schemes was about 77% of the forest area in 2014 . Many forests are certified to both FSC (6.9 million ha) and PEFC (7.3 million ha) standards. The forest area has systematically been expanding and now stands at 30.9% of total land area. Growing stock has also been expanding, and is to be 288 m3 o.b./ ha in 2020, 70% higher than in 1990 (although part of this increase may be due to improved inventory techniques). Above ground biomass has also been expanding. 37% of forests are protected for conservation of biodiversity, and 35% designated as protective forests. Currently there is no available data about forest undisturbed by man.

21.1.2. Institutional setup and legal framework

The main national regulations for forestry are the Forestry Act of 1991 and the national forest policy which dates back to 1997. Forest are also included in sectoral strategies (e.g. The National Environmental Policy 2030) The main sources of data are: statistical data (Statistics Poland), National Forest Inventory, Forest Data Bank, The State Environmental Monitoring (including habitat monitoring and forest monitoring).

21.1.3. Key actors and stakeholder organisations

Ministry of Climate and Environment; The State Forests National Holding; Forest Research Institute; Bureau of Forest Management and Geodesy; Statistics Poland; Chief Inspectorate of Environmental Protection.

21.1.4. Forest ownership

Forests in Poland are mainly publicly owned, accounting for 80,7% of the total. The State Forests National Forest Holding manages 76,9% of the total forest area. The remaining area is administered by National Parks - 2.0%, municipal and urban authorities – 0,9%, and other public entities (mainly the state Agricultural Real Estate Agency) - 0.9%. . The ownership structure of forests in the postwar period has not changed very much. Small changes in forest ownership during that time were due to afforestation.

21.1.5. Forest industry

Wood removals is steadily increasing, it amounted to 39.7 million m3 u.b. in 2020, . No information was supplied on the balance between fellings and net annual increment . Over 461,245 of people are employed in the forest sector in Poland, of which 51,984 people employed in forestry and logging, 137,123 in manufacturing of products of wood, cork, straw and wicker, 67,999 in manufacturing of paper and paper products, and 204 139 in manufacturing of furniture .

21.1.6. Key forestry issues

Enhancing expertise & capacities of private forest owners.

Research on expected changes in forests due to climate change & their mitigation through forests.

Promotion and support regarding carbon storage in forest products and substitution of non-renewable materials need to be intensified.

More detailed regulations and removing legal gaps concerning forests in urban areas in order to promote their protection and maintenance.

Drafting and implementation of a future National Forest Programme.

21.2. Forest monitoring

21.2.1. National Forest Inventory

There are two levels of forest management in Poland, national and local. The national forest management level is based on the Polish National Forest Inventory data. For all the forests managed by the State Forest Holding, the Forest Act stated that the State Forest holding are obliged to carry out the Polish NFI. The Forest Act entrusted with this task the Bureau of Forest Management and Geodesy.

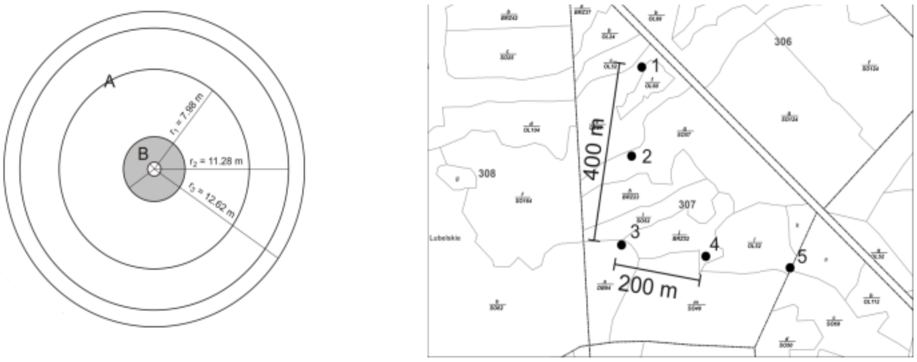
On the other hand, inventory methods applied in the forests outside State Forests National Forest Holding were different. Hence, the prevailing method was a visual assessment with the use of yield tables (Michalak and Zaja̧czkowski, 2010).

The first NFI in Poland started in 1999, when the General Directorate of the State Forests worked with the Institute of Forest Research to develop a set of guidelines to perform a large-scale forest inventory of national forests. In 2002, a first pilot plot was conducted in the province of Poznan. After the approval of the Minister of the Environment, the measurements for the first Polish NFI took place between 2005 and 2009 (Talarczyk, 2014).

The sampling systems is a systematic scheme with a 4 x 4 km square grid of permanent sample plots, located at the nodes of the grid. This grid is based on the European ICP-Forest 16 x 16 km grid. Every year, approximately 20% of the NFI plots are measured.

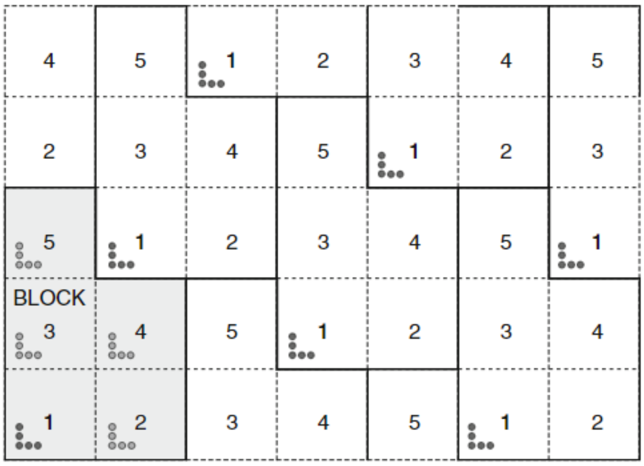
Sample plots were set up in a L-shaped tracts with equal arms, with five points spread by 200 m one from another. Each tract located in forest area is revisited after 5 years.

Figure 43 Polish NFI sample plot layout (left) and tract (right). Source: Talarczyk, 2014



In the first two cycles of the NFI (NFI1 2005-2009, NFI2 2010-2014), the sample plots were circular with 7.98 m (200 m2), 11.28 m (400 m2) and 12.62 m (500 m2) radii depending on the forest stand age. In the last recent cycle (NFI3 2015–2019), a radius of 11.28 m (400 m2) was used for all plots. At each NFI sample plot, many tree and stand characteristics were measured. The diameter at breast height was measured for all trees with a diameter equal or above 7 cm. The heights of the selected trees were measured to estimate the height curve. To obtain the growing stock volume for a sample plot, first, the allometric models are used to predict individual tree volumes. Then, after aggregation from single trees, the plot-level volume is calculated (Hawryło et al., 2020).

Figure 44 General scheme of Polish NFI. Each number indicates the year in a cycle (Michalak and Zaja ̨czkowski, 2010)



Polish NFI's forest definition (land spanning more than 0.5 hectares with trees higher than 5 meters and a canopy cover of more than 10 percent or trees able to reach these thresholds in situ) is in line with the one proposed by FAO (FAO, 2004).

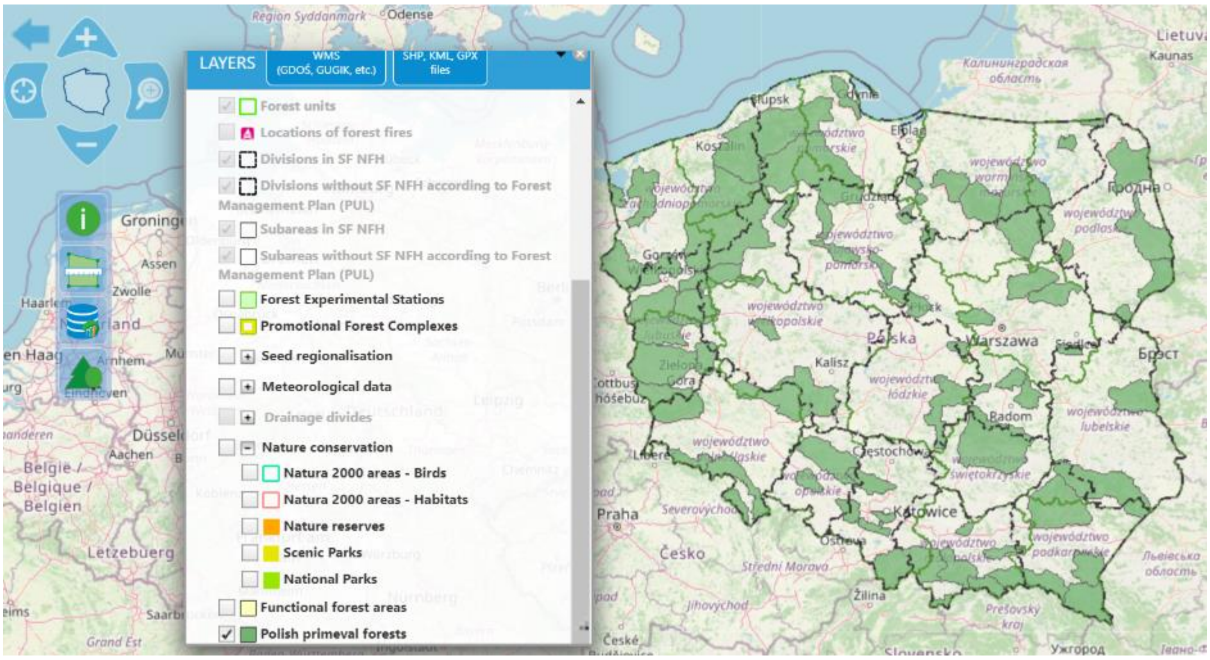
The NFI in Poland is jointly financed by the State Budget and State Forests National Forest Holding based on an agreement between the General Directorate of State Forests National Forest Holding and Office of Forest Management Planning and Geodesy (the unit responsible for the Polish NFI) which covers the entire 5-year cycle. Field work is carried out annually by 65–68 teams, each with two persons, that are created by all OFMPG regional divisions (Michalak and Zaja ̨czkowski, 2010).

21.2.2. Forest mapping

The Polish Forest Data Bank (https://www.bdl.lasy.gov.pl/portal/mapy-en) offers an online gis-based visualization of forest maps. The information reported are related to the (i) year of forest management planning, (ii) the presence of protected areas (Natura2000, National Parks, reserves) and primeval forests, (iii) the presence of Promotional Forest Complexes, and (iv) functional forests.

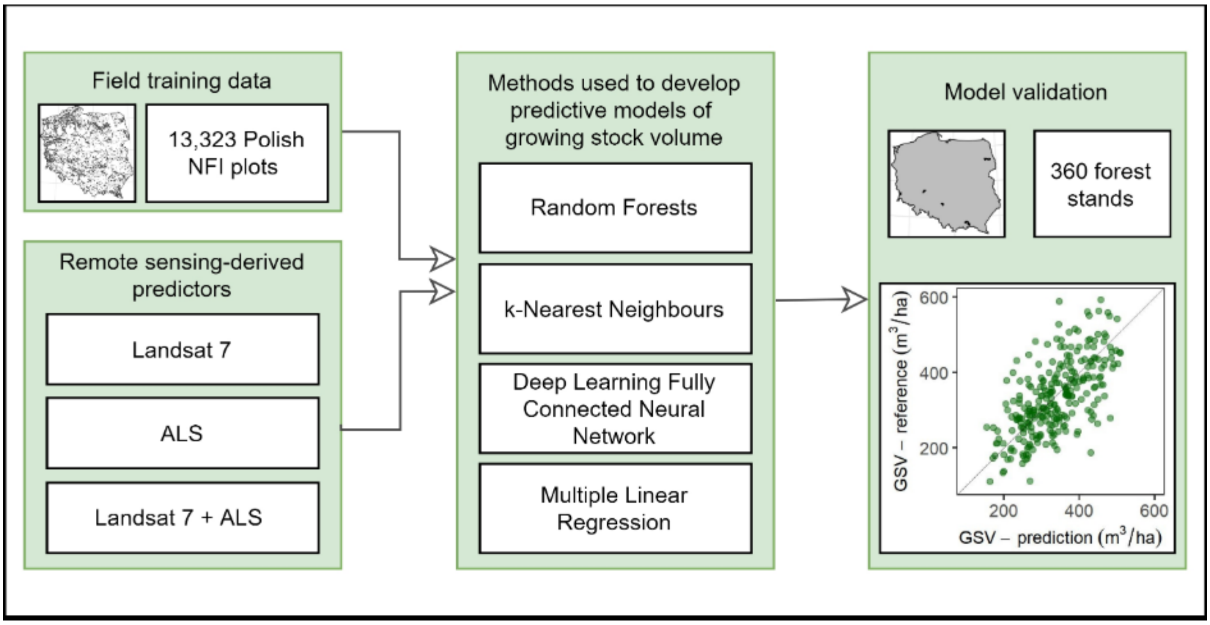
Promotional forest complexes are large forest areas that are part of one or more forest districts. Created throughout the country, they show the variability of habitat conditions, the diversity of forest species composition and the multiplicity of functions performed by it. As part of the LKP, foresters promote sustainable forest management, support scientific research and conduct forest education of the society.

Figure 45 Online GIS-based visualization of Polish primeval forests. Source: https://www.bdl.lasy.gov.pl/portal/mapy-en



While the Polish NFI does not directly produces remote-sensing based maps, an external study, conducted at national level, evaluated four predictive approaches trained-based on Polish NFI plots combined with ALS and Landsat imagery to predict growing stock volume at the stand level (Hawryło et al., 2020).

*Figure 46 External research aim*ed to evaluate Polish NFI plots as a source for the development of predictive models for forest growing stock volume using ALS and Landsat data in varying types of stands located in different parts of Poland (Hawryło et al., 2020)



21.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Poland.

Table 82 Poland: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	NFI	National		5y	FAO	yes				
Forest biomass	NFI	National		5y		yes				
Forest carbon										
Tree age	NFI	National		5y		yes				
Canopy height	NFI	National		5y		yes				
Forest structural diversity	NFI	National		5y		yes				
Forest soil properties										
Forest/tree cover change	NFI	National		5y		yes				
Tree age diversity	NFI	National		5y		yes				
Tree species/composition	NFI	National		5y		yes				
Tree species diversity	NFI	National		5y		yes				
Forest type	NFI	National		5y		yes				
Deadwood	NFI	National		5y		yes				
Presence of Red-list species										
Abundance of common forest birds										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system	NFI	National		5y		yes				
Main management objectives										
Forest area covered by a management plan	NFI	National		5y		yes				
Volume of wood harvested										
Ratio of annual fellings to annual increments										
Forest revenue										
Roundwood prices										
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth										
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										

21.2.4. SWOT analysis

Table 83 Poland: SWOT analysis

Strengths	Weaknesses
A long tradition of stand wise inventory combined with the new sampling based forest inventory.	The NFI does not produce official wall-to-wall maps but research activities are advanced.
Opportunities	**Threats**
Integrating NFI with remotely sensed data could provide substantial cost savings in the forest management inventory at a local scale.	Lack of wall-to-wall national forest maps.

21.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 84 Poland: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	State of Europe's Forests, 2020	Key information on forests
	Statistical Yearbook of Forestry, 2021	
	National Forest Inventory	Current data on forests
	State of Poland's Forests 2020	
Biodiversity	State of Poland's Forests 2020; Forest Act Act on Nature Protection	All forms of forest management and protection, aimed at ensuring their sustainability and biological resilience, also serve to maintain genetic resources and biodiversity.
	The programme of conservation and sustainable use of biodiversity along with Action Plan for the period 2015-2020	Improving the state of biodiversity and linking its protection more fully to the development of the country's social and economic development.
Bioeconomy	Woźniak & Twardowski, 2017	Agro-food, forestry-timber and environmental bioeconomy as a "national smart specialization" defined in the Polish government (Service of the Republic of Poland)
	Service of the Republic of Poland	
Ecosystem services	State of Polish Forests 2020	Description and acknowledgement of value of forest ecosystems
	The programme of conservation and sustainable use of biodiversity along with Action Plan for the period 2015-2020	Reference to EU documents & setting of several objectives
Climate change	The programme of conservation and sustainable use of biodiversity along with Action Plan for the period 2015-2020	Monitoring and limitation of hazards resulting from climate changes
	National Climate Change strategy 2020	Scenarios and actions
	National Forestry Accounting Plan	Modelling of carbon stock changes in forest ecosystems
	The National Energy and Climate Plan for 2021-2030	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF. Specific

Thematic area	Main Strategic reference	Summary of planning elements
		measures related to forests include afforestation and progress towards SFM, by increasing from 95.7% to 99% the share of forest areas subject to approved forest management documentation relative to the total forest area.

21.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 85 Poland: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Research on expected changes in forests due to climate change & their mitigation and adaptation through forests should be intensified. It should be a basis for further adaptive measures in forests. Several projects are implemented in Poland regarding climate change mitigation and adaptation, like small-scale water retention[2] and carbon forest project[3].
Ecosystem services	Ecosystem services are mainly carried out in the public forests, which in principle ensure, in accordance with national law, multifunctionality. Forest are available for public and actively shared in various forms. An on-line tourist platform has been created by the State Forests within the project “Czas w las”[4]. Public forests are, so far, excluded from any further payments for ecosystem services.
Interest conflicts	Further promotion among and education of the society on multiple forest functions and their importance.
Private forest owners	Provision of trainings, information and technical advice to private forest owners (incl. forest owners associations). Improvement of forest supervision in private forests (enhancing institutional and financial measures). A programme for adapting private forests to expected climate change should be developed and implemented.
Biodiversity conservation	Raising public awareness on biodiversity issues, support and trainings for private forest owners.
Bioeconomy	Promoting the idea of green economy in the society, private forest owners, entrepreneurs and officials. Introducing the issue of a green economy to forest-focused and forest-related polices. Active support for use of wood as a natural, renewable material and source of energy, as well as promoting use of non-wood forest products. Further implementation and widening the projects implemented by the State Forests Holding e.g. "Healthy Food from the Polish Forests")
Forest fires	Long-term meteorological observations in Poland show that average temperature across the country is increasing, climate change symptoms in Poland are, among other,

[2] https://www.lasy.gov.pl/en/information/news/more-and-more-water-reservoirs-in-forests
[3] https://projekty-rozwojowe.lasy.gov.pl/projekty-rozwojowe/-/asset_publisher/7PcENrBXlBZJ/content/lesne-gospodarstwa-weglowe
[4]https://czaswlas.pl/mapa?search=1&s_nazwa=&m_zoom=6&m_lat=50.89278141773402&m_lng=29.575195312500004

Major challenge	Summary description
	extended rainless periods, long-term droughts, extreme weather conditions of increasing frequency (e.g. hurricane winds). Water in Polish forests is periodically in short supply. Natural factors such as high temperature and the long lasting lack of precipitation are indicated as the reason for this state. Growing resilience of forests to natural disasters, as well as effectiveness of the early fire warning system in the State Forests, a broadened forest area monitoring and reduced time required for hazard detection, response and a reduced extent of fires, improved fire protection in areas adjacent to areas administered by the State Forests (eg. national parks, inhabited areas) and decrease in CO2 emissions by reducing the quantity and range of fires. In Poland constant monitoring and everyday forecasting of fire hazard is conducted by The Forest Research Institute within the National Forest Fire Information System.
Desertification	Maintenance and further development of the programme of strengthening water retention functions of forests.
Population-related challenges	No information
Financing	Support on all levels. In Poland in accordance with the Act on Forests Art. 50.1. the State Forests operate on the basis of financial independence and cover their operating costs from their own revenues.
Governance	Promotion and support regarding carbon storage in forest products and substitution of non-renewable materials need to be intensified. A programme for promoting the issue for general public should be developed at the ministerial level. Introducing more detailed regulations and removing legal gaps concerning forests in urban areas so that they could be maintained and protected in a more efficiently. Elaboration, introduction & future monitoring of the National Forest Programme for Poland.

21.4. References

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

Hawryło, P., Francini, S., Chirici, G., Giannetti, F., Parkitna, K., Krok, G., ... & Socha, J. (2020). The use of remotely sensed data and Polish NFI plots for prediction of growing stock volume using different predictive methods. Remote Sensing, 12(20), 3331. https://doi.org/10.3390/rs12203331

Talarczyk, A. (2014). National forest inventory in Poland. Balt. For, 20, 333-341.

State of Poland’s Forests, 2020:

https://www.bdl.lasy.gov.pl/portal/Media/Default/Publikacje/raport_o_stanie_lasow_2020_.pdf

SoEF, 2020:

https://foresteurope.org/wp-content/uploads/2016/08/SoEF_2020.pdf

National Forest Inventory Report, 2016-2020 https://www.bdl.lasy.gov.pl/portal/Media/Default/Publikacje/WISL2016_2020.pdf

Statistical Yearbook of Forestry 2021

https://www.bdl.lasy.gov.pl/portal/Media/Default/Publikacje/GUS_lesnictwo_2021.pdf

Forest Land Ownership Change in Poland, COST Action FP1201 FACEMAP country report 2015, EFI:

https://facesmap.boku.ac.at/library/FP1201_Country%20Report_POLAND.pdf

Forest Europe Report 2020:

Microsoft Word - QL_questions-responses_POL (foresteurope.org)

National Biodiversity Strategy:

https://www.cbd.int/doc/world/pl/pl-nbsap-v3-en.pdf

Woźniak, E., Twardowski, T., (2017), The bioeconomy in Poland within the context of the European Union, New Biotechnology 40: 96-102

https://reader.elsevier.com/reader/sd/pii/S1871678417300389?token=2FE77E401908CBC00F167C0055F6CEED20EFABFBAF207D53BC11C10B7724BD690A634BDC64B9D252519BB5EAAEC2CCD5&originRegion=eu-west-1&originCreation=20220824090506

Service of the Republic of Poland:

https://www.gov.pl/web/ncbr

The State Environmental Monitoring Programme for the years 2016-2020. Chief Inspector of Environmental Protection. Warsaw, 2015.

CAP Strategic Plan Poland: https://www.gov.pl/web/rolnictwo/plan-strategiczny-dla-wspolnej-polityki-rolnej-na-lata--2023-2027

The National Energy and Climate Plan for 2021-2030: https://energy.ec.europa.eu/system/files/2020-08/pl_final_necp_part_1_3_en_0.pdf

22. PORTUGAL

22.1. Country overview – major forest facts

22.1.1. Key forest data

Portugal is a country on the west of the Iberian Peninsula, including Azores and Madeira autonomous regions, where 66% is covered by forest (ca. 3.3 Mio ha) and other wooded land (ca. 2.8 Mio ha). The negative trend observed in the continental area between 1995 and 2010, with a loss of 4% ,has been reversed in the period 2010-2015, with an increase of 2%, however this trend is majorly linked with continental forest fires occurrence. The cork oaks and holm oaks are the main forest occupation in the continental area (33%), in Azores is Criptomeria (12%) and in Madeira is Laurisilva (15%). The major forest species available for wood supply are eucalyptus globulus (26%)and maritime pine (22%). Forest fires cause a major problem to Portuguese forests and to forest management, but that are also concerns regarding the occurrence of pests and diseases and of extreme weather events. All these forest decline drivers are already causing significative damages, but they are expected to become more evident with time. At present, 1.86 Mio ha are under management plans, corresponding to 58 % of the total forest area. About 15% of forest area is under third party certification. The Portuguese national forest inventory process started in 1963. 21.8% of forest and other wood land are protected for conservation of biodiversity; 7.7% are designated as protective forest. 24 thousand ha of forest is considered undisturbed by man.

22.1.2. Institutional setup and legal framework

The main legal frameworks are the Forest Policy Act 1996 and the National Forest Strategy 2015. Regarding risks, there are several legal norms subsidiary to the National Plan for Integrated Rural Fire Management and the Forest Health Operational Programme, published by the Resolution of the Council of Ministers nº 28/2014.

It is worth mentioning that a reasonable number of legal norms have been approved to reinforce the importance of compliance or best management practices in aspects concerning forest habitats' protection, montado's protection, the use of chemicals in forest management, prevention and control of quarantine forest pests. The Forest Permanent Fund (Part of the Environment Fund) and Rural Development Programme are the main sources of national public support for forest management. Forest management plans are obligatory in public areas and in private areas, if above the threshold defined for each Regional Forest Programme.

22.1.3. Key actors and stakeholder organisations

Public Administration; Ministry of Environment and Climatic Action and, in the Autonomous Regions, the Regional Secretariats of Agriculture and Rural Development (in the Azores) and of the Environment, Natural Resources and Climate Change (in Madeira); Instituto da Conservação da Natureza e das Florestas; AGIF – Agência para a Gestão Integrada e Fogos Rurais; APA; DGT; Private owners and community forest federations: Forestis - Associação Florestal de Portugal; Fórum Florestal; BALADI and FNAPF (national level associations) plus around 150 associations of regional and local level and cooperatives FENAFLORESTA – Federação Nacional das Cooperativas de Produtores Florestais, FCRL, UNAC - União da Floresta Mediterrânica; Portuguese Cork Association (APCOR – Associação Portuguesa da Cortiça); the Portuguese Pulp and Paper Association (CELPA), the Portuguese wood-industry and furniture Association AIMMP; Centro PINUS – Associação para a valorização da floresta de pinho; Resipinus – Associação de destiladores e exploradores de resina ANEFA – Associação Nacional de Empresas Florestais, Agrícolas e do Ambiente; EnvNGO: CPADA - Confederação Portuguesa das Associações de Defesa do Ambiente (confederation of 110 Environmental NGO of diferent levels and scope) ; Academia and Research INIAV; Forestwise CoLab; MED/UEVORA; ISA/ULISBOA; UTAD; ESAC; UAveiro; The National Council for Forests (Conselho Florestal Nacional); Forest Health Monitoring Group (GASF).

22.1.4. Forest ownership

Private ownership is dominant in Portugal representing more than 90% of the forestland. Generally, private forest corresponds to smallholdings (below 10ha) in the northern and central regions and to large agro-forestry exploitations (above 100ha) in the south regions.

22.1.5. Forest industry

Removals were more than 12.7 Mio m3 in 2020. In 2020, the production of wood fuel (incl. wood for charcoal) was 1.7 Mio m3, which represented 13% of total roundwood production. It is not possible to compare fellings with net annual increment as the latter was not calculated by the last NFI. In 2020, employment in the forest sector was 73.3 thousand people, nearly 27% less than in 2000, largely due to development for wood processing, but observing 2% increase since 2010. Employment in forestry itself rose between 2010 and 2020 at annual rates over 4.8%, on average, representing more than 9.4 thousand employees in 2020.

22.1.6. Key forestry issues

Increase forest productivity and resilience, promote forest environmental and social services, engage stakeholders to contribute to sustainable forest management and participation & prevent forest risks, mainly fire and pests

22.2. Forest monitoring

22.2.1. National Forest Inventory

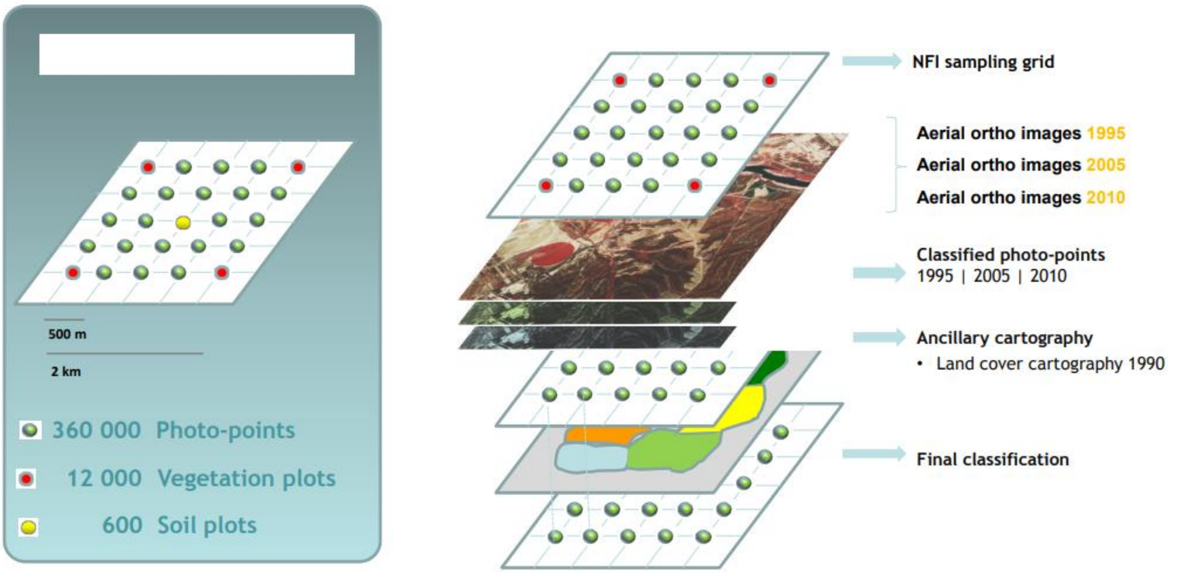
While forest monitoring in Portugal dates to XIX century, the first National Forest Inventory based on sample plots took place during the years 1965-1966. Since then, five more cycles took place (NFI2 1974, NFI3 1985, NFI4 1995, NFI5 2005), with approximately a 10-year periodicity. Since NFI5, sampling also includes the Autonomous Regions of Madeira and the Azores. NFI6 (2010) initiated a shortened 5-years cycle.

The first four Portuguese NFIs were based on temporary sample plots. Permanent sampling was introduced during the fifth NFI, along with the increase in photointerpretation sampling density.

The last Portuguese NFI (NFI6) followed the three-phased sampling approach introduced with NFI5. During the first phase, an evaluation of the area of different land use/land cover was carried out through the photointerpretation of aerial imagery. During the second phase, ground vegetation was characterized in the field (circular plots, linear transects and patches). The third phase was focused on the soil sampling on a sub-sample of second phase NFI plots. All three phases were based on a square sampling grid. This grid system consists of a 500 m x 500 m grid (ca. 360 thousand points), that is used for phase 1, and it includes a two sub-grids of 4 x 4 km, and 2 x 2 km that is the basis for field work in shrubs and forest respectively. Another sub-grid of 900 points for soil sampling is set.

The forest and other wooded lands definitions from FAO (FAO, 2004) have been used since NFI4.

*Table 86 Portugese NFI*6 point classification procedure and methodology (Uva, 2014)



The Portuguese NFI produces official estimates at various scales, from the national to local levels, even if with varying degrees of precision and information due to sample restrictions. A historical database of the evolution of the Portuguese forest has been developed, and it depicts the trends in biomass and forest area changes. The sample grid was applied to four different airborne aerial photography national coverages acquired in 1995, 2005, 2010, and 2015 to create a reliable monitoring system. Within the last NFI, it was possible to compute land use/cover transition matrices for the first time, which offered pertinent insight into Portugal's land use/cover dynamics.

All Portuguese NFIs included the measurement of a sample of field plots in order to characterize the forest stands with the most important forest tree species in Portugal. The main objectives of the first four Portuguese NFIs were to estimate standing volume, as well as the growing increment for the maritime pine (*Pinus pinaster* Ait.). During NFI4, shrub strata analysis was introduced, along with the evaluation of non-wood forest production (cork, resin, acorns). Moreover, for the first time, the assessment of forest damage – erosion and wildfires, mostly – and forest vitality occurred. With NFI5, biomass and carbon stock estimations, as well as the measurement of standing deadwood and shrub biomass, were introduced.

The results from the NFI6 are available, in local language, aggregated per NUT I-III regions

(https://www.icnf.pt/florestas/flestudosdocumentosestatisticasindicadores) on the ICNF (Instituto de Conservação de Natureza e das Florestas) website.

The scope of the last NFI was increased, with the inclusion of many topics: habitat identification and conservation status evaluation; soil characterization and organic carbon evaluation; a comprehensive deadwood evaluation for biomass and carbon quantification; shrubland species identification and carbon stock quantification; alien and exotic species quantification; and tree growth data collected with increment borers for biometric model development (Tomé et al., 2016).

The results of the Portuguese NFI are used as a basis for decision-making processes in forest and environment policy, forest management, forest products industries, and for evaluating the outcomes of the implemented plans and decisions. National reporting commitments with several national and international processes and organizations (FRA, Forest Europe, LILUCF, UNFCCC,) rely on Portuguese NFIs results. Portugal’s NFI data is also a valuable source for numerous research projects related to the estimations of Portuguese forests’ potential in the provision of wood and non-wood (especially cork) supply (Santi et al., 2013).

22.2.2. Forest mapping

On the ICNF portal, an online GIS-based map based on the information reported on the NFIs is available. The layers available are related to (i) forest carbon, (ii) land use/land cover, (iii) biomass, (iv) growing stock volume, (v) natural forest regeneration, and (vi) alien species.

No further information is provided on forest mapping in Portugal.

Figure 47 Invasive species map per NFI plot. The legend shows the abundance classes of invasive species by species within their area of occupancy (from low 1 to high 4).

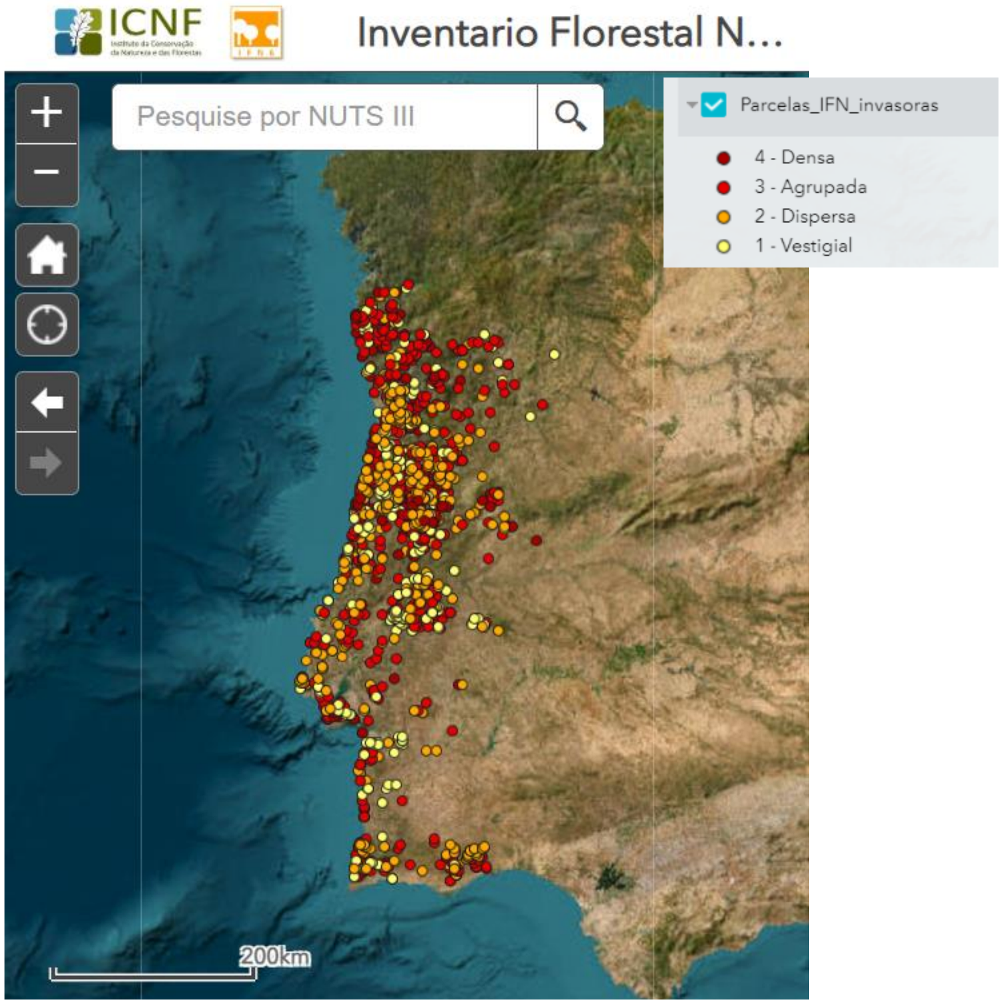
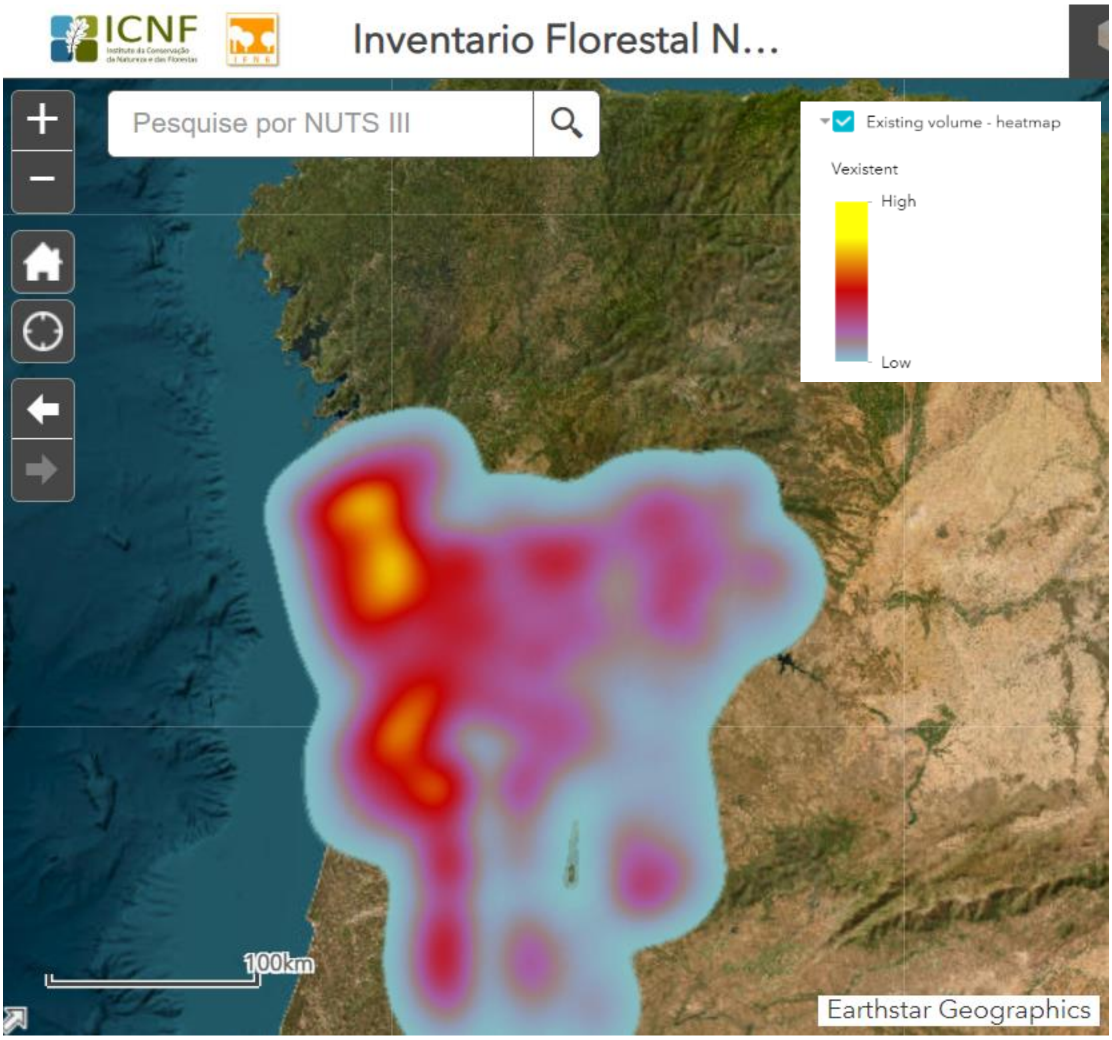


Figure 48 Detail of Portugal growing stock volume heating map. Higher volume is characterized by a yellow color, lower volume by a blue shade (ICNF).



22.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Portugal.

Table 87 Portugal: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	NFI	National	Complete	10y	FAO	yes				
Forest biomass	NFI	National	Complete	10y		yes				
Forest carbon	NFI, SNIERPA	National		10y		yes				
Tree age	NFI			10y						
Canopy height	NFI	National	Complete	10y		yes				
Forest structural diversity	NFI	National	Complete	10y						

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest soil properties	NFI			10y						
Forest/tree cover change	NFI	National	Complete	10y		yes				
Tree age diversity	NFI			10y						
Tree species/composition	NFI	National	Complete	10y	FRA and Forest Europe	yes				
Tree species diversity	NFI			10y						
Forest type	NFI	National	Complete	10y	FRA and Forest Europe	yes				
Deadwood	NFI	National	Complete	10y	FRA and Forest Europe	yes				
Presence of Red-list species	ICNF									
Abundance of common forest birds	CAC/SPEA									
Forest spatial patterns	NFI & COS/Corine/DGT				FRA and Forest Europe					
Areas of primary and old-growth forests	ICNF									
Forest ancientness	ICNF									
Forest area under protection	ICNF				Forest Europe and IUCN					
Silvicultural system	ICNF				FRA and Forest Europe					
Main management objectives	ICNF	National	Complete	3y	FRA and Forest Europe					
Forest area covered by a management plan	ICNF	National	Complete	3y	FRA and Forest Europe					
Volume of wood harvested	ICNF & INE				FRA, Forest Europe; FAO/UNECE/ITTO/EUROSTAT Joint Questionaire					
Ratio of annual fellings to annual increments	ICNF				FAO/UNECE/ITTO/EUROSTAT Joint Questionaire					
Forest revenue	INE	National	Complete	1y						
Roundwood prices	ICNF	National	Complete	1y						
Forest products trade	INE	National	Complete	1y	FAO/UNECE/ITTO/EUROSTAT Joint Questionaire			x		yes - public
Employment in the forest sector (*)	ICNF & INE	National	Complete	1y				x		yes - public
Employment in the forest sector	GEP (MTSSS)/ICNF	National	Complete	1y				x		yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest area with 3rd party certification	PEFC/FSC PT	National	Complete	1y						
Forest visitor statistics										
Forest foliage/phenology/ anomalies	NFI & POSF & ICP Forests				ICP-Forests (partially)					
Tree health	NFI & POSF & ICP Forests			6y						
Forest growth	NFI	National	Complete	10y	FRA and Forest Europe	yes				
Occurrence of forest fires	ICNF	National	Complete	1y					x	yes - public
Occurrence of storms	*ICNF*									
Forest disturbance	NFI & POSF & ICP Forests									
Number of forest fires	ICNF	National	Complete	1y					x	yes - public
Number of storms										
Non-wood forest products	INE & NFI	National	Complete	1y	Forest Europe			x		yes - public
Consumption of biomass	DGEG	National	Complete	1y					x	yes - public

22.2.4. SWOT analysis

Table 88 Portugal: SWOT analysis

Strengths	**Weaknesses**
Robust framework of official data collection following harmonized proceedings covered by international commitments and regulations; Official information outreach in digital format extensively used.	Weak integration of different data sources; Local language available only; Scarce availability of forest mapping based on NFI data.
Opportunities	**Threats**
Rationalize budget and logistics, avoiding budget and collection.	Budget and logistics limitations to collect, analyse and outreach; Confidentiality constraints.

22.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 89 Portugal: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	SoEF, 2020	Current data on forests, reference to the national forest inventory
	National forest inventory	Current data on forests
Biodiversity	National Forest Strategy	Biodiversity preservation measures and references to national & EU biodiversity strategy
	National Strategy for Nature Conservation and Biodiversity	3 key elements: i) improve the state of conservation of the natural heritage, ii) promote recognition of the value of the natural heritage and iii) foster the appropriation of natural values and biodiversity by society
Bioeconomy	Bio-based Industries Consortium	Identified Portugal`s potential to become Europe`s leader in bioeconomy
	Action Plan for Sustainable Bioeconomy – Horizon 2025 (Government Order 183/2021)	Promotion of active sustainable forest management; Scale up the unity of management areas (ex: from Integrated areas of Landscape Management to Forest Management Unities & land tenure reform); Strengthening research, development & Innovation, envisaging the sustainability of raw materials supply and along the value chains, is too considered of outmost relevance to promote bioeconomy based on forests.
Forest protection	National Plan for Integrated Management of Rural Fires	Comprises a Strategy and a Program to overcome major constrains. Considers four strategic guidelines: Valuing the rural areas, Active management of rural areas, Change behaviours, Efficient risk management. Establishes 3 main targets: the loss of lives in fires, although possible, is rare;, the ratio of fires extending across more than 500 ha is below 0.3% of the total number of fires; the cumulative burned area over the period of 2020-2030 is less than 660,000 ha (to be revised by 2023 to a figure that takes into account the loss of goods and services).
	Forest Health Operational Program (POSF)	Includes measures to increase knowledge about the presence of harmful biotic agents, diminish their negative effects on forests, reduce possibility of introduction new pests and diseases and increase knowledge about the behaviour of biotic agents

Thematic area	Main Strategic reference	Summary of planning elements
		themselves. In partnership with stakeholders' organisations, it considers a national monitoring program of forest pests.
	National Forest Health Monitoring Programme	Current data on the occurrence of some of the most relevant pests and diseases, reference to the national forest inventory
	National Forest Health Surveillance Programme	Current data on the surveillance of quarantine pests
Ecosystem services	National forestry accounting plan for Portugal	Recommendation to reinforce the distribution of support for ecosystem services and the maintenance of biodiversity
	National Forest Strategy	Recognition of importance and classification, updated with a view to integrate the outcome of the evaluation study of its implementation, as well as to incorporate guidance from the Forest Health and Vitality Operational Programme
Climate change	National forestry accounting plan for Portugal	One of the central forest management and biodiversity goals: Increasing the contribution f forests to climate change mitigation
	National Forest Strategy	Takes into account the efforts carried out within the framework of both the National Strategy for Climate Change adaptation and the National Action Plan to Combat Desertification
	Portugal National Energy and Climate Plan 2021-2030	Suitable agroforestry management reduce burnt areas and fire risk, thus increasing productivity and reinforcing ecosystem services that promote and contribute toward combating desertification, enhance the value of the land and increaser forest resilience to climate change. Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

22.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 90 Portugal: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Adaptation and mitigation efforts to address climate change are and will be a certainty as continual shifting of conditions is to be expected. The challenge here is to promote

Major challenge	Summary description
	sustainable adaptive forest management, aiming at decreasing forest vulnerability to environmental changes.
Ecosystem services	Strengthen efforts with a view to a valuation of ecosystem services namely of those that do not have a specific market yet; Further promote the resilience and sustainability (namely economic) of forest holdings by opening up new possibilities of more frequent and diversified incomes
Interest conflicts	Intensify awareness raising on the value of ecosystem services with a view to increase the willingness and acceptance of the society in general to recognise that value and financially support those ecosystem services
Private forest owners	Raise awareness on the different support programmes with a view to strengthen conditions to increase the competitiveness of related activities and to the full use of the related funding instruments
Biodiversity conservation	Rehabilitation of degraded forests namely by pests and rural fires. Enhance the implementation of forest and habitat protection legal normatives. Promote forest environmental services, through awareness and specific market strategies.
Bioeconomy	Further promote the use of renewable raw materials
Forest fires	Rural fires – add more value to forest products and services, allowing active forest management and effective fuel management at landscape level. A change of practices and a change of minds and attitudes are mandatory with a view to decrease not only the risk of fire ignition but also to strengthen efforts in relation to prevention measures to protect buildings and villages in forest lands.
Pests and diseases	Promote awareness on the need to implement plant health-related best practices measures. Enhance dedicated training to forest managers. Strengthen and implement early detection systems, with a view to more efficient and timely prevention and control measures. Continuously research, develop and test innovative resources and tools for pest detection, monitoring and control. Promote a regular forest health inventory and use the data obtained to support policies and forest management decisions.
Desertification	Strengthen the combat against the progress of desertification, namely through forests and sustainable forest management and rehabilitation of forests degraded through pests and rural fires; Devote further attention to the correct ground preparation and use of water; Contribute to address a major national problem which is abandonment of certain areas of national territory – this has to be dealt with through a multidisciplinary approach
Population-related challenges	Further promote efforts in relation to planning, creating and managing urban and peri-urban forests, namely by the local authorities, and explore their potential with a view to have more resilient and sustainable cities and to improve the physical and mental health of citizens
Financing	Full use of existing financing measures, namely those foreseen within the rural development programme; Enhancement of policies and measures that support settling/retaining population in rural areas
Governance	Enforcement of the forest regional planning programmes and management plans as they encompass different actions and measures that, overall, contribute to this goal

22.4. References

Uva JS (2014) – The Portugese National Forest Inventory: Applicability in semiarid areas monitoring. Training on indicators of desertification: early warning signs COST Action ES1104 | University of Lisbon | 19 May´2014. http://ecofun.fc.ul.pt/Activities/Desertification2014/docs2/Sousa-Uva_The%20Portuguese%20National%20Forest%20Inventory.pdf accessed on 31/12/2022

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

Santos PM, Soares P, Mendes AMSC, Caldeira B, Brígido S, Praxedes J, Pina JP, Paulo JA, Tomé M, Barreiro S, Borges JGC, Palma JHN, Garcia-Gonzalo J, Sottomayor M (2013) EstudoProspetivo Para o Setor Florestal - Relatóriofinal. AIFF - Associação para a Competitividadeda Indústria da Fileira Floresta

Tomé M, Barreiro S, Uva JS. in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

National Forest Strategy: https://files.dre.pt/1s/2015/02/02401/0000200092.pdf

National Forest Inventory: https://www.icnf.pt/api/file/doc/c8cc40b3b7ec8541

New EU Forest Strategy for 2030: https://environment.ec.europa.eu/strategy/forest-strategy_en

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Europe Report 2020: QL_questions-responses_PRT_16-4-2019_updated9-8-2019.pdf (foresteurope.org)

National forestry accounting plan for Portugal: https://apambiente.pt/sites/default/files/_Clima/Mitiga%C3%A7%C3%A3o/Plano%20Contabilidade%20Florestal%20Nacional%202021-

2025/National%20Forestry%20Accounting%20Plan_Revised%20version%20january%202020.pdf

National Strategy for Nature Conservation and Biodiversity: https://files.dre.pt/1s/2018/05/08700/0183501880.pdf

Bio-based Industries Consortium: https://biconsortium.eu/news/portugal-country-report

RCM/183/2021 Approves the Action Plan for a Sustainable Bio-economy Horizon 2025https://dre.pt/dre/detalhe/resolucao-conselho-ministros/183-2021-176631058

Valente, S. et al., (2015), Sustainable Forest Management in Portugal : transition from global policies to local participatory strategies, International Forestry Review 17(3)

National Plan for Integrated Management of Rural Fires : https://www.agif.pt/app/uploads/2020/12/20-30_NPIRFM_littledoc.pdf

Forest Health Operational Program (POSF) https://www.icnf.pt/api/file/doc/5a3fdf8ad95d7d62

RCM/28/2014 Approves the Forest Health Operational Program and makes it the reference in terms of policies and measures to support forest health

CAP Strategic plan for Portugal: https://www.gpp.pt/images/PEPAC/PEPAC_Submetido/Exportacao_SFC_versaoAprovao_29072022.pdf and https://agriculture.ec.europa.eu/system/files/2022-09/csp-at-a-glance-portugal_en.pdf

Portugal National Energy and Climate Plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-06/pt_final_necp_main_en_0.pdf

23. ROMANIA

23.1. Country overview – major forest facts

23.1.1. Key forest data

Romania is an eastern European country on the Black Sea, with nearly a third of forest cover. Forest area has expanded steadily, and stands at 30.1% of total land area. Growing stock stands at 340 m3 o.b./ ha. 81% of forests are under a management plan, which is obligatory for holdings over 10 ha, and is registered with an official body. Nearly 40% of forests are certified under a third party certification scheme, exclusively FSC. It is reported that in 2005, 7.8% of Romanian forests were protected for conservation of biodiversity, but data are not available for other years. Nearly 42% of forests are designated as having protective functions. About 165 thousand ha of forest are considered undisturbed by man.

23.1.2. Institutional setup and legal framework

The Forest Code was approved in 2008, with the most recent amendment in 2018. There is a national level NFP process. A national forest inventory, supplemented by stand-wise inventories, provides data for this study and for policy makers. Until 2010, data were estimated on the basis of a stand wise inventory covering forest fund land only, so data for 2015 and after may not be fully comparable with those for earlier years.

23.1.3. Key actors and stakeholder organisations

Ministry of Water and Forests; National Forestry Directorate – Romsilva; National Forest Fund.

23.1.4. Forest ownership

Compared with other ex-socialist countries, where small private forests survived to the nationalisation process, the Romanian State fully abolished the private ownership on forests during its communist phase. Land restitution after 1989 has opened a discussion regarding the sustainable use of the private forest resources. The private forestry has been generally perceived in a negative way given the fact that effects of deforestation and lack of forest management were more visible on private forests. The country report underlines that despite changes in the ownership patterns, little has changed in the management rights of private owners. The main policy changes favouring private forest management are related to the establishment of private forests administrative units which has offered an alternative to the state administration since 2002, when the first private forest districts have been created.

23.1.5. Forest industry

For many years removals were around 12 million m3, but after 2010, this increased, to the 15-16 million m3 range. In 2015, fellings were nearly 44% of net annual increment. Nearly 33 thousand people are employed in forestry (no data supplied on wood processing or pulp and paper), much lower than in 1990, when they were more than 100 thousand.

23.1.6. Key forestry issues

Forest restitution process in Romania is problematic which results in large areas of disputed and mismanaged forestlands.

23.2. Forest monitoring

23.2.1. National Forest Inventory

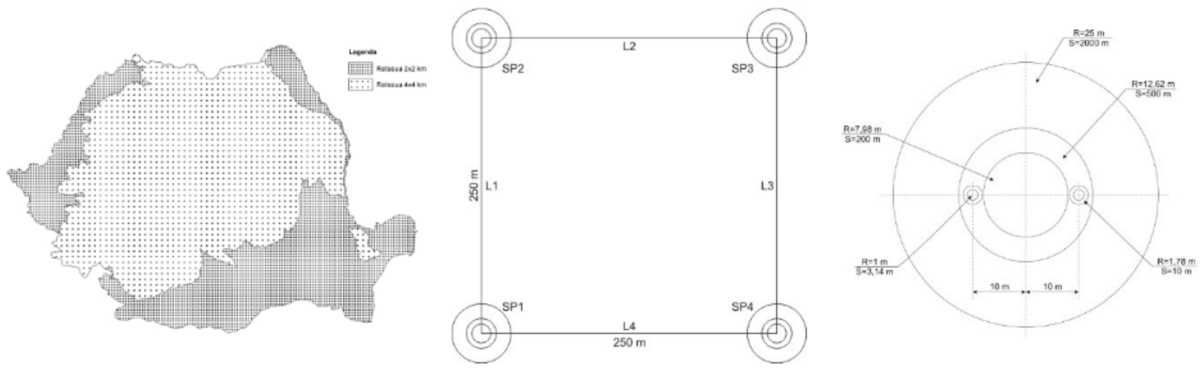
Forest inventory in Romania started in 1959 by aggregating management planning information from forest districts assessed during the period 1948–1958 for all Romanian forest fund land, which aims was assessing Romanian wood resources, particularly for the development of forest industry at the end of 1950s. The national inventories of forest fund were periodically completed in 1965, 1973, 1980 and 1984.

In 2006 the National Forest Inventory (NFI) was initiated covering all of Romania’s forests, which included the forest fund and forests outside the forest fund. The first sample-based NFI cycle was conducted in 2008–2012, with the main objective of providing accurate national and regional forest statistics on the current state of forests. The second cycle of the NFI started on October 2013 maintaining the sampling and estimation technique.

The Romanian NFI is designed as a continuous forest inventory with a five-year cycle. It is based on a systematic sampling, combining repeated measurements of permanent plots with measurements of temporary plots and it is a two stage NFI (aerial photos and field forest measurements and assessment). The Romanian NFI covers the entire country, and it is based on a 4x4 km grid (Marin et al. 2010). The density of grid is higher in plain area (2x2 km) because of a very low forest cover.

Measurements are carried out on four subplots of clusters located at the corners of a 250x250 m square in the southwest corner of the 4x4 (2x2) km grid. At the end of the five-year cycle, the field forest inventory includes about 24,000 permanent and 5,000 temporary plots.

Figure 49 Left: Romanian forest inventory grid; center: structure of cluster with four field sample plot per grid; right: layout of the plots, each circle represents a different sampling zone with specific measurement and measurement rules (more details in Vidal)



23.2.2. Forest mapping

No official forest mapping has been developed in Romania as part of the national forest inventory.

On the other hand, external research explored the potential use of remote sensing techniques and Earth Observation to monitor national vegetation characteristics. For instance, Griffiths et al. (2012), used an annual time series of Landsat images and LandTrender algorithm to study forest disturbances in the context of institutional and socioeconomic changes in Romania. Multi-temporal dynamics of forest cover change in the Carpathians are also studied by Vaninckelen and Van Rompaey (2015), through three forest maps constructed by classifying Landsat images. Rujoiu-Mare et al. (2017) produced high accuracy land cover maps, which includes four forest categories. in two study area in Romania through Sentinel-2 images.

Figure 50 Forest cover maps in Carpathian Ecoregion (A) 1985, (B) 1995, (C) 2010 (Vanonckelen and Van Rompaey, 2015)

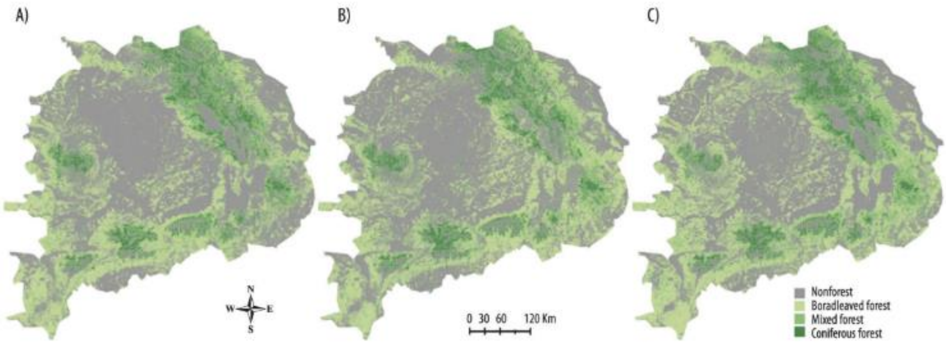
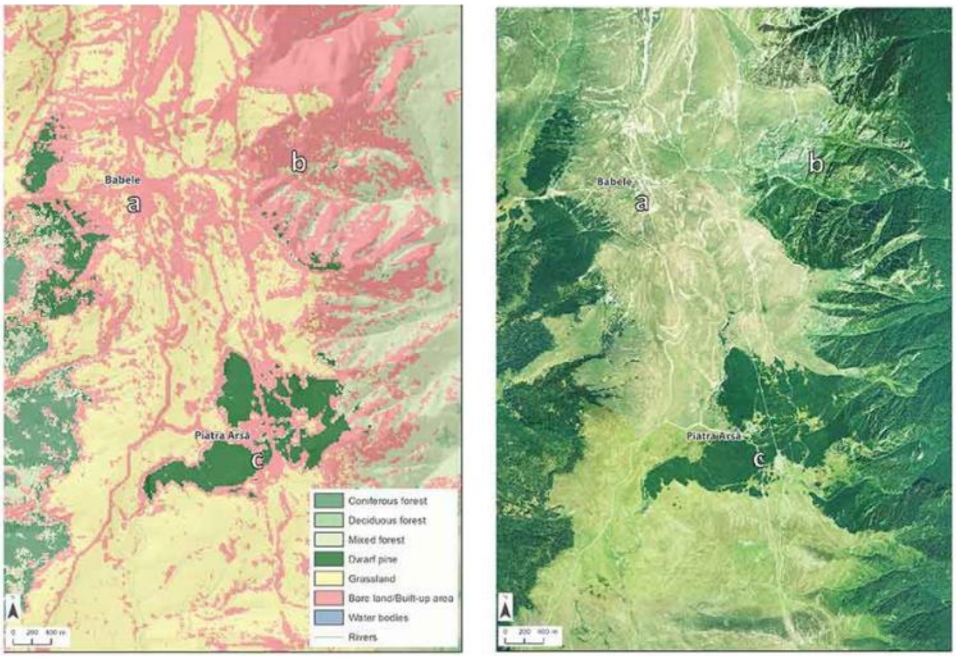


Figure 51 Carpatian study area classification with reference ortophoto (Rujoiu-Mare et al., 2017)



23.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Romania.

Table 91 Romania: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Forest/ tree cover	NFI	National	Complete	5y	FAO	yes		x		Yes - public
Forest biomass	NFI	National	Complete	5y		yes		x		Yes - public
Forest carbon	NFI	National	Complete	5y		yes		x		Yes - public
Tree age	NFI	National	Complete	5y		yes		x		Yes - public
Canopy height	NFI	National	Complete	5y		yes		x		Yes - public
Forest structural diversity	NFI	National	Complete	5y		yes		x		Yes - public
Forest soil properties	NFI	National	Complete	5y		yes		x		Yes - public
Forest/tree cover change	NFI	National	Complete	5y		yes		x		Yes - public
Tree age diversity	NFI	National	Complete	5y		yes		x		Yes - public
Tree species/composition	NFI	National	Complete	5y		yes		x		Yes - public
Tree species diversity	NFI	National	Complete	5y		yes		x		Yes - public
Forest type	NFI	National	Complete	5y		yes		x		Yes - public
Deadwood	NFI	National	Complete	5y		yes		x		Yes - public
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives										
Forest area covered by a management plan										
Volume of wood harvested	NIS	National	Complete	1y		yes		x		Yes - public
Ratio of annual fellings to annual increments										
Forest revenue	NIS	National	Complete	1y		yes		x		Yes - public
Roundwood prices	NIS	National	Complete	1y		yes		x		Yes - public
Forest products trade										
Employment in the forest sector										
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	NFI	National	Complete	5y		yes		x		Yes - public
Occurrence of forest fires										
Occurrence of storms										
Forest disturbance										
Number of forest fires										
Number of storms										
Alien species	NFI	National	Complete	5y		yes		x		Yes - public
Level of naturalness	NFI	National	Complete	5y		yes		x		Yes - public
Non-wood forest products	NIS	National	Complete	1y		yes		x		Yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Note*
Area of forest regeneration	NIS	National	Complete	1y		yes		x		Yes - public

23.2.4. SWOT analysis

Table 92 Romania: SWOT analysis

Strengths	**Weaknesses**
Romanian has a well-established NFI that is able to report robust statistics.	The NFI cycle in Romania is 5 years, however results of the second cycle (reference year 2018) are not yet available.
Opportunities	**Threats**
In anticipation of the next cycle of surveys, a new methodology based on the use of remotely sensed data can be implemented.	Limited research project for remote sensing applied to forestry. No official forest map produced from NFI data.

23.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 93 Romania: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Forestry Directorate - Romsilva	Current information about forests
	National Forest Inventory	Current data on forests
Biodiversity	National Forest Strategy	Conservation of biodiversity as part of Sustainable Forest Management
	National Strategy and Action Plan for Biodiversity Conservation 2014 - 2020	Forest protective function for biodiversity and as a habitat
Bioeconomy	National Forest Strategy	Increasing the competitiveness and sustainability of forest-based industries, bioenergy and the bioeconomy as a whole
Ecosystem services	National Forest Strategy	Adopt regulatory instruments on compensation for ecosystem services provided by forests; Assessment and monitoring of forest functions, ecosystem services and forest resources

Thematic area	Main Strategic reference	Summary of planning elements
	National Forestry Accounting Plan for Romania	Measure F: Evaluation and monitoring, forest functions, ecosystem services provided by forest and forest resources
Climate change	National Forest Strategy	Continued adaptation of forests to climate change
	The 2021-2030 Integrated National Energy and Climate Plan.	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF. Measures specifically related to forests to reduce GHG include: extending the forested area, harmonisation of the national system of indicators for SFM, conservation and improvement of biodiversity of forests, permanent adaptation of forests to climate change, increase the accessibility of the national forest fund, development of the integrated forestry information system.

23.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness. The challenges are largely unknown as the country report was not completed and the Member State did not revise the fiche.

Major challenge	Summary description
Climate change	No information
Ecosystem services	No information
Interest conflicts	No information
Private forest owners	No information
Biodiversity conservation	No information
Bioeconomy	No information
Forest fires	No information
Desertification	No information
Population-related challenges	No information
Financing	No information
Governance	No information

23.4. References

Griffiths, P., Kuemmerle, T., Kennedy, R. E., Abrudan, I. V., Knorn, J., & Hostert, P. (2012). Using annual time-series of Landsat images to assess the effects of forest restitution in post-socialist Romania. Remote Sensing of Environment, 118, 199-214. https://doi.org/10.1016/j.rse.2011.11.006

Rujoiu-Mare, M. R., Olariu, B., Mihai, B. A., Nistor, C., & Săvulescu, I. (2017). Land cover classification in Romanian Carpathians and Subcarpathians using multi-date Sentinel-2 remote sensing imagery. European Journal of Remote Sensing, 50(1), 496-508. https://doi.org/10.1080/22797254.2017.1365570

National Forestry Directorate - Romsilva: http://www.rosilva.ro/files/content/bucuresti/rap2021fin.pdf

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory: https://roifn.ro/site/

National Forest Strategy: http://www.mmediu.ro/app/webroot/uploads/files/2017-10-27_Strategia_forestiera_2017.pdf

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_ROU (foresteurope.org)

National Strategy and Action Plan for Biodiversity Conservation 2014 - 2020: http://www.mmediu.ro/img/attachment/32/biodiversitate-54784fdbc3ea5.pdf

Ministry of Research and Innovation`s workshop on the state-of-the-art of bioeconomy: https://www.scar-swg-sbgb.eu/lw_resource/datapool/_items/item_74/ws3_romania.pdf

Forest Land Ownership Change in Romania, COST Action FP1201 FACEMAP country report 2015, EFI: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_ROMANIA.pdf

The 2021-2030 Integrated National Energy and Climate Plan: https://ec.europa.eu/energy/sites/ener/files/documents/ro_final_necp_main_en.pdf

National Forestry Accounting Plan for Romania: http://www.mmediu.ro/app/webroot/uploads/files/National%20forestry%20accounting%20plan%20of%20Romania.pdf

CAP Strategic Plan: https://www.madr.ro/docs/dezvoltare-rurala/2022/PNS_2023-2027-versiunea_1.2-21.11.2022.pdf

The 2021-2030 Integrated National Energy and Climate Plan of Romania: https://energy.ec.europa.eu/system/files/2020-06/ro_final_necp_main_en_0.pdf

24. SLOVAKIA

24.1. Country overview – major forest facts

24.1.1. Key forest data

Slovakia is a mountainous country in central Europe, with 40% forest cover. All forests in Slovakia are under a management plan, which is compulsory and registered with an official body. 72% of Slovak forests are certified under a third party certification scheme, mostly through PEFC. Forest area has been roughly stable and is now at 40.1% of total land area. Growing stock has increased significantly over the thirty year period and now stands at 279 m3/ha over bark (211 m3 o.b./ha in 1990). Above ground biomass has followed a similar trend. 44.3% of forest and other wooded land is protected for conservation of biodiversity. This share has risen by ten percentage points over the thirty year period. 17.3% of forests are designated as protective forests. There are 10.6 thousand ha of forest undisturbed by man.

24.1.2. Institutional setup and legal framework

The Forest Act, enacted in 2005, was most recently amended in 2018. A national level NFP was approved in 2007, leading to a national action plan for 2014-2020. The information supplied is based on both a regular stand inventory and national forest inventory.

24.1.3. Key actors and stakeholder organisations

Ministry of Agriculture and Rural Development; National Forest Centre (state owned); Gemer Region Forest Owners Assiciation.

24.1.4. Forest ownership

According to the Compendum of Slovak Forestry Statistics (2013), the state holds property rights to 40% of the total forest area, but manages 53.9% of forest (forests leased from non-state owners and unclaimed forests. 44.8% of Slovak forests belong to non-state owners including forests under private, community, church, agricultural cooperatives and municipal ownership. The rest (15.2%) of the total forest area is under unidentified ownership. This category includes forests of owners who have applied for their property right, but their restitutions have not been completd yet.; forests of unknown owners or owners with unknown residence.

24.1.5. Forest industry

Removals have increased over the period and are now around 9.5 million m3 u.b. The ratio of fellings to net annual increment on forest available for wood supply in 2015 was 79%, but this included large amounts of fellings of natural losses (incidental fellings). Nearly 53 thousand people are employed in the forest sector in Slovakia, mostly in forestry and in wood processing.

24.1.6. Key forestry issues

Optimizing legislation and financing of Sustainable Forest Management, improving management

24.2. Forest monitoring

24.2.1. National Forest Inventory

The Slovakian National Forest Inventory represents one of the main information sources on national forests.

The first NFI was launched in 2004 (Šmelko et al., 2008) with the aim to create an objective, up to date and comprehensive forest monitoring framework with a 10-years interval. The decision to realize a NFI was made by the Ministry of Agriculture of the Slovak Republic, by adopting the point 5.B.a) as a part of the material No. 3473/2004-710 “Proposal for the realization of largescale inventory of the Slovak Republic (SR) in the years 2004–2005” on 23rd meeting of the directorate of the Ministry of Agriculture of SR held on July 1st, 2004. The Forest Research Institute in Zvolen was authorized to prepare the methodology and to realize the NFI in cooperation with other institutions of the present National Forest Center (Šmelko and Merganič, 2008)

The NFI in Slovakia was the first forest inventory based on statistical principles. It was established on a strictly defined grid over the national territory with strictly defined statistical principles and therefore it did not fit to any other monitoring systems being performed in Slovakia (e.g. monitoring plots within ICP Forests).
NFI data were collected between 2005 and 2006, and combined aerial-terrestrial sampling methods with a systematic distribution of sample units over a 4 x 4 km sampling grid covering the whole country. The terrestrial inventory was realized in concentric sampling plots with different radii, to assess the forest characteristics. If the sampling plots was not homogeneous in forest categories, it was divided into partial subplots located next to the each others (Bošeľa and Šebeň, 2016).

Figure 52Distribution of Slovakian NFI plots in the 4x4km grid (Šmelko and Merganič, 2008)

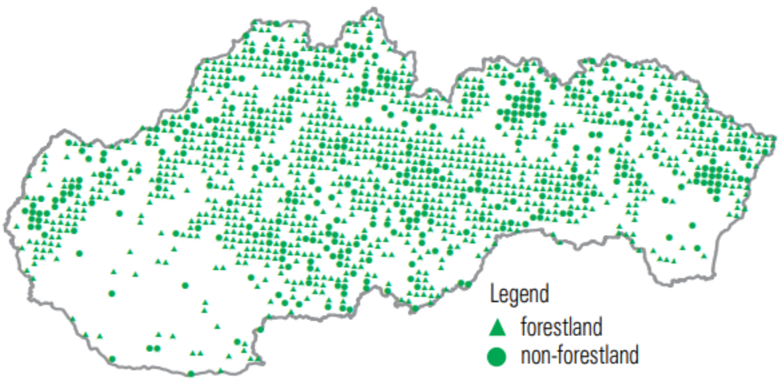
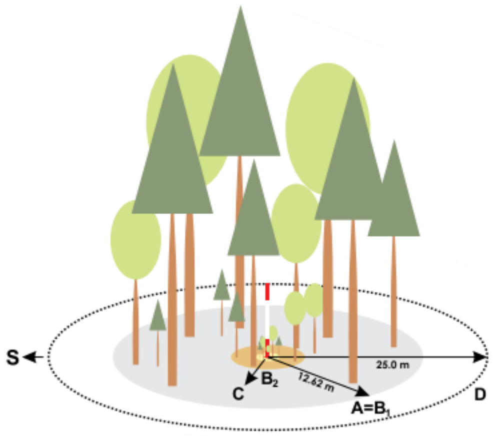


Figure 53 Ground Slovakian NFI plot detail. (Šmelko and Merganič, 2008)



A: circle plot (radius 12.62m) on which terrain site, stand and ecological characteristics are assessed. Lying deadwood and stumps are assessed. B1 and B2: concentric circles (radii 12.62 m and 3 m respectively) for larger trees characterizations. C: variable circle for thin trees sampling. D: larger circle (radius 25 m) to assess forest edges, forest roads and water sources

The aerial inventory was performed as a photointerpretation of orthophotos with the resolution of 1m. Here, the sampling units were circular sampling plots covering 2500 square meters each, distributed over a 2 x 2 km grid (12,667 plots in total). The aims of these plots were to be used in the identification of forest/non-forest areas, to support orientation during the fieldwork and to characterize the forested areas of Slovakia, along with the determination of forest categories.

The forest definition adopted by the Slovak NFI (tree species were growing on the plot, the area exceeded 0.3 ha and was a minimum of 20 m wide, the coverage – tree closure exceeded 20%, and the potential height of tree species was greater than 5 m (except for mountain pine *Pinus mugo*) differs from the one proposed by FAO (FAO, 2004).

24.2.2. Forest mapping

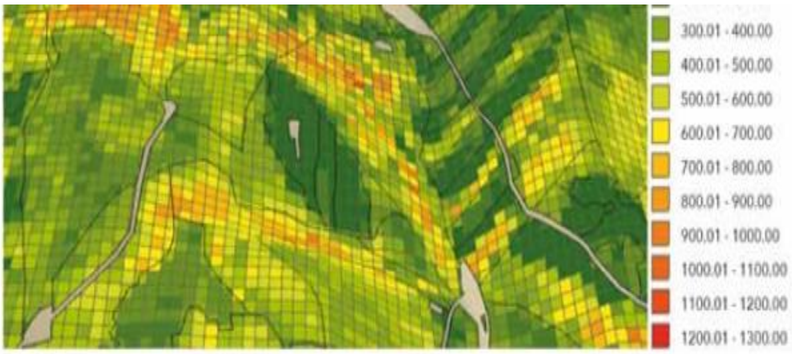
Currently, no information on national forest maps produced from NFI data is available.

On the other hand, several external studies on small areas, tested the use of ALS to assess the national forest volume, along with tree diameter and height.

A pilot study related to the integration of remote sensing data into forest inventory in Slovakia, was presented by Sačkov et al. (2017). The case study was carried out on the territory of the Pro Silva Demo Site Smolnícka Osada, where close-to-nature forest management has been historically applied. Here, aerial images and airborne laser scanning data were used to estimate forest stand characteristics, such as the number of trees, mean tree height, mean tree diameter, and growing stock.

More recently, Sačkov (2022) assessed the accuracy of Slovak NFI using the Canopy Height Model (20 m resolution) derived from ALS imagery. This study, focused on the 17,583 ha of forests located in the territory of Zvolen, central Slovakia.

Figure 54 Tridimensional visualization of CHM-predicted forest stand attributes (grid cell 20 x 20 m) (source: Sačkov, 2022)



On the other hand, the overall accuracy of the above-mentioned remote sensing-based forest inventory presented did not meet the requirements of forest management in Slovakia. Indeed, according to Slovak standards, 15% accuracy on 95% significance level is required for growing stock estimation in close-to-nature (selective) forests (Sačkov et al., 2017).

Consequently, continuous research and development of the implementation of remote sensing-based forest inventory is still a necessity.

24.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Slovakia.

Table 94 Slovakia: Overview of criteria and indicators. Information is reported only where available.

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregaated	Processed	*note*
Forest/ tree cover	NIFM	National	Complete			yes				
Forest biomass	NIFM	National	Complete			yes				
Forest carbon										
Tree age	NIFM	National	Complete			yes				
Canopy height	NIFM	National	Complete			yes				
Forest structural diversity	NIFM	National	Complete			yes				
Forest soil properties										
Forest/tree cover change	SOSR	National	Complete	1y				x		Yes - public
Tree age diversity	NIFM	National	Complete			yes				
Tree species/composition	NIFM	National	Complete			yes				
Tree species diversity	NIFM	National	Complete			yes				
Forest type	NIFM	National	Complete			yes				
Deadwood	NIFM	National	Complete			yes				
Presence of Red-list species	NIFM	National	Complete			yes				
Abundance of common forest birds										
Forest spatial patterns										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregaated	Processed	*note*
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection										
Silvicultural system										
Main management objectives	NIFM	National	Complete			yes				
Forest area covered by a management plan	NIFM	National	Complete			yes				
Volume of wood harvested	SOSR	National	Complete	1y				x		Yes - public
Ratio of annual fellings to annual increments										
Forest revenue	SOSR			1y				x		Yes - public
Roundwood prices	SOSR	National	Complete	1y				x		Yes - public
Forest products trade	SOSR			1y				x		Yes - public
Employment in the forest sector	SOSR			1y				x		Yes - public
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	NIFM	National	Complete			yes				
Occurrence of forest fires										
Occurrence of storms	NIFM	National	Complete			yes				
Forest disturbance	NIFM	National	Complete			yes				
Number of forest fires										
Number of storms										

24.2.4. SWOT analysis

Table 95 Slovakia: SWOT analysis

Strengths	Weaknesses
Well established NFI.	Current studies addressing the integration of remote sensing-based forest inventory did not meet the

	accuracy requirements of forest management in Slovakia.
Opportunities	**Threats**
Further implementation in the usage of Remote Sensing could improve NFI data and reports.	Discrepancies from FAO's forest definition.

24.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 96 Slovakia: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	National Forest Centre, Forest report 2020	Current information about forests
	National Forest Inventory	Current data on forests
Biodiversity	National Forest Centre, Forest report 2020	Promoting biodiversity and maintaining a favourable condition of rare forest ecosystems and habitats for protected flora and fauna; INTERREG V-A cross-border cooperation programme Slovenia- Poland
	National Forest Strategy	Biodiversity targets covered under priority 1 and priority 3
	Updated National Strategy for the Protection of Biodiversity to 2020	Reference to EU documents; forest biodiversity included in "thematic areas, targets and proposed measures"
Bioeconomy	CELEBio bioeconomy dossie	Biomass supply from forestry
Ecosystem services	National Forest Centre, Forest report 2020	Supporting the soil and water conservation functions of forests; INTERREG V-A cross-border cooperation programme Slovenia- Czech Republic
	National Forest Strategy	Ecosystem services covered under priority 1 and priority 7
Climate change	National Forest Strategy	Climate change mitigation and adaptation are covered under priority 1 and priority 4
	Integrated National Energy and Climate Plan for 2021 to 2030	Several references to forestry, esp. in relation to carbon storage

24.4. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 97 Slovakia: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	To elaborate the models of target forest structures and forest stands adaptation on climate change for the basic forest types. To implement into the forest management models the forestry measures related to the improvement of the carbon sequestration by the formulation of the most appropriate tree species composition, spatial structure of the forest stands, rotations, silvicultural systems as well as by conversion of low-productive and ecologically unstable forests.
Ecosystem services	To continue in research and development of a system of identification, quantification and payments for the use of the most important ecological and social functions of forests - ecosystem services; to permanently analyze the principles, methods and procedures of their assessment and valuation.
Interest conflicts	To radically improve acceptance of forestry and forest harvesting operations among general public, and effectively communicate wood and wood based products from sustainably managed forests as sustainable alternatives to „traditional“ raw materials and products. To improve cross-sectoral coordination with environmental sector, tackle conflicting policy objectives with this policy domain and implement effective conflict management at all levels in this respect. To ensure the promotion and awareness raising of the public about the importance of sustainable forest management and the practical benefits (environmental, social and economic) of using wood compared to other materials.
Private forest owners	To improve the awareness of forest owners and managers about the opportunities to engage them in business and marketing of the new products and services. Ensure sufficient funding/income.
Biodiversity conservation	To develop and implement a proposal for a legally binding solution to the calamity situations in protected areas, including its approval by both sectors (forestry and environment). To elaborate the concept of economically efficient close to nature forest management in the conditions of Slovakia. To intensify cooperation with the State Nature Conservancy of the Slovak Republic to achieve nature conservation goals through active management of protected areas and forests. To ensure regular monitoring of harmful agents including introduced; make better use of the Forest Protection Service expertise and share data through the electronic forest protection information system. To ensure the continuation of the monitoring of the state of health of forests I. and II. levels through annual monitoring and evaluation. Further improve research & management.
Bioeconomy	To identify the constraints and barriers until now hindering the economic realization of non-wood forestry products and services; to create favourable conditions and opportunities for establishing markets with non-wood forest products and services. To develop a quantification of available wood biomass resources in forest, non-forest lands and waste wood production suitable for energy production and alternative use - a project was launched by the R&D support agency. At the same time to develop a system of forest tree biomass removal limits focused on maintaining the balance of soil nutrient balance - the project was launched since 2016 within the sectoral research. To analyse of wood biomass flows used for energy purposes;
Forest fires	To create a joint inter sectoral working group on forest fire prevention and fire fighting.

Major challenge	Summary description
Desertification	No information
Population-related challenges	No information
Financing	To ensure every year the sufficient financial resources for competent forestry entities to adequately fulfil the tasks resulting from forest related policies and legislation in the context of sustainable forest management
Governance	To develop the new "National Forest Programme of the SR" for period post 2020 in accordance with the relevant forest related processes and policies; Improving the legal framework for sustainable forest management (some current mismatches act negatively on ensuring the basic principles and indicators of SFM). To develop a proposal to optimize the supply of fuel biomass in terms of the distribution of biomass producers and producers of energy in Slovakia.

24.5. References

Bošeľa M, Šebeň V in: Kučera M in: Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi.org/10.1007/978-3-319-44015-6

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

Sačkov I, M Sedliak, L Kulla & T Bucha, 2017. Integration of remote sensing data into forest inventory in close-to-nature forests: An initial case study in Smolnícka Osada, Slovakia. EARSeL eProceedings, 16(1): 1-8

Sačkov, Ivan. "Forest inventory based on canopy height model derived from airborne laser scanning data" Central European Forestry Journal, vol.68, no.4, 2022, pp.224-231. https://doi.org/10.2478/forj-2022-0013

Šmelko, Š., Merganič, J., 2008: Some methodical aspects of National forest inventory in Slovania. Journal of forest science (v tlači)

National Forest Centre, Forest report: https://www.lesy.sk/files/lesy/o-nas/vyrocne-spravy/zoznam/vyrocna-sprava-lsr-2020.pdf

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory: http://www.forestportal.sk/lesne-hospodarstvo/ekologia-a-monitoring-lesa/narodna-inventarizacia-a-monitoring/Stranky/default.aspx

National Forest Strategy: https://www.enviroportal.sk/lesnictvo/strategia-rozvoja-lesnictva-2008

Forest Europe Report 2020: QL_questions-responses_SVK_4-3-2019.pdf (foresteurope.org)

Updated National Strategy for the Protection of Biodiversity to 2020: https://www.cbd.int/doc/world/sk/sk-nbsap-v3-en.pdf

Integrated National Energy and Climate Plan for 2021 to 2030: https://energy.ec.europa.eu/system/files/2020-03/sk_final_necp_main_en_0.pdf

Forest Land Ownership Change in Slovakia, COST Action FP1201 FACEMAP country report 2015, EFI: https://www.researchgate.net/profile/Jaroslav-Salka/publication/275039621_Forest_Land_Ownership_Change_in_Slovakia/links/5530e3970cf27acb0de89243/Forest-Land-Ownership-Change-in-Slovakia.pdf?origin=publication_detail

CELEBio bioeconomy dossier: https://www.cei.int/sites/default/files/2022-04/CELEBIO_Bioeconomy%20Dossier_Slovakia.pdf

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-11/csp-at-a-glance-slovakia_en.pdf

25. SLOVENIA

25.1. Country overview – major forest facts

25.1.1. Key forest data

Slovenia is among the most forested countries in Europe. About 1.2 million ha of forests, i.e. 0.6 ha per citizen, cover 58.2% of Slovenia's surface. The growing stock of Slovenian forests amounts to 338 million cubic meters. Of this, 46.5% is coniferous and 53.5% deciduous growing stock. All Slovenian forests are under a management plan, which is compulsory and registered with an official body. 23% of forests are certified under third party certification schemes (PEFC and FSC, with double certification on state forests). 22% of forest and other wooded land is protected for the conservation of biodiversity, while 24% of forest is designated for its protective functions. 33.6 thousand ha of forest are considered undisturbed by man.

25.1.2. Institutional setup and legal framework

The forests are managed in line with the Forest Act, the objectives and guidelines of the Resolution on the National Forest Programme and plans for forest management. These acts provide the conditions for multifunctional forest management in accordance with the environmental protection and natural values, monitoring of the forest as an ecosystem and directing its development and thereby also providing all functions of the forest determined by the Constitution. According to the Forest Act, the ownership of the forests exercised to ensure their ecological, social and productive function. Forest owner must therefore manage their forests in accordance with the forest management and silviculture plans. Forest owners have the right to participate in the process of adoption of forest management plans and in the preparation of silvicultural plans. Their needs, proposals and requirements are taken into account as far as is possible with the ecosystem and legal constraints.

Data supplied for this study, and used as a basis for policy making, derive from a process of forest management planning and national forest inventory process and a number of other sources.

25.1.3. Key actors and stakeholder organisations

Ministry of Agriculture, Forestry and Food; Slovenian Forest Service; Slovenian Forestry Institute; Slovenian State Forests company (responsible for managing forests owned by the state); Ministry of environment and spatial planning; Chamber of Agriculture and Forestry of Slovenia; Associations of Forest Owners; Biotechnical Faculty, Department of Forestry and Renewable Forest Resources.

25.1.4. Forest ownership

79% of forests are privately owned and 21% are owned by the state or municipalities. Large, uninterrupted state-owned forest holdings allow for effective sustainable management, while private forest holdings are very fragmented. The average size of private forest holdings is approximately 2.9 ha and in general each holding is further divided into several separate plots. The fragmentation and large number of owners (431,000) and co-owners hinder professional work and optimum wood utilisation in private forests.

25.1.5. Forest industry

Removals were around 2 million m3 u.b. in the 1990s but have risen to over 5 million m3 around 2015. Until 2010, fellings were around 35% of net annual increment on forest available for wood supply but this ratio rose to over 60% in 2015. However, since 2010 about a third of fellings have been of natural losses (already deducted from gross annual increment to calculate net annual increment). Over 15 thousand people are employed in the forest sector of Slovenia, of which about half in the wood processing industries. Employment in both wood processing and paper industries has been falling, while employment in forestry itself has remained stable at just over 2 thousand people.

25.1.6. Key forestry issues

Ownership structure (large number of owners - 431,000 and co-owners) hinders intensification of forest management. Some owners are not interested in income from forests because of small properties, which results in low cutting rates.

The level of technology applied in harvesting in private sector is relatively low. Marketing of timber of small quantities is not optimal.

Difficult regeneration of forests due to an overabundance of wild animals (deer, roe deer) in the forests.

Increased frequency and intensity of natural disasters:

- Droughts and ice break following by bark beetle gradations;
- Blowdown of trees;
- Forest fires.

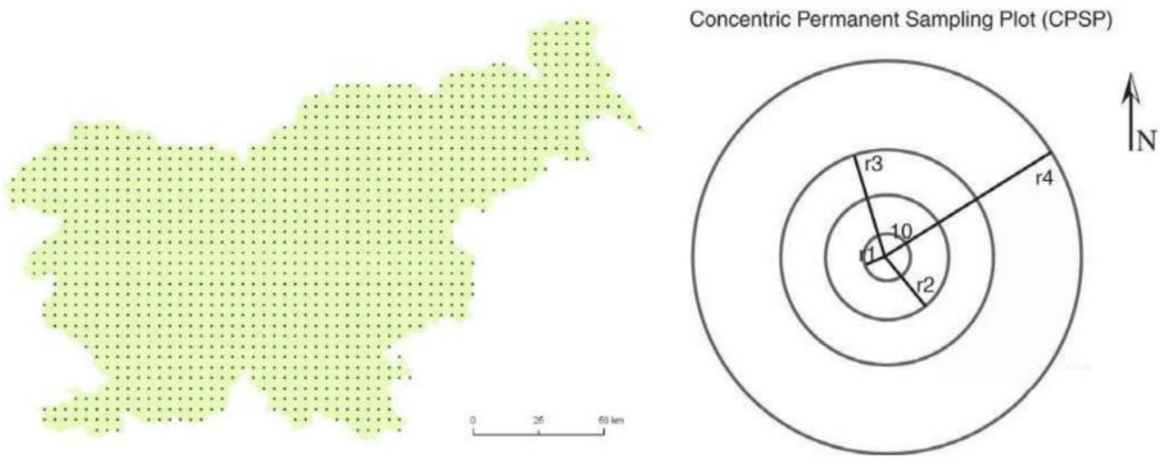
25.2. Forest monitoring

25.2.1. National Forest Inventory (FECS)

Large-scale statistically based forest monitoring has been initiated in Slovenia since 1985. However, robust data comparable with other European inventories are available since 2000 (Tomppo et al., 2010), after many improvements.

In Slovenia the term National Forest Inventory is not mentioned in legislation. However, rules on forest protection (nr. 92/2000) dictate that the inventorying is to be caried out periodically (5-10 years) on the 4 x 4 km grid in the framework of Forest and Forest Ecosystem Condition Survey (FECS). FECS was carried out for the first time in 2000 and has been repeated three times so far (2007, 2012, 2018), providing extensive and in-depth survey of all Slovenian forests, including information about composition, condition, distribution and size of our forests. It is of great importance for monitoring changes of forests through time, for developing suitable policy measures and for further support of sustainable management of forests (Skudnik et al., 2021). The selection of inventory plots is based on the use of LiDAR and aerial images. With the aim of these information strata, plots that are not located in the forest are eliminated. They also represent a valuable source of information for the assessment of forests located in inaccessible plots. A special data acquisition application was developed for the purpose of field inventory.

Figure 55 Left: systematic grid spacing 4x4km; right: concentric (four circles) permanent sampling plot



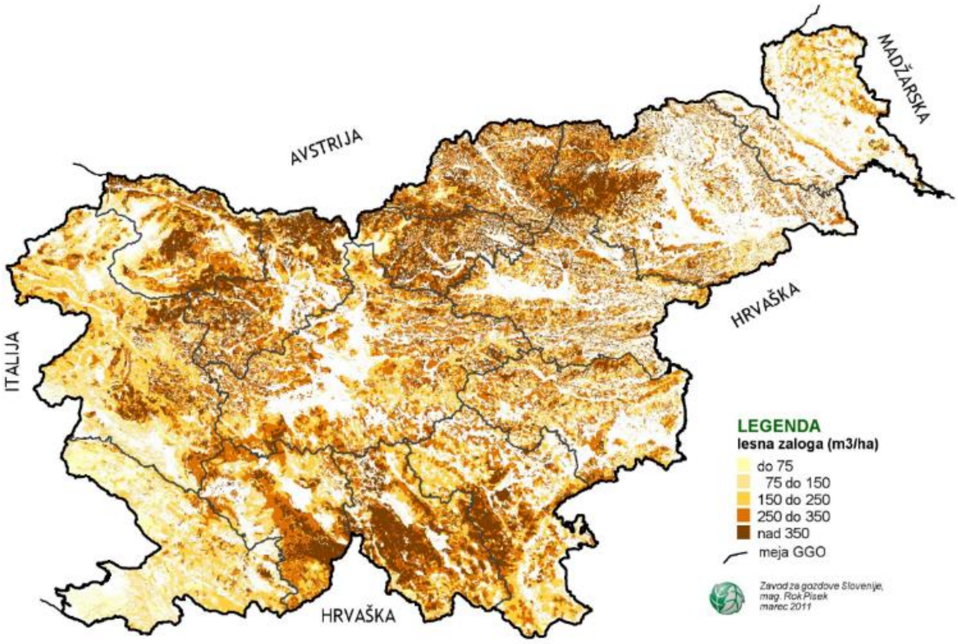
25.2.2. Forest mapping

So far, Slovenia has not produced any NFI based maps, nor maps based on NFI and remote sensing.

The Forest Service of Slovenia produces maps, which derived from stand-wise inventory, manual interpretation of digital orthophotos and field observations.

Among these are provided maps of wood stock, increment and forest types (http://www.zgs.si/eng/slovenian_forests/forests_in_slovenia/maps/index.html). However, these maps are not integrated with Slovenian NFI.

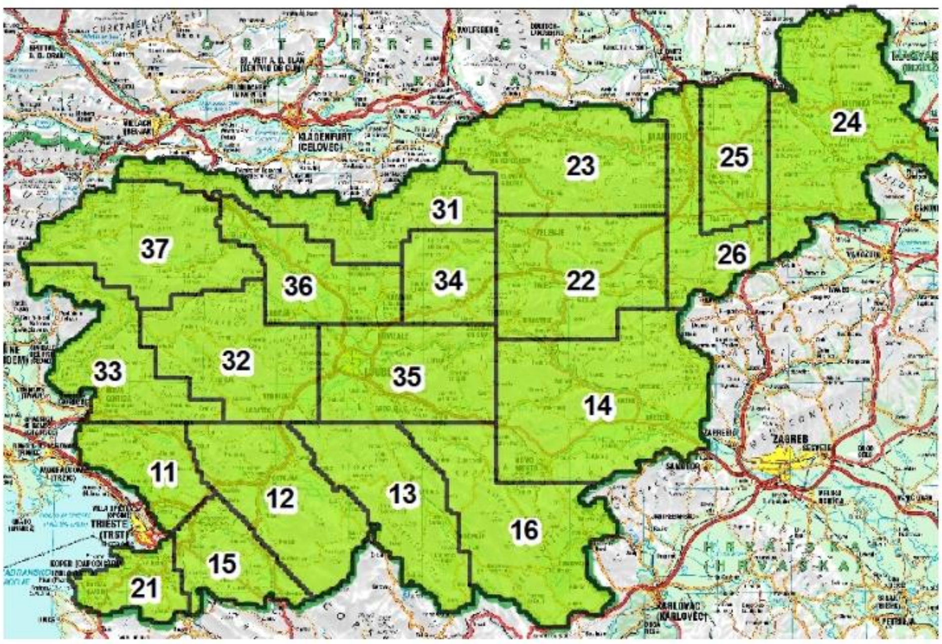
Figure 56 Slovenian wood stock map



25.2.3. LiDAR coverage

The Ministry of Environment and Territorial Planning makes LIDAR data available online for all interested users. Users can obtain a georeferenced point cloud for any area of Slovenia.

Figure 57 Lidar data acquisition blocks (http://www.evode.gov.si/index.php?id=69).



25.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Slovenia.

Table 98 Slovenia: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	SORS	National	Complete			yes				
Forest biomass	NFI	National	Complete			yes				
Forest carbon	NFI									
Tree age	NFI	National	Complete			yes				
Canopy height	NFI	National	Complete			yes				
Forest structural diversity	NFI	National	Complete			yes				
Forest soil properties	NFI	National	Complete			yes				
Forest/tree cover change	SORS									
Tree age diversity	NFI	National	Complete			yes				
Tree species/composition	NFI	National	Complete			yes				
Tree species diversity	NFI	National	Complete			yes				
Forest type	NFI	National	Complete			yes				
Deadwood	NFI	National	Complete			yes				
Presence of Red-list species										
Abundance of common forest birds										
Forest spatial patterns	NFI	National	Complete			yes				
Areas of primary and old-growth forests										
Forest ancientness	NFI	National	Complete			yes				
Forest area under protection	SORS	National	Complete					x		Yes - Public
Silvicultural system	NFI	National	Complete			yes				
Main management objectives	SFS	National								
Forest area covered by a management plan	SFS									
Volume of wood harvested	SFS	Provincial	Complete				x	x		
Ratio of annual fellings to annual increments										

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest revenue	SORS	National	Complete					x		Yes - Public
Roundwood prices	SORS	National	Complete					x		Yes - Public
Forest products trade	SORS	National	Complete					x		Yes - Public
Employment in the forest sector	SORS	National	Complete					x		Yes - Public
Forest area with 3rd party certification										
Forest visitor statistics										
Forest foliage/phenology/ anomalies	NFI	National	Complete			yes				
Tree health	ICPF L1	National	Complete			yes				
Forest growth	NFI									
Occurrence of forest fires	SFS	National	Complete					x		Yes - Public
Occurrence of storms										
Forest disturbance	NFI	National	Complete			yes				
Number of forest fires	SFS	National	Complete					x		Yes - Public
Number of storms										
Occurrence of lichens	NFI	National	Complete			yes				
Recreation functions	NFI	National	Complete			yes				
Non-wood products	NFI	National	Complete			yes				
Export and import of round wood	SORS	National	Complete					x		Yes - Public
*Consumption of fuels in forestry activities **	SORS	National	Complete					x		Yes - Public
Number of forestry machinery and equipment	SORS	National	Complete					x		Yes - Public
Production of forestry activities	SORS	National	Complete					x		Yes - Public

25.2.5. SWOT analysis

Table 99 Slovenia: SWOT analysis

Strengths	Weaknesses
Slovenia has a well-established forest inventory that can provide robust statistics for a large number of forest variables.	No wall-to-wall estimates (maps) are produced as part of the forest inventory
Opportunities	**Threats**
In anticipation of the next cycle of surveys, a new methodology based on the use of remotely sensed data can be implemented. The availability of wall-to-wall lidar data and the integration of multispectral data could ensure the development of accurate detail mapping.	Limited research project for remote sensing applied to forestry.

25.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 100 Slovenia: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Ministry of Agriculture, Forestry and Food, information website	Current forest-related information
	Forest management plans prepared by Slovenian Forest Service	Annual report on the state of Slovenian forests - based on data from forest management planning. Forest management plans, elaborated for a period of ten years, describe the state of forests and their development trends, set the goals of management in the future (also by taking into account the analysis of management in the past) together with guidelines and measures for the rational implementation of these goals.
	National Forest Inventory (carried out by the Slovenian Forestry Institute)	Current data on forests
Biodiversity	National Forest Programme	The National Forest Programme is also an implementation of the Environmental Action Programme at national level, which identifies four priorities: climate change, nature and biodiversity, environment and health and quality of life, natural resources and waste
	Forest management plans (for forest management regions and forest management units)	Forest management plans, which are also management plans for Natura 2000 sites in forests and contain integrated nature conservation measures,

Thematic area	Main Strategic reference	Summary of planning elements
		prepared by the Institute of the Republic of Slovenia for Nature Conservation.
	Operational program for the implementation of the National Forest Program 2017-2021 Operational program for the implementation of the National Forest Program 2022-2026	One of the five priorities: Conserve and enhance forest biodiversity at landscape, ecosystem, species, and genetic levels, and monitor its resilience and stability, as well as its vitality and health;
Bioeconomy	National Forest Programme	Promote the use of lower quality wood, wood residues, waste wood and waste wood products for energy and biofuels, including second-generation biofuels, in compliance with environmental standards.
	Action Plan for Increasing the Competitiveness of the Forest-Wood Chain in Slovenia	Goal is to increase the competitiveness of the entire forest-wood value chain, to increase the efficiency of forest management, and to revitalise and develop the processing of wood and the use of its residues. We strive to maximise added value in every link of the forest-wood processing chain, including the pulp, paper and chemical industries, as well as the use of wood biomass for energy purposes and new technologies.
	Overview of state of play on bioeconomy in Slovenia	Overview of strategic documents and target sectors
Ecosystem services	National Forest Programme	Sustainable development of forests as ecosystems in terms of their biodiversity and all their ecological, productive and social functions through sustainable and multifunctional management as a vision and one of the main objectives of the Programme.
	Forest management plans (for forest management regions and forest management units)	Determining and evaluating the importance of the ecological, social and productive functions of forests.
Climate change	National Forest Programme	The National Forest Programme is also an implementation of the Environmental Action Programme at national level, which identifies four priorities: climate change, nature and biodiversity, environment and health and quality of life, natural resources and waste
	Operational program for the implementation of the National Forest Program 2017-2021 Operational program for the implementation of the National Forest Program 2022-2026	One of the five priorities: Provide CO2 sinks in forests and adapt forests to climate change, especially with the aim of maintaining their resilience and stability as well as their vitality and health;
	Resolution on Slovenia`s Long-term Climate Strategy until 2050	Forestry sector - individual forestry contents were included in RSLCS

Thematic area	Main Strategic reference	Summary of planning elements
	Integrated national energy and climate plan of the Republic of Slovenia	Multiple mentions of forestry, particularly in the context of decarbonization and in relation to LULUCF

25.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 101 Slovenia: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Harmonization of forest functions in the time of major disturbances: Climate change increased number, period and intensity of disturbances (drought, wind throw, sleet, forest fires).
Ecosystem services	Forest services are gaining in importance and play a significant role in creating proper public attitudes to the forest, forestry, and the environment. This area remains under-researched. There was no inventory in place, the evaluation is not conducted and appropriate compensation to forest owners is not available. This is in addition to increasing pressure on the forest one of the reasons for the conflict between the interests of forest owners and the interests of the public. Since the valuation of non-wood forest goods and services is not assessed properly, the sustainability of management in this area cannot be assessed. Inadequate evaluation of some ecosystem services of forests has a negative impact on public awareness of the actual importance of forests and forestry and related rights and obligations of owners and non-owners of forests as well as restrictions and investments of public funds.
Interest conflicts	Private forests and public access: More than 75 % of forests are privately owned, however all forests, with exception of regulated entrance to virgin forests, are freely accessible to public. Major use of forest is of social function purposes, especially recreation and non-wood production. To promote forest multifunction schemes, manners and regulations on amount of benefited non-wood forest products were published. Despite organized control, inspection and forest service supervision, regulation violation and conflicts between private and public interest appear, especially in forests close to urban areas, recreational centres and in the specific areas in mushroom picking period.
Private forest owners	Safety in forest management activities: Combination of irregular, seasonal or occasional work, lack of experience and outdated equipment of private forest owners, especially of smaller size properties, results in low work and profit/cost efficiency, as well as in the number of accidents, connected to harvesting operations. In privately owned forests have been, in the time period 1980-2000, 13 deadly accidents annually. Despite many actions taken, from educating forest owners to stipulating buying newer, safer equipment, there are still possibilities to improve the situation; Forest co-ownerships; High number of forest co-ownerships, forest properties on several locations and their small sizes, hinder communication and work of forest service, as well as work efficiency of forest owners themselves (i.e. building new forest roads, joint harvest and sell of

Major challenge	Summary description
	harvested wood). Legal actions were taken to improve situation (right of pre-emption, limiting of forest property sizes to being not smaller than 5 ha); Logging cots; High costs of logging, especially in case of small forest owners, not properly equipped or with outdated equipment, reduce interests for forest management. This is most obvious in the group of forest owners, economically independent from forestry related income and with house heating system, not based on firewood.
Biodiversity conservation	Threat of new invasive species: Appearance or introduction of new invasive species is, especially in the light of increasing air temperatures and global trading market of wood and non-wood products, a constant threat for Slovenian forests, rich in forest types and biodiversity; Catastrophic events and climate change; Habitats of specific forest species are under the process of quick and powerful events like forest fires and wind throw, as well as slow change of environment, mostly climate, with air temperature increase and change in precipitation regime (amount, intensity). Recognition and identification of future threats is a step forward in preserving forest biodiversity today.
Bioeconomy	Forestry – Economic effects of forest management are increasing. The realization of allowable cut is increasing, but in private forests is still well below planned. Forest operations are modernised, and the forest road density has been improved thanks to the measures of the Rural Development Programme. The scope and content of professional, systematic, and more active encouragement of forest owners for management and business integration have not achieved the desired results as such cooperation is very rare. Tourism and other non-wood forest-based products and services should be one of the most important complementary activities in farms. There are still many untapped opportunities in this area. Wood processing industry - after the improvement of the business environment (also for the improvement of the competitiveness of wood and wood composite products), the most necessary investments are the investments in the most state-of-the-art primary wood processing practices, mainly wood that is currently not being used in Slovenia on an industrial scale, and investments in the processing of wood for furniture and other end products. In parallel, industrial stakeholders are accentuating the need to provide suitable quantities of raw materials that will be processed by workers and business managers into innovative products with the highest possible added value using better education, experiences, and skills. The connectivity and the constructive dialogue between the industry and the R&D, educational and creative sector, policymakers and other stakeholders in the national and international environment have been recognised by stakeholders as an urgent condition in order to improve the knowledge of market conditions and identify suitable market approaches (whereby the accent is on products for the creation of living environments and interior working environments) which will made it possible to create said added value.
Forest fires	Forest fires occur regularly, and it is very likely that the damage they cause will continue to increase due to climate change. Problems with forest fires occur mainly in the southwestern part of Slovenia where the karst landscape and abandoned rural areas prevail.
Desertification	No information
Population-related challenges	Forests in Slovenia are open to the public. This advantage is often abused. Inappropriate activities and actions often take place in the forests, leading to conflicts with forest owners. The most common negative incidents are:

Major challenge	Summary description
	the disposal of waste in the forest - unauthorised interventions in the forest area (quarries, sand pits, removal of soil, construction of various objects) - recreational activities, which are not adapted to the forest and its functions, - excessive collection of forest fruits and other forest products, as well as inappropriate activities in forest rest areas. People are becoming increasingly aware of the importance of forests. Interaction between people and forests, which used to be intense through the acquisition of wood and other material goods from forests, has increased, this time mainly because of the ecological role of forests and the popularity of forests as a place for recreation and relaxation, but also because of the importance of forests as a source of wood, a building material popular with everyone. Forests contribute significantly to the general well-being of people.
Financing	Forest policy generally follows the objectives and guidelines of the National Forest Programme and Forest management plans, but its financing is rather problematic. The main challenge is to ensure stable funding over time, which coincides with the need for long-term planning in forests and forestry.
Governance	The institutional framework in the field of forest management has practically not changed in the period up to 2016 (establishment of the Slovenian State Forests Enterprise). The specific performance indicators of the framework and individual institutions have not been changed. In this way, the existing organizations have generally not taken on new tasks and work. The Public Forest Service remains the cornerstone of the system of sustainable forest management in Slovenia within the current legal framework and the required activities and tasks. Due to the changing environment (social, economic and climatic) the tasks or priorities should be revised.

25.4. References

Skudnik, M., Grah, A., Guček, M., Hladnik, D., Jevšenak, J., Kovač, M., ... & Simončič, P. (2021). Stanje in spremembe slovenskih gozdov med letoma 2000 in 2018: rezultati velikoprostorskega monitoringa gozdov in gozdnih ekosistemov. Gozdarski inštitut Slovenije.

Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds) (2010) National forest inventories - pathways for common reporting. Springer, Heidelberg

Vidal, C., Alberdi, I., Hernández, L., & Redmond, J. J. (2016). National forest inventories. Assessment of wood availability and use. https://doi. org/10.1007/978-3-319-44015-6

Ministry of Agriculture, Forestry and Food, information website: https://www.gov.si/en/policies/agriculture-forestry-and-food/forestry/

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Programme: http://www.pisrs.si/Pis.web/pregledPredpisa?id=RESO56

National Forest Inventory (carried out by the Slovenian Forestry Institute): https://www.gozdis.si/

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_SVN (foresteurope.org)

Environmental Action Programme: https://www.gov.si/assets/ministrstva/MOP/Publikacije/okolje_en.pdf

Overview of state of play on bioeconomy in Slovenia: https://www.scar-swg-sbgb.eu/lw_resource/datapool/_items/item_76/ws3_slovenia.pdf

Resolution on Slovenia`s Long-term Climate Strategy until 2050: https://unfccc.int/sites/default/files/resource/LTS1_SLOVENIA_EN.pdf

Annual national reports on the state of the forest: http://www.zgs.si/zavod/publikacije/letna_porocila/index.html

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-10/csp-at-a-glance-slovenia_en.pdf

Integrated national energy and climate plan of the Republic of Slovenia: https://energy.ec.europa.eu/system/files/2020-06/si_final_necp_main_en_0.pdf

26. SPAIN

26.1. Country overview – major forest facts

26.1.1. Key forest data

Spain is a country in the Iberian Peninsula, where forest and other wooded land together account for more than half the land area. Spain`s forest area has been expanding steadily and now stands at 37,2% of total land area. In addition, nearly 19% of land area is covered by other wooded land. Growing stock has also been increasing and now stands at 60 m3 o.b./ha on average. Above ground biomass has also been expanding at a rate of 0,5%/year between 2010 and 2020 (SoEF 2020). 32% of Spanish forests are under a management plan or equivalent document. These are compulsory for certain forests, notably protected and protective forests, and are registered with an official body. 13% of forests are under a third party certification scheme, mostly PEFC. In 2015, 23% of forest and other wooded land were protected for conservation of biodiversity. 23,8% of forest and other wooded land were designated as protective forest. No forest is considered undisturbed by man.

26.1.2. Institutional setup and legal framework

Many of the policy responsibilities for forestry are at the subnational level. The Forestry law of 2003 modified in 2006 and 2015. A NFP process has resulted in a Spanish Forestry Plan 2002-2032. National Forest Inventory, combined with cartographic and other statistical information provides the necessary basis for policy making and for international reporting.

26.1.3. Key actors and stakeholder organisations

Ministry for Ecological Transition and the Demographic Challenge; Forest regional authorities; Confederation of Private Forest Owners of Spain (COSE); *Asociación Nacional de Empresas Forestrales* (ASEMFO); ASPAPEL (Spanish Association of Pulp and Paper Manufacturers); UNEMADERA (Business Union of Wood and Furniture of Spain); ANFTA (National Association of Wood Panels Manufacturers); AEIM (Spanish Association of Trade and Timber Industry); AVEBIOM (Spanish Association for Biomass Energy Appreciation); Forest certification bodies (FSC, PEFC); SECF (Spanish society of forestry sciences); National and Regional forestry research centres (INIA, CTFC, CIF Lourizán, NEIKER, IFAPA, etc.).

26.1.4. Forest ownership

66% of forest area is in private ownership, 6% is under unknown ownership, while the rest is publicly owned. Family ownership is the most common type of private ownership. Local authorities, esp. town councils, own most public forest area.

26.1.5. Forest industry

Removals fluctuate in the range between 14 and 17,5 Mio m3 u.b. Fellings on forest available for wood supply were 55.5% of net annual increment. Over 130 thousand people are employed in the forest sector, of which 26 thousand in forestry itself. Employment in the wood processing industries grew strongly between 1990 and 2005, but then dropped to about half the peak level.

26.1.6. Key forestry issues

Improving measures to prevent forest fires.

Forest abandonment and depopulation of rural areas is a challenge.

Promotion of the use of timber and non-wood forest products among the population.

Contributing to a rise in the added value of forest products.

26.2. Forest monitoring

26.2.1. National Forest Inventory

The first National Forest Inventory, based on aerial photointerpretation, was carried out between 1965 and 1974 in Spain. Initially, a 10-year cycle was prevised but NFI2 started only in 1986.

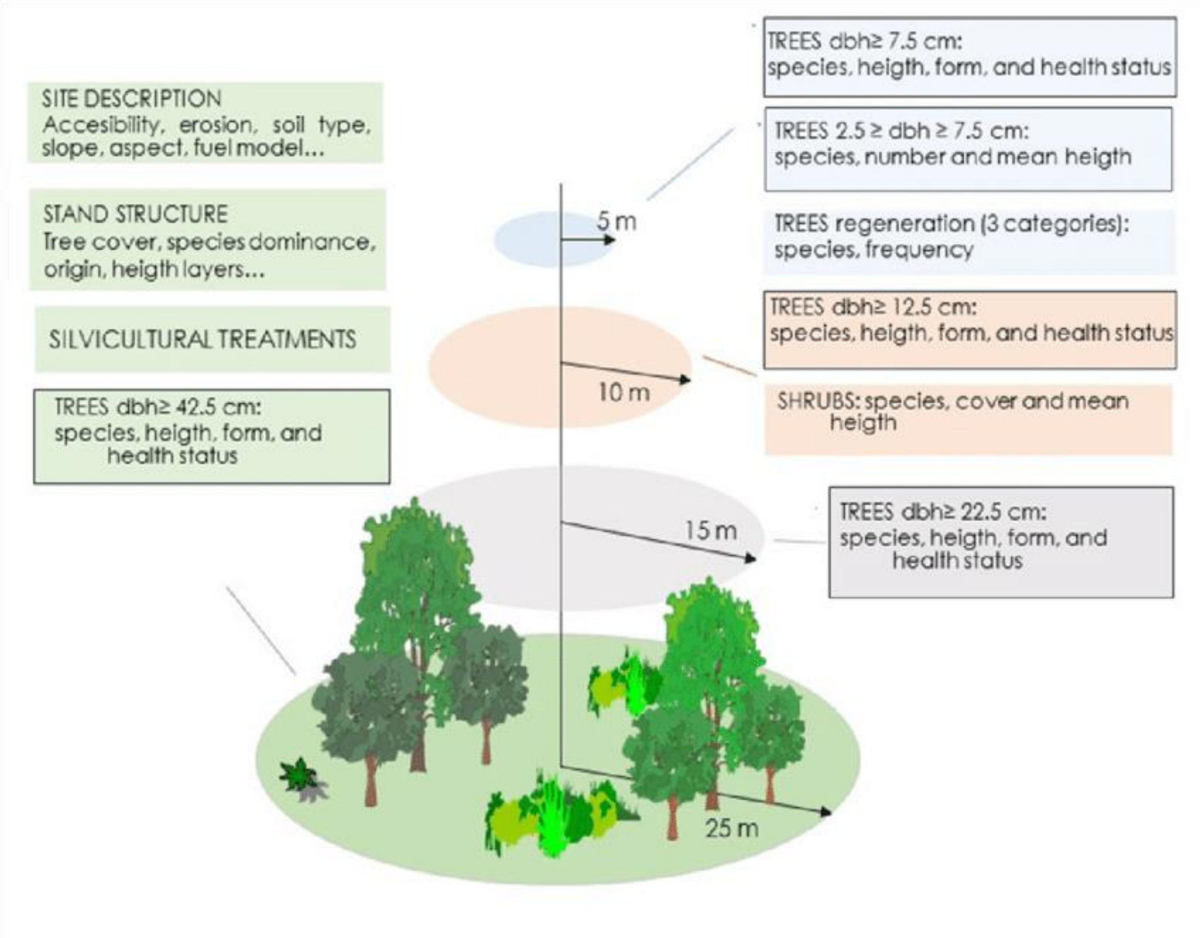
Since the second Spanish NFI, a continuous inventory with permanent plots was established. The third NFI (started in 1997 and concluded in 2007) included further forest measurements than NFI2. Hence, being based on recent global concerns in relation to forests, new forest indicators were required by different reporting obligations (e.g., LULUCF, Forest Europe, FRA). Moreover, with the COST Action E43 in 2010, the need to harmonize forest indicators and definitions worldwide led to the implementation of new field assessments into the NFI3 methodology (Alberdi et al., 2016). In 2008, NFI4 began, while the next NFI cycle will start in 2024.

In Spain, land cover classification and forest area estimation are described prior to the NFI using the National Forest Map (Vallejo & Sandoval, 2013). The Spanish NFI covers all forest land in Spain. From NFI2 the permanent plots enabled the comparison of growing stock volume and other forest stand characteristics.

Sample plots are established at the intersections of a 1x1 km UTM grid (Alberdi et al., 2010). Different field plots of variable radius, depending on the dbh of the trees, were sampled: a radius of 25 m for trees with dbh ≥ 42.5 cm, a radius of 15 m for trees with dbh ≥ 22.5 cm, a radius of 10 m for trees with dbh ≥ 12.5 cm and a radius of 5 m for trees with a dbh ≥ 7.5 cm. Trees with 2.5 ≤ dbh ≤ 7.5 cm were counted but not measured (Alberdi et al., 2016).

Among the others, Spanish NFI also collect information on economically valuable non-wood forest products, such as cork (Alberdi et al., 2017b).

Figure 58 Spanish NFI sampling plot details (Alberdi and Cañellas, 2017a)



26.2.2. Spanish National Forest Map

The Spanish National Forest Map (MFE – Mapa Forestal de Espana) represent the basic forest cartography database of Spain, which includes the distribution of national forests ecosystems. The project is led by the General Directorate of the Spanish Nature Data Bank (Banco de Datos de la Naturaleza).

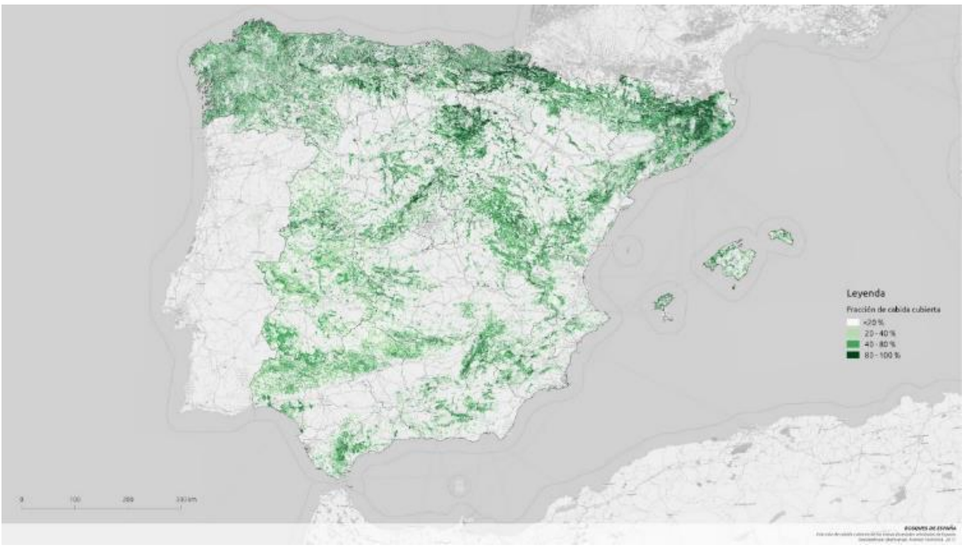
It constitutes the cartographic base of the Spanish NFI, and it is similarly updated regularly.

The photointerpretation and digitization are performed on digital orthophotos provided by the National Geographic Institute as part of the National Plan for Aerial Orthophotography. The methodology for producing the map comprises three phases: photointerpretation, field monitoring and quality control. The main stratification factors are: the main species, crown cover, stand age categories and sometimes ownership type. MFE represents a valuable tool for the forestry sector, providing information related to multiple fields such as carbon stock, forest fires and land use changes (Alberdi et al., 2016)

The most recent MFE is available at a scale of 1:25,000 as NFI4 cartography, while 1:50,000 scale is available for the autonomous communities of Castilla-La Mancha, Comunitat Valenciana, Andalucía and Aragón.

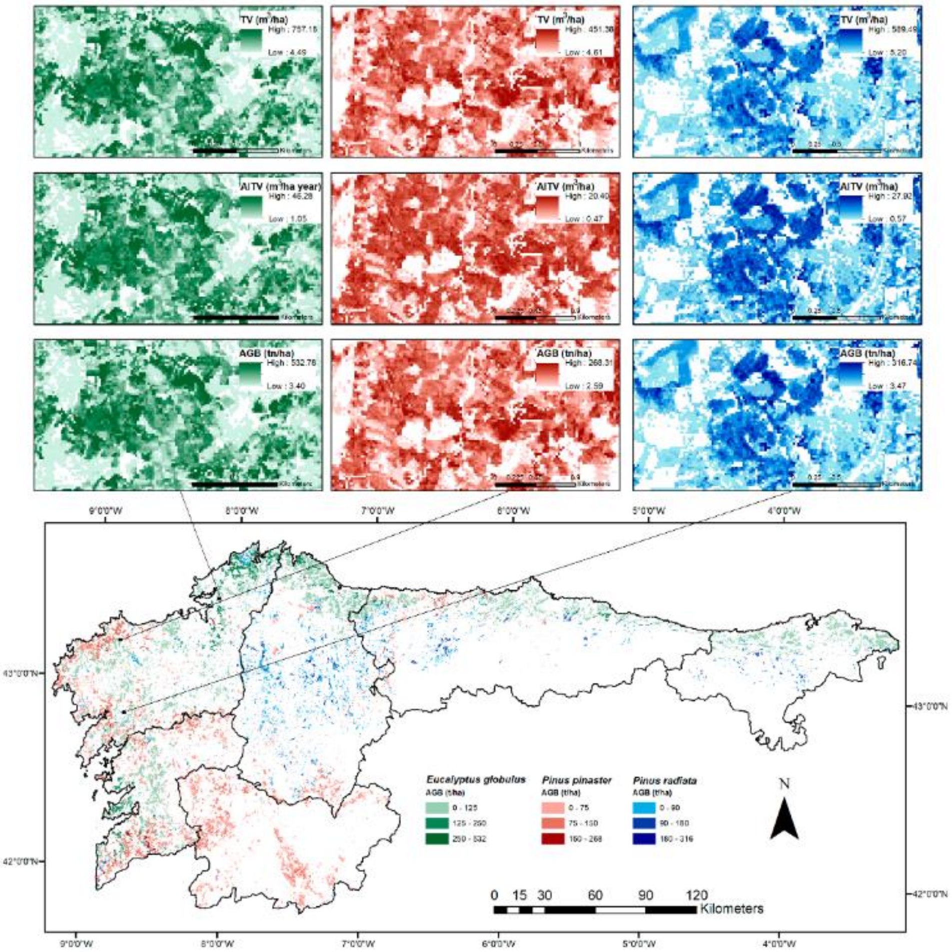
The map is open access and downloadable in vector format from the Ministry for the Ecological Transition and the Demographic Challenge website.

Figure 59 Forest Map of Spain (MFE25) representing the percentage of forest cover updated to 2017 (source: Ministry for the Ecological Transition and the Demographic Challenge)



Recently, data from the NFI4 and from the 1st nationwide Airborne Laser Scanning (ALS) survey were used to develop predictive yield models for the three major commercial tree forest species (Eucalyptus globulus, Pinus pinaster and Pinus radiata) grown in north-western Spain, at 25 m spatial resolution (Novo-Fernandez et al., 2019). The ALS data (2 x 2 km tiles) used in were collected during different flights between 2009 and 2012 for the PNOA-LiDAR project, and the data is available on the National Geographic Information Centre website.

Figure 60 Bottom: Spatial distribution of the total aboveground biomass (t ha-1) in north-western Spain. Top: Map details for total volume annual increase and above-ground biomass in E. globulus (row 1), P. pinaster (row 2) and P. radiata (row 3). Source: Novo-Fe



26.2.3. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Spain.

Table 102 Spain: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Forest/ tree cover	NFI	National	Complete	10y		yes	x			yes - public
Forest biomass	NFI	National	Complete	10y		yes	x			yes - public
Forest carbon										
Tree age	NFI	National	Complete	10y		yes	x			yes - public
Canopy height	NFI	National	Complete	10y		yes	x			yes - public
Forest structural diversity	NFI	National	Complete	10y		yes	x			yes - public
Forest soil properties										
Forest/tree cover change	NFI	National	Complete	10y		yes	x			yes - public
Tree age diversity	NFI	National	Complete	10y		yes	x			yes - public
Tree species/composition	NFI	National	Complete	10y		yes	x			yes - public
Tree species diversity	NFI	National	Complete	10y		yes	x			yes - public
Forest type	NFI	National	Complete	10y		yes	x			yes - public
Deadwood	NFI	National	Complete	10y		yes	x			yes - public
Presence of Red-list species	NFI	National	Complete	10y		yes	x			yes - public
Abundance of common forest birds	MTED	National	Complete	1y				x		Yes - aggregated per 3 years
Forest spatial patterns										
Areas of primary and old-growth forests										
Forest ancientness										
Forest area under protection	MTED									
Silvicultural system								x		yes - public
Main management objectives	MTED	Autonomous Communities	Complete	1y				x		yes - public
Forest area covered by a management plan	MTED	Autonomous Communities	Complete	1y				x		yes - public
Volume of wood harvested	MTED	Provincial	Complete	1y				x		yes - public

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*note*
Ratio of annual fellings to annual increments	NFI	National	Complete	10y		yes	x			yes - public
Forest revenue										
Roundwood prices	INE	National	Complete	1y				x		yes - public
Forest products trade	MTED	National	Complete	1y				x		yes - public
Employment in the forest sector	INE	National		each quarter						
Forest area with 3rd party certification	MTED	Autonomous Communities	Complete	1y				x		yes - public
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health	NFI/MTED	National	Complete	10y/1y		yes	x			yes - public
Forest growth	NFI	National	Complete	10y		yes	x			yes - public
Occurrence of forest fires	MTED	Provincial	Complete					x		yes - public
Occurrence of storms	MTED	Provincial	Complete	1d						
Forest disturbance										
Number of forest fires	MTED	Provincial	Complete							
Number of storms										
Forest invasive species	NFI	National	Complete	10y		yes	x			yes - public
Browsing	NFI	National	Complete	10y		yes	x			yes - public
Herbaceous vegetation	NFI	National	Complete	10y		yes	x			yes - public
Micro-sites	NFI	National	Complete	10y		yes	x			yes - public
Epiphitic lichens	NFI	National	Complete	10y	ICP forest methodology	yes	x			yes - public
Non-wood forest products	MTED	Provincial	Complete	1y				x		yes - public
Reforestation	MTED	Provincial	Complete	1y				x		yes - public

26.2.4. SWOT analysis

Table 103 Spain: SWOT analysis

Strengths	Weaknesses
Spain has a well-established NFI that is able to report robust statistics for a large number of forest variables.	Remote sensing could help in forest disturbance identification at national level.
Opportunities	**Threats**
Combination of NFI data and remote sensing data for the next NFI cycle (starting in 2024).	No official spatial products as wall-to-wall maps produced by the NFI.

26.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 104 Spain: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	Spanish forest strategy (in revision)	Multifunctionality and sustainable management
	National Forest Inventory	Current data on forests
Biodiversity	Spanish forest strategy, (in revision)	Definition of objectives and common actions with the SSBC), measures, guidelines for forest management planning & practices
	Strategic plan for natural heritage and biodiversity 2011-2017 (in revision)	The conservation and sustainable use of biodiversity, in its different strata of population, species and genes, currently and potentially contained in the different Spanish forest ecosystems, taking into consideration their different states of development.
Bioeconomy	Spanish Bioeconomy Strategy (span.), pp.10-11	Description of benefits and best practices for forestry-related production.
	Spanish forest strategy	Timber as a source of bio-energy - Reference to EU energy policy & exploration of possibilities Promotion of the use of forest products, extensive livestock and forest tourism.
Ecosystem services	Spanish forest strategy	Obtaining sufficient knowledge about the ecosystem functions and services derived from European forests; Maintenance of forest ecosystem health and vitality by enhancing regenerative capacity, resistance and adaptive capacity of forest ecosystems; definition of indicators;
	Common basic guidelines for sustainable forest management (in preparation)	Guidelines for SFM and regional instructions for management and use of forests. SFM criteria and indicators.
Climate change	Spanish forest strategy (in revision)	Reference to EU Climate policy & exploration of potential of forests to contribute to carbon storage, and their adaptation to the effects of climate change.
	National adaptation plan for climate change 2021-2030	The PNACC incorporates a specific line of action “Forestry, desertification, hunting and inland fisheries”, which will work on the prevention of desertification and land degradation and the promotion of adaptive restoration of degraded land.

Thematic area	Main Strategic reference	Summary of planning elements
	Climate Change and Energy transition Law	Several mentions of relevant forest functions
	Integrated national energy and climate plan 2021-2030	Multiple mentions of forestry, particularly in the context of decarbonization, waste management and in relation to LULUCF

26.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Major challenge	Summary description
Climate change	Evaluation of a system of climate change indicators for forests and implementation of an early warning system. Development and application of forest growth models under different climate change scenarios. Development of behaviour simulation models of pathogen agents under different climate conditions. Evaluation of the carbon balances for different types of forest ecosystems in the different stocks (above, below, deadwood, soils, litter). Quality maps of forests pests and diseases and evolution for monitoring.
Ecosystem services	Progressive implementation of payment systems for environmental services in accordance with the European framework. Foreseeable new amendment for a REGULATION OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL amending Regulation (EU) No 691/2011 as regards introducing new environmental economic accounts modules (ecosystems accounts)
Interest conflicts	Encourage territorial contract subscriptions (Royal Decree 1336/2011) or other formulas and mechanisms of co-responsibility between forest managers, town councils, neighbours and individuals for the conservation and sustainable management of their forests.
Private forest owners	Increase the size of the forest property and attain economically efficient forest holdings for a sustainable forest management. Improve livelihoods of rural area residents linked to forest activity.
Biodiversity conservation	Highlight the importance of multi-functionality of forests and traditional land uses for biodiversity, mainly combining grazing with forest and forestry. Include explicitly forest areas in the Spanish strategy on green infrastructures. Harmonization of forest and biodiversity inventories, and sample sites & improved monitoring.
Bioeconomy	Contribute to a rise in the added value of forest products. Increase the number of managed forest holdings with a long term plan. Support stakeholder´s and producer´s organisations for the mobilization of forest products.
Forest fires	Assess and manage the growing forest area coming from the abandonment of traditional grazing or agricultural practices. Implementation of strategic guidelines for forest fire management in Spain (approved in 2022).

Desertification	Integral assessment of the actions taken in both Agriculture and Forestry Policy in combating the progress of desertification. This challenge has been met by the national effort of reporting to the UN Convention to combat Desertification. Additional indicators have been developed. (Info available in www.unccd.int or upon request to Spain Forest Administration). Development of the already adopted National Register of Protective Forest (in part aimed to protect soils from desertification). Update the identification of priority areas to restore in order to fight desertification. Provide a political and institutional specific framework for combating desertification. Development of the national strategy to combat desertification (approved in 2022)
Population-related challenges	Include the forest sector in the digital agenda for rural areas and in the national strategy for the demographic challenge in abandoned rural areas.
Financing	Planning of public and private forest investments (National and Regional Forests Plans). Differentiated taxation in SSPA areas (Cuenca, Teruel, Soria).
Governance	Specific fiscal regulation adapted to the particular characteristics of the sector and the forest ownership. Develop a regulation for the establishment of a specific legal framework for the "forests belonging to partners in co-ownership".

26.4. References

Alberdi Asensio I, Condés Ruiz S, Millán JM, Saura Martínez de Toda S, Sánchez Peña G, Pérez Martín F, Villanueva Aranguren JA, Vallejo Bombín R, 2010. National Forest Inventories Report, Spain. In: National Forest Inventories. Pathways for Common Reporting; Tomppo E, Gschwantner T, Lawrence M, McRoberts RE (eds), pp: 529-540. Springer

Alberdi, I., Cañellas, I., & Bombín, R. V. (2017a). The Spanish National Forest Inventory: history, development, challenges and perspectives. Pesquisa Florestal Brasileira, 37(91), 361-368. http://dx.doi.org/10.4336/2017.pfb.37.91.1337

Alberdi, I., Bombín, R. V., González, J. G. Á., Ruiz, S. C., Ferreiro, E. G., García, S. G., ... & de Viñas, I. C. R. (2017b). The multi-objective Spanish national forest inventory. Forest systems, 26(2), 14.

FAO (2004) Global forest resources assessment update 2005: terms and definitions (final version).Forest resources assessment programme working paper 83/E, FAO Forestry Department, Rome

Novo-Fernández, A., Barrio-Anta, M., Recondo, C., Cámara-Obregón, A., & López-Sánchez, C. A. (2019). Integration of national forest inventory and nationwide airborne laser scanning data to improve forest yield predictions in north-western Spain. Remote Sensing, 11(14), 1693. https://doi.org/10.3390/rs11141693

Spanish Cartographic portal http://centrodedescargas.cnig.es/CentroDescargas/buscadorCatalogo.do?codFamilia=LIDAR#, last accessed on 29 December 2022

Spanish National Forest Map https://www.miteco.gob.es/es/cartografia-y-sig/ide/descargas/biodiversidad/mfe.aspx

National Forest Strategy: SFS.pdf (miteco.gob.es)

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

Forest Land Ownership Change in Spain, COST Action FP1201 FACEMAP country report 2015, EFI: https://facesmap.boku.ac.at/library/FP1201_Country%20Report_SPAIN.pdf

National Forest Plan: https://www.miteco.gob.es/es/cambio-climatico/legislacion/documentacion/plan_forestal_esp_tcm30-178745.pdf

National Forest Inventory: https://www.miteco.gob.es/es/biodiversidad/temas/inventarios-nacionales/inventario-forestal-nacional/default.aspx

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_ESP (foresteurope.org)

Spanish Strategy for Biodiversity Conservation and Sustainable Use: https://www.cbd.int/doc/world/es/es-nbsap-01-p1-en.pdf

Spanish Bioeconomy Strategy: https://www.mapa.gob.es/es/desarrollo-rural/temas/innovacion-medio-rural/estrategiaenbioeconomia23_12_15_tcm30-560119.pdf

Climate Change and Energy transition Law: https://www.boe.es/boe/dias/2021/05/21/pdfs/BOE-A-2021-8447.pdf

Strategic guidelines for forest fire management in Spain https://www.miteco.gob.es/es/biodiversidad/planes-y-estrategias/orientacionesestrategicasiiff_cs28072022_tcm30-543585.pdf

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-09/csp-a-a-glance-spain_en.pdf

Integrated national energy and climate plan 2021-2030: https://energy.ec.europa.eu/system/files/2020-06/es_final_necp_main_en_0.pdf

27. SWEDEN

27.1. Country overview – major forest facts

27.1.1. Key forest data

Sweden is a Nordic country with more than two thirds forest cover. Sweden`s forest area has been constant since 2000 and is 68.7% of total land area. This amounts to 28 Mio ha. Growing stock on forest available for wood supply and above ground biomass have been rising. Growing stock per hectare on forest available for wood supply is 139 m3 o.b./ha. The majority of land area is dominated by coniferous forests. The most common tree species are Norway spruce (40%), Scots pine (38%) and birch (12%). 98% of forests are under a management plan or equivalent, although these plans are not compulsory and are not registered with an official body. 60% of forests are under third party certification, both FSC and PEFC. 7.7% of forest and other wooded land is considered protection forest. 2.2 Mio ha of Swedish forest is considered undisturbed by man.

27.1.2. Institutional setup and legal framework

National forest legislation has been applied for more than 100 years. The latest Forestry Act was enacted in 1979, and the most recent major amendments were carried out in 2014. A NFP process was established in 2014 and the government launched the National Forest Programme in 2018. A continuous national forest inventory, supplemented as necessary by ad hoc studies, provides information for policy makers and international reporting. The Ministry of Enterprise and Innovation is responsible for forestry (including forestry’s environmental and energy related aspect, and green industries’ climate effect).The Ministry of the Environment is responsible for forest conservation; the Swedish Forest Agency is the administrative authority for issues concerning forestry.

27.1.3. Key actors and stakeholder organisations

Ministry of Enterprise and innovation; Ministry of the Environment; Swedish Forest Agency; Swedish Environmental Protection Agency; Swedish Forest Industries Federation; Swedish Agricultural University; Forest Owners Associations: LRF Forestry (*Södra; Mellanskog; Norra Skog*); *Sveaskog* (state owned company); Relevant NGOs, e.g. WWF Sweden, The Swedish Society for Nature Conservation; The Sami Council.

27.1.4. Forest ownership

48% of Swedish forests are owned by family enterprise (individual forest owners), 24% - by corporates, 12% are owned by state owned companies, 8% by the Swedish state, and 7% - by other owners.

27.1.5. Forest industry

Removals have been trending upwards, from around 50 Mio m3 u.b. in the 1990s to around 75 Mio m3 u.b.. The ration of fellings to net annual increment on forest available for wood supply is around 95%. However, natural losses are not included in net annual increment. If that is considered, it is lower%. Employment in the forest sector has fallen from 98 thousand people in 1990 to 78 thousand people in 2015. Employment in wood processing and pulp and paper industries has fallen, but employment in forestry itself has increased slightly, and stands at 22 thousand. Around 24% of Sweden`s primary energy supply comes from forest biomass, of which 20% from the harvesting residuals and nearly 70% from co-products and residues of the industries. A small number of large industrial forest enterprises own around 25% of all forest land. There are some 50 pulp and paper manufactories in a total of 25 groups of companies and around 115 saw mills. Only a few Swedish companies have forest holdings that are integrated with industrial capacity. Most enterprises buy wood from private forest owners.

27.1.6. Key forestry issues

To maintain and develop a skilled and diverse work force and forest owners in an urbanized society.

Developing a better understanding of ecosystem services, as seven ecosystem services have been identified as having an inadequate status. Ecosystem services with an inadequate status were primarily found among the regulating and supporting services, but also among some of the provisioning services.

27.2. Forest monitoring

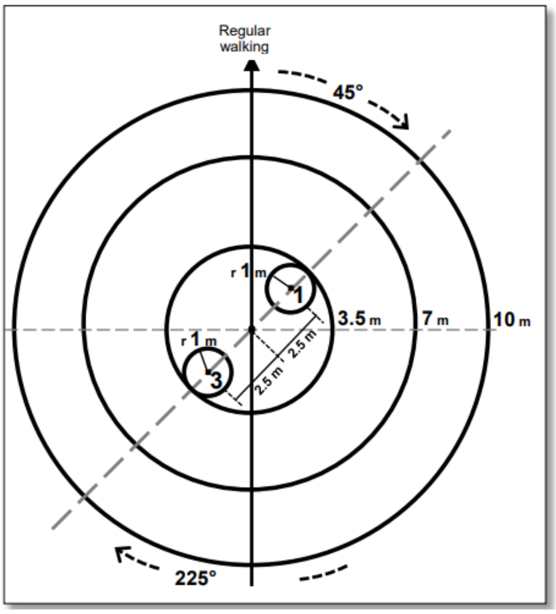
27.2.1. National Forest Inventory

In Sweden, the National Forest Inventory started in 1923 with the aim to monitor development of forest resources, state of forests, forest health and biodiversity (Thorell and Östlin, 1931). The Swedish NFI is organized within the Swedish University of Agricultural Sciences (SLU) and a part of the Swedish Official Statistics system. Statistics derived from NFI data are made freely available to society. The NFI website is the primary platform for this, however an annual summary document - *Skogsdata* (Forest data) - is also published and made available online.

Since 1953, the inventory has been conducted annually, covering the whole area of Sweden. In 1983 permanent clusters were established, and since then the NFI is based on both a temporal and a permanent systematic sample stratified into five geographical regions. Permanent clusters are re-inventoried with five-year intervals (Friedman et al., 2014). Sweden integrates the use of remote sensing in the NFI both for stratification purposes and for producing wall-to- wall maps of Swedish forests every five years, starting in 2000.

The Swedish NFI uses temporary (only surveyed once) and the permanent cluster. The temporary cluster is only surveyed once, whereas a permanent cluster is resurveyed regularly. The NFI defined circular plots (with radii 3.5 and 7m for temporary plots; 3.5 and10m for permanent plots) arranged into clusters that are systematically distributed over the whole of Sweden. The distance between them is less in southern Sweden than in northern Sweden.

Figure 61 Circular sample plot for stem counting in Swedish NFI. Radii: 10, 7, 3.5 and 1m. Small plots (radius 1m) laid out in directions 45° and 225° in relation to regular walking direction, with its center 2.5m from the sample plots center (SLU, 2021)



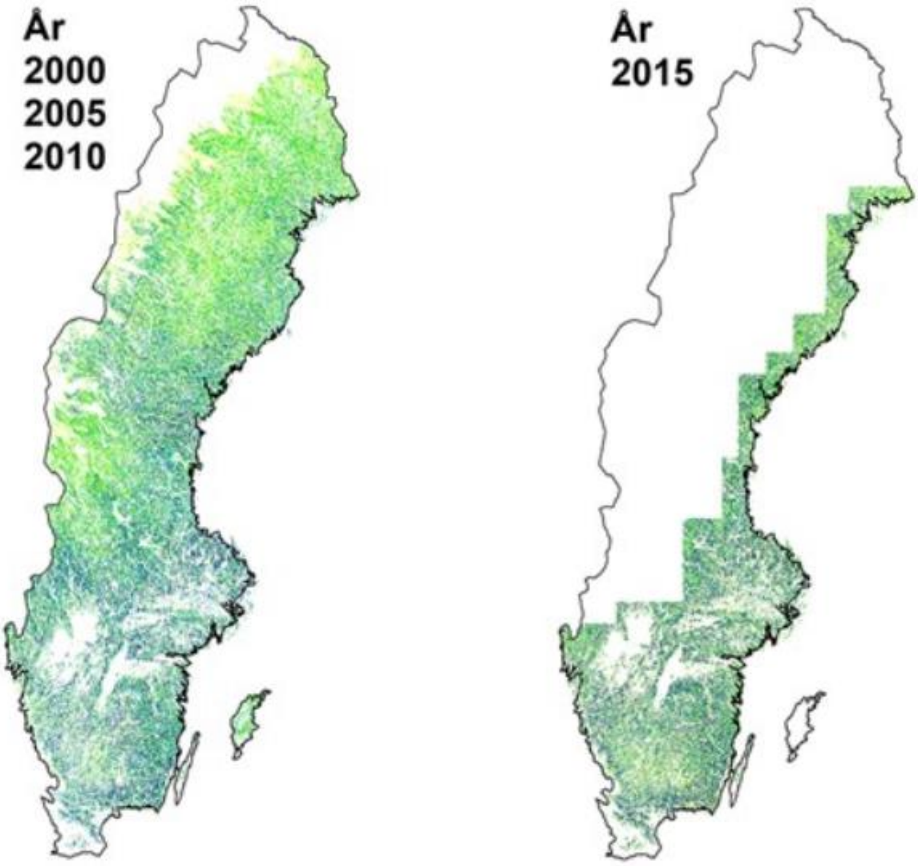
A highly detailed description of the fieldwork instruction related to the last Swedish NFI is available in English language (https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/faltinst/nfi_fieldwork_instructions_eng.pdf, lastly accessed on 02/01/2023).

27.2.2. Forest mapping

In the framework of NFI, Sweden forest maps are provided by SLU. The 2015 SLU forest Map contains the latest released maps created using NFI plots and remote sensing data such as aerial photographs, and satellite images from Sentinel-2. Each raster map cell (12.5 x 12.5 m) describes the volume per tree species, basal area with mean height, basal area with mean diameter, and biomass. The volume maps provide an idea of the timber resources categorized by the main tree species (i.e., pine, spruce, beech, oak, birch, and other deciduous trees).

Three national maps containing information about Sweden's woodlands and forests are already available. These maps include data collected in 2000, 2005 and 2010, each with cells of 25 x 25 m. Up until 2010, the maps were based solely on satellite images from Landsat and SPOT.

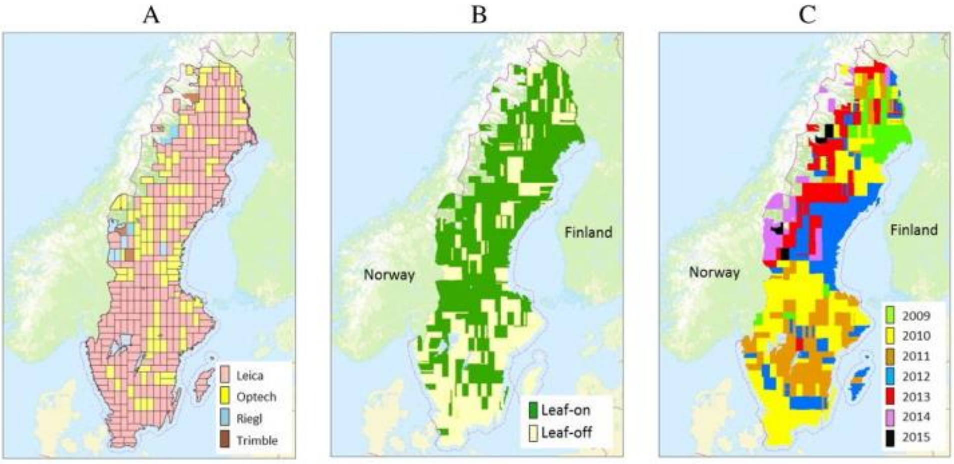
Figure 62 Forest Map in 2000, 2005, 2010 and 2015. The expansion of the SLU Forest Map in 2015 was limited to the areas for which high-resolution images were available.



27.2.3. LiDAR coverage

As reported in Nilsson et al. (2017) almost 100 percent of forest land was scanned with airborne laser scanner data from the Swedish National Mapping Agency between 2009 and 2015. The scanning campaign was organized in 397 blocks which were usually 25 km by 50 km in size. National wall-to-wall maps of several forest variables have been developed through these data. All raster databases can be downloaded free of charge from the Forestry Agency homepage http://www.skogsstyrelsen.se/skogligagrunddata.

Figure 63 Scanner brand (A), scanning season (B) and scanning year (C) for the ALS data used in the study. Copyright Lantmäteriet. (Nilsson et al., 2017). ALS data used in the study. Copyright Lantmäteriet. (Nilsson et al., 2017).



27.2.4. Criteria and indicators

The table below provides an overview of criteria and indicators monitored in Sweden.

Table 105 Sweden: Overview of criteria and indicators. Information is reported only where available. (Information on indicators which are not available for every country are indicated in italics).

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest/ tree cover	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Forest biomass	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Forest carbon	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Tree age	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Canopy height	NFI	National, Regional	complete	1y		yes		x		yes - public
Forest structural diversity	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Forest soil properties	NFI	National, Regional	complete	1y		yes		x		yes - public
Forest/tree cover change	NFI	National, Regional	complete	1y		yes		x		yes - public
Tree age diversity	NFI	National, Regional	complete	1y		yes		x		yes -

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
										public
Tree species/composition	NFI	National, Regional	complete	1y		yes		x		yes - public
Tree species diversity	NFI	National, Regional	complete	1y		yes		x		yes - public
Forest type	NFI	National, Regional	complete	1y		yes		x		yes - public
Deadwood	NFI	National, Regional	complete	1y		yes		x		yes - public
Presence of Red-list species	SLU									
Abundance of common forest birds	SEPA	National	complete	1y		yes		x		yes - public
Forest spatial patterns	SEPA	National	complete			yes				
Areas of primary and old-growth forests	NFI	National	complete	1y		yes		x		yes - public
Forest ancientness										
Forest area under protection	SEPA	National, Regional	complete	1y						
Silvicultural system	SFA	National	complete	1y		yes		x		yes - public
Main management objectives										
Forest area covered by a management plan	SFA	National	complete	1y		yes		x		yes-public
Volume of wood harvested	SFA	National	complete	1y	FAO, Forest Europe	yes		x		yes - public
Ratio of annual fellings to annual increments	NFI	National	complete	5y	FAO, Forest Europe	yes		x		yes - public
Forest revenue	SFA	National	complete	1y		yes			x	yes - public
Roundwood prices	SFA	National	complete	1y/quartely		yes			x	yes - public
Forest products trade	SFA	National	complete	1y		yes			x	yes - public
Employment in the forest sector	SFA	National	complete	1y		yes		x		

Indicator	Leading data provider	Geographical reporting unit	Geographical coverage	Assessment periodicity	Data harmonization	Data accuracy	Data availability			
							Raw	Aggregated	Processed	*Notes*
Forest area with 3rd party certification	SFA	National, Regional	complete	1y	FAO, Forest Europe, FSC, PEFC	yes		x		
Forest visitor statistics										
Forest foliage/phenology/anomalies										
Tree health										
Forest growth	NFI	National, Regional	complete	1y	FAO, Forest Europe	yes		x		yes - public
Occurrence of forest fires	MSB	National	partial	1y						
Occurrence of storms	SFA	National, Regional	partial	1y				x		yes - public
Forest disturbance	SLU	National	complete	1y		yes		x		yes - public
Number of forest fires	MSB	National	partial	1y						
Number of storms										
Production of berries	SLU	Regional	complete	1y				x		yes - public

27.2.5. SWOT analysis

Table 106 Sweden: SWOT analysis

Strengths	Weaknesses
Sweden has a well-established NFI that is able to report robust statistics for a large number of forest variables. Within the NFI, wall-to-wall estimates (maps) have been produced since 2000 and with updates every 5 years.	Maps of forest cuts are made externally and can lead to discordant data in mappings of forest variables.
Opportunities	**Threats**
Improved integration of different remote sensing data sources. Possible extension of NFI with socioeconomic parameters. Provision of additional mapping of forest interest such as disturbances, biodiversity, etc.	Forest disturbance (clearcut) carried out by an external agency not integrated in the NFI.

27.3. Main planning tools at national or, where appropriate, at regional level

The following table presents a summary overview of planning and reporting instruments, structured by thematic categories.

Table 107 Sweden: Overview of planning documents and reporting on planning

Thematic area	Main Strategic reference	Summary of planning elements
Forest resource status and trends	SoEF, 2020	Current data on forests
	National Forest Inventory	Current data on forests
Biodiversity	The Forestry Act	Biodiversity has to be preserved. List of respective considerations to take into account is provided.
	Sweden`s National Forest Programme	Sustainable forest management as a tool to preserve biodiversity
	Sweden's environmental objectives	The objective for Sustainable forests. Followed up annually.
	Sweden's national strategy for formal protection of forest	The strategy is expected to be updated
Bioeconomy	Sweden`s National Forest Programme	Focus area 3: Sweden`s forest industry to become a world leader in creating and utilizing innovation, sustainably producing processed forest products for a growing bioeconomy, and satisfying the demand for sustainable, fossil-free products and services in global markets
	Inquiry on a national bioeconomy strategy	An inquiry on a national bioeconomy strategy is ongoing. It will present its suggestion for a national bioeconomy strategy by 31 October 2023.
	National forestry accounting plan for Sweden	Forests as "green gold" to contribute to employment and sustainable growth; main aim: LULUCF Reporting
Ecosystem services	National forestry accounting plan for Sweden	A government bill on Biological Diversity and Ecosystem Services was presented in March 2014 including five environmental interim targets linked to already established national environmental quality objectives.
	Swedish Strategy for biodiversity and ecosystem services	The strategy covers everything from the protection of land and the sea, measures for endangered plant and animal species, genetic diversity, natural and cultural environment considerations in land and water use to increased cooperation with industry. The proposals in the bill will help achieve the Swedish environmental quality objectives, the generational goal, the targets in the EU Biodiversity Strategy to 2020, and the

		international Aichi Biodiversity Targets within the UN Convention on Biological Diversity (CBD).
Climate change	National forestry accounting plan for Sweden	Climate change as a parameter for forestry accounting
	The Swedish Climate Act	Forest as means to help achieving the 2045 climate goals
	Sweden's national Forest Programme	Focus area 1: A sustainable forestry with increased climate benefits". Substituting fossil resources with renewable ones, is part of climate mitigation.
	Sweden's Integrated National Energy and Climate Plan	Multiple mention throughout the document and separate section on forestry in the context of decarbonization

27.3.1. Major challenges and risks to forests and forest-based sector

The following table shows forest-related challenges that influence planning instruments and are relevant for risk identification and preparedness.

Table 108 Sweden: Forest-related challenges that influence integrated long-term planning

Major challenge	Summary description
Climate change	Research and dissemination of knowledge to implement sustainable forest management. This challenge is of relevance for wood production, biodiversity, recreational activities, climate change adaptation
Ecosystem services	Developing understanding of ecosystem services is imperative. Seven ecosystem services have been identified as having an inadequate status. Ecosystem services with an inadequate status are primarily found among the regulating and supporting services, but also among some of the provisioning services. The regular evaluation of the Swedish environmental quality objective. Sustainable Forests states that this objective will not be able to be reached within the instruments in place. Actions to counteract habitat loss and fragmentation are needed to increase to achieve goal fulfilment.
Interest conflicts	Presence of moose, roe deer, red deer and fallow deer are of great value for outdoor recreation, hunting and tourism. However, the large populations cause damage on young forest stands that reduces the growth substantially and is of high costs for the forest owners. Also, the browsing has a negative effect on biodiversity holding back regeneration of deciduous trees e.g. rowan, aspen, sallow and oak.
Private forest owners	To maintain and develop a skilled and diverse work force and forest owners in an urbanized society is a challenge, ensuring progress on gender equality and attractiveness of sector.
Biodiversity conservation	See ecosystem services

Bioeconomy	Increased need for forest biomass, central to meet global demand in the transition to fossil independence and ambitious national targets, and contribution to international efforts such as Agenda 2030, the Paris Agreement and CBD. Demand-driven and future-proof competence provision, in order to contribute fully to the green economy, is a challenge and the sector and associated value chains have to keep and attract skilled and diverse workforce with competences and abilities to this end. The matter of productivity development, along the value chain.
Forest fires	Adaptation to and management in a changing climate and more extreme weather events. Droughts, fires, pests, flooding, as well as regeneration material for the future climate.
Desertification	No information
Population-related challenges	No information
Financing	No information
Governance	No information

27.4. References

https://www.slu.se/en/Collaborative-Centres-and-Projects/the-swedish-national-forest-inventory/

Fridman J, Holm S, Nilsson M, Nilsson P, Ringvall AH, Ståhl G (2014) Adapting National Forest Inventories to changing requirements—the case of the Swedish National Forest Inventory at the turn of the 20th century. Silva Fenn 48:1095 https://doi.org/10.14214/sf.1095

Nilsson, M., Nordkvist, K., Jonzén, J., Lindgren, N., Axensten, P., Wallerman, J., ... & Olsson, H. (2017). A nationwide forest attribute map of Sweden predicted using airborne laser scanning data and field data from the National Forest Inventory. Remote Sensing of Environment, 194, 447-454. https://doi.org/10.1016/j.rse.2016.10.022

SLU – Fieldwork instruction 2021 in English

https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/faltinst/nfi_fieldwork_instructions_eng.pdf

Thorell KE, Östlin EO (1931) The national forest survey of Sweden. J Forest 4:585–591

Ministry of Enterprise and Innovation, Sweden`s National Forest Programme, 2018: https://www.government.se/48f05c/contentassets/859bb18d50494ec9b5b988a28ef99ae8/fact-sheet-swedens-national-forest-programme#:~:text=The%20strategy%20for%20the%20National,same%20time%20pre%2D%20serve%20biodiversity.

The Forestry Act, The Swedish Forest Agency: https://www.skogsstyrelsen.se/en/laws-and-regulations/skogsvardslagen/

SoEF, 2020: https://foresteurope.org/state-europes-forests-2020/

National Forest Inventory (in Swedish): https://www.slu.se/globalassets/ew/org/centrb/rt/dokument/skogsdata/skogsdata_2022_webb.pdf

Forest Europe Report 2020: Microsoft Word - QL_questions-responses_SWE (foresteurope.org)

Forests and Forestry in Sweden, 2015, Royal Swedish Academy of Agriculture and Forestry: https://www.ksla.se/wp-content/uploads/2015/08/Forests-and-Forestry-in-Sweden_2015.pdf

National forestry accounting plan for Sweden: https://www.government.se/4a9f07/contentassets/730d6345a5d745b1bc5f084e2f00fff7/revised-national-forestry-accounting-plan-for-sweden

Swedish Strategy for biodiversity and ecosystem services, 2015: https://www.government.se/articles/2015/08/swedish-strategy-for-biodiversity-and-ecosystem-services/#:~:text=Long%2Dterm%20Swedish%20nature%20conservation%20policy&text=The%20strategy%20covers%20everything%20from,to%20increased%20cooperation%20with%20industry.

The Swedish Climate Act: https://www.government.se/49c150/contentassets/811c575eb9654a6383cf0ed4e0d5db14/the-swedish-climate-act.pdf

Swedish Forest Agency: https://www.skogsstyrelsen.se/en/

Sweden`s environmental objectives: Sweden's environmental objectives – an introduction (naturvardsverket.se)

Sweden’s national strategy for formal protection of forest: Nationell strategi för formellt skydd av skog (naturvardsverket.se)

National forestry accounting plan for Sweden: https://www.government.se/4a9f07/contentassets/730d6345a5d745b1bc5f084e2f00fff7/revised-national-forestry-accounting-plan-for-sweden

CAP Strategic Plan: https://agriculture.ec.europa.eu/system/files/2022-10/csp-at-a-glance-sweden_en.pdf

Sweden’s Integrated National Energy and Climate Plan: https://energy.ec.europa.eu/system/files/2020-03/se_final_necp_main_en_0.pdf

Annex 1 – Overview of rules used to compile the “Criteria and indicators” database

Leading data provider	The monitoring framework that is the leading reference for regional or national data on a particular indicator	*Insert acronym of the frameworks reported in "Frameworks" sheet*
Geographical reporting unit	At what geographical level are the forest indicator data reported	*National, Regional, Forest district, Forest stands, plot, etc.*
Geographical coverage	If the data is available at whole national/regional level -> *complete*; Otherwise -> *partial*	
Assessment periodicity	Period between the acquisition of two subsequent indicators (E.g. price of Roundwood every week -> 10 w)	
Data harmonization	International indicator definitions that are complied with	*FAO, Forest Europe, etc. (when available)*
Data accuracy	Data accuracy is assessed and information thereof is publicly available	*Yes/No*
Data availability	If the raw-processed-aggregated data are available (mark it with an **X**), and add in a note how the data can be accessed	(R/P/A) Yes – public
Raw (R)		(R/P/A) Yes – upon request
Processed (P)		(R/P/A) Yes – upon payment
Aggregated (A)		(R/P/A) No
note		(R/P/A) Other *E.g. Plot data not available*; *Licence issue*
Cost	Cost per indicator – if the information is available. Alternatively, this can be calculated from the overall cost of a monitoring framework divided by number of indicators monitored.	*Euro – where available*

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