Supplementary materials

Table S1. Description of the stand-replaced and gradually ageing forests' processes.

	Stand-replaced forests	Gradually ageing forests
Process description	Stand-replaced forests emerge from substantial disturbances, transitioning rapidly from young growth to mature stages.	Gradually ageing forests typically involve stable management practices, such as thinning, with minimal substantial disturbances. These practices vary and do not involve stand replacements.
Forest age transition	Forests experience an age difference of less than ten years, indicating stand-replacement followed by regrowth between 2010 and 2020. Stand-replaced forests between 2010 and 2020 can be characterised as young, maturing, mature or old-growth before a stand-replacement event.	A gradual ageing process over ten years is assumed for forests without stand replacement between 2010 and 2020. This includes naturally ageing forests planted before 2010 and regrowth from pre-2010 disturbances.

Table S2. Total global forest area across age classes for 2010 and 2020 and the net global area changes for 2010-2020. Area estimates are expressed in billions of hectares. The median values and the quantiles 5% and 95% across the 20 members are reported.

	Young forests	**Maturing forests**			**Mature forests**						**Old-growth forests**	
	0-20	21-40	41-60	61-80	81-100	101-120	121-140	141-160	161-180	180-200	201-300	>300
Total area in 2010	$0.85^{0.95}_{0.67}$	$0.25^{0.31}_{0.22}$	$0.20^{0.26}_{0.17}$	$0.25^{0.31}_{0.19}$	$0.29^{0.35}_{0.24}$	$0.30^{0.33}_{0.26}$	$0.27^{0.34}_{0.12}$	$0.14^{0.24}_{0.04}$	$0.051^{0.10}_{0.017}$	$0.021^{0.038}_{0.008}$	$0.020^{0.032}_{0.006}$	$1.073^{1.16}_{0.97}$
Total area in 2020	$0.79^{0.91}_{0.58}$	$0.29^{0.35}_{0.22}$	$0.20^{0.24}_{0.17}$	$0.22^{0.28}_{0.16}$	$0.27^{0.33}_{0.22}$	$0.29^{0.34}_{0.25}$	$0.29^{0.32}_{0.20}$	$0.20^{0.30}_{0.06}$	$0.079^{0.15}_{0.026}$	$0.030^{0.060}_{0.011}$	$0.028^{0.044}_{0.010}$	$1.04^{1.12}_{0.94}$
Absolute net changes	-0.060	+0.043	-0.008	-0.033	-0.013	+0.019	+0.019	+0.064	+0.028	+0.0092	+0.0074	-0.036
Relative net changes	-7.21%	+17.20%	-3.42%	-13.15%	-3.75%	+0.65%	+17.10%	+71.56%	+59.46%	+42.74%	+38.10%	-3.38%

Table S3. Area-weighted forest age for 2010 and 2020 across the eleven TRANSCOM-land regions (Fig. S3). The difference between forest age in 2020 and 2010 is also reported. The median values and the quantiles 5% and 95% across the 20 members are reported.

Region	Forest age 2010	Forest age 2020	Forest age difference
Eurasia Boreal	$106.47^{116.09}_{85.35}$	$113.31^{122.72}_{92.45}$	$+6.83^{+7.20}_{+6.63}$
NA Boreal	$103.90^{115.92}_{84.49}$	$113.18^{125.16}_{93.87}$	$+9.28^{+9.39}_{+9.24}$
Eurasia Temperate	$53.96^{63.62}_{0.16}$	$62.48^{72.65}_{49.41}$	$+8.62^{+9.06}_{+7.47}$
Europe	$68.93^{82.50}_{60.72}$	$77.45^{90.78}_{69.08}$	$+8.52^{+8.66}_{+8.24}$
NA temperate	$86.88^{93.07}_{73.74}$	$94.72^{100.89}_{81.24}$	$+7.87^{+8.00}_{+7.69}$
SA Temperate	$74.89^{91.76}_{53.62}$	$80.30^{95.96}_{61.11}$	$+6.63^{+7.52}_{+4.10}$
SA tropical	$238.52^{247.36}_{220.15}$	$233.68^{242.24}_{217.34}$	$-4.29^{-3.05}_{-5.86}$
Tropical Asia	$136.95^{147.23}_{116.63}$	$128.72^{137.16}_{111.44}$	$-7.09^{-4.78}_{-9.41}$
Northern Africa	$73.89^{89.87}_{60.71}$	$78.24^{92.26}_{64.67}$	$+4.10^{+5.57}_{+1.44}$
Southern Africa	$84.10^{94.45}_{71.49}$	$88.77^{98.06}_{76.09}$	$+4.50^{+5.17}_{+2.84}$
Australia	$60.96^{83.36}_{42.66}$	$68.72^{91.19}_{49.87}$	$+7.64^{+8.00}_{+6.64}$

Table S4. Total NEE for 2010 and 2020 across TRANSCOM-Land regions. NEE changes between 2020 and 2010 have also been reported. The estimates are expressed in PgC year^{-1}. The median values and the quantiles 5% and 95% across the GCB2023 members are reported. For total NEE, a positive sign means carbon source, while it means a decrease in carbon sink or increase in carbon source for NEE changes and vice-versa. A forest mask was applied before doing the area-weighted total estimates.

Region	NEE 2010	NEE 2020	NEE changes
Australia	$-0.18^{-0.072}_{-0.38}$	$-0.12^{+0.020}_{-0.21}$	$+0.11^{+0.23}_{-0.026}$
Eurasia Boreal	$-0.56^{-0.32}_{-0.85}$	$-0.46^{-0.19}_{-0.90}$	$+0.065^{+0.25}_{-0.12}$
Eurasia Temperate	$-0.76^{-0.27}_{-1.35}$	$-0.62^{-0.20}_{-1.36}$	$+0.019^{+0.35}_{-0.17}$
Europe	$-0.66^{-0.17}_{-1.03}$	$-0.45^{-0.058}_{-0.78}$	$+0.061^{+0.52}_{-0.14}$
NA Boreal	$-0.36^{-0.11}_{-0.53}$	$-0.33^{-0.24}_{-0.48}$	$+0.0011^{+0.10}_{-0.14}$
NA Temperate	$-0.43^{+0.054}_{-0.90}$	$-0.72^{+0.10}_{-1.098}$	$-0.084^{+0.11}_{-0.50}$
Northern Africa	$-0.053^{+0.23}_{-0.32}$	$-0.059^{+0.37}_{-0.26}$	$+0.0098^{+0.26}_{-0.22}$
SA Temperate	$-0.21^{+0.20}_{-0.60}$	$-0.31^{+0.32}_{-0.41}$	$+0.063^{+0.26}_{-0.27}$
SA Tropical	$-0.20^{+0.30}_{-0.36}$	$+0.051^{+0.27}_{-0.47}$	$+0.064^{+0.56}_{-0.30}$
Southern Africa	$-0.075^{+0.15}_{-0.29}$	$+0.097^{+0.31}_{-0.20}$	$+0.15^{+0.43}_{-0.033}$
Tropical Asia	$-0.27^{+0.11}_{-0.90}$	$-0.26^{+0.063}_{-0.90}$	$-0.023^{+0.023}_{-0.17}$
Global	$-4.22^{-2.72}_{-4.65}$	$-3.51^{-2.18}_{-4.61}$	$+0.38^{+0.86}_{+0.030}$

Table S5. Regional fraction of gradually ageing and stand-replaced forests and their ratio. Fraction estimates are relative to the total area of gradually ageing and stand-replaced forests. Total area estimates are shown between brackets and are expressed in billions of hectares. The median values and the quantiles 5% and 95% across the 20 members are reported.

Region	Fraction of gradually ageing	Fraction of stand-replaced	Area ratio
Eurasia Boreal	$0.17^{0.17}_{0.16}$ ($0.56^{0.56}_{0.56}$)	$0.082^{0.11}_{0.064}$ ($0.020^{0.020}_{0.019}$)	$0.035^{0035}_{0.035}$
NA Boreal	$0.070^{0.072}_{0.069}$ ($0.24^{0.24}_{0.24}$)	$0.0096^{0.012}_{0.0073}$ ($0.0023^{0.023}_{0.0022}$)	$0.0097^{0.0097}_{0.0097}$
Eurasia Temperate	$0.065^{0.066}_{0.061}$ ($0.22^{0.22}_{0.20}$)	$0.089^{0.12}_{0.073}$ ($0.021^{0.038}_{0.015}$)	$0.097^{0.19}_{0.066}$
Europe	$0.10^{0.11}_{0.10}$ ($0.35^{0.35}_{0.35}$)	$0.029^{0.041}_{0.024}$ ($0.0070^{0.083}_{0.068}$)	$0.020^{0.024}_{0.019}$
NA temperate	$0.094^{0.095}_{0.092}$ ($0.31^{0.32}_{0.31}$)	$0.052^{0.069}_{0.047}$ ($0.012^{0.016}_{0.011}$)	$0.039^{0.053}_{0.036}$
SA Temperate	$0.048^{0.049}_{0.047}$ ($0.16^{0.16}_{0.16}$)	$0.045^{0.069}_{0.036}$ ($0.012^{0.015}_{0.0080}$)	$0.072^{0.094}_{0.049}$
SA tropical	$0.19^{0.20}_{0.19}$ ($0.64^{0.65}_{0.64}$)	$0.11^{0.13}_{0.097}$ ($0.028^{0.032}_{0.021}$)	$0.043^{0.050}_{0.032}$
Tropical Asia	$0.086^{0.091}_{0.085}$ ($0.29^{0.31}_{0.28}$)	$0.25^{0.27}_{0.21}$ ($0.062^{0.073}_{0.041}$)	$0.21^{0.27}_{0.13}$
Northern Africa	$0.079^{0.086}_{0.074}$ ($0.26^{0.30}_{0.24}$)	$0.21^{0.25}_{0.11}$ ($0.050^{0.072}_{0.018}$)	$0.19^{0.30}_{0.064}$
Southern Africa	$0.079^{0.082}_{0.076}$ ($0.27^{0.28}_{0.25}$)	$0.10^{0.13}_{0.069}$ ($0.025^{0.040}_{0.015}$)	$0.093^{0.16}_{0.054}$
Australia	$0.014^{0.015}_{0.014}$ ($0.049^{0.050}_{0.047}$)	$0.022^{0.026}_{0.017}$ ($0.0053^{0.0071}_{0.0035}$)	$0.11^{0.15}_{0.070}$

Table S6. The total area of gradually ageing and stand-replaced forests per age class. The median values and the quantiles 5% and 95% across the 20 members are reported.

	Young forests (0-20 years)	**Maturing forests (21-80 years)**	**Mature forests (81-200 years)**	**Old-growth forests (>200 years)**
Gradually ageing forests	$0.69^{0.76}_{0.60}$	$0.68^{0.75}_{0.60}$	$1.056^{1.15}_{0.88}$	$1.059^{1.12}_{0.99}$
Stand-replaced forests	$0.15^{0.23}_{0.093}$	$0.032^{0.039}_{0.024}$	$0.035^{0.036}_{0.032}$	$0.035^{0.043}_{0.030}$

Table S7. Total carbon stocks and changes of gradually ageing and stand-replaced forests across age classes. Total estimates are expressed in PgC, while the stock changes are expressed in PgC year^{-1}. The median values and the quantiles 5% and 95% across the 20 members are reported.

	Young forests (0-20 years)	**Maturing forests (21-80 years)**	**Mature forests (81-200 years)**	**Old-growth forests (>200 years)**	**All age classes**
AGC gradually ageing forests	$21.29^{25.46}_{18.82}$	$36.75^{41.71}_{31.72}$	$67.44^{88.87}_{52.18}$	$138.92^{168.92}_{107.28}$	$262.35^{318.29}_{214.10}$
AGC stand-replaced forests	$2.18^{3.86}_{1.58}$	$1.13^{1.28}_{0.96}$	$1.72^{2.23}_{1.38}$	$2.40^{2.82}_{1.74}$	$7.72^{9.02}_{6.50}$
AGC changes stand-replaced forests	$+0.073^{+0.13}_{+0.033}$	$+0.11^{+0.17}_{+0.089}$	$+0.10^{+0.11}_{+0.097}$	$+0.15^{+0.18}_{+0.12}$	$+0.43^{+0.52}_{+0.39}$

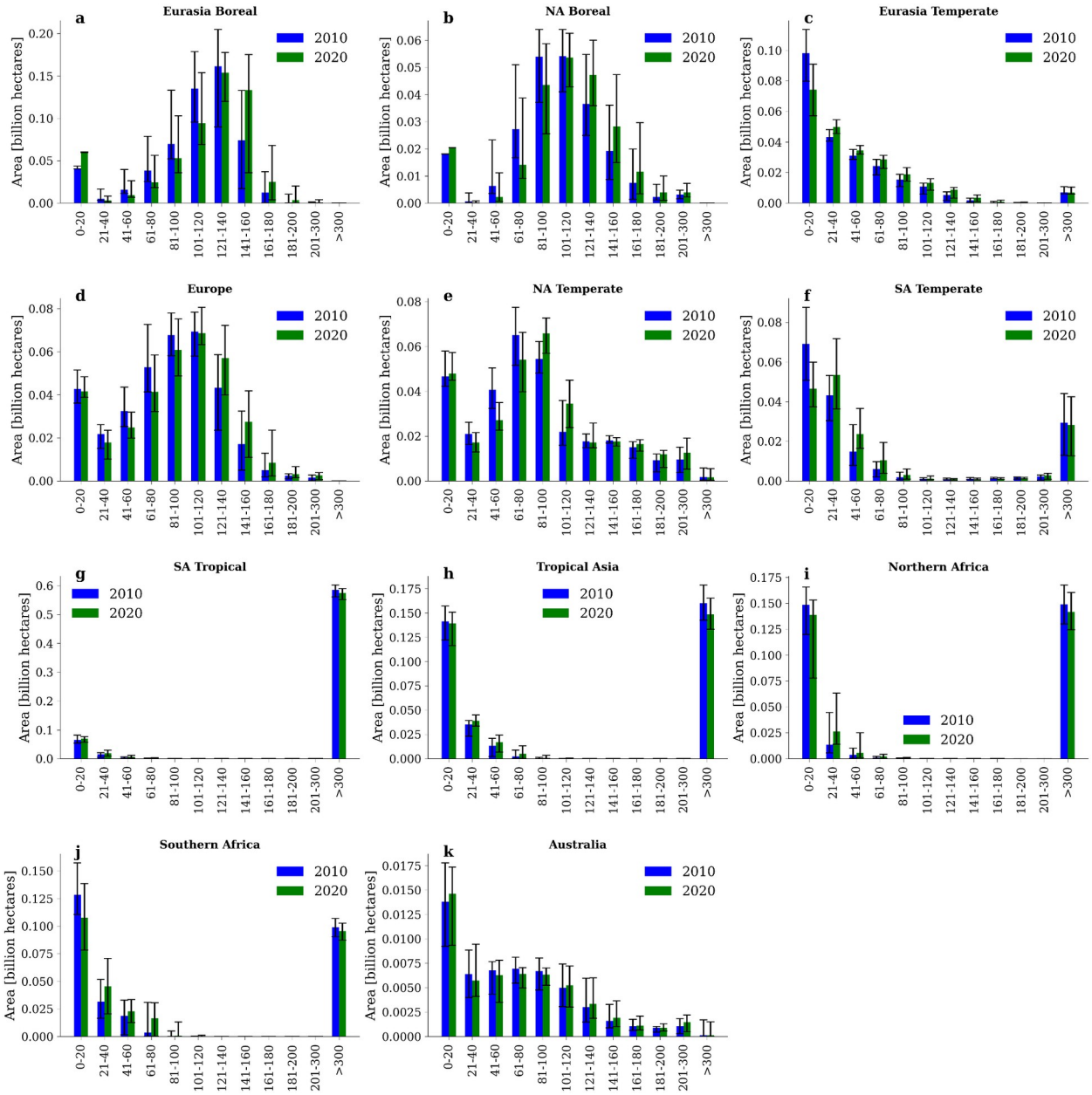


Fig. S1. The total area of each forest age class for 2010 (in blue) and 2020 (in green) across the eleven TRANSCOM-Land regions (Fig. S3). The total area represents the median values across the 20 members, and the error bars represent the 5% and 95% quantiles of the total areas across the 20 members.

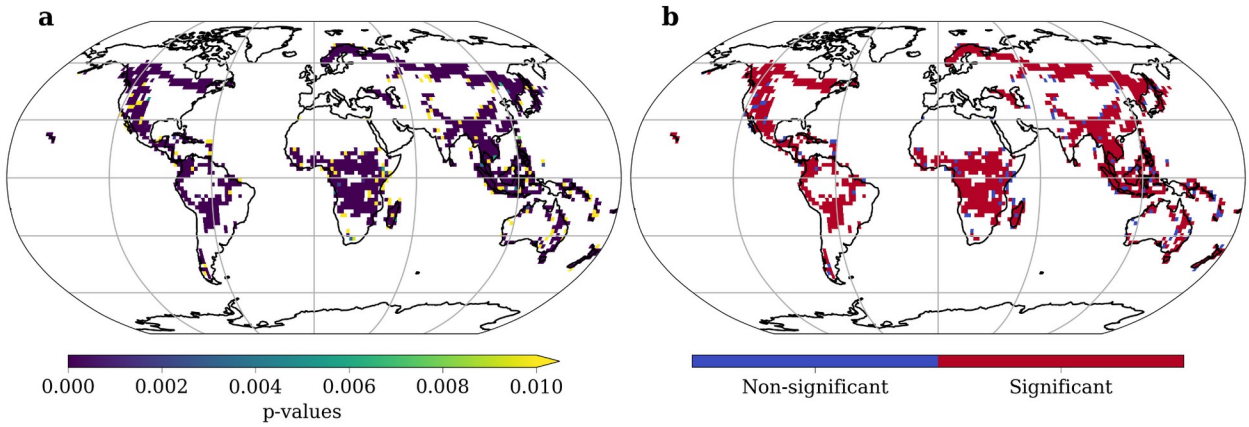


Fig. S2. Significant level of the role of management type on the relationship between forest age and biomass (see methods) within a 2x2 spatial window.

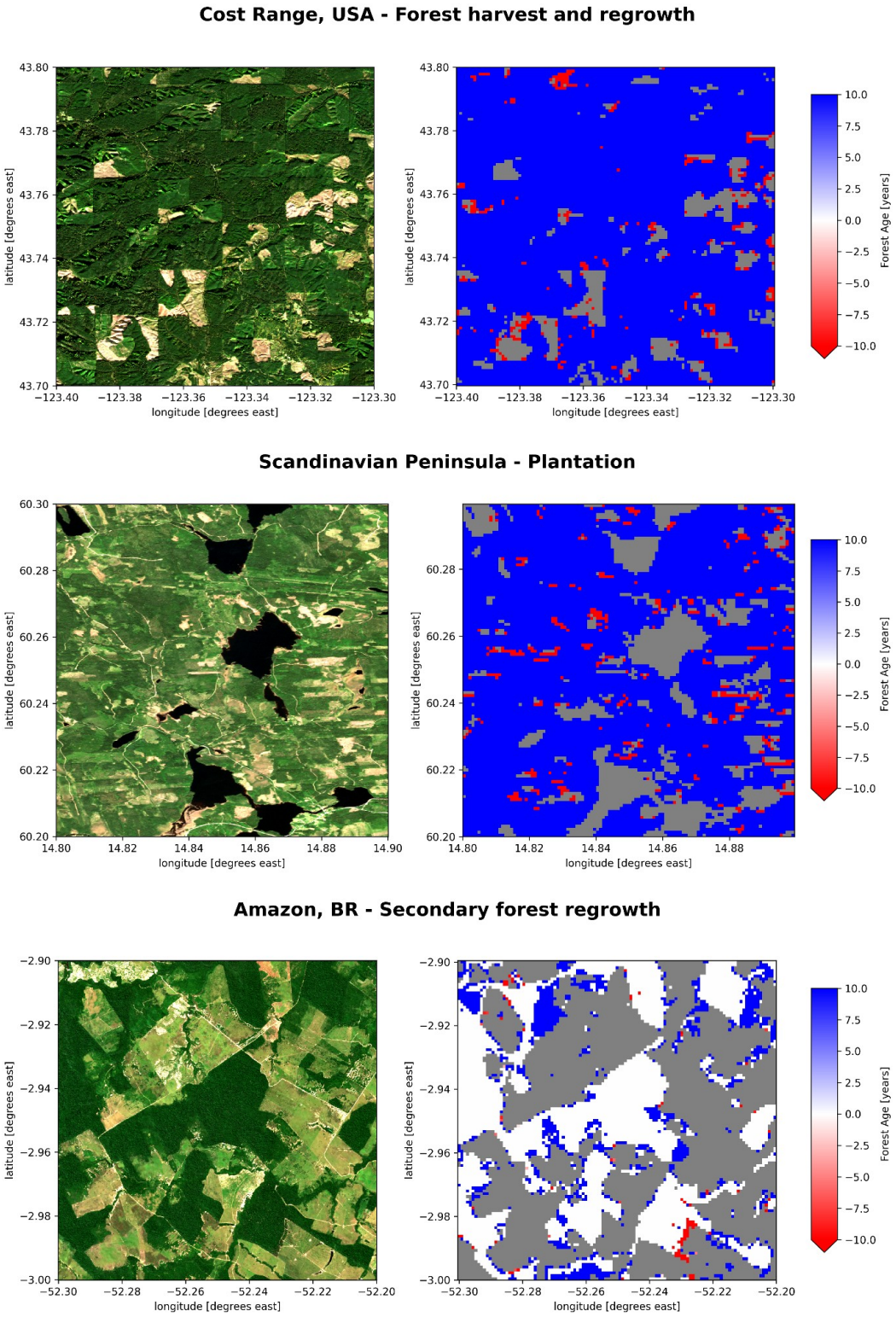


Fig. S3. The GAMIv2.0 forest age product at native resolution (i.e., 100m pixel size) provides a detailed view of substantial changes in forest age between 2010 and 2020, enhancing the precision of our analysis.

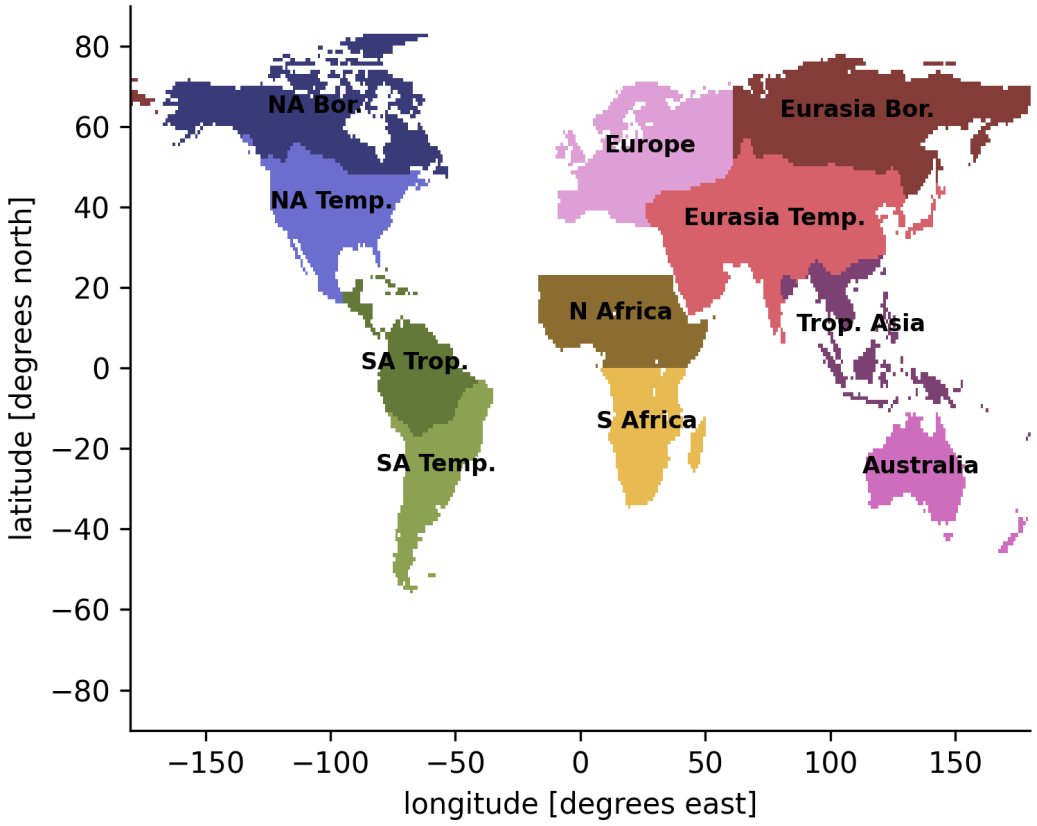


Fig. S4. Spatial distribution of the eleven TRANSCOM-land regions. NA: North America, SA: South America, N: Northern, S: Southern, Temp.: Temperate, Bor.: Boreal, Trop.: Tropical.

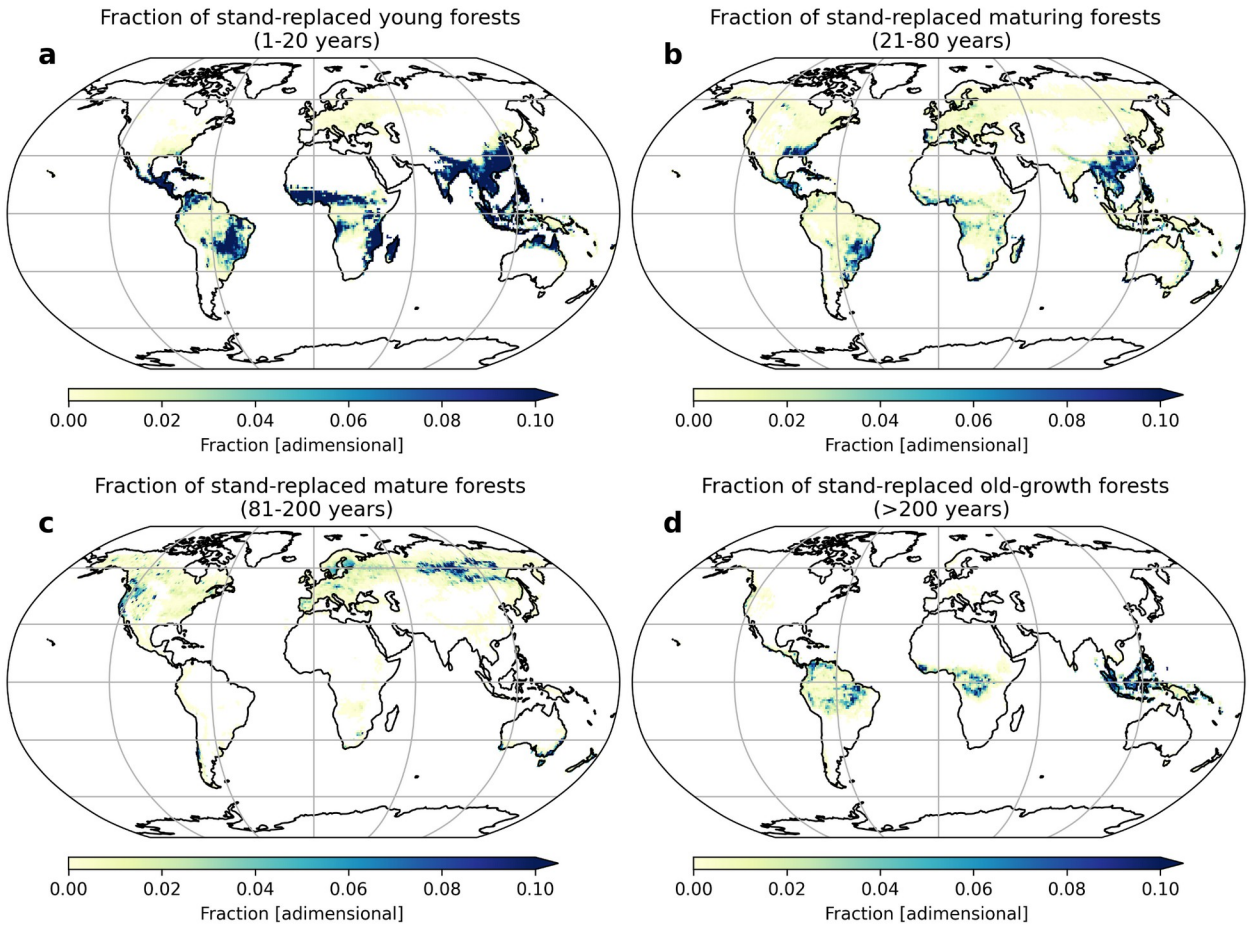


Fig. S5. Spatial distribution of stand-replaced forests that were (a) young (forest age <= 20 years old), (b) intermediate (21-80 years old), (c) mature (81-200 years old), and (d) old-growth forests (forest age > 200 years old) in 2010.

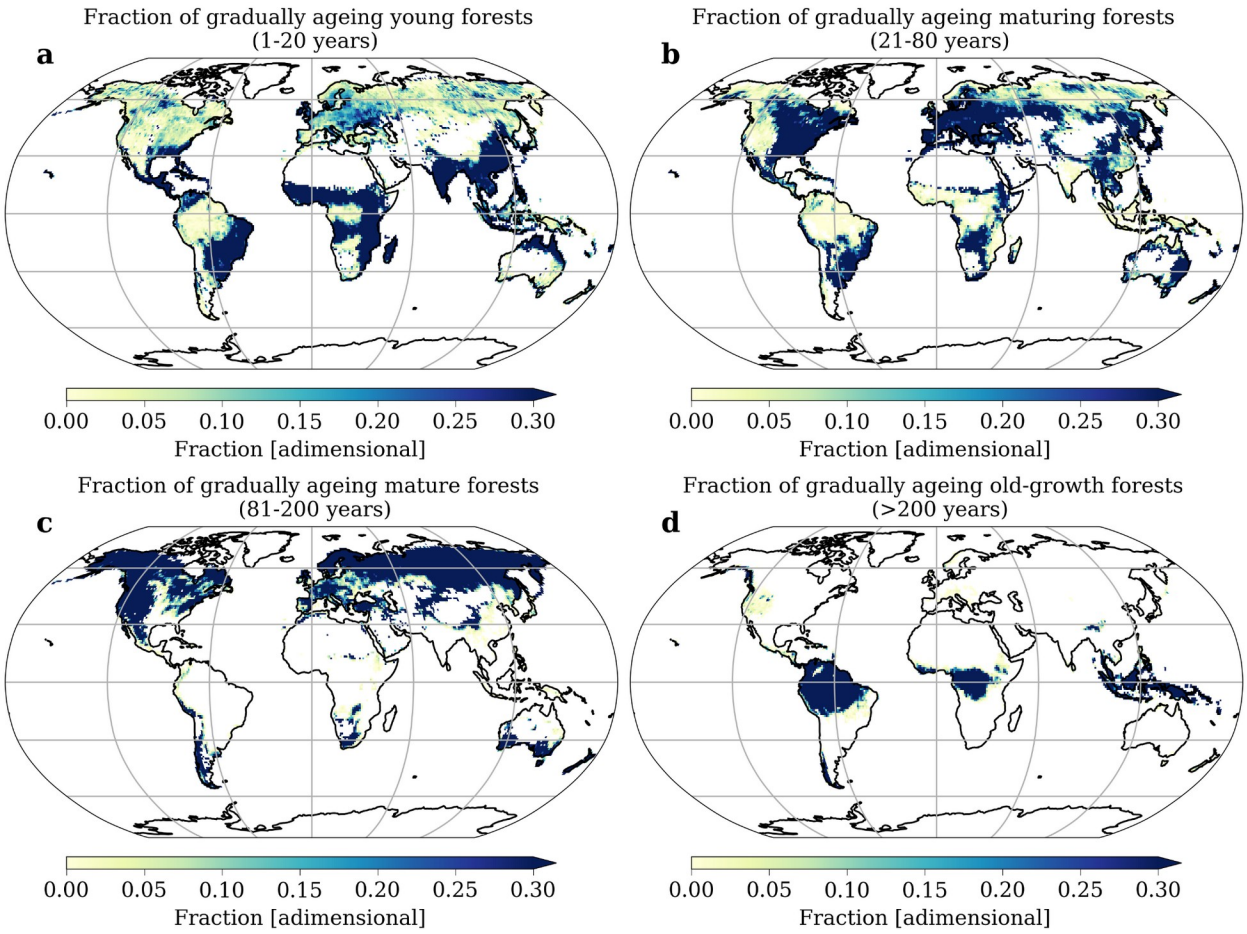


Fig. S6. Spatial distribution of gradually ageing forests (a) young (forest age <= 20 years old), (b) intermediate (21-80 years old), (c) mature (81-200 years old), and (d) old-growth forests (forest age > 200 years old) in 2010.

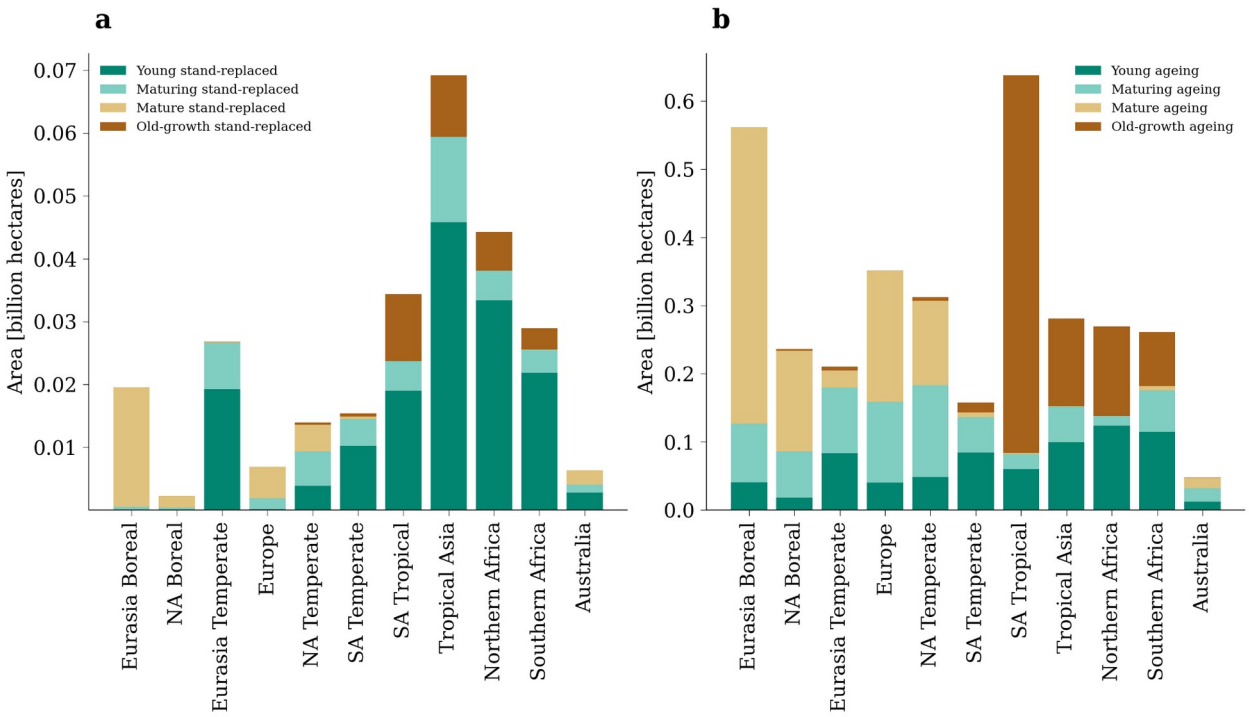


Fig. S7. Total area (in billion hectares) of (a) stand-replaced and (b) gradually ageing forests per age class across the eleven TRANSCOM-land regions (Fig. S3).

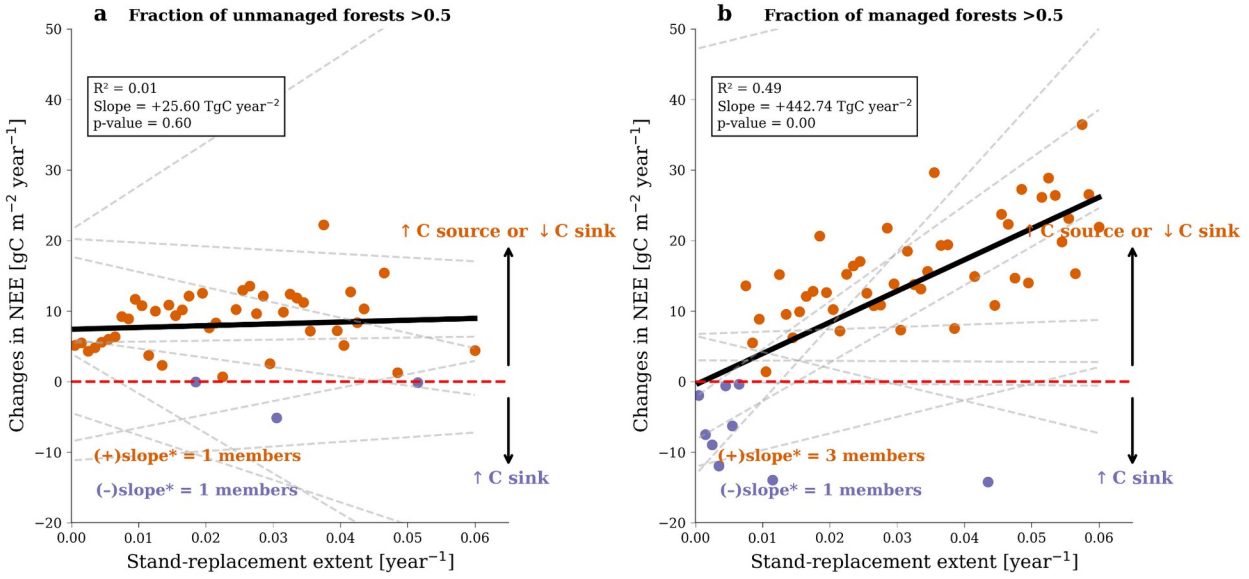


Fig. S8. The relationships between the total area of stand-replaced relative to gradually ageing forests (i.e., stand-replacement extent) against the changes in net CO_2 fluxes between circa 2020 (average between 2019-2021) and 2010 (average between 2009-2011) for unmanaged (i.e., the fraction of unmanaged forests >0.5 within one-degree pixel) (a) and managed (b) forests (i.e., the fraction of managed forests >0.5 within one-degree pixel).

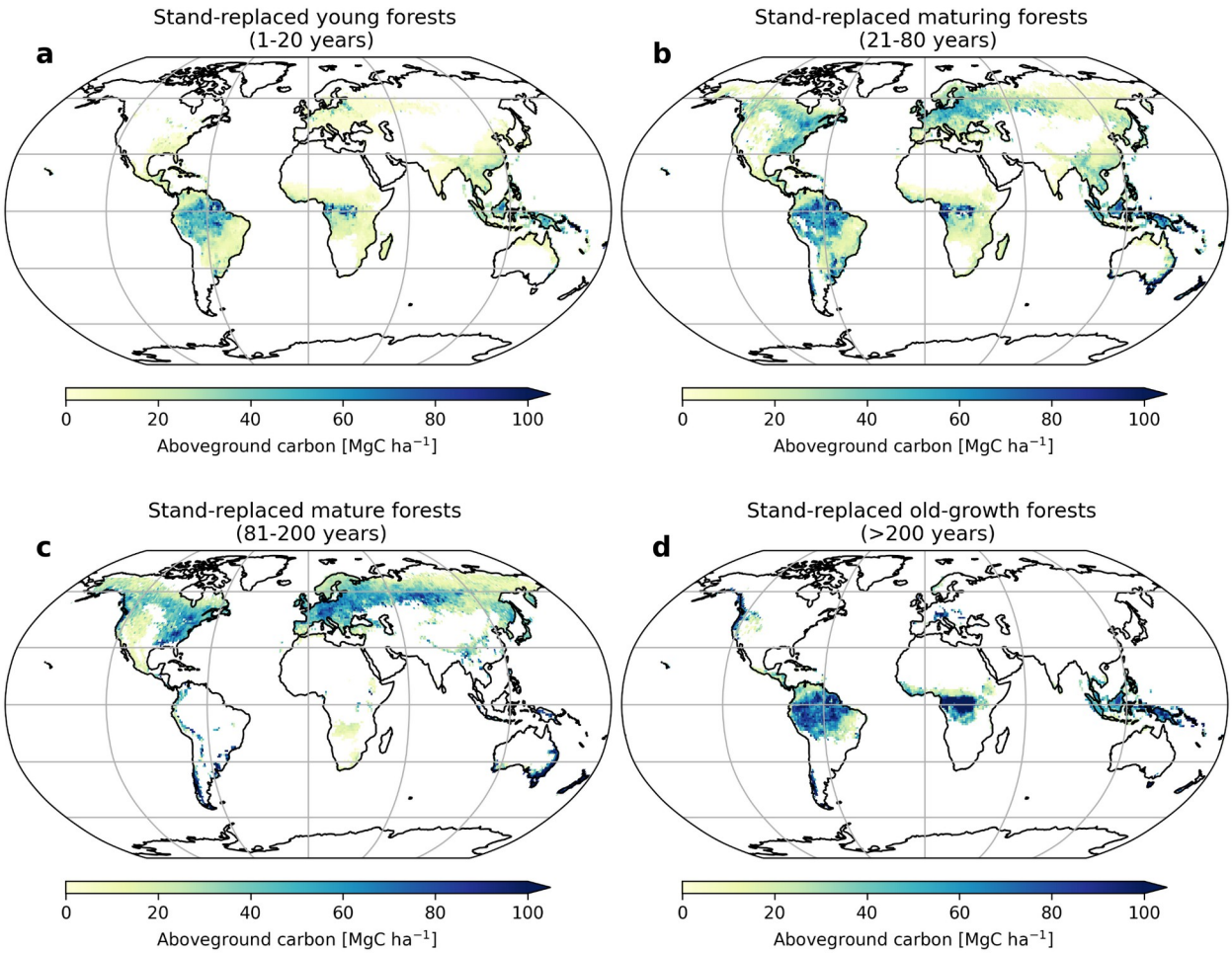


Fig. S9. Spatial distribution of carbon stocks (in MgC ha^{-1}) in stand-replaced forests (a) young (forest age <= 20 years old), (b) intermediate (21-80 years old), (c) mature (81-200 years old), and (d) old-growth forests (forest age > 200 years old) in 2010. Each pixel represents a median estimate of the 100m pixels belonging to a specific category within each one-degree pixel.

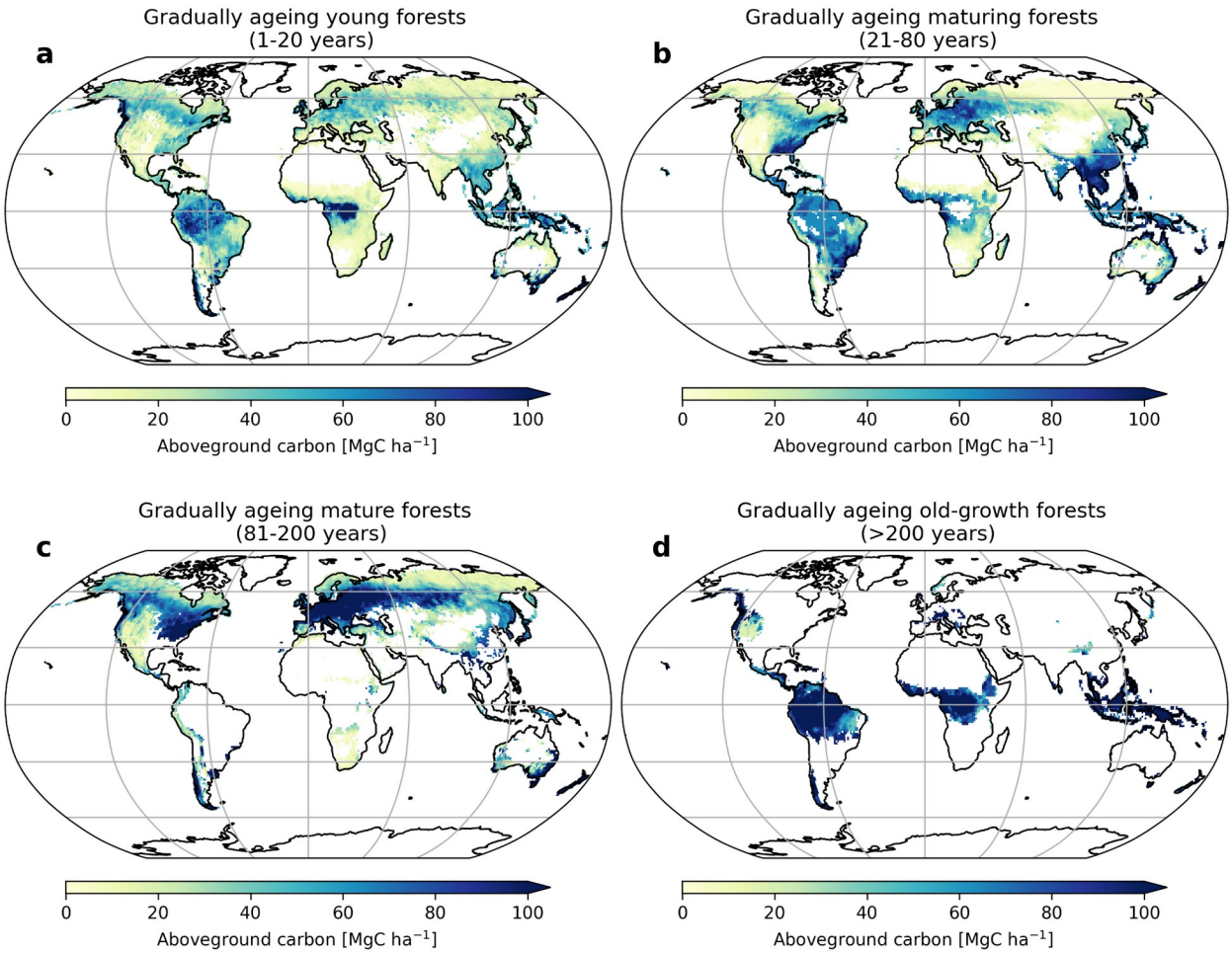
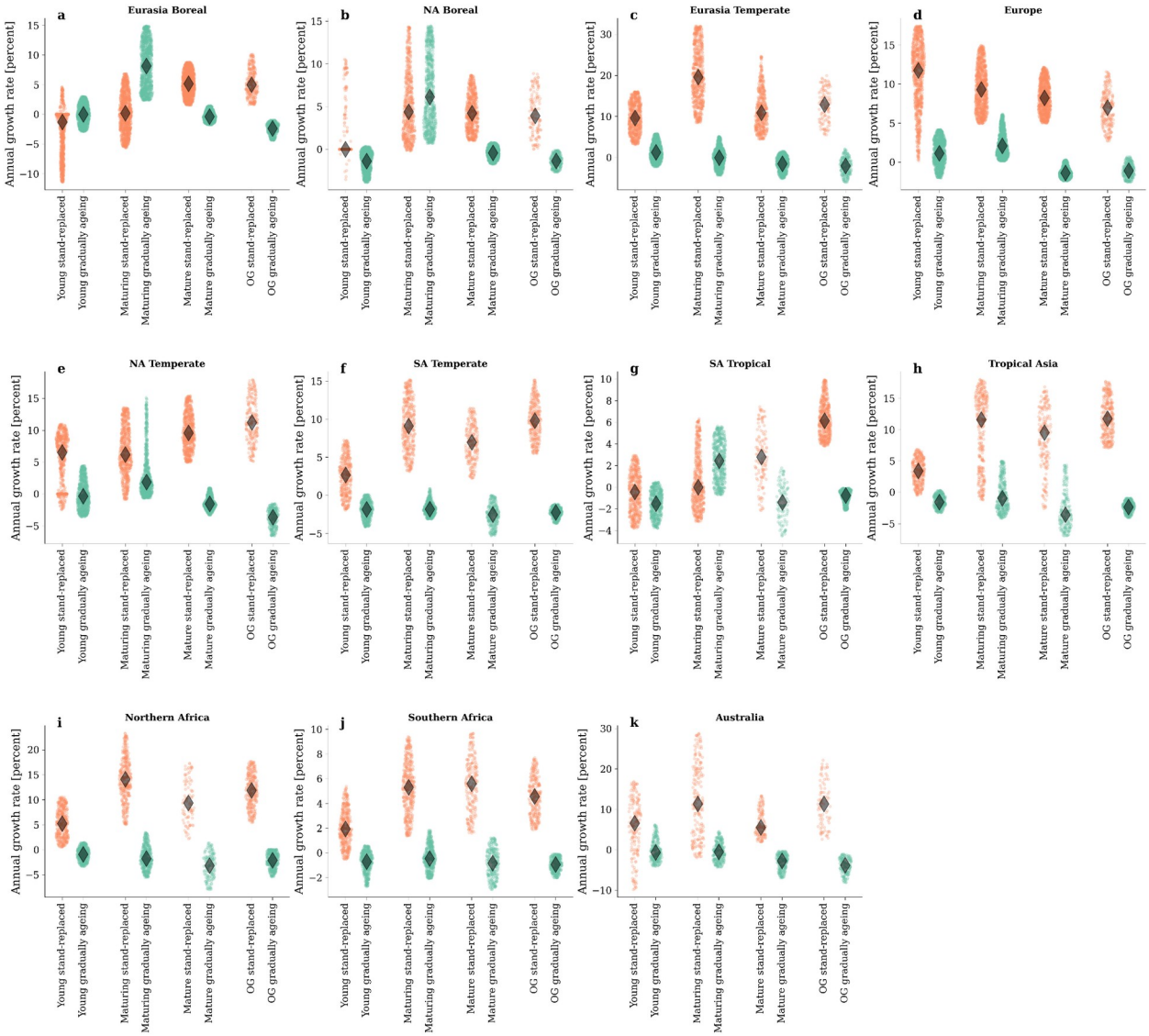


Fig. S10. Spatial distribution of carbon stocks (in MgC ha^{-1}) in gradually ageing established forests (a) young (forest age <= 20 years old), (b) intermediate (21-80 years old), (c) mature (81-200 years old), and (d) old-growth forests (forest age > 200 years old) in 2010. Each pixel represents a median estimate of the 100m pixels belonging to a specific category within each one-degree pixel.



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75 **Fig. S11.** Annual growth rates across age classes for stand-replaced forests for each
76 TRANSCOM-Land region.

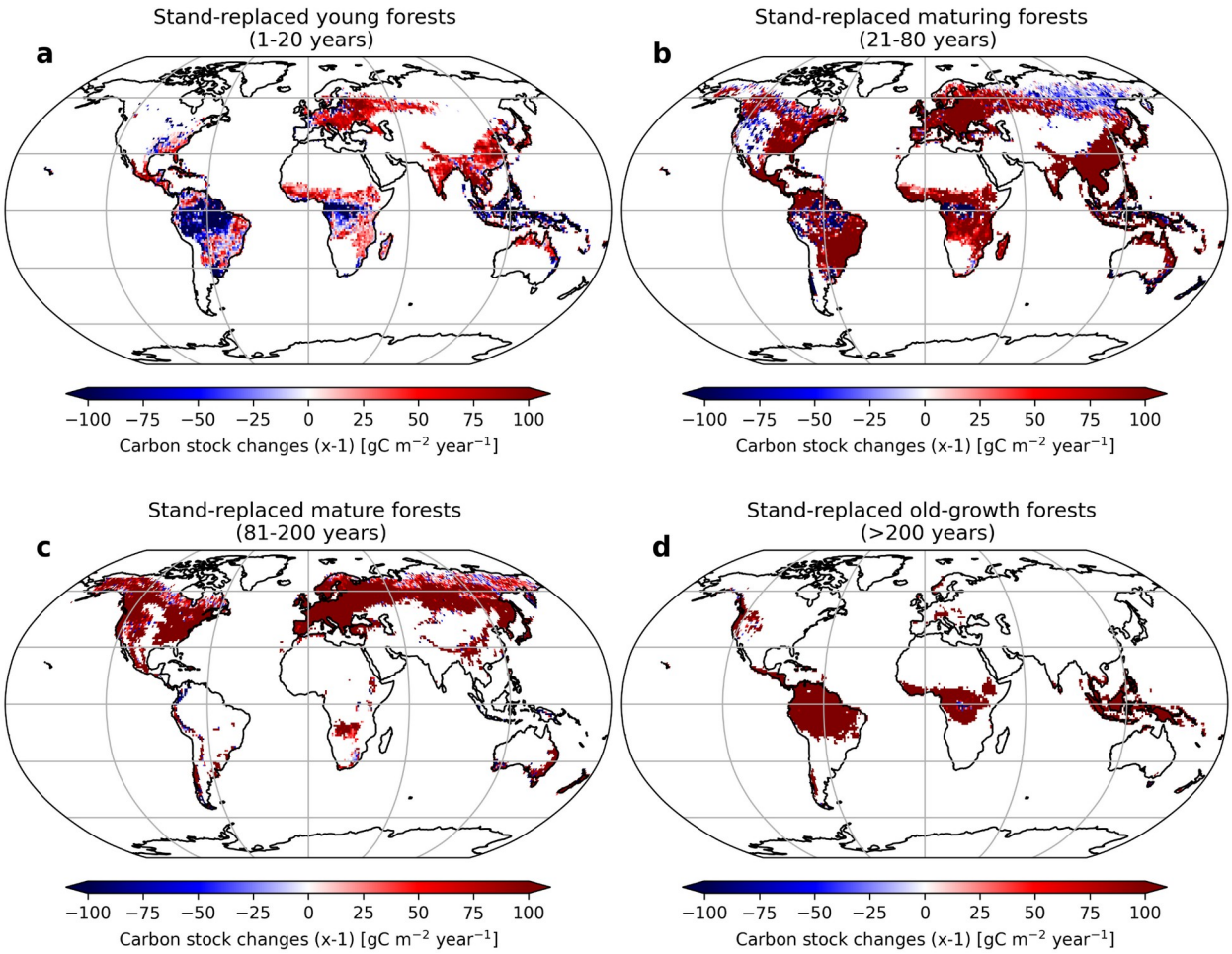

Fig S12. Spatial distribution of carbon stock changes (in gC m^{-2} $year^{-1}$) in stand-replaced forests (a) young (forest age <= 20 years old), (b) intermediate (21-80 years old), (c) mature (81-200 years old), and (d) old-growth forests (forest age > 200 years old) in 2010. Each pixel represents a median estimate of the 100m pixels belonging to a specific category within each one-degree pixel.

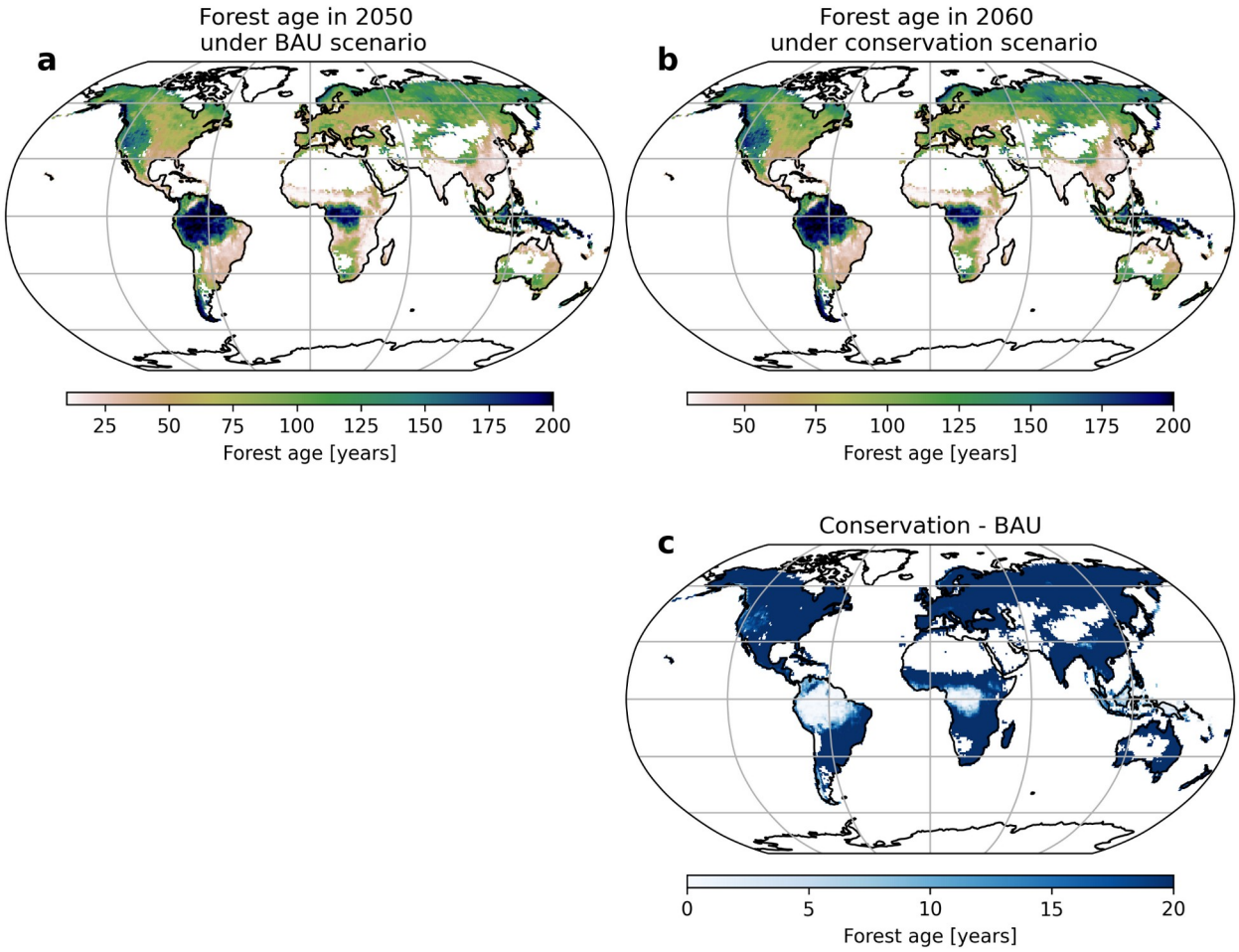

Fig. S13. Weighted-area average forest age for the (a) BAU and (b) forest conservation scenarios in 2050. The (c) difference between the forest age maps is also shown.

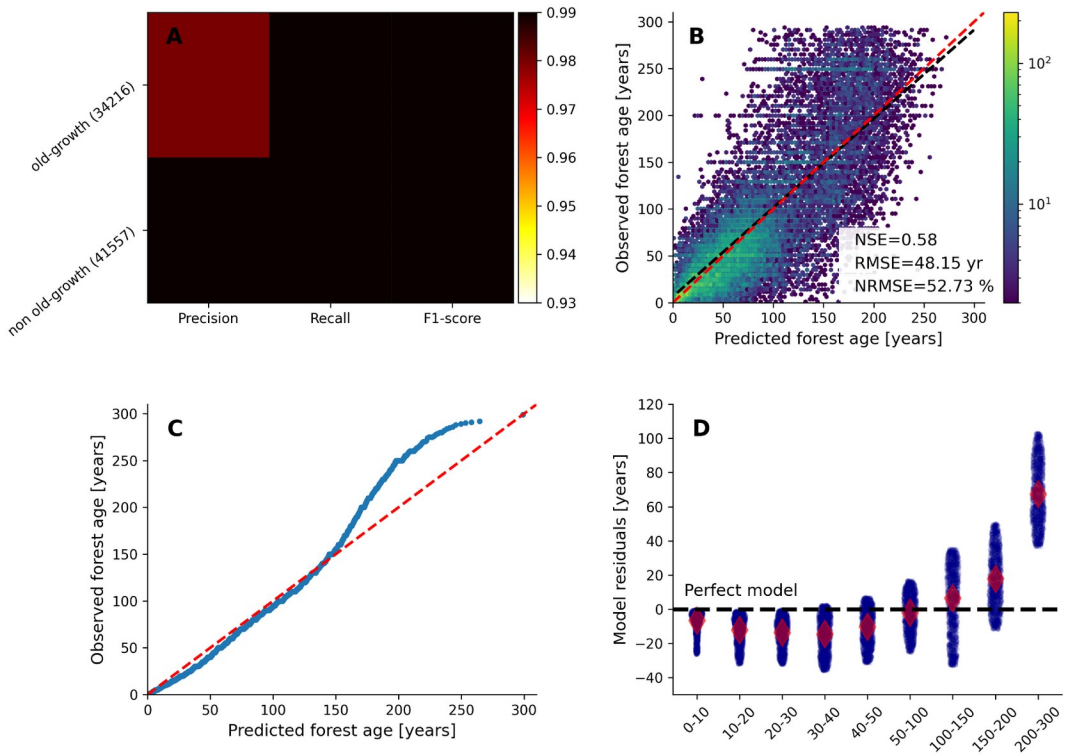

Fig. S14. Cross-validated results of the old-forest vs. non-old-forest classification (a) and comparison of predicted vs. observed forest age estimates from the regression model (b). The quantile-quantile plot (c) and the model residuals across age classes (d) are also shown.

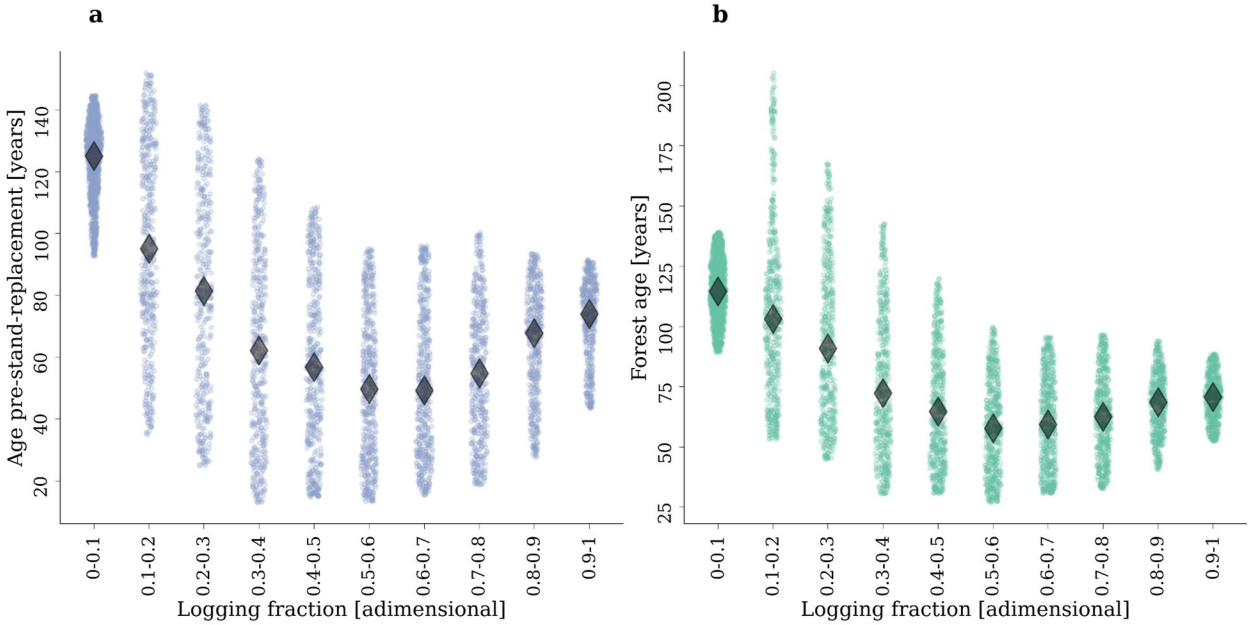

Fig. S15. Logging fraction against age pre-stand-replacement (a) and forest age (b).

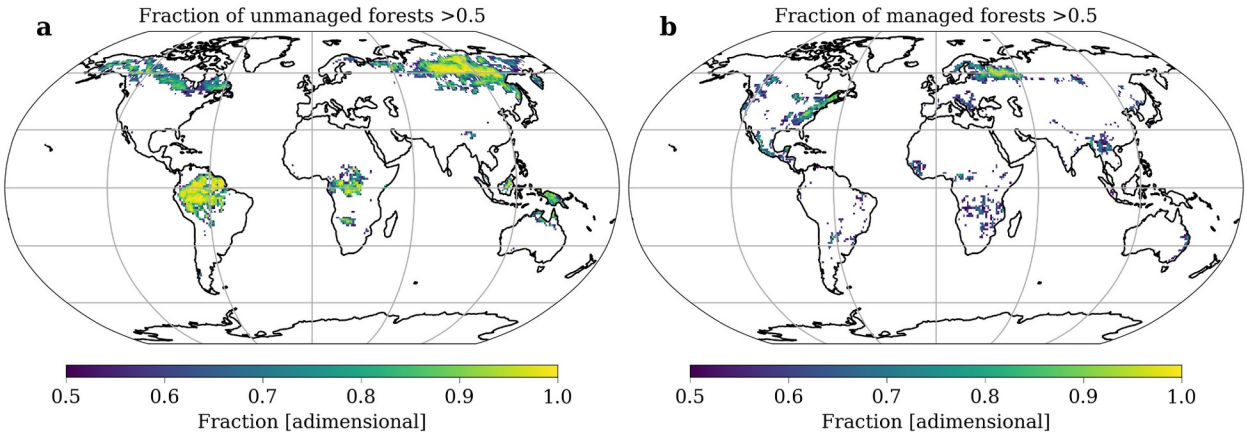

Fig. S16. Spatial patterns of (a) the unmanaged forests (fraction>0.5 within one-degree pixel) and (b) the managed forests (fraction>0.5 within one-degree pixel).