Food and Agriculture Organization of the United Nations

UNECE

Detailed methodology for the preparation of the forest sector outlook study 2020-2040

UNITED NATIONS

Food and Agriculture Organization of the United Nations

UNECE

Detailed methodology for the preparation of the forest sector outlook study 2020-2040

UNITED NATIONS

COPYRIGHT AND DISCLAIMER

Copyright © 2023 United Nations and the Food and Agriculture Organization of the United Nations.

All rights reserved worldwide.

Requests to reproduce excerpts or to photocopy should be addressed to the Copyright Clearance Center at copyright.com.

All other queries on rights and licenses, including subsidiary rights, should be addressed to: United Nations Publications, 405 East 42nd Street, S-09FW001, New York, NY 10017, United States of America. Email: permissions@un.org; website: https://shop.un.org.

The designations employed in publications of the United Nations Economic Commission for Europe (UNECE) and the Food and Agriculture Organization of the United Nations (FAO), which are in conformity with United Nations practice, and the presentation of material therein do not imply the expression of any opinion whatsoever on the part of UNECE or FAO concerning the legal status of any country, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. The responsibility for opinions expressed in studies and other contributions rests solely with their authors, and publication does not constitute an endorsement by UNECE or FAO or its officials or Member States of the opinions expressed. Reference to names of firms and commercial products and processes, whether or not these have been patented, does not imply their endorsement by UNECE or FAO, and any failure to mention a particular firm, commercial product or process is not a sign of disapproval.

This work is copublished by the United Nations (UNECE) and FAO.
This publication is issued in English.
Photo credits: Pexels

Abstract:

This methodology report provides a detailed description of background, assumptions, approaches and modelling tools utilized in the UNECE Forest Sector Outlook Study 2020-2040 (FSOS) main report. The main report summarizes and discusses the forest sector impacts in UNECE region and subregions of reference and "what-if" scenarios depicting future trajectory of socioeconomic changes, climate change, and structural changes in demand, supply and trade of forest products, globally and in the UNECE region and subregions.

More specifically, this methodology report provides detailed information on i) the selected sets of reference and the alternative "what-if" scenarios, including their development and selection process, assumptions, and justification, and ii) the modelling approaches and global models utilized to simulate and analyse those scenarios, including the Global Forest Products Model (GFPM) and an adjunct to the GFPM that generates separate estimates of carbon sequestered in forest biomass and in harvested wood products

ECE/TIM/DP/90
UNITED NATIONS PUBLICATION
Sales No. E.22.II.E.37
ISBN 978-92-1-117322-2
eISBN 978-92-1-002374-0
ISSN 1020-7228
eISSN 2412-1304

ACKNOWLEDGEMENTS

The UNECE/FAO Forestry and Timber Section expresses its deep gratitude to Jeffrey Prestemon and Prakash Nepal, the authors of this Discussion Paper, which describes in detail the methods and variable used for modeling the various scenarios of the Forest Sector Outlook Study 2020-2040. The UNECE/FAO Forestry and Timber Section is grateful to the Netherlands and the Swiss Confederation for their financial support to the preparation of the Outlook Study, including this Discussion Paper.

This Discussion Paper and the Forest Sector Outlook Study 2020-2040 are the result of a cooperative effort involving a network of authors, reviewers, editors, the UNECE/FAO Team of Specialists on Forest Sector Outlook, and the Joint UNECE/FAO Forestry and Timber Section in Geneva as well as FAO in Rome. In combination, this network provided an unrivalled source of expertise and knowledge, which is the hallmark of the Outlook Study, including this Discussion Paper.

The UNECE/FAO Forestry and Timber Section would like to express its gratitude to the individuals and organizations who contributed their time, expertise, and resources to this Discussion Paper and the Forest Sector Outlook Study 2020-2040. Douglas Clark edited the Discussion Paper. The study was managed by the UNECE/FAO Forestry and Timber Section and reviewed by the FAO.

This manuscript was completed on 1 December 2023.

EXPLANATORY NOTES

For ease of reading, the publication mostly provides value data in United States dollars (indicated by the sign "$" or as "dollars").

The list of countries in the annex provides a breakdown of the region into its subregions. References to EU27 refer collectively to the 27 country members of the European Union. When "Europe" or "EU" is mentioned in connection with a reference, i.e. not as part of the modelling analysis, then it refers to the group of countries as defined by the reference. The term Eastern Europe, Caucasus and Central Asia (EECCA) is used for reasons of geographic proximity and similarities in economic structure and refers collectively to 12 countries: Armenia, Azerbaijan, Belarus, Georgia, Kazakhstan, Kyrgyzstan, Republic of Moldova, Tajikistan, Turkmenistan, Ukraine and Uzbekistan. It is used solely for the reader's convenience. The Russian Federation, normally included in the country group of the EECCA, is referred to separately due to the model setup and importance of the Russian Federation in the global context.

The term industrial roundwood is used interchangeably with logs.
All references to tonnes in this text represent the metric unit of 1,000 kilograms unless otherwise indicated. A billion refers to a thousand million (10^9). One trillion refers to one million million, or 10^{12}.

Contents

List of tables

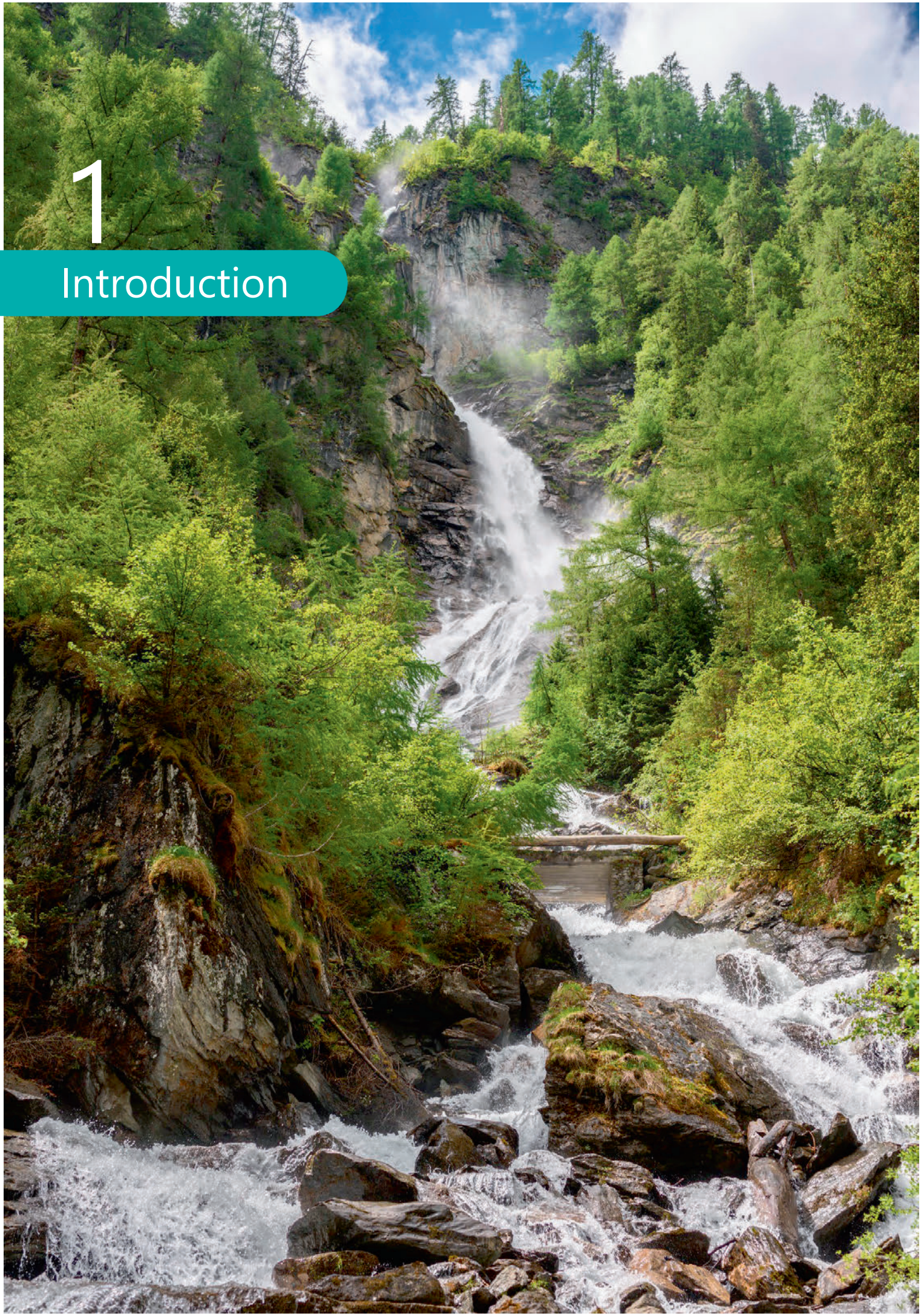
List of figures

List of abbreviations, acronyms and symbols

(Infrequently used abbreviations spelled out in the text may not be listed here)

$	United States dollar(s) unless otherwise specified
CAGR	compounded annual growth rate
CCPC	Climate change related productivity change
CLT	cross-laminated timber
CO_2	Carbon dioxide
EKC	Environmental Kuznets Curve
FAO	Food and Agriculture Organization of the United Nations
FBND	Forest based natural disturbances
FSOS	Forest Sector Outlook Study
FSOS III	Forest Sector Outlook Study 2020-2040
GDP	Gross Domestic Product
GFPM	Global Forest Products Model
HFA	High Forest Area
HFA	High forest area
HPFA	High planted forest area
HWC	High Wood Consumption
HWFC	High Wood Fibre Consumption
HWP	Harvested wood products
IIASA	International Institute of Applied System Analysis
IPCC	Intergovernmental Panel for Climate Change
m2	square metre(s)
m3	cubic metre(s)
MT	Metric tonne
NPP	Net Primary Productivity
RCP	Representative Concentration Pathway
SDG	Sustainable Development Goal
SSP	Shared Socioeconomic Pathway
ToS	Team of specialists
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US	United States of America
USDA	United States Department of Agriculture
W/m2	Watts per square meter

1 Introduction



This methodology report provides a detailed description of background, assumptions, approaches and modelling tools utilized in the UNECE Forest Sector Outlook Study 2020-2040 (FSOS III) main report. The main report summarizes and discusses the forest sector impacts in UNECE region and subregions of reference (see annex E) and "what-if" scenarios depicting future trajectory of socioeconomic changes, climate change, and structural changes in demand, supply and trade of forest products, globally and in the UNECE region and subregions. More specifically, this methodology report provides detailed information on i) the selected sets of reference and the alternative "what-if" scenarios, including their development and selection process, assumptions, and justification, and ii) the modelling approaches and global models utilized to simulate and analyse those scenarios, including the Global Forest Products Model (GFPM) and an adjunct to the GFPM that generates separate estimates of carbon sequestered in forest biomass and in harvested wood products.

2 Scenarios development and selection process

The scenarios developed and modelled in this outlook are based on FSOS country representatives' own suggestions, gathered through outreach by the Secretariat and the FSOS leadership in 2018, on the most important policy and management questions and related issues likely to be affecting the forest sector of the UNECE. After a series of meetings and workshops, the UNECE/FAO Team of Specialists on Forest Sector Outlook as well as the Joint UNECE/FAO Working Party on Forest Statistics, Economics and Management (Joint Working Party), developed a set of possible policy questions to be considered for the FSOS III. The set of questions were expected to cover most of the current policy debates relevant for the UNECE region and subregions as of 2018[1]. The identified important policy questions were categorized into three broad themes of inquiry: i) climate change mitigation and adaptation, ii) structural changes in forest products demand and supply, and iii) the green economy and sustainable development goals. Within each of the three broad themes, a range of possible scenarios were proposed that would potentially shed light on some of the most important forest policy and economics issues. The scenarios were further prioritized, based on the priority ranking by the participants in a meeting of the Team of Specialists on Forest Sector Outlook, on a scale from 1 (low) to 3 (high) priority. The scenarios receiving average priority ranking of more than 2 were climate change mitigation, growth of specific products (construction, fibres, biorefineries), climate change adaptation, upcoming market scenarios (e.g., a shift in wood products demand in China and supply in Africa), economic disturbances, forest-based natural disturbances, nature conservation, and trade barriers (Annex A, TABLE A3). Seventeen specific alternative scenarios were recommended to incorporate these high priority scenarios (Annex A, TABLE A1), including: 1) the potential of carbon sequestration in wood products resulting from the assumed increase in wood construction in the UNECE region or globally, 2) the potential of carbon sequestration in traditional wood products due to policy-driven significant increases in demand for wood products in the UNECE region or globally, 3) the potential of carbon sequestration in new products consuming wood fibres due to assumed technological advances allowing a significant increase of wood fibre use, 4) the potential of carbon sequestration through (re-) forestation due to assumed policy driven significant increase of forest area in the UNECE region and subregions, 5) the maximization of carbon sequestration by changing silvicultural methods (updating the EFSOS II scenario "maximizing biomass carbon"), 6) the potential of climate change mitigation through substitution in the energy sector through an increased use of energy, 7) a combination of above scenarios to determine the maximum carbon sequestration that could be achieved, given competing demands for wood products (possibly looking at climate smart forestry), 8) differences in the supply of forest resources (timber stocks) under the four representative concentration pathways (RCPs) from the IPCC's 5th Assessment Report (possibly looking at resilience as well), 9) a massive increase in demand for wood used in construction within UNECE region or outside (especially China), 10) a significant increase in demand for wood-fibres for textiles and other products (linked to no. 3 above), 11) a significant economic collapse globally and/or in specific countries/regions/subregions, 12) the successful development of an alternative energy source and thus a drastic decrease in the demand for wood energy, 13) a significant decrease in demand for printing and writing (graphics) paper with a simultaneous increase in the demand for packaging paper, 14) a significant increase in biorefinery capacity, 15) a significant increase in the area of forest plantations outside of the UNECE region (e.g., in Africa and/or Asia), 16) a significant increase in the rate, severity, or extent of forest-based natural disturbances, and 17) the adoption of new and more highly restrictive trade barriers between countries and/or regions/subregions.

The modelling team worked on the feasibility of modelling all of the recommended high priority scenarios to the extent possible and finally selected a set of reference and alternative scenarios, believed to address the majority of the suggested policy questions. The scenario selection process was guided by several criteria, including: 1) the availability of a

[1] See Appendix A for the list of recommended and prioritized policy scenarios.

global forest sector model with the capability to model the majority of recommended scenarios in an integrated way (i.e., avoiding a need to separately model UNECE subregions as done in past forest sector outlook studied carried out by the Team of Specialists on Forest Sector Outlook, 2) the availability of up-to-date literature that could provide answers to the recommended policy questions in lieu of new modelling, and 3) the availability of the financial resources and expertise needed to model the recommended scenarios.

Based on the above-mentioned criteria, the modelling team were able to model 12 different scenarios (including 3 reference scenarios) addressing most of the suggested high priority policy questions relevant in the UNECE subregions (see TABLE A1, TABLE A2 and TABLE A3 in Annex A). A detailed description of the selected sets of scenarios follows next, focusing on the assumptions about future socio-economic and forest sector variables and how the selected scenario assumptions are linked to those recommended important policy questions relevant in the UNECE subregions.

Following the conventional approach to forest sector outlook studies, the FSOS III modelled reference and alternative scenarios so that the differences in model outcomes between the given reference and the alternative scenario pair could represent the forest sector impacts of a given policy shock. However, in contrast to the conventional approach in developing reference scenarios, where it usually would represent only one future under which current trends would be assumed to continue and policies would remain unchanged, the modelling team selected three distinct reference scenarios representing three contrasting socioeconomic futures. While one of the selected reference scenarios for the next FSOS represents conventional "business-as-usual" or the "continuation of the current trends" scenario, the other two reference scenarios additionally represent contrasting visions of the future, one of a relatively poor world and the other of a relatively rich world. In other words, the three reference scenarios facilitate an understanding of how markets and aggregate measures of forests may potentially evolve into the future under varying expectations regarding economic and population changes spanning 2015 to 2040 but holding constant policies, historical rates of technology change, and potential new products, and no changes in climate. The alternative scenarios quantify the effects of imagined structural changes in the forest sector in addition to the economic and population changes. The main purpose of such scenario modelling is to evaluate how significant departures from recent patterns of supply, demand, trade, and forest productivity (structural changes) could impact forests and forest products markets of the UNECE region. Structural changes are modelled under the rubric of "what-if" scenarios, which alter specific, individual assumptions about an element of supply or demand in the forest sector of the UNECE region and globally.

TABLE B1 in Annex B summarizes three sets of SSP reference scenarios, and eight alternative "what-if" scenarios, paired mostly with the SSP2 reference scenario, totalling to 11 individual scenarios, which are believed to address most of the policy debates in the UNECE subregions identified for the current forest sector outlook study (FSOS III).

2.1 Reference scenarios

To understand the effects of the structural changes modelled in each of the alternative (what-if) scenarios discussed in the next section, it is necessary to understand how the future of the UNECE forest sector would unfold under assumed continuation of market structures, absent shifts in policies, historical rates of technology change, and potential new products, and under historical climate. Such projected futures for the period 2015 to 2040 are provided for three of five Shared Socioeconomic Pathways (SSPs) defined by the International Institute for Applied Systems Analysis (IIASA): SSP2, SSP3, and SSP5. Any one of these three SSPs can serve as a reference benchmark for this outlook study, the projected outcomes of each of which can be used to gauge the effects of the alternative what-if scenarios. However, the effects of assumed changes in various demand and supply elements under the alternative what-if scenarios are described, in the main report, relative to the SSP2 reference scenario only, except for the climate change what-if scenario, whose effects are described relative to the SSP5 reference scenario. This outlook study chose the framework of the SSPs because (i) with data provided by modelling teams such as the IIASA, they offer a transparent set of quantitative descriptions of

future income and population by country under each SSP through the end of our projection period for this Outlook, (ii) they offer a plausible range of potential economic and demographic futures for the UNECE region and the world, and (iii) they are the same framework used by other forward-looking assessments done for individual countries and subregions of the UNECE (e.g., the United States Department of Agriculture (USDA) Forest Service's 2020 Resources Planning Act Assessment) and carried out for other economic sectors, enabling more consistent comparisons across studies.

Shared socioeconomic pathways (SSPs) were developed in concert with projections of greenhouse gas concentrations to 2100, representative concentration pathways (RCPs), to provide scenarios of plausible alternative projections of societal development in the coming decades. They are comprised of storylines that include both quantitative data on population and aggregate economic output and qualitative descriptions of other societal factors such as technology and governance. These five SSPs were defined by the degree of challenges facing societies to either adapt to or mitigate climate change. The SSPs do not provide policy options, nor do they include climate feedbacks on society (O'Neill et al. 2014, 2017). Policy options, for example to achieve particular rates of climate change or particular concentrations of greenhouse gases, are left to the analyst to define. The detailed descriptions of the narratives are provided in O'Neill et al. (2017). Here, we briefly summarize the important elements shaping alternative world futures envisioned under the three SSPs used as reference scenarios in the current Outlook.

SSP2 represents the "business-as-usual" or the "middle-of-the-road" world vision, where future development pathways are assumed to be in consistent with historical social, economic, and technological trends.

SSP3 is described as "regional rivalry–a rocky road" and represents a vision of a fragmented and poorer world compared to other SSPs. It projects the lowest overall per capita income and contains the most disparate income per capita across countries compared to all other SSPs. High policy, economic,

and technological challenges to both mitigation and adaptation are expected, due to assumed slow economic and technological development, worsening global inequalities, material-intensive consumption, a large dependence on fossil fuels, low international cooperation, and higher population growth in developing countries compared to wealthy countries.

Finally, SSP5, described as the "fossil-fuelled development–taking the highway", represents the wealthiest future and higher levels of economic equality than SSP2 and SSP3. This pathway emphasizes the development of an enhanced social and human capital base that is obtained through high levels of investments in health, education, and institutions. However, there remains a strong dependence on fossil fuels for energy into the foreseeable future, with limited investment targeted at addressing global environmental problems compared to SSP2, implying increased challenges to climate change mitigation efforts. Robust economic growth coupled with attainment of human development goals, however, reduce society's challenges in climate change adaptation.

Although these narratives qualitatively describe how various socioeconomic variables would look in the future, the quantitative projections are available for only limited subset of those variables (dimensions) of each SSP. Key among those quantitative variables are gross domestic product (GDP) and population by country (IIASA 2018) and the shares of urban and rural

populations by country (Jiang and O'Neill 2017). The quantification of future land use change is also available at the regional and global level for each SSP (e.g., Riahi et al. 2017), although not by country. In addition, the modelling team assembled for this Outlook developed quantitative projections of future total forest area by country by implementing an Environmental Kuznets Curve (EKC) approach (Buongiorno 2015) and of future planted forest area, also based on the EKC approach, as described in Korhonen et al. (in review). These projections of total and planted forest areas by country were incorporated as inputs to the global forest products model used to model the majority of the scenarios for this Outlook.[2]

Varying visions about how economic and demographic conditions of individual countries could change in future, together with assumptions imposed by the modelling approach, shape the outlook of forest resources and forest product markets in the UNECE region. These variations are effectively characterized by contrasting future trajectories of key socioeconomic drivers under different shared socioeconomic pathways (SSP2, SSP3 and SSP5). Projected changes in per capita income, rural population density, and labour force per unit of forest area result in distinct trends in forest area (total forest area and planted forest area) by country, which in turn drive trends in forest stock volumes. Because stocks affect the availability of industrial roundwood needed to produce various intermediate and final wood products in each country, more (less) forest means higher (lower) quantities of forest products supplied at every price level. Simultaneously, increases (decreases) in income act to increase (decrease) the quantity of forest products demanded at every price level. Market-clearing conditions produce, for each period, country by country results on final market prices, production, consumption, imports, and exports. Likewise, the market-clearing conditions allow for a characterization of the net carbon sequestration offered by standing forests and storage in harvested wood products.

2.2 Alternative or "what-if" scenarios

The alternative scenarios, which assume departures from historical levels or trends in a single element of demand or supply, are modelled under the rubric of "what-if" scenarios. The "what if…" posited in each scenario was based upon suggestions by UNECE member States of critical uncertainties about the future. Eight sets of alternative scenarios were developed to address most of the suggested policy questions relevant to the forest sector in all or parts of the UNECE region or globally.

The what-if scenarios representing structural changes with impacts on the demand for forest products side included the following: (1) What if China starts building every tenth new housing unit with wood? This scenario is referred to as the China-High Wood Consumption of China-HWC. (2) What if Europe were to increase its per capita consumption of sawnwood and wood-based panels by 2040 to the same per-capita consumption of these products as observed in the United States of America (US) in 2015? This scenario is referred to as the Europe-High Wood Consumption or Europe-HWC scenario. (3) What if the global textiles sector were to replace 30% of its total fibre consumption with wood-based fibre by 2040? This scenario is referred to as the Textile-High Wood Fibre Consumption or Textile-HWFC scenario.

The what-if scenarios representing structural changes in forest products on the supply side include the following: (4) What if aggressive climate change mitigation policies worldwide lead to an overall increase in global total forest area? This scenario is referred to as the High Forest Area or HFA scenario. (5) What if there is a significant increase of planted forest area outside of UNECE region? This scenario is referred to as the High Planted Forest Area or HPFA. (6) What if there are productivity changes in forests due to CO_2 fertilization from greenhouse gas accumulations and associated changes in temperatures, precipitation, and disturbances? This scenario is referred to as the Climate Change Related Productivity Change or CCPC scenario. (7) What if the UNECE region experience increased rates of forest-based natural disturbances linked to climate change and to spread of invasive exotic pests? This scenario is referred to as the Forest Based Natural Disturbances or FBND scenario.

Finally, the what-if scenario representing changes in forest products trade policy intervention—effectively, a structural change in conditions affecting global equilibria in both

[2] Initially, all five SSPs were considered reference scenarios, and therefore the GFPM model runs were obtained for each SSP, where forest products demand and supply were driven by GDP, population, forest area, and planted forest area in 180 countries, exogenously projected in each SSP. However, because the projected results and trends were very similar between SSP1 and SSP5, and between SSP2 and SSP4, the modelling team utilized only SSP2, SSP3, and SSP5 as the reference scenarios for this outlook study.

forest product demand and supply, is: (8) What if global trade in forest products between countries and/or regions/subregions is significantly restricted? This scenario is referred to as the Restricted Trade in Forest Products or RTFP.

2.2.1 China-High Wood Consumption (China-HWC) scenario

The China-HWC scenario is intended to model the effects within the UNECE forest sector of a potential (sizable, unanticipated) increase in wood products demand outside of the UNECE region. China's housing market was chosen because its large size would make it globally influential in markets for forest products, should wood-based construction there increase substantially. Because the current use of wood in housing in China accounts for a small share of wood consumed there, less than 0.1% of the 10 million annual units built in recent years (Geng et al. 2019), a sudden policy change which imagines that 10% of new housing units are of the same square footage and wood content found in the typical multifamily (apartment) dwelling in the United States would represent a significant shock to China's and the world's total construction wood demand, approaching (but still less than) average rates of new residential wood-based construction levels currently experienced in the United States.

To evaluate the effect of this scenario using the Global Forest Products Market Model, it was necessary to estimate the additional sawnwood and wood-based panels consumption resulting from assumed increases in wood use in China's residential construction sector. Such estimated additional wood consumption, above rates observed in this Outlook's reference scenarios, was derived from a combination of data sources and assumptions (TABLE 22.1). First, future numbers of total housing units built in China were estimated by dividing projected population in China under SSP2 (IIASA 2018) by the average household size (persons/house) in China (United Nations 2017), the latter assumed to remain unchanged during the projection period (2015-2040). By assumption of this scenario, 10% of new estimated total housing units would be built of wood. The new units with wood could either be built from additions to the existing or projected housing stock or from replacements of units lost/destroyed. We estimate that 1% of housing stocks are lost/destroyed annually. Although the estimated average lifespan of new building in China is reported to be much lower (e.g., 35 years[3]), the analysis assumed similar average lifespan of a single-family unit as in the United States (Skog and Nicholson 1998). Thus, approximately 25% of existing housing units would be replaced with wood-framed house during the projection period (25 years). Another assumption pertains to floor space per housing unit, which is assumed as 100 square metres (m^2) (1074 square feet), the median square footage floor space constructed in 2015 in a single unit of multifamily housing units in the United States (US Census Bureau 2020). The next assumption needed to estimate increased wood consumption in China's housing sector relates to the intensity of wood use in construction, which can range from 0.2 to 0.6 cubic metres (m^3) per m^2 of installed floor space, depending on the design of the building (Hurmekoski 2017). The lower value represents commonly used wood intensity in light frame structures (e.g., in Sweden), and the higher values are common in cross-laminated timber (CLT)-based structural frames in high rise buildings (e.g., in Central Europe) (Hurmekoski 2017); this analysis assumed the midpoint (0.4 m^3/m^2) in that range.

To estimate the additional amounts of total solidwood (sawnwood plus panels) consumption in China, the estimated total new wood-framed housing units were multiplied by assumed floor space per housing unit (100 m^2/unit) and by average intensity of wood use per square meter (0.40 m^3) (TABLE 22.1). The estimated total solidwood consumption was then disaggregated into sawnwood and panels consumption using the 2015 shares of sawnwood and panels consumptions, respectively in total 2015 solidwood consumption in China (TABLE 22.1). Such calculations gave rise to an estimated annual increase in sawnwood and panels consumption in the China-HWC scenario of about 3.4% per year during 2015-2040 (TABLE 22.1), which were used to shift the demand curves for these two products in the Global Forest Products Market Model.

[3] https://chinaeconomicreview.com/unstable-foundations-part-2/

TABLE 22.1

Values and assumptions used to estimate increased sawnwood and panels consumption in construction sector in China.

Variables	Value
Household size (person/house) [1]	3.1
Average floor space (square metres/house) [2]	100
Intensity of wood use in a wooden house (cubic metres per square metre) [3]	0.40
Assumed share of new wooden house in total constructed house	10%
Cumulative lumber consumption 2015-2040 in China-HWC scenario (million cubic metres) [4]	273
Cumulative panels consumption 2015-2040 in China-HWC scenario (million cubic metres) [4]	450
2015 lumber consumption (million cubic metres) [5]	119
2015 panels consumption (million cubic metres) [5]	196
Annual growth rate of lumber and panels consumption in China-HWC scenario [4]	3.4%

[1] United Nations (2017).
[2] Median floor space of a single multi-family housing unit in the United States (US Census Bureau 2020)
[3] The average intensity of wood use in construction that can range from 0.2 to 0.6 m^3/m^2, depending on the structural system used (light-frame to mass-timber framing) (Hurmekoski 2017).
[4] See TABLE C1, Annex C for detailed calculation.
[5] FAO (2019).

2.2.2 Europe-High Wood Consumption (Europe-HWC) scenario

The Europe-High Wood Consumption or Europe-HWC scenario assumes a steady rise in the per capita consumption of sawnwood and structural wood-based panels in Europe and the Russian Federation, which by 2040, would reach the same per capita consumption of these products as observed in the United States in 2015. The Europe-HWC is designed to evaluate how increased wood consumption within the UNECE region nations would affect market conditions in the UNECE region. Although we do not specify precisely what single factor or combination of factors induce an outward shift in construction wood demand in Europe and the Russian Federation, we can identify the general categories of factors that might be available. These include: (i) changes in international building standards to allow for larger and taller wood-frame structures, e.g., in the United States (American Wood Council 2018) and China (Zhang 2017); (ii) increased availability and acceptance by the architectural design community, builders, and property owners of mass timber products, including cross-laminated timber (CLT), glulam beams, etc. (The Beck Group 2018, Breneman et al. 2019); and (iii) policies and programs designed to favour wood over non-wood construction inputs as a way of mitigating climate change.

Regarding mass timber, current market research forecasts that the overall value of the global CLT market will rise at a compounded annual growth rate (CAGR) of 15% during 2017-2025, from its 2016 global value of US$ 670.2 million. Studies indicate that Europe currently accounts for about half of the current global market share of production and would comprise half of the forecasted market share of production of CLT, followed by North America, forecasted to have 25% of global CLT market share of production (Transparency Market Research 2019, Zion Market Research 2018). These figures indicate a strong potential to increase construction wood product consumption in Europe in near future, similar to the level observed currently in the United States.

Based on wood products consumption data reported by FAO (2019) and population data reported by The World Bank (2019), per capita consumption of sawnwood and wood-based panels (the sum of plywood, particleboard and fibreboard) in the United

States in 2015 were 0.29 and 0.14 m^3, respectively. In contrast, per capita consumption of sawnwood and wood-based panels in Europe in the same year were about 52% less (0.14 m^3) and 30% less (0.10 m^3) than per capita consumption in the United States for these two products, respectively.

To achieve the same per capita consumption of these products in Europe by 2040 as that of the United States in 2015, we estimated the total quantity of these products needed to be consumed in Europe in 2040. This was achieved by multiplying 2015 United States per capita consumption of sawnwood and all forms of wood-based panels reported by FAO (2019) (0.29 and 0.14 m^3, respectively) by projected population in Europe in 2040 (TABLE 2.2). The estimates show that the annual consumption of sawnwood and the aggregate of all wood-based panels in Europe would need to grow by 3% and 1.5%, respectively, from 2015 to 2040, to achieve the same per capita consumption level in 2040 that was observed in the United States in 2015. These estimated rates of growth of consumption of sawnwood and wood-based panels were used to shift demand curves for these two products in all countries in Europe including the Russian Federation in the Europe-HWC scenario.

TABLE 2.2

Values and assumptions used to estimate quantities of sawnwood and panels consumed in Europe sufficient to achieving the same per capita consumption of these products as observed in the United States in 2015.

Variables	2015		2040		Annual growth rate 2015-2040	
	Sawnwood	*Panels* [1]	*Sawnwood*	*Panels* [1]	*Sawnwood*	*Panels* [1]
US consumption [2]	94.51	44.82				
US population [3]	320.74	320.74				
US per capita consumption	0.29	0.14				
Europe consumption [2]	106.51	73.61	220.97	106.68	2.96%	1.5%
Europe population [3]	743.11	743.11	761.97	761.97		
Europe per capita consumption	0.14	0.10	0.29	0.14		

[1] The sum of plywood/veneer, particleboard and fibreboard.

[2] The 2015 data is the observed consumption quantity (FAO 2019), and 2040 data is estimated consumption quantity needed to achieve 2015 United States per capita consumption level given the projected 2040 Europe population including the Russian Federation of 761.97 million (IIASA 2018).

[3] The 2015 value is the reported population (The World Bank 2019) and the 2040 value is projected population in the SSP2 reference scenario (IIASA 2018).

2.2.3 Textile-High Wood Fibber Consumption (Textile-HWFC) scenario

Over the last three decades, North American, European, and now, more recently, global demand for graphics paper has declined. Such a decline has led to the closure of pulp and paper manufacturing facilities in much of the UNECE region. New technologies and climate-related policies have bolstered demand for the same wood fibres presently demanded by the paper sector, and these technologies and policies are not confined to textile or packaging manufacture. New markets for second-generation liquid biofuels, wood pellets for energy (Nepal et al. 2019a), and new biochemicals offer some support for a lower limit (floor) on domestic and possibly global industrial roundwood prices (Hurmekoski et al. 2018, Nepal et al. 2019a). The Textile-High Wood Fibre Consumption or the Textile-HWFC scenario assumes that wood-based fibres would comprise 30% of total fibre consumption in the textile sector by 2040. Such a large increase in the consumption share of wood-based fibres in the textiles sector could be expected to emerge from either technology changes in the textiles sector or specific

policies favouring use of wood fibres for textiles manufacture in the UNECE region and globally. This scenario intends to model how increased use of wood-based fibres in the textiles sector would affect forest products markets in the UNECE region, subregions and globally.

TABLE 2.3 shows estimated additional demand for roundwood in this scenario. For the purpose of this scenario, the following assumptions were taken. Global fibre consumption in the textiles sector in 2019 was 111 million metric tonnes (MT), out of which 7.1 million MT (or 6.4%) was wood based (Textile Exchange, 2020). Between 2000 and 2019, global textiles production grew at the CAGR of 3.3%, from 60 million MT in 2000 to 111 million MT in 2019 (Textile Exchange, 2020). Extrapolating with a CAGR of 3.3% from 105 million MT in 2017 gives rise to an estimated global textile fibre demand of about 222 million MT by 2040. Assuming that the current share of wood-based fibre (6.4%) in the global fibre market remains unchanged, this translates to a projected 14 million MT of wood-based fibre consumption in the textiles sector by 2040. If, by assumption, 30% of total fibre demand in the textile sector were to be replaced by wood-based fibres by 2040 – due to a policy change, technological advancements or business strategies – about 67 million MT wood-based fibres would need to be produced. This figure would translate to an additional 53 million MT of wood-based fibre (wood pulp) production, implying an additional 265 million MT roundwood-equivalent production in the Textile-HWFC scenario. As a conversion factor, 5.0 m^3 of roundwood per ton of fibre was assumed to reflect different technologies in producing textile fibres from wood.

In the modelling of this scenario, we assumed that the estimated additional quantity of roundwood (265 million MT) needed to meet global demand, 2017 to 2040, for wood-based fibres destined to the textiles sector would be distributed among the top 10 wood pulp producing nations (TABLE 2.4) based on their global production shares for dissolving pulp (FAO 2019).

TABLE 2.3

Estimated quantity of roundwood equivalent needed to meet assumed increases in wood fibre consumption by the global textiles sector by 2040.

Scenario	Global fibre consumption by 2040 [1] (million metric tonnes)	Share of wood-based fibre by 2040 [2]	Projected wood-based fibre used in the textile-sector by 2040 (million metric tonnes)	Conversion factor [3] (RW cubic metres /ton fibre)	Roundwood equivalent
Baseline	222	6.4%	14	5	70
Alternate	222	30%	67	5	335
Additional (alternate minus baseline)			53		265

[1] Extrapolated value with a CAGR of 3.3% from 105 million MT in 2017 (Textile Exchange 2019).
[2] The baseline scenario assumes constant share of wood-based fibre in total global fibre consumption at 6.4% (Textile Exchange 2020) and the alternate scenario assumes its share will increase to 30% by 2040.
[3] Assumed to reflect different technologies in producing textile fibres from wood.

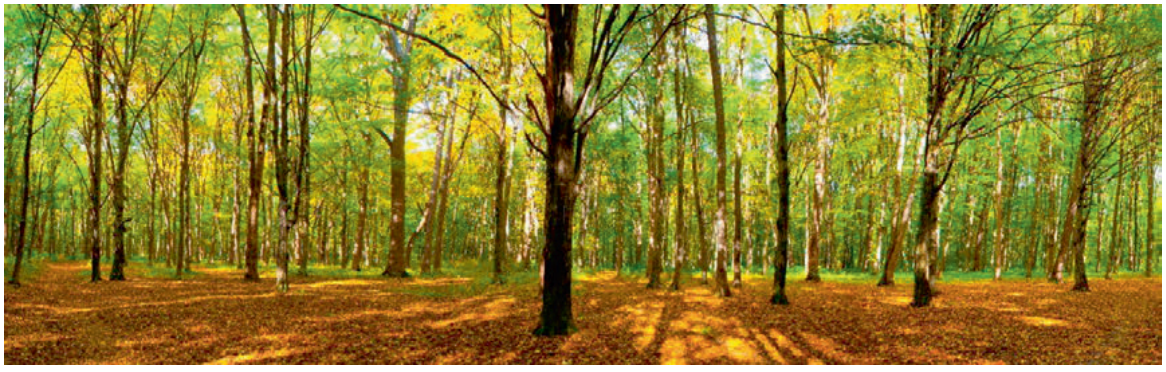


TABLE 2.4

Distribution of estimated additional roundwood produced by major pulpwood producing countries and the estimated wood pulp production needed to meet assumed increases in wood fibre consumption by the textiles sector by 2040.

Major pulp producing country	2017 wood pulp production [1] (million metric tonnes)	Global market share [1]	Additional roundwood equivalent [2] (million cubic metres)	Roundwood input per unit of wood pulp output [3] (cubic metres per metric tonne)	Additional wood pulp production (million metric tonnes)
China	1.80	25.60%	68.35	1.30	52.58
United States	1.22	17.30%	46.19	2.65	17.43
South Africa	0.97	13.70%	36.58	2.65	13.80
Brazil	0.66	9.40%	25.10	3.67	6.84
Canada	0.54	7.70%	20.56	2.65	7.76
Sweden	0.50	7.10%	18.96	3.04	6.24
Austria	0.46	6.50%	17.36	2.65	6.55
Finland	0.42	5.90%	15.75	2.65	5.94
India	0.26	3.60%	9.61	4.00	2.40
Czech Republic	0.22	3.20%	8.54	2.65	3.22
Total	**7.04**	**100%**	**267.00**		**122.76**

[1] FAO (2019).
[2] Estimated total additional roundwood quantity (265 million MT, TABLE 2.3), multiplied by the reported market share for wood pulp (column 2).
[3] GFPM calibrated input-output coefficients.
[3] Estimated additional roundwood production quantities, by country (column 4), divided by the input-output coefficient (column 5).

Because production, consumption, trade, prices, and elasticities of demand for textiles as an end-product are not available for all countries, it was not possible to introduce textiles as a separate commodity in the GFPM. Therefore, an indirect approach was followed to evaluate the effects of increased wood-based fibre use in the textiles sector. The indirect approach involved artificially shifting outward the demand for some categories of paper (printing and writing paper and other paper and paperboard) by an amount that would use the extra amount of estimated wood fibres needed to meet the simulated fibre demand in the textiles sector. To achieve such a textiles-focused demand shift for paper products, the estimated wood pulp production quantities by country (TABLE 2.4) were translated into equivalent quantities of printing and writing paper and other paper and paperboard consumption (TABLE C2, Annex C), based on the specified input of wood pulp per unit of paper product output in GFPM. Next, demand curves of paper products were shifted by the estimated growth rates of paper products during 2017-2040 in the top ten pulp producing nations (TABLE C2, Annex C). To ensure that the needed additional wood fibre production would go to the paper sector (the simulated proxy for textiles sector in this analysis), the supply of recovered paper (recycled fibres) entering the paper sector was restricted so that no additional quantity of recycled fibres than used in the reference scenario would be used in paper production in the Textile-HWFC scenario.

It is important to note that the GFPM does not distinguish between sawlog and pulpwood categories. Instead, a single industrial roundwood category is used as an input to solidwood (sawnwood and panels) and wood pulp (input to

paper production; wood pulp can use other inputs such as other fibre pulp and waste paper as) production. The implication of such a modelling approach is that the projected price for industrial roundwood in each country/subregion/region modelled will dictate its economic use in producing a particular end-use product (sawnwood, panels or papers), depending on the projected prices and specified manufacturing costs of these end products in individual countries. Consequently, increased demand for wood fibre in the paper sector (a proxy for textiles) would shift demand for industrial roundwood outward leading to the following outcomes: 1) the price of industrial roundwood would increase, 2) the production of industrial roundwood would increase, and 3) the price of wood pulp would increase. Next, because the price of industrial roundwood is negatively related to sawnwood and panels supply, their supply curves shift backward, leading to the following outcomes: 4) the price of sawnwood (and panels) would increase, 5) the production of sawnwood and panels would decrease. The outward shift in industrial roundwood demand would also cause a backward shift in pulp and paper supply, as well, but the effect is counteracted by the simulated large increase in paper demand (our proxy for textiles), which was achieved by exogenously shifting outward the demand for paper and paperboard in this analysis, leading to higher prices and higher production of paper and paperboard products, making use of industrial roundwood in the paper sector more profitable. Thus, it should be noted that given the way this scenario is modelled, it is not possible to account for the competition between the use of wood for textiles and the paper industry. Therefore, the readers should be cautioned that this would result in somewhat larger impacts on sawnwood and panels than would have been the case if this competition would have been modelled directly.

Another word of caution is that GFPM does not directly model "cascading" uses of wood; it thus has no directly estimated parameters that quantify the volumes or values or transfers of mill residues. The parameters of the GFPM, however, do quantify these effects indirectly in the input coefficients of the sawnwood and panels manufacturing processes, but do not fully capture them when simulating large structural changes such as those modelled in this scenario. Thus, depending on the degree to which higher industrial roundwood costs are offset by higher revenues on wood product plus residue sales, the effects of textiles sector wood demand on sawnwood and panels could be smaller than projected.

2.2.4 High Forest Area (HFA) scenario

The High Forest Area (HFA) scenario represents one of the three scenarios that intends to evaluate the effects of structural changes in timber supply via projected changes in forest area and the associated changes in forest stocks. An increase in forest area, beyond rates historically observed, or even the reverse of trends observed in some regions of the world, would be consistent with recently advanced goals and initiatives occurring in many countries. Although global forest area declined from 4.3 billion hectares in 1990 to 4.0 billion hectares in 2015 (FAO 2015), some modelling suggests a reversal of this trend into the 21st Century under plausible rates of change in population and income globally, largely as a result of increased planted forest investments directed toward producing outputs by the forest products sector and increased desires by people to enjoy the services provided by forests (e.g., Nepal et al. 2019b). Additionally, as described by Freer-Smith et al. (2019), such projected increases in forest area could also arise through policy driven actions by governments that seek to reduce net carbon emissions under the Paris Climate Agreement and in achievement of United Nations (UN) Sustainable Development Goals (SDGs). Within the UNECE region, Forest Europe and the EU Forest Strategy could bring about policy changes that would encourage increased forests within the continent (European Commission 2013).

The HFA scenario models the effects of a steady rise in global total forest area that is 10% higher by 2040 than that projected under the reference conditions (SSP2 scenario), leading to increases in forest stocks by similar magnitudes. The scenario is run with the socioeconomic assumptions of the SSP2 reference scenario. Hence, the forest products sector effects of the simulated forest area increase can be extracted by taking the difference between market outcomes in the HFA and SSP2 reference scenario.

2.2.5 High Planted Forest Area (HPFA) scenario

The High Planted Forest Area (HPFA) scenario intends to evaluate the effects of a potential increase in wood supply outside of the UNECE region, resulting from a projected increase in planted forest area outside of the UNECE region. The quantitative assessment of such a scenario in the UNECE region and globally was extracted from Nepal et al. (2019c), which was conducted outside of the context of this Outlook study. Nepal et al. (2019c) described the effects of global increases in planted forests, which permits a basic assessment of the effects of rapidly rising wood supplies not only in the UNECE region but also globally. These authors simulated the global forest sector, with and without planted forests specifically modelled, under all five SSPs (1-5). Projections ran from 2015 to 2070 and were made using the GFPM, the same modelling platform used in this Outlook. Because the area of planted forests was projected to change little within the UNECE region under SSP2 but more substantially outside the UNECE region under SSP2, their effects on forest sector variables would be similar in sign, if not magnitude, as a what-if scenario of supply structural change that posits an increase in wood supply (only) outside the UNECE region.

Planted forest area projections by Nepal et al. (2019c) were done for 180 countries using the econometrically estimated models of planted forest area by OECD and non-OECD country groups. Equations predicting planted forest area included GDP and roundwood production quantities as driving variables; other variables in the equations (other economic, institutional and environmental policy factors) were held constant at 2015 levels throughout the projections to 2070. The projected planted forest area in individual country across SSPs was then translated into changes in forest growth and stock in the GFPM, given that planted forests generally grow faster than natural forests. The growth rates of planted forests varied by world region (TABLE 2.5). The higher forest growth and yield associated with the planted forests would shift the supply of industrial roundwood outward and lower its price, relative to a scenario without changes in planted forests, leading to effects on the market equilibria (prices, production, consumption, trade).

TABLE 2.5

Estimated wood productivity in planted and natural forest in major world regions, reported in Nepal et al. (2019c).

Regions	Planted forests	Natural forests	Assumed average growth of stock in planted forests
	Cubic metres/hectare/year		*number of times higher than natural forests*
World	4.6	<1 (certified)	
World regions			
Africa (east and south)	6.0	1	6
Asia (south and southeast)	6.4	1	6
Europe	3.2	1-3 (intensively managed)	2
North America	7.6	1-3 (intensively managed)	4
Oceania	17.2	2	8
South America	24.0	2	12

2.2.6 Climate Change Related Productivity Change (CCPC) scenario

The Climate Change Related Productivity Change (CCPC) scenario investigates the effects of projected productivity changes in forests due to CO_2 fertilization from greenhouse gas accumulations and associated changes in temperatures, precipitation, and disturbances (in the form of wildfire only). The effects of such CO_2 and related climate changes on the forest sector were evaluated by Tian et al. (2016) with one global market model. This Outlook also applies the same kinds of projected changes in forest productivity globally in the Global Forest Products Model, which more comprehensively models the effects of such productivity shifts on supply and demand for a wider set of forest products and in detail by country for the UNECE region (and globally). The estimated effects of productivity changes on forest product markets in this report are assumed to match projected changes in net primary productivity (NPP) in a climate change scenario that closely resembles the Intergovernmental Panel on Climate Change (IPCC) 's Representative Concentration Pathway (RCP) 8.5. RCP 8.5 (i.e., 8.5 watts per m^2 of radiative forcing) represents the greenhouse gas concentrations (plus assumed rates of changes in aerosols and global land use/land cover) by 2100 expected to deliver global CO_2 that are double today's concentrations, yielding high rates of warming. It represents a situation in which greenhouse gases increase rapidly throughout the 21st century, unconstrained by policy or technology changes. NPP projections were generated by the dynamic global vegetation model MC2 (Kim et al. 2017), in conjunction with the CENTURY Soil Organic Matter Model (Parton 1996).

Projections of NPP were provided for 16 different world regions defined in MC2 (see map in Kim et al., 2017) and covered the period 1980-2100. The projected NPP change over 120 years in each region was provided for seven different ensemble members, called realizations, representing different assumed combinations of climate sensitivities, net aerosol forcing, and initial conditions, the projections for which were obtained using the Massachusetts Institute of Technology Integrated Global System Model-Community Atmosphere Model (IGSM-CAM) general circulation model (Kim et al. 2017, Tian et al. 2016). For this scenario of this Outlook, we used the seven-member average of the annual rates of change in NPP for each world region and assumed that forest productivity (the annual increment in forest stock per unit of forest area) for each world region changed by the same percentage as NPP for that same world region over the projection (TABLE 2.6).

The effects of net annual increment shifts due to high emissions would be manifested in outward (and in some cases inward) shifts in timber supply, relative to the shifts in timber supply modelled under the reference scenario. Because rates and directions of such productivity shifts varied by region (and hence, by country), the specific effects on regional and global market conditions are unknown in advance but are likely to align with how supply shifts affect relative comparative advantages of each country. This what-if scenario was run under reference scenario SSP5; hence, national, regional, and global market outcome effects of the what-if scenario can be quantified by comparing them with the outcomes under reference scenario SSP5 (which did not include the productivity changes). The climate change effect on forest products market was evaluated using SSP5 because the socioeconomic vision assumed under SSP (e.g., fossil fuelled development) best aligns with the RCP 8.5.

TABLE 2.6

MC2 projected trends in NPP value (grams per square centimetre) under the RCP 8.5 scenario, 2015-2040. The values represent average trends (1980-2100) for seven different realizations encompassing different combinations of climate sensitivities, net aerosol forcing, and initial conditions.

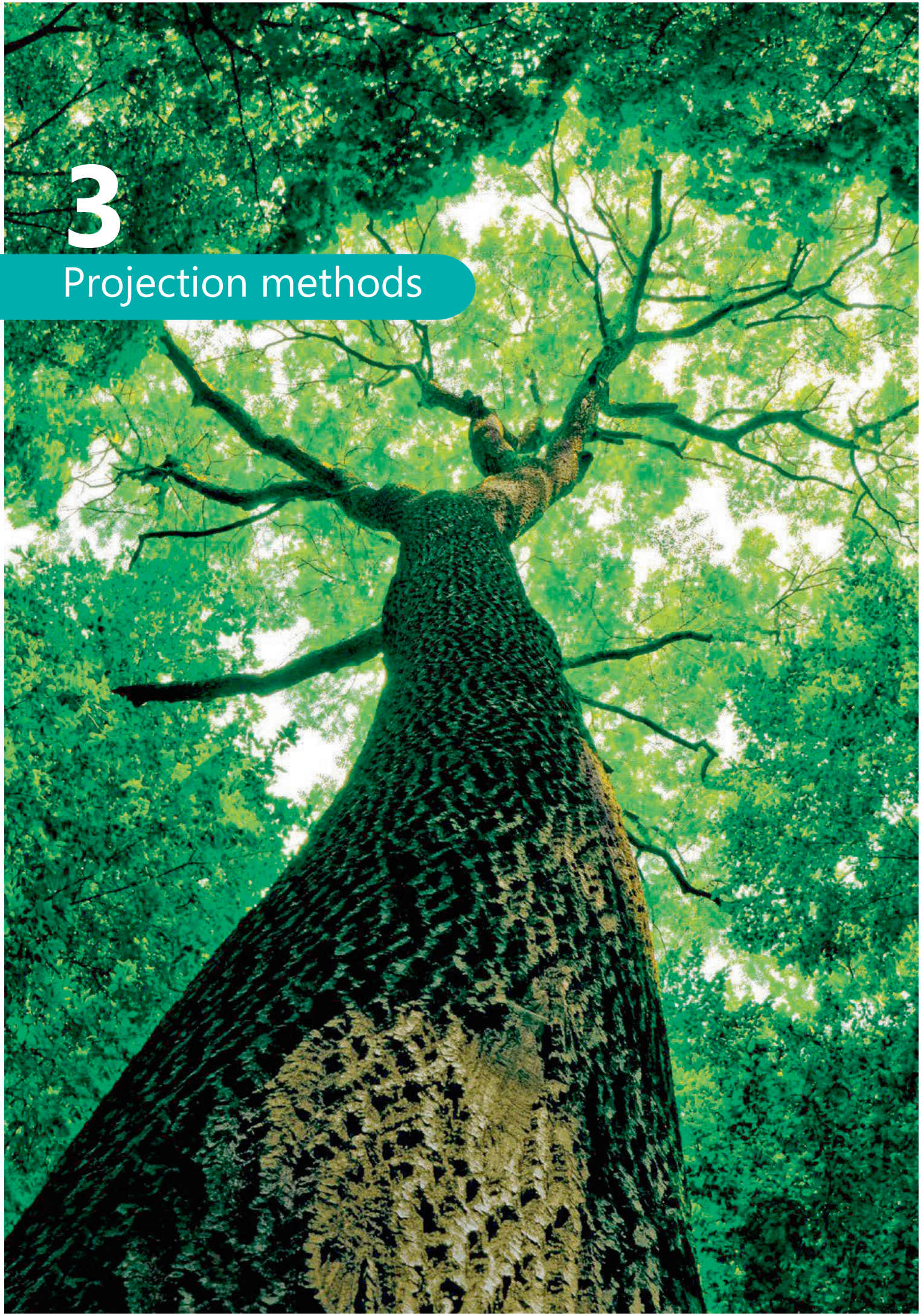
	MC2 projected NPP values (grams per square centimetre)		
Regions	**2015**	**2040**	**% change**
Australia/ New Zealand	509	525	3%
Central America	944	947	0%
Canada	233	250	7%
China	409	423	3%
Eastern Europe	187	186	-1%
India	664	682	3%
Japan	1,143	1,264	11%
Korea/Asian nes	634	690	9%
Northern Africa	218	233	7%
Russian Federation	172	178	3%
Southern Africa	1,041	1,097	5%
South America	1,634	1,762	8%
Asian Islands	2,139	2,257	6%
United States	358	413	15%
Western Europe	534	541	1%
Western South America	1,192	1,258	6%
World (average)	**751**	**794**	**6%**

2.2.7 Forest Based Natural Disturbances (FBND) scenario

The Forest Based Natural Disturbances (FBND) scenario intends to evaluate the forest sector effects of increased rates of forest-based natural disturbances, linked especially to climate change and the spread of invasive exotic pests in the UNECE region and globally. Due to the complex nature of disturbance effects and limited efforts to date to develop a framework for evaluating how disturbance regime shifts would affect markets, this analysis did not undertake any specific scenarios that can quantify those effects at national, UNECE regional, and global spatial scales. Instead, a general quantitative and qualitative assessments of such effects on forest sector in the UNECE subregions and globally were evaluated based on findings and discussions from various studies that described the effects of wildfire, native and exotic insect epidemics, native and exotic disease epidemics, wind storms, and droughts (e.g., Holmes 1991, Dale et al. 2001, McNulty 2002, Prestemon et al. 2006, Stanturf et al. 2007, Prestemon and Holmes 2008, Schwab et al. 2009, Seidl et al. 2011, Seidl and Blennow 2012, Thom et al. 2013, Seidl et al. 2014, Corbett et al. 2015, Sommerfeld et al. 2018).

2.2.8 Restricted Trade in Forest Products (RTFP) scenario

The Restricted Trade in Forest Products (RTFP) scenario is not tied to supply or demand structural changes, unlike previously described what-if scenarios. Instead, this scenario represents a global phenomenon of trade policy intervention, in the form of increased barriers to global trade of forest products, affecting UNECE member States directly or indirectly. The assessment of the effects of this scenario are not modelled for this Outlook but instead are extracted and summarized from Buongiorno and Johnston (2018). Buongiorno and Johnston (2018) modelled the effects of trade barriers using the GFPM, the same model employed for this Outlook. Although their study was limited to quantifying the effects of simulated trade frictions led by actions initiated by the United States, the study is informative in revealing how such barriers, involving the world's largest timber producer and consumer, would lead to pan-ECE and global production, consumption, price, and trade effects. The outcomes of such trade barriers reported in the study is based on simulations of two different scenarios. The first scenario involved the effects of higher import barriers (tariffs) imposed by the United States (alone) against its trading partners. The second scenario quantified the effects of these tariffs in combination with retaliatory trade barriers (tariffs) erected against the United States as a result of the simulated U.S. protectionism.



3 Projection methods

3.1 Projections of the global forest products market

While there were several demand and supply models with varying geographic coverages that could be utilized to model the recommended policy scenarios, the core Team of Specialist on Forest Sector Outlook decided to utilize the Global Forest Products Model (GFPM) (Buongiorno et al. 2003, Buongiorno 2015) to carry out the quantitative modelling for this Outlook. The GFPM was chosen because it had the technical capacity to accommodate the majority of the recommended scenarios and because of its global coverage. The GFPM generates projections of forest stocks and area and the quantities and values of derived product consumption, production, trade, and prices of 14 different forest products (defined by FAO[4]) in 180 individual countries including all UNECE subregions.[5]

The selected sets of scenarios were modelled using the 2019 version of the Global Forest Products Model (GFPM). The model projection covered 2020-2040, with 2017 being the base year, data for which represents the average values of years 2016-2018. GFPM is a partial equilibrium model of the global forest sector, where the projections of market clearing prices, production, consumption, and transport quantities of 14 different forest products are provided by maximizing economic welfare of consumers and producers in forest sector in 180 individual countries, based on the optimization approach described by Samuelson (1952) in regional market modelling (Buongiorno et al. 2003, Buongiorno 2015). The GFPM has been widely utilized in investigating the impacts of numerous forest sector related policy questions at global, multinational, and individual country levels, including its application in the UNECE/FAO North American Forest Sector Outlook Studies (UNECE and FAO 2012), the USDA Forest Service Resources Planning Act (RPA) assessment studies (USDA Forest Service 2012), and numerous journal publications.

A detailed description of the model structure and parameters are available in several past studies (e.g., Buongiorno et al. 2003, Buongiorno 2015). Here, only a brief description is provided on how the GFPM models demand, supply, production, consumption, and trade of various products as well as forest growth, forest stocks and forest area for individual countries. The GFPM models the supply of four primary products, including industrial roundwood, fuelwood, wastepaper (recovered paper), and other fibre pulp. The supply of industrial roundwood, which is the only input to sawnwood and panels and a major input to wood pulp production for use in manufacturing paper products, is modelled as a function of its own price and forest stock, both of which are projected endogenously. The supply of wastepaper (input to wood pulp production) is modelled as a function of its own price and GDP, along with a specified recycled paper recovery rate. The current version of the GFPM specifies a maximum recovery rate of recovered paper to be 80%. The actual recovery rate, from 0 to 80%, is determined by the input-output coefficient (units of recovered paper used to produce per each unit of paper product, which differs by country) and the specified supply curve of recovered paper, which responds to its own price and GDP. The supply of other fibre pulp (input to wood pulp production) is modelled as a function of its own price and GDP.

On the demand side, the GFPM models demand for nine manufactured (secondary) wood products, each of which is a function of its endogenously projected own price and exogenously projected GDP. These manufactured products include fuelwood, other industrial roundwood, sawnwood, plywood, particleboard, fibreboard, newsprint, printing and writing paper, and other paper and paperboard, which mainly include tissue and packaging papers. GFPM additionally models two intermediate products, mechanical pulp and chemical pulp, which are used as inputs to paper production. Projected production quantities of intermediate and final manufactured products are determined by the specified manufacturing costs and their respective input-output coefficients (units of industrial roundwood required to produce a unit of manufactured product) in each country, which

[4] See http://www.fao.org/forestry/34572-0902b3c041384fd87f2451da2bb9237.pdf .

[5] However, the GFPM does not model Iceland or any European microstate (Andorra, Lichtenstein, Malta, Monaco, San Marino, Vatican City).

reflects the comparative advantage of a country in producing that product.

Trade (imports and exports of all primary and manufactured products) is modelled between a country and the rest of the world. Quantities of products imported or exported are driven by the competitive advantage of a country or a region in producing and shipping each product. Competitive advantage is a function of transport costs, manufacturing costs, input-output coefficients, and the endogenously solved domestic and world prices of a product. The domestic consumption quantity of a product is calculated as the import quantity minus the export quantity plus the domestic production quantity.

Forest stock, which drives industrial roundwood and fuelwood supply curves in each country, evolves over time as the previous year's stock quantity plus the projected current year growth quantity minus the roundwood harvest quantity. Forest stock growth (net of mortality) before harvest is modelled as a nonlinear function of forest stock density (forest stock divided by forest area), a relationship based on Turner et al. (2006). The specified nonlinear negative relationship between forest growth and forest stock density implies that forest growth increases with declining stock density and decreases with increasing stock density. Changes in forest stock density are determined by the endogenously projected changes in forest stock and the exogenously projected changes in forest area.

Total forest area in each country is exogenously projected in the GFPM as a quadratic function of GDP and its squared term, based on the Environmental Kuznets Curve (EKC) model estimated by Turner et al. (2006). The scenario modelling for the current FSOS was augmented by allowing for the GFPM projected forest stock in each country to be adjusted by the exogenously projected planted forest area in each country across each of the SSPs, based on the recent work by Nepal et al. (2019c) and Korhonen et al. (in review). Planted forests contribute to higher forest growth (and stock). Because the GFPM does not distinguish forest growth by planted and natural forests, the modelling done for this Outlook adjusted the endogenously calculated forest growth in GFPM to account for the effect on forest stock of projected changes in planted forest area. Planted forest area was projected to be driven by its separately estimated EKC model coefficients (TABLE D1, Annex D) and projected GDP per capita, rural population density and labour growth in each SSP (FIGURE D1, FIGURE D2 and FIGURE D3, Annex C). According to the estimated planted forest area projection model (TABLE D1, Annex D), the GDP per capita and labour growth have positive effects while rural population density has a negative effect on planted forest area.

3.2 Projection of carbon sequestration in forest and harvested wood products (HWP)

Projected estimates of forest sector carbon in each country include carbon stored in above- and below-ground live biomass and in harvested wood products (HWP). While the projected changes in carbon stored in forest biomass are based on the projected changes in forest stocks, the carbon stored in HWP is estimated, based on the projected wood products consumption, production, and trade quantities endogenously projected by GFPM. The approach to estimating carbon in above- and below-ground forest biomass is taken from Johnston et al. (2019), which relies on estimated regional emission factors, obtained using the observed forest stocks in 2015 and the estimated carbon in above- and below-ground carbon pool reported in the Global Forest Resource Assessment report (FAO 2015). Changes in carbon stored in wood products were also estimated, following Johnston and Radeloff (2019), which were derived from the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC 2006). The reported estimates of HWP carbon in this paper are based on the production approach, which includes carbon stored in domestically produced and exported wood products but excludes carbon stored in imported forest products.

Finally, the carbon benefits of substituting wood products for non-wood products for the alternative what-if scenarios are provided based on the projected difference in wood products consumption between the alternative and the reference scenario and on published substitution factors reported in Leskinen et al. (2018).

References

Alkhagen, M., Å. Samuelsson, F. Aldaeus, M. Gimåker, E. Östmark, and A. Swerin. 2015. Roadmap 2015 to 2025. Textile materials from cellulose. RISE - Research Institutes of Sweden.

American Wood Council. 2018. AWC: Tall Mass Timber code changes get final approval. Available at: https://awc.org/news/2018/12/19/awc-tall-mass-timber-code-changes-get-final-approval, accessed Oct. 17, 2020.

Breneman, S., Timmers, M., and Richardson, D. 2019. Tall wood buildings in the 2021 IBC up to 18 stories of mass timber. WoodWorks Wood Solution Paper, WoodWorks – Wood Products Council. Available at: https://www.woodworks.org/wp-content/uploads/wood_solution_paper-TALL-WOOD.pdf, accessed Oct. 17, 2020.

Buongiorno J. 2015. Income and time dependence of forest product demand elasticities and implications for forecasting. Silva Fennica 49(5):1395.

Buongiorno, J., and C. Johnston. 2018. Potential effects of US protectionism and trade wars on the global forest sector. Forest Science 64(2):121–128

Buongiorno, J., S. Zhu, D. Zhang, J. Turner, and D. Tomberlin. 2003. The Global Forest Products Model. Academic Press, London, UK. 301pp.

Corbett, L.J., P. Withey, V.A. Lantz, V.A., and T.O. Ochuodho. 2015. The economic impact of the mountain pine beetle infestation in British Columbia: provincial estimates from a CGE analysis. Forestry 89(1):100-105. https://doi.org/10.1093/forestry/cpv042.

Dale, V.H., L.A. Joyce, S. McNulty, R.P. Neilson, M.P. Ayres, M.D. Flannigan, P.J. Hanson, L.C. Irland, A.E. Lugo, C.J. Peterson, D. Simberloff, F.J. Swanson, B.J. Stocks, and B.M. Wotton. 2001. Climate change and forest disturbances: climate change can affect forests by altering the frequency, intensity, duration, and timing of fire, drought, introduced species, insect and pathogen outbreaks, hurricanes, windstorms, ice storms, or landslides. Bioscience 51(9):723–734.

European Commission. 2013. A new EU Forest Strategy: for forests and the forest-based sector. Brussels, 20.9.2013 COM (2013) 659 final.

FAO. 2015. Global Forest Resources Assessment. Food and Agriculture Organization of the United Nations, Rome, Italy. Available at http://www.fao.org/3/a-i4808e.pdf, accessed Oct. 21, 2018.

FAO. 2019. FAOSTAT forestry database. Forestry Production and trade. Available at: http://www.fao.org/forestry/statistics/84922/en/, accessed Dec. 8, 2020.

Geng, A., J. Chen, and H. Yang. 2019. Assessing the greenhouse gas mitigation potential of harvested wood products substitution in China. Environmental Science & Technology 53:1732-1740. DOI: 10.1021/acs.est.8b06510.

Holmes, T.P. 1991. Price and welfare effects of catastrophic forest damage from forest damage from southern pine beetle epidemics. Forest Science 37: 500–516.

Hurmekoski, E. 2017. How can wood construction reduce environmental degradation? European Forest Institute. Available at http://www.efi.int/sites/default/files/files/publication-bank/2018/efi_hurmekoski_wood_construction_2017_0.pdf, accessed Feb 10, 2020.

IIASA. 2018. SSP Database, International Institute for Applied Systems Analysis. Available at https://tntcat.iiasa.ac.at/SspDb, accessed June 03, 2018.

IPCC. 2006. Chapter 12: Harvested Wood Products. Contribution to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. Vol. 4 Agriculture, Forestry and Other Land Use. Pingoud, K., Skog, K., Martino, D.,

Tonosaki, M., Xiaoquan, Z. Available at http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/4_Volume4/V4_12_Ch12_HWP.pdf, accessed Oct. 06, 2018.

Jiang, L., and B.C. O'Neill. 2017. Global urbanization projections for the Shared Socioeconomic Pathways. Global Environment Change 42:193–199.

Johnston, C.M.T., and V.C. Radeloff. 2019. Global mitigation potential of carbon stored in harvested wood products. Proceedings of the National Academy of Sciences of the United States of America 116(29): 14526–14531.

Johnston, C., J. Buongiorno, P. Nepal, and J. Prestemon. 2019. From source to sink: past and projected changes in carbon sequestration in the global forest sector. Journal of Forest Economics 34(1-2): 47–72.

Kim, J.B., E. Monier, B. Sohngen, G.S. Pitts, R. Drapek, J. McFarland, S. Ohrel, S., and J. Cole. 2017. Assessing climate change impacts, benefits of mitigation, and uncertainties on major global forest regions under multiple socioeconomic and emissions scenarios. Environmental Research Letters 12, 045001. doi.org/10.1088/1748-9326/aa63fc.

Korhonen, J., P. Nepal, J.P. Prestemon, and F.W. Cubbage. In review. Estimating the Environmental Kuznets Curve for global planted forest area projection. Data on file with Dr. Prakash Nepal, available upon request.

Leskinen, P., G. Cardellini, S. González-García, E. Hurmekoski, R. Sathre, J. Seppälä, C. Smyth, T. Stern, and P. J. Verkerk. 2018. Substitution effects of wood-based products in climate change mitigation. From Science to Policy 7. European Forest Institute, Helsinki, Finland.

McNulty, S.G. 2002. Hurricane impacts on US forest carbon sequestration. Environmental Pollution 116(Supplement 1):S17–S24. https://doi.org/10.1016/S0269-7491(01)00242-1.

Nepal, P., K.L. Abt, K.E. Skog, J.P. Prestemon, and R.C. Abt. 2019a. Projected market competition for wood biomass between traditional products and energy: A simulated interaction of US regional, national, and global forest product markets. Forest Science 65(1): 14–26.

Nepal, P., J. Korhonen, J.P. Prestemon, and F.W. Cubbage. 2019b. Projecting global and regional forest area under the Shared Socioeconomic Pathways using an updated Environmental Kuznets Curve model. Forests 10, 387. https://doi.org/10.3390/f10050387.

Nepal, P., J. Korhonen, J.P. Prestemon, and F.W. Cubbage. 2019c. Projecting global planted forest area developments and the associated impacts on global forest product markets. Journal of Environmental Management 240: 421–430.

O'Neill, B. C. *et al.* 2014. 'A new scenario framework for climate change research: the concept of shared socioeconomic pathways', *Climatic Change*, 122(3), pp. 387–400. doi: 10.1007/s10584-013-0905-2.

O'Neill, B.C., E. Kriegler, K.L. Ebi, E. Kemp-Benedict, K. Riahi, D.S. Rothman, B.J. van Ruijven, P. van Vuuren, J. Birkmann, K. Kok, M. Levy, and W. Solecki. 2017. The roads ahead: Narratives for shared socioeconomic pathways describing world futures in the 21st century. Global Environmental Change 42:169–180.

Parton, W. J. 1996. The CENTURY Model. In: Powlson, D.S., P. Smith, J.U. Smith (eds) Evaluation of soil organic matter models. NATO ASI Series (Series I: Global Environmental Change), vol 38. Springer.

Prestemon, J.P., S. Zhu, J.A. Turner, J. Bungiorno, and R. Li. 2006. Forest product trade impacts of an invasive species: Modeling structure and intervention trade-offs. Agricultural and Resource Economics Review. 35(1):128–143.

Prestemon, J.P., and T.P. Holmes. 2008. Timber salvage economics. P. 167-190 in Holmes, T.P., J.P. Prestemon, and K.L. Abt (Eds.), The Economics of Forest Disturbances: Wildfires, Storms, and Invasive Species. Springer: Dordecht, Netherlands.

Pöyry Inc. 2015. World fibre outlook up to 2030. Vantaa, Finland.

Riahi, K., D.P. van Vuuren, E. Kriegler, J. Edmonds, B.C. O'Neill, and other. 2017. The shared socioeconomic pathways and their energy, land use, and greenhouse gas emissions implications: An overview. Global Environmental Change 42 (2017): 153-168.

Samuelson, Paul A. 1952. Spatial price equilibrium and linear programming. American Economic Review 42(3): 283–301.

Schwab, O., T. Maness, G. Bull, and D. Roberts. 2009. Modeling the effect of changing market conditions on mountain pine beetle salvage harvesting and structural changes in the British Columbia forest products industry. Canadian Journal of Forest Research 39(10):1806–1820. https://doi.org/10.1139/X09-099.

Seidl, R., M-J. Schelhaas, and M.J. Lexer. 2011. Unraveling the drivers of intensifying forest disturbance regimes in Europe. Global Change Biology 17(9):2842-2852. https://doi.org/10.1111/j.1365-2486.2011.02452.x.

Seidl, R., and K. Blennow. 2012. Pervasive Growth Reduction in Norway Spruce Forests following Wind Disturbance. PLoS ONE 7(3): e33301. https://doi.org/10.1371/journal.pone.0033301.

Seidl, R., M-J. Schelhaas, W. Rammer, W., and P.J. Verkerk. 2014. Increasing forest disturbances in Europe and their impact on carbon storage. Nature Climate Change 4:806-810.

Skog, K., and G. Nicholson. 1998. Carbon cycling through wood products. The role of wood and paper products in carbon sequestration. Forest Products Journal 48(7/8): 75–83.

Sommerfeld, A., C. Senf, B. Buma, A.W. D'Amato, T. Després, I. Díaz-Hormazábal, S. Fraver, L.E. Frelich, A.G. Gutiérrez, S.J. Hart, B.J. Harvey, H.S. He, T. Hlásny, A. Holz, T. Kitzberger, D. Kulakowski, D. Lindenmayer, A.S. Mori, J. Müller, J. Paritsis, G.L.W. Perry, S.L. Stephens, M. Svoboda, M.G. Turner, T.T. Veblen, R. Seidl. 2018. Patterns and drivers of recent disturbances across the temperate forest biome. Nature Communications 9, Article 4355.

Stanturf, J.A., S.L. Goodrick, and K.W. Outcalt. 2007. Disturbance and coastal forests: A strategic approach to forest management in hurricane impact zones. Forest Ecology and Management 250(1-2):119-135. https://doi.org/10.1016/j.foreco.2007.03.015.

TextileExchange. 2020. Preferred Fibre & Materials Market Report 2019. Available at https://store.textileexchange.org/wp-content/uploads/woocommerce_uploads/2019/11/Textile-Exchange_Preferred-Fiber-Material-Market-Report_2019.pdf, accessed Feb 21, 2020.

The Beck Group. 2018. Mass timber market analysis. The Beck Group, Forest Products Planning & Consulting, Portland, Oregon. Available at: https://www.oregon.gov/ODF/Documents/ForestBenefits/Beck-mass-timber-market-analysis-report.pdf, accessed Oct. 17, 2020.

The World Bank. 2019. World Development Indicator Database. Available at https://databank.worldbank.org/, accessed Oct 20, 2019.

Thom, D., R. Seidl, G. Steyrer, H. Krehan, and H. Formayer. 2013. Slow and fast drivers of the natural disturbance regime in Central European forest ecosystems. Forest Ecology and Management 307:293-302. https://doi.org/10.1139/X09-099

Tian, X. et al. (2016) 'Global climate change impacts on forests and markets', Environmental Research Letters, 11(3), p. 035011. doi: 10.1088/1748-9326/11/3/035011.

Transparency Market Research 2019. Widespread advancements in construction industry boosts growth in cross laminated timber (CLT) market. Available at: https://www.transparencymarketresearch.com/pressrelease/cross-laminated-timber-market.htm, accessed Oct. 18, 2020.

Turner, J.A. J. Buongiorno, and S. Zhu. 2006. An economic model of international wood supply, forest stock and forest area change. Scandinavian Journal of Forest Research 21(1): 73–86.

UNECE and FAO. 2012. The North American Forest Sector Outlook Study II: 2006-2030. Geneva timber and forest study papers, 29. United Nations Economic Commission for Europe and Food and Agriculture Organization of the United Nations.

United Nations. 2017. Household size and composition around the world 2017– Data booklet (ST/ESA/ SER.A/405), United Nations, Department of Economic and Social Affairs, Population Division.

US Census Bureau. 2020. Median and average square feet of floor area in units in new multifamily buildings completed. Available at https://www.census.gov/construction/chars/pdf/mfu_medavgsqft.pdf, accessed February 03, 2020.

USDA Forest Service. 2012. Future of America's Forests and Rangelands: Forest Service 2010 Resources Planning Act Assessment. USDA For. Serv. Gen. Tech. Rep. WO-GTR-87. 198 p.

Zhang, H. 2017. China introduces tall wood building code. Available at: https://canadawood.org/china-introduces-tall-wood-building-code/, accessed Feb 12, 2020.

Zion Market Research 2018. Global cross laminated timber (CLT) market set for rapid growth, to reach USD 1606 million by 2024. Available at: https://www.zionmarketresearch.com/news/cross-laminated-timber-market, accessed March 23, 2020.

Annexes

ANNEX A: POLICY SCENARIOS RECOMMENDED FOR THE UNECE/FAO FOREST SECTOR OUTLOOK STUDIES (FSOS) III BY THE UNECE TEAM OF SPECIALISTS (TOS) ON FSOS AND THE UNECE/FAO WORKING PARTY ON FOREST, STATISTICS, ENVIRONMENT AND MANAGEMENT (FSEM) AND THEIR DEVELOPMENT AND SELECTION PROCESS.

TABLE A1

First draft of the possible scenarios discussed by the ToS members in their meeting on 21 March 2018

General aspect	Policy questions	Reference Scenario / Variables to compare	Possible alternative scenarios
Climate Change	What is the potential of UNECE forest sector for climate change mitigation? What can the UNECE forests contribute?	Carbon sequestration and avoided emissions in forests and wood products under a normal economic growth scenario = reference scenario (no change in forest land)	CC1: Potential of carbon sequestration in wood construction; assumption: significant increase in wood construction (UNECE and/or worldwide) CC2: Potential of carbon sequestration in traditional wood products; assumption: (policy-driven) significant increase in demand for wood products (UNECE and/or worldwide) CC3: Potential of carbon sequestration in new products based on wood fibres; assumption: technological advances that allow a significant increase of use of wood fibres CC4: Potential of carbon sequestration through (re-)forestation; assumption: policy- driven, significant increase of forests area in the UNECE region (e.g. Bonn challenge) CC5: Maximising carbon sequestration by changing silvicultural methods (update to the EFSOS II scenario "Maximising biomass carbon") CC6: Potential of climate change mitigation through substitution in the energy sector through an increased use of wood energy CC7: Combination of the above – what is the maximum that could be achieved given competing demands for wood products (possibly looking at Climate Smart Forestry)
	How will UNECE forests be affected by climate change? How will adaptation look like?	Supply of forest resources under current forest growth scenario (no further	CC7-CC10: Differences in supply of forest resources under the four representative concentration pathways (RCPs) from the IPCC 5th Assessment Report (possibly looking at resilience as well)

General aspect	Policy questions	Reference Scenario / Variables to compare	Possible alternative scenarios
		climate change)	
Structural Changes	How would different demand changes affect the UNECE forest product market?	Demand and prices for wood products under reference scenario	SC1: Massive increase of demand for wood constructions – within UNECE – and outside (especially China); closely linked to calculations for CC1 SC2: Significant increase of demand for wood-fibres for textiles and other products; closely linked to calculations for CC3 SC3: Significant economic collapse (whole world and/or specific countries/regions) SC4: Successful development of an alternative energy source and thus drastic decrease in demand for wood energy SC5: Significant decrease of demand for print and paper with simultaneous increase of demand for packaging SC6: Significant increase of biorefineries.
	How would different supply changes affect the UNECE forest product market?	Supply and prices for wood products under reference scenario	SC7: Significant increase of forest plantations outside of UNECE (e.g. Africa and/or Asia) SC8: Significant increase of natural disasters
	What would be the effect of massive restrictions to trade on the UNECE forest product market?	Supply, demand and prices under reference scenario	SC9: Trade between countries and/or regions is significantly restricted
Green Economy & SDGs	What are opportunities and challenges regarding green jobs?	Employment under the reference scenario	GS1: Effect of a significant increase of technology in forest employment (qualitative analysis) GS2: Effect of a significant decrease of qualified labour supply (qualitative analysis)
	What is the potential of the Payment of Ecosystem Services	What are current examples of PES	GS3: Effects of a wide-spread use of PES (qualitative & quantitative analysis)
	What is the potential contribution of UNECE forests and forest products to the achievement of the SDGs	SDG achievement under the reference scenario	GS4: Effects of a specific focus on the achievement of certain SDG targets (qualitative analysis)

TABLE A2

Second draft of the possible scenarios discussed by the ToS based on technical feasibilities.

Possible scenario	Technical feasibility
Climate change mitigation (different aspect: potential carbon sequestration in wood construction and other wood products, different silvicultural methods, reforestation, substitution in energy (wood energy) and combination of the previous)	Feasible with a set of models
Climate change adaptation	Country-based review (no or little modelling involved)
Upcoming market scenarios (China, Africa)	Feasible, based on SSPs
Growth of specific products (construction, fibres, biorefineries)	Feasible
Economic disturbances	Feasible
Significant increase of forest plantations outside of UNECE	Feasible
Impact on forest product market by significant increase of natural disasters	Feasible
Impact of trade barriers (increase or decrease)	Feasible
Potential of Payment for Ecosystem Services	Not feasible as a full outlook scenario; parts could be covered (carbon payment), and current case studies be added
Employment	Not feasible as an outlook scenario, could potentially be a "post-analysis" on all scenarios
SDGs	Not feasible as an outlook scenario, could potentially be a "post-analysis" on all scenarios; labour-intensive
Circular Economy/Cascading-use of wood	Difficult to define well as a scenario, could be a "post-analysis" on all scenarios

TABLE A3

Third draft of the possible scenarios prioritized by the participants at the 40th session of the Joint Working Party

Possible scenario	Average priority
Climate change mitigation	2.8
Growth of specific products (construction, fibres, biorefineries)	2.8
Climate change adaptation	2.6
Upcoming market scenarios (China, Africa)	2.6
Economic disturbances	2.6
Impact on forest product market by significant increase of natural disasters	2.4
Nature conservation	2.4
Impact of trade barriers (increase or decrease)	2.2
Potential of Payment for Ecosystem Services	1.8
SDGs	1.8
Circular Economy/Cascading-use of wood	1.8
Employment	1.6

ANNEX B: SUMMARY OF THE REFERENCE AND ALTERNATIVE WHAT-IF SCENARIOS EVALUATED IN THE CURRENT OUTLOOK STUDY

TABLE B1

Reference and the alternative scenarios evaluated in the current forest sector outlook study.

Modelled scenarios	Policy questions addressed	Projected variables

1. Shared Socioeconomic Pathways 2 (*SSP2*)
• One of the three reference scenarios
• Middle-of-the-road world vision
• Continuation of current trend in income and population
	• How would forest area, planted forest area, forest stock, and forest products market evolve during 2020-2040 under the "middle-of-the-road" world vision?
	• How the projected forest sector development in the middle-of-the-road world vision would contribute to climate change mitigation?
		• Planted area
		• Total forest area
		• Forest stock
		• Wood harvest
		• Products prices
		• Consumption
		• Production
		• Trade
		• Forest sector C sequestration
		  ○ C in forest biomass
		  ○ C in wood products

2. Shared Socioeconomic Pathways 3 (*SSP3*) • One of the three reference scenarios • Poorest world vision • increasing inequality • high population growth	• How would forest area, planted forest area, forest stock, and forest products market evolve during 2020-2040 under the "poorest" world vision? • How the projected forest sector development in the poorest and unequal world vision would contribute to climate change mitigation? • What are the forest sector impacts of future collapse in global economies?	Same as above
3. Shared Socioeconomic Pathways 5 (*SSP5*) • One of the three reference scenarios • Wealthiest world vision • Global equality	• How would forest area, planted forest area, forest stock, and forest products market evolve during 2020-2040 under the "wealthiest" world vision? • How the projected forest sector development in the wealthiest and equal world vision would contribute to climate change mitigation?	Same as above

• Low population growth		
4. China-High Wood Consumption (*China-HWC*) paired with SSP2 reference • Assumes a rapid increase in the use of wood in the construction sector of China • Every tenth new housing unit is assumed to be built with the similar amount of wood as that used in a single unit of a multifamily dwelling in the United States in 2015.	• Intends to model the effects within the UNECE forest products sector of a potential increase in wood products demand outside of the region (e.g. China).	Same as above
5. Europe-High Wood Consumption (*Europe-HWC*) paired with SSP2 reference • Assumes a steady rise in the per capita consumption of sawnwood and panels in Europe and the Russian Federation by 2040, to the same level as was observed in the United States in 2015	• Intends to model the effects within the UNECE forest sector of a potential increase in wood products demand inside the region, mainly Europe, the Russian Federation, the Caucuses and Central Asia.	Same as above
6. Textile-High Wood Fibre Consumption (*Textile-HWFC*) paired with SSP2 reference • Assumes that wood-based fibre would replace 30% of total wood fibre consumption in the global and UNECE textile sector by 2040	• Intends to model how increased use of wood-based fibre in the textile sector would affect forest products markets in the UNECE regions and globally.	Same as above
7. High Forest Area (*HFA*) paired with SSP2 reference • Assumes a 10% increase in total forest area by 2040, relative to the forest area projected in SSP2 reference scenario in 2040.	• Intends to evaluate the effect of structural changes in the supply of wood via projected changes in forest area and the associated changes in forest stocks • How future climate change mitigation policies, contributing to increased planted and total forest area during 2020-2040 would affect forests and forest product sector in UNECE regions?	Same as above

	• What would be UNECE regions forest sector contribution to climate change mitigation with an aggressive climate change mitigation policy leading to overall increase in total forest area?	
8. High Planted Forest Area (*HPFA*) • Not modelled in the context of this outlook • The effects of future increases in planted forest area are extracted from Nepal et al. (2019c)	• Evaluates the effects of a rapid increase in timber inventory, created by an increase in planted forest area outside of the UNECE region	Same as above
9. Climate Change Related Productivity Change (*CCPC*) paired with SSP5 reference • The market effects are modelled based on the projected changes in net primary productivity (NPP) under the unconstrained greenhouse gas emissions scenario, simulated by the Dynamic Global Vegetation Model, MC2 (Kim et al. 2017)	• Intends to investigate the effects on global and UNECE forest products market of projected productivity changes in forests due to CO_2 fertilization from greenhouse gas accumulations and associated changes in temperatures, precipitation, and disturbances	
10. Forest Based Natural Disturbance (*FBND)* • Not modelled in the context of this outlook • Analytical assessments of effects of FBND on forest sector are evaluated based on the findings from various studies.	• Intends to evaluate the forest sector effects of increased rates of forest-based natural disturbances, linked especially to climate change and spread of invasive exotic pests in the UNECE regions and globally.	
11. Restricted Trade in Forest Products (*RTFP)* • Not modelled in the context of this outlook • The quantitative assessments of the effects increasing barriers to global trade of forest products are extracted from Buongiorno and Johnston (2018).	• Intends to model the effect of increasing barriers to global trade of forest products in globally and in the UNECE region.	

ANNEX C: VALUES, ASSUMPTIONS, AND CALCULATIONS USED TO ESTIMATE ADDITIONAL WOOD CONSUMPTION IN ALTERNATE SCENARIOS

TABLE C1

Assumptions and values used to estimate additional sawnwood and panel consumption in assumed new construction in China's housing market under the China-High Wood Consumption (China-HWC) scenario.

Assumptions/Values	2015	2020	2025	2030	2035	2040
Population[1] (mill.)	1371	1379	1385	1381	1365	1340
Total housing units (mill.)[2]	442	445	447	445	440	432
New housing unit constructed with wood (mill./year)[3]		0.05	0.04	-0.03	-0.10	-0.17
New housing units constructed to replace existing units after their life span (mill./year)[4]		0.44	0.45	0.45	0.44	0.43
Total new housing units constructed with wood (mill./year)		0.50	0.48	0.42	0.34	0.27
Total new wood volume used to construct new housing units (mill. cubic metres/year)[5]		20.19	19.72	16.93	13.87	10.83
2015 sawnwood consumption (mill. cubic metres)[6]	119 (38%)					
2015 panels consumption (mill. cubic metres)[6]	196 (62%)					
Additional sawnwood consumption (mill. cubic metres/year)[7]		36	35	30	24	19
Additional panels consumption (mill. cubic metres/year)[7]		58	57	49	40	31
Cumulative total sawnwood consumption, 2015-2040 (mill. cubic metres)						273
Cumulative total panels consumption 2015-2040 (mill. cubic metres)						450
Annual growth rate of sawnwood and panels consumption, 2015-2040 (%)	3.4%	3.4%	3.4%	3.4%	3.4%	3.4%

[1] The World Bank (2019).

[2] Population divided by person/household (3.10, United Nations 2017)

[3] Difference in housing units between two periods multiplied by the assumed share of wooden house (10%) divided by 5.

[4] Housing units in a period times % of house replaced over 25 years (25%) multiplied by the assumed share of wooden house (10%) divided by 25.

[5] Total new housing units constructed with wood multiplied by the assumed floor space per housing unit (100 m^2) multiplied by the assumed intensity of wood use per square meter (0.41 m^3).

[6] FAO (2019). The numbers in parentheses indicate the share of sawnwood and panels in total solidwood consumption.

[7] Total wood volume multiplied by the share of sawnwood (and panels).

TABLE C2

Growth rates used to shift demand of printing and writing paper and other paper and paperboard in the alternate scenario in top 10 wood pulp producing countries to simulate the effects of growth in wood fibres consumption in the textiles sector.

Top 10 wood pulp producing country	Paper product	Reference scenario, 2017 consumption	Reference scenario, 2040 consumption	Additional consumption by 2040[1]	Alternate scenario, 2040 consumption	Alternate scenario, 2017-2040 consumption growth [2]
		million metric tons				*Annual growth (%)*
China	P& W paper	24.39	44.92	0.00	44.92	2.69%
	Other paper & paperboard	83.79	129.04	13.74	142.77	2.34%
United States	P& W paper	15.96	19.01	1.73	20.74	1.14%
	Other paper & paperboard	51.15	60.41	8.89	69.30	1.33%
South Africa	P& W paper	0.60	0.89	1.16	2.05	5.48%
	Other paper & paperboard	1.54	2.15	5.37	7.52	7.14%
Brazil	P& W paper	1.58	2.10	0.88	2.99	2.82%
	Other paper & paperboard	7.37	9.47	2.76	12.23	2.22%
Canada	P& W paper	1.34	1.74	0.79	2.52	2.80%
	Other paper & paperboard	3.85	4.77	1.01	5.78	1.78%
Sweden	P& W paper	0.15	0.22	0.72	0.94	8.32%
	Other paper & paperboard	0.91	1.23	2.29	3.52	6.04%
Austria	P& W paper	0.36	0.36	0.61	0.97	4.38%
	Other paper & paperboard	1.59	1.65	1.47	3.12	2.96%
Finland	P& W paper	0.00	0.00	1.42	1.42	67.47%
	Other paper & paperboard	0.91	1.07	1.40	2.47	4.44%
India	P& W paper	5.39	12.85	0.24	13.08	3.93%
	Other paper & paperboard	10.41	19.25	0.25	19.50	2.77%
Czech Republic	P& W paper	0.37	0.36	3.47	3.83	10.76%
	Other paper & paperboard	0.99	1.02	2.46	3.49	5.62%
Total	P& W paper	**50.13**	**82.43**	**11.01**	**93.44**	**2.74%**
	Other paper & paperboard	**162.51**	**230.06**	**39.63**	**269.69**	**2.23%**

[1] Estimated based on the amount of wood pulp quantity estimated in Table 3 and the GFPM specified input output coefficients (Mt wood pulp/Mt paper products).

[2] Growth rates used to shift demand for paper products in GFPM in the alternate scenario to simulate estimated growth in wood fibre consumption in the Textile-HWFC scenario.

ANNEX D: ESTIMATED COEFFICIENTS OF PLANTED FOREST AREA ENVIRONMENTAL KUZNETS CURVE MODEL AND VARIABLES DRIVING PROJECTIONS OF PLANTED FOREST AREA IN REFERENCE SSP SCENARIOS.

TABLE D1

Estimated coefficients, standard errors, and significance levels of the Environment Kuznets Curve (EKC) model of planted forest area, which were further used to project development in planted forest area in all countries.

Variables	Fixed Effects Model[1]		
$(Y/N)_{it}$, GDP per capita	1.07	(0.58)	*
$(Y/N)^2_{it}$	-0.052	(0.034)	
U_{it} rural population density	–1.31	(0.36)	***
$(L/A)_{it}$, labour per forest area	1.98	(0.01)	***
$(K/A)_{it}$, capital per forest area	0.030	(0.091)	
$(L/A)_{it}$*$(K/A)_{it}$	-0.047	(0.010)	***
I_{it}	0.21	(0.30)	
I_{it}*$(Y/N)_{it}$	-0.054	(0.076)	
I_{it}*$(L/A)_{it}$	0.16	(0.12)	
I_{it}*$(K/A)_{it}$	0.032	(0.060)	
I_{it}*$(L/A)_{it}$ * $(K/A)_{it}$	-0.021	(0.010)	
Dummy- South America	-0.41	(1.48)	
Dummy- Asia	-0.48	(1.43)	
Dummy- Africa	-1.64	(1.38)	
Dummy- Europe	0.23	(1.41)	*
Dummy- North America	-2.48	(1.47)	***
Intercept	26.83	(5.92)	**
R^2 (adjusted)	0.26		
Pooling test	40.79	***	

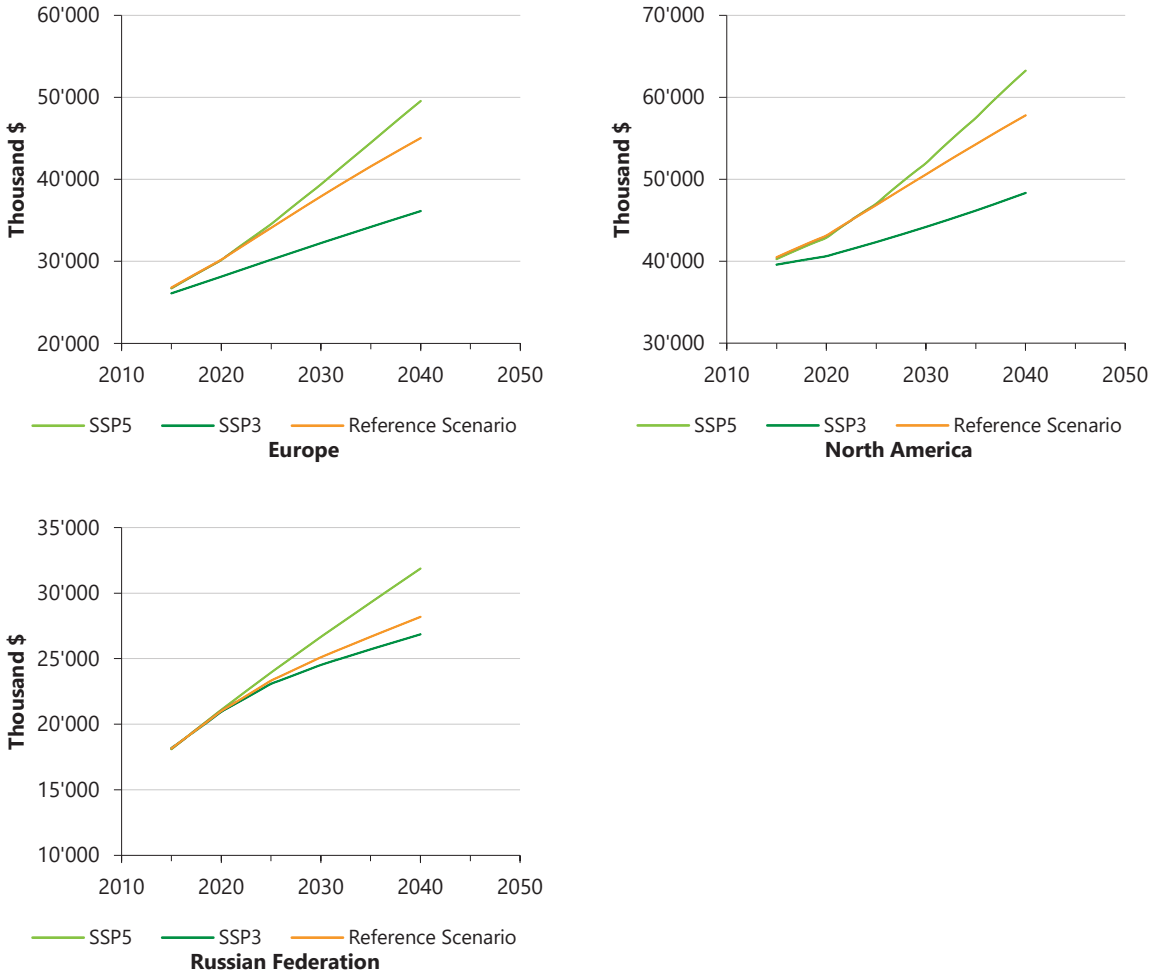
Note: numbers in parentheses are standard errors.

[1] Specified model was a log-log model and therefore the estimated coefficients are also estimates of elasticities.

*** Statistically significant at 1% or stronger, ** statistically significant at 5% or stronger * statistically significant at 10% or stronger.

FIGURE D1

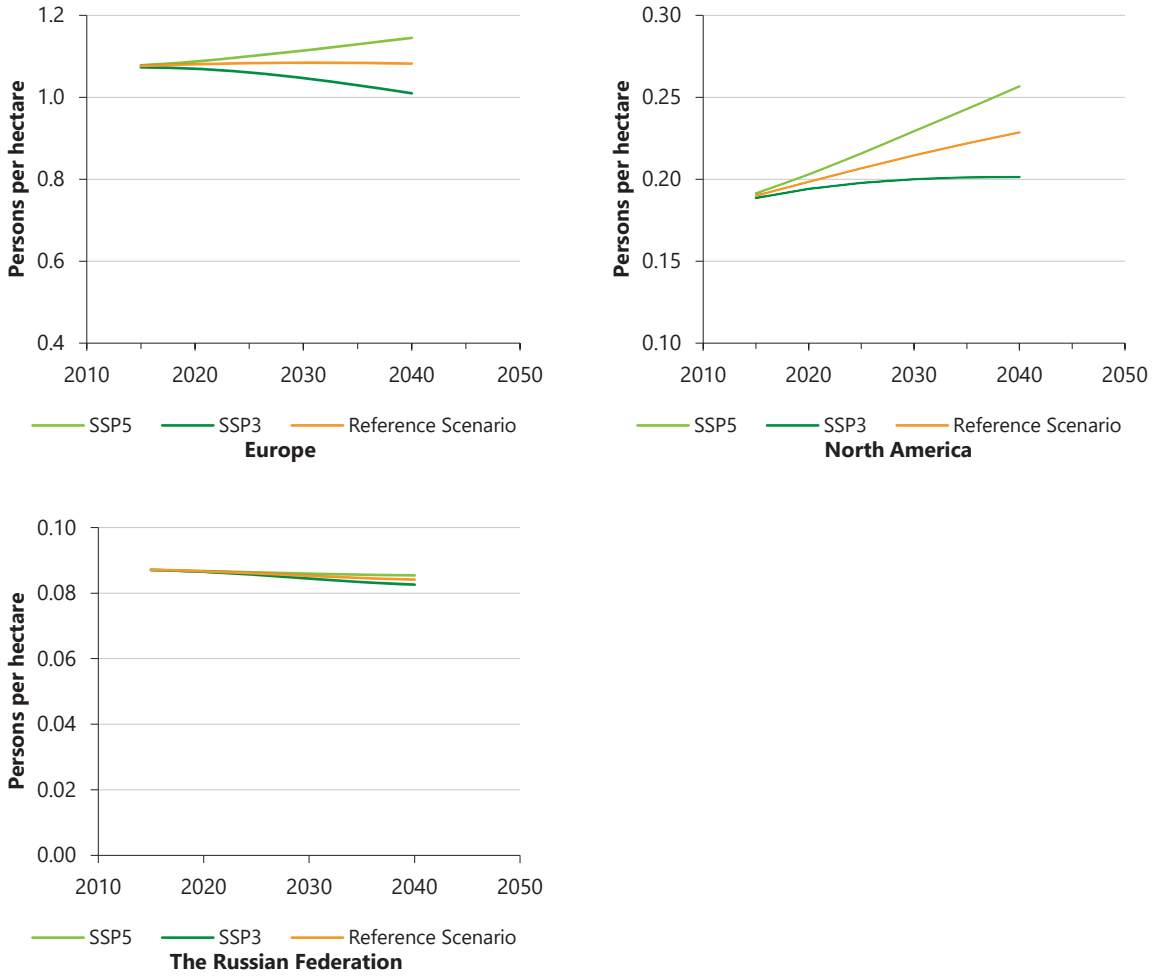
PROJECTED AVERAGE PER CAPITA GROSS DOMESTIC PRODUCT (2010 CONSTANT $) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040



Source: IIASA database (IIASA 2018).

FIGURE D2

PROJECTED RURAL POPULATION DENSITY (PERSONS PER HECTARE) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040

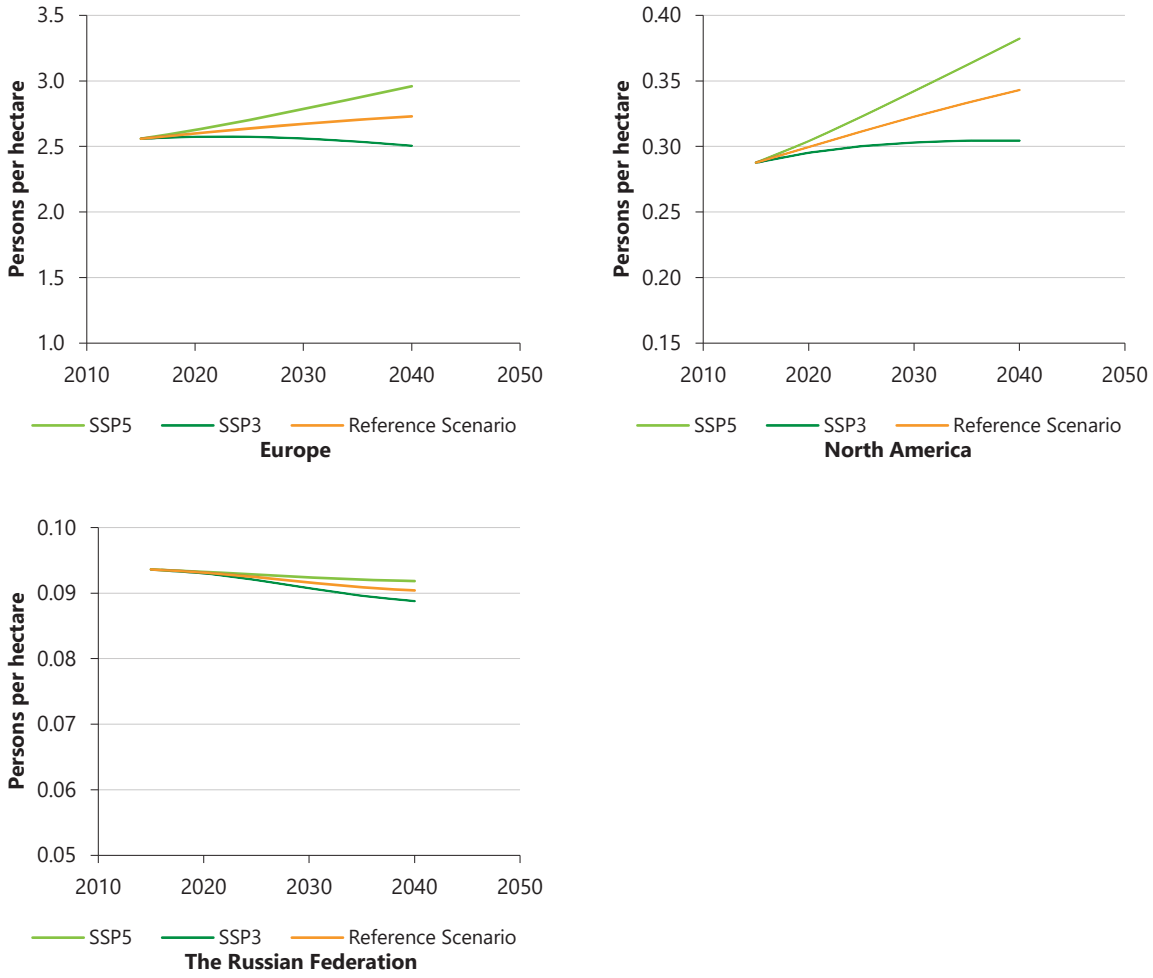


Sources: World Bank (2018), Jiang and O'Neill (2017), and IIASA (2018).

Notes: Rural land area was assumed to change in the future in proportion to the projected trends in rural population.

FIGURE D3

PROJECTED AVERAGE LABOUR PER FOREST AREA (PERSON PER HA) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040



Sources: World Bank (2018), Jiang and O'Neill (2017), and IIASA (2018).

Notes: The base year labour per forest area was assumed to follow the population growth trends projected in respective SSPs.

ANNEX E: COUNTRIES IN THE UNECE REGION AND ITS SUBREGIONS

Eastern Europe, Caucasus and Central Asia
Armenia
Azerbaijan
Belarus
Georgia
Kazakhstan
Kyrgyzstan
Republic of Moldova
Russian Federation
Tajikistan
Turkmenistan
Ukraine
Uzbekistan

North America
Canada
United States of America

European Union	
Austria	Italy
Belgium	Latvia
Bulgaria	Lithuania
Croatia	Luxembourg
Cyprus	Malta
Czech Republic	Netherlands
Denmark	Poland
Estonia	Portugal
Finland	Romania
France	Slovakia
Germany	Slovenia
Greece	Spain
Hungary	Sweden
Ireland	

Europe other countries
Albania
Andorra
Bosnia and Herzegovina
Iceland
Israel
Liechtenstein
Monaco
Montenegro
North Macedonia
Norway
San Marino
Serbia
Switzerland
Türkiye
United Kingdom of Great Britain and Northern Ireland

ANNEX F: SOME FACTS ABOUT THE EUROPEAN FORESTRY COMMISSION

The European Forestry Commission (EFC), which was created in 1947, is one of six regional forestry commissions established by FAO to provide a policy and technical forum for countries to discuss and address forest issues on a regional basis.

The purpose of the EFC is to advise on the formulation of forest policies and to review and coordinate their implementation at the regional level; exchange information; advise on suitable practices and actions to address technical and economic problems (generally through special subsidiary bodies); and make appropriate recommendations in relation to the foregoing. The EFC meets every two years and its official languages are English, French and Spanish.

The EFC has a number of associated subsidiary bodies, including the Working Party on the Management of Mountain Watersheds; the UNECE/FAO Working Party on Forest Statistics, Economics and Management; and seven UNECE/FAO Teams of Specialists. The Committee on Mediterranean Forestry Issues (Silva Mediterranea) informs the EFC.

FAO encourages the wide participation of government officials from forestry and other sectors as well as representatives of international, regional and subregional organizations that deal with forest-related issues in the region, including non-governmental organizations and the private sector. Accordingly, the EFC is open to all members and associate members whose territories are situated wholly or in part in the European Region or who are responsible for the international relations of any non-self-governing territory in that region. Membership comprises such eligible member nations as have notified the Director-General of their desire to be considered as members.

The EFC is one of the technical commissions serving the FAO Regional Office for Europe and Central Asia (REU), and the EFC Secretary is based in Geneva. EFC work is regulated by its Rules of Procedures, which were adopted by the FAO Conference in 1961 and amended at the Eighteenth Session of the EFC in 1977.

ANNEX G: SOME FACTS ABOUT THE COMMITTEE ON FORESTS AND THE FOREST INDUSTRY

The UNECE Committee on Forests and the Forest Industry (COFFI) is a principal subsidiary body of the UNECE based in Geneva. It constitutes a forum for cooperation and consultation between member countries on forestry, the forest industry and forest product matters. All countries of Europe and the EECCA, as well as the United States, Canada and Israel, are members of the UNECE and participate in its work.

The UNECE Committee on Forests and the Forest Industry shall, within the context of sustainable development, provide member countries with the information and services needed for policymaking and decision-making with regard to their forest and forest industry sectors, including the trade and use of forest products and, where appropriate, it will formulate recommendations addressed to member governments and interested organizations. To this end, it shall:

1. with the active participation of member countries, undertake short-, medium- and long-term analyses of developments in, and having an impact on, the sector, including those developments offering possibilities for facilitating international trade and for enhancing the protection of the environment;
2. in support of these analyses, collect, store and disseminate statistics relating to the sector, and carry out activities to improve their quality and comparability;
3. provide a framework for cooperation, for example by organizing seminars, workshops and ad hoc meetings and setting up time-limited ad hoc groups, for the exchange of economic, environmental and technical information between governments and other institutions of member countries required for the development and implementation of policies leading to the sustainable development of the sector and the protection of the environment in their respective countries;
4. carry out tasks identified by the UNECE or the Committee on Forests and the Forest Industry as being of priority, including the facilitation of subregional cooperation and activities in support of the economies in transition of central and eastern Europe and of the countries of the region that are developing from an economic perspective; and
5. keep under review its structure and priorities and cooperate with other international and intergovernmental organizations active in the sector, particularly FAO and its European Forestry Commission and the International Labour Organization, in order to ensure complementarity and avoid duplication, thereby optimizing the use of resources.

More information about the work of the EFC and COFFI may be obtained by contacting:

UNECE/FAO Forestry and Timber Section
Forests, Land and Housing Division
United Nations Economic Commission for Europe/
Food and Agriculture Organization of the United Nations
Palais des Nations
CH-1211 Geneva 10, Switzerland

info.ECE-FAOforests@un.org
www.unece.org/forests

ANNEX H: UNECE/FAO PUBLICATIONS

Geneva Timber and Forest Study Papers

Forest Products Annual Market Review 2019-2020	ECE/TIM/SP/50
Forests in a Circular Economy	ECE/TIM/SP/49
Forest Products Annual Market Review 2018-2019	ECE/TIM/SP/48
State of Forests of the Caucasus and Central Asia	ECE/TIM/SP/47
Forest Products Annual Market Review 2017-2018	ECE/TIM/SP/46
Forests and Water	ECE/TIM/SP/44
Forest Ownership in the ECE Region	ECE/TIM/SP/43
Wood Energy in the ECE Region	ECE/TIM/SP/42
Forest Products Annual Market Review 2016-2017	ECE/TIM/SP/41
Forest Products Annual Market Review 2015-2016	ECE/TIM/SP/40
Forest Products Annual Market Review 2014-2015	ECE/TIM/SP/39
Promoting sustainable building materials and the implications on the use of wood in buildings	ECE/TIM/SP/38
Forests in the ECE Region: Trends and Challenges in Achieving the Global Objectives on Forests	ECE/TIM/SP/37
Forest Products Annual Market Review 2013-2014	ECE/TIM/SP/36
Rovaniemi Action Plan for the Forest Sector in a Green Economy	ECE/TIM/SP/35
The Value of Forests: Payments for Ecosystem Services in a Green Economy	ECE/TIM/SP/34
Forest Products Annual Market Review 2012-2013	ECE/TIM/SP/33
The Lviv Forum on Forests in a Green Economy	ECE/TIM/SP/32
Forests and Economic Development: A Driver for the Green Economy in the ECE Region	ECE/TIM/SP/31
Forest Products Annual Market Review 2011-2012	ECE/TIM/SP/30
The North American Forest Sector Outlook Study 2006-2030	ECE/TIM/SP/29
European Forest Sector Outlook Study 2010-2030	ECE/TIM/SP/28
Forest Products Annual Market Review 2010-2011	ECE/TIM/SP/27
Private Forest Ownership in Europe	ECE/TIM/SP/26
Forest Products Annual Market Review 2009-2010	ECE/TIM/SP/25
Forest Products Annual Market Review 2008-2009	ECE/TIM/SP/24
Forest Products Annual Market Review 2007-2008	ECE/TIM/SP/23
Forest Products Annual Market Review 2006-2007	ECE/TIM/SP/22
Forest Products Annual Market Review, 2005-2006	ECE/TIM/SP/21
European Forest Sector Outlook Study: 1960 – 2000 – 2020, Main Report	ECE/TIM/SP/20
Forest policies and institutions of Europe, 1998-2000	ECE/TIM/SP/19
Forest and Forest Products Country Profile: Russian Federation	ECE/TIM/SP/18
(Country profiles also exist on Albania, Armenia, Belarus, Bulgaria, former Czech and Slovak Federal Republic, Estonia, Georgia, Hungary, Lithuania, Poland, Romania, Republic of Moldova, Slovenia and Ukraine)	
Forest resources of Europe, CIS, North America, Australia, Japan and New Zealand	ECE/TIM/SP/17

Note: *Additional market-related information is available in electronic format at* **www.unece.org/forests.**

Geneva Timber and Forest Discussion Papers (original language only)

COVID-19 Impacts on the Forest Sector in Countries in countries in the Western Balkans	*ECE/TIM/DP/89
COVID-19 Impacts on the Forest Sector in Countries in countries Eastern Europe, Caucasus and Central Asia	*ECE/TIM/DP/88
Forest Landscape Restoration in Eastern and South-East Europe	ECE/TIM/DP/87
Overview of the State of Forests and Forest Management in Uzbekistan	ECE/TIM/DP/85
Overview of the State of Forests and Forest Management in Turkmenistan	ECE/TIM/DP/84
Overview of the State of Forests and Forest Management in Tajikistan	ECE/TIM/DP/83
Overview of the State of Forests and Forest Management in Kyrgyzstan	ECE/TIM/DP/82
Overview of the State of Forests and Forest Management in Kazakhstan	ECE/TIM/DP/81
Overview of the State of Forests and Forest Management in Georgia	ECE/TIM/DP/80
Overview of the State of Forests and Forest Management in Azerbaijan	ECE/TIM/DP/79
Overview of the State of Forests and Forest Management in Armenia	ECE/TIM/DP/78
Guidelines on the Promotion of Green Jobs in Forestry	ECE/TIM/DP/77
Forest Sector Workforce in the UNECE Region	ECE/TIM/DP/76
Rovaniemi Action Plan for the Forest Sector in a Green Economy: Mid-term Review	ECE/TIM/DP/75
Trends in green jobs in the forest sector in the UNECE region	ECE/TIM/DP/74
Guidelines for the Development of a Criteria and Indicator Set for Sustainable Forest Management	ECE/TIM/DP/73
Forest Landscape Restoration in the Caucasus and Central Asia	ECE/TIM/DP/72
Green Jobs in the Forest Sector	*ECE/TIM/DP/71
Measuring the Value of Forests in a Green Economy	*ECE/TIM/DP/70
Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2016-2018	*ECE/TIM/DP/69
Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2015-2017	*ECE/TIM/DP/68
ECE Committee on Forests and the Forest Industry and European Forestry Commission: 70 years working in the Service of Forests and people	ECE/TIM/DP/67
Pilot project on the System for the Evaluation of the Management of Forests (SEMAFOR)	ECE/TIM/DP/66
Comparative assessment of wood biomass for energy in Europe	*ECE/TIM/DP/65
Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2014-2016	ECE/TIM/DP/64
Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2013-2015	ECE/TIM/DP/63
Competitiveness of the European Forest Sector	ECE/TIM/DP/62
Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2012-2014	ECE/TIM/DP/61

Forecast of the Committee on Forests and the Forest Industry: Forest Products Production and Trade 2011-2013	ECE/TIM/DP/60
Econometric Modelling and Projections of Wood Products Demand, Supply and Trade in Europe	ECE/TIM/DP/59
Swedish Forest Sector Outlook Study	ECE/TIM/DP/58
The Importance of China's Forest Products Markets to the UNECE Region	ECE/TIM/DP/57
Good Practice Guidance on Sustainable Mobilisation of Wood: Proceedings from the Grenoble Workshop	*ECE/TIM/DP/56
Harvested Wood Products in the Context of Climate Change Policies: Workshop Proceedings - 2008	*ECE/TIM/DP/55
The Forest Sector in the Green Economy	ECE/TIM/DP/54
National Wood Resources Balances: Workshop Proceedings	*ECE/TIM/DP/53
Potential Wood Supply in Europe	*ECE/TIM/DP/52
Wood Availability and Demand in Europe	*ECE/TIM/DP/51
Forest Products Conversion Factors for the UNECE Region	ECE/TIM/DP/49
Mobilizing Wood Resources: Can Europe's Forests Satisfy the Increasing Demand for Raw Material and Energy Under Sustainable Forest Management? Workshop Proceedings - January 2007	*ECE/TIM/DP/48
European Forest Sector Outlook Study: Trends 2000-2005 Compared to the EFSOS Scenarios	ECE/TIM/DP/47
Forest and Forest Products Country Profile; Tajikistan	*ECE/TIM/DP/46
Forest and Forest Products Country Profile: Uzbekistan	ECE/TIM/DP/45
Forest Certification – Do Governments Have a Role?	ECE/TIM/DP/44
International Forest Sector Institutions and Policy Instruments for Europe: A Source Book	ECE/TIM/DP/43
Forests, Wood and Energy: Policy Interactions	ECE/TIM/DP/42
Outlook for the Development of European Forest Resources	ECE/TIM/DP/41
Forest and Forest Products Country Profile: Serbia and Montenegro	ECE/TIM/DP/40
Forest Certification Update for the UNECE Region, 2003	ECE/TIM/DP/39
Forest and Forest Products Country Profile: Republic of Bulgaria	ECE/TIM/DP/38
Forest Legislation in Europe: How 23 Countries Approach the Obligation to Reforest, Public Access and Use of Non-Wood Forest Products	ECE/TIM/DP/37
Value-Added Wood Products Markets, 2001-2003	ECE/TIM/DP/36
Trends in the Tropical Timber Trade, 2002-2003	ECE/TIM/DP/35
Biological Diversity, Tree Species Composition and Environmental Protection in the Regional FRA-2000	ECE/TIM/DP/33
Forestry and Forest Products Country Profile: Ukraine	ECE/TIM/DP/32
The Development of European Forest Resources, 1950 To 2000: a Better Information Base	ECE/TIM/DP/31
Modelling and Projections of Forest Products Demand, Supply and Trade in Europe	ECE/TIM/DP/30
Employment Trends and Prospects in the European Forest Sector	ECE/TIM/DP/29
Forestry Cooperation with Countries in Transition	ECE/TIM/DP/28
Russian Federation Forest Sector Outlook Study	ECE/TIM/DP/27
Forest and Forest Products Country Profile: Georgia	ECE/TIM/DP/26
Forest certification update for the UNECE region, summer 2002	ECE/TIM/DP/25

Forecasts of economic growth in OECD and central and eastern European countries for the period 2000-2040	ECE/TIM/DP/24
Forest Certification update for the UNECE Region, summer 2001	ECE/TIM/DP/23
Structural, Compositional and Functional Aspects of Forest Biodiversity in Europe	ECE/TIM/DP/22
Markets for secondary processed wood products, 1990-2000	ECE/TIM/DP/21
Forest certification update for the UNECE Region, summer 2000	ECE/TIM/DP/20
Trade and environment issues in the forest and forest products sector	ECE/TIM/DP/19
Multiple use forestry	ECE/TIM/DP/18
Forest certification update for the UNECE Region, summer 1999	ECE/TIM/DP/17
A summary of "The competitive climate for wood products and paper packaging: the factors causing substitution with emphasis on environmental promotions"	ECE/TIM/DP/16
Recycling, energy and market interactions	ECE/TIM/DP/15
The status of forest certification in the UNECE region	ECE/TIM/DP/14
The role of women on forest properties in Haute-Savoie (France): Initial research	ECE/TIM/DP/13
Interim report on the Implementation of Resolution H3 of the Helsinki Ministerial Conference on the protection of forests in Europe (Results of the second enquiry)	ECE/TIM/DP/12
Manual on acute forest damage	ECE/TIM/DP/7

* signifies electronic publication only

Many of the above publications can be downloaded free of charge at:

www.unece.org/forests

Publications and subscriptions are available through United Nations Publications Offices as follows:

Sales and Marketing Section, Room DC2-853
United Nations
2 United Nations Plaza
New York, NY 10017
United States of America
Fax: + 1 212 963 3489
E-mail: publications@un.org
Web site: https://shop.un.org

Detailed methodology for the preparation of the forest sector outlook study 2020-2040

The Forest Sector Outlook Study 2020-2040 (FSOS) for the UNECE region provides information that supports decision-making by showing the possible medium- and long-term consequences of specific policy choices and structural changes, using scenario analyses whenever possible. The study is the first to cover the entire UNECE region and provides results for the main UNECE subregions of Europe, North America and the Russian Federation.

This methodology report provides a detailed description of background, assumptions, approaches and modelling tools utilized in the UNECE Forest Sector Outlook Study 2020-2040 (FSOS) main report. The main report summarizes and discusses the forest sector impacts in UNECE region and subregions of reference and "what-if" scenarios depicting future trajectory of socioeconomic changes, climate change, and structural changes in demand, supply and trade of forest products, globally and in the UNECE region and subregions.

More specifically, this methodology report provides detailed information on i) the selected sets of reference and the alternative "what-if" scenarios, including their development and selection process, assumptions, and justification, and ii) the modelling approaches and global models utilized to simulate and analyse those scenarios, including the Global Forest Products Model (GFPM) and an adjunct to the GFPM that generates separate estimates of carbon sequestered in forest biomass and in harvested wood products.

Information Service
United Nations Economic Commission for Europe

Palais des Nations
CH - 1211 Geneva 10, Switzerland
Telephone: +41(0)22 917 12 34
E-mail: unece_info@un.org
Website: http://www.unece.org

ISBN 978-92-1-117322-2

Printed at United Nations, Geneva – 2326215 **(E)** – May 2024 – 406 – **ECE/TIM/DP/90**