Forest bioenergy markets, policy, and sustainability considerations

Alice Favero
Georgia Tech

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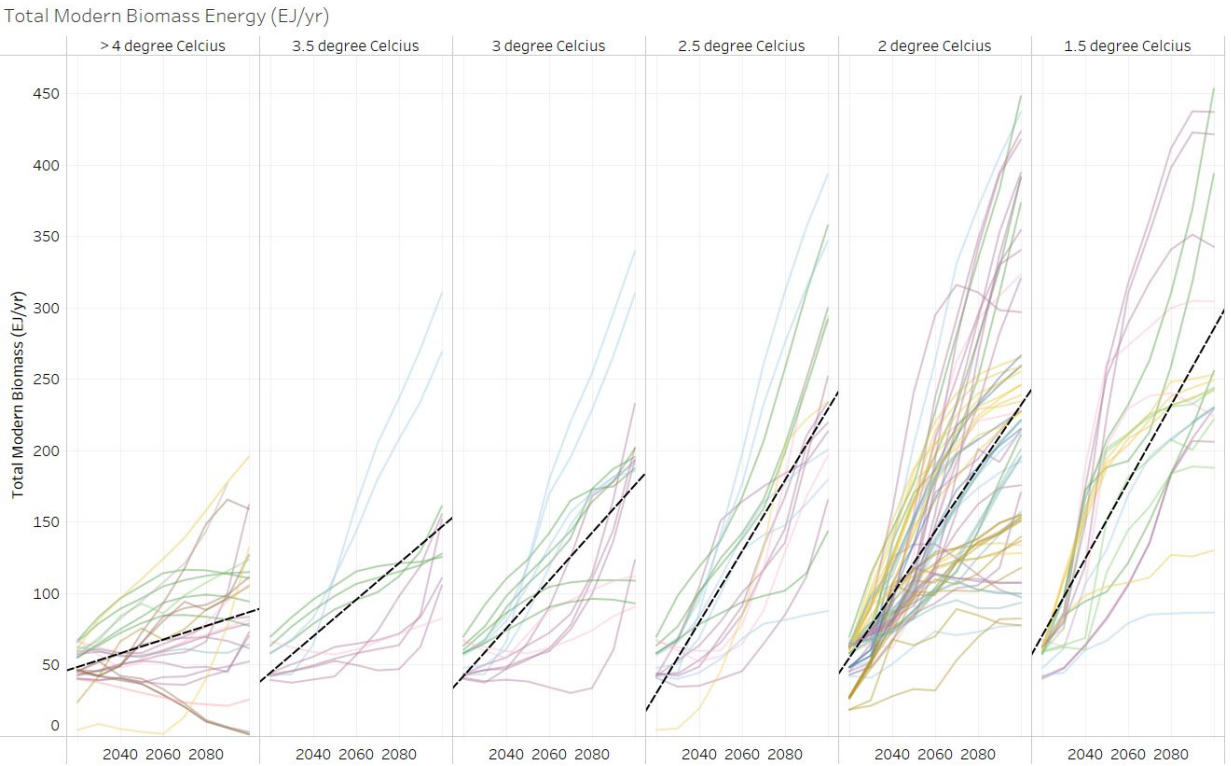
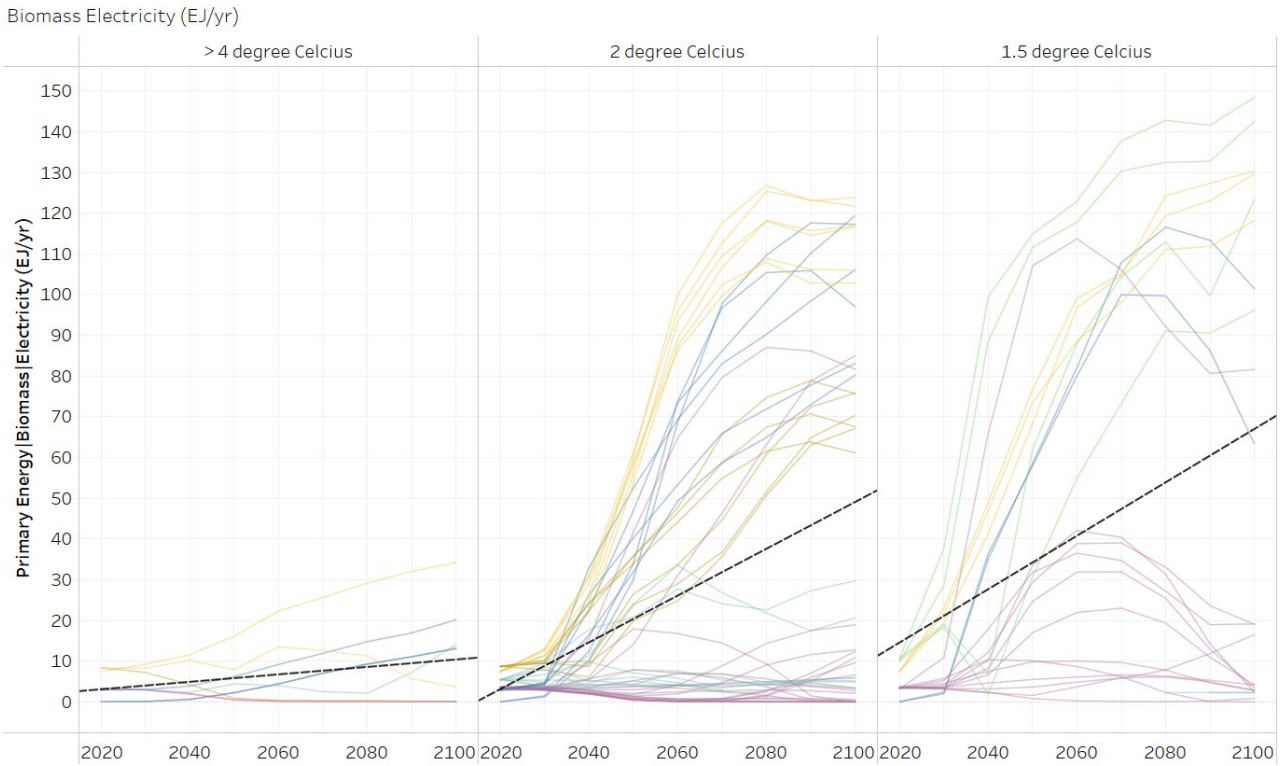
Bio-energy in IAMs

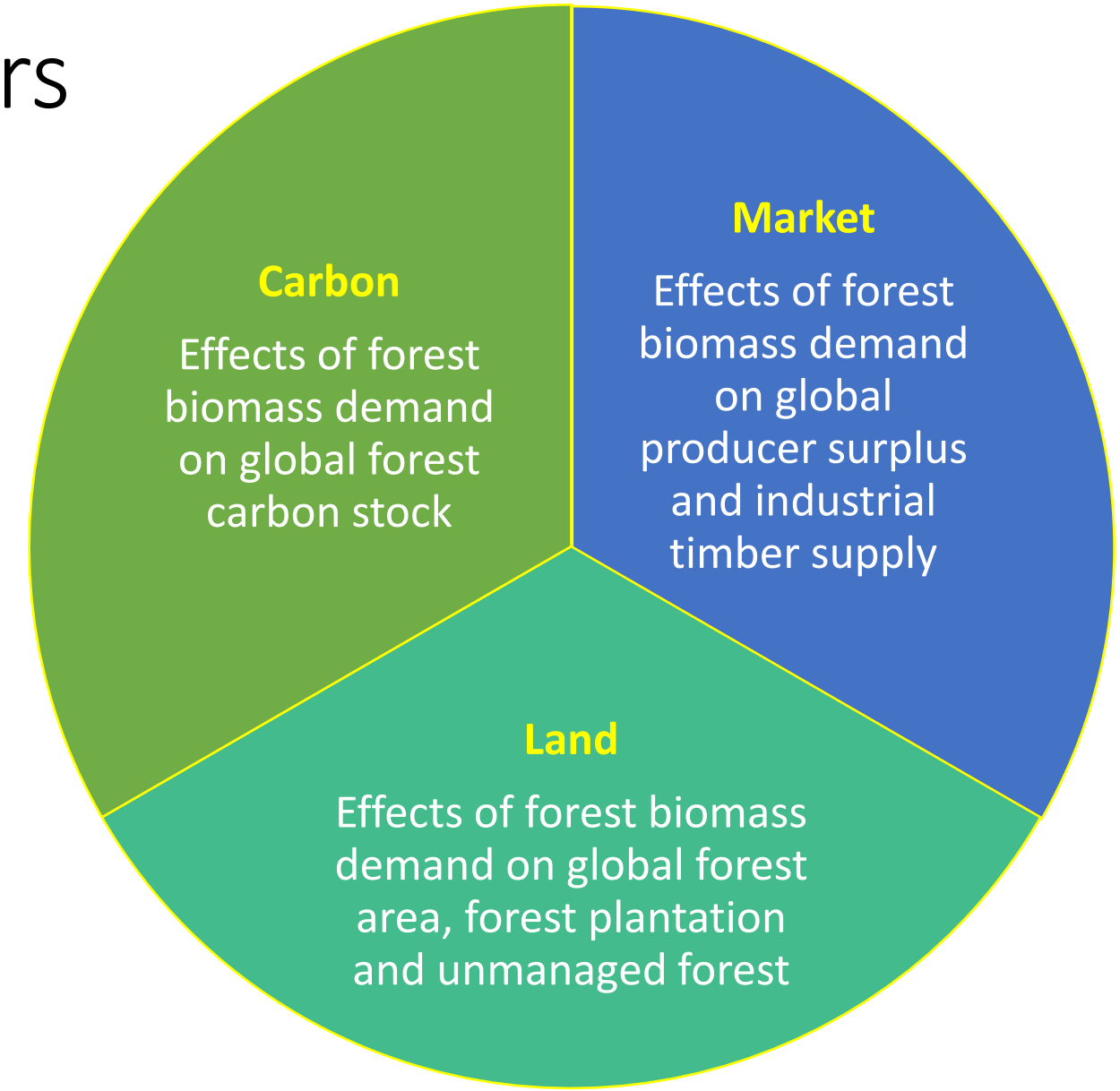




- Its consumption is likely to increase as the stringency of the temperature targets increases
- Increasing role of bio-energy in the energy mix (e.g. 30% energy in 2050 under 1.5C target)

Source: IIASA IAMC 1.5°C Scenario Explorer

Indicators


Carbon
Effects of forest biomass demand on global forest carbon stock
Market
Effects of forest biomass demand on global producer surplus and industrial timber supply
Land
Effects of forest biomass demand on global forest area, forest plantation and unmanaged forest

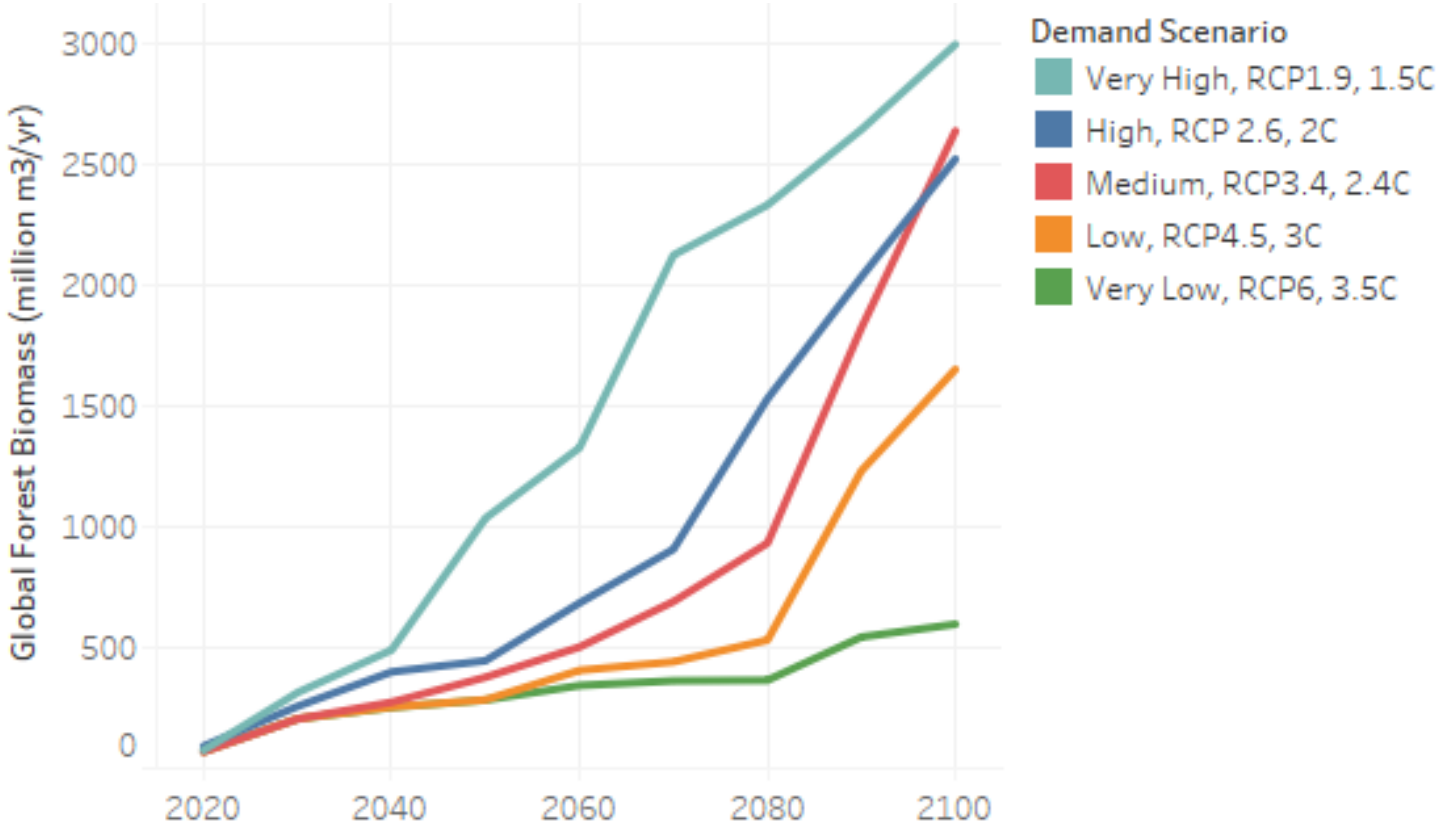
GTM

GTM is a forward-looking model: it maximizes the NPV of CS and PS in the forestry sector by selecting the age of harvesting timber and land conversion and management decisions

$$max \sum_{0}^{\infty} \rho^t \left\{ \int_0^{Q_t^{tot}} \{D(Q_t^{ind}, Z_t) - \overbrace{C(Q_t^{tot})}^{\text{Production costs}}\} dQ_t^{tot} - \overbrace{\sum_i C_G^i(m_t^i, G_t^i) - \sum_i C_N^i(m_t^i, N_t^i)}^{\text{Management/conversion costs}} - \overbrace{\sum_i R_t^i \left(\sum_a X_{a,t}^i \right)}^{\text{Land Rental costs}} \right\} [1]$$

- System-wide approach: multiple ecosystem services / goods are considered simultaneously
- Intertemporal and spatial assessment: forests within and across regions are linked through markets
  - Today's supply in one region will affect investment and land use decision in all the other regions
  - Expected future demand will affect present investments decisions

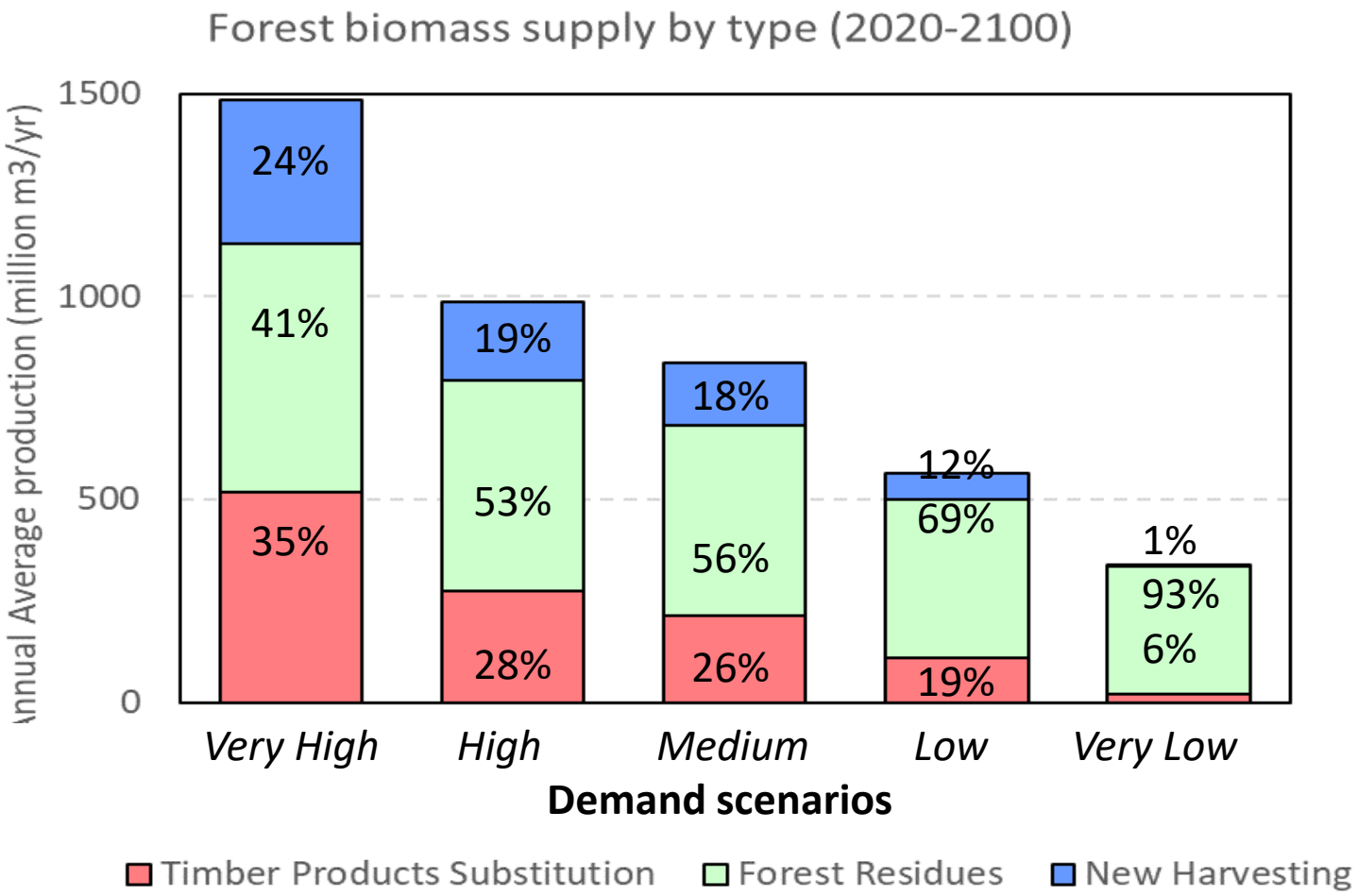
Exogenous forest biomass demands in GTM



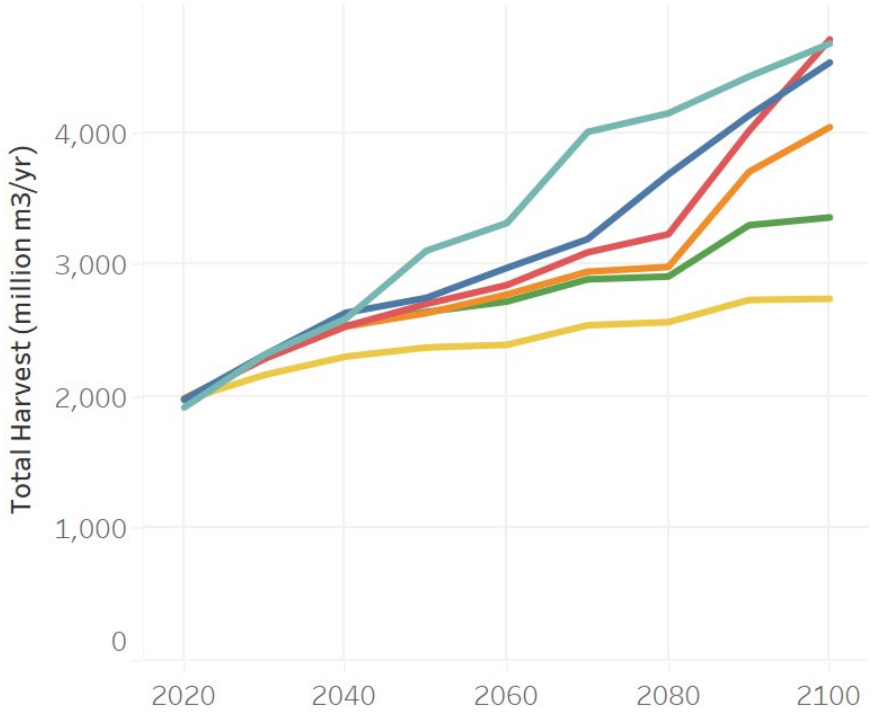
$$max \sum_{0}^{\infty} \rho^t \left\{ \int_0^{Q_t^{tot}} \{D(Q_t^{ind}, Z_t) + \boldsymbol{Q_t^{bio}} - C(Q_t^{tot})\} dQ_t^{tot} - \sum_i C_G^i(m_t^i, G_t^i) - \sum_i C_N^i(m_t^i, N_t^i) - \sum_i R_t^i \left(\sum_a X_{a,t}^i \right) \right\} [1]$$

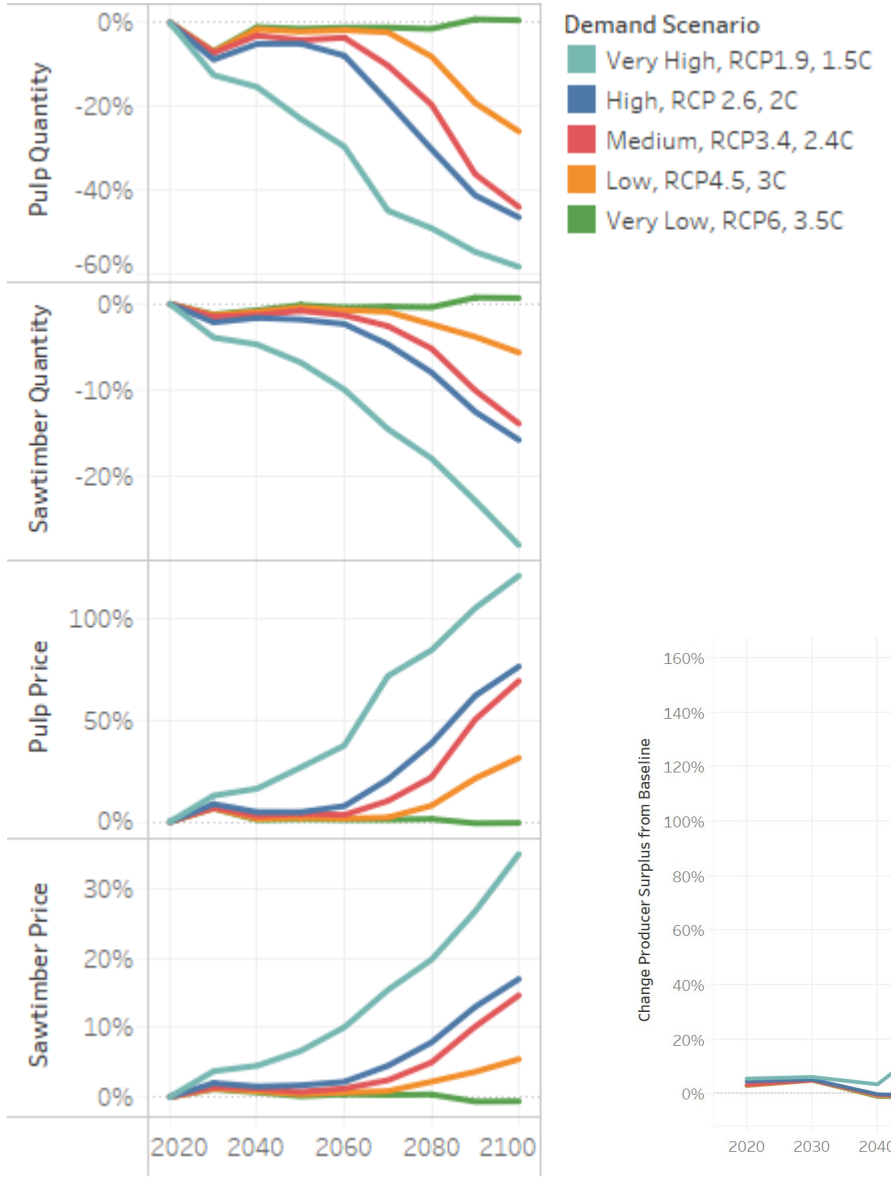
Baseline scenario

Forest Biomass supply



Market effects





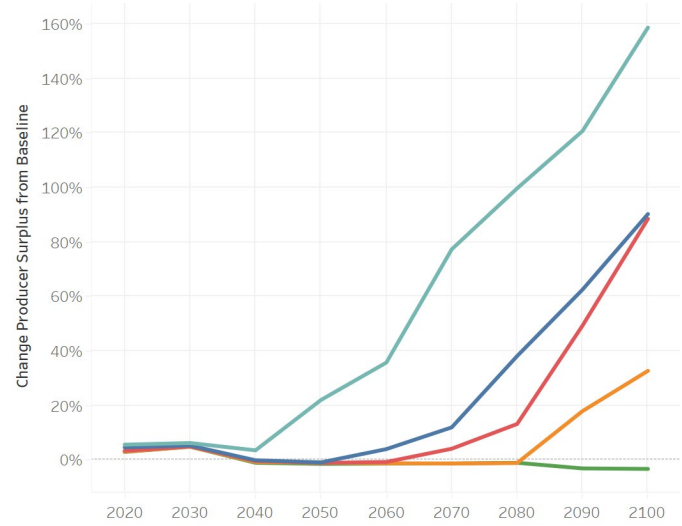


Figure: Change in market variables from baseline under different forest biomass pathways

Land use effects

Level of forest management for timber production

- *Zero:* Natural/Unmanaged Forests
- *Medium*: Naturally regenerated forests (managed with a wide range of harvesting techniques, but regenerated naturally)
- *High:* Intensively managed plantations

Figure: Change in forestland from baseline under different forest biomass pathways by type

Future loss of forest area

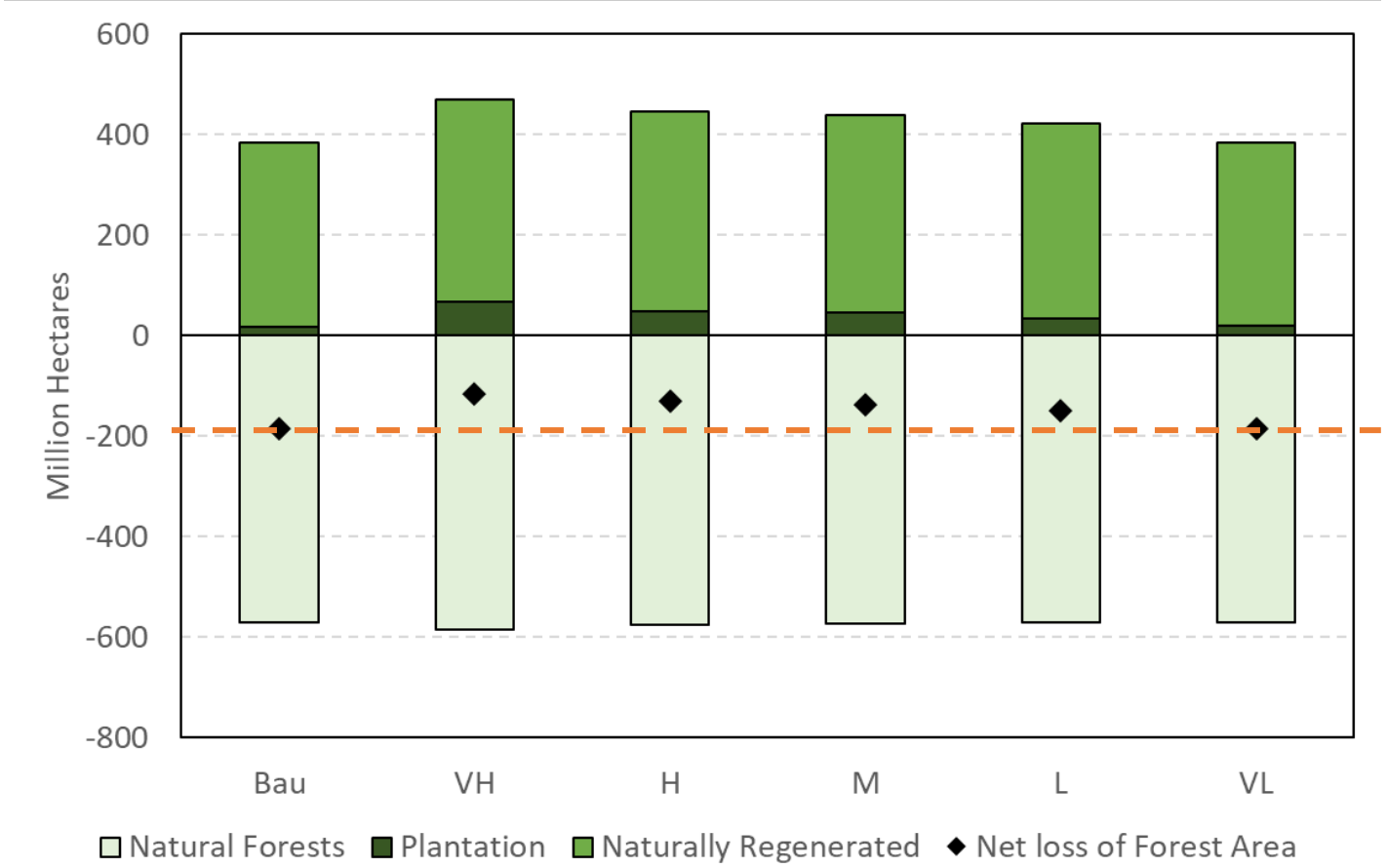


Figure: Change in forest area from present under different forest biomass pathways in 2100

Forest carbon stock effects and carbon debt

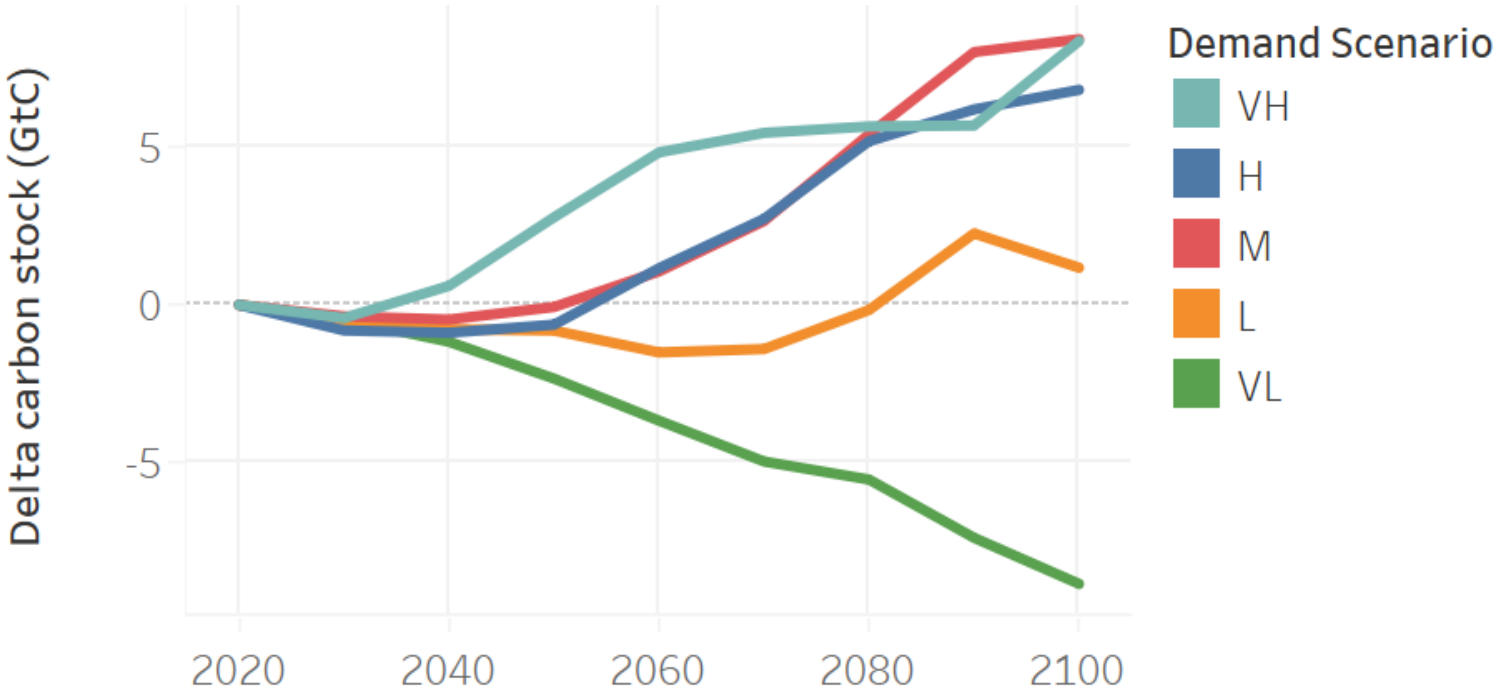


Figure: Change in forest carbon stock from baseline under different forest biomass pathways

Forest carbon stock effects and carbon debt

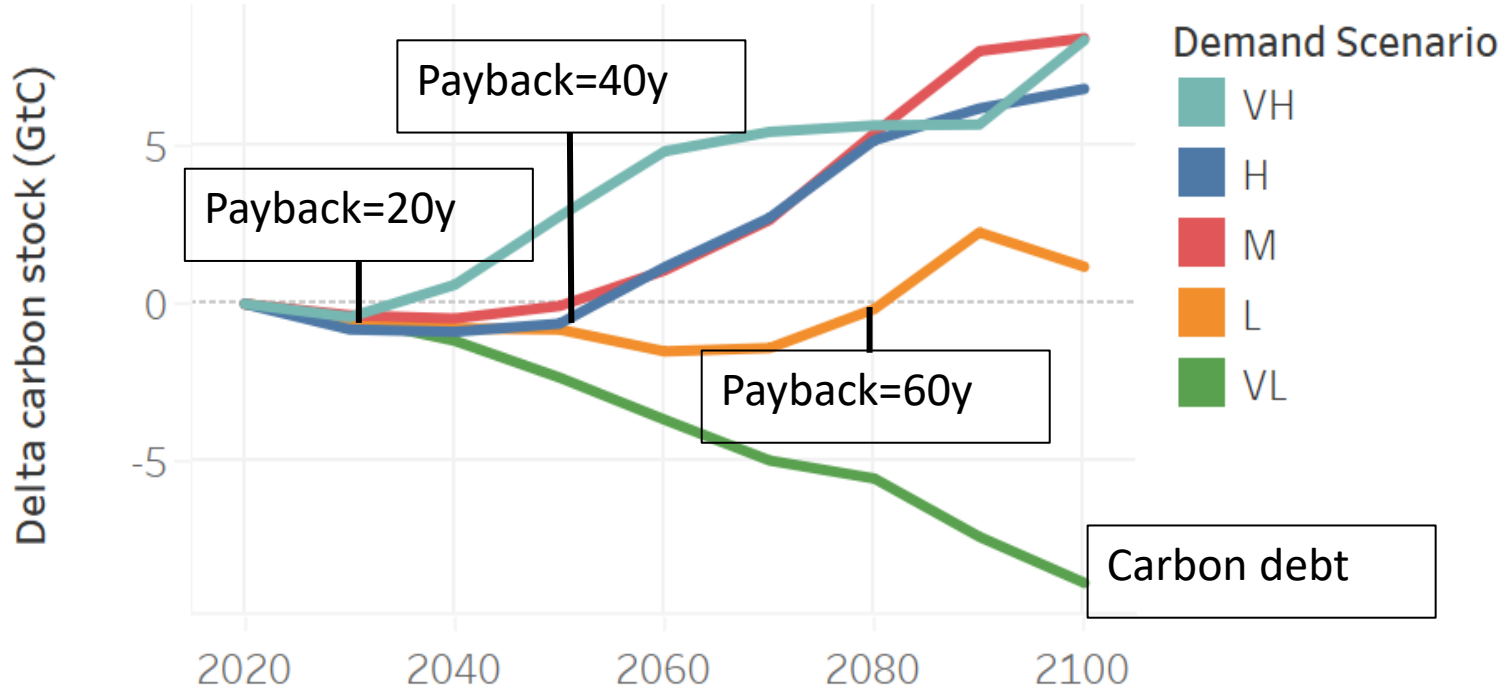


Figure: Change in forest carbon stock from baseline under different forest biomass pathways

Change in Forest carbon pools

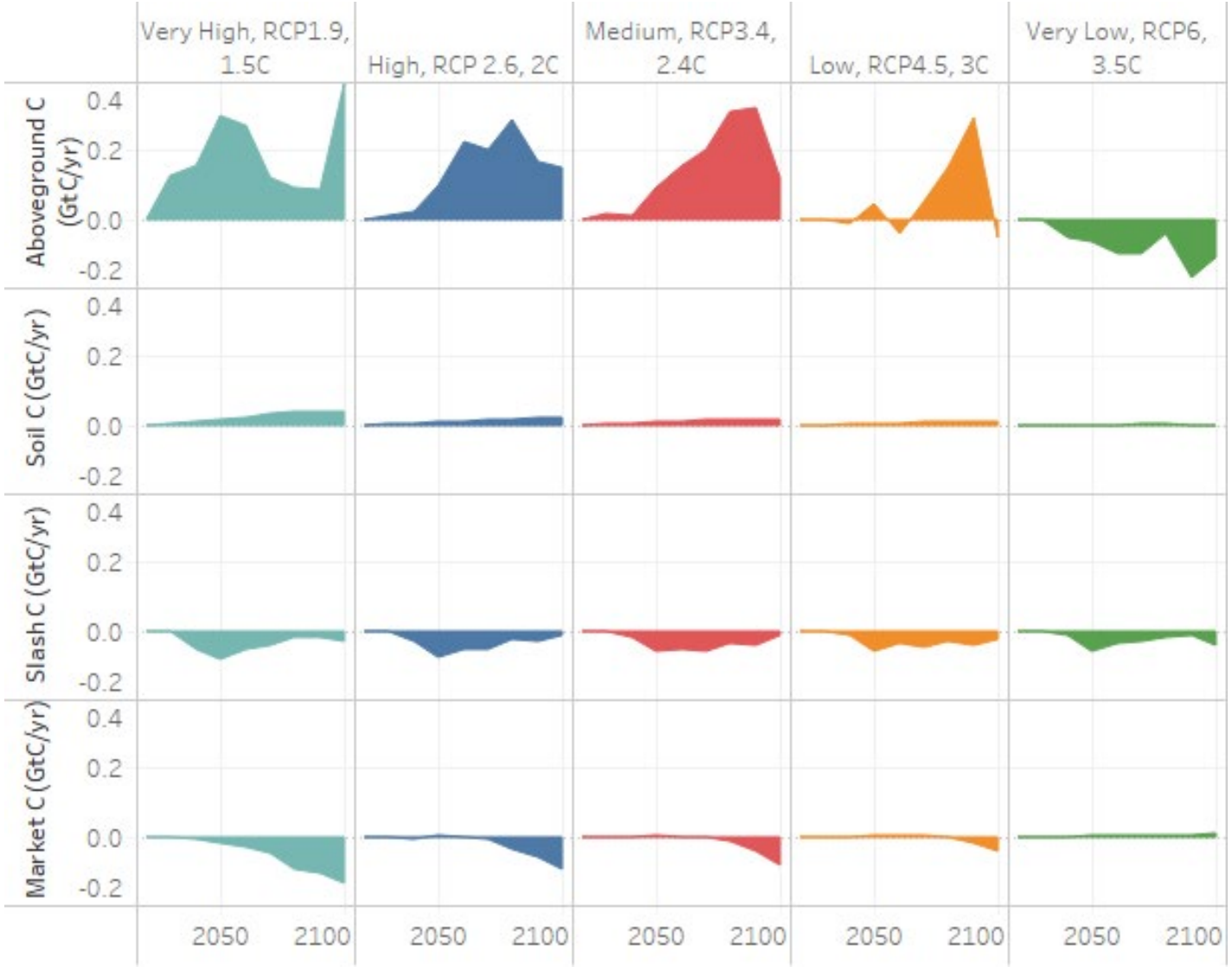
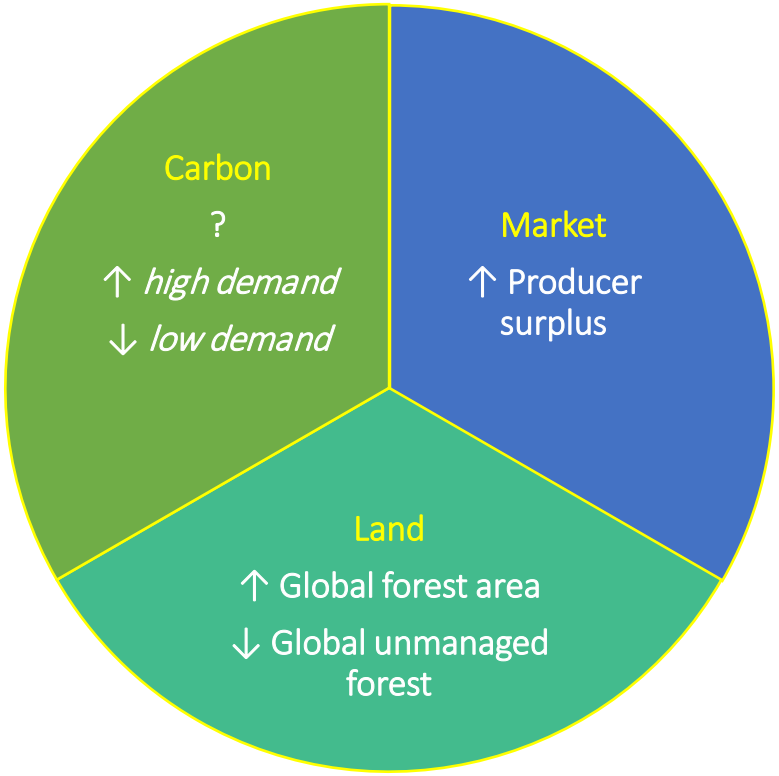


Figure: Changes in forest carbon pools from baseline scenario (GtC/yr)

Summary

Effects of Forest biomass demand on the market-land-climate system

- More land will be converted to managed forests either from natural forests or future low value farmland
- Some traditional timber products will be replaced by forest biomass production with corresponding effects on the traditional timber market
- More investments will be devoted to increasing growth and yield of managed forests

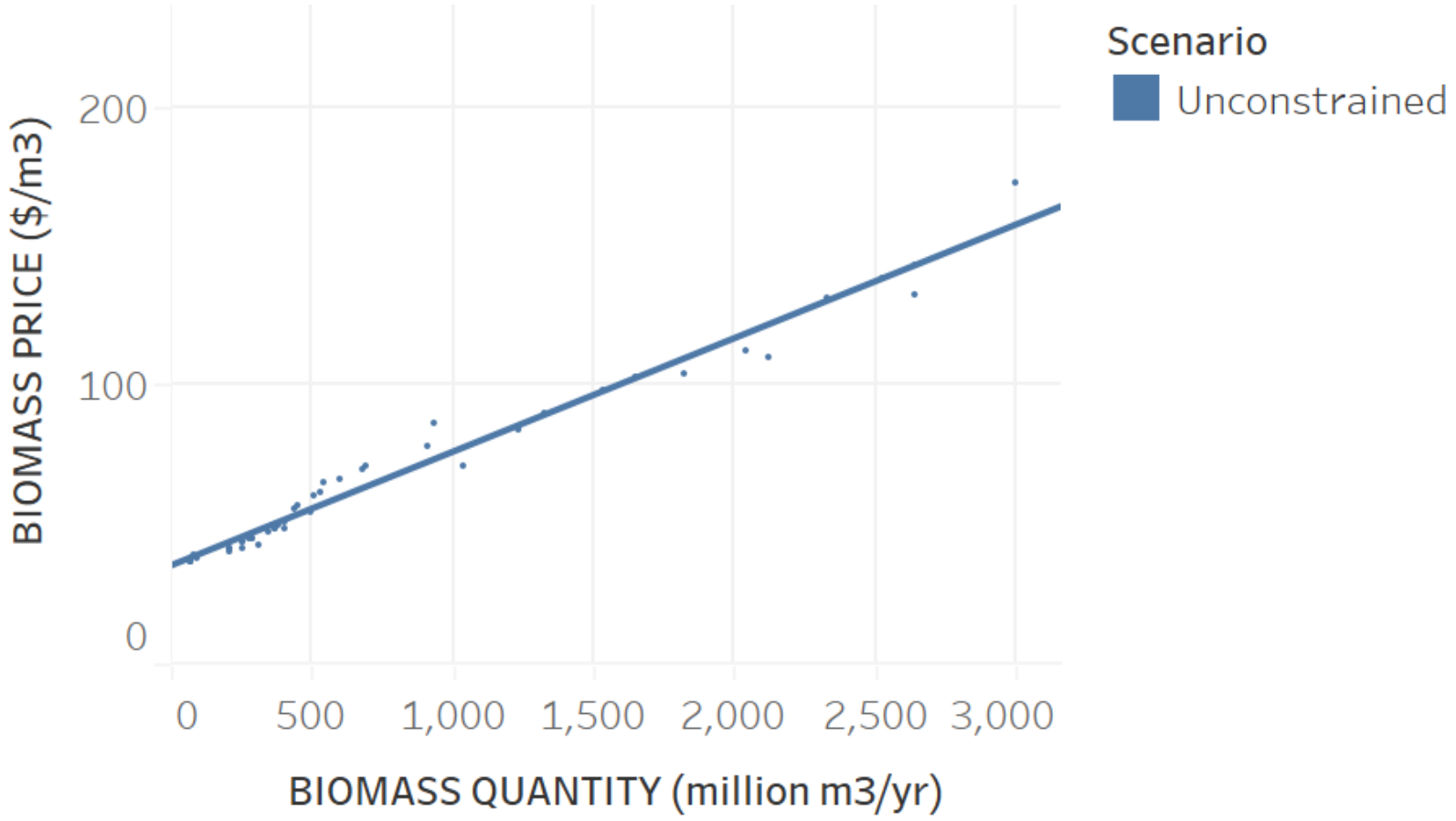


Biomass policy supply scenarios

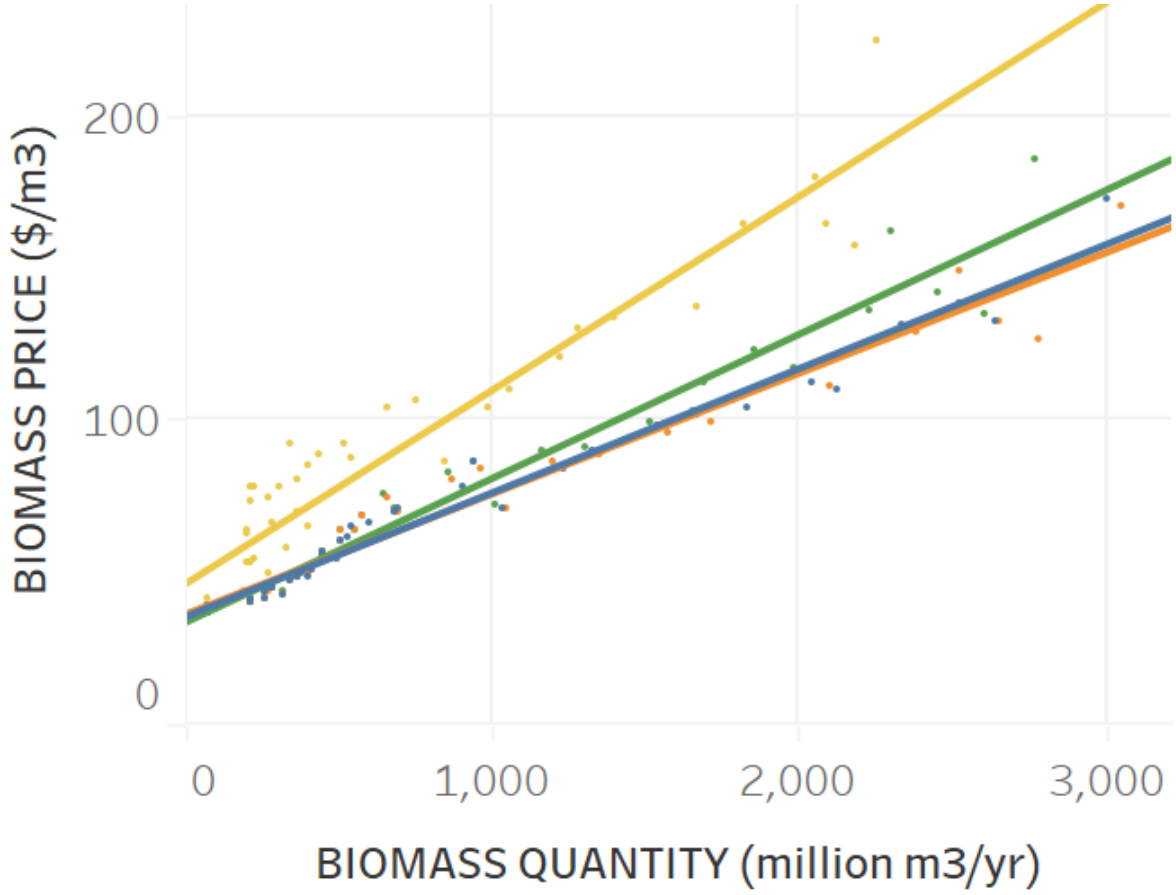
- Unconstrained scenario (*starting point*)

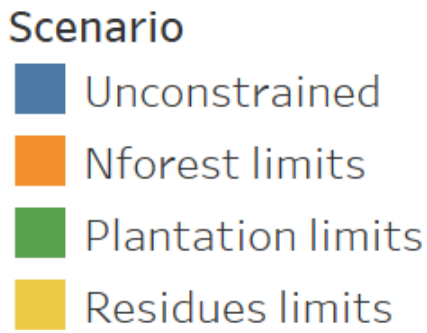
- NForest limits = Constrained policy on Natural Forest
  Unmanaged forest area (t) ≥ **Baseline** unmanaged forest area (t)
- Plantation limits = Constrained policy on plantation
  Forest plantation (t) ≤ **Baseline** Forest plantation (t)
- Residues limits = Constrained policy on residues
  Residues Utilization rate = 0%

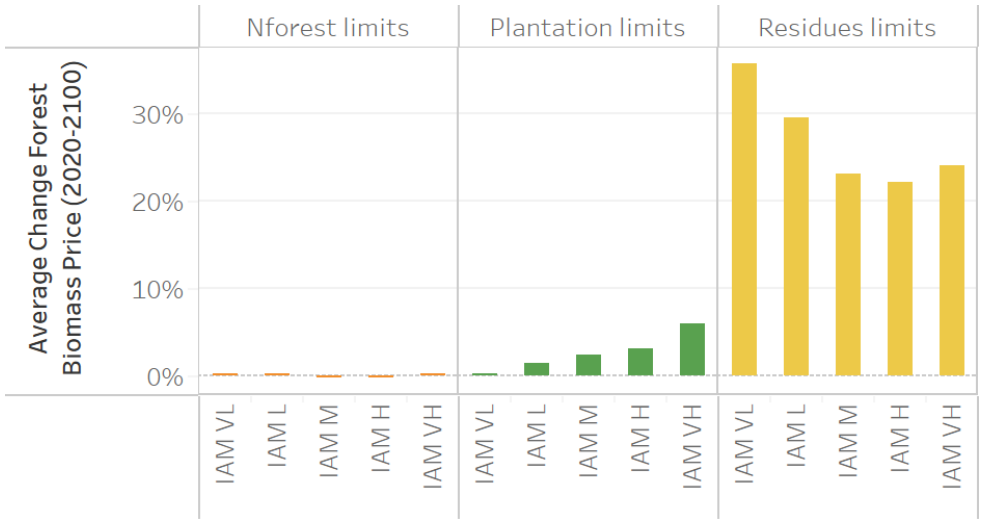
Forest biomass supply



Forest biomass supply







Market effects

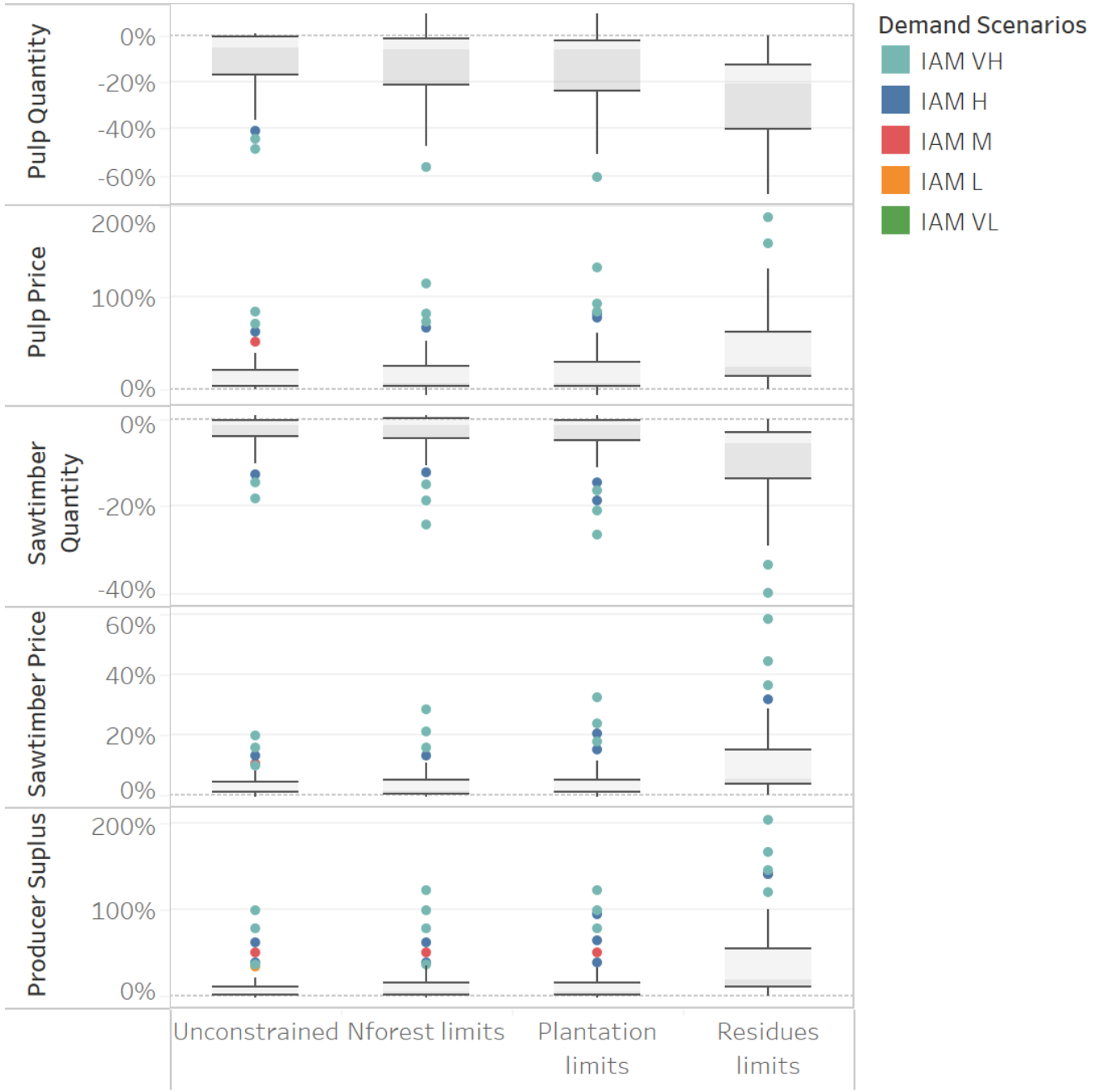


Figure: Average change in market variables from the Baseline scenario (2020-2100), all demand scenarios

Land effects

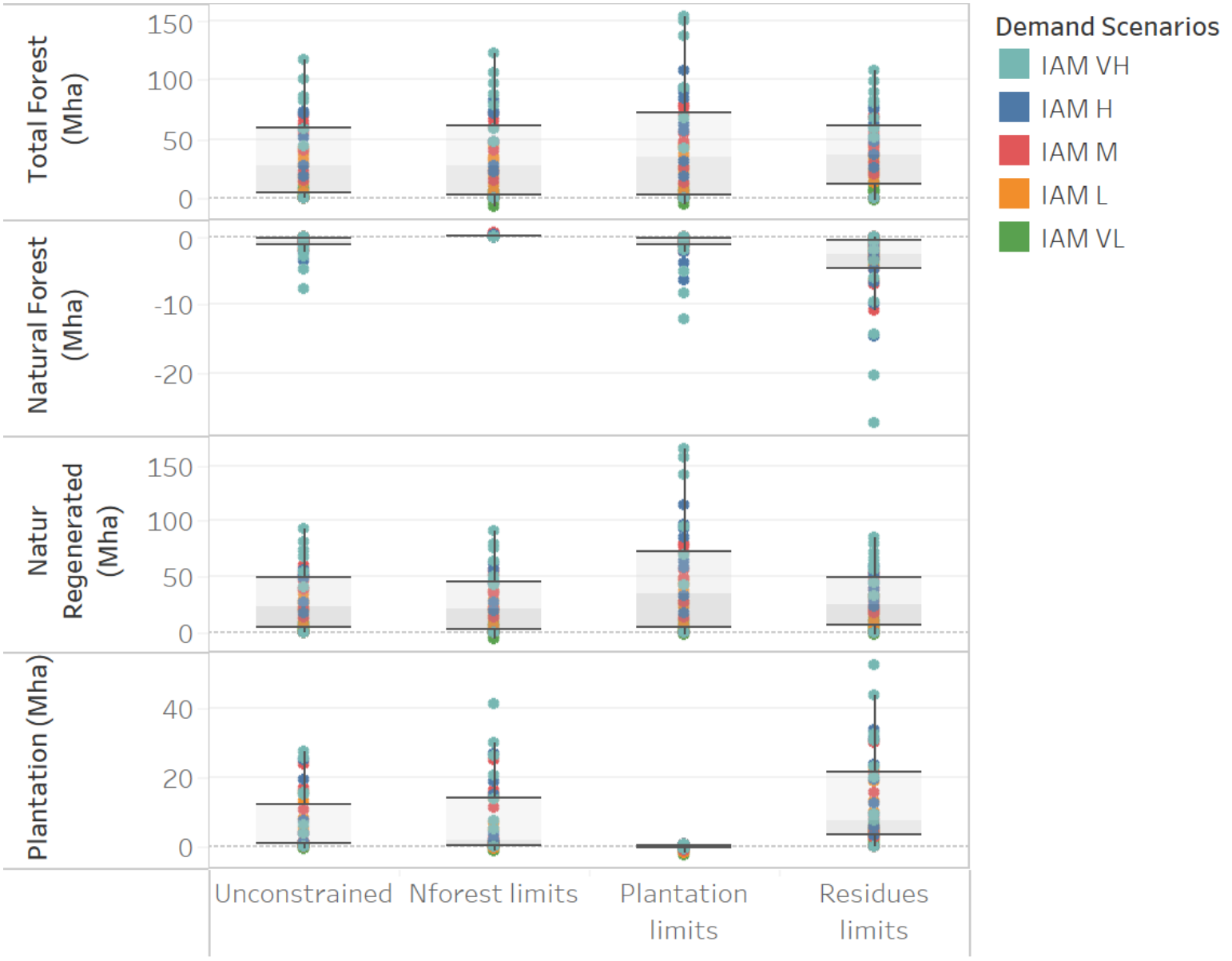


Figure: Average change in land variables from the Baseline scenario (2020-2100), all demand scenarios

Carbon effects

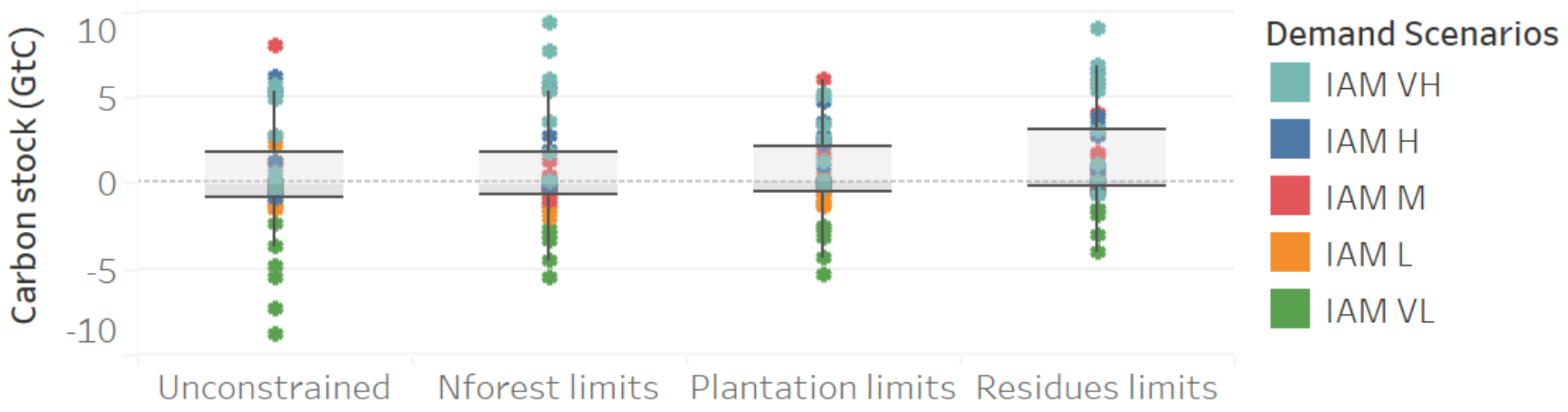


Figure: Change in forest carbon stock from baseline under each policy scenario, all demand scenarios, 2020-2100

Summary

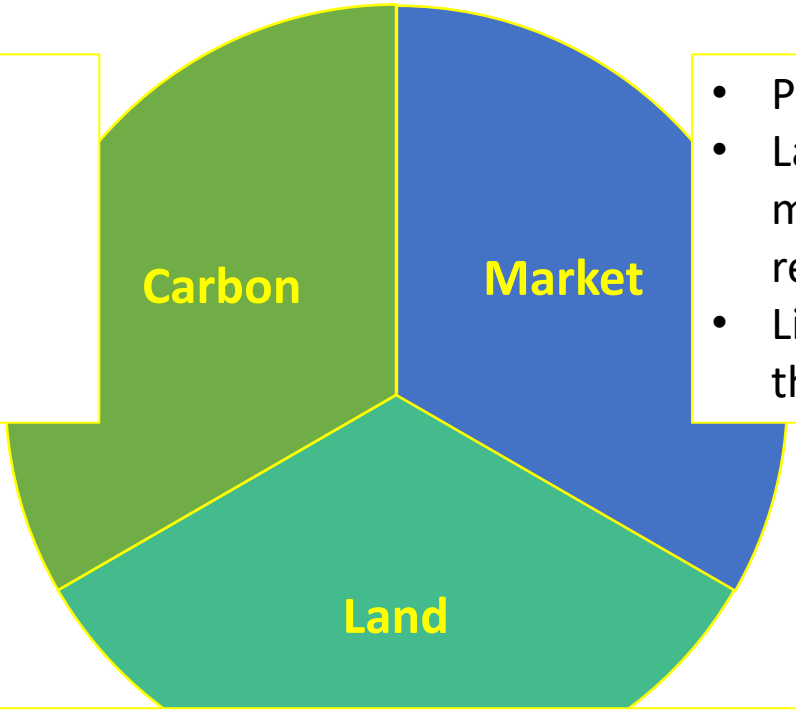
- Natural forest limit scenario:
  - No natural forests conversion without increasing the cost of biomass production
  - Lower the carbon debt (low demand scenario) and lower the payback period (high demand scenario)
- Residues limit scenario:
  - Largest effect on the timber market
  - More loss of natural forestland
  - Lower the carbon debt (low demand scenario) and lower the payback period (high demand scenario)
- Plantation limit scenario:
  - More land converted to forests

Thank you!

alice.favero@gatech.edu

Summary

- Less uncertainty under regulation
- Regulation cannot avoid an initial decline of the stock but reduce payback period
- Carbon debt persists under low demand with regulation



- PS likely to increase under all scenarios
- Larger implications on traditional timber market under scenario with limits on residues
- Limits on natural forests are unlikely to affect the results

- Highest **increase** in forestland under **plantation limit scenario**
- Highest **decrease** in natural forestland under the **residues** limit scenario
- Natural forestland can be preserved without high costs (natural forest limit scenario)

Change in Forest Carbon Stock in 2100 from present levels