A Global Data Set of Leaf Photosynthetic Rates, Leaf N and P, and Specific Leaf Area

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Revision Date: June 25, 2014

Summary:

This global data set of photosynthetic rates and leaf nutrient traits was compiled from a comprehensive literature review. It includes estimates of Vcmax (maximum rate of carboxylation), Jmax (maximum rate of electron transport), leaf nitrogen content (N), leaf phosphorus content (P), and specific leaf area (SLA) data from both experimental and ambient field conditions, for a total of 325 species and treatment combinations. Both the original published Vcmax and Jmax values as well as estimates at standard temperature are reported.

The maximum rate of carboxylation (Vcmax) and the maximum rate of electron transport (Jmax) are primary determinants of photosynthetic rates in plants, and modeled carbon fluxes are highly sensitive to these parameters. Previous studies have shown that Vcmax and Jmax correlate with leaf nitrogen across species and regions, and locally across species with leaf phosphorus and specific leaf area, yet no universal relationship suitable for global-scale models is currently available.

These data are suitable for exploring the general relationships of Vcmax and Jmax with each other and with leaf N, P and SLA. This data set contains one *.csv file.

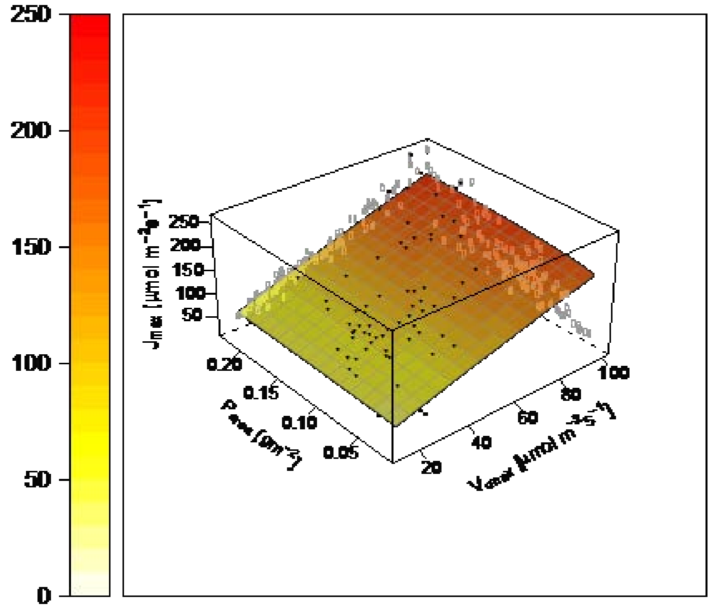

Figure 1. The relationship between Jmax and Vcmax as modified by leaf P, from Walker et al. 2014.

Data and Documentation Access:

Get Data: http://daac.ornl.gov/cgi-bin/dsviewer.pl?ds_id=1224

Data Citation:

Cite this data set as follows:

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1. Data Set Overview:

This global data set of photosynthetic rates and leaf nutrient traits was compiled from a comprehensive literature review. It includes estimates of Vcmax (maximum rate of carboxylation), Jmax (maximum rate of electron transport), leaf nitrogen content (N), leaf phosphorus content (P), and specific leaf area (SLA) data from both experimental and ambient field conditions, for a total of 325 species and treatment combinations. Both the original published Vcmax and Jmax values as well as estimates at standard temperature are reported.

The maximum rate of carboxylation (Vcmax) and the maximum rate of electron transport (Jmax) are primary determinants of photosynthetic rates in plants, and modeled carbon fluxes are highly sensitive to these parameters. Previous studies have shown that Vcmax and Jmax correlate with leaf nitrogen across species and regions, and locally across species with leaf phosphorus and specific leaf area, yet no universal relationship suitable for global-scale models is currently available.

Table 1. List of data contributors.

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2. Data Characteristics:

Spatial Coverage

Latitude, longitude and elevation are provided for each study site.

Temporal Coverage

Compilation from published measurements taken between 1993/01/01 to 2010/12/31.

Temporal Resolution

None

Site boundaries: (All latitude and longitude given in degrees and fractions)

Site (Region)	Westernmost Longitude	Easternmost Longitude	Northernmost Latitude	Southernmost Latitude
Global	-122.40	176.13	58.42	-43.2

Data File Information

There is one data file in this data set archive: **Leaf_Photosynthesis_Traits.csv**. The data set is in comma-separated values format (*.csv) and the file is <1

MB in size. Missing data in all numeric columns are represented by -9999.99. Full literature citations referred to in the data file are provided at the end of this guide document.

Table 2. Parameters in the data file.

Missing values are reported as -9999.

Column	Name	Units/format	Description
1	Author		Study author and year (full citations provided in Table 3)
2	Species		Taxonomic name of plant species
3	Plant_taxonomy	categorical	A = Angiosperm or G = Gymnosperm
4	Plant_type	categorical	Coded following the classification used by Domingues et al 2010: A = crop, D = deciduous, E = evergreen, F = forb, G = grass, SD = semi-deciduous
5	Longitude	decimal degrees	Longitude of study site
6	Latitude	decimal degrees	Latitude of study site
7	Elevation	meters	Elevation of study site
8	Measurement year		Year measurements were taken, if known
9	Vcmax_reported	umol/m2/s	Vcmax value reported in published study
10	Jmax_reported	umol/m2/s	Jmax value reported in published study
11	Vcmax_25C	umol/m2/s	Standardized estimate from Walker et al 2014
12	Jmax_25C	umol/m2/s	Standardized estimate from Walker et al 2014
13	Leaf_N	g/m2	Leaf nitrogen concentration reported in published study
14	Leaf_P	g/m2	Leaf phosphorous concentration reported in published study
15	SLA	m2/g	Specific leaf area reported in published study
16	Needle_age	years	Gymnosperms only: age of the needle, if known.
17	Treatment_CO2	categorical	Experimental CO2 treatment from original study, if applicable: amb = ambient, ele = elevated
18	Treatment_N	categorical	Experimental nitrogen treatment from original study, if applicable (refer to original study for details)
19	Treatment_P	categorical	Experimental phosphorous treatment from original study, if applicable (refer to original study for details)
20	Treatment_light	categorical	Experimental light or canopy treatment from original study, if applicable (refer to published study for details)
21	Treatment_other		Other experimental treatment applied
22	Treatment_other_levels		level of other experimental treatment applied
23	Measurement_temperature	degrees C	Temperature at which the parameters were reported in the manuscript. Where a range of values was reported, the reported temperature was corrected to a standard temperature using a temperature sensitivity function
24	Photosynthetic_reference		Literature source for photosynthetic parameter temperature correction
25	Kinetic_reference		Literature source for kinetic parameter temperature function.
26	Km	Pa	Michaelis-Menten constant for RuBisCO (Km = Kc(1 + O/Ko))
27	Kc	Pa	Michaelis-Menten constant of RuBisCO for CO2 (see Walker et al 2014)
28	Ko	kPa	Michaelis-Menten constant of RuBisCO for O2

			(see Walker et al 2014)
29	Tau	unitless	Carboxylation to oxygenation ratio
30	Gamma_star	Pa	CO2 compensation point in the absence of dark respiration (gamma*)
31	Wj_reference		Literature source for function to describe light limited rate of carboxylation. Standard equation: J= J (C_i-gamma*)/(4 C_i+8gamma*
32	J_reference		Literature source for function that describes electron transport rate as a function of incident photosynthetically active radiation
33	J_flag		If yes, the original study reported J (actual rate of electron transport at saturating CO2) and Walker calculated the values reported in column “Jmax_reported”
34	Irradiance	W/m2	Values reported by original study
35	Alpha	mol e/mol photons	Apparent quantum yield (alpha) values reported by original study
36	Theta	unitless	Curvature of light response (theta) values reported by original study
37	O2_reported	kPa	O2 partial pressure values reported by original study
38	Notes		

3. Data Application and Derivation:

These data are suitable for exploring relationships of Vcmax and Jmax with each other and with leaf N, P and SLA.

4. Quality Assessment:

While the general relationship between Vcmax and Jmax is robust across data sets, there is substantial variation of individual species data from this relationship. Some of this variation may arise due to measurement error or temperature sensitivity. The study authors measured the temperature sensitivity of carbon assimilation by comparing predictions from Jmax and Vcmax standardized to 25°C to predictions based on the original data. Errors introduced by the standardisation were well within the measurement error of A/Ci curves (see Walker et al. 2014 Supplementary material 1 for details). Results were compared to relationships in the TRY database (Kattge et al 2011) and A/Ci curves reported by Wullschleger (1993).

5. Data Acquisition Materials and Methods:

The data in this compilation are based on a comprehensive literature survey. The aim was to find papers that had simultaneously measured as many of the following leaf traits: Vcmax, Jmax, leaf N, leaf P and specific leaf area (SLA) or leaf mass to area ratio (LMA). Minimum requirements for inclusion in this data set were that either Vcmax or Jmax were calculated from A/Ci curves along with two of the other three leaf traits. This literature search yielded data from 25 papers published between 1998 and 2011, represemting 135 species by location combinations, distributed globally (Table 3). Some of these data were collected on plants in their natural environment and subject to natural environmental variation, while other data were collected on lab grown plants (mostly tree species) subjected to experimental treatments. The majority of the species used in the greenhouses and labs were native to the area of the research centre. Either species means or treatment means were collected leading to a dataset of 325 species by treatment combinations.

Using a method (detailed in the supplementary material of Walker et al. 2014) similar to Kattge & Knorr (2007), the authors removed the variation in Vcmax and Jmax across studies caused by different parametric assumptions by standardizing Vcmax and Jmax to a common set of kinetic parameters. They also corrected Vcmax and Jmax to a common measurement temperature of 25 degrees C and to the O2 partial pressure at the measurement elevation. To generate a larger SLA data set where leaf mass per unit area (LMA) was reported, LMA was converted to SLA by taking the reciprocal.

Table 3: Data sources, study locations, and experimental manipulations included in this compilation. PFT abbreviations: Temp – temperate, Trop – tropical, Ev – evergreen, Dc – deciduous, Nl – needleleaf tree, Bl – broadleaf tree.

Reference	Num. species	PFT	Long (degrees)	Lat (degrees)	Elevation (m)	Location	Country	Experiment	N	P
Aranda et al. 2005	1	Temp Ev Bl	-3.43	39.23	650	Alburquerque	Spain	light * water	y	n
Bauer et al. 2001	6	Temp Dc Bl & Ev N1	-71.03	42.21	40	Harvard Forest	USA	CO2*N	y	n

Bown et al. 2007	1	Temp Ev Nl	176.13	-38.26	600	Purokohukohu Experimental Basin	New Zealand	N*P	y	y
Brück & Guo 2006	1	Temp legume crop	10.08	54.19	40	Kiel	Germany	NH4 vs NO3	y	n
Calfapietra 2005	1	Temp Dc Bl	11.48	42.22	150	Viterbo	Italy	CO2*N canopy level	y	n
Carswell et al. 2005	4	Temp Dc Bl & Ev Nl	170.3	-43.2	90	Okarito	New Zealand	N*P	y	y
Cernusak et al. 2011	2	Trop Ev Bl	139.56	-22.59	150	Boulia	Australia	none	y	y
Cernusak et al. 2011	2	"	133.19	-17.07	230	Sturt plains	Australia	none	y	y
Cernusak et al. 2011	2	"	132.22	-15.15	170	Dry creek	Australia	none	y	y
Cernusak et al. 2011	2	"	131.23	-14.09	70	Daly river	Australia	none	y	y
Cernusak et al. 2011	2	"	131.07	-13.04	80	Adelaide river	Australia	none	y	y
Cernusak et al. 2011	2	"	131.08	-12.29	40v	Howard Springs	Australia	none	y	y
Domingues et al 2010	3	Trop Dc Bl	-1.5	15.34	280-300	Hombori	Mali	none	y	y
Domingues et al 2010	7	"	-1.17	12.73	50	Bissiga	Burkina Faso	none	y	y
Domingues et al 2010	8	"	-3.15	10.94	300	Dano	Burkina Faso	none	y	y
Domingues et al 2010	5	"	-1.86	9.3	370	Mole	Ghana	none	y	y
Domingues et al 2010	8	"	-1.18	7.3	170	Kogye	Ghana	none	y	y
Domingues et al 2010	21	Trop Dc Bl & Ev Bl	-1.7	7.72	200	Boabeng Fiame	Ghana	none	y	y
Domingues et al 2010	4	"	-2.45	7.14	25	Asukese	Ghana	none	y	y
Grassi 2002	1	Sub-trop Ev Bl	149.07	-35.18	600	Canberra	Australia	N	y	n
Han et al. 2008	1	Temp Ev Nl	138.8	35.45	1030	Canberra	Australia	N	y	n
Katahata et al 2007	1	Ev shrub	138.4	36.51	900	Niigata	Japan	light*leaf age	y	n
Kubiske et al 2002	2	Temp Bl Dc	84.04	45.33	215	Pellston	USA	N* CO2*light	y	n
Manter et al 2005	1	Temp Ev Nl	-122.4	45.31	75	Portland	USA	N	y	n
Merilo et al 2006	2	Temp Ev Nl	26.55	58.42	65	Saare	Estonia	light	y	n
Midgley et al 1999	4	Temp Ev shrub	20	-34.5	120	Cape Agulhas	South Africa	CO2*N&P	y	n
Porte & Lousteau 1998	1	Temp Ev Nl	-0.46	44.42	60	Bordeaux	France	leaf age*canopy level	y	y
Rodriguez-Calcerrada et al. 2008	2	Temp Dc Bl	-3.3	41.07	50	Madrid	Spain	light	y	n
Sholtis et al 2004	1	Temp Dc Bl	-84.2	35.54	230	Oak Ridge	USA	CO2*canopy level	y	n
Turnbull et al. 2007	1	Temp Ev Bl	142.05	-37.03	470	Ballarat	Australia	defoliation	y	y

Warren 2004	1	Temp Ev Bl	143.53	-37.25	450	Creswick	Australia	N	y	n
Watanabe et al. 2011	1	Temp Dc Nl	141	43	180	Asapporo	Japan	CO2*N	y	y
Wohlfahrt et al. 1999	28	Temp C3 grass & forb	11.01	46.01	1540-1900	Monte Bondone	Eastern Alps (Italy and Austria)	none	y	n
Zhang & Dang 2006	1	Temp Dc Bl	89.14	48.22	200	Ontario	Canada	CO2*age	n	y

6. Data Access:

This data is available through the Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC).

Data Archive Center:

Contact for Data Center Access Information:

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Telephone: +1 (865) 241-3952

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