Energetic equivalence underpins the size structure of tree and phytoplankton communities

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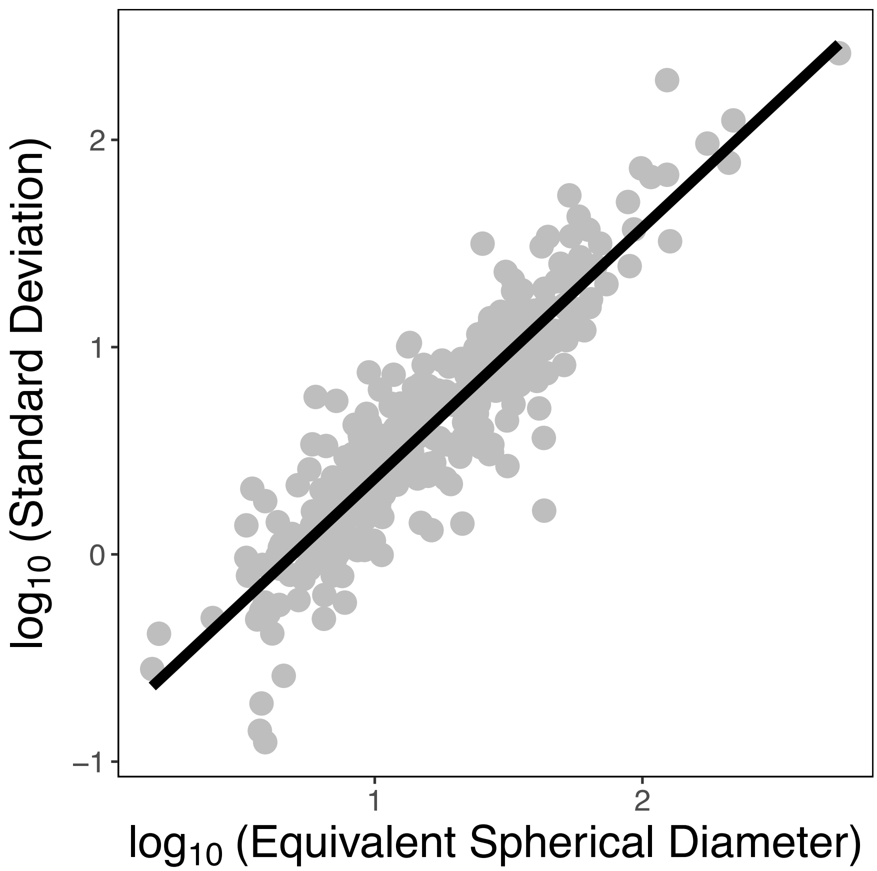
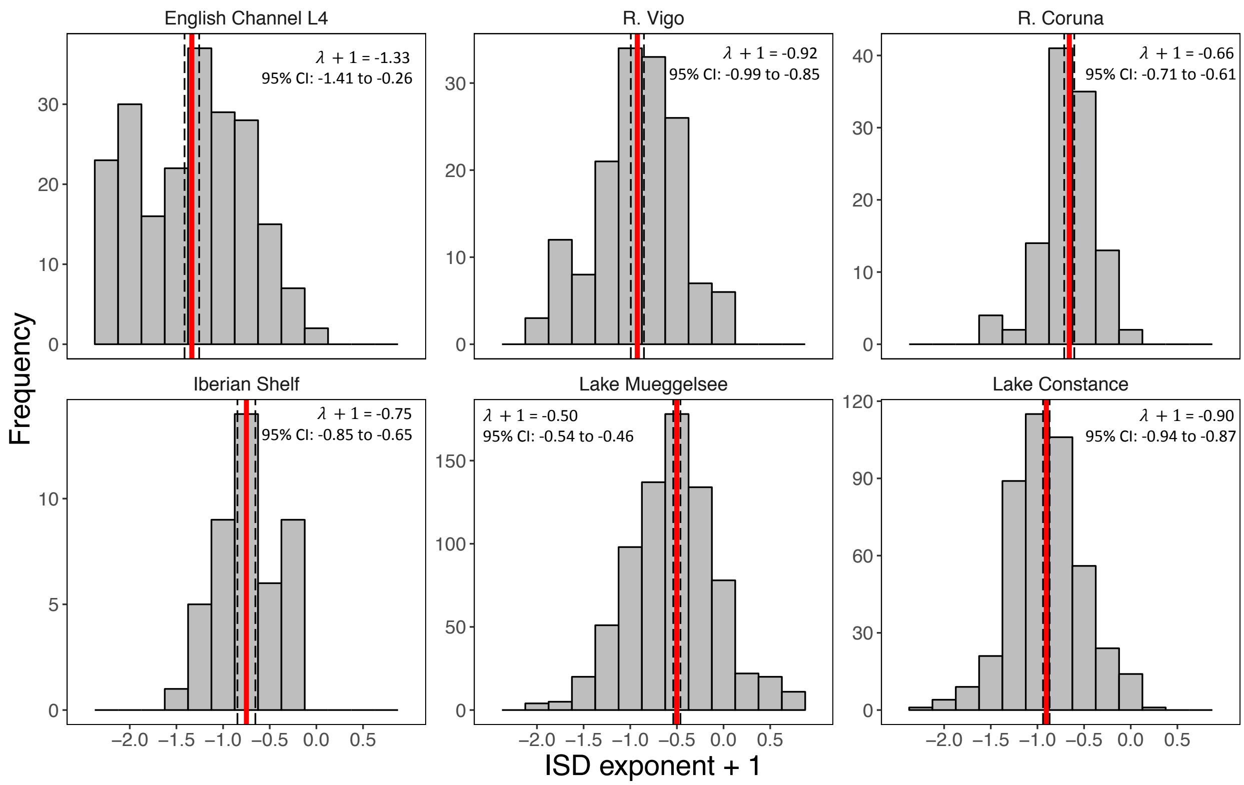


Supplementary Figure 1| Relationship between the mean and standard deviation of phytoplankton size. The strong fitted relationship derived for the size variation (Equivalent Spherical Diameter, ESD, µm) for marine and freshwater species (SD[ESD] = 0.144 $ESD^{1.21}$, conditional $R^2 = 0.81$), allows the continuous individual size distribution to be estimated for phytoplankton datasets, where individual size measurements were not available. This was achieved by randomly sampling individual sizes for each species from a normal distribution with the reported taxon-specific ESD in the original data sources and the standard deviation estimated from the derived relationship.



Supplementary Figure 2| Frequency histogram of individual size distribution exponents from point measurements of phytoplankton size structure. The mean among-site ISD exponent for the six stations ($\bar{\lambda} + 1$ =-0.85; 95% confidence interval: -1.06 to -0.63) does not differ from the mean among-site ISD exponent after temporal aggregation (see Results in main text) or ISD exponents from spatially distributed communities (two-sample t-test: t = -0.49, df = 93, P = 0.627; Fig. 2b). Thus, the stations included in the temporal data set can be considered representative of the stations in the spatial data set and the general form of the ISD is invariant with temporal scale. The mean within-site exponent and 95 % confidence intervals are indicated in each panel by the solid and dashed vertical lines, respectively.

Supplementary Table 1| Details of the datasets complied in this study.

Dataset	Description	Region	Number of sites	Spatial or temporal survey	Number of surveys	Sampling area or sampling depth	Survey year(s)	References
Gentry	Tropical and temperate closed-canopy forest communities	Africa (15), Asia (18), Australasia (1), Europe (4), Mesoamerica (24), North America (23), South America (102)	187	S (transect)	187	0.1 ha	1970's-1990's	[1,2]
Western Ghats	Wet evergreen / moist / dry deciduous forests	Asia	34	S (plot)	34	1 ha	1996-1997	[3]
La Selva	Tropical wet forest	Mesoamerica	5	S (plot)	5	2.24 ha	2009	[4,5]
Lahei	Tropical moist forest	Asia	3	S (plot)	3	1 ha	1998	[6–9]
DeWalt Bolivia forest plots	Tropical moist forest	South America	2	S (plot)	2	1 ha	N/A	[10]
Serimbu	Tropical rainforest	Asia	2	S (plot)	2	1 ha	1995*	[8,9,11,12]
Shirakami	Beech forest	Asia	2	S (plot)	2	1 ha	2006	[8,9,13]
ACA Amazon Forest Inventories	Tropical moist forest	South America	1	S (plot)	1	1 ha	2000-2001	[14]
Barro Colarado Island	Tropical moist forest	Mesoamerica	1	S (plot)	1	50 ha	2010	[15–17]
Cocoli	Tropical moist forest	Mesoamerica	1	S (plot)	1	4 ha	1998	[18–20]
Luquillo	Tropical moist forest	Mesoamerica	1	S (plot)	1	16 ha	1994-1996†	[21,22]
Oosting	Hardwood forest	North America	1	S (plot)	1	6.55 ha	1989	[23,24]
Sherman	Tropical moist forest	Mesoamerica	1	S (plot)	1	5.96 ha	1999	[17,19,20]
UCSC FERP	Mediterranean mixed evergreen forest	North America	1	S (plot)	1	6 ha	2007	[25]
AMT 1-3	North & south Atlantic Ocean	Equatorial (23), North Subtropical	75	S	75	7-160 m	1995-1997	[26]

TRYNITROP	Subtropical Atlantic Ocean	gyre (6), North Temperate (13), South Subtropical gyre (21), South Temperate (12) Equatorial (10), North Subtropical gyre (4), South Subtropical gyre (3)	17	S	17	surface	2007	27
Iberian Shelf	Coastal shelf	North Temperate	1	T (weekly)	44	0-70 m	2001-2002	26
PML L4 English Channel	Coastal shelf	North Temperate	1	T (weekly)	209	surface	1992-2007	26,28
Ría de Vigo	Coastal embayment	North Temperate	1	T (weekly)	150	0-20 m	1990-1992	26
Ría of A Coruña RADIALES	Coastal shelf	North Temperate	1	T (monthly)	111	0-5 m	1993-2002	29,30
Lake Constance	Deep (mesotrophic) lake	North Temperate	1	T (weekly)	440	0-20 m	1988-1998	31,32
Müggelsee	Shallow (eutrophic) lake	North Temperate	1	T (weekly)	774	0-4 m	1996-2014	33

The number of sites per region is denoted in parentheses. S and T indicate datasets used in the spatial and temporal analyses, respectively. *One plot has a more recent survey in 1998, however it lacks species ID. † Census 2 was chosen because information for multiple stems is not available in Census 3, and the unit of diameter is unclear in Census 4.

Supplementary Table 2| Power-law and related statistical distributions that were fitted to the data. For each distribution we give the basic functional form $f(x)$, the appropriate normalization constant C such that $\int_{x_{\min}}^{\infty} Cf(x) = 1$ and the limits. The function $\Gamma(a,b)$ is the upper incomplete gamma function, such that $\Gamma(a,0) = \Gamma(a)$ is the gamma function.

Probability density function $p(x) = Cf(x)$			
	$f(x)$	C	limits
Power-law	x^{λ}	$-(\lambda+1)x_{\min}^{-(\lambda+1)}$	$x_{\min} \le x \le \infty$
Power-exponential	$x^{\lambda}\,\mathrm{e}^{-\gamma x}$	$\dfrac{\gamma^{\lambda+1}}{\Gamma(\lambda+1,\gamma x_{\min})}$	$x_{\min} \le x \le \infty$
Bounded power-law	x^{λ}	$\dfrac{\lambda+1}{x_{\max}^{\lambda+1} - x_{\min}^{\lambda+1}}$ if $\lambda \ne 1$ $\dfrac{1}{\log(x_{\max}) - \log(x_{\min})}$ if $\lambda = 1$	$x_{\min} \le x \le x_{\max}$
Log-normal	$\dfrac{1}{x}\mathrm{e}^{-\frac{(\log x-\mu)^2}{2\sigma^2}}$	$\sqrt{\dfrac{2}{\pi\sigma^2}}\left[\mathrm{erfc}\left(\dfrac{\log(x_{\min})-\mu}{\sigma\sqrt{2}}\right)\right]^{-1}$	$x_{\min} \le x \le \infty$
Weibull	$\left(\dfrac{\beta}{\eta}\right)\left(\dfrac{x}{\eta}\right)^{(\beta-1)} \mathrm{e}^{-\left(\frac{x}{\eta}\right)^{\beta}}$	$\left[1 - \mathrm{e}^{-\left(\frac{x_{\min}}{\eta}\right)^{\beta}}\right]^{-1}$	$x_{\min} \le x \le \infty$

Supplementary Table 3| Identifying the best-fitting individual size distribution model.

Dataset	Number of sites	Power law	Bounded power law	Power exponential	Weibull	Log-normal
Trees	242	0.13	0.82	0.39	0.22	0.17
Phytoplankton	95	0.32	0.58	0.37	0.45	0.44

The proportion of occasions that a model was ranked among the best models for each form of power-law distributions (power law, bounded power law and power exponential) and alternative distributions (Weibull and log-normal) is given for each dataset.

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