Supporting information for

Damage to living trees contributes to almost half of the biomass losses in tropical forests

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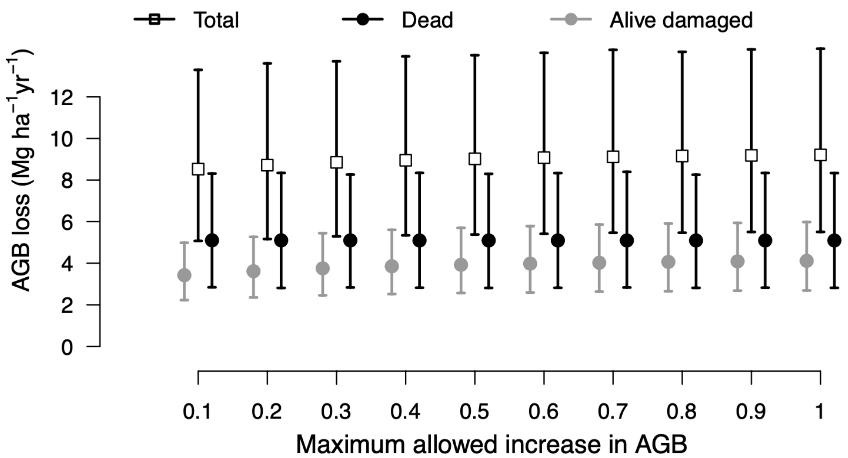

Fig. S1. Annual aboveground biomass (AGB) losses using different ‘maximum allowed increases in AGB’ values across seven tropical forests (*see* Methods). Solid points and squares show the average AGB loss rates (Mg ha^{-1} yr^{-1}); vertical bars show the 95% confidence limits based on bootstrapping over trees in each period. Results presented in the main text correspond to a value of 0.2.

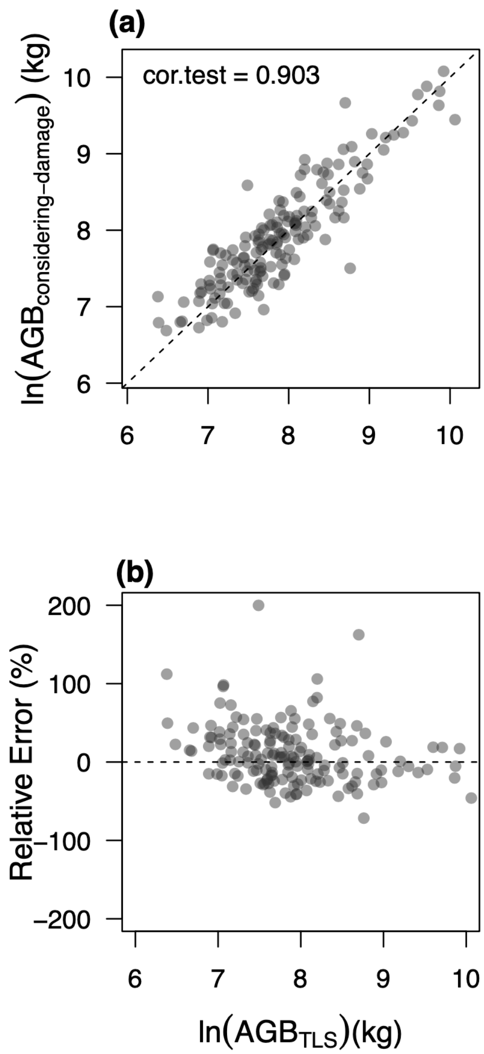

Fig. S2. (a) Aboveground (AGB) estimates considering field-based damage estimates ($AGB_{considering\text{-}damage}$) vs. AGB estimated using high-resolution 3D terrestrial laser scanning (AGB_{TLS}) for 159 trees in BCI. (b) Relative error (estimated minus observed AGB, divided by observed AGB, in%) assuming AGB_{TLS} as the observed AGB. The dashed line indicates the 1:1 line in (a). TLS data were collected from 25 subplots of 40 m × 40 m (total 60 m × 60 m to account for edge effects) within the 50-ha plot on BCI between January and March 2019 using a commercial scanner (RIEGL VZ-400 with a narrow infrared laser beam of wavelength 1550 nm and a beam divergence of 0.35 mrad). In each subplot, TLS data were collected from locations spaced 15 m apart (25 scans per subplot). We registered the point clouds from these 25 locations into a single high-resolution point cloud per subplot using the RISCAN Pro software (version 2.5.3, RIEGL Laser Measurement Systems GmbH, Horn, Austria). We manually segmented the individual trees from the plot-level point clouds using the open-source CloudCompare software (version 2.10.2) (CloudCompare 2021). The total wood volume of each tree was estimated by fitting Quantitative Structure Models (QSMs) using the TreeQSM algorithm (Raumonen *et al.* 2013; Krishna Moorthy *et al.* 2020).

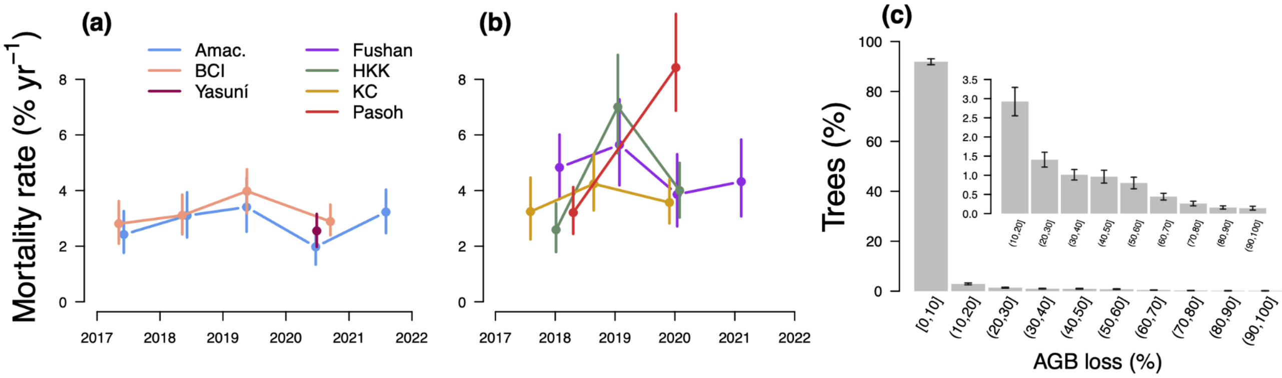

Fig. S3. Estimated forest-wide annual mortality rates (a,b) and percentage of trees that get damaged (c) across seven tropical forests. Solid points in (a) and (b) show the annual mortality rate (% yr^{-1}) with points centered in the mid-dates of each period; vertical bars show the 95% confidence limits based on bootstrapping over trees in each period for sites in the Neotropics and Asia, respectively. The distribution of living trees in the forests across 10 aboveground biomass (AGB) loss classes is shown in (c), with means (bars) and SE (whiskers) calculated over 22 sites by census interval combinations. All values are based on extrapolating from the observed sample to all trees ≥ 10 mm diameter at the point of measurement (dbh) in the forest as a whole, with extrapolation based on weighting factors accounting for differences in abundances across classes defined by combinations of dbh and taxonomic group. Amac.: Amacayacu; BCI: Barro Colorado Island; HKK: Huai Kha Khaeng; KC: Khao Chong.

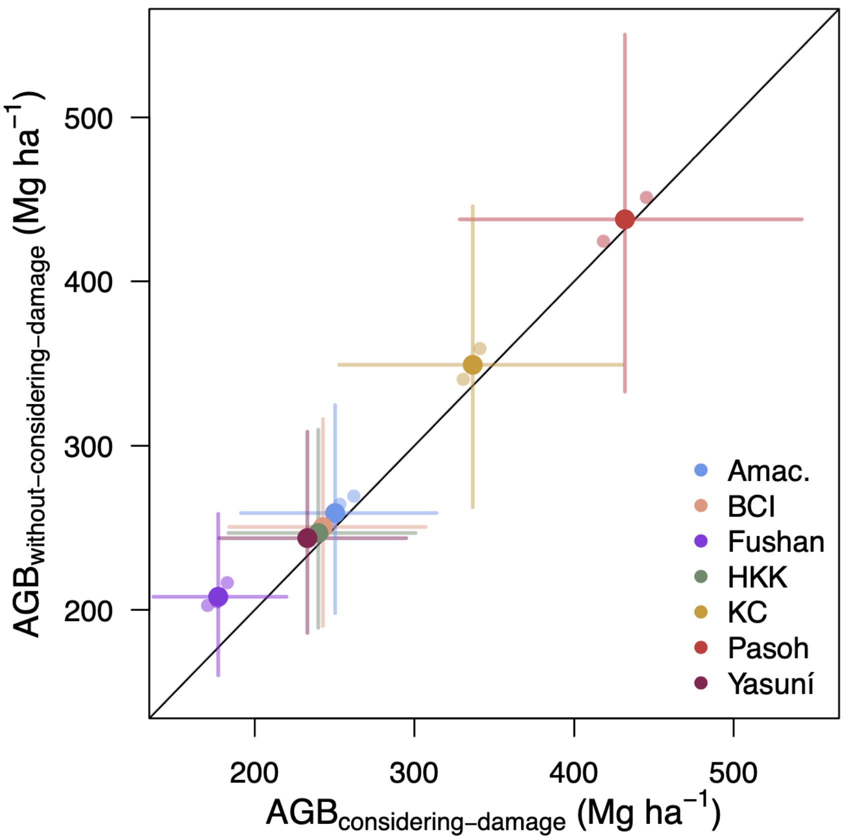

Fig. S4. AGB stock comparisons with and without considering damage in seven tropical forests. Black line indicates the 1:1 line. Amac.: Amacayacu; BCI: Barro Colorado Island; HKK: Huai Kha Khaeng; KC: Khao Chong.

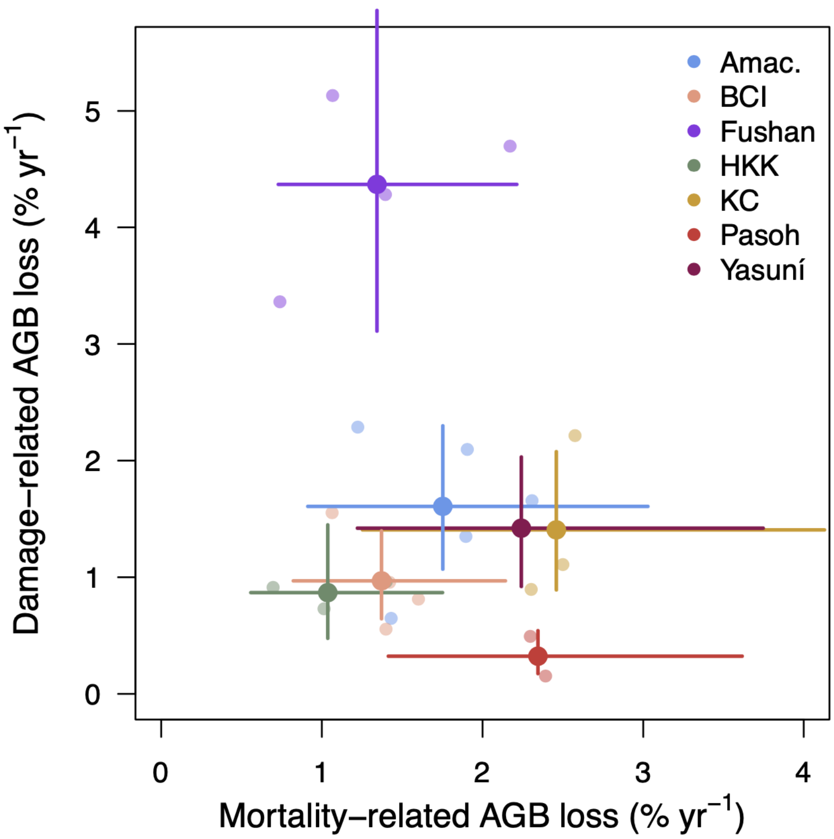

Fig. S5. Damage- and mortality-related AGB loss rates are uncorrelated (P=0.247 all sites, P=0.699 excluding Fushan and Pasoh in linear mixed-effect models for damage rates as a function of mortality rates with site random intercepts). Bars show the 95% confidence limits based on bootstrapping over trees in each period. Amac.: Amacayacu; BCI: Barro Colorado Island; HKK: Huai Kha Khaeng; KC: Khao Chong.

Table S1. ForestGEO site-level characteristics and estimates. AMS: Annual Mortality and damage Surveys. Mostly based on Anderson-Teixeira, et al. (2015) and Davies et al. (2021).

Site, Country	Latitude	Longitude	Area (ha); dimensions (m)	Elevation range (m a.s.l.)	Dominant soil order(s)	Mean annual temperature	Mean annual precipitation	Koppen-Geiger climate zone	Dominant PFT(s)	Major Natural Disturbance Types	Stems in AMS sampling	Tree individuals in AMS sampling	Species in AMS sampling	Genera in AMS sampling	Families in AMS sampling	Tree stems in forest plot	Tree individuals in forest plot	Species in forest plot	Representation of AMS species in the forest (%)	Number of AMSs	Maximum tree height (m)	References for plot description	Start date of the mortality surveys
Amacayacu, Colombia	-3.8091	-70.2678	25; 500 x 500	89-108	Ultisol	25.8	3215	Tropical rainforest	Broadleaf evergreen	Local wind storm	4771	4669	728	287	80	115581	111171	1259	93.9	6	50	Duque et al. (2017), Zuleta et al (2017, 2020)	Nov, 2016
Barro Colorado Island (BCI), Panamá	9.1543	-79.8461	50; 1000 x 500	120-160	Oxisol	27.1	2551	Tropical monsoon	Broadleaf evergreen; Broadleaf drought deciduous	Drought; Local wind storm	8447	7688	221	153	56	278100	276419	301	98.3	5	40	Hubbell (1979), Condit (1998)	Nov, 2016
Fushan, Taiwan	24.7614	121.555	25, 500 x 500	600-733	Ultisol; Inseptisol	18.2	4271	Subtropical rainforest	Broadleaf evergreen	Cyclone	5492	4168	68	48	29	162557	115651	109	96.9	5	23	蘇聲欣, et al. (2007)	Jul, 2017

Huai Kha Khaeng (HKK), Thailand	15.6324	99.217	50; 1000 x 500	549-638	Alfisol	23.5	1473	Tropical wet and dry	Broadleaf evergreen; Broadleaf drought deciduous	Fire; Drought	5353	5005	201	142	52	257158	193894	327	93.0	4	45	Bunyavejchewin et al. (2012)	Jun, 2017
Khao Chong (KC), Thailand	7.54347	99.798	24; 600 x 400	110-360	Ultisol; Inceptisol	27.1	2870	Tropical monsoon	Broadleaf evergreen	Local wind storm, Landslides	4464	4319	382	213	73	126431	98172	639	96.8	4	45	Bunyavejchewin et al. (2019)	Jan, 2017
Pasoh, Malaysia	2.982	102.313	50; 1000 x 500	70-90	Ultisol	27.9	1788	Tropical rainforest	Broadleaf evergreen	Local wind storm	5344	5294	554	225	74	304888	295122	897	74.9	3	60	Manokaran (1990)	Jun, 2017
Yasuni, Ecuador	-0.6859	-76.397	25; 500 x 500	218-248	Ultisol	28.3	3081	Tropical rainforest	Broadleaf evergreen	Local wind storm	5653	5368	741	288	78	164084	150631	1082	94.1	2	50	Valencia et al. (2004)	Nov, 2019

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