Supplementary online material

Methods

Extracting polygon t ha^{-1} values from the raster grid

Our global mangrove map from Spalding *et al.* (2010) is a polygon dataset, whereas the Bioclim climate data on which the model was based is in raster format. The values from this grid therefore had to be extracted and applied to the polygons. This was carried out using ArcGIS 10.1, Quantum GIS 1.7.4 (Quantum GIS Development Team 2011) and R 2.14 (R Development Core Team 2011). For small polygons (< 500 ha), the model value (in t ha^{-1}) at the centroid point was applied to the entire polygon, and the total biomass calculated by multiplying this value by the area of the polygon. For larger polygons (> 500 ha), the “extract” function in the R package “raster” (Hijmans & van Etten 2011) was used. This returns the t ha^{-1} value of the cells of the model layer overlapped by each polygon ($value_{cell}$) and the proportion of each cell covered ($prop_{cell}$). The “area” function was then used to provide an estimate of the area of the relevant cells ($area_{cell}$). The biomass of the area of a polygon in a given cell was then calculated as the $value_{cell}$ x $area_{cell}$ x $prop_{cell}$. The total biomass of the polygon is the sum for all cells overlapping the polygon.

The Bioclim raster grid only has data for land areas. Where some cells in a large polygon were classed as water and had no model value, they were assigned the mean value of all non-water cells in the polygon. Where large polygons fell entirely in areas classed as water, they were assigned the value of the nearest non-water cell. Small polygons whose centroids fell in areas classified as water were ignored, as they accounted for just 0.7% of the total mangrove area.

Results

In addition to the AGB and BGB results detailed in the main text, we collected data on soil carbon stocks and primary productivity in our literature review. These are summarised in Table 2, and are described in more detail below.

Soil carbon: Our soil carbon dataset has a mean value of 433 t C ha^{-1} (n = 40, S.D. = 180 t ha^{-1}) in the top metre of soil. Extrapolation of this mean value would give a total of 6.63 Pg C globally. Such a value would most likely be highly conservative because, although there is considerable spatial variation in soil carbon, many mangrove soils are considerably deeper than 1m: Donato et al. (2011) sampled to 3m depth, and found a mean value of 1023 t C ha^{-1}. They also note that in many of the mangrove areas they studied, soils were deeper than their 3m sampling depth. Soil carbon is also influenced by external sediment delivery into mangrove systems from terrestrial and marine sources, and this would likely need to be factored into any model (Soares 2009). More work is therefore needed before soil carbon can be accurately assessed on a global scale.

Productivity: Our dataset gave reasonable sample sizes for both above-ground net primary productivity (ANPP) and litterfall (n = 37 and n = 46 respectively). For litterfall, we could find no significant relationship with our climate variables. The ANPP data were collected using two different techniques. Around half of them came from the sum of change in biomass (estimated from measures of basal area or stem diameter increments, using pre-determined allometric relations), combined with litterfall, over a given period. The remainder came from estimates of photosynthetic rate, calculated using light attenuation through the canopy. The allometry-based values (n = 15, mean = 19.5 t ha^{-1} yr^{-1}, S.D. = 8.13) had a lower mean and much smaller variance than the light attenuation based values (n = 20, mean = 24.1 t ha^{-1} yr^{-1}, S.D. = 25.7). After separating data according to methods, sample sizes were insufficient for model development. Alongi (2009) suggests that allometry based methods are likely to be most accurate, and our numbers match well with figures of 19.8 t ha^{-1} yr^{-1} from a review by Bouillon *et al.* (2008). Using just the allometry based statistics, the range of values is 3.4-31 t ha^{-1} yr^{-1}. This is remarkably high – higher indeed than many estimates of ANPP for tropical evergreen forests (1.4-15 t ha^{-1} yr^{-1}) (Kloeppel et al, 2007) – confirming that although very variable, mangroves can be highly productive ecosystems.

Supplementary references

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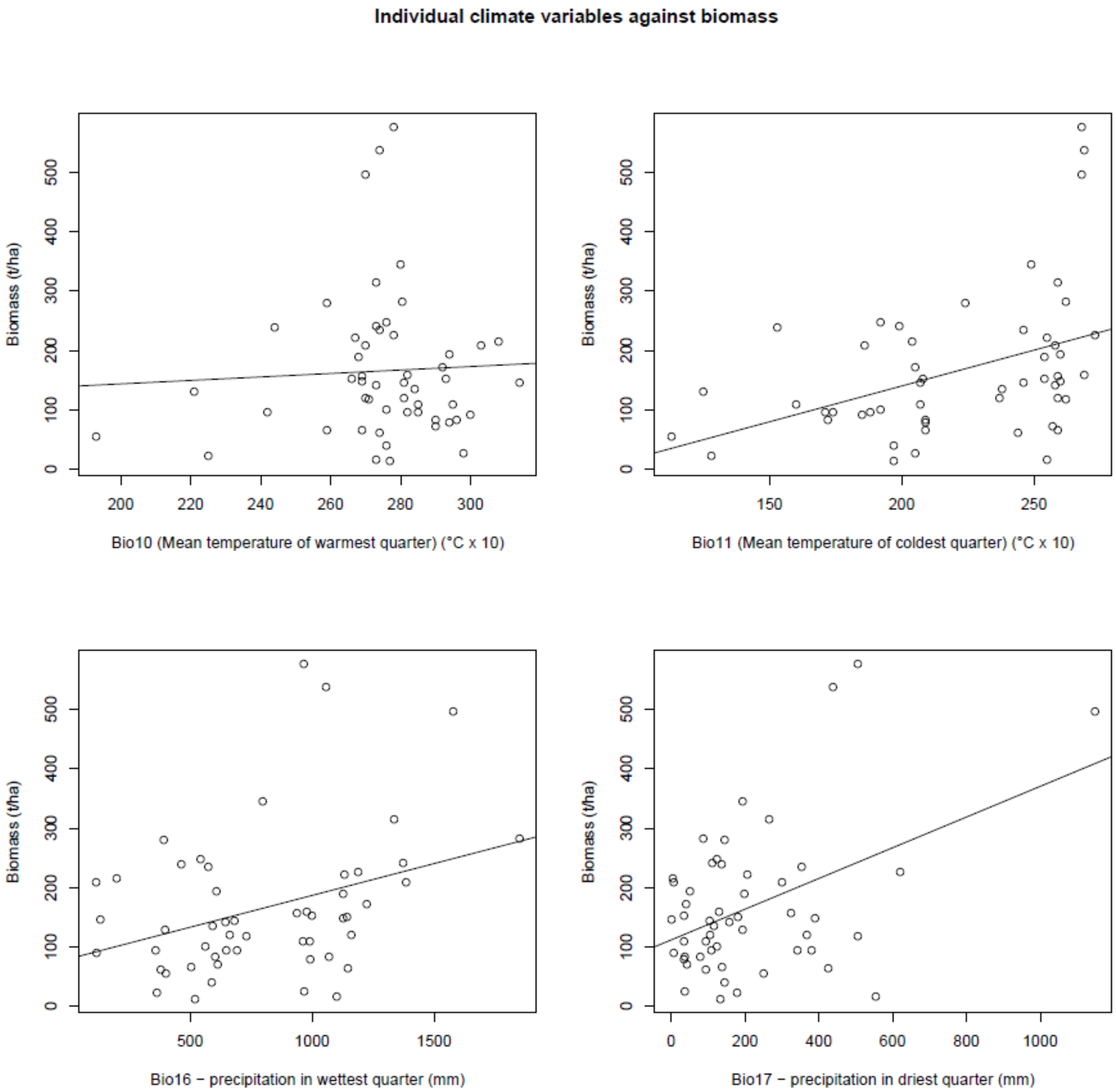

Figure S1: Plots of the 52 AGB data points against the climate variables used in the final model.

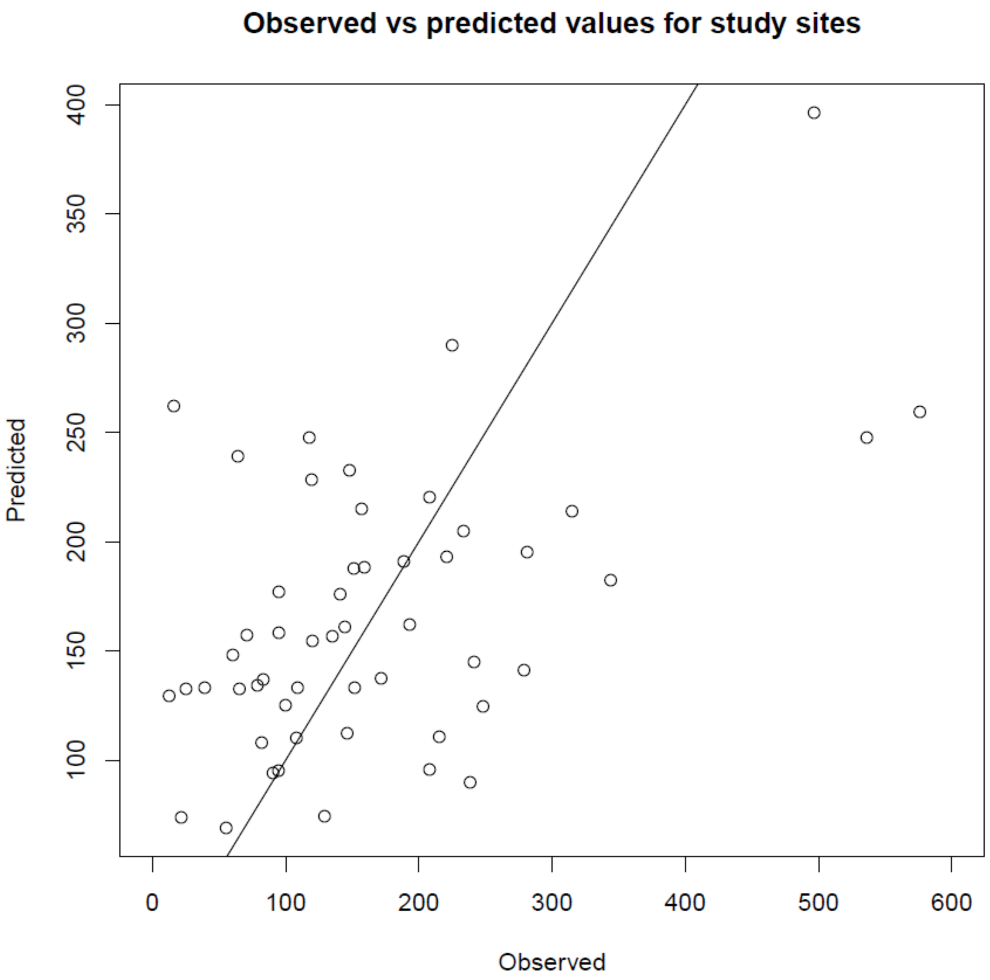

Figure S2: Plot of the 52 AGB observed values against the values predicted by the model for those locations, with a 1:1 line.

Table S1: References for biomass and flux data found by the literature search.

Reference	Location of field data
Aké-Castillo, J. A., Vázquez, G. & López-Portillo, J. Litterfall and Decomposition of Rhizophora mangle L. in a Coastal Lagoon in the Southern Gulf of Mexico. *Hydrobiologia* 559, 101–111 (2006).	Mexico
Alongi, D. M. Patterns of Mangrove Wood and Litter Production Within a Beach Ridge-Fringing Reef Embayment, Northern Great Barrier Reef Coast. *Estuaries and Coasts* (2010).doi:10.1007/s12237-010-9289-y	Australia
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Table S2: AGB and BGB mean and total by country, sorted by total AGB, for all countries with >5000 ha of mangroves.

Country	Mean AGB (t ha)	Total AGB (t)	Mean BGB (t ha)	Total BGB (t)	Area (ha)
Indonesia	244.1	729,075,000	103.9	310,218,000	2,986,496
Brazil	168.7	227,460,000	63.4	85,465,000	1,347,998
Mexico	139.9	134,907,000	49.7	47,925,000	964,438
Nigeria	195.1	152,010,000	76.7	59,762,000	778,944
Malaysia	252.5	179,186,000	107.9	76,598,000	709,661
Australia	135.2	85,489,000	47.7	30,177,000	632,164
Mozambique	128.1	67,121,000	45.3	23,751,000	523,903
Burma	173.1	89,001,000	65.7	33,800,000	514,261
Cuba	140.4	69,628,000	49.9	24,772,000	495,975
Bangladesh	137.3	67,299,000	50.2	24,616,000	490,048
Papua New Guinea	235.7	98,684,000	99.4	41,617,000	418,611
Colombia	253.2	103,870,000	108.1	44,351,000	410,152
India	141.8	57,326,000	55.3	22,351,000	404,390
Venezuela	180	64,143,000	64.7	23,066,000	356,444
USA (Florida)	122.7	37,067,000	41.7	12,605,000	302,041
Madagascar	144.1	43,326,000	51.6	15,523,000	300,621
Guinea-Bissau	163	48,990,000	60.8	18,259,000	300,497
Philippines	212.9	54,893,000	79.4	20,483,000	257,815
Thailand	188.2	47,002,000	72.8	18,191,000	249,779
Guinea	192	39,226,000	75	15,333,000	204,323
Panama	170.9	29,999,000	64.5	11,322,000	175,544
Gabon	148.6	23,894,000	53.6	8,618,000	160,754
Ecuador	141.5	22,515,000	50.1	7,981,000	159,145
Cameroon	193	30,378,000	75.6	11,904,000	157,424
French Guiana	202	28,044,000	80.3	11,145,000	138,849
Senegal	142.2	18,355,000	56.3	7,262,000	129,077
Tanzania	155.2	19,853,000	59.2	7,580,000	127,959
Vietnam	149.6	15,767,000	54.4	5,735,000	105,392
Sierra Leone	180.2	17,743,000	69.1	6,801,000	98,438
Pakistan	106.3	10,429,000	41.6	4,075,000	98,060
Belize	156.9	15,186,000	58	5,614,000	96,794
Bahamas, The	138.4	12,153,000	50.7	4,455,000	87,795
Iran	103.5	7,770,000	33.2	2,495,000	75,103
Nicaragua	186.2	12,556,000	72.7	4,906,000	67,449
Honduras	180.7	11,386,000	68.2	4,299,000	63,024
Solomon Islands	275.8	17,039,000	105.5	6,519,000	61,773
Kenya	150.6	9,241,000	55.1	3,380,000	61,355
Cambodia	189	11,455,000	72.4	4,385,000	60,607

The Gambia	144.9	8,437,000	51.8	3,014,000	58,229
Fiji	190.6	9,875,000	71	3,677,000	51,800
Suriname	200.4	10,286,000	75.2	3,859,000	51,320
Costa Rica	186.6	9,273,000	72.6	3,610,000	49,702
Guyana	222.9	8,969,000	83.2	3,347,000	40,242
Angola	117.8	4,004,000	45	1,528,000	33,989
Saudi Arabia	122.1	3,811,000	43	1,343,000	31,212
El Salvador	152.9	4,734,000	55.6	1,720,000	30,962
Guatemala	162.3	4,924,000	60.2	1,828,000	30,341
New Zealand	77.5	2,021,000	25.9	676,000	26,082
Equatorial Guinea	167.2	4,297,000	62.5	1,607,000	25,700
New Caledonia	132.7	3,030,000	57.9	1,322,000	22,841
Dominican Republic	176.3	4,003,000	59.6	1,354,000	22,700
China	96.8	1,898,000	32.4	635,000	19,604
Congo, (Kinshasa)	121.5	2,375,000	43.9	858,000	19,548
Brunei	297.6	5,183,000	134.5	2,343,000	17,418
Ghana	166.9	2,297,000	57.1	786,000	13,759
Haiti	154.8	2,109,000	56.7	772,000	13,621
Turks And Caicos Islands	146.5	1,633,000	53.4	595,000	11,148
Liberia	212.3	2,325,000	73.3	803,000	10,951
Eritrea	143.7	1,473,000	56.9	583,000	10,248
Cote d'Ivoire	177.9	1,772,000	62.3	621,000	9,962
Jamaica	160.8	1,576,000	60.1	589,000	9,801
Sri Lanka	173.1	1,548,000	65.4	585,000	8,945
Micronesia, Federated States of	341	2,864,000	126.2	1,060,000	8,398
Puerto Rico	164	1,218,000	61.4	456,000	7,423
United Arab Emirates	75.4	516,000	24.1	165,000	6,846
Benin	160.6	1,070,000	59.3	395,000	6,663
Trinidad and Tobago	166	1,098,000	62	410,000	6,614
Cayman Islands	159.1	1,010,000	58.6	372,000	6,348
Guadeloupe	165.5	885,000	61.7	330,000	5,346
Peru	116.4	618,000	43.3	230,000	5,312
Palau	279.7	1,440,000	103.1	531,000	5,148