

Supplementary information

Article

The New EU Forest Strategy for 2030: A new understanding of sustainable forest management?

Supplementary Tables

Table S1: Updated pan-European Indicators for Sustainable Forest Management as proposed by the FOREST EUROPE Advisory Group on the updating of the pan-European Indicators for Sustainable Forest Management [14]. *In this list we underlined the key words applied in the Atlas.ti search.*

	No.	Indicator
Forest policy and governance	1	National Forest Programmes or equivalent
	2	Institutional frameworks
	3	Legal/regulatory framework: National (and/or sub-national) and international commitments
	4	Financial and economic instruments
	5	Information and communication

Criteria	No.	Indicator	Full text
Criterion 1: Maintenance and Appropriate	C.1	Policies, institutions and instruments to maintain and appropriately enhance forest resources and their contribution to global carbon cycles	
	1.1	<u>Forest area</u>	<u>Area of forest and other wooded land</u> , classified by forest type and by availability for wood supply, and <u>share of forest and other wooded land</u> in total land area

Criteria	No.	Indicator	Full text
Enhancement of Forest Resources and their Contribution to Global Carbon Cycles	1.2	<u>Growing stock</u>	Growing stock on forest and other wooded land, classified by forest type and by availability for wood supply
	1.3	<u>Age structure and/or diameter distribution</u>	Age structure and/or diameter distribution of forest and other wooded land, classified by availability for wood supply
	1.4	Forest <u>carbon</u>	Carbon stock and carbon stock changes in forest biomass, forest soils and in harvested wood products
Criterion 2: Maintenance of Forest Ecosystem Health and Vitality	C.2	Policies, institutions and instruments to maintain forest ecosystem health and vitality	
	2.1	<u>Deposition and concentration of air pollutants</u>	Deposition and concentration of air pollutants on forest and other wooded land
	2.2	<u>Soil condition</u>	Chemical soil properties (pH, CEC, C/N, organic C, base saturation) on forest and other wooded land related to soil <u>acidity</u> and <u>eutrophication</u> , classified by main soil types
	2.3	<u>Defoliation</u>	Defoliation of one or more main tree species on forest and other wooded land in each of the defoliation classes
	2.4	Forest <u>damage</u>	Forest and other wooded land with damage, classified by primary damaging agent (abiotic, biotic and human induced)
	2.5	Forest land <u>degradation</u>	Trends in forest land degradation
Criterion 3: Maintenance and Encouragement of Productive Functions of Forests (Wood and Non-Wood)	C.3	Policies, institutions and instruments to maintain and encourage the productive functions of forests	
	3.1	<u>Increment and fellings</u>	Balance between net annual increment and annual fellings of wood on forest available for wood supply
	3.2	<u>Roundwood</u>	Quantity and market value of roundwood
	3.3	<u>Non-wood goods</u>	Quantity and market value of non-wood goods from forest and other wooded land
	3.4	<u>Services</u>	Value of marketed services on forest and other wooded land
Criterion 4: Maintenance,	C.4	Policies, institutions and instruments to maintain, conserve and appropriately enhance the biological diversity in forest ecosystem	
	4.1	Diversity of <u>tree species</u>	Area of forest and other wooded land, classified by number of tree species occurring

Criteria	No.	Indicator	Full text
Conservation and Appropriate Enhancement of Biological Diversity in Forest Ecosystems	4.2	<u>Regeneration</u>	Total forest area by stand origin and area of annual forest regeneration and expansion
	4.3	<u>Naturalness</u>	Area of forest and other wooded land by class of naturalness
	4.4	<u>Introduced tree species</u>	Area of forest and other wooded land dominated by introduced tree species
	4.5	<u>Deadwood</u>	Volume of standing deadwood and of lying deadwood on forest and other wooded land
	4.6	<u>Genetic resources</u>	Area managed for conservation and utilisation of forest tree genetic resources (in situ and ex situ genetic conservation) and area managed for <u>seed</u> production
	4.7	Forest <u>fragmentation</u>	Area of continuous forest and of patches of forest separated by non-forest lands
	4.8	<u>Threatened forest species</u>	Number of threatened forest species, classified according to IUCN Red List categories in relation to total number of forest species
	4.9	<u>Protected forests</u>	Area of forest and other wooded land protected to <u>conserve</u> biodiversity, landscapes and specific natural elements, according to MCPFE categories
	4.10	Common forest <u>bird species</u>	Occurrence of common breeding bird species related to forest ecosystems
Criterion 5: Maintenance and Appropriate Enhancement of Protective Functions in Forest Management (notably soil and water)	C.5	Policies, institutions and instruments to maintain and appropriately enhance of the protective functions in forest management	
	5.1	<u>Protective forests – soil, water and other ecosystem functions - infrastructure and managed natural resources</u>	Area of forest and other wooded land designated to prevent soil erosion, preserve water resources, maintain other protective functions, protect infrastructure and managed natural resources against natural hazards

Criteria	No.	Indicator	Full text
Criterion 6: Maintenance of other socioeconomic functions and conditions	C.6	Policies, institutions and instruments to maintain other socioeconomic functions and conditions	
	6.1	Forest <u>holdings</u>	Number of forest holdings, classified by ownership categories and size classes
	6.2	Contribution of forest sector to <u>GDP</u>	Contribution of forestry and manufacturing of wood and paper products to <u>gross domestic product</u>
	6.3	<u>Net revenue</u>	Net revenue of forest enterprises
	6.4	<u>Investments</u> in forests and forestry	Total public and private investments in forests and forestry
	6.5	Forest sector <u>workforce</u>	Number of persons <u>employed</u> and labour input in the forest sector, classified by gender and age group, education and job characteristics
	6.6	<u>Occupational safety and health</u>	Frequency of occupational <u>accidents</u> and <u>occupational diseases</u> in forestry
	6.7	<u>Wood consumption</u>	Consumption per head of wood and products derived from wood
	6.8	<u>Trade</u> in wood	<u>Imports</u> and <u>exports</u> of wood and products derived from wood
	6.9	Wood <u>energy</u>	Share of wood energy in total primary energy supply, classified by origin of wood
6.10	<u>Recreation</u> in forests	The use of forests and other wooded land for recreation in terms of right of <u>access</u> , provision of <u>facilities</u> and <u>intensity of use</u>	

∑ = 34 quantitative indicators + 11 qualitative indicators (total 45 indicators)

Table S2: Identified objectives and commitments of the New EU Forest Strategy for 2030 and the relevant pan-European indicators which can contribute to monitoring progress

Objectives and commitments (quotations)	Page	Parameter(s) to be measured or monitored	Compatibility with existing pan-European indicators	Pan-European indicators appropriate to monitor progress?	Relevant pan-European indicators which can contribute to monitoring progress
Sub-section 2.1. Promoting sustainable forest bioeconomy for long-lived wood products					
"From this perspective, the most important role of wood products is to help turn the construction sector from a source of greenhouse gas emissions into a carbon sink". Objectives and commitments mentioned:					
<i>"stimulating the demand in downstream industries..."</i>	5	Production of forest products Wood consumption by forest industries	Indicators on <i>Production of forest products</i> and <i>Wood consumption by forest industries</i> are currently not included in the pan-European indicators. But indicator 6.7: consumption per head of wood and products derived from wood monitors the outcome at the level of consumers (including imports from outside the EU), but not "demand" from EU industries.	Partial	6.7 Wood consumption
<i>"... promoting forest management practices, production tools and processes that are better adapted to different future forest resources"</i>	5	Increased use of "better adapted" practices etc.	The pan-European indicators do not address forest management practices (except for forest regeneration).	No	None
<i>"investments are needed throughout the wood processing chain"</i>	6	Volume and nature of investments	Investments in the forests and forestry (but not the whole value chain) are addressed in the pan-European indicators.	Partial	6.4 Investments in forests and forestry
<i>"wood processing industries should be supported to better adapt to the changing and diversifying resources of forests"</i>	6	Extent of public support to industries Ability of industries to adapt	The pan-European indicators address policy instruments for the socio-economic functions of forests, including for the value chain and its contribution to GDP. However, currently there is information on adaptation of industry to a changing and diversifying resources of forests.	Partial	Qualitative indicator C.6 Policies, institutions and instruments to maintain other socioeconomic functions and condition:
<i>"combating misconceptions about fire risk and lack of durability and acknowledging the multiple advantages of wood products"</i>	6	Understanding of wood's properties in fire and durability	Not compatible. The pan-European indicators do not address public (mis)conceptions)	No	None

<i>“construction engineers and architects should be incentivised to design buildings with wood”</i>	6	Share of wood designed buildings	Not compatible. The current pan-European indicators address total consumption, with no analysis of share of wood in end-use sectors like construction.	No	None
<i>“construction companies should reflect the full benefits of wood construction in their risk premiums and business models”</i>	6	Lack of unjustified penalisation of wood in risk premiums and business models	Not compatible.	No	Forest Europe does not address internal business matters of construction companies
<i>“research and innovation on architecture, green design and construction materials should be amplified”</i>	6	Increased research and innovation on these topics	Partial (enquiry into policy instruments, including research)	Partial	Qualitative indicator C.6 Policies, institutions and instruments to maintain other socioeconomic functions and condition: includes research and innovation
<i>Regulatory approaches: ... “Member States should be encouraged to reflect best available scientific knowledge in the design of regulations favourable to long-lasting wood products including ...”</i>	6	Regulations based on best available scientific knowledge	Not compatible. The pan-European indicators do not address construction regulations.	No	None
<i>“acting on energy and environmental performance of building and construction products”</i>	6	Energy and environmental performance of buildings	Not compatible. The pan-European indicators do not address construction regulations.	No	None
<i>“promoting ecolabel related with carbon sequestration and increased circularity”</i>	6	Existence of ecolabel(s) on carbon sequestration and circularity	Not compatible. The pan-European indicators do not address ecolabels.	No	None
<i>“targeting the crucial phases in the life of buildings, including construction, renovation and deconstruction”</i>	7	Not clear what is meant by “targeting”	Not compatible. The pan-European indicators do not address building methods.	No	None
<i>“the upcoming carbon farming initiative and carbon removals certificates framework should include dedicated actions for the production and use of long-lived wood products”</i>	7	Inclusion of wood dedicated actions in the two instruments as well as increased use of long lived wood products to store carbon.	Indicator 6.7: consumption per head of wood and products derived from wood At present the pan-European indicators do not mention production; and there is no distinction between “long-lived” and other wood products	Partial	6.7 Wood consumption

<i>“the Commission will develop a 2050 roadmap for reducing whole life-cycle carbon emissions in buildings”</i>	6	Existence of roadmap	Not compatible. The pan-European indicators do not address carbon emissions in buildings.	No	None
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Sub-section 2.2. Ensuring sustainable use of wood-based resources for bioenergy

Sustainable forest-based bioenergy: “The overall objective of the Union should be to ensure that the share of forest-based bioenergy in the EU renewable energy mix remains within the limits of sustainability and its possible negative externalities are adequately mitigated.” The following objectives under 2.2 are quotations from the two Renewable Energy Directives, which were taken up with no modifications or additions.

<i>“2018 RED included enhanced sustainability criteria for all types of biomass for energy”</i>	7	Supply of sustainable biomass (“sustainable” according to 2018 RED criteria)	The pan-European indicators mention wood energy, and – as a set – are meant to monitor SFM at national level. However, the indicators cannot be used to determine sustainability of specific sources of wood energy. In addition, Forest Europe does not provide “sustainability criteria for biomass”.	Partial	6.9 Wood energy
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<i>EU Biodiversity Strategy 2030 “said that the use of whole trees for energy production, whether from the EU or imported, should be minimised”</i>	8	Use of whole trees for energy production	The Joint Wood Energy Enquiry (JWEE) and thus the State of Europe’s Forests (SoEF) reporting record origin and destination of wood energy. However, JWEE does not identify “whole trees” (only “wood direct from forest” – as opposed to residues and recovered wood).	Partial	6.9 Wood energy
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The proposal for the revision of the Renewable Energy Directive as part of the Fit-for-55 package set out additional concrete safeguards. It includes strengthened sustainability criteria for bioenergy, as follows:

<i>“this means prohibiting the sourcing of forest biomass from primary forests and limiting it in highly biodiverse forests to ensure no interference with nature protection purposes”</i>	8	Use for energy of biomass from 1) primary forests and 2) highly biodiverse forests	The JWEE and thus the SoEF record origin and destination of wood energy. However, JWEE does not identify wood from primary forests or highly biodiverse forests, only “forest”.	Partial	6.9 Wood energy
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<i>“the proposal also applies greenhouse gas emission saving criteria to existing installations and extends the scope of the sustainability and greenhouse gas saving criteria to cover installations with a capacity equal or above 5 MW”</i>	8	GHG emissions from biomass burning installations above 5MW	No mention of GHG emissions from biomass burning	No	None
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In addition, the proposal reinforces the implementation of the cascading principle as a main driver for changes in bioenergy policies, ensuring fair access to the biomass raw material market for the development of innovative, high value-added bio-based solutions and a sustainable circular bioeconomy. It proposes that Member States shall design their support schemes for the use of biomass for energy in a way that minimises undue distortive effects on the biomass raw material market and harmful impacts on biodiversity, as follows:

it proposes that Member States shall design their support schemes for the use of biomass for energy in a way that minimises undue distortive effects on the biomass raw material market and harmful impacts on biodiversity.					
<i>“need to further strengthen the sustainability safeguards of forest-based bioenergy”</i>	7	Strengthen the sustainability safeguards of forest-based bioenergy	Need to define "sustainability safeguards". The pan-European indicators address wood energy in indicator 6.9.	Partial	6.9 Wood energy
<i>“ensure that the share of forest-based bioenergy in the EU renewable energy mix remains within the limits of sustainability and its possible negative externalities are adequately mitigated”</i>	7	Forest based bioenergy remains “within the limits of sustainability”	“Limits of sustainability” needs to be defined. Indicator 6.9 gives background but nothing on sustainability of wood energy supply.	No/Partial	6.9 Wood energy
<i>“ensuring fair access to the biomass raw material market for the development of innovative, high value-added bio-based solutions and a sustainable circular bioeconomy”</i>	7	“Fair access to Biomass raw material market” “Development of innovative high value-added bio-based solutions” “Sustainable circular bioeconomy”	Many definitional problems: “fair”, “innovative” “bio-based solutions”. Sustainable circular bioeconomy has been set as an objective, but is much wider than the forest sector.	No	None
<i>“no support shall be granted to the production of energy from saw logs, veneer logs, stumps and roots”</i>	8	Production of energy from sawlogs, veneer logs, stumps and roots	JWEE (and thus SoEF) records origin and destination of wood energy. However, JWEE does not identify “sawlogs, veneer logs stumps and roots” (only “wood direct from forest” – as opposed to residues and recovered wood).	Partial	6.9 Wood energy
<i>“ensure a more efficient energy-use of woody biomass, by limiting state aid support for electricity-only plants”</i>	8	State aid support for “electricity only plants” (as opposed to combined heat-and-power)	Type of power generation is not covered by the pan-European indicators and is outside the existing scope of the set.	No	None
Sub-section 2.3. Promoting non-wood forest-based bioeconomy, including ecotourism					
Objectives on the sustainable production of non-wood forest product					
<i>“promote the elaboration of coordinated and integrated regional, national and subnational programmes on the sustainable production of non-wood forest products”</i>	9	Promote programmes on the sustainable production of non-wood forest product	The pan-European indicators address policies, institutions and instruments to maintain and encourage the productive functions of forests under qualitative indicator C.3.	Partial	Qualitative indicator C.3 Policies, institutions and instruments to maintain and encourage the productive functions of forests 3.3 Non-wood goods

Objectives on sustainable (eco)tourism					
<i>“promote collaboration between the tourism sector, forest-owners and nature protection services, and standards and norms for eco-tourism activities”</i>	9	Absence/reduction of tensions between tourism, forest and nature advocates Existence of standards/norms for ecotourism	The indicators 3.4 and 6.10 provide background information, but they do not address institutional issues of inter-sector collaboration	No	None
<i>“tourism industry should work in close cooperation with the forest managers to develop sustainable tourism products that positively influence human health, without having negative impacts on the natural values of the intended destinations, especially in protected areas”</i>	9	Sustainable tourism products that do not have negative impacts, especially in protected areas	The pan-European indicators provide information on protected areas and recreation in forests. There are currently no indicators on negative impacts on natural values nor on number and spatial coverage of sustainable tourism products.	Partial	4.9 Protected forest areas 6.10 Recreation in forests
Sub-section 2.4. Developing skills and empowering people for sustainable forest-based bioeconomy					
Objectives on skills development					
<i>“develop respective curricula, knowledge and skills (related to increasing multifunctional role that forests will play in the transition to a sustainable and climate neutral future will require an increased skill-set)”</i>	9	Development of knowledge and skills related to multifunctional role of forests	The pan-European indicators provide information on forest sector workforce (6.5). There is a need to define "multifunctional role", "transition to a sustainable and climate neutral future".	No	None
<i>“Through the Education for Climate Coalition, further promote cooperation and connect pupils, students, teachers and stakeholders on the role of forests , including on the benefits of outdoor learning”</i>	9	Cooperation initiatives which include the role of forests and connect participants (pupils, students, teachers and stakeholders).	Not compatible. The pan-European indicators do not address cooperation initiatives which include the role of forests and that connect participants.	No	None
Sub-section 3.1. Protecting EU’s last remaining primary and old-growth forests					
Objectives on the protection of forests, notably primary and old-growth forests					
<i>“protect at least 30% of the EU land area under effective management regime, out of which 10% of the EU</i>	11	Forest area protected and strictly protected.	The pan-European indicators cover protected and within that strictly protected forest area. The 30% target refers to total EU land area: it remains however unclear what	Yes	4.9 Protected forest areas

<i>land should be put under strict legal protection. Forest ecosystems will need to make a contribution to this target"</i>			percentage the "contribution" of forest should be, and whether that percentage should be the same in each country.		
<i>"all primary and old growth forests, in particular, will have to be strictly protected"</i>	11	Area of primary/old growth forests strictly protected	Indicator 4.3 Naturalness provides only information on "forests undisturbed by man", which is not exactly the same as "Primary and old-growth forests"	Partial	4.3 Naturalness
<i>"The Commission is working in cooperation with Member States and stakeholders to agree, by the end of 2021, on a common definition for primary and old-growth forests and the strict protection regime"</i>	11	Area of primary and old growth forests	See above (Indicator defines "forest undisturbed by man" not "primary and old-growth forest"	Partial	4.3 Naturalness
<i>"Member States should urgently engage in completing the mapping and monitoring of these (primary and old-growth) forests, and ensuring no deterioration until they start to apply the protection regime"</i>	11	Extent, location and protection status of all EU primary and old-growth forests	Indicator 4.3 Naturalness identifies provides information on forests "undisturbed by man". The related data is not suitable to produce georeferenced maps. Lack of information on "deterioration" in the status of individual forests and no particular data on old-growth forests within indicator 4.3	Partial	4.3 Naturalness 4.9 Protected forest areas
<i>"leave the dynamic of the forest cycle in these forests as much as possible to natural processes, limiting extractive human activities, while finding synergies with sustainable ecotourism and recreational opportunities"</i>	11	Natural processes Extractive human activities Synergies with sustainable ecotourism and recreational opportunities	Definitional challenges for: -natural processes -extractive human activities -synergies with sustainable ecotourism and recreational opportunities The pan-European indicators do provide information on recreation in forests but for the other issues they do not provide data.	Partial	4.3 Naturalness 6.10 Recreation in forests
Sub-section 3.2. Ensuring forest restoration and reinforced sustainable forest management for climate adaptation and forest resilience					
Objectives on forest related management practices to achieve genetically and functionally biodiverse forests, forest risk management, uneven-aged and continuous-cover forestry management					
<i>"all forests should be increasingly managed so that they are sufficiently biodiverse, taking into account the differences in natural conditions, biogeographic regions and forest typology"</i>	11	All forests managed so that they are "sufficiently biodiverse"	Need to assess the management methods and biodiversity status of all forests. Need to define "sufficiently biodiverse" for a wide range of conditions (as recognised in the text). Nota bene: Here biodiversity is the only criterion used, with no mention of other dimensions. Forest Europe provides a range of national	Partial	All biodiversity indicators: 4.1 -4.10

			biodiversity indicators, but not for biogeographic regions nor for forest typologies.		
<i>“certain management practices that support biodiversity and resilience, are essential in this context, such as the creation or maintenance at stand and landscape level of genetically and functionally diverse, mixed-species forests, especially with more broadleaves and deciduous trees and with species with different biotic and abiotic sensitivities and recovery mechanisms following disturbances, instead of monocultural plantations”</i>	12	Implementation of management practices intended to produce: Genetically and functionally diversity Diversity of tree species Species with different biotic and abiotic sensitivities and recovery mechanisms following disturbances	The pan-European indicators can provide information on outcomes such as 4.1 diversity of tree species, 4.2 regeneration, 4.6 genetic resources. Definition challenges e.g. "species with different biotic and abiotic sensitivities and recovery mechanisms following disturbances". However, the indicators do not address management practices, although these are addressed in the Pan European Operational Level Guidelines (PEOLG) Resilience, is not precisely defined, and not at present, measurable, at the national or EU level.	Partial	4.1 diversity of tree species 4.2 Regeneration 4.6 Genetic resources
<i>“management practices like uneven-aged and continuous-cover forestry, sufficient quantities of deadwood, regulation of wildlife densities and the establishment of protected habitat patches or set aside areas in production forests help ensure long-term environmental and socio-economic viability of forests”</i>	12	implementation of management practices intended to produce uneven-age stands, deadwood, acceptable wildlife densities ultimately "long-term environmental and socio-economic viability of forests	The pan-European indicators do not address "management practices" but can provide information on indicators 1.1 forest area, 1.3 age structure, 4.5 dead wood and 4.9 protected areas.	Partial	1.1 Forest area 1.3 Age structure and/or diameter distribution 4.5 Dead wood 4.9 Protected forest areas
<i>“forest related risk management practices, such as integrated landscape fire management systems will increase forest resilience against wildfires, pests, diseases and create other positive spill over effects.</i>	12	Implementation of forest related risk management practices.	The pan-European indicators do not address "management practices" but can provide information on indicator 2.4 forest damages but not on related risk management nor on increased resilience. Resilience, is not precisely defined, and not at present, measurable, at the national or EU level.	Partial	2.4 Forest damage
<i>“other practices should be approached with caution, notably these which affect above ground biodiversity, and cause the loss of carbon in the roots and part of the carbon in the soil. These silvicultural practices include clear-cutting, for which environmental and</i>	12	No implementation of "negative" management practices, including clearcuts. Carbon in biomass, carbon in Soils Clear-cutting	The pan-European indicators do not address "management practices" But provide information on soil carbon and on carbon in biomass but not particularly in roots. No information on clearcutting can be provided.	Partial	1.4 Forest carbon All biodiversity indicators 4.1-4.10

<i>ecosystem concerns, including the needs of certain species, should be increasingly taken into account. These practices should be used only in duly justified cases”</i>					
<i>“also be avoided is removing stumps and roots, which should be left in the forest”</i>	12	Removing of stumps and roots	The pan-European indicators do not address "management practices". They do also not provide information removing of stumps and roots.	No	None
<i>“logging during bird-nesting period must comply with the Birds Directive”</i>	12	Logging activities during bird-nesting period	The pan-European indicators do not address "management practices". They do also not provide time related information on logging activities.	Partial	4.10 Common forest bird species
<i>“soil properties and soil ecosystem services must be protected as the very foundation of healthy and productive forests”</i>	12	Soil properties and soil Ecosystem protection	The pan-European indicators provide information on soil condition and on protective forest area but not on soil ecosystem services	Partial	2.2 Soil condition, 5.1 Protective functions
Objectives on increasing forest resilience					
<i>“everything should be done to prevent climate related damages and increase forest resilience”</i>	14	Forest damages Forest resilience	The pan-European indicators can provide information on 2.4 forest damages. Resilience, is not precisely defined, and not at present, measurable, at the national or EU level.	Partial	2.4 Forest damage
<i>“‘restore and reforest better’ conditions in line with the above-described management practices that increase forest resilience”</i>	14	Restored and reforested forests, Forest resilience	Pan European Guidelines on Afforestation and Reforestation were published in 2008 (with UNEP/PEBLDS). Resilience, is not precisely defined, and not at present, measurable, at the national or EU level. 2.5 Forest land degradation is new indicator, but not yet properly functional.	No	None
Objectives on improved forest reproductive material					
<i>“secure and sustainably use – based on ecological principles – the genetic resources on which a more climate-proof forestry depends; to increase the production and availability of such material; to provide better information on its suitability for future climatic</i>	14	Availability of forest reproductive material suitable for future climatic conditions	Indicator 4.6 addresses genetic diversity, but the EUFORGEN analysis concentrates on protecting genetic diversity in situ, not improving reproductive material. However, the genetic resources referred to by the Strategy would be based on the in situ genetic diversity analysed by EUFORGEN for the State of Europe’s Forests reports.	Partial	4.6 Genetic diversity

<i>conditions; to support research into the principles and application methods of assisted forest species migration; and to enhance its collaborative production and transfer across national borders”</i>					
<i>“Supplement the revision of the legislation on forest reproductive material with measures to promote the production and marketing of forest reproductive material suitable for future climatic conditions, by the end of 2022.”</i>		Availability of forest reproductive material suitable for future climatic conditions	Indicator 4.6 addresses genetic diversity, but the EUFORGEN analysis concentrates on protecting genetic diversity, not improving reproductive material. This provision addresses the "production and marketing" of appropriate forest reproductive material.	No	None
Objectives related to forest health					
<i>“monitor the situation of tree health in the EU, including the impact of invasive alien species, diseases and pests such as bark beetles, and encourage the necessary preventive actions for early detection and eradication”</i>	14	Tree health (= “forest health and vitality”), notably the situation as regards invasive alien species, pest and diseases. Existence of systems to monitor and protect forest ecosystems, Invasive species	The pan-European indicators und Criterion 2 cover the ground, but SoEF 2020 and predecessors show necessity of radical improvement of concepts and monitoring systems. The pan-European indicators can provide information on tree health aspects (2.3, 2.4) and on introduced tree species (4.4).	Yes	2.2 Soil condition 2.3 Defoliation 4.4 Introduced tree species
<i>“pest management strategies to identify areas most at risk, exchange of best practices, support and cooperation on phytosanitary controls, as well as the development of innovative and sustainable plant protection tools in respect of ecological principles favourable to biodiversity”</i>	14	Pest management strategies, Exchange of best practices, Phytosanitary control, Plant protection tools	No respective indicators available.	No	None
Objectives related to sustainable forest management, criteria and indicators, thresholds and ranges					
<i>“the sustainable forest management framework will have to be enhanced, notably as regards criteria relating to ecosystem health, biodiversity and climate change so that it can become a</i>	13	Enhanced SFM framework, addressing more effectively, in particular: Forest ecosystem health Forest biodiversity	The pan-European indicators already provide information on forest health and vitality and biodiversity, as well as (to a limited extent on climate change mitigation. This would serve as a foundation for the enhanced framework, but it is not clear what extra	Partial	All forest health indicators: 2.1 -2.5 All biodiversity indicators: 4.1 -4.10

<i>more detailed screening tool to determine and compare different management approaches, their impact and the overall state of EU forests.” Therefore, building on the Forest Europe sustainable forest management criteria, the Commission, together with the Member States and in close cooperation with different forest stakeholders, will identify additional indicators as well as thresholds or ranges for sustainable forest management concerning forest ecosystem conditions, such as health, biodiversity and climate objectives</i>		Climate change Thresholds and ranges to act as a "detailed screening tool to determine and compare different management approaches"	indicators are required. It is clear however that the existing indicators, as used by Forest Europe in the past, do not contain thresholds and ranges which could be used in the way suggested in the Strategy.		
<i>“Guidelines on closer-to-nature forestry are being developed by the Commission and will feed into the work on indicators and new thresholds for sustainable forest management that will be undertaken in close partnership and cooperation with Member States through the updated EU forest governance framework”</i>	13	Existence of guidelines on closer-to-nature forestry Increased application of closer-to-nature forestry Existence of voluntary closer-to-nature forest management certification scheme (area certified?)	Forest Europe has addressed these issues, but not in indicators and could provide a framework to draw up guidelines (it already has produced guidelines, notably the PEOLsG on which PEFC was based). As regards certification, there are a number of EU bio certification schemes available	No	None
Sub-section 3.3 Re- and afforestation of biodiverse forests					
Objectives on tree planting activities					
<i>“Increase of forest area”</i>	15	Forest area	The pan-European indicators address this issue under indicator 1.4 forest area	Yes	1.4 Forest carbon
<i>“plant at least 3 billion additional trees by 2030 in full respect of ecological principles”</i>	15	Number of trees planted (in addition to what would normally be planted)	The pan-European indicators address this issue in indicator 4.2 regeneration. Estimation necessary to move from area planted/regenerated to number of trees.	Partial	4.2 Regeneration
<i>“over time, it (plant at least 3 billion additional trees by 2030 in full respect of ecological principles) will also contribute to increasing the EU forest</i>	15	Forest area Soil carbon Carbon in biomass	The pan-European indicators can provide information on 1.1 forest area and do provide information on soil carbon and on carbon in biomass (1.4) but not particularly in roots.	Yes	1.1 Forest area 1.4 Forest carbon

cover and, with that, the EU land carbon sink and stock”

Sub-chapter 3.4. Financial incentives for forest owners and managers for improving the quantity and quality of EU forests

Objective on forest protection and restoration in publicly and private owned forests

<i>“in publicly owned forests it is only reasonable for Member States to strengthen forest protection and restoration efforts to achieve the commonly agreed increased EU climate and biodiversity ambition and to ensure the transition to a climate-neutral economy”</i>	15	Forest protection Forest restoration Transition to a climate-neutral economy	The pan-European indicators can provide information on 4.9 protected areas, however not in the different ownership classes. The pan-European indicators do not provide information on forest restoration and on the transition to a climate-neutral economy.	Partial	4.9 Protected forests 2.5 Forest land degradation
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Objectives on payments for ecosystem services

<i>“forest owners and managers need drivers and financial incentives to be able to provide, in addition to wood and non-wood materials and products, also ecosystem services through forest protection and restoration and to increase the resilience of their forests through the adoption of most climate and biodiversity friendly forest management practices”</i>	16	Ecosystem services Forest protection and restoration Resilience of their forests Adoption to climate change Biodiversity friendly forest management practices	The pan-European indicators provide information on quantity and market value of roundwood (3.3), quantity and market value of non-wood goods from forest and other wooded land (3.4), and Net revenue of forest enterprises (6.3). The pan-European indicators do not include information on payment scheme for ecosystem services. Resilience and biodiversity friendly forest management practices, are not precisely defined, and not at present, measurable, at the national or EU level.	Partial	3.2 Roundwood 3.3 Non-wood forest products 3.4 Services 6.3 Net revenue of forest enterprises
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<i>“Member States are specifically encouraged, as relevant to their national circumstances, to set up a payment scheme for ecosystem services for forest owners and managers, in order to cover for costs and income foregone”</i>	17	Payment schemes for ecosystem services	The pan-European indicators provide information on quantity and market value of roundwood (3.3), quantity and market value of non-wood goods from forest and other wooded land (3.4), and Net revenue of forest enterprises (6.3). The pan-European indicators do not include information on payment scheme for ecosystem services.	Partial	3.2 Roundwood 3.3 Non-wood forest products 3.4 Services 6.3 Net revenue of forest enterprises
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Objective on carbon farming, biodiversity-friendly re- and afforestation, agroforestry and other non-productive investments for environment- and climate-related objectives

<i>“Member States are also encouraged to accelerate the roll out of carbon farming practices, for instance via eco-schemes on agroforestry or rural</i>	17	Carbon farming Biodiversity-friendly re- and afforestation Agroforestry	Pan European Guidelines on Afforestation and Reforestation were published in 2008 (with UNEP/PEBLDS). Biodiversity friendly re- and afforestation, is not precisely defined, and not at	No	None
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<i>development interventions to cover biodiversity-friendly re- and afforestation investments, agroforestry and other non-productive investments for environment- and climate-related objectives”</i>			present, measurable, at the national or EU level. The pan-European indicators do not address agroforestry and trees outside forests.		
Section 4. Strategic forest monitoring, reporting and data collection					
Objectives proposed for forest management plans					
<i>“share of forest areas covered by forest management plans (FMPs) should cover all managed public forests and an increased number of private forests”</i>	21	Area covered by FMP FMP broken down by managed public and private forests	Not addressed in the quantitative pan-European indicators but within the qualitative indicators this information is covered quantitatively.	Partial	Qualitative indicator C.3 Policies, institutions and instruments to maintain and encourage the productive functions of forests
<i>“FMPs should include forest-related risk assessment and management, as well as better integrate biodiversity-related data”</i>	21	Inclusion of risk assessment in forest management plans	Forest risk assessment in not part of the pan-European indicators.	No	None
<i>“the Commission will (...) perform a comparative assessment of requirements and criteria included in FMPs and consider setting further criteria in close cooperation with Member States to ensure that the FMPs meet the climate, biodiversity, bio-economy and social and rural development objectives of this strategy”</i>	21	requirements and criteria included in FMP	Not compatible.	No	None
Section 5. A strong research and innovation agenda to improve our knowledge on forests					
<i>“promote a science-based contribution of EU forests to the European Green Deal ambitions of climate neutrality and resilience, biodiversity and sustainable growth.”</i>	22	Science-based contribution	Not compatible. The pan-European indicators do not address science-based contribution.	No	None

<i>"reinforcing the knowledge on climate change impacts, contributing to a greater diversity of forests and genetic resources, and providing evidence-based and practically feasible guidance for climate change mitigation and adaptation in line with biodiversity objectives"</i>	22	Knowledge Evidence-based and practically feasible guidance	Not compatible. The pan-European indicators do not address knowledge and evidence-based and practically feasible guidance.	No	None
<i>"holistic approach on new and emerging pests and diseases will aim to reduce biotic disturbances and risks"</i>	22	Forest damages	The pan-European indicators provide information on 2.4 forest damages but not on related risk management nor on increased resilience.	Partial	2.4 Forest damage
<i>"sound and site-adapted forest and soils restoration will be supported including through the research and innovation mission on soil health and food."</i>	22	Soil properties Forest restoration	The pan-European indicators provide information on soil condition, but not on forest restoration.	Partial	2.2 Soil condition
<i>"an improved understanding of primary and old-growth forests and of their biodiversity and climate functions will be sought."</i>	22	Primary and old-growth forests and their biodiversity and climate functions	Indicator 4.3 Naturalness provides only information on the area of forests undisturbed by man. Primary and old-growth forests are not reported separately.	No	None
<i>"more value on sustainable and multifunctional forests and to maximise their benefits for society"</i>	22	Socio-economic functions of forests	The pan-European indicators address policy instruments for the socioeconomic functions of forests, including for the value chain and its contribution to GDP.	Partial	Qualitative indicator C.6 Policies, institutions and instruments to maintain other socioeconomic functions and condition:
<i>"research and innovation on agroforestry systems and other trees outside the forests will be reinforced"</i>	22	Agroforestry Trees outside forests	Not compatible. The pan-European indicators do not address agroforestry and trees outside forests.	No	None
<i>"Forest-based projects should help diversify the income of forest owners and managers, and increase the sustainability and circularity of the forest-based economy"</i>	22	Forest owner income Sustainability and circularity of the forest-based economy	The pan-European indicators provide information on quantity and market value of roundwood (3.3), quantity and market value of non-wood goods from forest and other wooded land (3.4), and Net revenue of forest enterprises (6.3). The pan-European indicators do not include sustainability and circularity of the forest-based economy.	Partial	3.2 Roundwood, 3.3 Non-wood forest products, 6.3 Net revenue of forest enterprises

Section 6. Inclusive and coherent EU forest governance framework

No relevant quotations found

Section 7. Stepping up implementation and enforcement of existing EU acquis

No relevant quotations found

Table S3: Commitments of the New EU Forest Strategy 2030 compared to the pan-European indicator framework

Commitments	Parameter(s) which might be monitored	Compatibility with the pan-European indicator framework of the Forest Europe process	Pan-European indicators to monitor progress?	Pan-European indicators relating to commitments
Section 2. Supporting the socio-economic functions of forests for thriving rural areas and boosting forest-based bio-economy within sustainability boundaries				
As part of the review of the construction products regulation establish a standard, robust and transparent methodology to quantify the climate benefits of wood construction products and other building materials, reflecting the most advanced dynamic life cycle analysis techniques.	Carbon stocks and flows in harvested wood products (HWP) Substitution factors	HWP and substitution are not addressed. (HWP is addressed in IPCC reporting)	Partial	1.4 Forest carbon
As part of the Common Agricultural Policy and to increase forest support, provide new means to share information on good practices on best design and implementation of forest-relevant interventions.	Implementation of “good practices” for “forest-relevant interventions”	Not addressed (the pan-European indicators address only national, not stand level sustainability. “Good practices” are not defined.	No	
Promote the use of the Natura 2000 logo for non-wood forest-based products and services.	Change in production and consumption of non-wood forest-based products and services (especially originating in Natura 2000 sites)	3.3 and 3.4 on production of non-wood goods (NWG) and services (many data issues). 4.9 on protected forests But no links between indicators under Criterion 3 and Criterion 4 and we do not have data for NWG and services from only Natura 2000 sites	Partial	3.3 Non-wood goods 3.4 Services 4.9 Protected forests
Review, complement and update the Taxonomy Climate Delegate Act technical screening criteria for forestry and bioenergy where necessary to take better into account biodiversity friendly practices that are under development such as close to nature forestry. Consider including sustainable activities related to harvesting, production and use of wood products in the forthcoming delegated acts of the	Support through EU funds for “biodiversity friendly” close to nature forestry, sustainable activities related to harvesting, production and use	“Activities” are not addressed. No possibility to address whether particular activities (inside or outside the forest) are sustainable or not (focus on national level, unwillingness to set thresholds or determine sustainability.	No	

Regulation Taxonomy on other environmental objectives.	of wood products etc. Increase in these activities			
Create a new alliance between the professionals of tourism and foresters, involving the World Tourism Organisation and the network for Europe's natural and cultural heritage.	Closer links between tourism and forest management. More forest dependent (forest related) tourism.	6.10 on forest recreation (includes tourism alongside many other types of recreation) provides some information on the use of forests for tourism, but the data are very weak, and no information on forest-tourism links.	Partial	6.10 Recreation in forests
Build a toolkit to help Member States to establish life-long programs and advice to foresters and adapt education and training to the challenges and needs of today's forest needs and realities, and develop employment opportunities	Improvement in forest related education and training making it more relevant to today's needs. Improved employment opportunities.	Education and training feature in the pan-European countries' reporting on "institutions" (although they are not asked to report whether they are relevant to "today's forest needs and realities". 6.5 monitors the forest sector workforce.	Partial	6.5 Forest sector workforce
Encourage forest and forestry stakeholders to establish a skills partnership under the Pact for Skills and make use of the European Social Fund Plus to work together to increase the number of upskilling and reskilling opportunities in forestry.	Upskilling and reskilling in forestry	6.5 on forest workforce considers skills level of workforce but not in much detail.	Partial	6.5 Forest sector workforce
Section 3. Protecting, restoring and enlarging EU's forests to combat climate change, reverse biodiversity loss and ensure resilient and multifunctional forest ecosystems				
Propose a legally binding instrument for ecosystem restoration, including forest ecosystems, by the end of 2021.	State of forest restoration (hectares restored? Share of degraded forest which has been restored?)	2.5 Forest land degradation is a rather new indicator (included in 2015 into the set), but as yet not properly functional. There are no definitions of forest restoration, not even by the Bonn Challenge.	Partial	2.5 Forest degradation
Develop guidelines on the definition of primary and old-growth forests, including their definition, mapping, monitoring and strict protection, by the end of 2021.	Extent, location and protection status of all EU primary and old-growth forests	4.3 Naturalness identifies forests "undisturbed by man" (The FAO Forest Resources Assessment uses the term "primary forests"), but there is tension over definitions and no information on the share of	Partial	4.3 Naturalness

		old-growth forests, as primary forests could also be in a succession stage after excess of age.		
Together with the Member States and in close cooperation with different forest stakeholders, identify the additional indicators as well as thresholds or ranges for sustainable forest management, and assess how these could best be used, starting on a voluntary basis, by the Q1 2023.	Progress towards functional and accepted SFM monitoring system (with “thresholds or ranges”)	The pan-European indicator framework could be used for this, but so far, there are no agreed thresholds or ranges available for the 45 pan European member countries and the EU and a joint agreement seems very difficult to be reached.	Partial	Whole set
Develop guidelines on biodiversity friendly afforestation and reforestation, by Q1 2022.	Existence of useful and widely accepted guidelines	Pan European Guidelines on Afforestation and Reforestation were published in 2008 (with UNEP/PEBLDS). They could be amended and updated.	Yes	4.1 Diversity of tree species 4.3 Naturalness 4.4 Introduced tree species
Develop a definition and adopt guidelines for closer-to-nature-forestry practices, by Q2 2022, as well as voluntary closer-to-nature forest management certification scheme, by Q1 2023.	Existence of guidelines on closer-to-nature forestry Increased application of closer-to-nature forestry Existence of voluntary closer-to-nature forest management certification scheme (area certified?)	No definition available. Forest Europe has addressed these issues, but not in its indicator framework. They could provide a framework to draw up guidelines (they already have produced guidelines). As regards certification, there are a number of EU bio certification schemes (mostly for agriculture), but presumable FSC/PEFC would not be too delighted, and would resist encroachment.	Partial	Whole set
Provide guidance and promote knowledge exchanges on good practices on climate adaptation and resilience, using inter alia the Climate-ADAPT platform	Availability of knowledge and guidance is clearly a good thing, but hard to measure.	Forest Europe does some knowledge exchange, but on a small scale.	Partial	1.4 Forest carbon 2.4 Forest damage
Supplement the revision of the legislation on forest reproductive material with measures to promote the production and marketing of forest reproductive	Availability of forest reproductive material suitable for future climatic	4.6 addresses genetic diversity, but the EUFORGEN analysis concentrates on protecting genetic diversity, not on improving reproductive material.	No	

material suitable for future climatic conditions, by the end of 2022.	conditions (assumes we know what is needed)			
Promote forest-related interventions in the future CAP (2023-2027) in relation to the European Green Deal objectives, in particular the set-up of ecosystem services payment schemes and roll-out of carbon farming practices, and in other EU financial instruments (e.g., Cohesion Policy, LIFE, Horizon Europe, EU crossborder cooperation programs (Interreg))	Existence/size/effectiveness of schemes for payment for ecosystem services and carbon farming	3.4 addresses value of marketed services (which might include “carbon farming”), but not the schemes to provide these services.	Partial	3.4 Services
Provide advice and technical guidance on the development of ecosystem service payment scheme, by November 2021.	Implementation of Payments for Forest Ecosystem Services (PES) schemes	3.4 and 6.3 provide some relevant information on PES. Forest Europe has an Expert Group on Valuation and Payments for Forest Ecosystem Services.	Partial	3.4 Services 6.3 Net revenue
Promote forest-related remuneration schemes in an action plan for both carbon farming and carbon removal certification, to be adopted by the end of 2021	Action plan for carbon farming Action plan for carbon removal certification	1.4 addresses carbon stocks and flows, but nothing as specific as carbon farming or Carbon certification.	Partial	1.4 Forest carbon
Carry out a study on behavioral science regarding the uptake of public funds by foresters to better identify further policy improvement routes.	Uptake of public funds by foresters	Public funds are included in net revenue (6.3), but nothing on forester behaviour.	No	
Identify and address possible hurdles posed by current EU legislation and the State Aid Guidelines to grant adequate public support to services beneficial for the public interest	Removal of “hurdles” (incidentally, no mention of forests in this commitment)	No policy analysis	No	
Section 4. Strategic forest monitoring, reporting and data collection				
Put forward a proposal for a new legislative proposal on EU Forest Observation, Reporting and Data Collection to ensure a coordinated EU forest monitoring, data collection and reporting system...	Effective forest monitoring system Strategic Plans for forests and the forest based sector	Forest Europe is, together with UNECE/FAO and others, part of the existing forest monitoring system. Its effectiveness could be improved. is true that it is possible to improve it. Many countries have National Forest Programmes, which they report to Forest Europe. The	Partial	Whole set

		Commission proposal appears to be for a purely EU-centred strategic plan. There are two issues: improving the information and who should be responsible for it.		
... As part of this, Member States competent authorities would prepare Strategic Plans for Forests for forests and the forest based sector, in full respect of the subsidiarity principle and the Treaty, by Q1 2023.			Partial	Qualitative indicator 1 National Forest programmes or equivalent
As part of the Forest Information System for Europe (FISE), on the basis of improved Copernicus products, other remote-sensing data and ground-based monitoring, strengthen the existing monitoring of climate effects and other natural or human-induced disturbances on forests.	Improved monitoring of forest/climate issues, and access to results	FISE appears to be an open and comprehensive arrangement, with links to Forest Europe and many others.	Yes	2.4 Forest damage
Prepare and publish regular reports and lay summaries on the forests in the EU with the support of a broader European forest science partnership.	Availability of regular high-quality information	This mandate is very similar to the activities of Forest Europe, notably the preparation of the State of Europe's Forests reports. Need for cooperation!	Yes	Whole set
Through its Joint Research Centre, develop a European forest science partnership, with a view to support the development of new indicators based on remote sensing and the latest research results	New indicators	There is presently also an ESA call open on monitoring SDG15 indicators by remote sensing	Yes	Whole set
Section 5. A strong research and innovation agenda to improve our knowledge on forests				
Develop a "Planning our Future Forests" research and innovation agenda together with Member States and stakeholders by jointly identifying research gaps and future priorities for forestry and the forest-based sector.	Forestry research and innovations		No	
Support the evidence-based design and implementation of forest restoration strategies with engagement of the society and in different ecological and socio-economic settings, including through the planned research and innovation mission on soil health for forest soils.	Implementation of forest restoration strategies (qualitative)		Partial	2.5 Forest land degradation
Enhance EU cooperation by proposing a Research and Innovation partnership on forestry, including flagships	Forestry research and innovations		No	

for testing and demonstrating solutions on selected key strategic domains			
Through the Horizon Europe Civil Security for Society programme, implement complementary actions in support of Disaster Risk Reduction policies (including forest fires), to enhance capacities in risk and resilience management and governance.	Disaster risk related actions	No	
Develop a Citizens' science Programme for forest biodiversity, notably engaging citizens and civil society in monitoring forest biodiversity	Indicator species	Partial	C4 all indicators