

Projecting scenario-based future forest sector activity with FOROM: The case of wood energy

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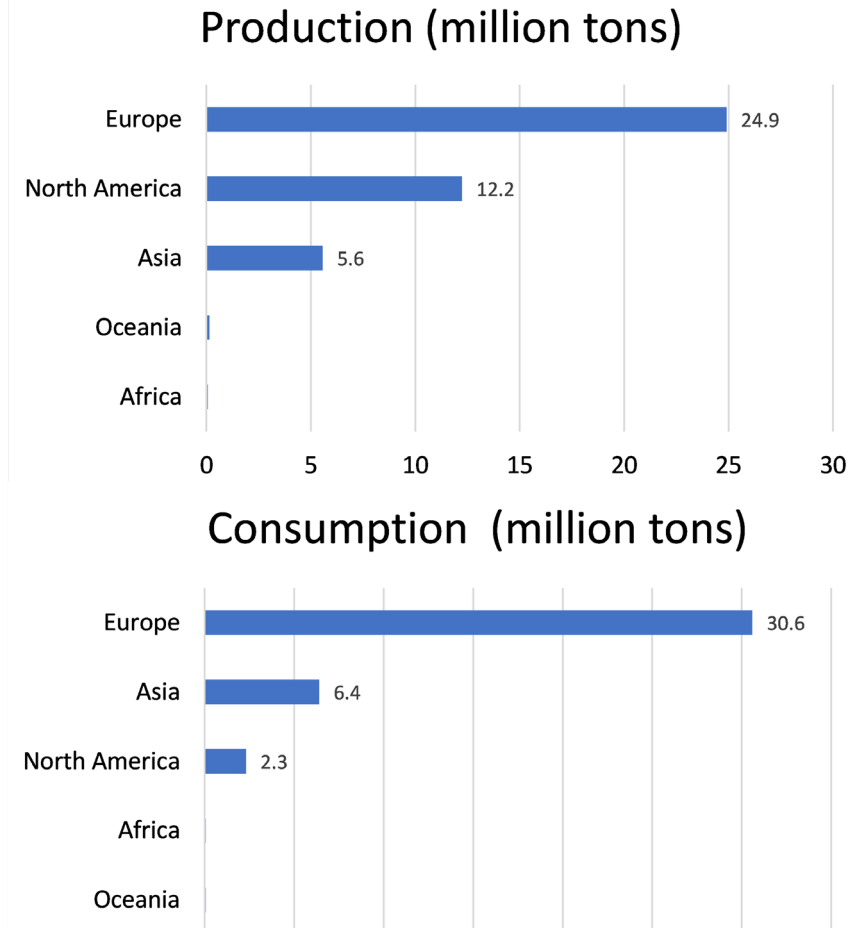
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Forest-based bioenergy markets have been rapidly evolving

- In comparison with other solid biofuels, wood pellets offer several unique advantages: high energy content, uniform size, ease of transport and storage, and ability to supply existing energy generating facilities with relatively minor retrofits
- Due in part to these reasons, global wood pellets markets have witnessed significant growth for heat and electricity production
- Between 2012 and 2020, global wood pellets production increased from 18.1 million tons to 43.7 million tons, with the U.S. being the largest producer, at 19.2% of the total

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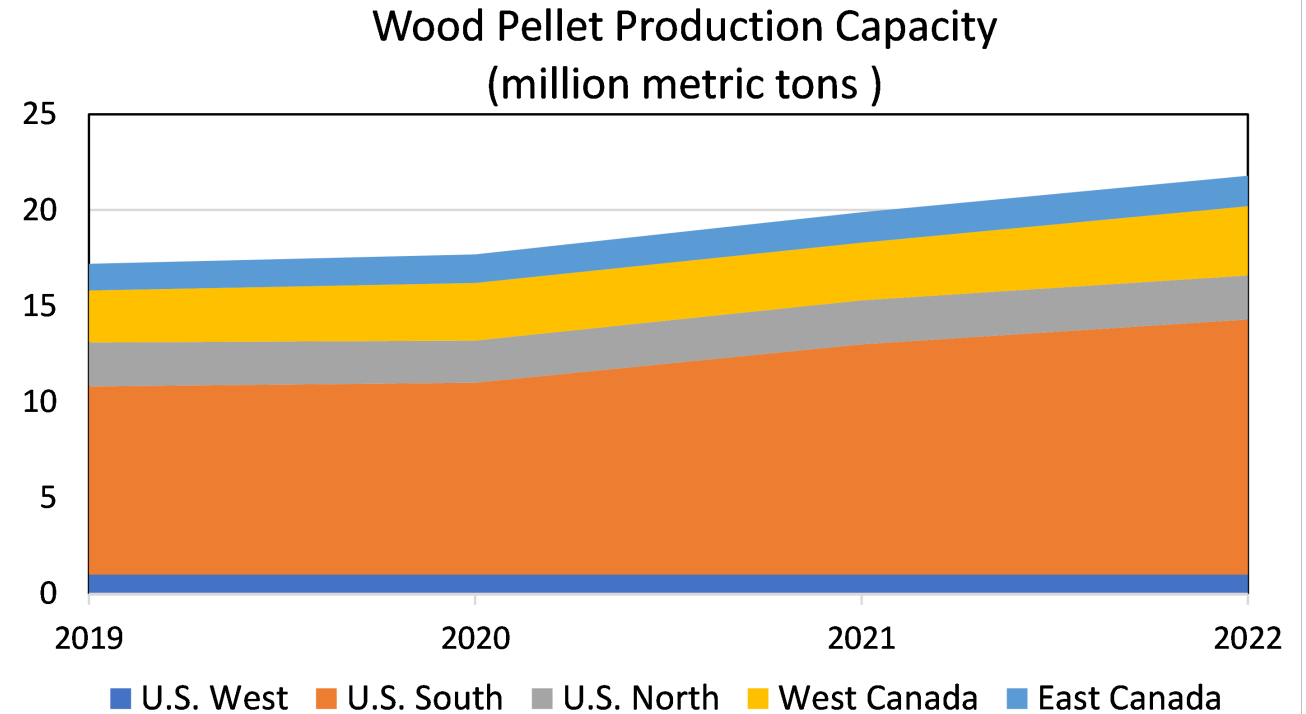
- Europe has been the largest consumer of wood pellets, with a consumption of 30.6 million tons of pellets in 2020, of which about a third were imported from the **U.S. South**
- Europe's renewable energy policy is a major factor behind the strong growth in demand for wood pellets. As the EU 2050 net-zero target proceeds, the wood pellets market is likely to continue to grow.



Source: FAOSTAT

Why U.S. South

- U.S. South softwood timber resource is significant
- Wood costs are competitive and stable
- Decline of pulp and paper demand
- Port infrastructure facilitates international trade



Source: Forisk

An expanding literature on Forest-based bioenergy

- Past and present wood pellets markets have been thoroughly examined, including:
 - analysis on the wood pellet market supply chain (Boukherroub et al. 2017, Visser et al. 2020)
 - wood pellet market integration (Olsson et al 2011, Johnston and van Kooten 2016)
 - life cycle emissions and carbon neutrality (Magelli et al. 2009, Laschi et al. 2016, Repo et al. 2015) and costs (Zhang et al. 2010)
- Given that forest by-products and small-diameter trees are the major sources of raw material for wood pellets, understanding the interactions between wood bioenergy and forest product markets has vital implications for forest industry development and forest management:
 - Jonsson and Rinaldi (2017) found that an increased wood pellet demand in the EU drove up forest biomass feedstock prices and led to lower production and consumption of wood-based panels and pulp.
 - Nepal et al. (2019) projected that competition for wood inputs would negatively impact the wood-based panel and pulp and paper sector in the U.S. but have positive effects on softwood lumber by reducing the effective net cost of lumber production through higher-value sales of mill residues. However, the wood energy sector was highly aggregated in their study.
 - Parajuli (2021) found that the wood pellet industry had driven pine pulpwood prices up in the US South region, but the study did not account for the interactions between U.S. regional markets and global timber markets.

Estimates of the future wood energy markets remain highly uncertain

- For one, they significantly rely on social and economic developments – which are subject to high levels of uncertainty themselves
- Several plausible representations of socioeconomic futures have been constructed by the climate change research community over the years, including a new set of scenarios described as the Shared Socioeconomic Pathways (SSPs; e.g. O'Neill et al. 2014)
- These SSPs outline the trajectory of population, urbanization, and economic growth up to 2100.
 - High socioeconomic growth could considerably drive up demand for timber and lead to greater harvested area in the future. Shifting from sustainable development to fragmented socio-economic development may trigger a 60% increase in harvest volumes in the long run (Lauri et al. 2019)
- To elaborate specifically on forest sector development, Daigneault et al.(2019) developed detailed narratives for how the global forest sector could vary across the five different SSPs, through the development of Forest Sector Pathways (FSPs).
- However, illustrating the impacts of these FSPs on future wood energy markets is still in its infancy (Lauri et al. 2019) though some attempts have been made (Daigneault and Favero 2021)
- Since the U.S. South is the world's largest wood-energy-producing region, there is also a growing need to address the impact of expanded global wood energy demand on the U.S. regional forest product markets.

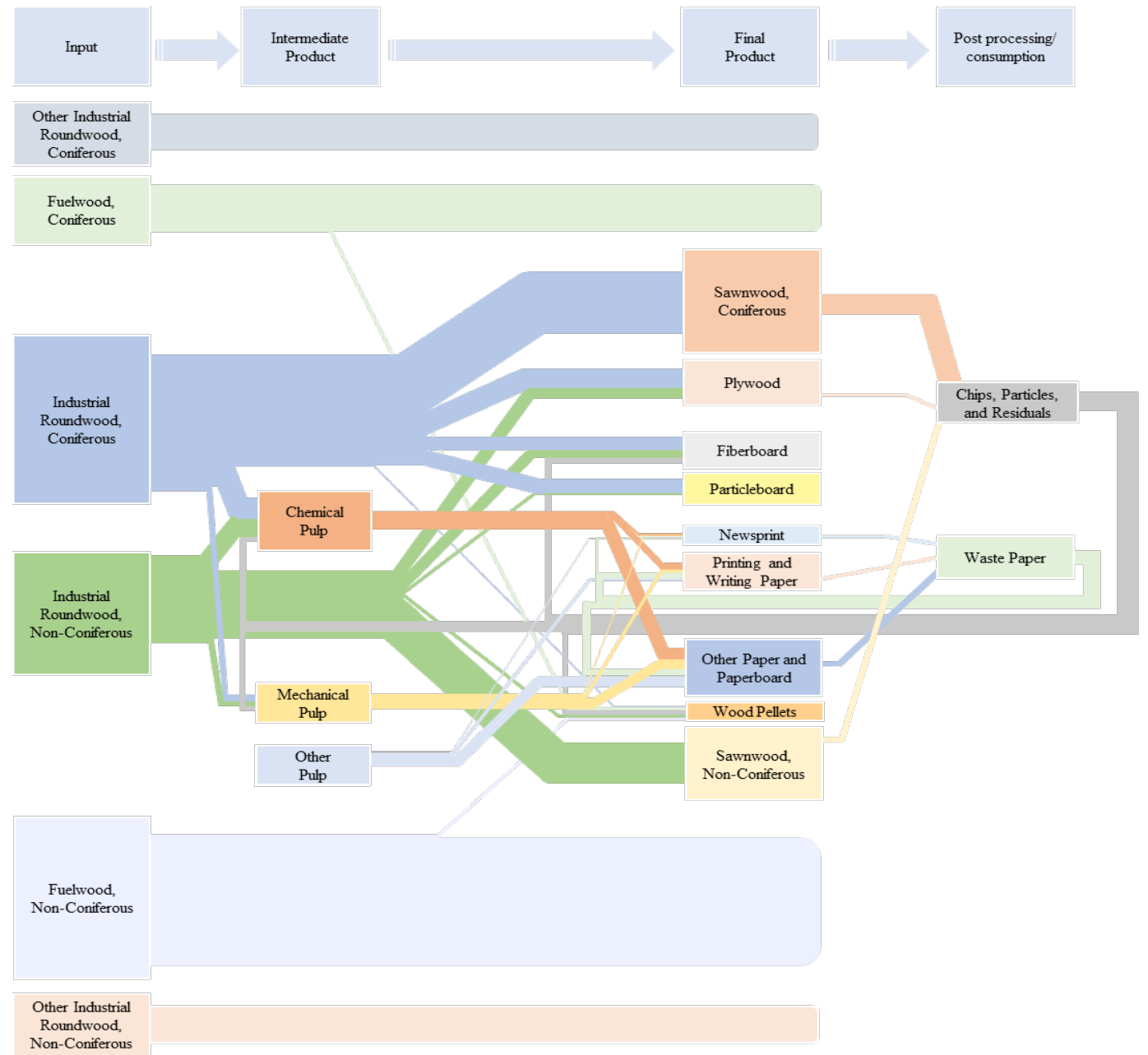
Objectives

- The aim of this paper is to provide projections of future wood energy market trends under five distinct socio-economic scenarios using a forest sector partial equilibrium model.
- We extend the previous research on the economic assessment of the fuelwood and wood pellets market in two aspects.
 - First, we investigate the effects of socioeconomic drivers on the production, consumption, and trade of wood energy on a global scale, with an emphasis on the largest wood-pellet-producing region in the world, the United States.
 - Second, we disaggregate the broad category of wood-based bioenergy into two categories—fuelwood and wood pellets—which depend heavily on the production of other primary forest products in a complex manner.
- In addition, by considering market interactions with other forest products (i.e., sawnwood and pulp and paper), we contribute to the discussion about the potential impacts of growing wood pellet demand on the dynamics of different forest product markets into the future.

FOrest Resource Outlook Model (FOROM)

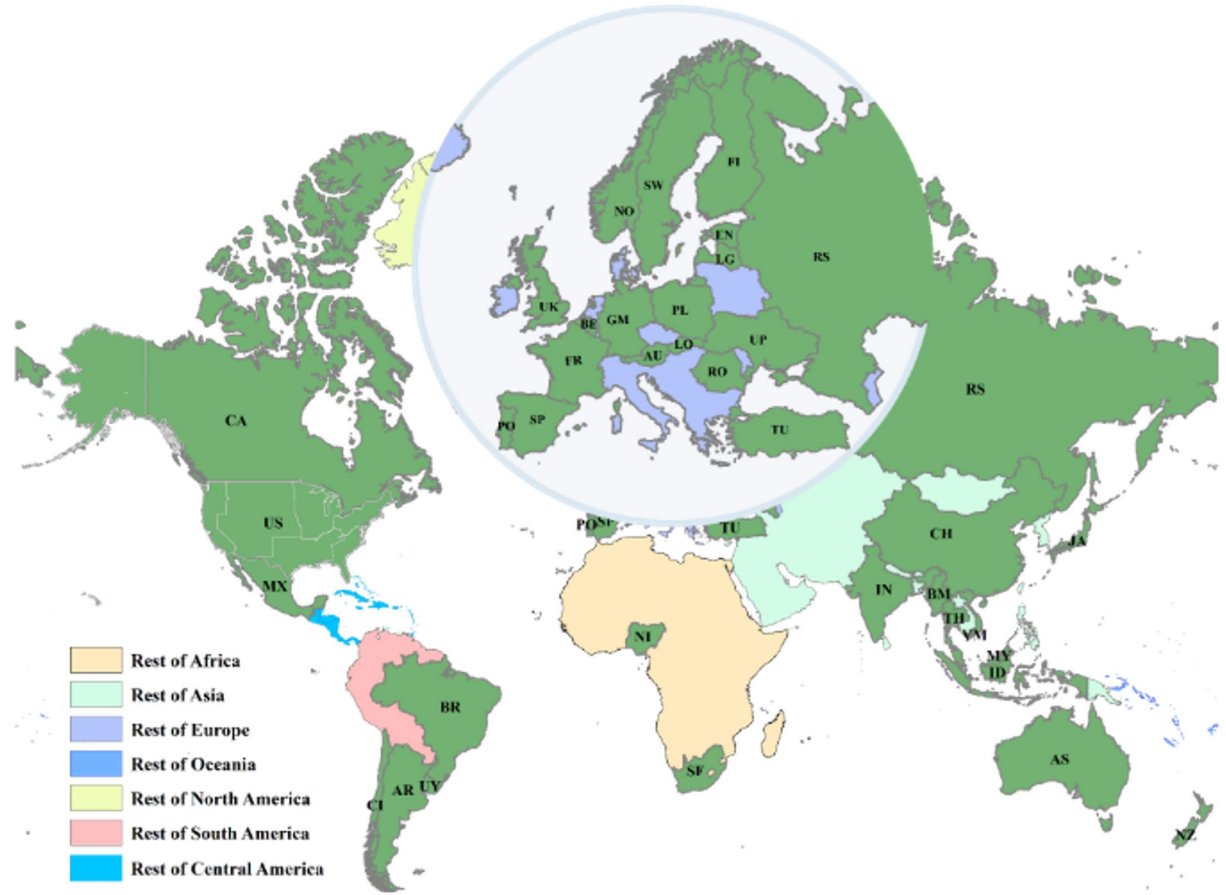
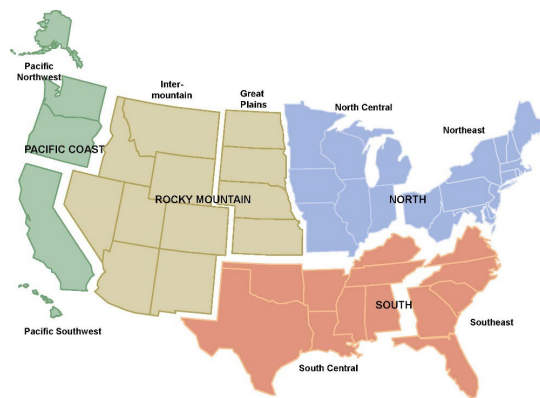
- A partial equilibrium model of the world's forest sector that includes forest resources, timber supply, demand for intermediate and final products, and international trade
 - see Johnston, Guo, and Prestemon USDA Forest Service General Technical Report SRS-254, 2021
- The modelling framework enables investigations into the influence of external shocks and changes in future socioeconomic conditions on the production, consumption, trade, and prices of raw material, intermediates, and final products, controlling for changes in forest land area and forest standing stock.
- The FOROM was originally designed to provide the outlook of the global and U.S. forest sector for the U.S. Forest Service 2020 Resource Planning Act (RPA) Assessment.

20 distinct interconnected products



FOrest Resource Outlook Model (FOROM)

- The current version of the FOROM represents the global wood product market across 55 countries and regions of the world.
- The United States is disaggregated into six Resources Planning Act (RPA) Assessment regions



Key exogenous drivers of SSP scenarios

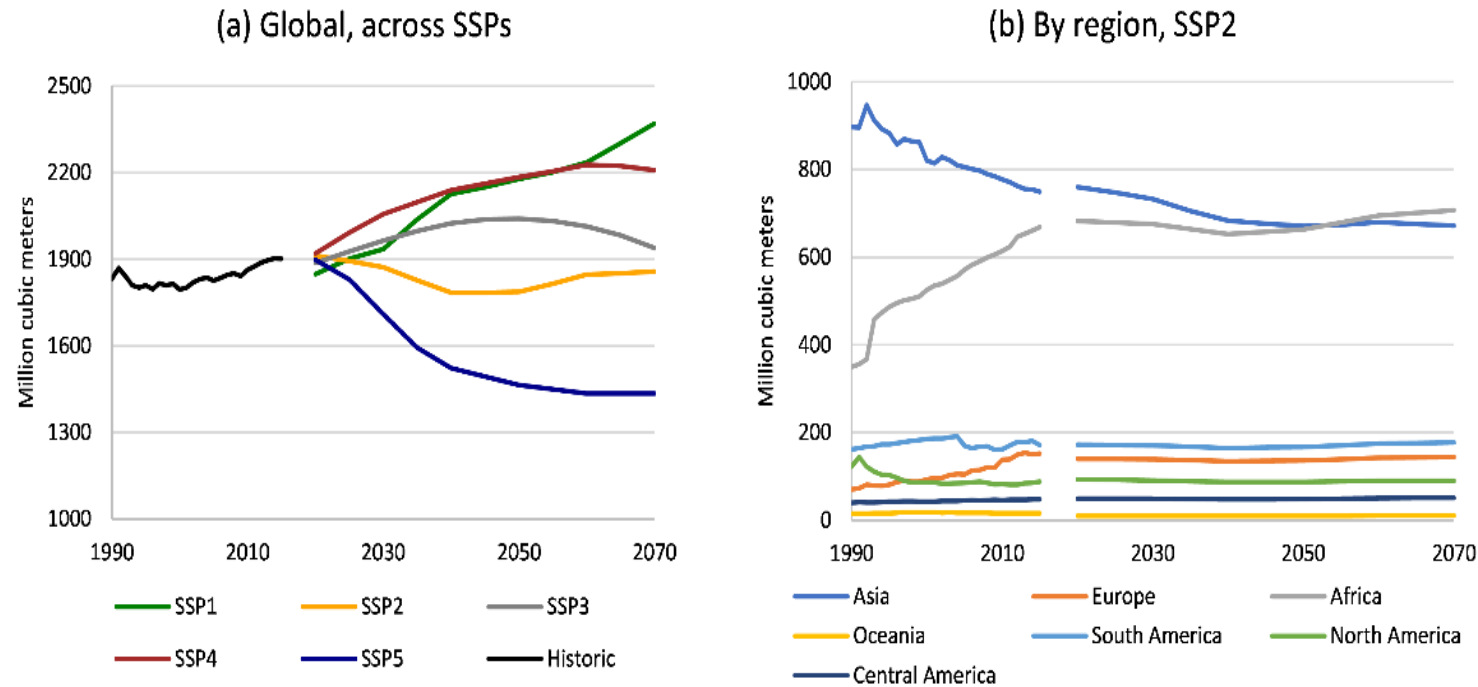
Exogenous Driver	SSP1	SSP2	SSP3	SSP4	SSP5
GDP	High in LICs, MICs; moderate in HICs	Moderate	Low	Low in LICs, moderate in other countries	High
Population	Relatively low	Moderate	Low in OECD, high in other countries	High in LICs, low in other countries	High in OECD, low in other countries
Technological change	High	Moderate	Low	High in HICs, moderate in other countries	High
Trade openness	Moderate	Moderate	Low	Moderate	High
Secondary bioenergy demand	High	Moderate	Low	Moderate	High
Fuelwood demand	High	Moderate	Moderate	High	Low

* LIC = low-income country; MIC = middle-income country; HIC = high-income country.

Projections of Fuelwood and Pellets to 2070

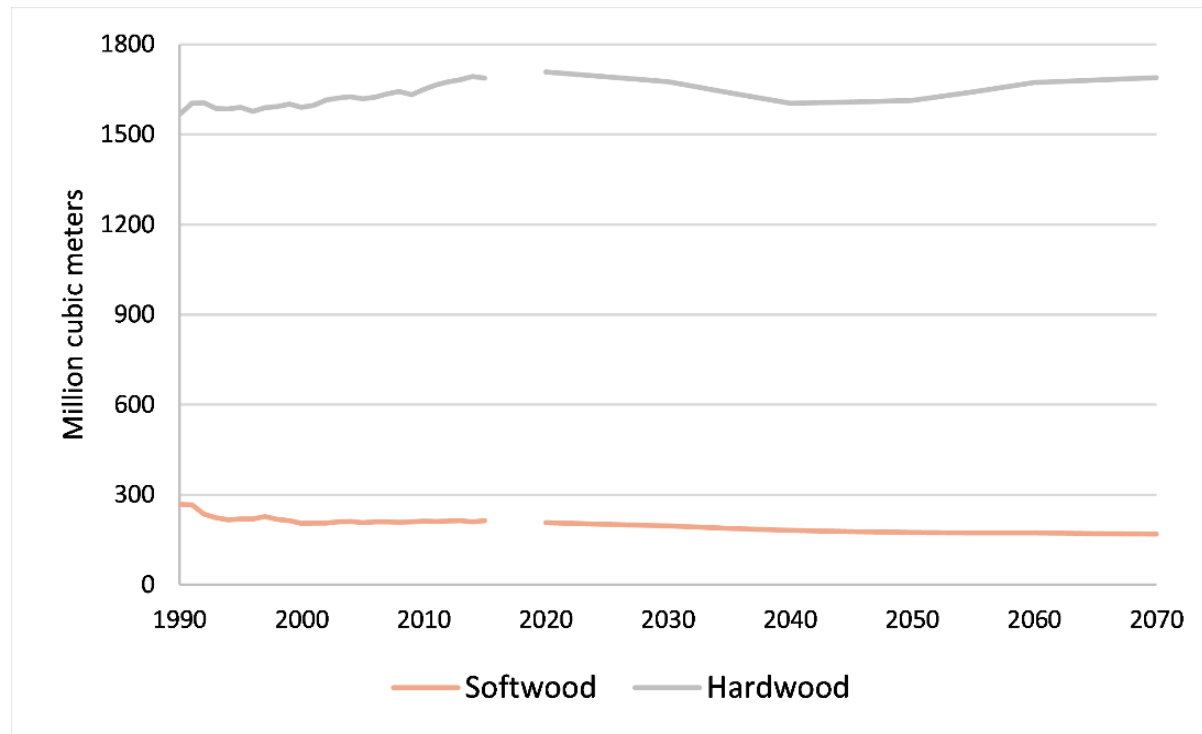
Wide variation in global fuelwood projections, tied to economic growth

Global consumption of fuelwood (a) across SSPs and (b) by region within SSP2
1990 to 2015 historic, 2020 to 2070 projections from FOROM



About 90% of fuelwood is from hardwoods, a trend expected to continue

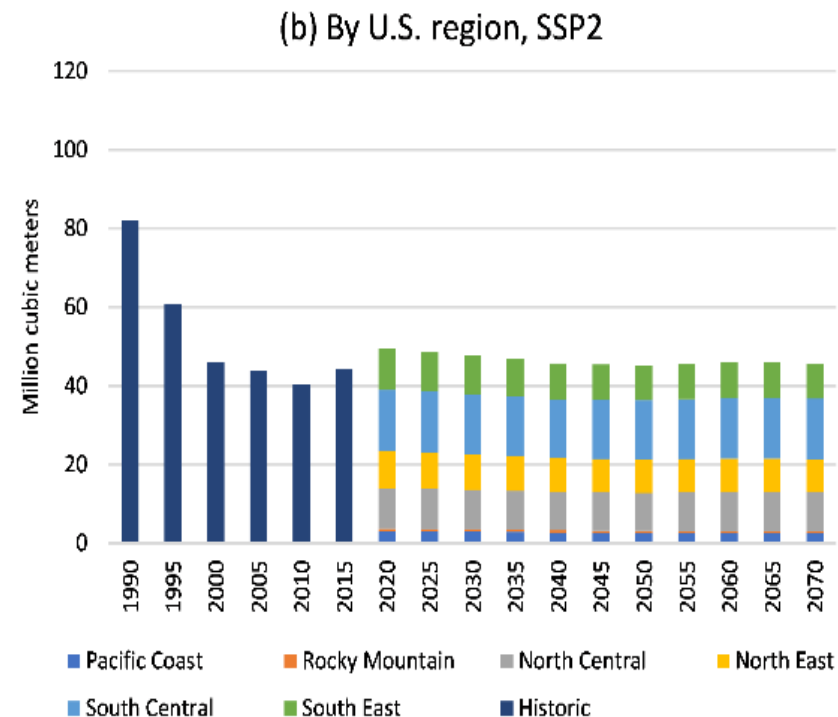
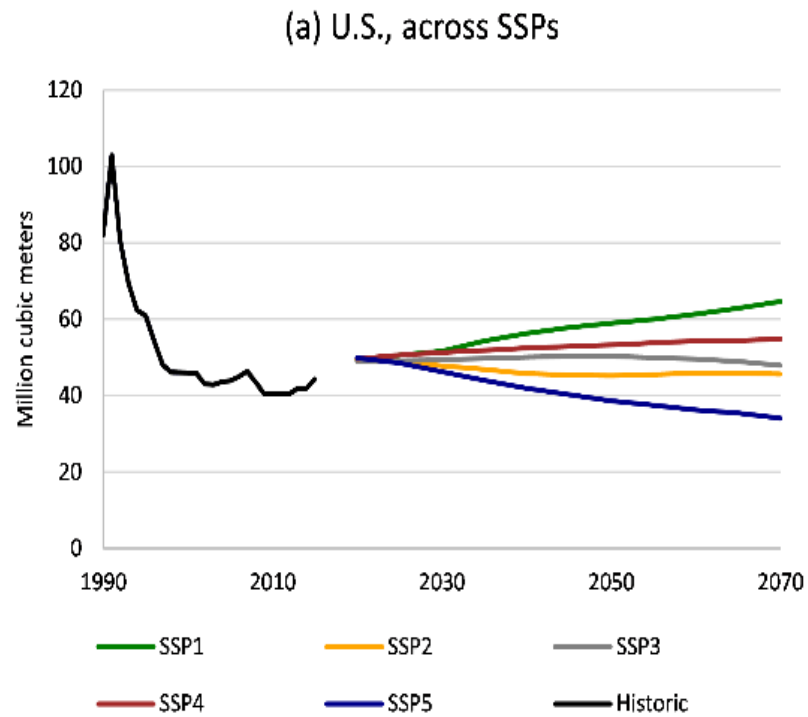
Global production of fuelwood by species type, SSP2
1990 to 2015 historic, 2020 to 2070 projections from FOROM



Source: Johnston, C.M.T.; Guo, J.; Prestemon, J.P. U.S. and Global Wood Energy Outlook under Alternative Shared Socioeconomic Pathways. *Forests* 2022, 13, 786.

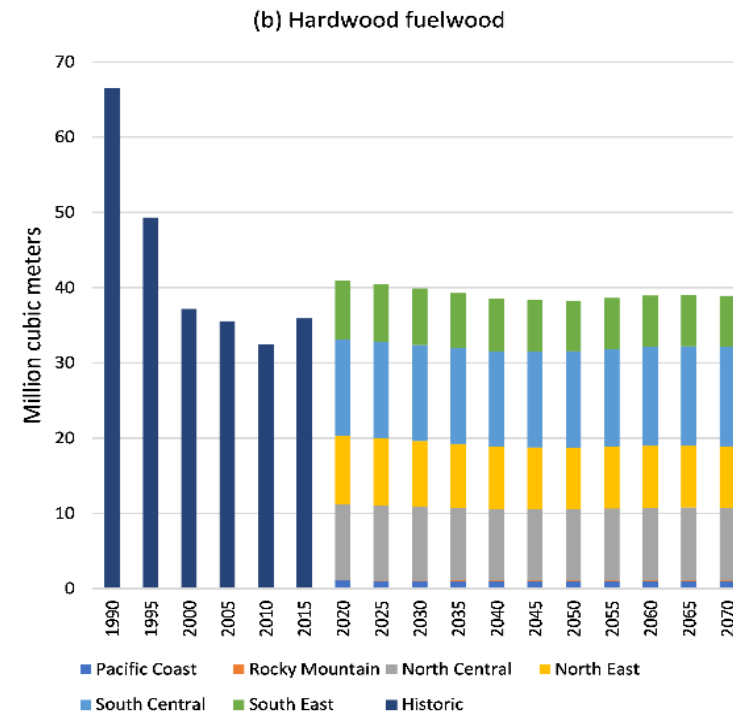
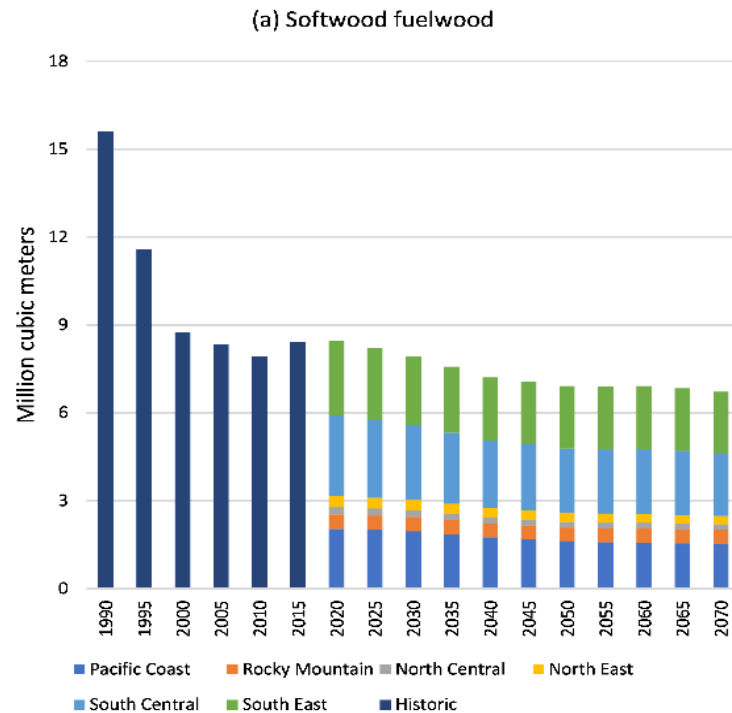
US fuelwood production halved since 1990, and expected to remain lower

United States production of fuelwood (a) across SSPs and (b) by region within SSP2 1990 to 2015 historic, 2020 to 2070 projections from FORUM.



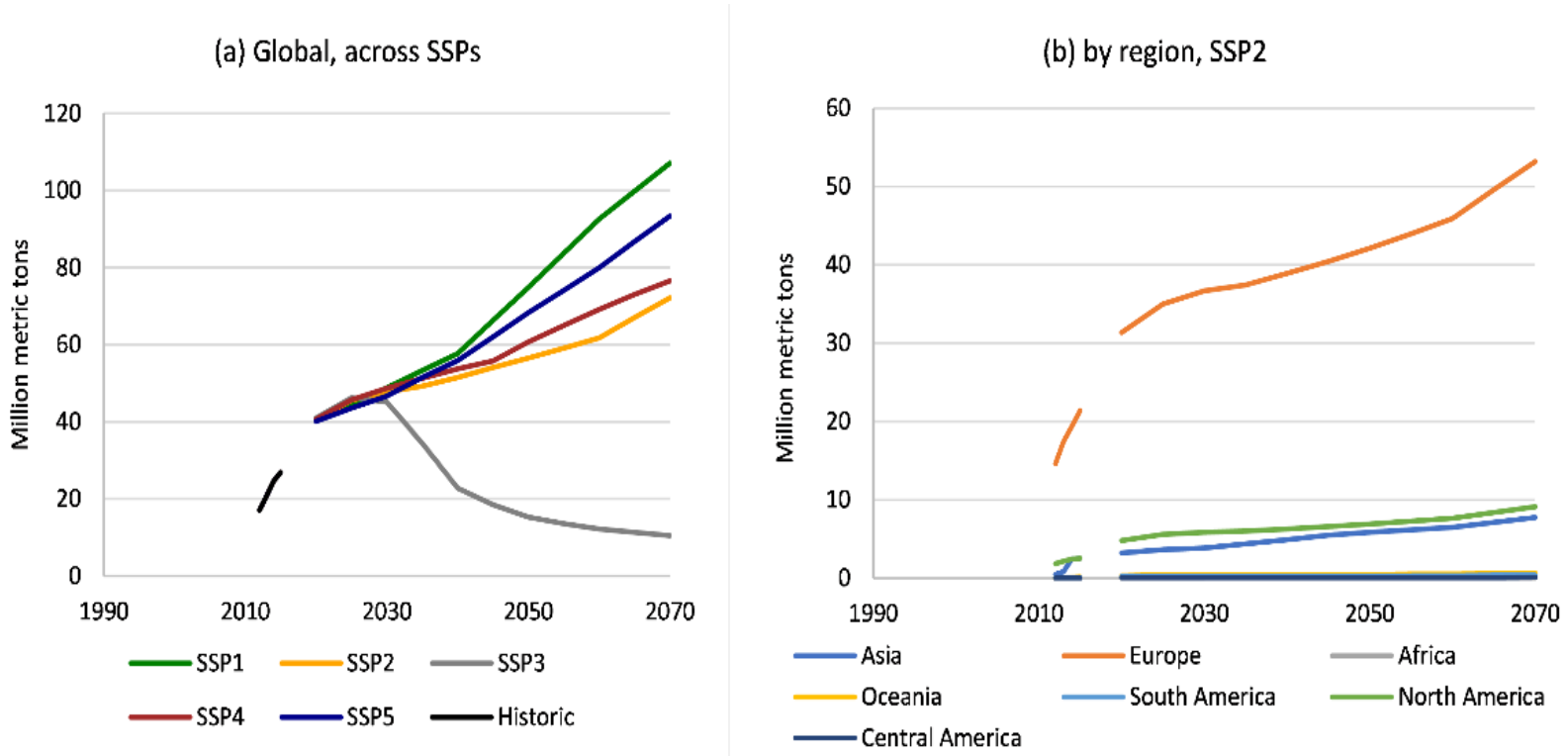
US fuelwood production reliant on hardwoods, east of the Rockies

United States production of fuelwood by (a) softwood and (b) hardwood species groups, within SSP2 1990 to 2015 historic, 2020 to 2070 projections from FOROM.



Increasing global wood pellet demand in most scenarios, driven by Europe

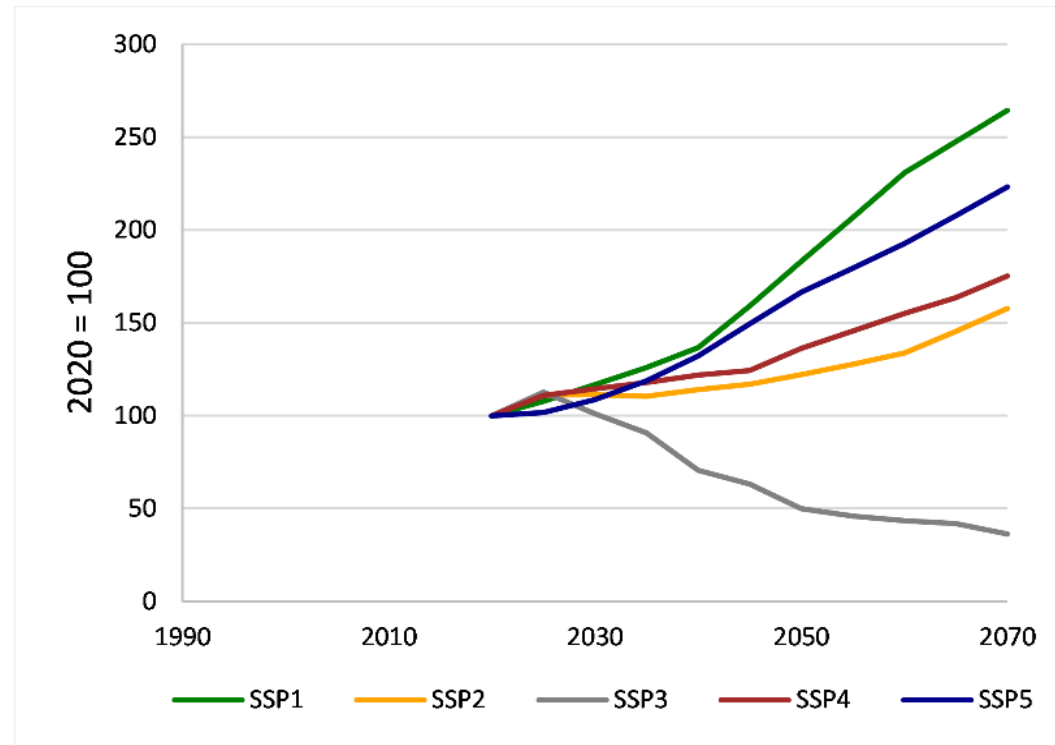
Global consumption of wood pellets (a) across SSPs and (b) by region within SSP2
1990 to 2015 historic, 2020 to 2070 projections from FOROM



Source: Johnston, C.M.T.; Guo, J.; Prestemon, J.P. U.S. and Global Wood Energy Outlook under Alternative Shared Socioeconomic Pathways. Forests 2022, 13, 786.

Pellet prices follow global demands patterns

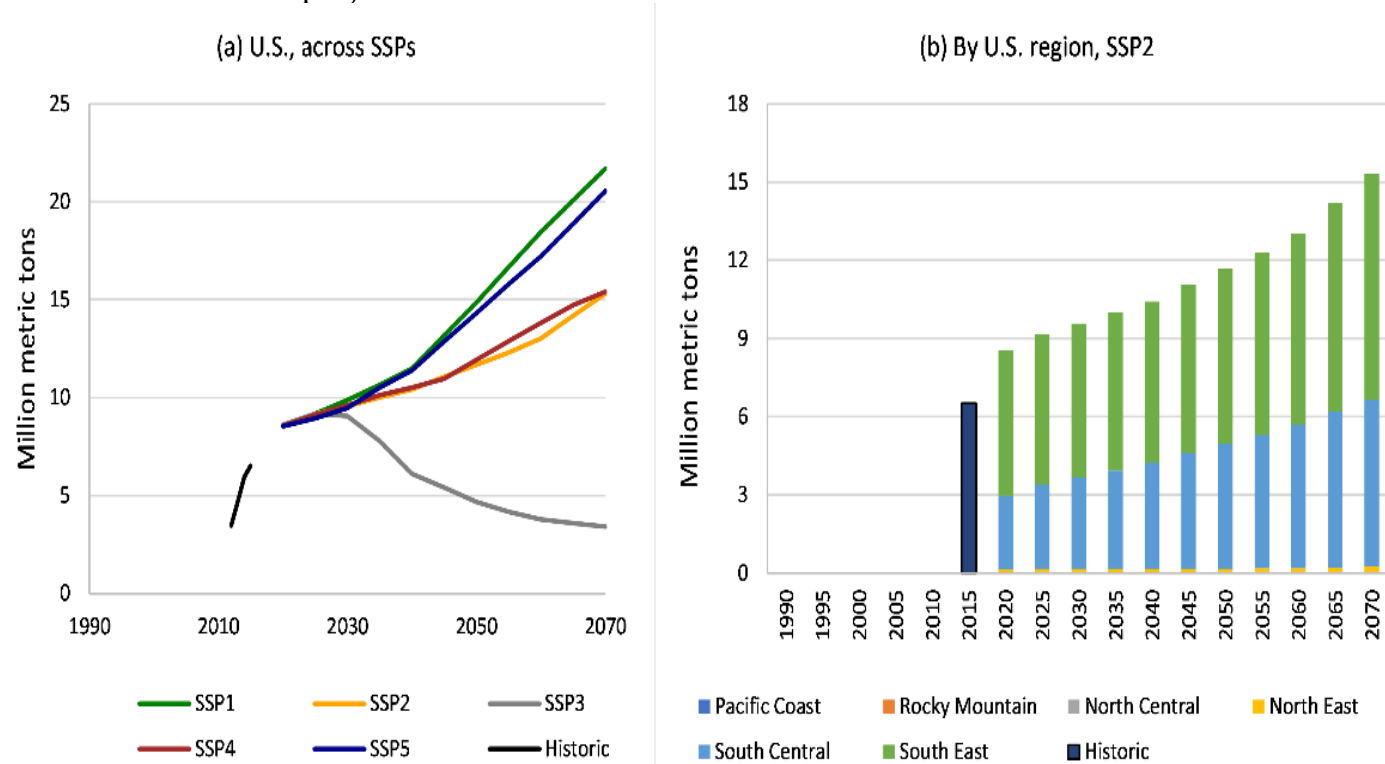
Global price of wood pellets across SSPs
2020 to 2070 projections from FOROM



Source: Johnston, C.M.T.; Guo, J.; Prestemon, J.P. U.S. and Global Wood Energy Outlook under Alternative Shared Socioeconomic Pathways. Forests 2022, 13, 786.

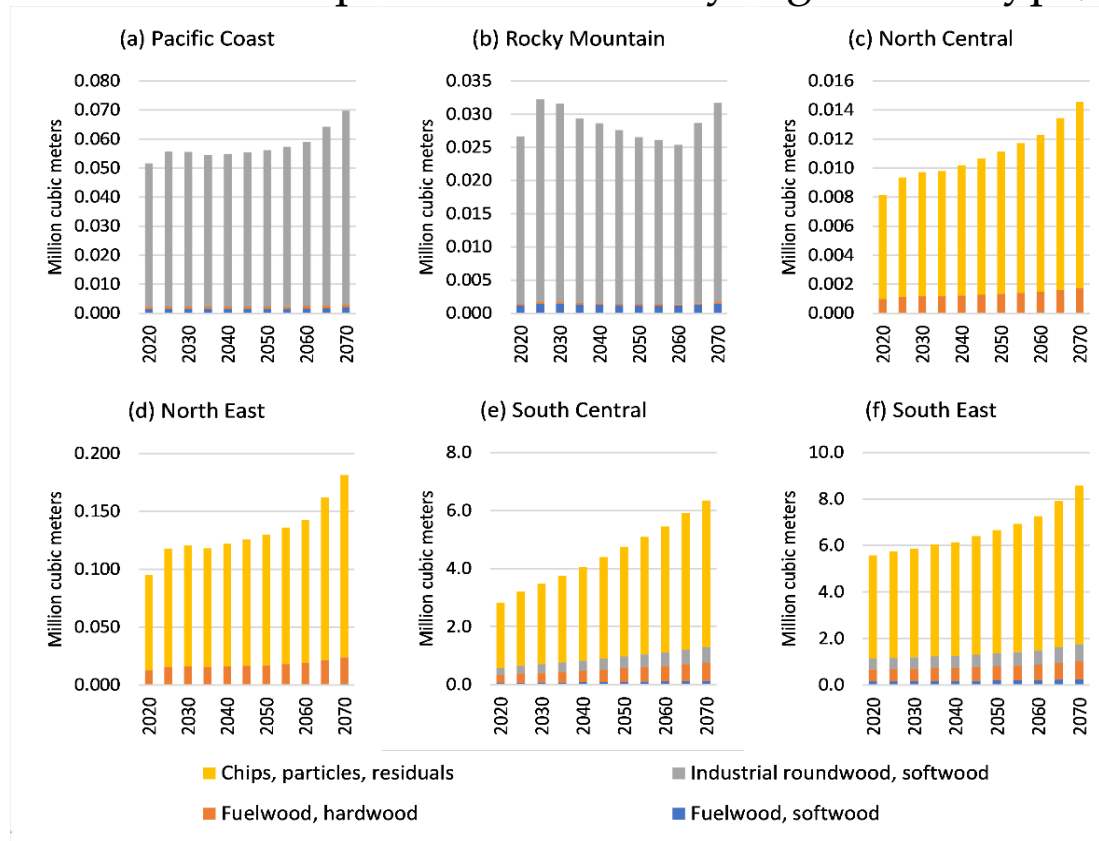
US production continues to rise in most scenarios; US South key producer

United States production of wood pellets (a) across SSPs and (b) by region within SSP2
1990 to 2015 historic, 2020 to 2070 projections from FOROM



Chips, particles, residuals continue to be key input in wood pellets

United States wood pellet feedstock by region and type, SSP2



Source: Johnston, C.M.T.; Guo, J.; Prestemon, J.P. U.S. and Global Wood Energy Outlook under Alternative Shared Socioeconomic Pathways. *Forests* 2022, 13, 786.

Discussion/Conclusion

- Across four out of five scenarios evaluated, we project a rising use of roundwood and mill chips, particles, and residuals to produce a growing output of wood pellets in the United States and globally.
- The results on wood pellet production and consumption presented here are in part the outcome of assumptions on pellet demand that were designed in our study to adhere to the storylines embedded in the SSPs.
 - Europe's dominance of global demand for wood pellets, to help that continent achieve its own climate goals, further explains the sustained and growing supply position of the U.S. South regions to meet that demand
- It also bears mentioning that wood pellet consumption has been and is projected under all scenarios to represent wood quantities that are less than 5% the size of fuelwood.
 - Large portions of the world, particularly in Africa and Asia, have been and are projected to remain reliant on fuelwood as a primary energy source for heating and cooking, even though overall consumption of fuelwood declines under some scenarios.

Discussion/Conclusion

- Wood pellet production and consumption, while small relative to fuelwood, has demonstrated influences in product markets that are projected to continue and grow
 - Our modeling indicates an eventual slowdown in wood pellet consumption growth across all scenarios compared to the high rates evident in the last decade. Nevertheless, growth is projected to expand under SSP2 by 150% over fifty years, an annualized rate of just under 2%
- Wood pellets are projected under SSP1, 2, 4, and 5 to more than double in output and thereby consume an increasing share of total wood production in the US
 - rising from about 2% to 3.5
- These results suggest an increasing direct competition for materials with composite mills and pulp and paper manufacturers, in the South regions especially
- Although softwood industrial roundwood is not projected under most scenarios to represent the majority of wood pellet manufacturing input volume overall in the United States, that input category also is projected to rise in total volume, implying rising competition that puts upward pressure on softwood industrial roundwood prices

Thank you

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