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**A forest model inter-comparison project (For-MIP) to assess the future of forests under  
climate, policy and technological stressors**

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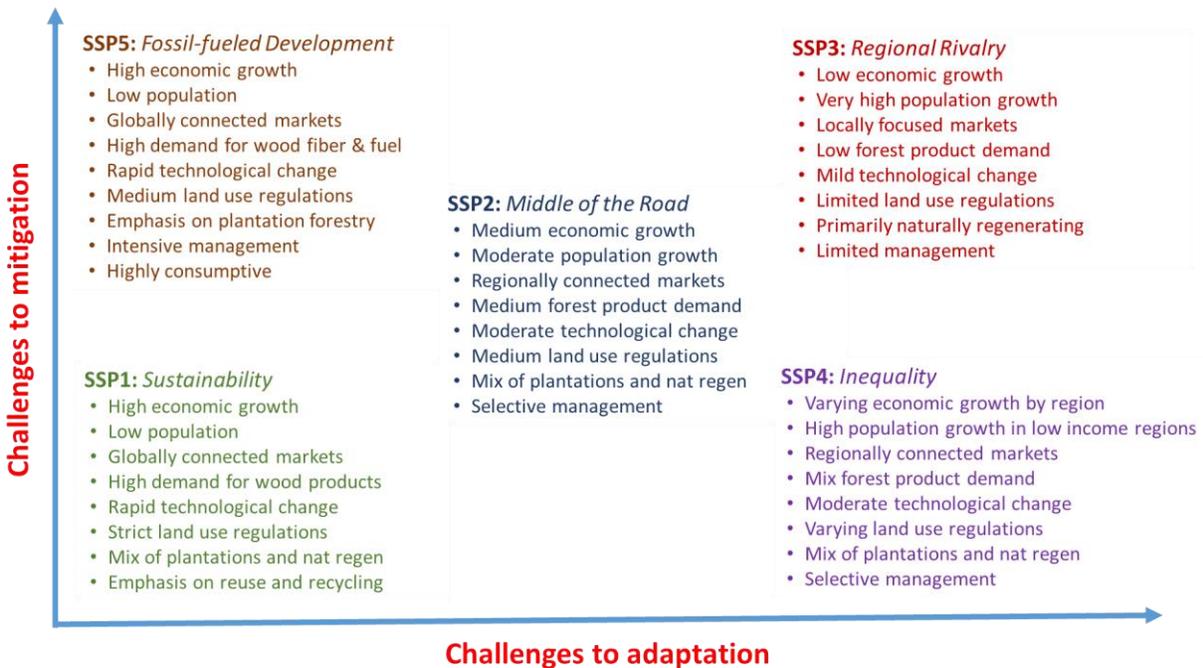
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The forest sector is recognized as a key source of climate change mitigation in the scientific community (Lauri et al., 2017; Canadell and Raupach 2008) as well as at the policymaker level. For instance, many countries have explicitly included forest mitigation strategies in their Nationally Determined Contributions submitted under the Paris Agreement (Grassi et al., 2017). While there is optimism on the role of forests to contribute to near- and long-term climate action goals, many uncertainties remain regarding the expected changes in future emissions from the sector (Forsell et al., 2016). Incorporating future socioeconomic, demographic, technological, lifestyle, policy, and institutional trends into the forestry sector is a fundamental task to address the uncertainty over future land use and emissions. The global change research community has recently developed a set of narratives known as shared socioeconomic pathways (SSPs) to clearly, consistently, and logically present trends for different future socio-economic developments (O'Neill et al 2017) and some scholars have looked at the impact of SSPs on global land use (Riahi et al., 2017; Popp., et al., 2017). However, their research has typically used integrated assessment models (IAM) with relatively crude and static representation of the forest sector, especially managed forest resource systems, and results are typically aggregated across regions and forest type. On the other hand, recent forest sector modelling efforts have started incorporating the SSP framework but are often limited in terms of geographical scope (Hu et al., 2018; Daigneault, 2019; Nepal et al., 2019) and/or SSPs elements accounted for in the model (Favero et al., 2018; Johnston and Radeloff, 2019).

This paper adds to the literature by assessing possible variation in future forest product markets, land use/management, and greenhouse gas (GHG) emissions under alternative SSPs using three different economic modeling platforms with widely different attributes to systematically model and compare the five SSPs. This forest model inter-comparison (For-MIP)

efforts includes the an intertemporal optimization model of global forest resource management and markets (the Global Timber Model [GTM]), and two recursive dynamic frameworks, including a detailed partial equilibrium and resource allocation model of the global land use sectors (the Global Biosphere Management Model [GLOBIOM]), and a global forest product markets and timber supply simulation model (The Global Forest Products Model [GFPM]). The SSPs, which consists of five scenarios with varying degrees of climate mitigation and adaptation challenges, inform the model parametrization and scenario analysis. Key components of these pathways include population and economic growth, market connectivity, technological change, wood product demand, land use regulations, forest management intensity, and competing land rents (Figure 1). All three models in the For-MIP project will use the same scenario narratives and key SSP data (e.g., population, GDP, bioenergy consumption, etc.) as inputs to facilitate a consistent model inter-comparison.

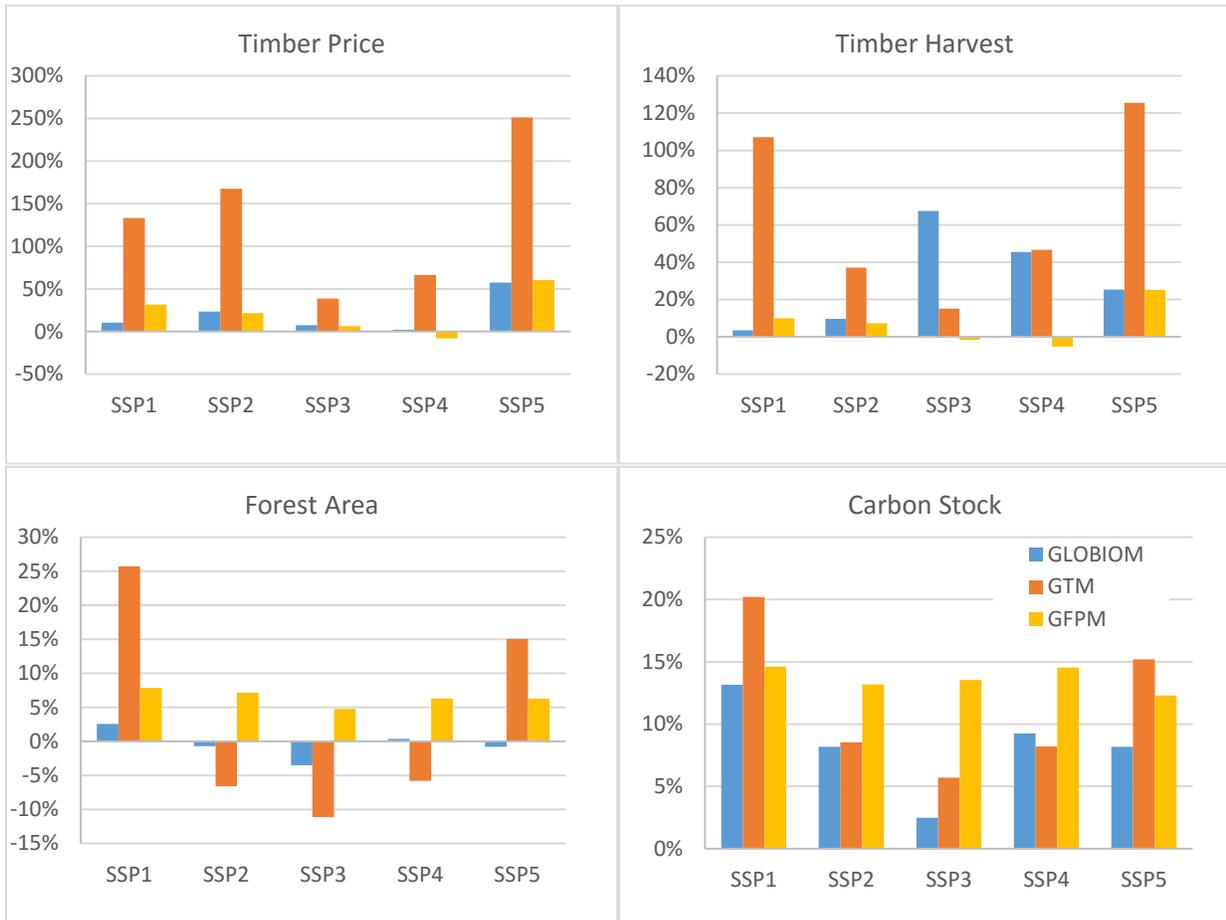


**Figure 1.** Key SSP components of the For-MIP project (Source: O’Neill et al. 2017; Daigneault et al., 2019)

Preliminary global estimates of some key forest sector outputs indicate that there is a relatively wide variation across the 5 SSPs as well as the 3 models (Figure 2). In terms of variation across the SSPs, one of largest differences across scenarios is the industrial roundwood price, which ranges from being relatively small for SSP3 (regional rivalry) to increasing by 50% or more over the next century for the SSP5 (fossil fuel case with high demand for wood products). The assessment also indicates that timber prices have a strong correlation with the other estimates, as higher prices incentivize more land to remain in forests and/or expand via afforestation, as well as more intensive management associated with improved technological change. Collectively, this results in forests to becoming a larger carbon sink over time. Furthermore, even with significant variation across models and scenarios, this initial For-MIP analysis shows increasing global forest carbon stocks over time for all scenario and model combinations. As forestland declines under some scenarios, our results indicate that that forest management on existing forests can have a meaningful impact on projected carbon outcomes, a result that is emphasized in other recent studies (Favero et al., 2020; Tian et al., 2018, Jones et al., 2019).

The result of increasing carbon stocks with higher levels of income growth diverges from much of the integrated assessment modeling literature, which often projects decreased baseline forest carbon stocks in the future under land use change pressures. A key takeaway from this result is that projected forest carbon stocks are heavily influenced by the role of forest management and in existing forest systems. As forest product demand grows and prices rise, there is incentive to invest in the forest resource base at both the extensive and intensive margin to increase inventories and improve productivity, which increases terrestrial carbon storage even in the absence of a carbon sequestration policy incentive. Future integrated assessment modeling

studies should better account for forest product market feedback, carbon dynamics on forests remaining forests, and improved forest management to improve both baseline land carbon projections and policy analyses.



**Figure 2.** Estimated change in global timber price, harvest, forest area, and carbon stock across 5 SSPs, 2010 to 2100.

This initial For-MIP analysis builds on the long history of comparative multi-model analyses in the energy and agricultural sectors, and future efforts will use results from this comparison to inform model development priorities national- or regional-scale modeling integrating forest resource management and market components. Our results suggest that additional work should focus on model harmonization and sensitivity analysis to identify the key sensitivities across both models and socioeconomic scenarios. The analysis also indicates that these aggregate

results are influenced by variation in wood product and bioenergy demand, technological change associated with forest management and timber processing, and competition for other land uses. Future work that will be conducted prior to the presentation of this paper at the 2020 AAEA meeting will also identify the most important drivers behind these results, explore alternative parameterization options, and differentiate results by specific regions tracked in the global models. In addition, we will develop detailed estimates of forest product and bioenergy supply for the various models and scenarios. Finally, we will explore opportunities to incorporate projected changes in regional forest productivity (i.e., growth less die back) impacts of various Representative Concentration Pathways (RCPs) to quantify the potential effect of climate change on the SSP scenario estimates.

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