Food and Agriculture Organization of the United Nations

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STRUCTURAL CHANGES IN THE FOREST SECTORAND THEIR LONG-TERM CONSEQUENCES FOR THE FOREST SECTOR

A CONTRIBUTION TO THE FOREST SECTOR OUTLOOK STUDY 2020-2040

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Structural Changes in the Forest Sector and their Long-term Consequences for the Forest Sector a Contribution to the Forest Sector Outlook Study 2020-2040

UNITED NATIONS

Geneva, 2022

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ABSTRACT

This Discussion Paper is a background document to the Forest Sector Outlook Study 2020-2040 (FSOS) for the UNECE region (ECE/TIM/SP/51). It provides the details that are summarized in chapter 3 of the main study. It analyses how markets and forests may evolve under different assumptions of economic growth, population growth, and climate change and covers the years 2020-2040, starting with 2017 as the base year for projections. It focuses on how departures from recent patterns of supply and demand – i.e. structural changes – might affect the UNECE region. Modelling these structural changes asks 'what-if' questions about specific factors that might influence supply or demand, in the UNECE forest sector, and globally. The analyses compare the outcomes to a business-as-usual, or reference scenario. The 'what-if' questions follow suggestions from UNECE member States about critical uncertainties to be faced in the future.

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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 12 November 2021.

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}.

Nonwood forest products are part of the broader concept of the provision of ecosystem services through forests. However, due to limitations in resources available and guidance received by member States and the necessity of focusing on the six questions identified at the beginning of the process. The study was not able to assess the impact of future trends on important services and products such as e.g. honey, medicinal plants, nuts, fruits, mushrooms, pollination, erosion prevention, etc. In some regions of the UNECE, these goods and services may even exceed the social and economic value of wood and wood products from forests.

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List of abbreviations, acronyms and symbols

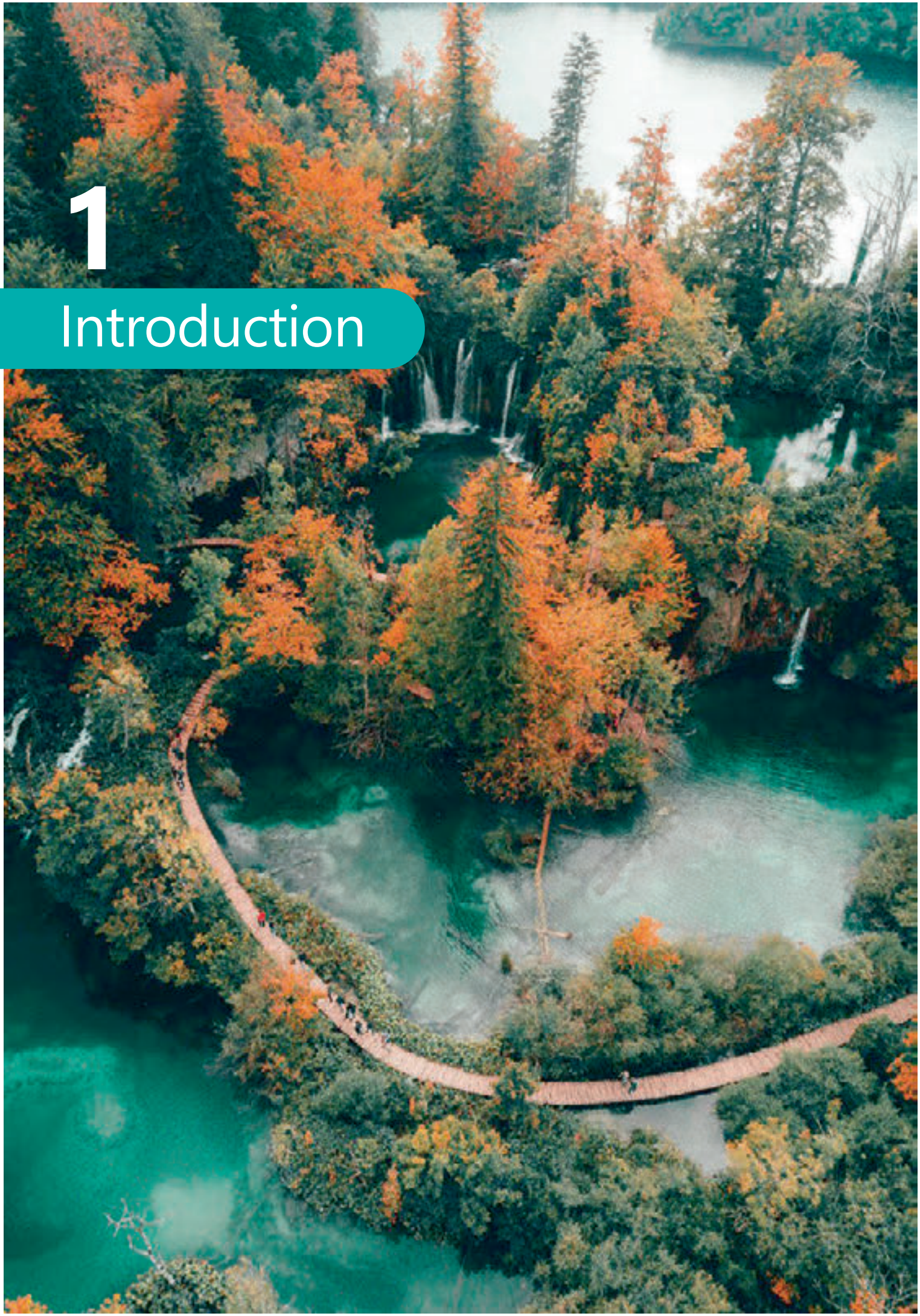
(Infrequently used abbreviations spelled out in the text may not be listed here)

AWC	American Wood Council
CAD	Canadian dollar
CAGR	Compounded annual growth rate
CLT	Cross-laminated timber
COVID-19	Coronavirus disease of 2019
ECE	United Nations Economic Commission for Europe
EECCA	Eastern Europe, Caucasus and Central Asia
EFI	European Forest Institute
EU	European Union
FAO	Food and Agriculture Organization of the United Nations
FORMASAM	Forest Management Scenarios for Adaptation and Mitigation
FRA	Forest Resources Assessment
GDP	Gross domestic product
GFPM	Global Forest Products Model
HFA	High Forest Area
HWC	High Wood Consumption
HWFC	High Wood Fibre Consumption
IIASA	International Institute of Applied System Analysis
IRW	Industrial roundwood
RCPs	Representative Concentration Pathways
SSP	Shared Socioeconomic Pathway
UN	United Nations
UNECE	United Nations Economic Commission for Europe
US	United States of America
USD	United States dollar(s)
USDA	United States Department of Agriculture

Note to the reader about this "Forest Sector Outlook Study 2020-2040" Discussion Paper

This Discussion Paper presents the detailed analysis and findings on structural changes in the forest sector and their long-term consequences for the forest sector based on modelling conducted for the preparation of the "Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2021). Chapter 3 of the "Forest Sector Outlook Study 2020-2040" was drafted based on the analysis and findings presented in this Discussion Paper.

The detailed methodology for the Forest Sector Outlook Study, including the methodology used in this Discussion Paper, is presented in the companion publication "Detailed Methodology for the Preparation of the Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2022a). A detailed analysis of the outlook under climate change is presented in another publication, "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2022b).



1 Introduction

Key Points

- A simulated scenario in which China would build every tenth new housing unit with wood, suggests that prices could rise to 9% above the business-as-usual level, favouring increased exports from the UNECE region, but cutting consumption within the region by up to 2%.
- If per capita wood consumption in Europe were to rise, by 2040, to current United States levels, prices globally might rise by up to 4% above reference levels, potentially boosting production by as much as 9%, and reducing exports from the UNECE region to meet consequent increased demand within Europe and the Russian Federation. Price increases for industrial roundwood (IRW) would result in reduced wood pulp and paper production within the UNECE region (by up to 2%) but would raise revenues earned by timber owners in the UNECE region and beyond.
- If, by 2040, wood-based fibre would replace polyester, to make up 30% of the total fibre demand of the textile sector, this would divert IRW from the production of sawnwood and panels within the UNECE region, potentially increasing roundwood prices, and benefiting forest owners and wood product manufacturers.
- A simulation of the effects of a 10% increase in global forest by 2040 (reflecting policies to foster afforestation and reforestation with productive plantations) suggested this might drive down IRW prices by up to 3% by 2040, compared to the business-as-usual scenario, but could boost global production/consumption of manufactured products like sawnwood, panels, and paper, by about 1% overall, while increasing production in the UNECE region by as much as 4%.
- Salvaging roundwood after natural disturbances can temporarily flood markets and push down roundwood prices: in the longer term, prices may rise in surrounding areas as future roundwood supplies may be less readily available.
- A global trade war, particularly if it were initiated by a UNECE member State, would worsen UNECE and global welfare, with the impact felt most strongly by the countries involved.

This Discussion Paper analyses how markets and forests may evolve under different assumptions of economic growth, population growth, and climate change. It covers the years 2020-2040, starting with 2017 as the base year for projections. It focuses on how departures from recent patterns of supply and demand – i.e. structural changes – might affect the UNECE region. Modelling these structural changes asks 'what-if' questions about specific factors that might influence supply or demand in the UNECE forest sector, and globally. The analyses compare the outcomes to a business-as-usual, or reference scenario. The 'what-if' questions follow suggestions from UNECE member States about critical uncertainties to be faced in the future (1.1). Not all the suggested uncertainties could be analysed with the model applied in this Outlook study. Fortunately, others have already researched some of these aspects, providing insights that are shared in this paper.

The Global Forest Products Model (GFPM), 2019 version, was used to model the 'what-if' questions, as well as the business-as-usual reference (Buongiorno et al., 2003, Buongiorno and Zhu, 2019). Planted forests often produce high yields (Payn et al., 2015), and in developing the models for this Outlook, calculations of forest growth derived from the GFPM were adjusted, to take account of the dividend from projected changes in planted forests, based on recent assessments (Korhonen et al.; 2020, Nepal et al., 2019a). The model results for each structural change, based on the "what-if" questions, describe outcomes against a reference projection that assumes the structural change did not happen. The results cover industrial roundwood removals; prices; production; consumption; imports and exports of traded products; forest growing stock; total and planted forest area; and net carbon sequestration. Net carbon sequestration covers forest carbon stocks and carbon stored in wood products, including the substitution effect (substituting products with a large carbon footprint with products having a smaller carbon footprint). The results for carbon are not covered in this paper but can be found in the Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040" (UNECE & FAO, 2022).

TABLE 1.1 Overview of 'What-if?' scenarios in this study

How would UNECE forest products markets react to changed circumstances?	**Method** (and if applicable GFPM scenario name)	**Section (carbon results)**
Demand changes: What if…		
… China started to build every tenth new housing unit with wood?	GFPM: China-High Wood Consumption (China-HWC)	3.1
… Europe and the Russian Federation significantly increased the amount of wood used in construction?	GFPM: Europe-High Wood Consumption (Europe-HWC)	3.2
… the textile sector replaced 30% of its fibre intake with wood-based fibre?	GFPM: Textile-High Wood Fibre Consumption (Textile-HWFC)	3.3
Supply changes: What if…		
…the global forest area were 10% greater?	GFPM: High Forest Area (HFA)	4.1
…there were a rapid increase in forest growing stock, resulting from increased planted forest outside the UNECE region?	Literature review	4.2
… natural disturbance of forest were to be become more frequent and severe?	Literature review	4.3
Trade: What if…		
… there were substantial restrictions to trade in forest products?	Literature review	5

The analysis of future outcomes focused on how structural changes would affect demand and supply. On the demand side, three scenarios were considered.

(1) A rapid increase in the use of wood in the construction sector of China, whereby every tenth new housing unit is built with the same volume of wood used in a single multi-family dwelling in the United States in 2015 (China-HWC scenario).

(2) A steady rise, from 2020 to 2040, in per capita consumption of timber and wood-based structural panels in Europe and the Russian Federation to match 2015 levels in the United States (Europe-HWC scenario).

(3) A steady rise, from 2020, in the consumption of wood-based fibres by the global textile sector so that, by 2040, 30% of the intake of fibres were wood-based (Textile-HWFC scenario). The details of how these demand changes were simulated are in the "Detailed Methodology for the Preparation of the Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2022a).

Three scenarios of structural change to wood supply were analysed.

(1) A steady increase in global forest area to 10% higher, by 2040, than under business-as-usual conditions, leading to global increases in forest growing stocks and carried out with the GFPM (HFA scenario).

(2) A rapid increase in forest growing stocks, resulting from increases in planted forest taking place outside the UNECE region, with the results, regionally and globally, extracted from the study by Nepal et al. (2019a).

(3) Increased forest-based disturbances caused by any combination of various agents, including climate change, and invasive exotic pest species. The results are summarized based on a review of literature about how disturbances, such as wildfire, beetle epidemics, and wind events, have affected markets in the UNECE region. The Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2022b) goes into more detail about the effects of climate change and forest disturbance.

Finally, this paper includes a what-if scenario that evaluates the effects of a trade policy that jointly affects supply and demand: a trade policy intervention in the form of increased barriers to global trade in forest products.

The modelling of the reference and what-if scenarios was completed before the outbreak of the COVID-19 pandemic. Many questions have come up on how this unexpected event would affect the modelling results. Box 1 provides insights into these questions.

The modelling using the GFPM has attempted to incorporate the growth of the circular bioeconomy. Such growth could come about through policies and programmes that foster increasing adherence to the concepts of a sustainable circular bioeconomy, which favours replacing fossil hydrocarbons with plant and animal biomass resources, and has a strong emphasis on reducing, reusing, and recycling materials (Antikainen et al,. 2017, McKormic and Kautto, 2013). Although the structural change scenarios developed in this Outlook are not designed to conform precisely to a process of production and consumption consistent with a circular bioeconomy, the GFPM employed for quantitatively modelling the selected scenarios considers the potential recovery of wastepaper in the manufacture of new paper and paperboard products. The supply of wastepaper, which is one of the inputs to wood pulp production, is modelled as a function of its own price and GDP and varies from nothing to 80%, depending on the existing technology and the specified supply curve parameters in individual countries.

BOX 1

The effect of the COVID-19 pandemic on the Global Forest Products Model modelling

The COVID-19 pandemic and recession are affecting many key variables of interest to the forest sector. This does not necessarily influence the scenarios in the Outlook study, because of its basic design and how it sets out to assess potential futures. The modelling and results that appear in this study (and, for carbon, parts of the UNECE/FAO 2022 Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040") were undertaken with a scenario-based format. This approach was used to assess how key variables might differ from alternative future views and to examine how structural changes might affect the forest sector.

The most influential factor affecting forest sector key variables is likely to be overall economic growth. This affects consumer spending and how much producers will manufacture to meet demand at given prices. The large historical interannual variations in key forest sector variables were, in large part, driven by economic growth. History shows that rates of economic growth vary from year to year in all countries. Long-term predictions about the timing of high and low economic growth are not possible. For that reason, this study adopted a scenario approach. The growth rates that were the basis for the reference scenario (SSP2), and the other scenarios (SSP3, and SSP5) span a range of potential long-term averages. Excluding short-term economic growth dynamics does not invalidate the net effects identified in comparing the 'what-if' and reference scenarios.

The GFPM is a multi-country representation of the sector, described by a set of equations defining relationships between input and output variables. Relationships are quantified by parameters (or coefficients), which include wood conversion efficiencies; manufacturing costs; transport costs; trade costs (including tariffs); sensitivities of demand to prices and GDP; and sensitivities of supply to prices and forest growing stock. The values of input variables, which include GDP growth; population growth; tariffs; transport costs; and rates of technology change, are assumptions. The values of output variables are the result of parameters interacting with input variables during modelling.

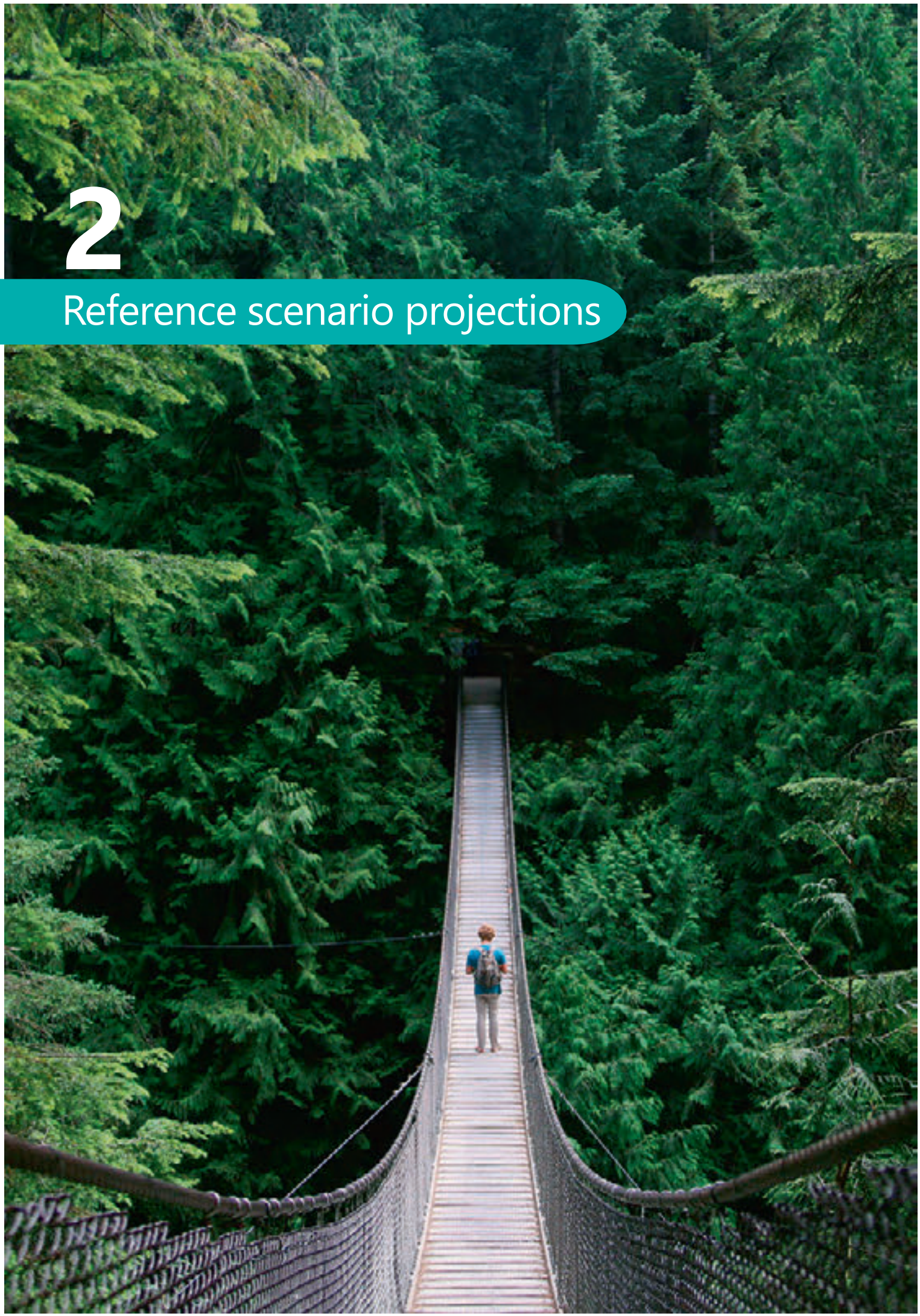
Parameters of GFPM generally do not change during the span of a projection. Estimates of parameters are made using econometric modelling of historical data from national statistical reports and represent the average historical relationships between input and output variables. All historical data correspond to years before the pandemic and cannot reflect permanent changes in average relationships caused by the pandemic. It would be those changes that could have affected the magnitude of the projected changes in the sector which are reported in this Outlook. National statistics for many variables of interest to the forest sector often lag by one to two years, so new econometric modelling that quantifies how parameters may change as a consequence of the pandemic cannot be done yet. Analysts can only speculate whether the parameters of the GFPM might have changed. Normally, the changes would only be in magnitude, not in sign.

Conclusions

- The pandemic has affected input variables and output variables in the GFPM.
- The effects of short-term dynamics in variables are not likely to significantly influence the direction or even the magnitude of most projected forest sector variables.
- Changes in the conclusions of this Outlook would occur only in cases in which certain parameters changed permanently, due specifically to the pandemic and the associated recession.
- It is too soon to know whether parameters in the GFPM might have been permanently impacted by the pandemic

2

Reference scenario projections



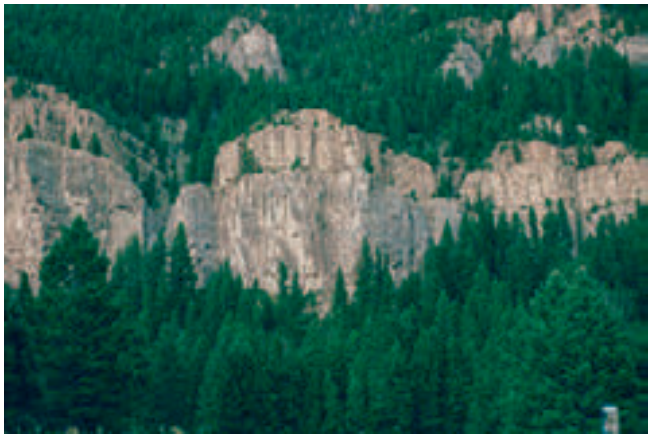
Understanding how structural changes might impact the forest sector and its markets needs a business-as-usual reference, of a future unaffected by structural change. The GFPM assumes that market structures, historical rates of technology change, and the climate regime remain unchanged from those observed to 2017. Projections for 2020 to 2040 follow Shared Socioeconomic Pathways as defined by the International Institute for Applied Systems Analysis.

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 challenge that societies face to either adapt to or mitigate climate change (O'Neill et al. 2014, 2017).

For this Outlook, three SSPs were modelled for the forest sector with the GFPM - SSP2, SSP3 and SSP5.

SSP2 is the "business-as-usual", "middle-of-the-road" vision of the future, where development pathways are assumed to be consistent with historical social, economic, and technological trends. This is the reference scenario used in this report (and the "Forest Sector Outlook Study 2020-2040") and is referred to as the "reference scenario" in the remainder of this paper.

SSP3 is the "regional rivalry – a rocky road" scenario. It represents an economically fragmented world that is poorer than in other SSPs, projecting the lowest overall per capita income (on a global basis) and containing the most disparate income per capita across countries. It assumes policy, economic, and technological challenges to both mitigation and adaptation, based on weak economic growth; slow 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.



SSP5 is the "fossil-fuelled development – taking the highway". It represents the wealthiest future, with higher levels of economic equality than in the reference scenario and SSP3. It emphasizes an enhanced social and human capital base, obtained through high levels of investment in health, education, and institutions. There remains strong dependence on fossil fuels into the foreseeable future, with limited investment targeted at addressing global environmental problems, compared to the reference scenario, implying a greater challenge to mitigate climate change. Robust economic growth coupled with attainment of human development goals, reduce challenges to climate change adaptation. [1]

The reasons for choosing SSPs were:

(i) They provide a transparent set of quantitative descriptions of future income and population by country for each SSP through to 2040, the end date for this Outlook.

(ii) They are the framework that other forward-looking assessments have used for individual countries and subregions of the UNECE, such as the United States Forest Service's 2020 Resources Planning Act Assessment, and carried out for other economic sectors, enabling comparisons across studies.

The outlook for forest resources and forest product markets in the UNECE region is shaped by differing views of how economic and demographic conditions of individual countries might change (covered by the three

[1] Initially, it was considered to model all five SSPs in this Outlook. However, because the projected results and trends were very similar between SSP1 and SSP5, and between the reference scenario and SSP4, the modelling team utilized only the reference scenario, SSP3, and SSP5 as the scenarios for this study. SSP1 is described as a "sustainable development" world view with vigorous economic growth and rapid economic development in low-income countries, an open and globalized economy, and decreased global inequalities. SSP4 represents a divided world, with wide gaps in economic and technological development across countries (O'Neill et al. 2017).

SSPs), along with assumptions imposed by the modelling approach. Projected changes in per capita income, rural population density, and labour force per unit of forest area (see A1, A2, and A3 in the Annex) result in distinct trends in forest area (total forest area and planted forest) by country, which in turn drive trends in forest growing stock. The availability of roundwood to meet the demands of industry in countries will reflect the area, volume, and growth rates of forests. The demand for forest products at all price levels, mirrors rises and falls in disposable incomes. Market-clearing[2] conditions produce, for each period and by country, results for final market prices, production, consumption, imports, and exports. Market-clearing conditions also provide results for net carbon sequestration and storage in standing forests and wood products. Among the SSPs, the reference scenario projects a future that traces out recently observed rates of change (the "business-as-usual" future) and is the benchmark for comparing the 'what-if' scenarios reported subsequently in this paper.

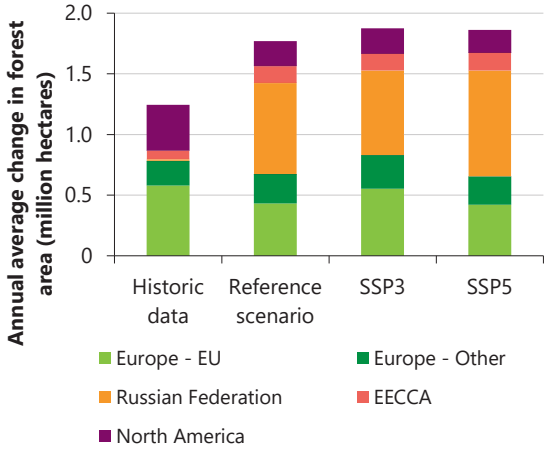
The results of the SSPs (including the reference scenario) and 'what-if' modelling are reported for five subregions in the UNECE region: North America; Europe-EU; Europe-Other; the Russian Federation; and Eastern Europe, the Caucasus and Central Asia (EECCA). Annex C provides an overview of the countries of the UNECE region and its subregions. Results for the world outside UNECE or the whole world are included sometimes when this illustrates noteworthy effects. The limitations of the chosen model did not permit reporting historical or projected data for Andorra, Iceland, Liechtenstein, Malta, Monaco, San Marino, and the Vatican City.

2.1 Projected total forest area

The model assumes that per capita income is what drives projections of forest area. In Europe-EU, Europe-Other, the Russian Federation, and EECCA, rising per capita income is expected to result in an expansion of forest in most countries, between 2020 and 2040. Projections for North America also suggest that forest area will expand, but at a declining rate in all three SSPs ().

Historically, the forest area of the Russian Federation has largely remained constant. Under the reference scenario, the area of forest is projected to expand more sharply than other regions, increasing by roughly 0.1% per year, between 2020 and 2040. The reasoning behind this accelerating expansion of forest area in the Russian Federation are projections of rising per capita income, and its status as a middle-income economy. The Environmental Kuznets Curve[3], which is applied in the model, suggests that as incomes rise, countries experience high rates of forest expansion. These results indicate that forest area dynamics in the Russian Federation operate in ways not wholly consistent with an Environmental Kuznets Curve.

FIGURE 2.1 HISTORIC AND PROJECTED ANNUAL AVERAGE CHANGE IN FOREST AREA IN FIVE UNECE SUBREGIONS



Notes: Historic data 1990-2015; Reference scenario and other SSPs 2020-2040. 2017 is the base year for projections and is the average of 2016-2018. The values for 2016-2018 have been interpolated from the 2015 forest area growth rate reported by FAO (2015b).

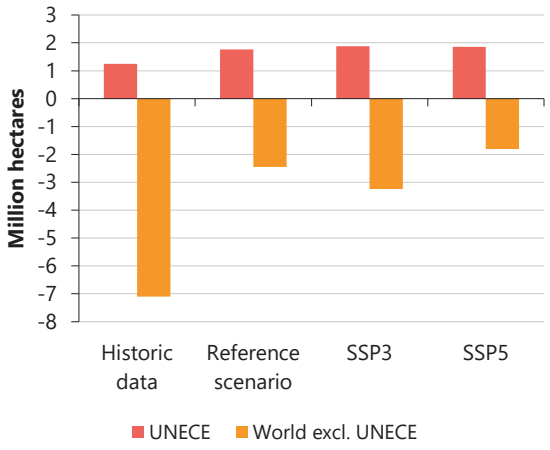
Sources: FAO, 2015 and GFPM projection.

While projections show rising forest area in the UNECE, the rate of change under the reference scenario for the rest of the world is projected to fall, by 0.1% annually, between 2020 and 2040. As forest area expands in the UNECE region, there may be gains in ecosystem services linked to forest. compares the UNECE region to the rest of the world.

[2] Market clearing is the process by which the supply of whatever is traded is equated to the demand, so that there is no leftover supply or demand.

[3] The environmental Kuznets curve suggests that economic development initially leads to a deterioration in the environment, but after a certain level of economic growth, a society begins to improve its relationship with the environment and levels of environmental degradation reduce.

FIGURE 2.2 HISTORIC AND PROJECTED ANNUAL AVERAGE CHANGE IN FOREST AREA IN THE UNECE REGION AND THE REST OF THE WORLD



Notes and sources: See .

2.2 Projected area of planted forest

The model assumes that projections of planted forest area are driven by a combination of per capita income, rural population density, and labour force per unit of forest (, Annex). Projections range from slow increases to slight decreases in planted forest area in the UNECE region. SSP3 projects the smallest expansion or the strongest reduction of planted forest. Under the reference scenario, Europe-Other at +14%, and North America at +12% would experience the biggest expansion between 2015 and 2040.

The EECCA at +5%, Europe-EU with +3%, would see smaller expansion, and the Russian Federation would show a reduction of -1% (2.3). Outside the UNECE region, the rest of the world is projected to see planted forest area expand by +14%.

The implication of these projections of planted forest area within the UNECE region is that any associated increase in forest productivity (discounting the effects of climate change) is likely to be modest, compared with productivity increases in the rest of the world.

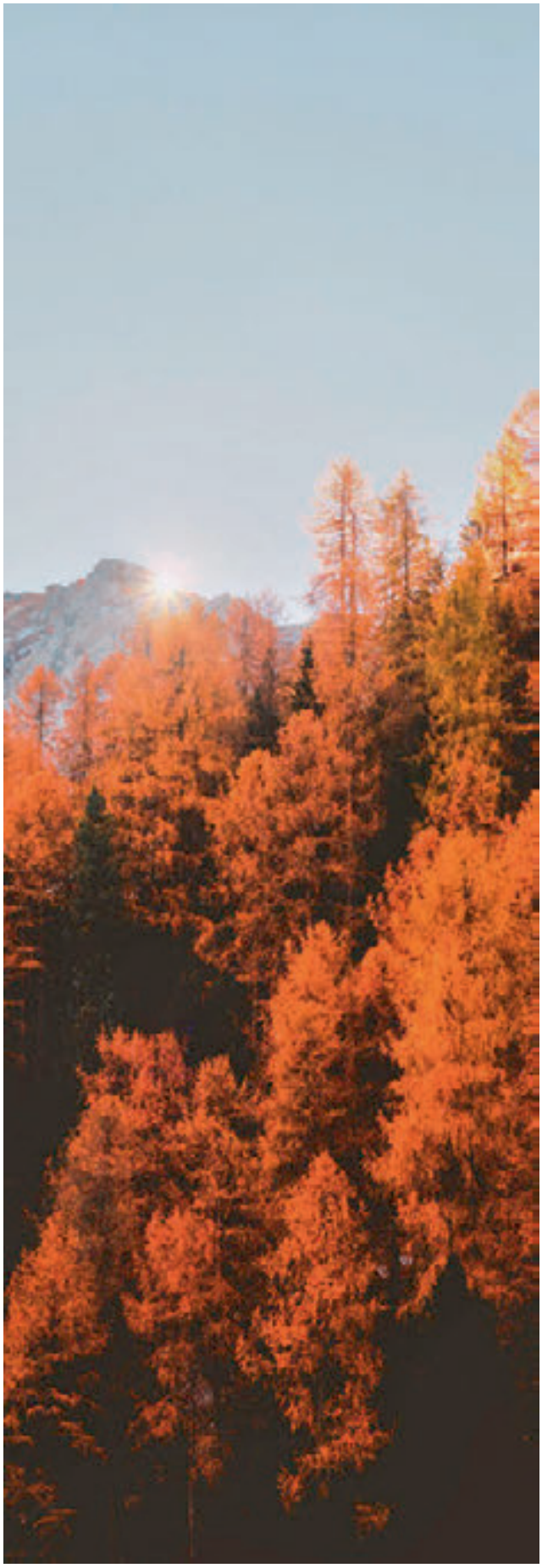
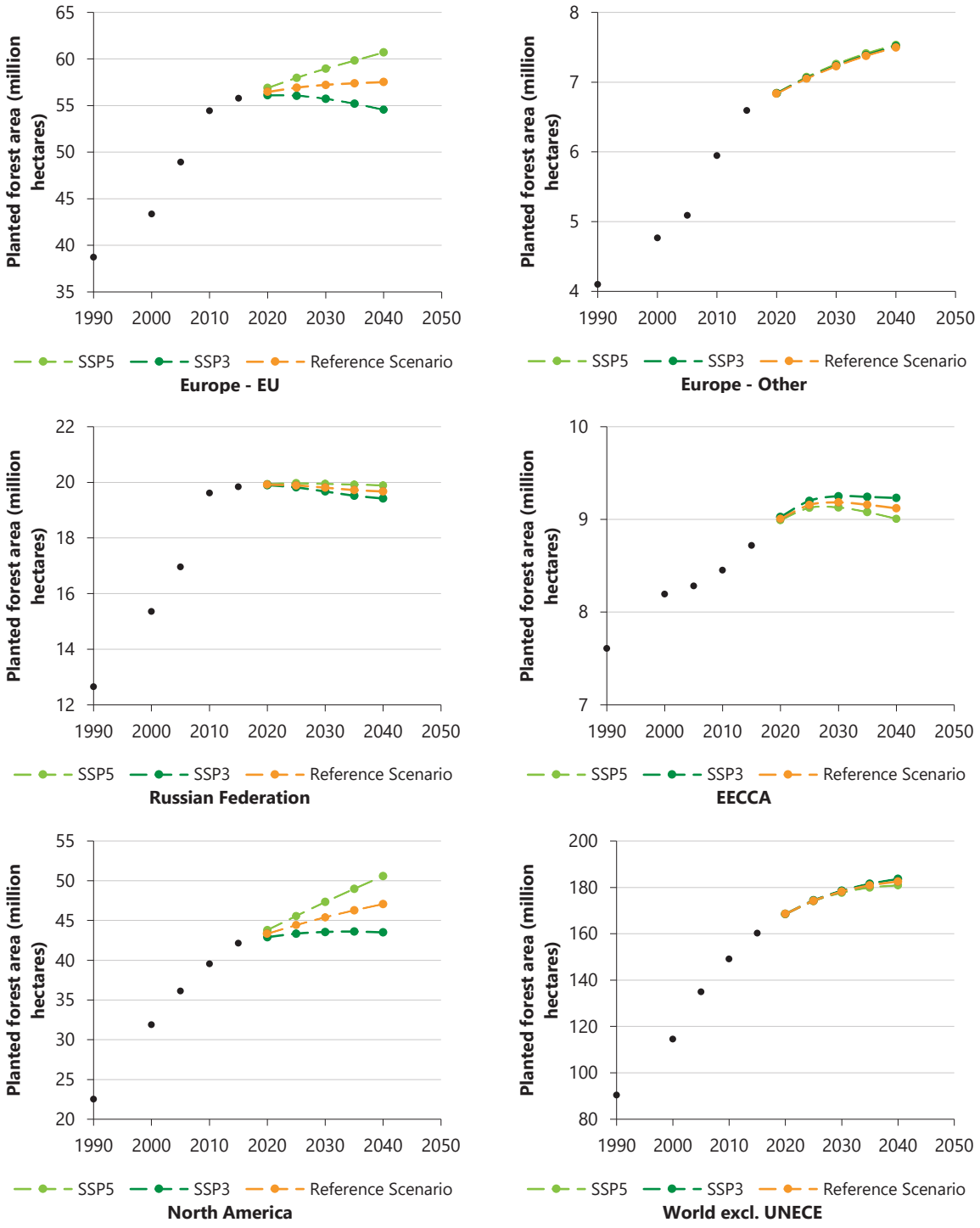


FIGURE 2.3 PROJECTED PLANTED FOREST AREA FOR UNECE SUBREGIONS AND THE WORLD EXCLUDING THE UNECE, 2020-2040.



Note: Historical levels 1990-2015 (FAO, 2015)

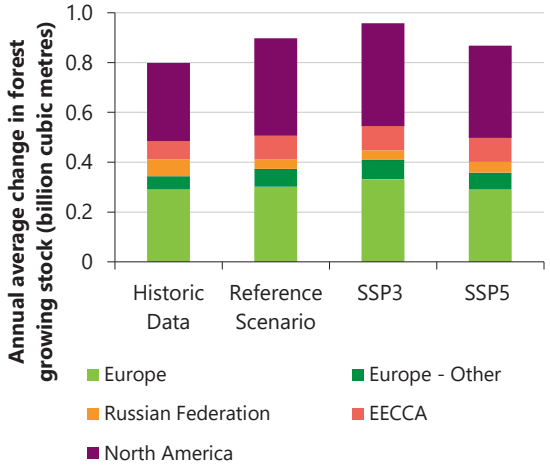
Sources: FAO, 2015 and GFPM projection.

2.3 Projected forest growing stock

Forest growing stock is projected to rise steadily from 2020 to 2040 in all UNECE subregions under all three SSPs, continuing historic patterns. Global growing stock, excluding the UNECE region, is projected to continue a downward trend (2.4 and 2.5). The supply of roundwood is expected to increase in the UNECE region, in parallel with the growth in forest growing stock, supporting an expansion of wood processing capacity. This will affect production, consumption, trade, and prices for all forest products.

Countries and regions that enjoy the greatest gains in forest growing stock can be expected to benefit in international trade, compared to countries with smaller forest growing stock gains, allowing them to increase their net exports. Between 2020 and 2040, the EECCA is projected to see the largest increase in growing stock (+47%) under the reference scenario. Projected growing stock increases for the other subregions are Europe-Other (+43%), Europe-EU (+29%), the Russian Federation (+13%), and North America (+2%). Growing stock in the rest of the world, excluding the UNECE region, are projected to decline over the same period (-2%).

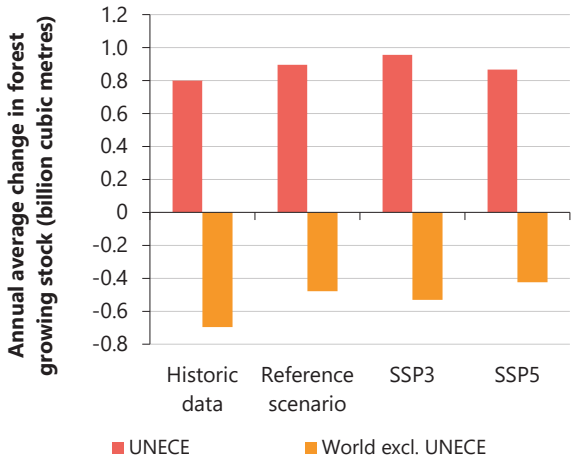
FIGURE 2.4 HISTORIC AND PROJECTED ANNUAL AVERAGE CHANGE IN FOREST GROWING STOCK IN FIVE UNECE SUBREGIONS



Notes: Historic data 1995-2016; SSPs 2020-2040. 2017 is the base year for the projections and is the average of 2016-2018. The values for 2016-2018 have been interpolated from the 2015 forest growing stock growth rate reported by FAO (2015b).

Sources: FAO, 2015 and GFPM projection.

FIGURE 2.5 HISTORIC AND PROJECTED ANNUAL AVERAGE CHANGE IN FOREST GROWING STOCK IN THE UNECE REGION AND REST OF WORLD



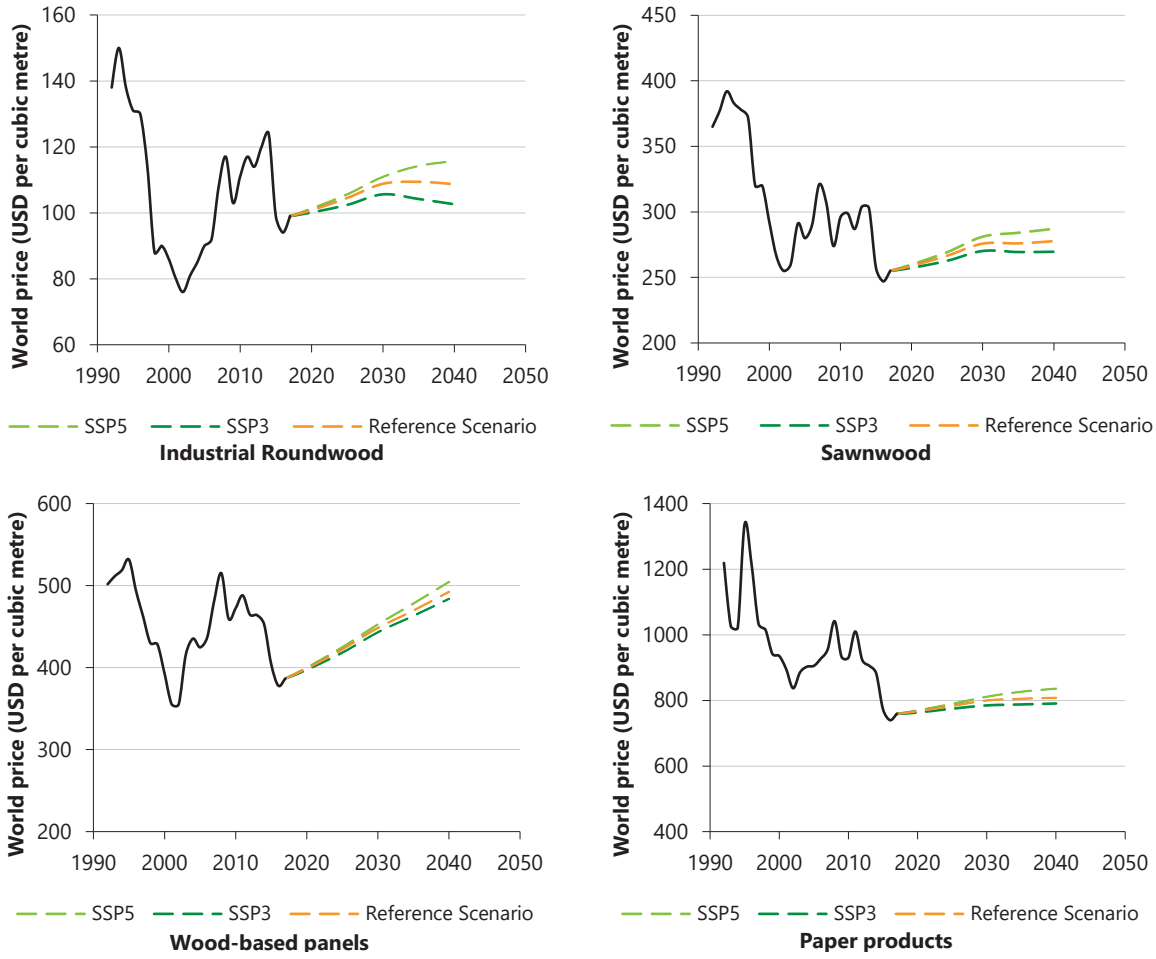
Notes and sources: See 2.4.

2.4 Projected forest product prices

Projected prices across the reference scenario, SSP3 and SSP5 for primary and secondary wood products recorded increases in real terms, in line with increasing GDP and GDP per capita, in spite of increasing global forest growing stock (2.4, 2.5, and 2.6). The projected world price changes for all primary and secondary products were shown to be lowest in SSP3 and highest in SSP5.

The projected rise in prices to 2040 was modest, and within historical price ranges since 1990. Such modest rises indicate no major wood scarcity.

FIGURE 2.6 HISTORICAL AND PROJECTED WORLD PRICES FOR DIFFERENT WOOD PRODUCTS



Notes: Historical levels 1990-2016; SSPs 2020-2040. 2017 is the base year for projections and is the average of 2016-2018 (FAO, 2019).
Wood-based panels use the average of prices for plywood, particle board and fibreboard.
Paper products use the average of prices for newsprint, printing and writing paper, and other paper and paper board.
Sources: FAO, 2015 and GFPM projection.

2.5 Projected production, consumption, and trade of forest products

All three SSPs project increased industrial roundwood production globally, and in every UNECE subregion. The increase is greatest for SSP5 and least for SSP3 (2.7). The trend globally, and within the UNECE region, is upwards. Under all three SSPs, the production increase in the Europe-EU subregion is similar to the world excluding the UNECE region. North American production is projected to increase more slowly than in most of Europe. Net exports of roundwood follow historical trends: Europe-EU is projected to remain a net importer. Other UNECE subregions are projected to remain net exporters of industrial roundwood, although the net exports of the Russian Federation are projected to fall (B1, Annex).

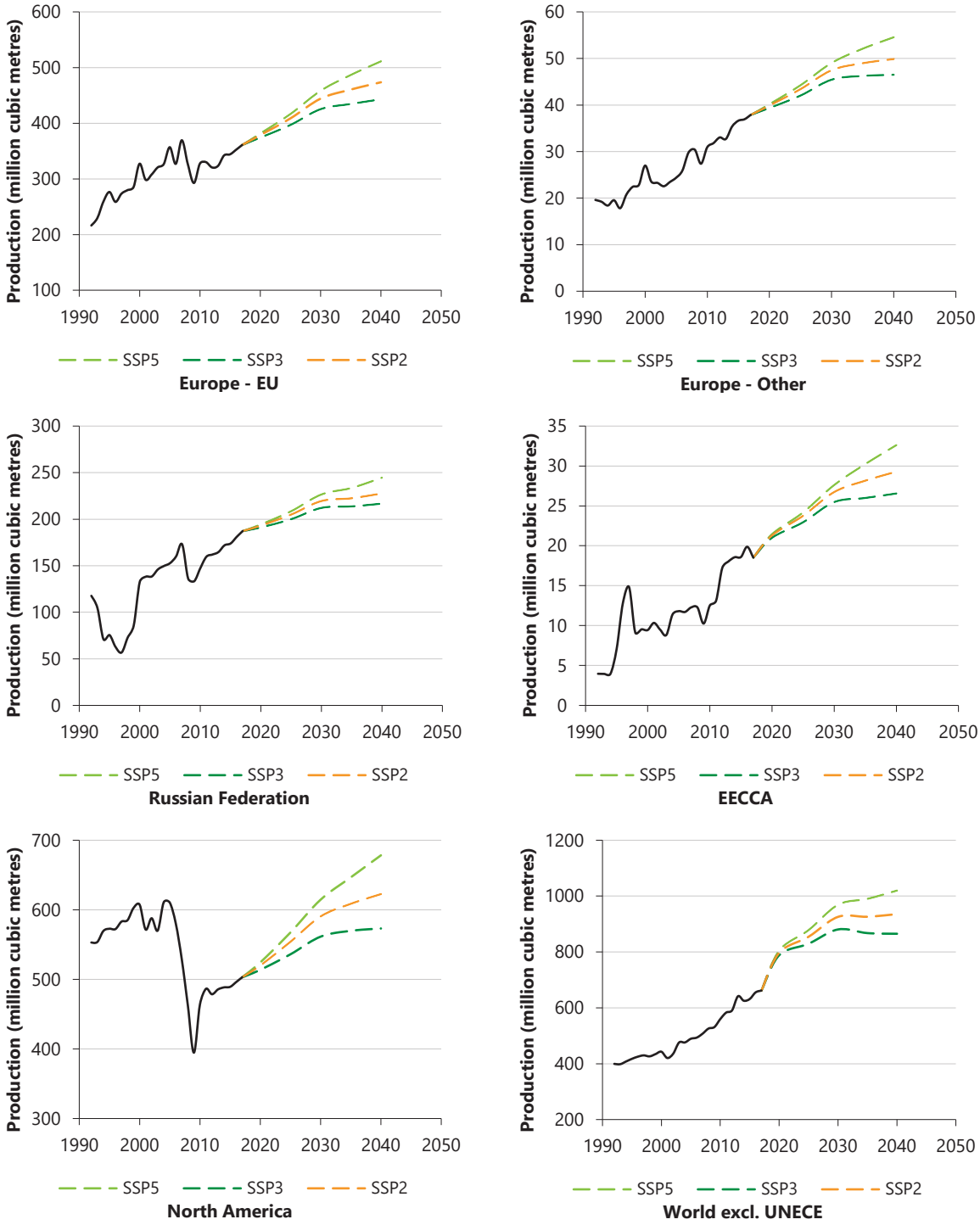
Sawnwood production (B2, Annex) is projected to rise strongly in Europe-EU, outperforming other UNECE subregions and the rest of the world. Europe-EU is projected to be an increasingly important global source of sawnwood over the 20 years from 2020 to 2040 and net exports of sawnwood (B3, Annex) from this subregion are projected to rise from below 20 million m^3 per year to more than 70 million m^3 per year over this period, in line with historical trends. By contrast, North America's share of the total UNECE region and world output is projected to fall. The Russian Federation is projected to continue as a net exporter of sawnwood. North America is also projected to remain a net exporter, but with declining volumes after 2030. Europe-Other, the EECCA, and the world excluding the UNECE region are projected to continue to be net importers of sawnwood.

Projections for wood-based panels production (B4, Annex) indicate rising volmes in almost every subregion, except for North America, where overall production is projected to remain largely unchanged. This disguises changes for individual panel products in North America, where falling particle board production is projected to be offset by rising plywood, veneer, and fibreboard production, until 2040. Continuing recent trends, North America is projected to further increase its net imports of panels. The Russian Federation is projected to increase net exports steadily to 2040 (B5, Annex).

Pulp and paper production is projected to increase in the UNECE region by 2040. Newsprint, printing and writing paper (graphics paper) show continuing stagnation in production and consumption due primarily to electronic media substitution, while the category 'other paper and paperboard' continue to show modest growth driven by increasing demand for tissue and packaging papers. Other paper and paperboard production is projected to rise between 5% and 20% in Europe-EU, and between zero and 15% in North America; production of total paper and paperboard (the sum of graphics paper and other paper and paperboard) is projected to rise between 7% and 31% in Europe-EU and to vary between a fall of -13% and a rise of 17% in North America depending on the SSP (B6, Annex). The UNECE region's share of global paper production is projected to continue to fall, affecting Canada, Finland, Sweden, and the United States, which have been the dominant producers historically; nevertheless, these four countries are projected to continue as positive net exporters through to 2040. North America, especially, is projected to be an increasingly important global exporter of wood pulp, especially to China, as an input to Chinese paper manufacture.

Results for consumption of forest products generally followed projected trends in production despite projected increases in product prices, mainly due to GDP growth assumed in all three SSPs. The projected changes in consumption were smaller than in production, meaning that countries/regions with projected production gains would increase net exports. There were two exceptions to this general finding. Consumption of industrial roundwood is projected to increase for most of Europe, resulting in a projected decline in net exports of roundwood (B1, Annex). North America's consumption of sawnwood, wood-based panels, and paper products are all projected to increase more than projected increased production, leading to negative net exports for these products (B3, B5, and B7, Annex). In North America, industrial roundwood supply is projected to outstrip consumption, allowing an increase in exports (B1, Annex).

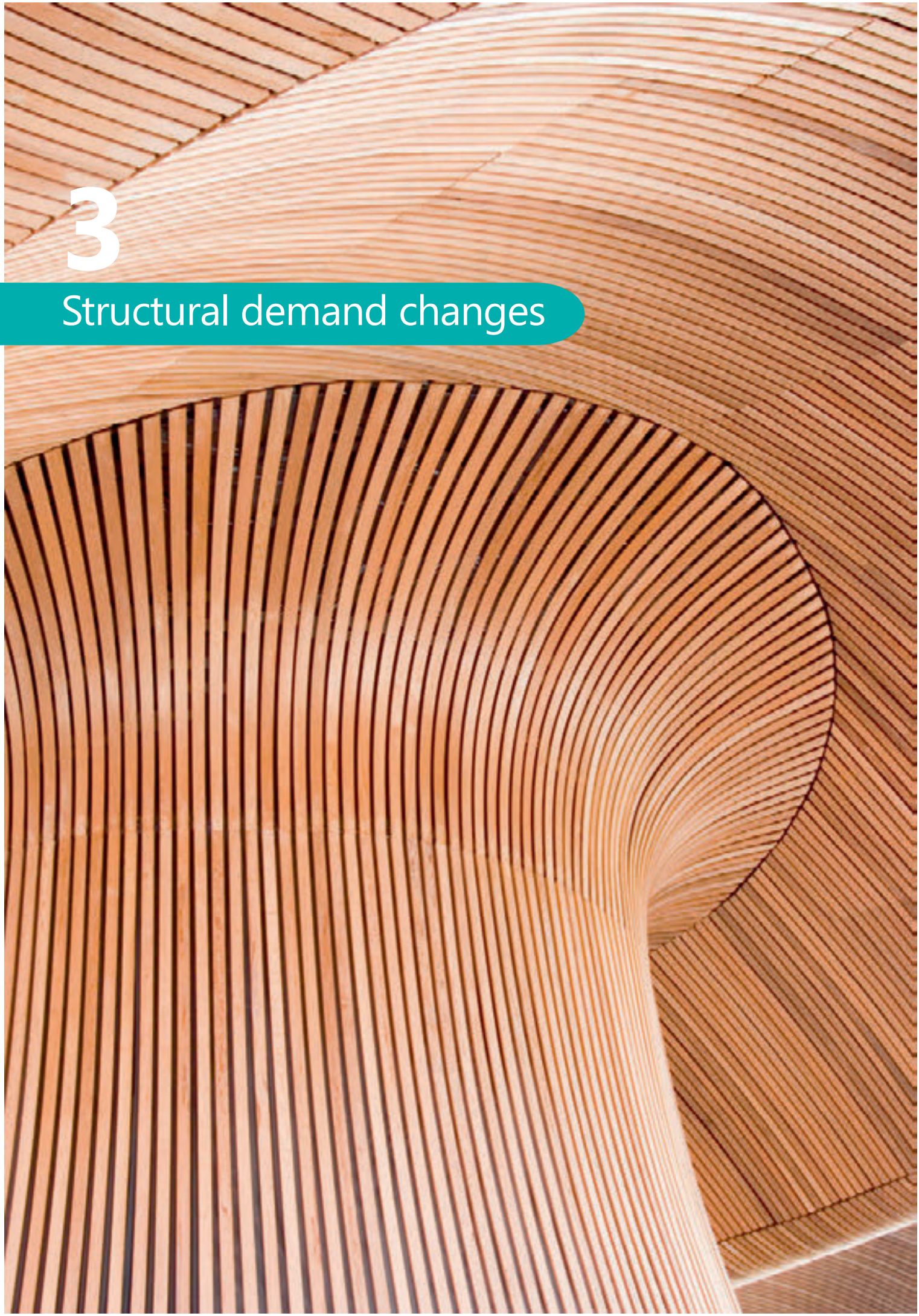
FIGURE 2.7 PROJECTED INDUSTRIAL ROUNDWOOD PRODUCTION IN UNECE SUBREGIONS, AND THE WORLD (EXCLUDING UNECE)



Note: Historical levels 1990-2016; SSPs 2020-2040. 2017 is the base year for projections and is the average of 2016-2018 (FAO, 2019).
Sources: FAO, 2015 and GFPM projection.

3

Structural demand changes



KEY QUESTION:

How would different demand changes affect the UNECE forest products market?

This section describes the various 'what-if' scenarios and compares them against the reference scenario (SSP2). The 'what-if' projections assume a change in just one element, such as the demand for a specific wood product, and results are then compared to the reference scenario that does not incorporate that change but continues business as usual. This scenario-analysis method hereby reveals how the structural change might impact the forest sector in the UNECE region and globally.

In all three demand-side 'what-if' scenarios, increased wood demand is assumed to leave forest area in all countries unaffected. Increased wood demand from forests is limited to its influence on forest density, the growing stock volume per unit area of forest, which would change according to projected roundwood removals and forest stock growth. Higher wood demand will increase harvesting, lowering overall average forest growing stock globally, in comparison with the reference scenario. Although some reported 'what-if' scenarios involve significant change in industrial roundwood demand and supply, the GFPM does not impose constraints on any country's timber harvests. In the model, harvests are constrained by economic variables, and not by laws, national specifications of maximum (or minimum) annual allowable cuts or any assumed conception of the meaning of "sustainability."

3.1 Increased demand for wood products by China

What-if ...

China started to build every tenth new housing unit with wood?

Assumption:

China would build every tenth new housing unit with the same volume of wood used to construct a single unit of a multifamily dwelling in the United States, in 2015.

The China-High Wood Consumption (China-HWC) scenario models the effects on markets in the UNECE region of greater use of wood for construction by a country outside the UNECE region. The model uses China's housing market because of its size and significance for other markets: if wood construction played a significantly greater role in China than currently, this may well influence other regions and lead to further growth in forest products markets.

Wood's current share of housing construction in China is less than 0.1% of 10 million annual units (Geng et al., 2019). If a sudden policy change required 10% of new housing units in China to match the floor area and wood content of a typical United States multifamily (apartment) dwelling, this would cause a significant surge in worldwide demand for construction wood. (The detail of the simulation appears in the "Methodology Report of the Forest Sector Outlook Study 2020-2040"[4].)

Modelling results (3.1)

The additional demand caused by such a policy shift would require global industrial roundwood production (and consumption) to rise by 271 million m^3 (12%), with one-third being met from domestic production in China. The higher prices for roundwood that could be expected to result from growing demand from China for sawnwood and panels might spur increased roundwood production of 126 million m^3 in the UNECE region, meeting almost half of the increased global need for roundwood.

By 2040, in comparison to the reference scenario, sawnwood consumption by China is projected to rise by almost 60%. Sawnwood production capacity in China would be unlikely to keep pace with this higher consumption. Capacity is projected to expand only slightly. The consumption shortfall would have to be made up by importing more sawnwood, and most of that, more than 75%, is projected to come from the UNECE region.

In contrast to the results in the sawnwood sector, China is projected to meet most of its increased wood-based panel quantities needed to build the housing units through domestic production. The reason is that China already has an established panel manufacturing sector, which is more price responsive. Only North America and Europe-EU are expected to export significantly more panels to China. Production and consumption of paper in the UNECE region and globally are not expected to be significantly affected in this scenario.

[4] UNECE/FAO, 2022a. The methodology report is available at https://unece.org/forests/forest-sector-outlook-study-fsos-2040.

TABLE 3.1 Projected 2040 differences between the reference and China-High Wood Consumption scenarios for production, consumption, net exports and prices of wood products[1]

	Production		Consumption		Net exports		Price[2]		Forest growing stock	
	million m³	*%*	*million m³*	*%*	*million m³*	*%*	*$/ m³*	*%*	*million m³*	*%*
Ind. roundwood										
EECCA	5.0	15.5	4.4	18.9	0.1	na	na	na	-16.1	-0.2
Europe-EU	42.9	9.1	23.8	4.7	19.0	na	na	na	-184.1	-0.5
Europe-Other	6.8	13.6	1.0	2.2	5.7	na	na	na	-25.2	-0.4
Russian Federation	31.6	13.9	29.7	13.6	1.8	na	9.1	8.2	-122.9	-0.1
North America	40.6	6.5	39.1	7.0	1.6	na	na	na	-164.0	-0.2
UNECE- Total	126.4	9.0	98.1	7.2	28.3	na	na	na	-512.3	-0.2
China	96.4	30.5	146.2	32.2	-49.8	na	26.6	21.0	-1712.2	-7.3
World	270.7	11.6	270.7	11.6	0	na	10.2	9.4	-2439.2	-0.5
Sawnwood										
EECCA	4.7	42.9	-0.4	-2.6	5.0	na	na	na		
Europe-EU	14.2	8.0	-2.1	-2.0	16.3	na	na	na		
Europe-Other	1.4	9.5	-0.4	-2.1	1.8	na	na	na		
Russian Federation	14.6	29.6	-0.4	-3.3	14.9	na	26.7	8.7		
North America	16.4	12.0	-1.4	-1.1	17.9	na	na	na		
UNECE- Total	51.3	13.2	-4.6	-1.7	55.9	na	na	na		
China	30.4	30.5	103.9	58.4	-73.5	na	22.7	8.2		
World	96.8	16.1	96.8	16.2	0	na	22.7	8.2		
Panels[3]										
EECCA	-0.5	-4.2	-0.3	-2.6	-0.2	na	na	na		
Europe-EU	-0.5	-0.5	-1.5	-2.2	1.1	na	na	na		
Europe-Other	-0.6	-3.5	-0.4	-2.5	-0.2	na	na	na		
Russian Federation	-0.4	-1.4	-0.5	-4.0	0.1	na	16.7	3.4		
North America	4.5	10.1	-1.0	-1.7	5.6	na	na	na		
UNECE- Total	2.5	1.3	-3.8	-2.2	6.3	na	na	na		
China	118.8	34.9	128.6	37.2	-9.8	na	29.3	5.8		
World	123.0	19.9	123.0	20.0	0	na	13.8	2.8		
Paper & paperboard[4]	*million tonnes*	*%*	*million tonnes*	*%*	*million tonnes*	*%*	*$/ tonne*	*%*		
EECCA	0	1.5	0	-0.3	0.1	na	na	na		
Europe-EU	-2.1	-1.9	-0.5	-0.5	-1.6	na	na	na		
Europe-Other	-0.2	-2.2	-0.1	-0.5	-0.2	na	na	na		
Russian Federation	-0.4	-4.2	-0.1	-1.5	-0.3	na	14.3	1.8		
North America	2.1	2.5	-0.5	-0.5	2.5	na	na	na		
UNECE- Total	-0.6	-0.3	-1.2	-0.6	0.6	na	na	na		
China	-0.5	-0.3	-0.6	-0.4	0.1	na	1.9	0.2		
World	-2.6	0	-2.6	-0.5	0	na	8.1	1.0		

Notes:

na indicates "not applicable"

[1] Numbers in "%" columns represent the percentage change from the reference scenario (without high wood consumption in China) in 2040.

[2] Prices for panels represent the average of prices for plywood, particle board, and fibreboard. Prices for paper and paperboard represent the average of prices for newsprint, printing and writing paper, and other paper and paperboard.

[3] Production, consumption and net export values for panels represent the sum of values for plywood, particle board, and fibreboard

[4] Production, consumption and net export values for paper and paperboard represent the sum of values for newsprint, printing and writing paper, and other paper and paperboard. Tonnes are metric tonnes.

Source: GFPM projections.

The extra demand for wood in China is projected to lead to a rise of 9% in world roundwood prices by 2040 compared to the reference scenario. Sawnwood prices are also projected to rise by 8% and panel prices by 3%.

Forest growing stock in the UNECE region would be less than 1% lower than in the reference scenario. In China, the sharp increase in domestic roundwood production is projected to lead to a 7% reduction of forest growing stock. Despite these lower values compared to the reference scenario, forest growing stock would still increase in absolute terms in the 'what-if' scenario.

3.2 Increased wood construction in Europe[5] and the Russian Federation

What if ...

Europe and the Russian Federation significantly increased the amount of wood used in construction?

Assumption

Per capita consumption of sawnwood and wood-based structural panels in Europe and the Russian Federation would rise steadily from 2020 to 2040, to match 2015 levels in the United States.

This Europe-High Wood Consumption (Europe-HWC) scenario simulates how increased wood consumption within the UNECE region would affect markets in the region. The factors that might result in higher wood consumption in Europe and the Russian Federation are:

- Changes in international building standards, allowing larger and taller wood-frame structures (American Wood Council, 2018).
- Increased availability and acceptance of mass timber products, including cross-laminated timber (CLT) and glulam beams, by architects, builders, and property owners (The Beck Group, 2018, Breneman et al., 2019).
- Favourable policies and programmes preferring wood in construction, as part of climate change mitigation measures.
- Higher prices of non-wood substitutes.

All these factors are intensively discussed at present and some are actively promoted at the policy level. Forecasts indicate that the market for mass timber will grow significantly. In the case of CLT, current market research estimates that its global value will rise at a 15% compounded annual growth rate (CAGR) during 2017-2025, from a 2016 global value of $670.2 million. Europe accounts for about half of the current market share and would also comprise half of the forecasted market share of CLT, followed by North America, forecast to have a 25% share of the global CLT market (Transparency Market Research, 2019; Zion Market Research, 2018). A recent study projected that demand for CLT within the Council of Western State Foresters region (17 western United States' states and 6 United States' Pacific Island territories) would double every five years, from 2020 values of 0.26 million m^3. These projections imply 0.5 million m^3 of additional sawnwood consumption in 2020, rising to 2.5 million m^3 by 2040, or between 1% and 2% of all North American sawnwood consumption (The Beck Group, 2018, Beyreuther et al., 2016).

Modelling results (3.2)

In this scenario, UNECE region industrial roundwood production would be 54 million m^3, or 4%, higher in 2040 compared to the reference scenario. The increases range between 6% in EECCA, to just under 3% in the Russian Federation. Globally, roundwood prices would be 4% higher and production would increase by 90 million m^3 by 2040 as countries beyond the UNECE region would help to meet the global demand resulting from Europe and the Russian Federation using more wood in construction. Consumption of roundwood also increased in line with the assumed increase in sawnwood and panel demand in the UNECE region. The exception was the Russian Federation, where consumption fell, as producers took advantage of higher global prices to increase net exports, an outcome enabled by the widening gap between low domestic prices and higher export prices.

The scenario assumed increased consumption of wood products compared to the reference scenario in Europe and the Russian Federation. As an effect, production of sawnwood increased in Europe while net exports from

[5] The term "Europe" in this specific scenario refers to the group of countries of Europe-EU, Europe-Other excluding Israel and Turkey, as well as Georgia and Ukraine.

this subregion decreased compared to the reference scenario. Sawnwood production increased by 16% in Europe-EU and Europe-Other and 26% in EECCA, with smaller increases in North America and globally. The higher consumption modelled in Europe and the Russian Federation under this scenario results in additional 66 million m^3 of sawnwood consumed within the UNECE region, with most of that in Europe-EU, where the majority of the increased wood demand is focused in this scenario. An interesting outcome of generally higher sawnwood prices is that sawnwood production in the Russian Federation is projected to fall, while net exports would decline by 16 million m^3. In total, net exports of sawnwood from the UNECE region decline by 34%, with only North America increasing net exports compared to the business-as-usual case.

Historically, the difference in per capita consumption of wood-based panels between the United States and Europe as well as the Russian Federation has been smaller than the difference for sawnwood. Consequently, the modelled increases of wood-based panel consumption for Europe and the Russian Federation are smaller than those for sawnwood. Production of wood-based panels increased by 8% in the UNECE region. Effects on the paper sector were insignificant.

In line with expectations, world prices would be higher for all products, not only for roundwood. Higher product prices outside Europe and the Russian Federation would lead to lower consumption and higher net exports from these outside regions to partially satisfy the higher demand in Europe and the Russian Federation.

Higher prices and higher rates of harvesting in the UNECE region are projected to reduce forest growing stock by less than 1% by 2040, compared to the reference scenario. The effect in the UNECE region is projected to be much smaller than the effect in China in the China-HWC scenario. Though Europe would be more reliant on imports of industrial roundwood from outside the region, the effect on global forest growing stocks would also be minimal. In absolute terms, forest growing stocks in the UNECE region, and globally, are projected to grow between 2020 and 2040 in the reference scenario as well as SSP3 and SSP5.

TABLE 3.2 Global forest products model projected differences in the production, consumption, net exports, and prices of wood products by 2040 (projected values in 2040 in Europe-high wood consumption scenario minus reference projected values)[1]

	Production		Consumption		Net exports		Price[2]		Forest growing stock	
	million m³	*%*	*million m³*	*%*	*million m³*	*%*	*$/ m³*	*%*	*million m³*	*%*
Ind. roundwood										
EECCA	1.8	6.2	3.8	16.3	-2.0	na	na	na	-14.8	-0.2
Europe-EU	22.1	4.7	46.3	9.0	-24.2	na	na	na	-262.7	-0.7
Europe-Other	2.6	5.2	3.3	7.2	-0.8	na	na	na	-24.1	-0.4
Russian Fed.	6.5	2.8	-19.7	-9.0	26.2	na	1.9	1.7	-103.9	-0.1
North America	20.6	3.3	19.1	3.4	1.6	na	na	na	-175.0	-0.2
UNECE - Total	53.6	3.8	52.7	3.9	0.9	na	na	na	-580.5	-0.3
World	90.4	3.9	90.4	3.9	0	na	3.9	3.6	-924.3	-0.2
Sawnwood										
EECCA	2.8	25.7	1.2	8.8	1.6	na	na	na		
Europe-EU	28.2	15.9	56.0	53.6	-27.9	na	na	na		
Europe-Other	2.4	15.9	3.6	18.8	-1.2	na	na	na		
Russian Fed.	-9.6	-19.5	5.9	54.1	-15.6	na	4.9	1.6		
North America	8.2	6.0	-0.8	-0.6	9.1	na	na	na		
UNECE - Total	31.9	8.2	65.9	23.6	-34.0	na	na	na		
World	63.9	10.7	63.9	10.7	0	na	4.8	1.7		
Panels[3]										
EECCA	0.9	7.5	1.4	11.1	-0.4	na	na	na		
Europe-EU	8.2	8.9	14.5	20.9	-6.3	na	na	na		
Europe-Other	0.5	2.7	0.6	3.7	-0.1	na	na	na		
Russian Fed.	1.6	5.5	2.6	21.7	-1.0	na	3.8	0.8		
North America	4.3	9.6	0.3	0.6	4.0	na	na	na		
UNECE - Total	15.6	7.9	19.5	11.3	-3.9	na	na	na		
World	16.2	2.6	16.2	2.6	0	na	4.7	1.0		
Paper & paperboard[4]	*million tonnes*	*%*	*million tonnes*	*%*	*million tonnes*	*%*	*$/ tonne*	*%*		
EECCA	0	1.3	0	-0.2	0	na	na	na		
Europe-EU	-0.8	-0.7	-0.3	-0.3	-0.5	na	na	na		
Europe-Other	-0.1	-1.2	0	-0.3	-0.1	na	na	na		
Russian Fed.	-0.2	-1.5	0	-0.5	-0.1	na	4.7	0.6		
North America	-0.2	-0.2	-0.2	-0.3	0.1	na	na	na		
UNECE - Total	-1.2	-0.5	-1.2	-0.6	-0.6	na	na	na		
World	-1.3	-0.2	-1.3	-0.2	0	na	3.4	0.4		

Notes:
na indicates "not applicable"
[1] Numbers in "%" columns represent the percentage change from the reference scenario (without high wood consumption in Europe) in 2040.
[2] Prices for panels represent the average of prices for plywood, particle board, and fibreboard. Paper prices are average prices for newsprint, printing and writing paper, and other paper and paperboard.
[3] Production, consumption and net export values for panels represent the sum of values for plywood, particle board, and fibreboard
[4] Production, consumption and net export values for paper and paperboard are the sum of newsprint, printing and writing paper, and other paper and paperboard. Tonnes are metric tonnes.
Source: GFPM projections.

3.3 Increased demand for wood-based textiles

What if ...

the textile sector replaced 30% of its fibre intake with wood-based fibres?

Assumption

By 2040, wood-based fibres would replace polyester, to make up 30% of the total fibre demand of the textile sector.

The Textile-High Wood Fibre Consumption scenario assumes expanded consumption of wood-based fibres (also called Manmade Cellulosic Fibres or MMCFs) in the manufacture of textiles.

The textile industry is one of the worlds largest industrial sectors and is expected to see rapidly increasing global demand due to growing population and higher average incomes (Hurmekoski et al., 2018). Currently, synthetic fibres made from oil (mainly polyester) dominate the market with a share of 63% in 2019, followed by cotton with 23% and wood-based fibres such as viscose and lyocell with 6% (Textile Exchange, 2020).

Cotton production is water intensive, using scarce freshwater for irrigation and using significant amounts of pesticides, which are likely to be unsustainable in future (Pöyry, 2015). With the global population projected to rise by 1.3 billion by 2040, there is likely to be competition for arable land, to feed this growth in population. Some experts predict a "cellulose gap" with cotton production stagnating and manufacturers looking to new sources of fibre, including wood (Hämmerle, 2011). On the other hand, synthetic fibres emit on average substantially more greenhouse gases compared to the main fibre alternatives (UNECE/FAO, 2014).

There is an argument in favour of wood-based fibres having a superior environmental footprint over other main fibre types, though older technology for producing viscose, as used in much of Asia, has harmful side effects (Shen at al., 2010). Newer production technologies have overcome most of the disadvantages of older viscose production and have a significantly better environmental footprint (Hurmekoski et al, 2018). A lot of research in this field is currently undertaken in the UNECE region. Lyocell, one of the newer wood-based fibres, is already in commercial production. It is estimated to store more carbon than is emitted in its production process and uses a closed-loop system in terms of chemical use (Kalnbalkite et al., 2017).

The demand for sustainable wood-based fibres will maintain rapid growth as manufacturers look increasingly to become more sustainable. Lyocell, for instance, is estimated to have a 15% compound annual growth rate from 2017 until 2022 (Textile Exchange, 2020). Between 1990 and 2019, wood-based fibre production had already doubled in volume. Given this positive outlook, wood-based fibres may partially compensate for declining demand in the graphic paper sector. (Hurmekoski et al., 2018).

Several newer wood-based fibres use harvesting residues and sawmilling co-products as feedstock (these are not directly accounted for in the modelling), though it is likely that demand for industrial roundwood would increase as well.

For this scenario, the following approach and assumptions were taken. Of the 111 million tonnes of fibre consumed globally by the textiles sector in 2019, about 7.1 million tonnes (or 6.4%) were wood based (Textile Exchange, 2020). Between 2000 and 2019, global textile production grew at a CAGR of 3.3%, from 60 million tonnes in 2000 to 111 million tonnes in 2019 (Textile Exchange, 2019)[6]. Extrapolating at a CAGR of 3.3% from 105 million tonnes in 2017 predicts global textile fibre demand of 222 million tonnes by 2040. If wood-based fibre maintained its current share of the global fibre market (6.4%), the textile sector would produce a projected 14 million tonnes of wood-based fibres in by 2040.[7] Assuming that the textile sector replaced 30% of its fibre intake with wood-based fibre by 2040, whether for policy reasons, technological advancement or as a business strategy, the result would be that 67 million tonnes of wood-based fibres would need to be produced, adding another 53 million tonnes to the 14 million tonnes in the reference scenario. This would imply an additional 265 million tonnes of roundwood, based on a conversion factor of 5.0 m^3 roundwood to one tonne of fibre (reflecting varying rates from differing technologies).

[6] Hämmerle (2011) calculated a CAGR of 3.1%. However, he used 2010 production levels for the calculation and the growth since then until 2019 has already been above 3.1%.

[7] As a comparison, Pöyry (2015) estimated a production of 12 million tonnes of wood-based fibres for 2030 in the business-as-usual scenario.

The modelling of this scenario assumed that the 265 million tonnes would be supplied by the top ten wood pulp producing countries, based on their current shares of global wood pulp production (FAO, 2019). Assessing the impact of this extra demand from the textiles sector had to use an indirect approach because the GFPM does not have a specific category for wood fibre linked directly to textiles. The approach taken was to increase the demand for 'printing and writing paper' and 'other paper and paperboard' by an amount that would require an equivalent amount of additional roundwood, (265 million tonnes) as required by the estimated additional wood-based fibres. This resulted in 123 million tonnes of additional wood pulp demand by 2040.

In this scenario, global roundwood prices are projected to be slightly higher by 2040 than in the reference scenario. Higher roundwood prices would make sawnwood and panel manufacture more expensive, which would reduce their supply as well as their consumption. Likewise, higher roundwood prices would lead to a reduction in the supply of wood pulp for the paper sector and consequently higher paper prices and lower paper production. Those effects are not explicitly quantified in this study. Paper and paperboard demand were artificially increased, leading to higher prices and higher production of paper, to simulate the effect of increased wood-based fibre use in the textile sector. It was not possible, given the modelling approach used in this scenario, to account for the competition between the use of wood for textiles and the paper industry. This also results in somewhat larger impacts on wood-based panels and sawnwood than would have been the case if this competition would have been modelled.

Modelling results (3.3)

The increased demand from the textile sector, over and above the reference scenario, was projected to boost industrial roundwood supply globally by 81 million m^3, of which 51 million m^3 would be produced in the UNECE region. The consumption of industrial roundwood likewise increased in the UNECE subregions, but the magnitude of the projected increase in consumption was higher than the projected increases in production, leading to lower net exports. An exception to this trend was observed for the Russian Federation, where consumption of roundwood declined by 12 million m^3 by 2040, relative to the reference scenario projection. The effects on the Russian Federation are largely due to the effects of significantly lower projected domestic prices compared to global roundwood prices, making it more profitable to reduce its domestic consumption in favour of more exports.

More costly industrial roundwood inputs to the sawnwood and panels sectors in the UNECE region lead to a reduction in supply of both sawnwood and panels. In the sawnwood sector, production reduces by 26 million m^3 relative to the reference scenario, with impacts highest for North America, Europe-EU, and the Russian Federation. Globally the effects are smaller, as some of the reduced production in the UNECE region is offset by higher production in non-UNECE countries, such as China, with smaller relative changes in their sawnwood manufacturing costs. Consequently, sawnwood exports from the UNECE region decrease, while China reduces its net imports. The higher cost of industrial roundwood inputs to the panel's sector has effects that are substantially smaller than those in the sawnwood sector, due to wood's relatively smaller share of total manufacturing cost in panel production.

Finally, the 'what-if' scenario results in small reductions in forest growing stock in the UNECE region (by less than 0.2%) and globally (by 0.1%) by 2040, compared to the reference scenario. The small changes emerge because of the offsetting effects of reduced wood products (sawnwood, panels) production and increased wood fibre production to meet the new demands of the textiles sector. Regardless, UNECE regional and total global stocks rise steadily through 2040 in this scenario, continuing recent trends.

As a note of caution, the results of the textiles scenario depend on how the GFPM accounts for the higher value of sawmilling co-products on the sawmill and wood panel industries. The GFPM does not directly model the "cascading" uses of wood. There are no directly estimated parameters that quantify the volumes, value, or transfers of sawmill residues. The GFPM does quantify these effects indirectly, via the input coefficients of sawnwood and panel manufacturing processes but cannot capture them fully when simulating large structural changes. Depending on the degree to which higher industrial roundwood costs are offset by higher revenues on wood product and residue sales, the effects of the textile sector's wood fibre demand on sawnwood and panels could be smaller than projected. The projected changes need to be viewed with a degree of caution.

There is one more caveat. The scenario simulates higher consumption of wood fibre by the textile sector, applying an across-the-board increase in pulp demand to the ten

countries that are the largest producers of dissolving pulp. It is unlikely that the increased supply of fibre would be delivered in such an evenly spread manner. Hence, price, production, and trade effects of the textile sector use of wood fibre would differ somewhat from what is reported in this Outlook. Nevertheless, the overall direction of change in these variables is informative of the impacts that could be expected.

TABLE 3.3 Global Forest Products Model projected differences in production, consumption, net exports, and prices of wood products by 2040 (projected values in 2040 in Textile-High Wood Fibre Consumption scenario minus projected values in the reference scenario)[1].

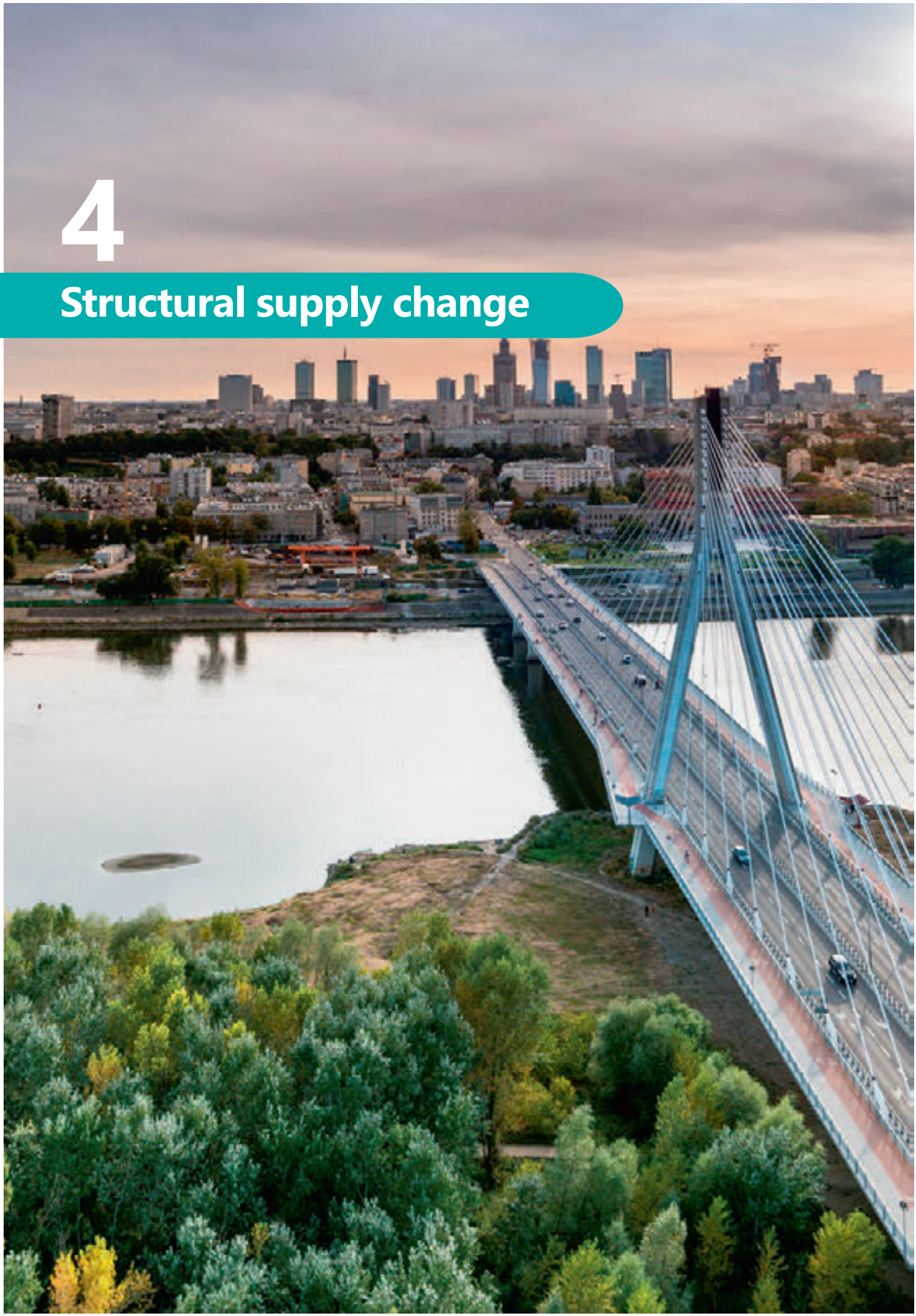
	Production		Consumption		Net exports		Price[2]		Forest growing stock	
Ind. roundwood	*million m³*	*%*	*million m³*	*%*	*million m³*	*%*	*$/ m³*	*%*	*million m³*	*%*
EECCA	1.4	4.7	2.2	9.7	-0.9	na	na	na	-9.1	-0.1
Europe-EU	13.5	2.8	18.1	3.5	-4.6	na	na	na	-144.9	-0.4
Europe-Other	1.9	3.8	4	8.7	-2.1	na	na	na	-14	-0.2
Russian Fed.	5.3	2.3	-11.5	-5.3	16.9	na	1.6	1.4	-56.1	-0.1
North America	28.8	4.6	28	5.0	0.8	na	na	na	-260.4	-0.3
UNECE - Total	50.9	3.6	40.8	3.0	10.1	na	na	na	-484.5	-0.2
China	12.3	3.9	20.4	4.5	-8.1	na	3.2	2.5	-103.6	-0.4
World	81.4	3.5	81.4	3.5	0	na	3.1	2.9	-768.3	-0.1
Sawnwood										
EECCA	2.1	19.3	-0.1	-0.5	2.2	na	na	na		
Europe-EU	-10.4	-5.9	-0.6	-0.6	-9.8	na	na	na		
Europe-Other	0.1	1.0	-0.1	-0.5	0.3	na	na	na		
Russian Fed.	-7.3	-14.7	-0.1	-0.6	-7.2	na	4.0	1.3		
North America	-11	-8.0	-1	-0.8	-9.9	na	na	na		
UNECE - Total	-26.4	-6.8	-1.9	-0.7	-24.5	na	na	na		
China	17.2	17.3	0	0	18.2	na	3.9	1.4		
World	-3.5	-0.6	-3.5	-0.6	0	na	3.9	1.4		
Panels[3]										
EECCA	0.1	0.5	-0.1	-0.9	0.2	na	na	na		
Europe-EU	-1.3	-1.4	-0.5	-0.7	-0.8	na	na	na		
Europe-Other	0.6	3.6	-0.1	-0.9	0.8	na	na	na		
Russian Fed.	-0.1	-0.3	-0.1	-0.7	0	na	3.0	0.6		
North America	-1.3	-2.8	-0.5	-0.8	-0.8	na	na	na		
UNECE - Total	-2	-1.0	-1.3	-0.8	-0.6	na	na	na		
China	0	0	0	0	0.2	na	3.0	0.6		
World	-3.9	-0.6	-3.9	-0.6	0	na	3.4	0.7		
Paper & paperboard[4]	*million tonnes*	*%*	*million tonnes*	*%*	*million tonnes*	*%*	*$/ tonne*	*%*		
EECCA	-0.3	-14.0	-0.2	-5.2		na	na	na		
Europe-EU	12.3	11.8	10.4	12.2	1.9	na	na	na		
Europe-Other	0.5	4.8	-1.2	-5.4	1.3	na	na	na		
Russian Fed.	1.5	15.0	-0.3	-3.8	1.8	na	49.4	4.8		
North America	0.3	33.2	16.2	18.3	11.6	na	na	na		
UNECE - Total	40.3	20.1	24.8	12.7	16.5	na	na	na		
China	11.4	6.1	19.8	11.1	-8.3	na	103	10.5		
World	51.5	9.2	51.5	9.2	0.0	na	83.4	8.3		

Notes: na indicates "not applicable"; [1] Numbers in "%" columns represent the percentage change from the reference scenario (without high wood fibre consumption) in 2040; [2] Prices for panels represent the average of prices for plywood, particle board, and fibreboard, and prices for paper and paperboard represent the average of prices for newsprint, printing and writing paper, and other paper and paperboard; [3] Production, consumption and net export values for panels represent the sum of values for plywood, particle board, and fibreboard; [4] Production, consumption and net export values for paper and paperboard are the sum of newsprint, printing and writing paper, and other paper and paperboard. Tonnes are metric tonnes.

Source: GFPM projections.

4

Structural supply change



KEY QUESTION:

How would different supply changes affect the UNECE forest product market?

Increases in global forest growing stock could occur through policies or programmes to foster forest expansion or increased density, through intense silviculture, making more industrial roundwood available to the forest products sector.

4.1 Increased forest area globally

What-if ...
the global forest area were 10% greater?

Assumption
By 2040, the global forest area would be 4.4 billion ha or 10% more than projected under the reference scenario (4.0 billion ha).

The global forest area has declined from 4.24 billion hectares in 1990 to 4.06 billion hectares in 2015 (FAO, 2020). There is good reason to believe that this declining trend could be halted and even reversed in some regions. This view is consistent with recently adopted goals and initiatives by many countries. It is plausible that changing population, rising global incomes, and evolving public sentiment about forests and their many benefits may result in increased investment in forest planting (Nepal et al., 2019b). A projected increase in forest area may also happen as a result of countries' efforts to cut carbon emissions under the Paris Climate Agreement and work towards the UN Sustainable Development Goals (SDGs) (Freer-Smith et al., 2019). The Bonn Challenge is a global initiative with just such an objective. It aims to restore 150 million hectares of the world's deforested and degraded land by 2020 and has an even more ambitious target of 350 million hectares by 2030. Within the UNECE region, the EU Forest Strategy could bring about policy changes that would encourage forest expansion in Europe (European Commission, 2013). Furthermore, the European Union, as part of its 2030 climate and energy framework, promotes forestry as one means of achieving a reduction in net greenhouse gas emissions. The European Green Deal is a set of policy initiatives by the European Commission with the overarching aim of making Europe climate neutral by 2050. Its focus on achieving carbon neutrality, preserving and restoring ecosystems and biodiversity (European Commission, 2019) should also bolster the role and significance of the forest sector.

The High Forest Area (HFA) scenario discussed here projected increases in planted and natural forests, resulting in greater forest growing stock in all countries. This would lead to higher global roundwood production and consumption, and lower prices for timber and wood products. The reduced prices were shown to alter the individual countries' comparative advantages in producing and trading forest products, resulting in reduced production of various forest products in countries with low comparative advantages and increased production of these products in countries with higher comparative advantages. Reduced prices increased the consumption of manufactured wood products in every country. The projected scale of reduced prices and their impact on production, consumption and net exports, were modest in comparison to the projected 10% increase in forest growing stock over the reference scenario, by 2040.

Modelling results (Table 4.1)

Global industrial roundwood production and consumption increased by 40 million m^3 (or 2%) in 2040 compared to the reference scenario, the natural result of a projected roundwood price that was 3% lower. Production of roundwood in the UNECE region increased by 24 million m^3, with the largest increases in Europe-EU, North America and the Russian Federation. The effect on roundwood consumption was much higher for the UNECE region, with the region consuming 41 million m^3 more in 2040 relative to the business-as-usual case. Higher consumption than the projected production quantities resulted in lower net exports of roundwood from the UNECE region under this 'what-if' scenario.

There were similar effects on the sawnwood sector in the UNECE region. However, the projected price decline for sawnwood was smaller at 2%, and production increased more than consumption, leading to higher net exports of 13 million m^3 from the UNECE region. The effects on the panels sector were smaller. The UNECE region increased wood-based panel production and consumption by about 2 million m^3, in line with the projected smaller (1%) price decline. The effect of increasing forest stock on the paper sector was very slight in the UNECE region (4.1).

TABLE 4.1 Projected 2040 differences between the High Forest Area scenario and reference scenario for production, consumption, net exports, and prices of wood products.

	Production		Consumption		Net exports		Price[2]		Forest growing stock	
Ind. roundwood	*million m^3*	*%*	*million m^3*	*%*	*million m^3*	*%*	*$/ m^3*	*%*	*million m^3*	*%*
EECCA	-0.1	-0.2	-1.3	-5.7	1.3	na	na	na	794	10.4
Europe-EU	9.4	2.0	12.4	2.4	-3.0	na	na	na	4,153	11.1
Europe-Other	0.6	1.2	0.6	1.3	0	na	na	na	655	10.7
Russian Federation	6.7	2.9	10.7	4.9	-4.0	na	-1.9	-1.7	8,673	10.4
North America	7.4	1.2	18.2	3.3	-10.9	na	na	na	9,578	10.4
UNECE- Total	23.9	1.7	40.6	3.0	-16.7	na	na	na	23,852	10.5
World	39.7	1.7	39.7	1.7	0	na	-3.6	-3.3	56,544	10.6
Sawnwood										
EECCA	-1.4	-12.8	0.1	0.6	-1.5	na	na	na		
Europe-EU	2.1	1.2	0.8	0.7	1.3	na	na	na		
Europe-Other	0.1	0.6	0.1	0.7	0	na	na	na		
Russian Federation	4.7	9.4	0.1	0.7	4.6	na	-4.6	-1.5		
North America	9.4	6.9	0.9	0.7	8.5	na	na	na		
UNECE- Total	14.9	3.8	2.0	0.7	12.9	na	na	na		
World	4.3	0.7	4.3	0.7	0	na	-4.7	-1.7		
Panels[3]										
EECCA	0.1	0.9	0.1	1.1	0	na	na	na		
Europe-EU	2.2	2.4	0.8	1.1	1.4	na	na	na		
Europe-Other	0.2	0.9	0.2	1.0	0	na	na	na		
Russian Federation	0	0.1	0.1	0.9	-0.1	na	-3.7	-0.8		
North America	-0.7	-1.4	0.6	0.9	-1.2	na	na	na		
UNECE- Total	1.9	1.0	1.8	1.0	0.1	na	na	na		
World	4.9	0.8	4.9	0.8	0	na	-4.3	-0.9		
Paper & paperboard[4]	*million tonnes*	*%*	*million tonnes*	*%*	*million tonnes*	*%*	*$/ tonne*	*%*		
ECCA	*0*	*-1.8*	*0*	*0.2*	*-0.1*	*na*	na	*na*		
Europe-EU	*-0.3*	*-0.3*	*0.3*	*0.3*	*-0.7*	*na*	na	*na*		
Europe-Other	*0*	*0.3*	*0*	*0.3*	*0*	*na*	na	*na*		
Russian Federation	*0.1*	*0.6*	*0*	*0.4*	*0*	*na*	-4.0	*-0.5*		
North America	*0.6*	*0.7*	*0.3*	*0.4*	*0.2*	*na*	na	*na*		
UNECE- Total	*0.3*	*0.1*	*0.7*	*0.3*	*-0.5*	*na*	na	*na*		
World	*1.6*	*0.3*	*1.6*	*0.3*	*0*	*na*	-4.1	*-0.5*		

Note:

na indicates "not applicable"

[1] Numbers in "%" columns represent the percentage change from the reference scenario (without increase in forest area) in 2040.

[2] Prices for panels represent the average of prices for plywood, particle board, and fibreboard, and prices for paper and paperboard represent the average of prices for newsprint, printing and writing paper, and other paper and paperboard.

[3] Production, consumption and net export values for panels represent the sum of values for plywood, particle board, and fibreboard

[4] Production, consumption and net export values for paper and paperboard represent the sum of values for newsprint, printing and writing paper, and other paper and paperboard. Tonnes are metric tonnes.

Source: GFPM projections.

4.2 Increased planted forest area outside the UNECE region

What if …

there were a rapid increase in forest growing stocks, resulting from increased planted forest outside the UNECE region?

(Assessment through literature review)

This supply scenario was examined by reviewing recent research that quantified how an increase in planted forests or forest growing stock outside the UNECE region might alter supply and demand in the UNECE region. A paper published by Nepal et al. (2019a) described the effects of global increases in planted forests, which permits a basic assessment of the effects of rapidly rising wood supplies globally. Using the GFPM, the model simulated the changes in global forest area under SSP1-SSP5, for the period from 2015 to 2070, with and without planted forests. Under the reference scenario, there was little change in the area of planted forests in the UNECE region, but a more substantial change in the rest of the world. 77% of the projected global expansion in planted area by 2040 (81 million ha) occurred outside the UNECE region (63 million ha). Consequently, the effects on forest sector variables would be similar in sign, if not magnitude, as a 'what-if' scenario that would assume an increase in wood supply from outside the UNECE region only.

Nepal et al. (2019a) found that global forest growing stock would be 1.9% higher by 2040 with the planted forest version of the GFPM, rather than modelled using the base version of GFPM without planted forests specifically modelled under the reference scenario. The overall effect of increased planted forests would be to decrease prices for industrial roundwood inputs and all derived wood products, and the effects would be lower by single digit percentages by 2040. Due to the lower prices, global production and consumption, would be higher for all products by 2040 and beyond.

Under the reference scenario, and consistent with little overall increase in forest growing stocks in Europe under the reference scenario, the authors report no change in industrial roundwood production in Europe under the planted forest version of GFPM compared to the base version. Effects on other world regions varied substantially, with lower production in North America and South America and higher production in Africa and Asia.

4.3 Increased natural disturbances

What if ...
natural disturbance of forest were to be become more frequent and severe?
(Assessment through literature review)

Natural disturbances such as wildfires; insect epidemics or pathogens, whether native or exotic; storms, including hurricanes; and droughts, are influenced by environmental factors, forest history and forest management. They affect supply and demand of forest products, as well as forest condition. Climate change is expected to result in increased frequency and severity of such future events (more detail is available in the 2022 UNECE/FAO Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040") (UNECE/FAO, 2022b). Forest disturbance tends to have short-term effects on forest product markets, mostly at the regional/national level, and much less frequently with international impacts. Short-term effects may include gluts of timber from salvage harvesting, which may drive down roundwood prices temporarily. In the longer-term, reduced forest growing stock may drive up prices, affecting production for decades in the affected regions (Prestemon and Holmes, 2008).

Research focused on the United States, has shown that even the most damaging hurricanes have spatially limited, though temporally extended, impacts on production, consumption, prices, and economic welfare (Prestemon and Holmes, 2000, 2004). Simulation studies on the market effects of wildfires imply significant effects on forest growing stock and wood product markets (Prestemon et al., 2006). Similar studies of bark beetle epidemics have shown regional impacts that are similar to those caused by hurricanes (Holmes, 1991; Schwab et al., 2009; Thom et al., 2013). The provincial economy of British Columbia is estimated to have suffered a long-term welfare loss of CAD 90 billion, as a result of the mountain pine beetle outbreak (Corbett et al., 2015).

Natural disturbances are unpredictable to a large extent. This hampers long-term projections of their effects on market variables. The market effects of disturbances are not directly modelled in the GFPM. There are, however, some general assumptions that can be made about the possible effects of disturbances over the next 25 years on the UNECE region forest products market:

(i) Markets will always contain an unpredictable proportion of roundwood from salvage operations.

(ii) Salvage timber will tend to drive down roundwood prices in the short-term.

(iii) Where disturbances kill a significant proportion of standing timber, tight supply will likely cause long-term price increases.

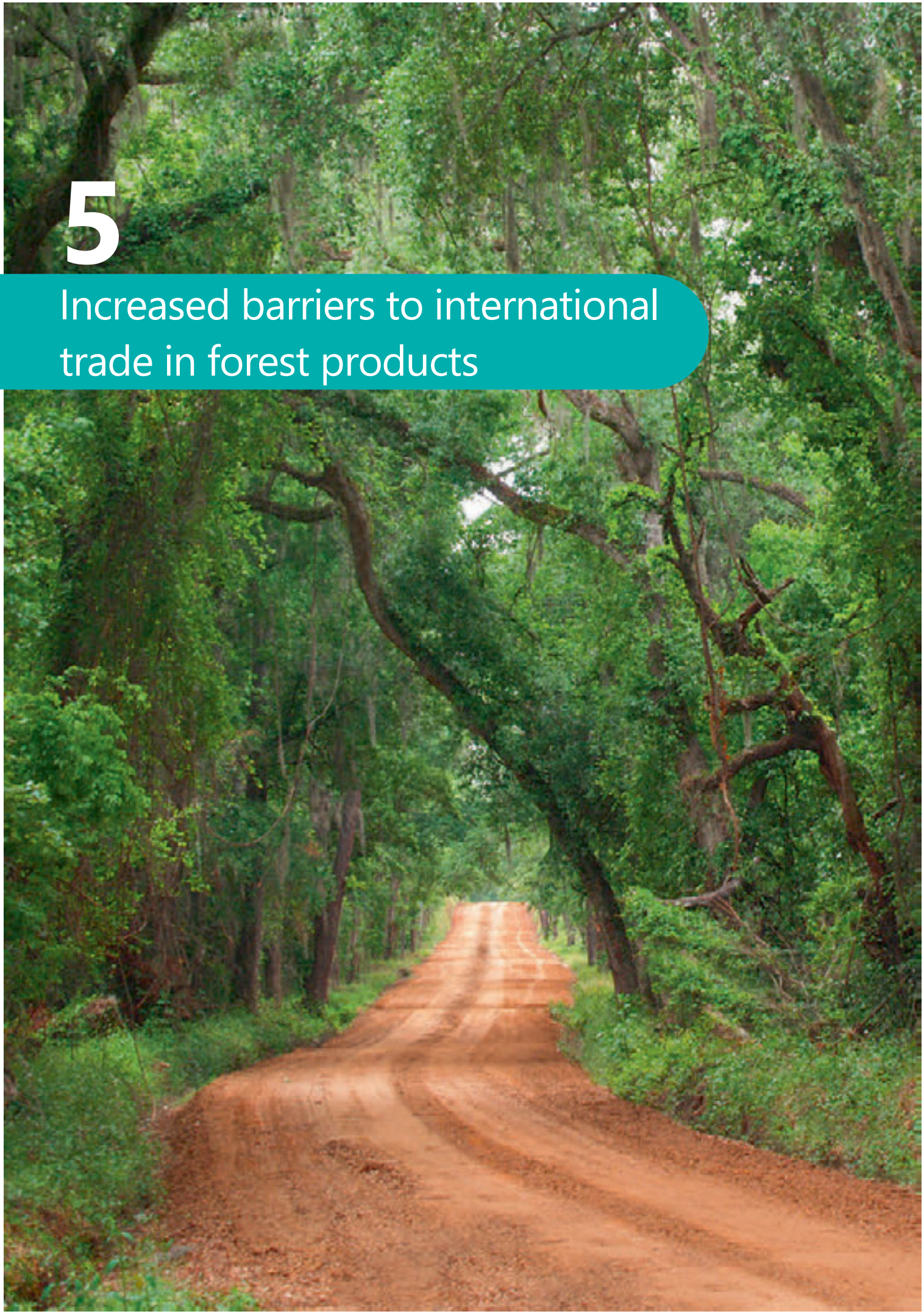
(iv) The effects of disturbances on forest growing stock and national or regional industrial roundwood prices may be profound, making it important to explore forest dynamics models at those scales.

(v) Where disturbance is extensive it is possible that the market effects are on an international scale.

(vi) In a similar fashion, significant tree mortality in smaller countries may also have market impacts that extend across international borders.

5

Increased barriers to international trade in forest products



KEY QUESTION (and what-if scenario)

What if there were massive restrictions to trade in forest products?
(Assessment through literature review)

A final 'what-if' scenario, not specifically tied to structural changes in supply or demand, called for an assessment of how increased trade barriers might affect forest products markets. The UNECE region has witnessed higher tariffs in the years since 2017, with the United States as a central focus. As the largest producer of forest products in the world and the UNECE region, there are large bilateral flows in forest products between the United States and Canada, which is the world's and UNECE region's second largest producer. Both countries trade extensively with Europe and other countries of the UNECE region. Higher tariffs have impacted such trade. Studies that analyse these impacts can help to reveal what sustained, higher tariffs could mean for the UNECE region in the future.

Buongiorno and Johnston (2018) modelled the effects of trade barriers using the Global Forest Products Model, the same model employed for this Outlook. Although their study was limited to quantifying the effects of simulated trade friction associated with only 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-UNECE region and global production, consumption, price, and trade effects.

The study considered two simulations. The first simulated the effects of higher import tariffs levied by the United States (alone) against its trading partners. The second simulated the effect of these tariffs, in combination with retaliatory tariffs.

With higher United States import tariffs, but no retaliatory measures, the welfare of United States producers rises but by less than the losses experienced by United States consumers, due to higher domestic (US) prices and lower United States consumption. Outside the United States, producers lose more than consumers gain by paying lower prices and consuming more.

When the effects of retaliatory measures were added, the results were reversed within the United States, with welfare of United States consumers rising due to lower prices and higher consumption, but their gains were outweighed by United States producer losses. In the rest of the world under that second simulation, consumer welfare decreases more than producer welfare increases, also a net loss. A trade war such as this would reduce total welfare (producer and consumer surplus) of most countries.

While some of the impacts highlighted by the authors are dependent on the countries most directly involved in any trade barrier or other trade measure (in this case the United States), the results are informative of what a trade war could mean for forest product markets on a global basis.

Non-tariff barriers too, in the forms of quotas, embargoes, sanctions, or export bans, can impact the forest sector in the UNECE region. Measures by individual countries or trade blocs that may be categorized as non-tariff barriers are often a source of trade disputes. Environmental policies or phytosanitary controls that are designed to prevent transfer of exotic pests and disease across borders may be viewed as non-tariff barriers (Li et al., 2007). While their use may be conditionally allowed under the provisions of the World Trade Organization (WTO, 2020), they do have real impacts on international trade and are sometimes the source of trade disputes (FAO, 2005). For the forest sector, the effects of such measures are to raise global timber prices, increase consumer expenditure, and to limit production and overall trade. Specific impacts will vary widely depending on which countries are involved and the targeted products. This study did not specifically model the effects of such barriers, nor was it able to judge whether or not such barriers would be more or less common in the future.

6 Conclusion

Under the three SSP scenarios, by 2040, total forest area is projected to rise in Europe and the Russian Federation, but to fall slightly in North America. The reduction in North America would be slightly offset by an increase in the area of high productivity planted forest. Annual cuts in all three scenarios are projected, on average, to be lower than global annual net volume increment: total forest growing stock is projected to rise in all scenarios, which would raise net carbon sequestration and carbon stored in forests. Higher forest growing stock would increase production capacity in the wood manufacturing sector, increasing roundwood supply and production of derived wood products in all UNECE subregions. In turn, this is projected to lead to higher levels of stored carbon in manufactured wood products.

While the exact scale of the effects caused by the modelled structural changes, may be open to question, the results of the scenarios do at least indicate directions of change in prices, trade, production, and consumption. The GFPM used in this study relies on established theories of markets and trade. The values of parameters are based on historical ranges of market variables. Consequently, they may be less accurate when applied to extreme assumptions, such as those featured in the different 'what-if' scenarios. The 'what-if' scenarios were based on the best available knowledge to derive numerical assumptions that were then applied in the forest sector model. Other published studies have addressed such uncertainties by alternately raising or lowering parameters to observe how the variables of interest, such as prices and trade volumes, change in response. Limited time and modelling capacity precluded this approach in this Outlook study.

Even so, the 'what-if' scenarios provide insight into how large structural changes might affect the future for the UNECE region and global forest sector and what sort of changes might result. For example, increased demand for wood fibre from an expanding construction sector, be it inside the UNECE region or in a country like China, would tend to reduce carbon sequestration by forest biomass (discussed in the UNECE/FAO 2020 Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040") (UNECE/FAO, 2022b), and increase overall product prices.

The 'what-if' scenario that looked at the potential effects of increasing demand for wood fibre from the textile sector, found that this structural demand change would lead to higher prices for industrial roundwood. In turn, higher roundwood prices would raise production costs in other sectors too, such as sawmilling. This would be likely to reduce Europe's net exports of sawnwood. As a note of caution, the results of the textile scenario, are contingent upon how the model dealt with manufacturing residues from sawmilling and the panel industry.

The 'what-if' scenarios examining structural changes in timber supply involved both modelling and a literature review. Results demonstrated that an expanding global forest growing stock, whether within the UNECE region or the rest of the world, might depress prices slightly but would increase the outputs of timber and wood products overall. The increase in forest growing stock would give rise to higher carbon sequestration by forests and also greater carbon storage in wood products.

An examination of the potential effects on forests of natural disturbances showed that salvaging roundwood after natural disturbances can have significant short-term effects by lowering timber prices. In the longer term, prices may rise in surrounding areas as future roundwood supplies may be less readily available. The analysis also revealed that little is known about the aggregated international impact of such disturbances. Additional research and modelling could shed more light on the scale of these impacts, especially as climate change is predicted to result in more frequent and more severe storms, drought and fire events. The Discussion Paper "The outlook for UNECE forest sector in a changing climate: a contribution to the Forest Sector Outlook Study 2020-2040" (UNECE/FAO, 2022b), provides more information about the current state of knowledge and research needs related to climate change.

Finally, this paper considered an increase in tariff and non-tariff barriers on the forest sector, globally and within the UNECE region. Published research indicates clearly that higher tariffs, and non-tariff barriers to trade, depress overall economic output in the forest sector. If an individual country were to restrict imports, the global impact, and even the impact on an area like the UNECE region, would be relatively small. If other countries adopted retaliatory measures in response, this could have a much broader impact globally, significantly increasing welfare losses. The impact felt within the UNECE region might be particularly strong, due to high income and consumption levels compared to other countries and regions.

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8 Annexes

8.1 ANNEX A: MODELLING BACKGROUND INFORMATION

TABLE A1 Estimated coefficients, standard errors, and significance levels of a planted forest area Environmental Kuznets Curve model

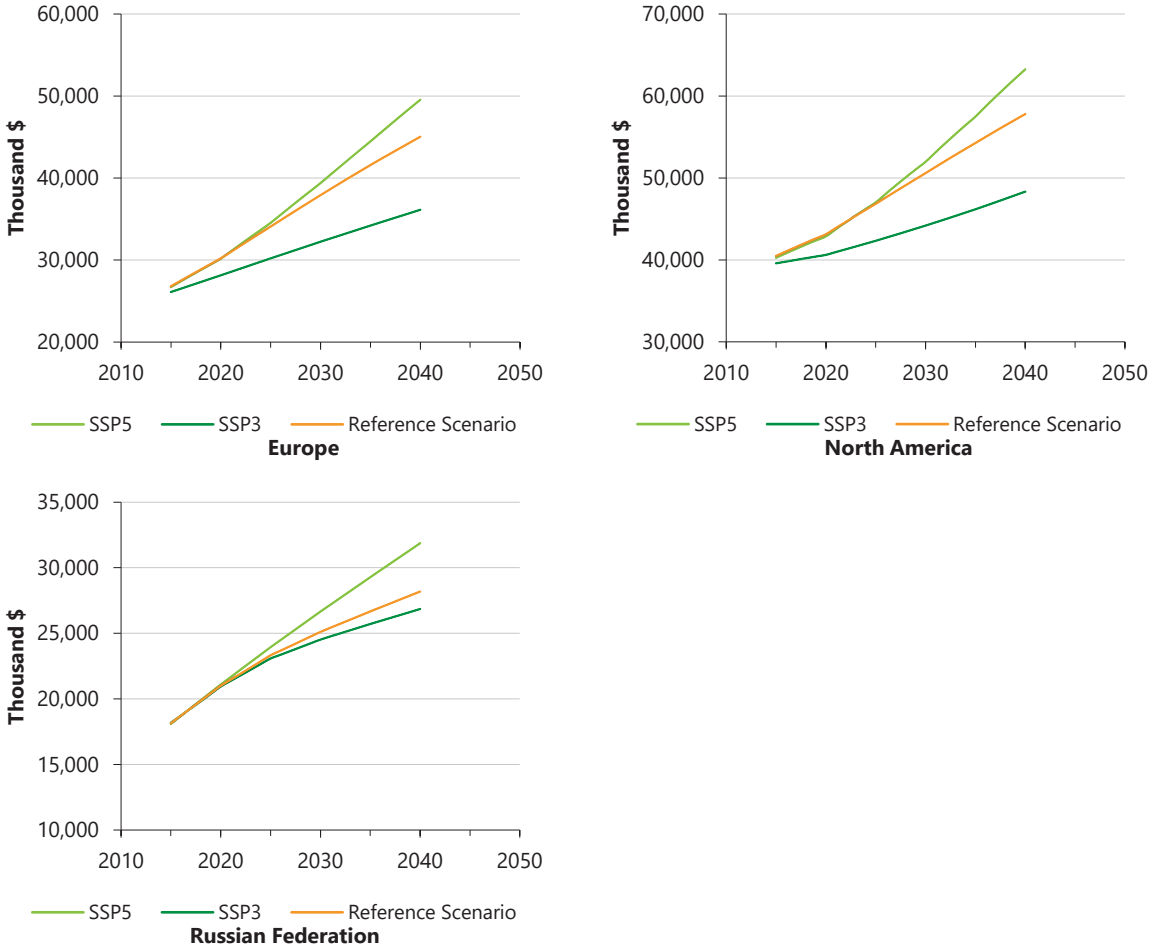
Variables	Fixed Effect Model[1]
$(Y/N)_{it}$, GDP per capita	1.0734 (0.5800)*
$(Y/N)^2_{it}$	–0.0519 (0.0340)
U_{it}, rural population density	–1.3069 (0.3600)***
$(L/A)_{it}$, labour per forest area	1.9764 (0.0070)***
$(K/A)_{it}$, capital per forest area	0.0296 (0.0908)
$(L/A)_{it}$* $(K/A)_{it}$	–0.0470 (0.0100)***
I_{it}	0.2057 (0.2954)
I_{it}* $(Y/N)_{it}$	–0.0538 (0.0762)
I_{it}* $(L/A)_{it}$	0.1592 (0.1200)
I_{it}* $(K/A)_{it}$	0.0315 (0.0597)
I_{it}* $(L/A)_{it}$ * $(K/A)_{it}$	–0.0213 (0.0103)
Dummy- South America	–0.4110 (1.4827)
Dummy- Asia	–0.4805 (1.4319)
Dummy- Africa	–1.6366 (1.3843)
Dummy- Europe	0.2334 (1.4100)*
Dummy- North America	–2.4846 (1.47)***
Intercept	26.8300 (5.92)**
R^2 (adjusted)	0.26
Pooling test	40.79***

Notes: numbers in parentheses are standard errors; *** indicates that the parameter estimate or test statistic was significantly different from zero at 1%, ** at 5%, and * at 10%.

[1] The specified model was estimated with the continuous variables (i.e., not the intercept or dummy variables) transformed by the natural logarithm; therefore, the estimated coefficients of the continuous variables are also estimates of their elasticities.

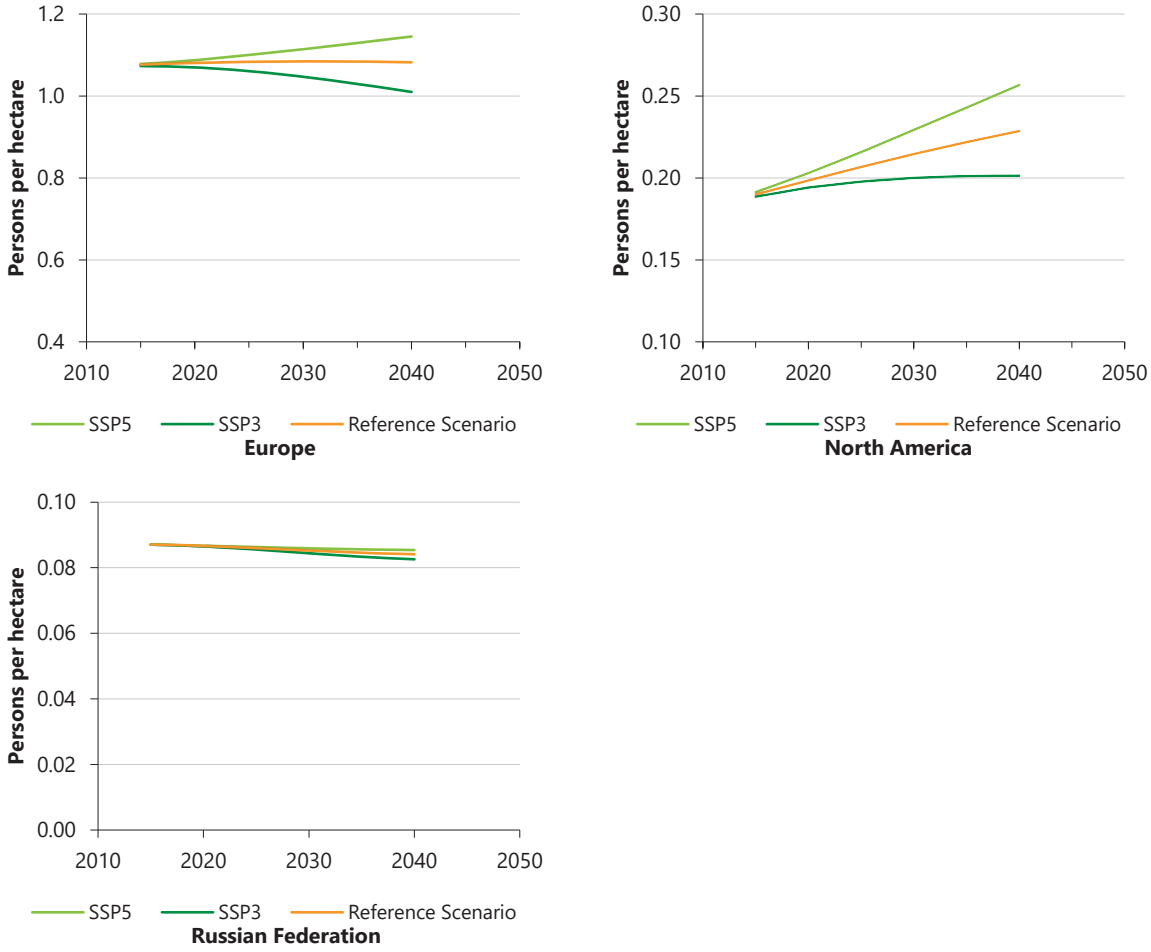
Source: Korhonen et al. (2020)

FIGURE A1 **PROJECTED AVERAGE PER CAPITA GROSS DOMESTIC PRODUCT (2010 CONSTANT $) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040**



Source: IIASA database (IIASA 2018)

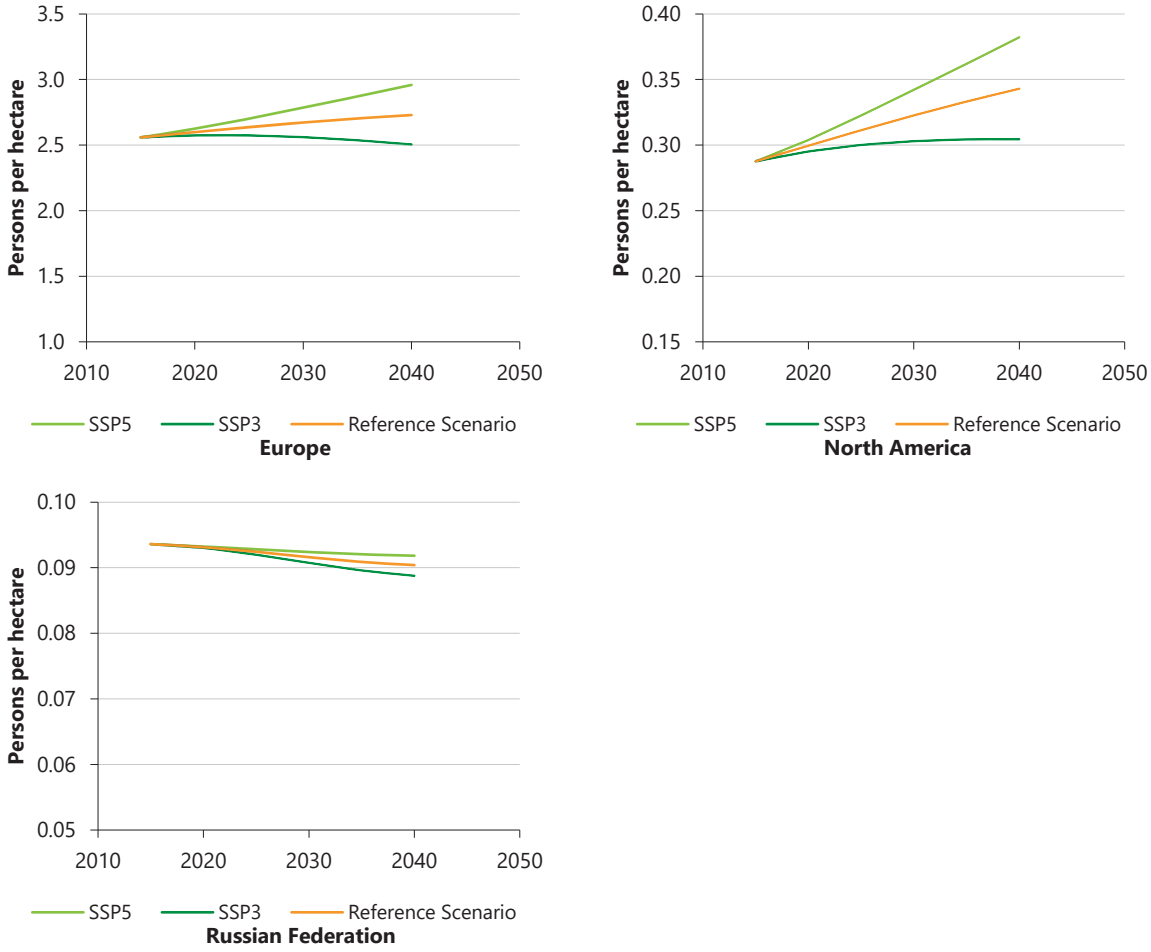
FIGURE A2 PROJECTED RURAL POPULATION DENSITY (PERSONS PER HECTARE) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040



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

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

FIGURE A3 PROJECTED AVERAGE LABOUR PER FOREST AREA (PERSON PER HA) BY SUBREGION UNDER DIFFERENT SOCIOECONOMIC PATHWAYS, 2015-2040

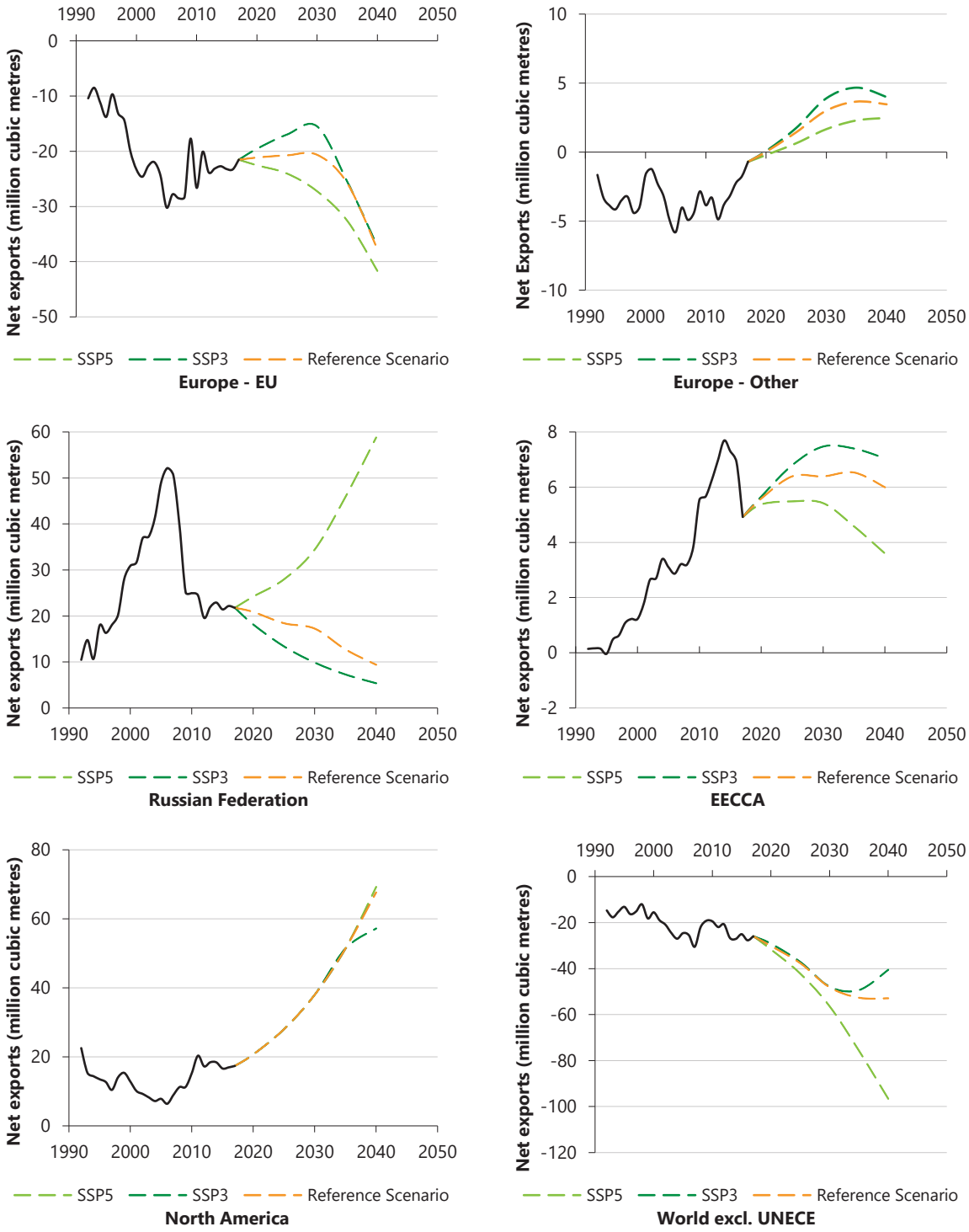


Notes: The base year labour per forest area was assumed to follow the population growth trends projected in respective SSPs.

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

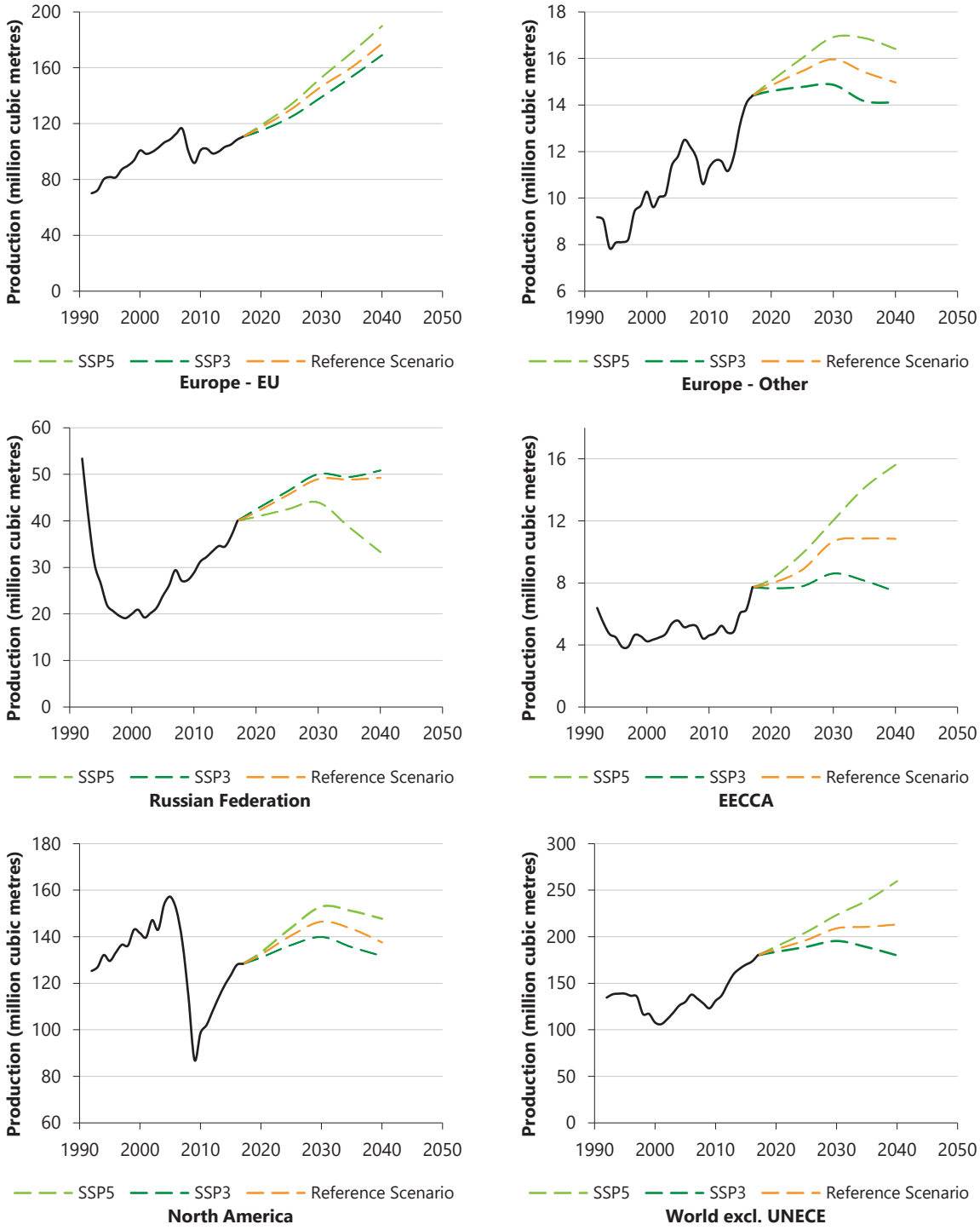
8.2 ANNEX B: PROJECTED OUTPUTS FOR THE REFERENCE SCENARIO, SSP3, AND SSP5

FIGURE B1 PROJECTED INDUSTRIAL ROUNDWOOD NET EXPORTS FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



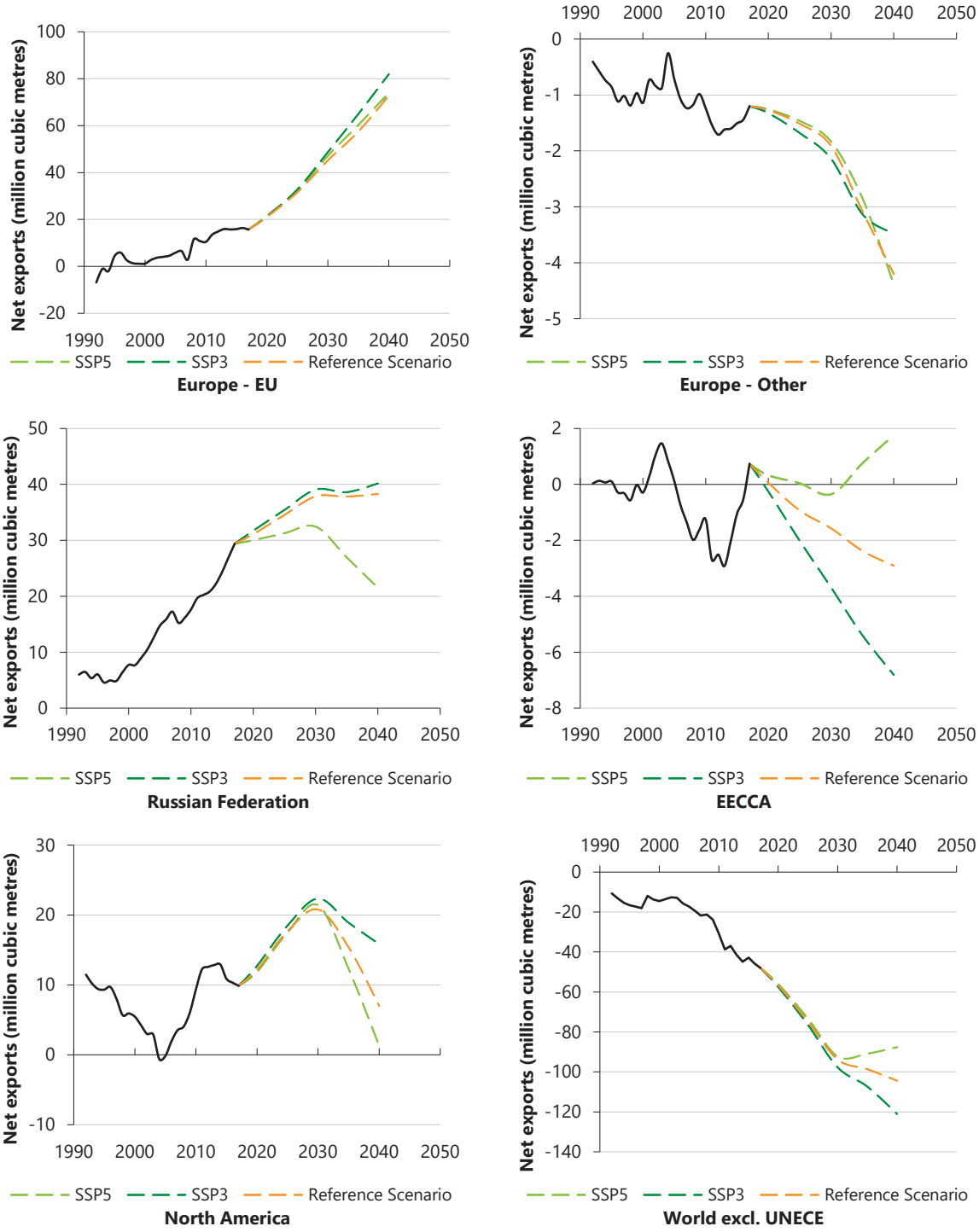
Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B2 PROJECTED SAWNWOOD PRODUCTION FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



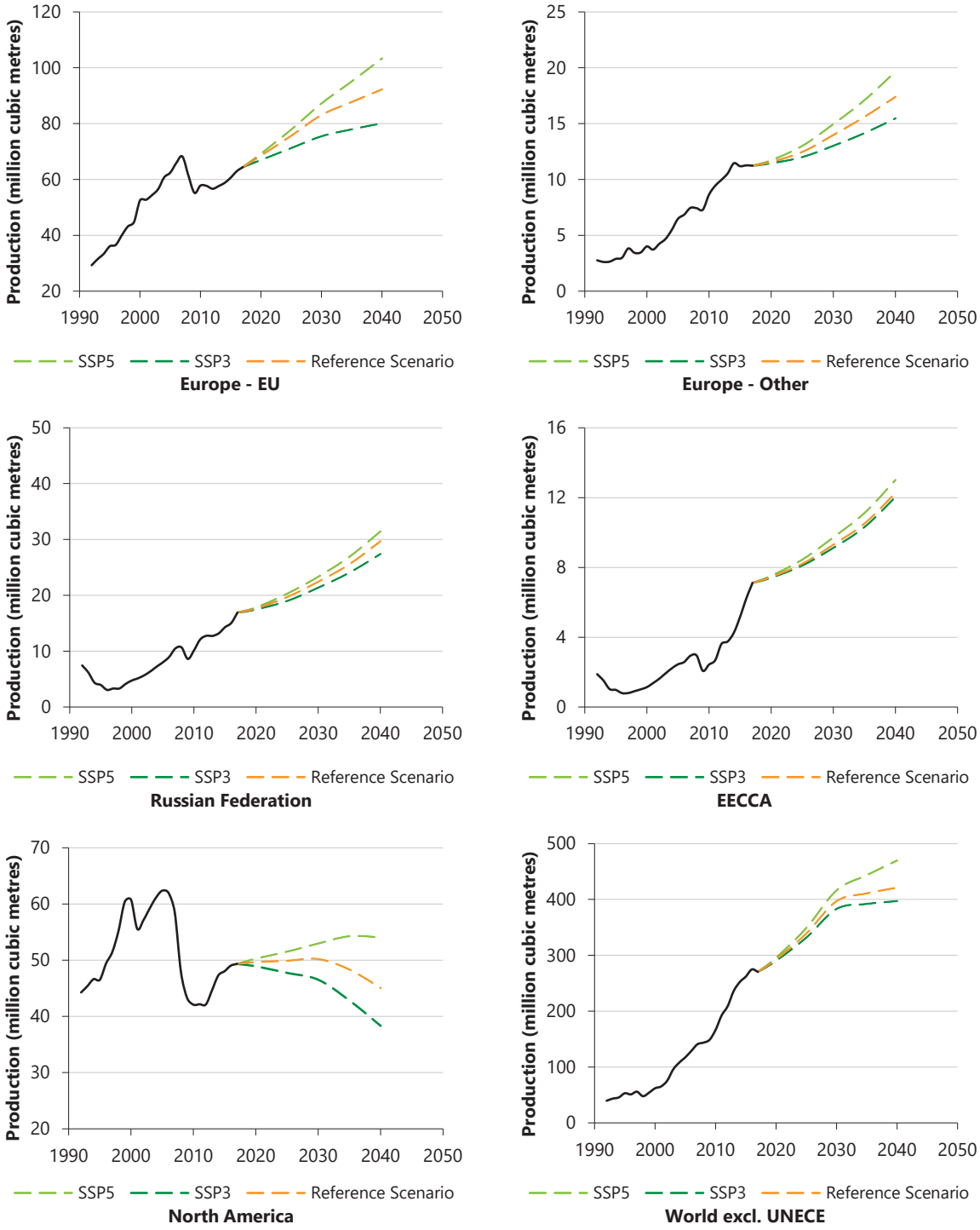
Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B3 PROJECTED SAWNWOOD NET EXPORTS FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



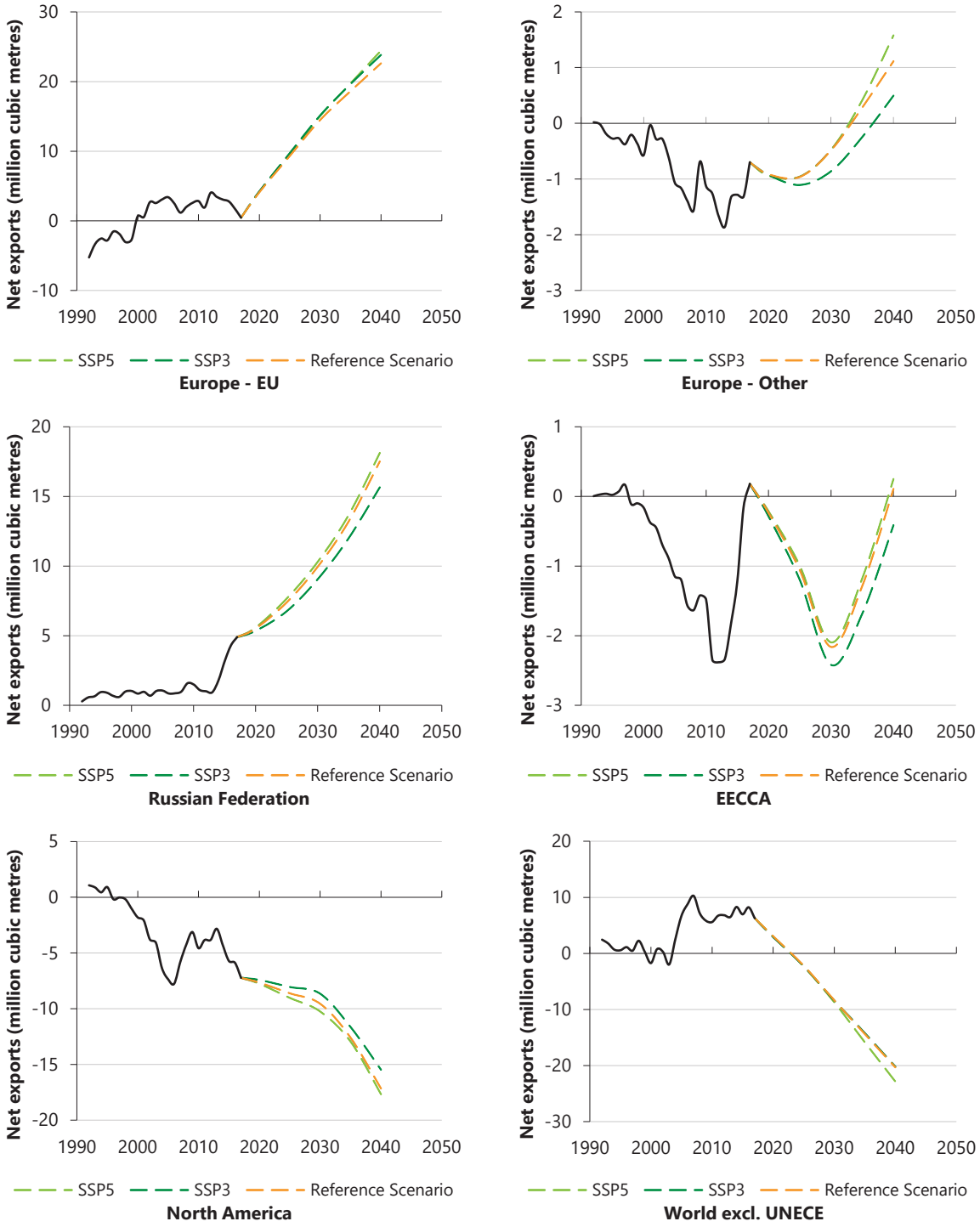
Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B4 PROJECTED PANELS (THE SUM OF PLYWOOD, PARTICLE BOARD, AND FIBREBOARD) PRODUCTION FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



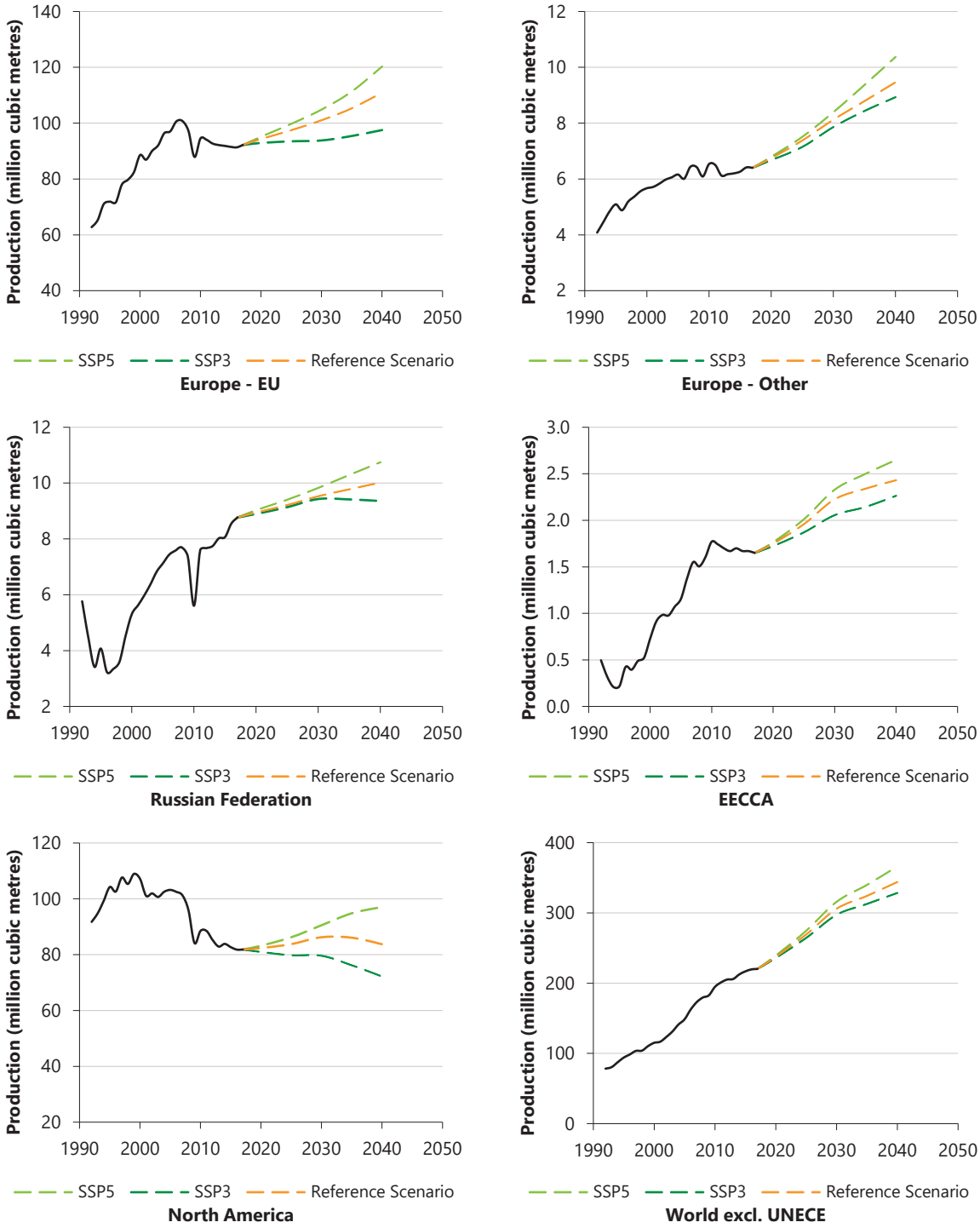
Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B5 **PROJECTED PANELS (THE SUM OF PLYWOOD, PARTICLE BOARD, AND FIBREBOARD) NET EXPORTS FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)**



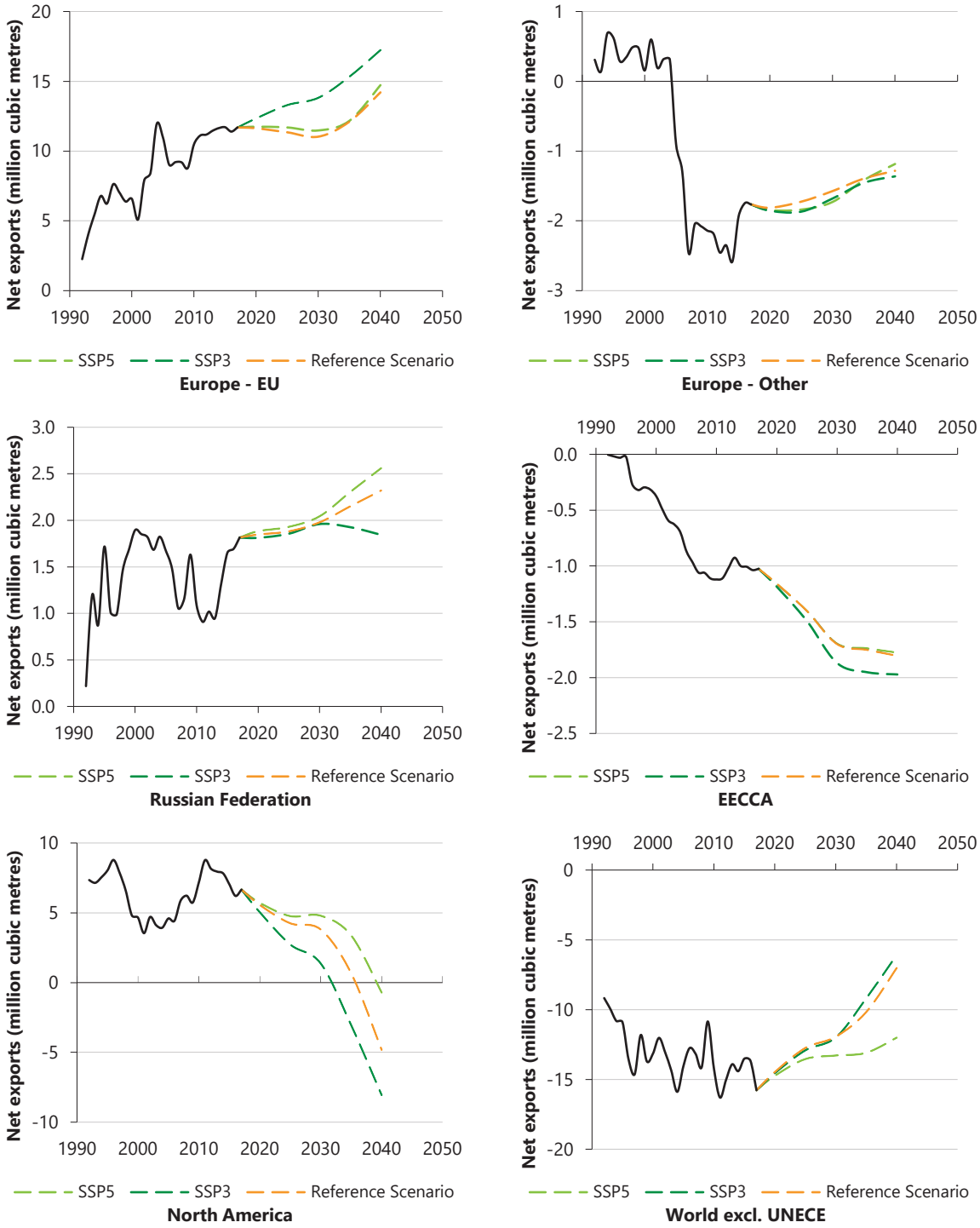
Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B6 PROJECTED PAPER (THE SUM OF NEWSPRINT, PRINTING AND WRITING PAPER, AND OTHER PAPER AND PAPERBOARD) PRODUCTION FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

FIGURE B7 PROJECTED PAPER (THE SUM OF NEWSPRINT, PRINTING AND WRITING PAPER, AND OTHER PAPER AND PAPERBOARD) NET EXPORTS FOR UNECE SUBREGIONS AND THE WORLD (EXCLUDING UNECE)



Notes: Historical levels 1990-2016; reference scenario and SSPs 2020-2040. 2017 is the base year for the projections, the average of 2016-2018
Sources: FAO (2019) and GFPM Projection.

8.3 ANNEX C: 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		Europe other countries
Austria	Italy	Albania
Belgium	Latvia	Andorra
Bulgaria	Lithuania	Bosnia and Herzegovina
Croatia	Luxembourg	Iceland
Cyprus	Malta	Israel
Czech Republic	Netherlands	Liechtenstein
Denmark	Poland	Monaco
Estonia	Portugal	Montenegro
Finland	Romania	North Macedonia
France	Slovakia	Norway
Germany	Slovenia	San Marino
Greece	Spain	Serbia
Hungary	Sweden	Switzerland
Ireland		Türkiye
		United Kingdom of Great Britain and Northern Ireland

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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.

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 Joint 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.

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

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ANNEX G: UNECE/FAO PUBLICATIONS

Geneva Timber and Forest Study Papers

Forest Products Annual Market Review 2021-2022	ECE/TIM/SP/54
Reporting on Forests and Sustainable Forest Management in the Caucasus and Central Asia	ECE/TIM/SP/53
Forest Products Annual Market Review 2020-2021	ECE/TIM/SP/52
Forest Sector Outlook Study 2020-2040	ECE/TIM/SP/51
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
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STRUCTURAL CHANGES IN THE FOREST SECTOR AND THEIR LONG-TERM CONSEQUENCES FOR THE FOREST SECTOR
A CONTRIBUTION TO 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.

Together with this Discussion Paper and other supporting publications, the FSOS 2020-2040 provides insight on six priority questions which were identified through a transparent and participatory process: (i) *How would different demand changes affect the UNECE forest products market?*; (ii) *How would different supply changes affect the UNECE region forest products markets?* (iii) *How would significant trade restrictions affect the UNECE region forest product markets?* (iv) *How will UNECE forests be affected by climate change?* (v) *How could UNECE region forests and the forest sector contribute to climate change mitigation?* (vi) *How could UNECE forests adapt to climate change?*

The FSOS 2020-2040 main report and the supporting Discussion Papers contain information on the possible impacts of future trends regarding the future forest carbon sink in tonnes of CO_2 equivalents, and on harvest, production, consumption, net exports and prices of wood products by 2040. The study takes a pragmatic, transparent and objective approach to answering these key questions, sometimes using a modelling approach. It enables stakeholders to evaluate the long-term consequences of policy choices.

The FSOS 2020-2040 contributes to evidence-based policy formulation and decision making. It is not a forecast of what will happen in the future. Rather, it sheds light on the possible consequences of policy choices and of factors external to the forest sector, most notably anthropogenic climate change. The study draws attention to the following issues emerging from the analysis in the study, and asks questions which policy makers and stakeholders might consider: (i) *Disturbances and the forest sink*; (ii) *Demand for land for increased carbon sequestration by forests*; (iii) *Putting substitution in a wider context*; (iv) *Trade measures*, and; (v) *Need for a system-wide, holistic approach to strategies and policies*

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