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Supplementary Materials for

Biodiversity recovery of Neotropical secondary forests

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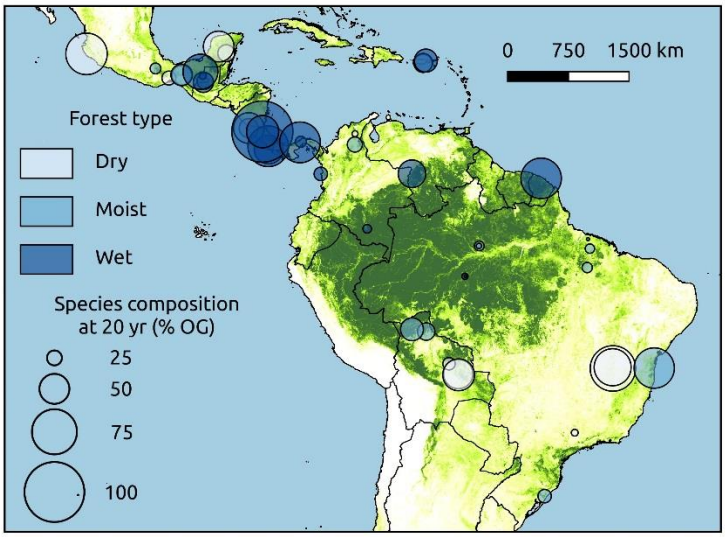

Fig. S1. Relative recovery of species composition [% old-growth (OG)] for Neotropical secondary forests after 20 years. The 45 study sites are indicated, the size of the symbols scales with predicted recovery 20 years after abandonment. Green shading indicates forest cover (*39*).

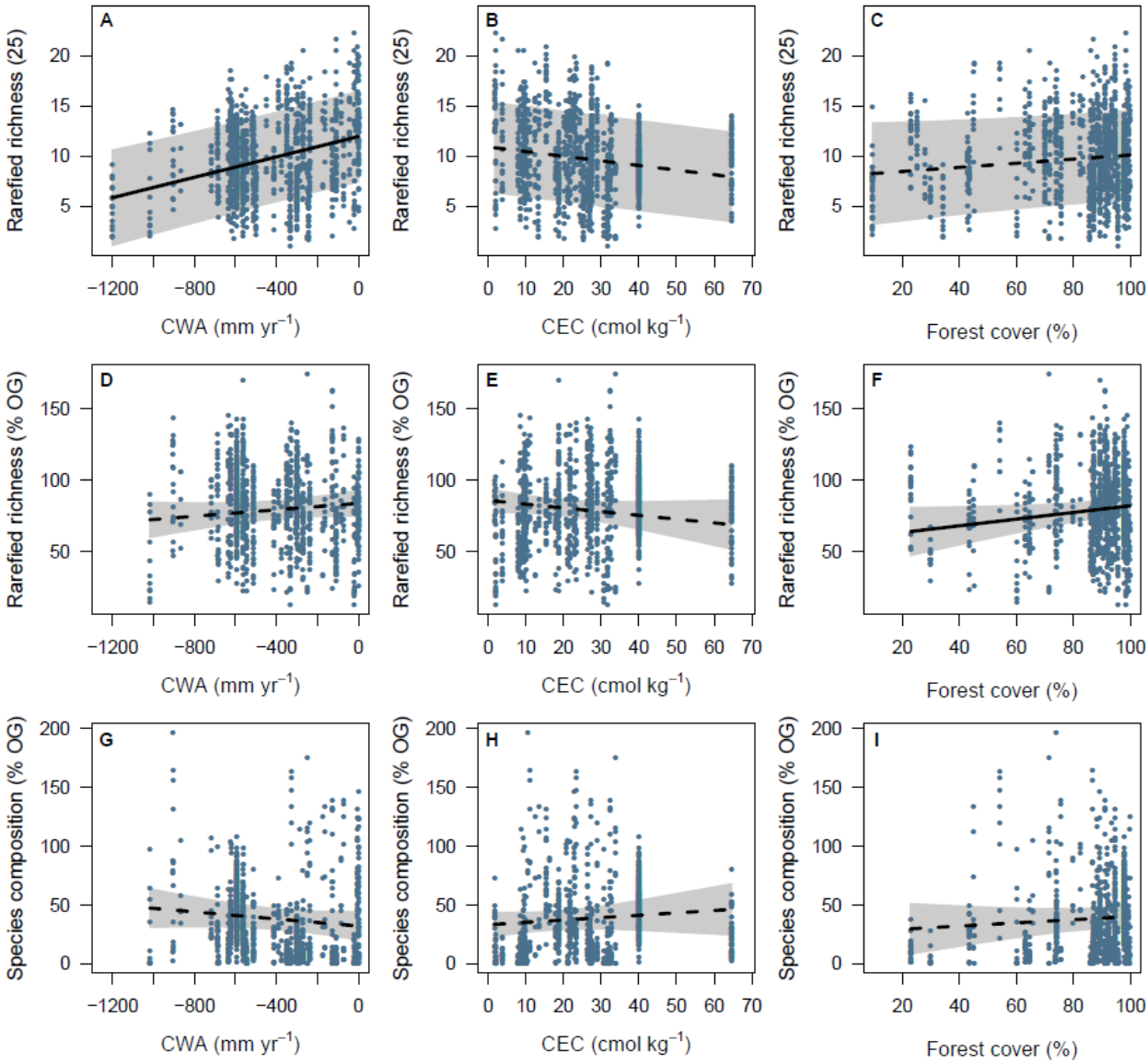

Fig. S2. Absolute recovery of species richness, and relative recovery of species richness and species composition, in relation to CWA, CEC, and forest cover in the landscape matrix for Neotropical secondary forests. All predictions are indicated for shifting cultivation as type of previous land use, other predictors are kept constant at the mean. Solid lines indicated significant relationships; dashed lines indicate non-significant relationships.

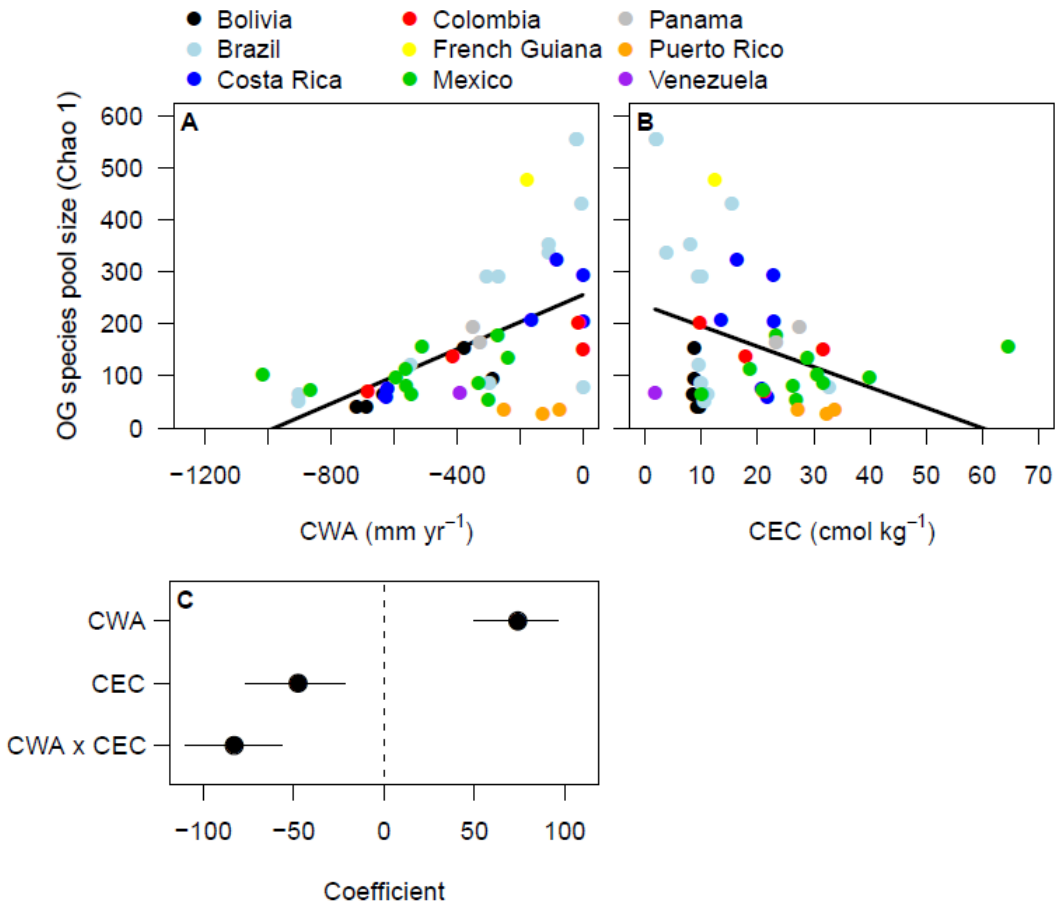

Fig. S3. Effects of CWA and soil fertility (CEC) on the local old-growth species pool (based on the Chao 1 estimator) for 45 Neotropical secondary forest sites. (**A**) old-growth species pool vs. CWA. (**B**) old-growth species pool vs. CEC. (**C**) effects of CWA, CEC, and their interaction on the size of the old-growth species pool based on results of a mixed-effects model. CWA, CEC, and their interaction were included as fixed effects. We included a random intercept for the general region (South America vs. Central America and Mexico). CWA and CEC were standardized by subtracting the mean and dividing by the standard deviation.

Table S1. Characteristics of the included Neotropical secondary forest sites. The name of the chronosequence site, country, latitude (Lat.) and longitude (Long.), annual rainfall (in mm yr^{-1}), CWA (in mm yr^{-1}), CEC (in cmol(+) kg^{-1}), forest cover in the landscape matrix (FC; in %), previous land use (LU), the number of secondary forest (SF) plots with plot size (or plot size range; in ha) indicated in parentheses, the age range of secondary forests (in yr) included in the chronosequence, the number of old-growth forest plots with plot size (or plot size range; in ha) indicated in parentheses, and a reference (Ref.) for the site are indicated. Only plots with ≥ 25 stems were included. Note that CWA values have been updated compared to a previous study (*15*), because of the availability of more detailed coordinates for many of the sites now.

Site	Country	Lat.	Long.	Rainfall	CWD	CEC	FC	LU	# SF (size)	Age	# OGF (size)	Ref.
El Tigre	Bolivia	-11.98	-65.72	1780	-378	8.8	90.3	SC	5 (0.06-0.16)	5-25	1 (0.05)	(*40*)
El Turi	Bolivia	-11.75	-67.33	1833	-288	8.8	99.7	SC	6 (0.04-0.14)	2-40	1 (0.11)	(*40*)
Lomerio	Bolivia	-16.62	-61.91	1061	-688	9.6	94.6	SC	23 (0.1)	3-15	7 (0.1)	
Salvatierra	Bolivia	-15.5	-63.03	1200	-635	8.5	98.8	SC	25 (0.1)	1-36	8 (0.1)	(*41*)
San Lorenzo	Bolivia	-16.7	-61.87	1129	-719	9.3	94.5	SC	10 (0.6)	5-50	7 (0.1)	(*42*)
Bahia	Brazil	-14.48	-39.09	2000	-6	15.4	94.5	SC	27 (0.1)	10-40	15 (0.06)	(*43*)
Cajueiro	Brazil	-14.98	-43.95	840	-906	10.5	73.9	PA	6 (0.1)	14-27	3 (0.1)	
Eastern Pará 1	Brazil	-4.26	-47.73	1898	-549	9.5	63.1	SC & PA	15 (0.025)	5-25	5 (0.025)	(*44*)
Eastern Pará 2	Brazil	-2.19	-47.5	2460	-270	9.4	64.6	SC & PA	25 (0.025-0.25)	5-40	9 (0.025)	(*44*)
Eastern Pará 3	Brazil	-1.17	-47.75	2785	-306	10	73.6	PA	8 (0.025)	6-70	9 (0.025)	(*44*)
Manaus (*Cecropia* pathway)	Brazil	-2.38	-59.91	2400	-22	2	98.4	SC	13 (0.03-0.06)	5-31	10 (0.05)	(*45*)
Manaus (*Vismia* pathway)	Brazil	-2.39	-59.94	2400	-20	2	99	PA	9 (0.02-0.06)	2-25	10 (0.05)	(*45*)
Maquiné	Brazil	-29.57	-50.2	1720	0	32.7	94.6	SC	20 (0.03)	6-45	9 (0.03)	(*46*)
Mata Seca	Brazil	-14.85	-43.99	825	-904	11.1	86.6	PA	11 (0.1)	12-42	6 (0.1)	(*47*)
Middle Madeira River (anthropogenic soil)	Brazil	-5.78	-61.46	2507	-109	3.8	86.9	SC	22 (0.025)	5-30	8 (0.1)	(*48*)
Middle Madeira River (oxisol)	Brazil	-5.76	-61.41	2507	-110	8	86	SC	26 (0.025)	6.5-30	8 (0.1)	(*48*)
Patos	Brazil	-7.12	-37.47	750	-1201	13.2	34.2	SC & PA	15 (0.1)	20-62	-	(*49*)
Sao Paulo	Brazil	-22.32	-47.57	1367	-297	9.9	22.8	PA	18 (0.09)	11-45	2 (0.09-0.094)	
Serra do Cipo	Brazil	-19.3	-43.61	1519	-334	10.6	27.8	PA	8 (0.1)	4-50	-	
Araracuara	Colombia	-0.6	-72.37	3059	-14	9.7	92.1	SC	4 (0.04-0.05)	7-30	1 (0.05)	(*50*)
Cabo Corrientes	Colombia	5.57	-77.5	6000	0	31.7	45.2	SC[a]	3 (0.1)	3-35	1 (0.1)	
Cesar (dry forest)	Colombia	10.04	-73.73	1343	-684	21.1	29.7	SC & PA	12 (0.02)	8-32	4 (0.02)	
Cesar (moist forest)	Colombia	8.83	-73.74	1643	-414	17.9	43.3	PA	17 (0.02)	3-40	9 (0.02)	
Mingueo	Colombia	11.19	-73.44	1504	-571	24.3	82.3	PA	9 (0.1)	12.5-45	-	
Providencia Island	Colombia	13.35	-81.37	1584	-501	31.8	9.4	SC & PA	33 (0.01)	6-56	-	(*51*)
San Juan	Colombia	9.91	-75.17	1824	-450	22.4	83.3	PA	9 (0.1)	17.5-35	-	
Nicoya Peninsula	Costa Rica	9.97	-85.3	2130	-619	27.4	69.9	SC & PA	52 (0.12)	8-35	-	
Osa 1	Costa Rica	8.4	-83.33	3750	-164	13.5	44.8	PA	8 (0.5)	10-40	3 (0.5)	(*52*)
Osa 2	Costa Rica	8.77	-83.39	4750	-85	16.3	79.7	PA	6 (0.5)	10-40	2 (0.5)	(*52*)

Palo Verde	Costa Rica	10.36	-85.31	1444	-623	24.5	42.8	PA	19 (0.1)	7-60	-	(*53*)
Santa Rosa (oak forest)	Costa Rica	10.89	-85.6	1765	-609	20.1	75.7	PA	17 (0.1)	5-70	-	(*53*)
Santa Rosa 1	Costa Rica	10.85	-85.61	1765	-626	21.7	74.1	PA	40 (0.1)	6-70	3 (0.1)	(*53*)
Santa Rosa 2	Costa Rica	10.86	-85.61	1765	-621	20.7	82.5	SC & PA	6 (0.1)	30-41	3 (0.1)	(*54*)
Sarapiquí 1	Costa Rica	10.43	-84.07	4000	0	22.8	89.1	PA	6 (1)	10-41	2 (1)	(*55*)
Sarapiquí 2	Costa Rica	10.42	-84.05	4000	0	22.9	88.3	PA	23 (0.1)	10-42	7 (0.1)	(*56*)
Arbocel	French Guiana	5.3	-53.05	3040	-176	12.5	99.9	SC[a]	5 (0.081-0.212)	3.5-28.5[b]	5 (0.2)	(*57*)
Chajul	Mexico	16.09	-90.99	3000	-272	23.3	88.6	SC	14 (0.1)	2-27	3 (0.5)	(*58*)
Chamela	Mexico	19.54	-105	788	-867	21	65.7	PA	5 (0.1)	7-15	3 (0.1)	(*59*)
Chinantla	Mexico	17.75	-96.65	1593	-546	10.1	99.5	SC	24 (0.008-0.053)	5-50	2 (0.024-0.031)	
Comunidad Lacandona	Mexico	16.81	-91.1	2500	-333	31.7	95.6	SC & PA	41 (0.1)	1-30	23 (0.1)	
El Ocote 1	Mexico	16.92	-93.54	1500	-563	26.3	91.7	SC	28 (0.1)	2-75	14 (0.1)	(*60*)
El Ocote 2	Mexico	16.97	-93.55	2000	-563	18.6	89.4	SC	61 (0.1)	3-75	14 (0.1)	(*60*)
JM Morelos	Mexico	19.31	-88.58	1250	-512	64.6	92.3	SC & PA	54 (0.05)	3-80	22 (0.05)	
Kaxil Kiuic	Mexico	20.08	-89.51	1100	-595	39.9	97.8	SC	234 (0.02)	4-70	17 (0.04)	(*61*)
Marqués de Comillas	Mexico	16.2	-90.8	2250	-302	26.9	87.2	SC & PA	71 (0.1)	2-40	10 (0.1)	
Nizanda	Mexico	16.65	-95.01	878	-1018	30.6	60.1	SC	11 (0.04)	9-60	14 (0.05)	(*62*)
Tenosique	Mexico	17.27	-91.41	2750	-238	28.8	93.4	SC	24 (0.05)	6-15	23 (0.05)	
Zona Norte of Selva Lacandona	Mexico	17.09	-91.47	2750	-243	25.2	85.7	SC & PA	37 (0.1)	2-52	-	
Agua Salud	Panama	9.21	-79.75	2700	-350	27.5	91.1	SC & PA	40 (0.2)	5-31	10 (0.2)	(*9*, *63*)
Barro Colorado Nature Monument	Panama	9.14	-79.85	2600	-328	23.3	54.1	SC & PA	8 (0.32)	20-100	2 (0.32)	(*8*)
Playa Venado	Panama	7.43	-80.18	1550	-520	20.8	25.1	PA	13 (0.2)	6-80	-	
Pucallpa	Peru	-8.53	-74.88	1570	-45	12.4	71.8	SC & PA	14 (0.1)	5-30	-	
Cayey	Puerto Rico	18.02	-66.08	2000	-251	33.8	71.4	PA	12 (0.058)	20-80	3 (0.058)	(*64*)
El Carite	Puerto Rico	18.08	-66.07	1822	-128	32.3	91.1	PA	27 (0.1)	4-77	3 (0.1)	(*65*)
Luquillo	Puerto Rico	18.34	-65.76	2660	-73	27.2	75.6	PA	12 (0.1)	9-76	3 (0.1)	(*65*)
Gavilán	Venezuela	5.55	-67.4	2673	-391	1.7	99.3	SC	12 (0.1)	5-20	3 (0.1)	

[a]Forest was clear-cut, but land was not subsequently used.
[b]Chronosequence included longitudinal data; ages refer to the same plots, but at distinct points in time.

Table S2. Characteristics of the dataset for 56 Neotropical secondary forest sites. The minimum dbh (in cm), the total area sampled across all plots in secondary forest and old-growth forest (in ha) the study design (nested vs. non-nested), the total number of species in secondary forest plots, the size of the local species pool based on old-growth forest plots only (Chao 1), the average within old-growth similarity based on the Chao-Jaccard index, and the percentage of stems identified to family, genus, species and morpho species, are indicated.

Site	Country	Min. dbh	Area SF	Area OG	Nested	No. spp SF	Chao 1 (pool)	Chao-Jaccard OG	Family (%)	Genus (%)	Species (%)	Morpho (%)
El Tigre	Bolivia	5 cm	0.47	0.05	no[a]	53	152	-	99	95	78	100
El Turi	Bolivia	5 cm	0.52	0.11	no[a]	68	92	-	99	94	80	100
Lomerio	Bolivia	10 cm	2.3	0.7	no	107	39	0.8	91	88	86	100
Salvatierra	Bolivia	5 cm	2.5	0.8	no	111	65	0.72	97	97	86	100
San Lorenzo	Bolivia	10 cm	6	0.7	yes	44	39	0.8	96	95	94	99
Bahia	Brazil	5 cm	2.7	0.9	no	437	430	0.43	100	99	95	100
Cajueiro	Brazil	5 cm	0.6	0.3	no	76	50	0.84	100	100	100	100
Eastern Pará 1	Brazil	5 cm	0.38	0.13	no	120	121	0.2	100	100	100	100
Eastern Pará 2	Brazil	5 cm	2.28	0.23	no	281	290	0.3	100	100	100	100
Eastern Pará 3	Brazil	5 cm	0.2	0.23	no	113	290	0.3	100	100	100	100
Manaus (*Cecropia* pathway)	Brazil	5 cm	0.49	0.5	no	193	555	0.42	100	97	91	100
Manaus (*Vismia* pathway)	Brazil	5 cm	0.38	0.5	no	80	555	0.42	100	97	92	100
Maquiné	Brazil	5 cm	0.6	0.27	yes	97	77	0.36	100	100	100	100
Mata Seca	Brazil	5 cm	1.1	0.6	no	59	63	0.59	100	100	99	100
Middle Madeira River (anthropogenic soil)	Brazil	5 cm	0.55	0.8	no	142	336	0.39	100	99	94	100
Middle Madeira River (oxisol)	Brazil	5 cm	0.65	0.8	no	166	353	0.38	100	99	95	100
Patos	Brazil	5 cm	1.5	-	no	21	-	-	100	100	100	100
Sao Paulo	Brazil	5 cm	1.62	0.18	no	180	86	0.06	94	94	80	97
Serra do Cipo	Brazil	5 cm	0.8	-	no	73	-	-	100	100	97	100
Araracuara	Colombia	5 cm	0.19	0.05	no	84	203	-	98	98	92	98
Cabo Corrientes	Colombia	5 cm	0.3	0.1	no	58	150	-	100	100	85	100
Cesar (dry forest)	Colombia	5 cm	0.24	0.08	no	42	70	0.14	100	86	58	100
Cesar (moist forest)	Colombia	5 cm	0.34	0.18	no	60	137	0.11	100	100	80	100
Mingueo	Colombia	5 cm	0.9	-	no	83	-	-	100	99	80	100
Providencia Island	Colombia	5 cm	0.33	-	no	58	-	-	94	91	71	100
San Juan	Colombia	5 cm	0.9	-	no	128	-	-	99	91	73	100
Nicoya Peninsula	Costa Rica	5 cm	6.24	-	no	192	-	-	100	100	99	100
Osa 1	Costa Rica	5 cm	4	1.5	no	226	206	0.81	99	99	97	99
Osa 2	Costa Rica	5 cm	3	1	no	217	322	0.59	98	98	94	98
Palo Verde	Costa Rica	10 cm	1.9	-	no	70	-	-	100	100	100	100
Santa Rosa (oak forest)	Costa Rica	10 cm	1.7	-	no	72	-	-	100	100	100	100
Santa Rosa 1	Costa Rica	10 cm	4	0.3	no	118	60	0.03	100	100	100	100
Santa Rosa 2	Costa Rica	5 cm	0.6	0.3	no	77	74	0.39	100	100	100	100
Sarapiquí 1	Costa Rica	5 cm	6	2	no	252	292	0.66	100	100	99	100
Sarapiquí 2	Costa Rica	5 cm	2.3	0.7	no	218	204	0.55	100	100	99	100
Arbocel	French Guiana	5 cm	0.66	1	no	147	477	0.83	100	100	99	100
Chajul	Mexico	5 cm	1.4	1.5	yes[b]	117	178	0.58	100	98	95	100
Chamela	Mexico	5 cm	0.5	0.3	no	55	72	0.59	100	100	98	100
Chinantla	Mexico	5 cm	0.73	0.05	no	109	64	0	97	96	88	97
Comunidad Lacandona	Mexico	5 cm	4.1	2.3	yes	84	85	0.16	99	99	98	100
El Ocote 1	Mexico	5 cm	2.8	1.4	yes	95	79	0.31	98	98	98	100
El Ocote 2	Mexico	5 cm	6.1	1.4	yes	153	112	0.21	100	100	99	100
JM Morelos	Mexico	5 cm	2.7	1.1	no	152	155	0.29	100	100	99	100
Kaxil Kiuic	Mexico	5 cm	4.68	0.68	no	125	96	0.31	100	100	100	100
Marqués de Comillas	Mexico	5 cm	7.1	1	yes	111	53	0.08	96	91	85	100

Nizanda	Mexico	5 cm	0.44	0.7	no	48	101	0.61	100	100	91	100
Tenosique	Mexico	5 cm	1.2	1.15	no	110	134	0.68	100	100	97	100
Zona Norte of Selva Lacandona	Mexico	5 cm	3.7	-	yes	86	-	-	99	97	97	100
Agua Salud	Panama	5 cm	8	2	no	223	193	0.75	100	100	100	100
Barro Colorado Nature Monument	Panama	5 cm	2.56	0.64	no	206	163	0.7	100	100	100	100
Playa Venado	Panama	5 cm	2.6	-	no	92	-	-	100	100	100	100
Pucallpa	Peru	5 cm	1.4	-	no	196	-	-	98	96	80	98
Cayey	Puerto Rico	10 cm	0.69	0.17	no	40	34	0.5	94	94	92	94
El Carite	Puerto Rico	5 cm	2.7	0.3	yes	89	27	0.77	99	99	99	99
Luquillo	Puerto Rico	5 cm	1.2	0.3	yes	65	34	0.71	99	99	99	99
Gavilán	Venezuela	5 cm	1.2	0.3	no	55	66	0.75	100	97	86	100

[a] Plot sizes were variable (*15*).
[b] Only OG plots had a nested design.

Table S3. Correlations between predictors for 56 Neotropical secondary forest sites. Pairwise correlations (Pearson's *r*) between secondary forest plot age, CWA, CEC, forest cover, and plot size are indicated (*n* = 1303 secondary forest plots).

	age	CWA	CEC	FC
CWA	-0.12			
CEC	0.09	-0.21		
FC	-0.11	0.13	0.21	
plot size	0.01	0.14	-0.22	-0.06

Table S4. Correlations between predictors for 45 Neotropical secondary forest sites for which data from old-growth plots were included. Pairwise correlations (Pearson's *r*) between secondary forest plot age, the size of the old-growth species pool (based on the Chao 1 estimator), CWA, CEC, forest cover, and plot size are indicated (*n* = 1053 secondary forest plots).

	age	Chao 1 (pool)	CWA	CEC	FC
Chao 1 (pool)	-0.09				
CWA	-0.06	0.57			
CEC	0.12	-0.33	-0.26		
FC	-0.06	0.02	-0.05	0.29	
plot size	0.02	0.07	0.18	-0.21	-0.12