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The critical role of optimal forest management in China for meeting its wood demand and climate target

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Woody materials: domestic production below demand, imports increasing

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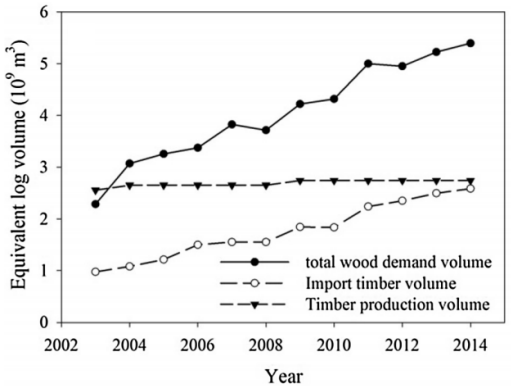
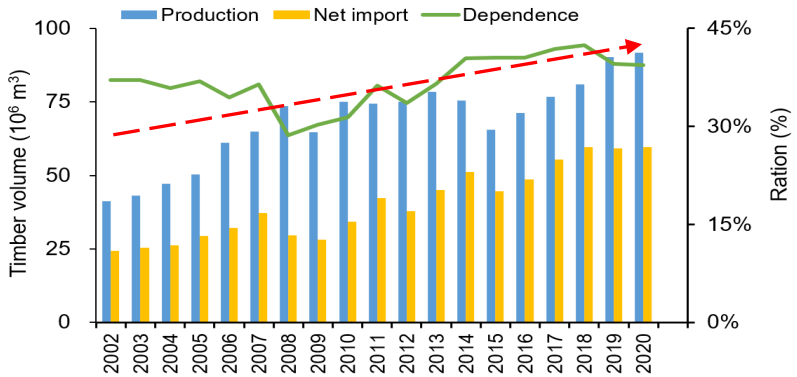
Demand



2.36-fold increase in wood consumption (2003-2014)

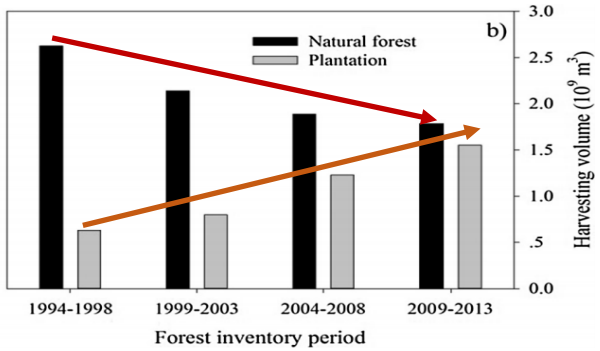
165-fold increase in annual forestry output (1978-2017)

Import



The import dependence reaches 40%

Supply



Supply/demand	2010	2012	2014
Total supply	431.89	494.91	539.45
Domestic production of commercial timber	80.89	81.74	82.33
Other materials for particleboard/fiberboard/ woodworks	93.74	136.29	143.88
Farmers' fuelwood and construction uses	52.69	39.69	41.94
Imported roundwood and processed wood products	183.56	234.96	258.59
Inventory	21.00	22.11	12.69
Total demand	431.77	494.91	539.45

Natural forests are the main source of timber

Domestic production falls far short of consumption

Natural forest logging ban

ENGLISH.GOV.CN
THE STATE COUNCIL
THE PEOPLE'S REPUBLIC OF CHINA

Logging to be prohibited in natural forests

Updated: August 22, 2019 09:22 China Daily

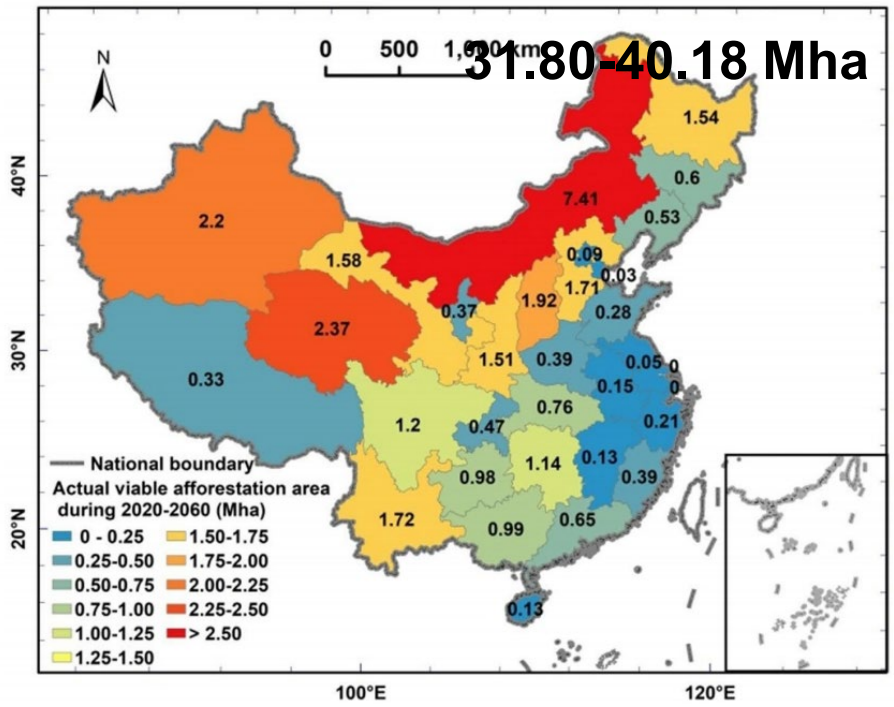
Ban on commercial logging of natural forests from 2017

Managed forests will be the main source

*(Ke et al., 2021, **Forest Policy Econ.**; Dai et al., 2018, **Forest Ecol. Manag.**)*

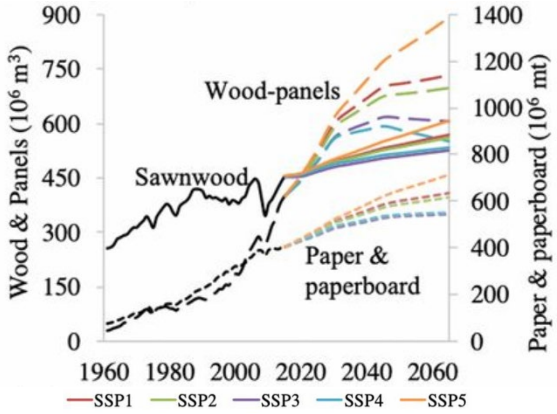
Limited afforestation area and growing demand for woody products widen the gap

Maximum afforestation area



Limited reforestation survival area after 2020

Future timber demand



Industrial roundwood production	(10^6 m^3)						
	Historical		Projection to 2065				
	1992	2015	SSP1	SSP2	SSP3	SSP4	SSP5
ASIA	**277.9**	**399.7**	**623.5**	**610.1**	**556.4**	**549.1**	**680.4**
China	92.4	167.2	316.0	311.7	292.6	287.7	334.3
India	36.3	49.5	97.4	95.1	79.8	79.3	111.9
Indonesia	43.1	74.0	62.8	60.9	53.4	52.1	69.8
Japan	27.1	21.3	20.1	19.0	16.3	17.0	23.4
Korea, Republic of	1.1	4.5	17.3	16.1	14.6	15.0	20.3
Malaysia	45.0	17.8	27.3	25.9	22.2	21.9	32.6

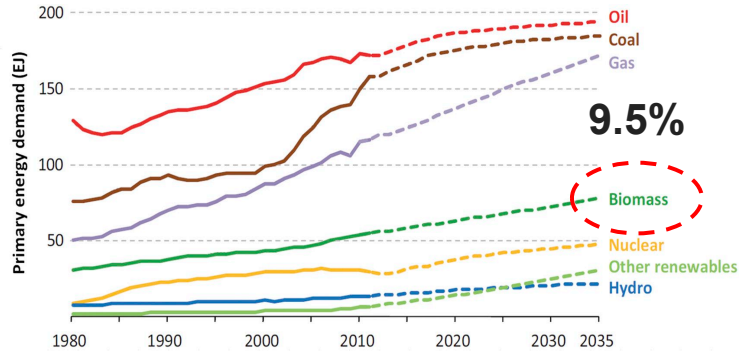
Timber demand continues to rise rapidly over the next 40 years

Growing gap between timber supply and demand

*(Lu et al., 2022, **Nat. Clim. Change**; Johnston et al., 2019, **PNAS**)*

Wood biomass for energy (BE): vital for achieving the 1.5℃ target

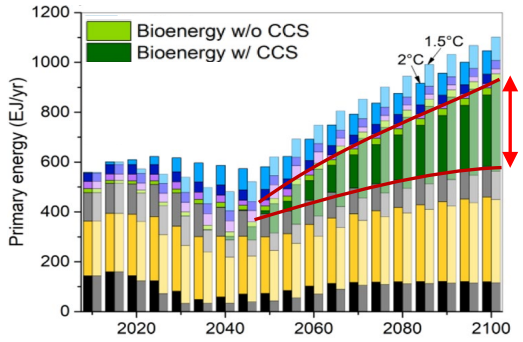
Global bioenergy use



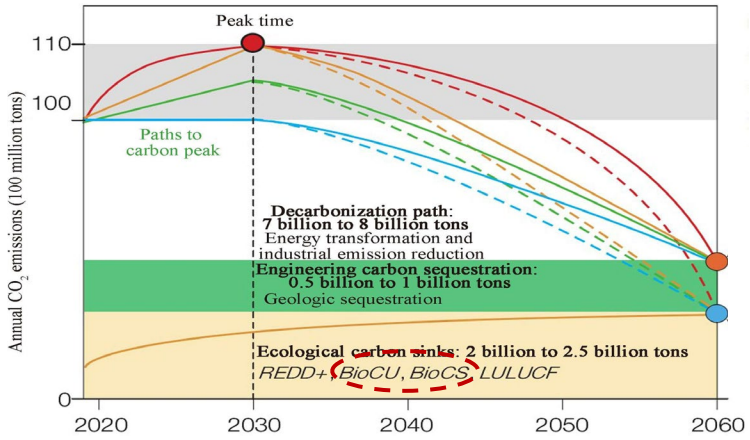
IEA global primary energy use

China bioenergy use

China is developing biomass power generation from agriculture and forestry sectors



There is a strong possibility that BECCS will be part of the solution to reach 1.5℃ target

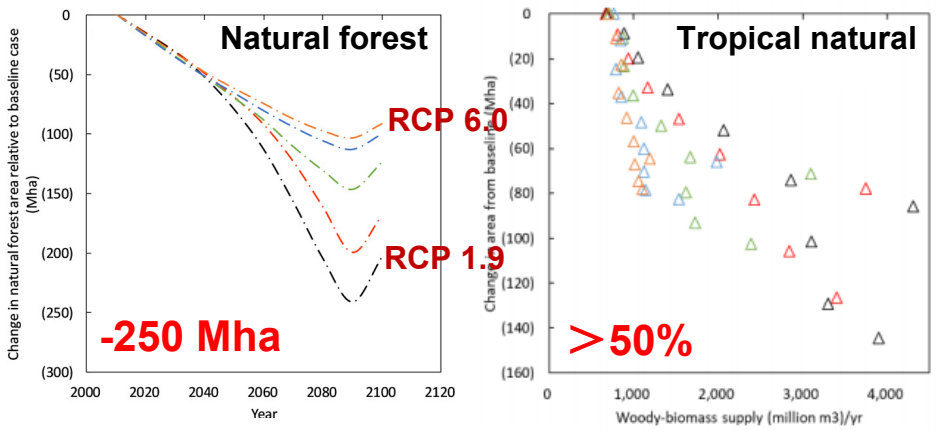


BE with CCS is needed in China to achieve carbon neutrality

*(Gustavsson et al., 2017, **Renew. Sust. Energ. Rev.**; Fajardy et al., 2021, **Global Environ. Chang.**; Yu et al., 2022, **Bulletin of Chinese Academy of Sciences**)*

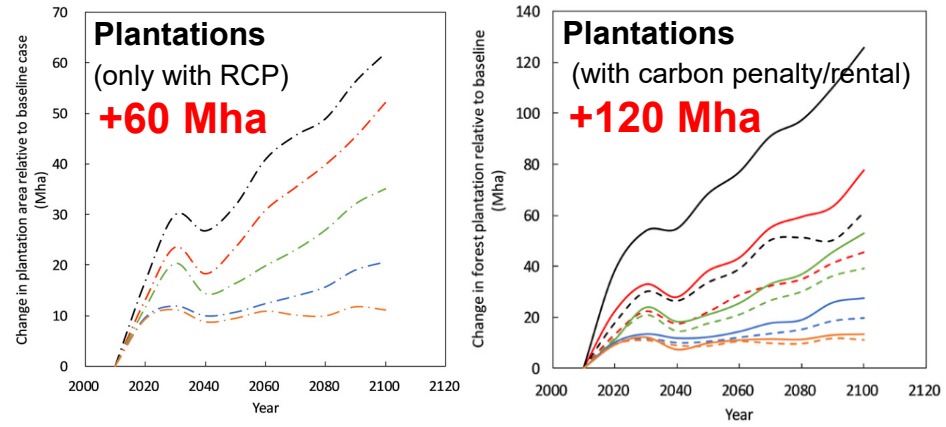
Timber for BE threatens food security and competes with woody materials

Effects of increasing woody BE



Natural forests loss mainly from tropical

Threaten biodiversity

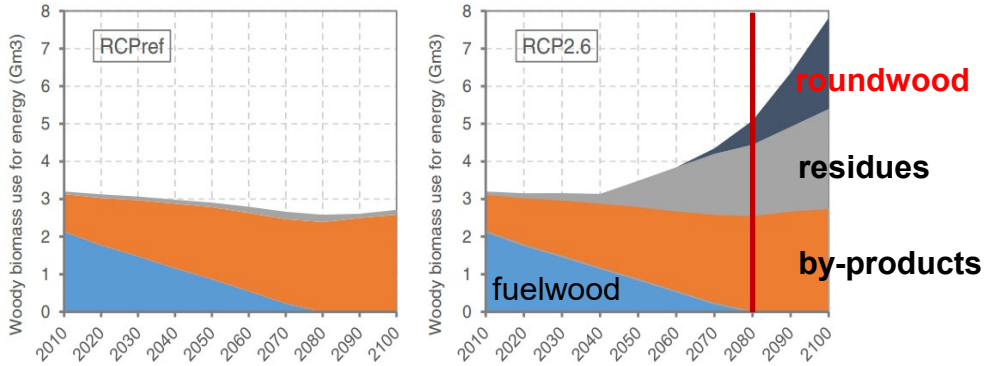


Short-rotation plantations expansion exacerbated by carbon allowances

Threaten food security

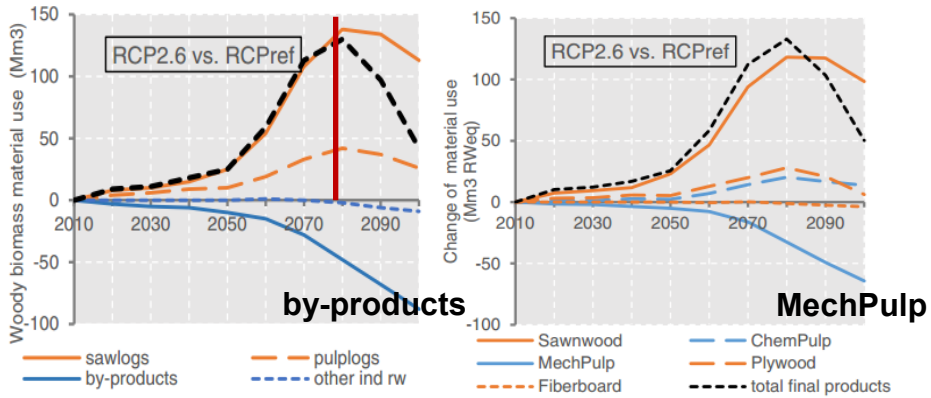
*(Favero et al., 2020, **Science Advances**; Lauri et al., 2017, **Forest Policy Econ.**)*

Biomass for energy



Woody BE comes from by-products, residues and roundwood

Biomass for material

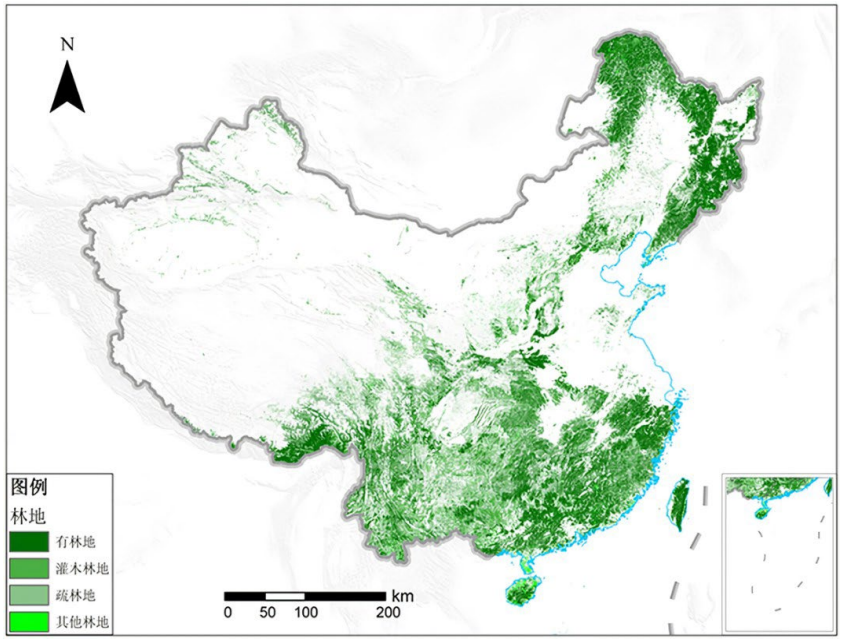


Competition by-products and roundwood

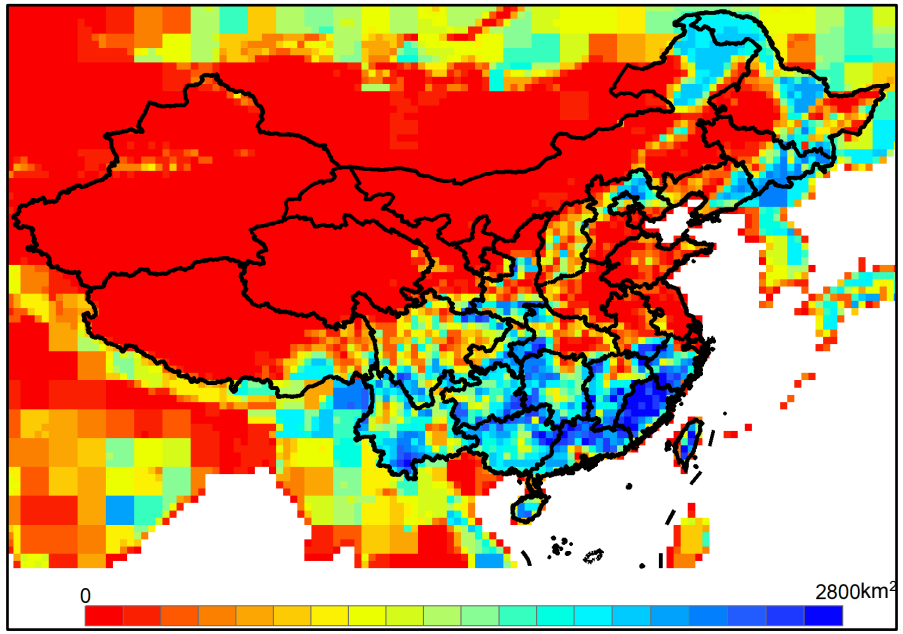
GLOBIOM-China MODEL

-GLOBIOM-China model (difference to global version):

1) Higher resolution for China (200x200km -> 50x50km)
2) New land-use data (GLC2015+NaturMap+FRA2020)
3) China forest policies: 1 natural forest harvest ban, 2 afforestation plan
4) Separate bioenergy demand function for China
5) Bilateral trade in 2000-2020 based on FAOSTAT trade flow database
6) FAOSTAT production data corrected to match China material balance



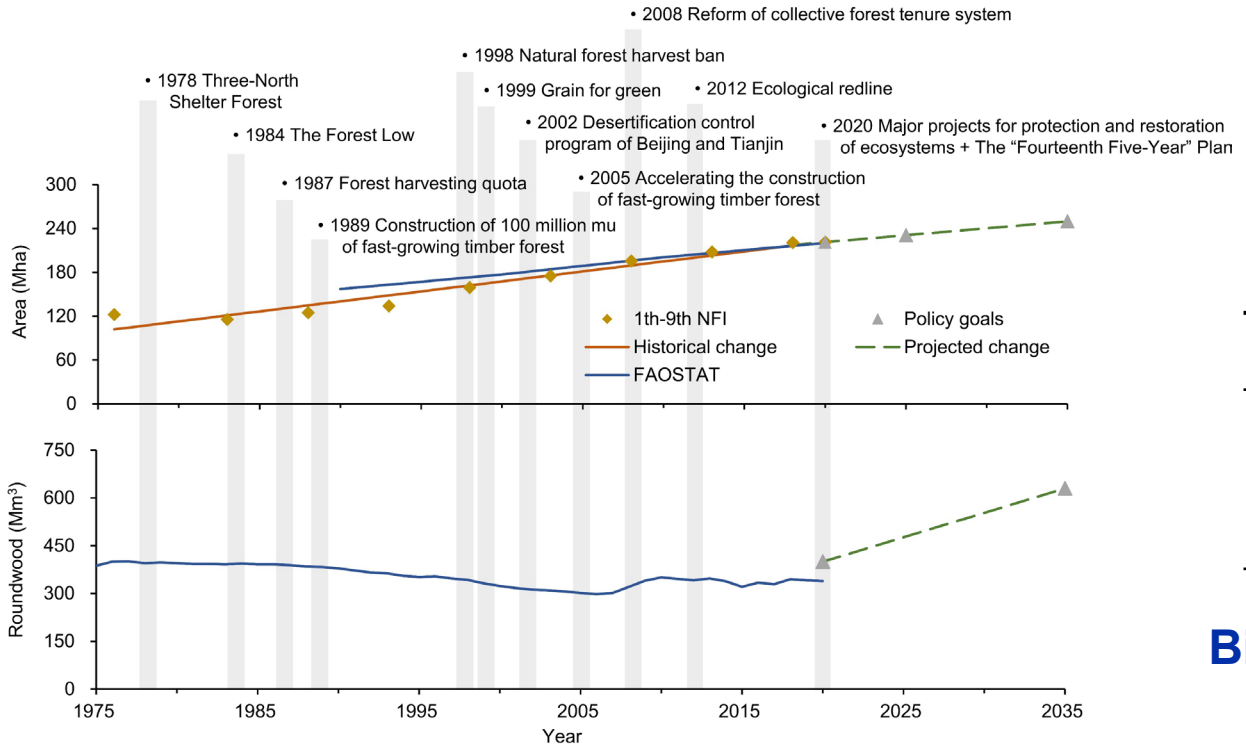
CHN F&G bureau



GLOBIOM-China

☐ Historical trajectory

Forest area and roundwood production



Materials demand

- **2000-2020:** based on **FAOSTAT**, Sawnwood, plywood and fiberboard production in FAOSTAT data is decreased, **50%** to match better on raw material use

Comparison of FAOSTAT forestry data with China Forestry Administration data

GLOBIOM variable	FAOSTAT products	FAOSTAT		China Forestry Administration	Difference value	Difference percentage	Unit
		Production	Summary	Production			
SW_Biomass	Sawlogs and veneer logs, coniferous	1488.97	9001.58	7775.87	1225.71	15.76%	10^4 m³
	Sawlogs and veneer logs, non-coniferous	7512.61					10^4 m³
Plywood	Plywood	6816.50	6816.50	16381.78	-9565.28	-58.39%	10^4 m³

Calculation of the conversion ratio of sawnwood and plywood

Year	Sawlogs and venner logs (production+net import) (10^4 m³)	Log equivalent of sawnwood (10^4 m³)	Log equivalent of veneer (10^4 m³)	Log equivalent of plywood (10^4 m³)	Conversion ratio
2020	156337.31	109252.91	6830.25	171160.00	1.88
2019	157334.86	117312.91	6830.25	159660.00	1.84
2018	156465.56	117312.91	7580.25	159660.00	1.86
2017	141981.73	111852.91	7580.25	159160.00	2.02
2016	141665.87	100422.01	7582.25	170412.50	2.02
2015	129853.24	96663.71	7582.25	163162.50	2.13
2014	130312.66	88949.51	7585.00	170412.50	2.11

Bioenergy demand

- **2000-2020:** based on IEA, agricultural residues and waste share 60%, and woody biomass share 40%

Scenarios

Scenario	Description		
	Future demand	Harvest potential	pellet import / plantations
BAU	Baseline: SSP2 + afforestation + natural forest harvest ban		
HBC	High bioenergy	low harvest potential	no pellet import but plantations
HB_L		low harvest potential	no pellet import
HB_M		medium harvest potential	
HB_H		High harvest potential	
HB_L_P		low harvest potential	Pellet import
HB_M_P		medium harvest potential	
HB_H_P		High harvest potential	
HM_L	High Material	low harvest potential	no pellet import
HM_M		medium harvest potential	
HM_H		High harvest potential	
HM_L_P		low harvest potential	Pellet import
HM_M_P		medium harvest potential	
HM_H_P		High harvest potential	

Bioenergy demand

- BAU: no additional BE demand
- High bioenergy: China share 9.3% of RCP1.9 global BE demand

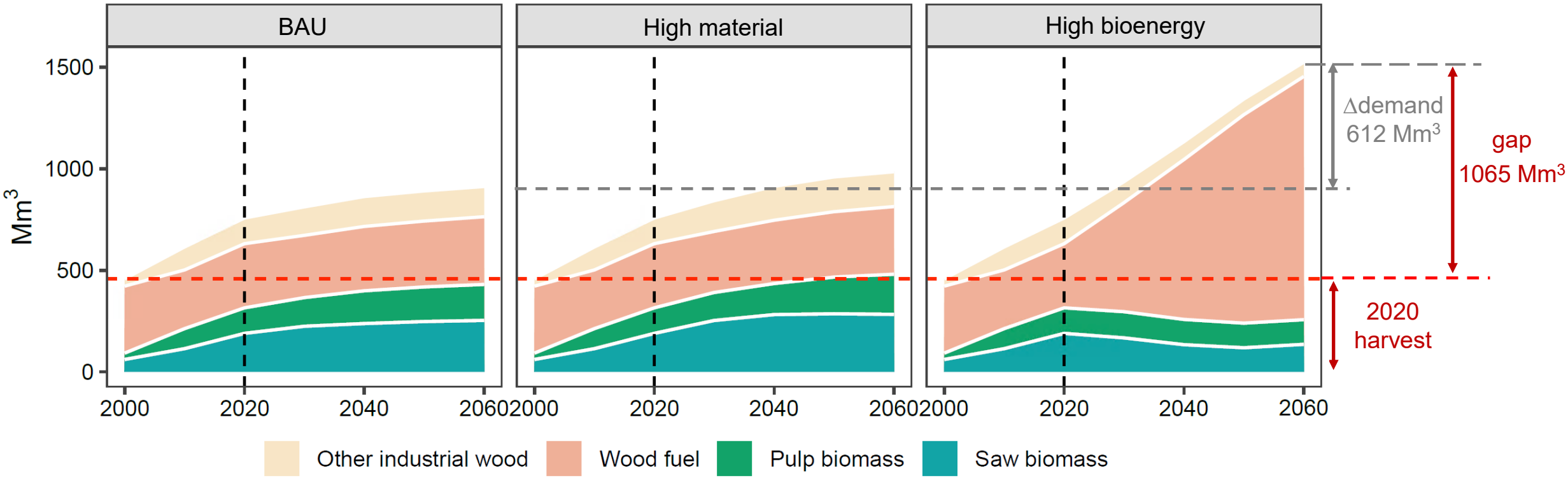
Material demand

- BAU: based on SSP2 POP and GDP development
- High materials: demand is based on SSP5

Harvest potential

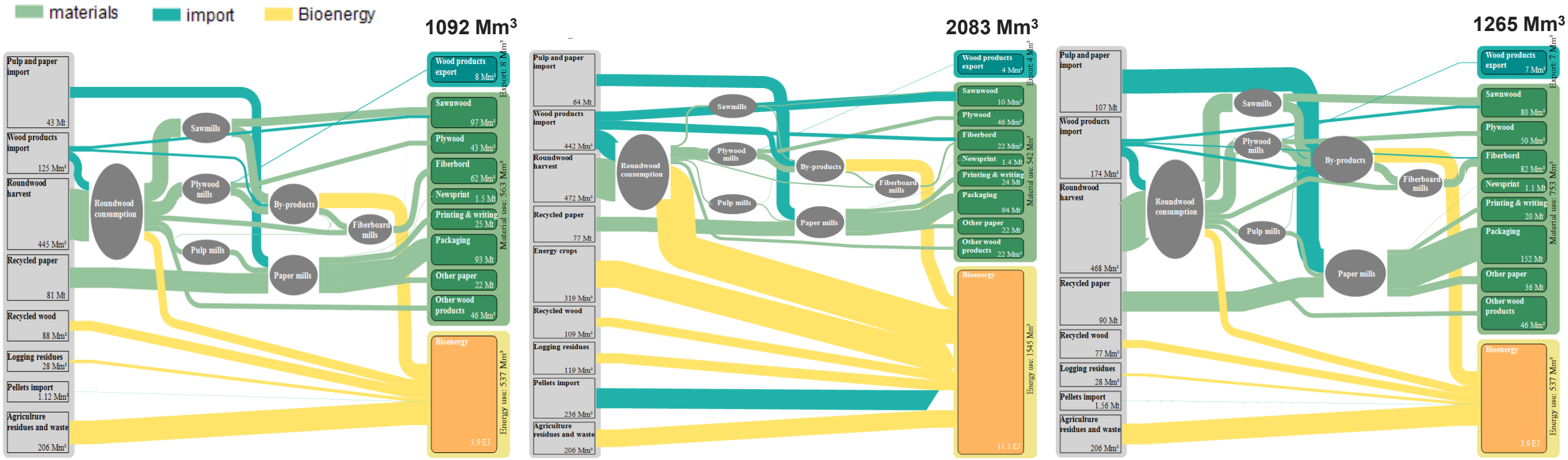
Scenarios	Area (after 2020)		Yield/ m^3/ha/yr	Harvest potential/ Mm^3/yr
	Natural forests (harvest ban)	Planted forests		
Low	140	80 (previous) + 13 (new)	**5**	**465**
Medium	140	80 (previous) + 13 (new)	**6.67**	**620**
High	140	80 (previous) + 13 (new)	**10**	**930**

Woody biomass demand



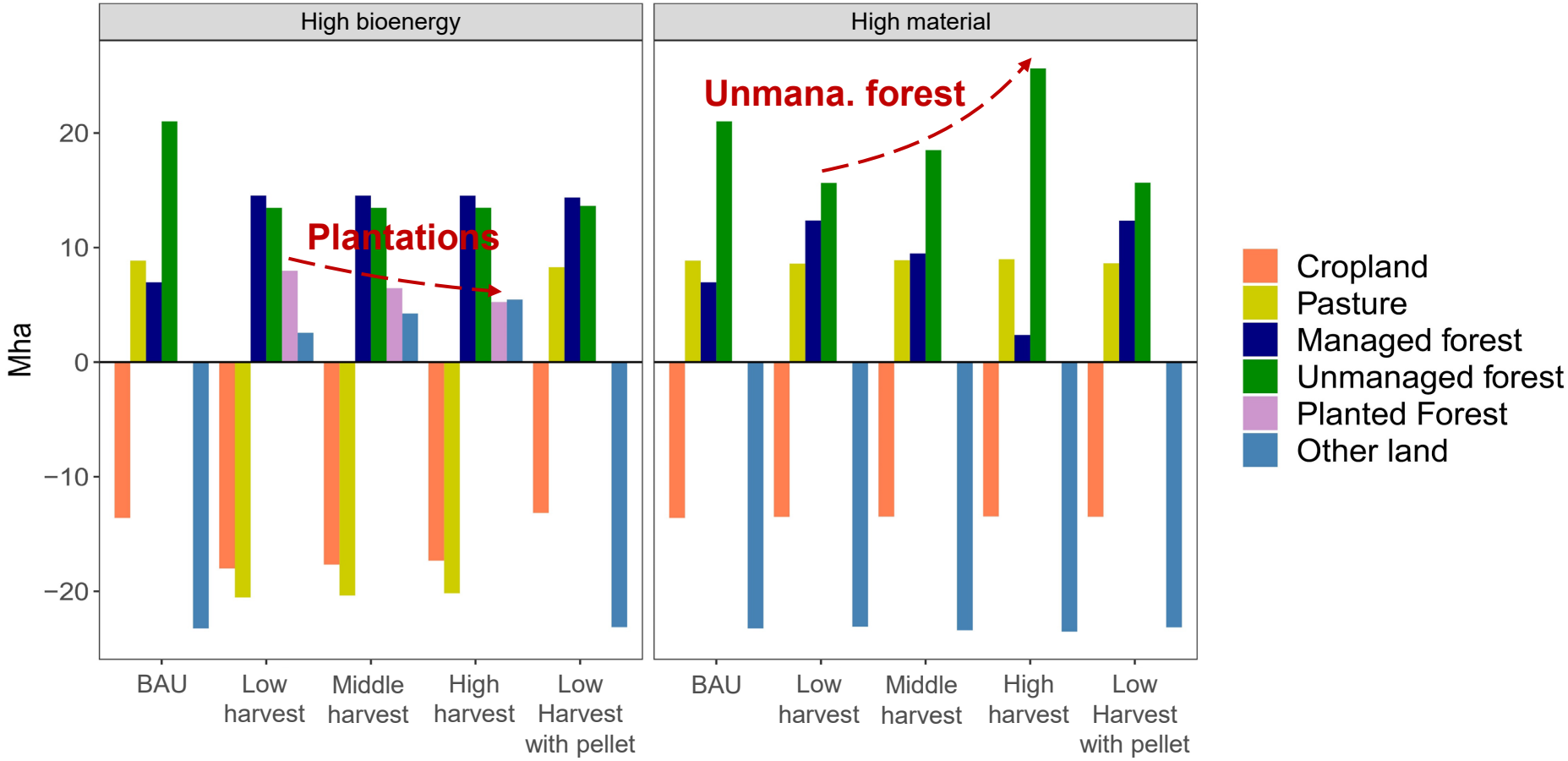
- Biomass demand increases by 73 Mm^3 and 612 Mm^3 in the high material and high bioenergy scenarios, resulting in timber gap of 526 Mm^3 and 1065 Mm^3, respectively, 2060
- Biomass originally used for material is converted to energy use in order to meet climate goals

Woody biomass flows



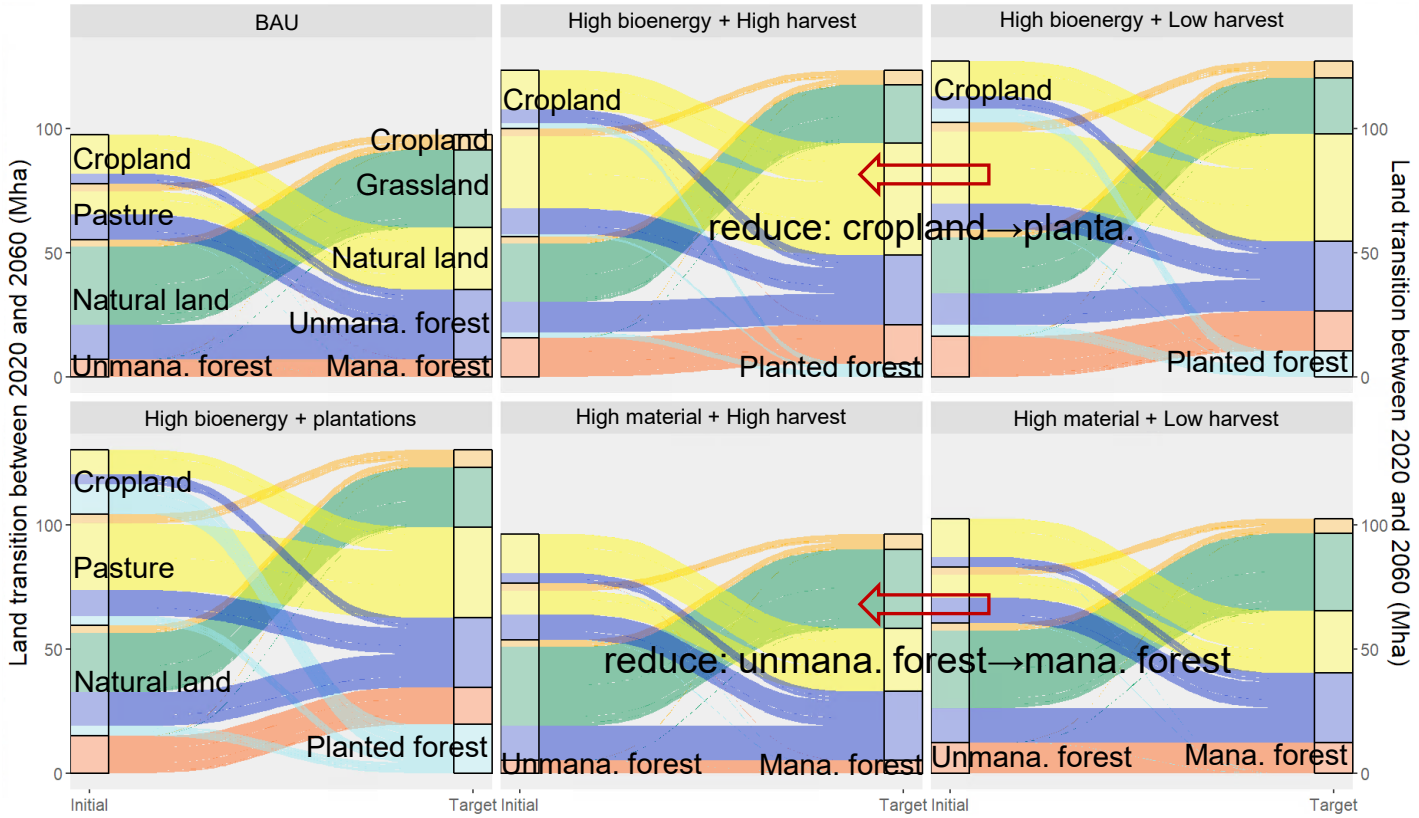
- High BE demand and high materials demand lead to 1008 Mm^3 and 190 Mm^3 increase in biomass for energy and materials, respectively
- Biomass for energy and materials use competes with roundwood and residues

Land use change



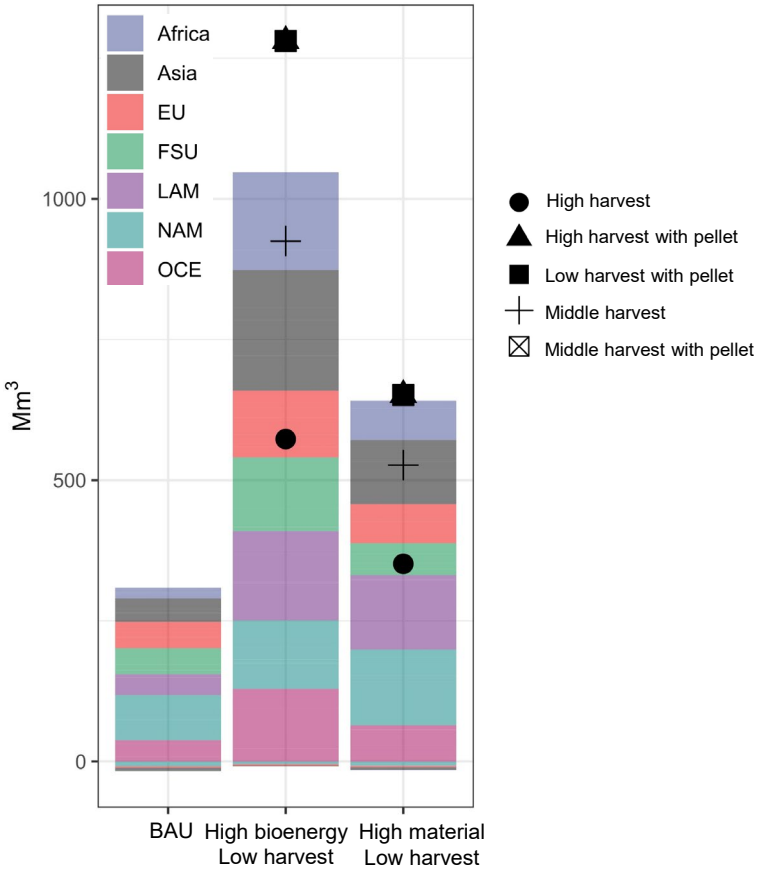
- Increased logging potential could meet future material demand and avoid reduction of unmanaged forests
- Increased logging potential doesn't meet climate goals, requires plantation expansion or pellet import

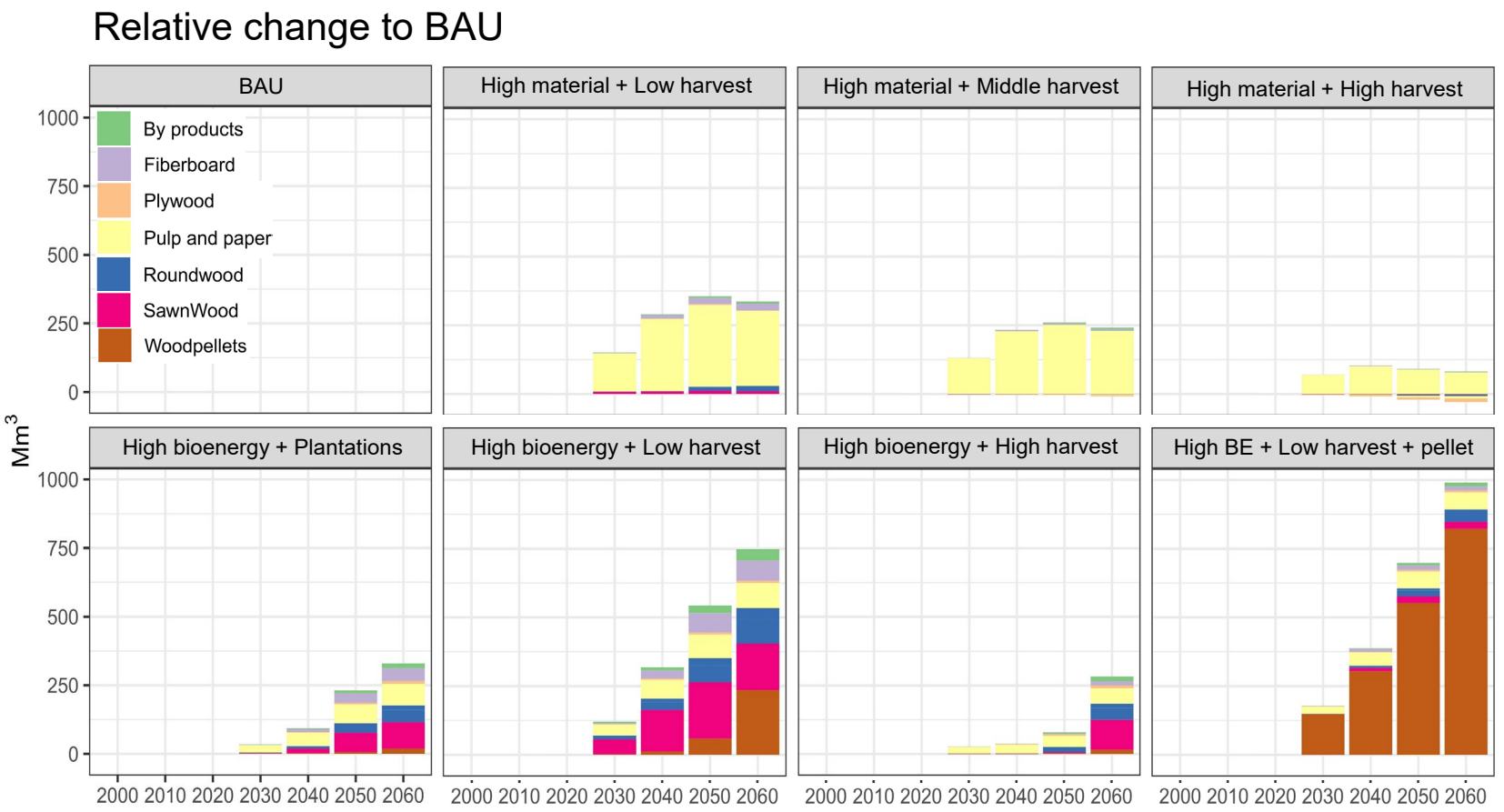
Land transition



- Afforestation land mainly derived from other natural land and pasture
- Plantations can lead to the occupation of cropland
- Increased logging potential can reduce the gross land use change and contribute to food security and biodiversity

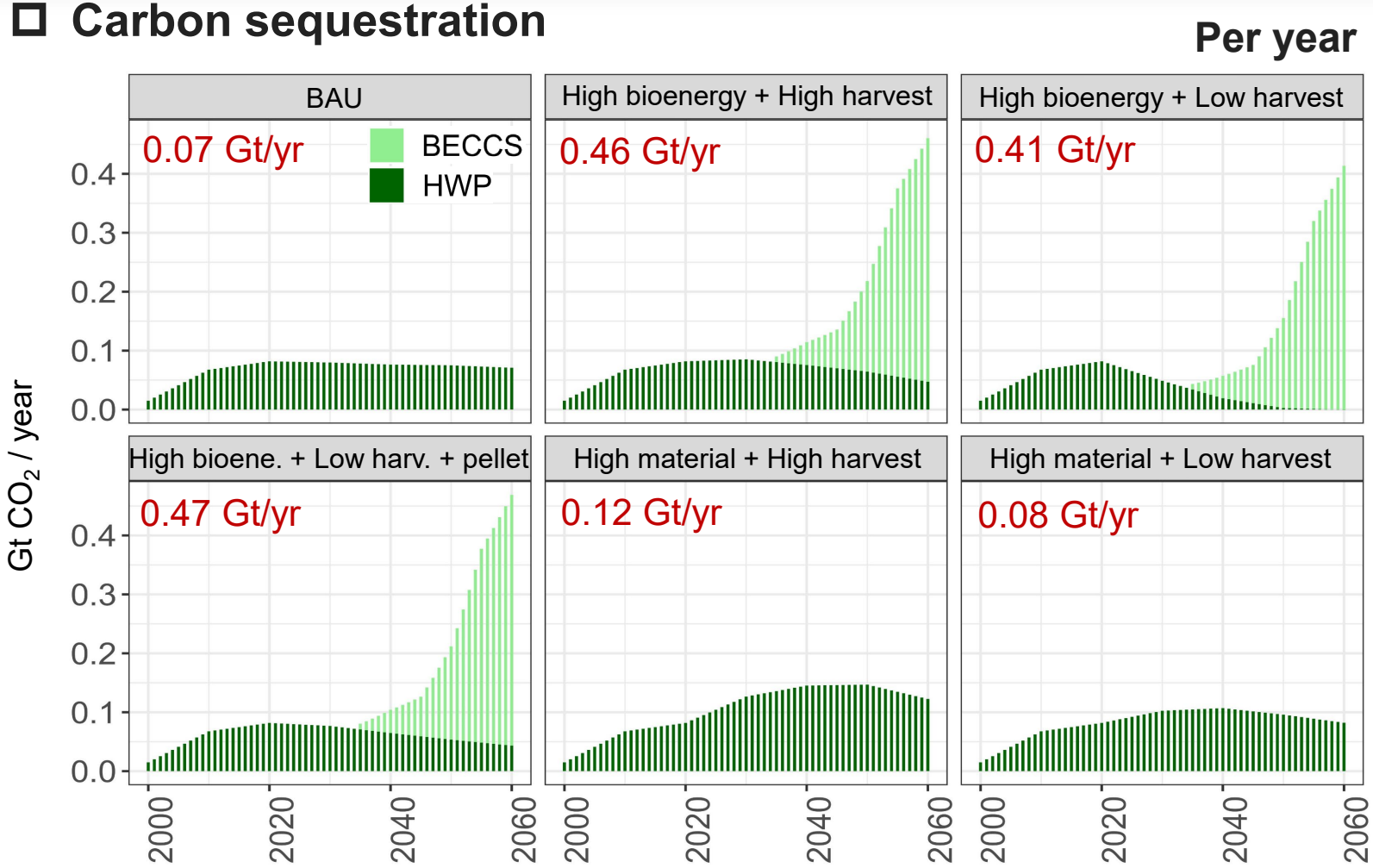
International trade

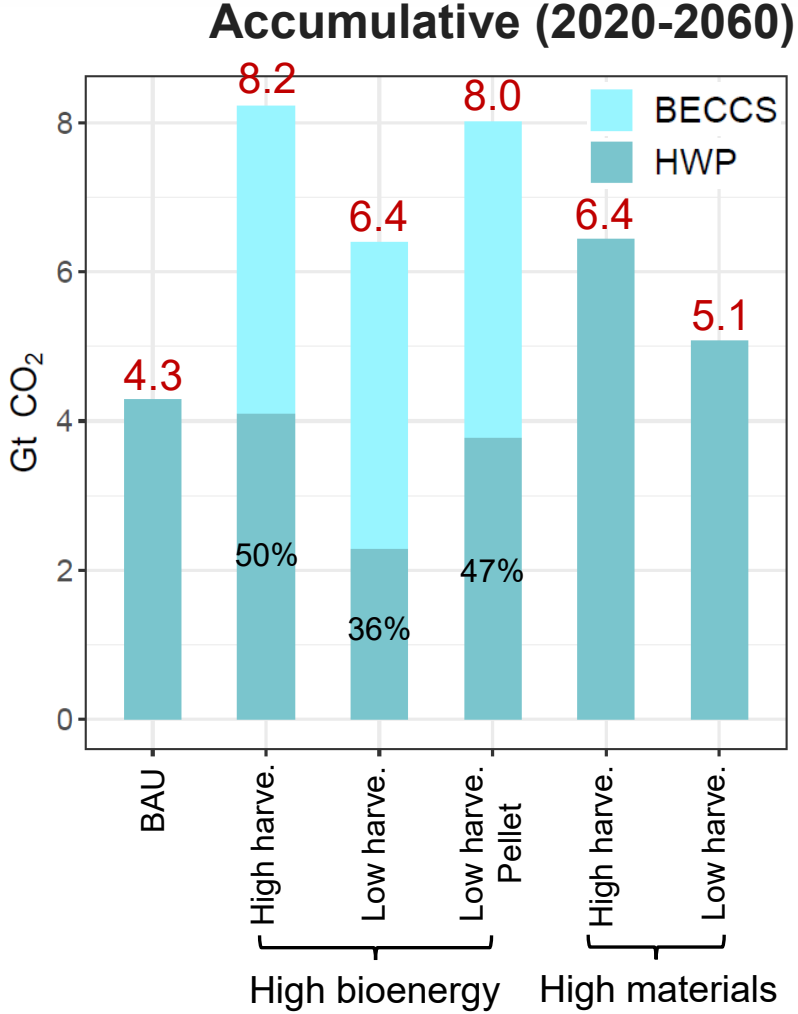




- Timber imports mainly from Latin America, South-East Asia, Africa and North America
- Imported products are dominated by pulp when demand for materials increases
- Timber imports to meet climate goals are dominated by roundwood and sawnwood

Carbon sequestration





- Increased logging could store an additional 0.04-0.05 Gt CO_2 per year, and totally store 6.4-8.2 Gt CO_2
- HWP accounts for 36-50% of the total carbon sequestration under high bioenergy scenarios

Conclusion

- China's demand for woody biomass will reach **913-1524 Mm^3** by 2060, with a gap of **526-1065 Mm^3**
- Woody biomass for energy would compete with material production for **residues** and **roundwood**
- Increased harvesting potential could avoid the **loss of unmanaged forests**, reduce **expansions of plantations** on cropland and **decline carbon leakage**
- A 2-fold harvest could result in an additional **1.3-1.8 Gt CO_2** sequestration, and HWP accounts for **36-50%** of the total carbon sequestration