





Plant Metaphenomics: Building a unified framework for interpreting plant growth responses to diverse environmental variables

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ICG-3: Phytosphere
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Website: <http://www.jppc.de>

<http://www.plantphenomics.com/phenotyping2009>





Meta-phenomics:

building a unified framework for interpreting plant growth responses to diverse environmental variables

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Bayesian statistics:




Data + Prior knowledge

→

Posterior

Prior knowledge:




Current knowledge:

		Pages / year
1	J. Exp. Bot.	3700
2	New Phytologist	3500
3	Oecologia	3200
4	Glob. Change Biol.	2500
5	Plant Physiology	2400


3200 pages * 30 journals ≈
10⁵ pages year⁻¹ !!!

Structured knowledge:

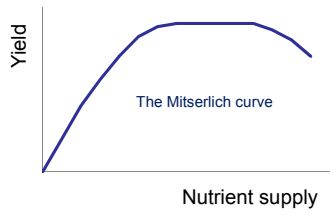


↔

Unstructured knowledge:

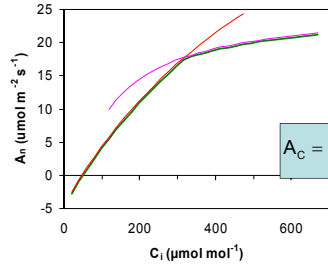


Dose-response curves:



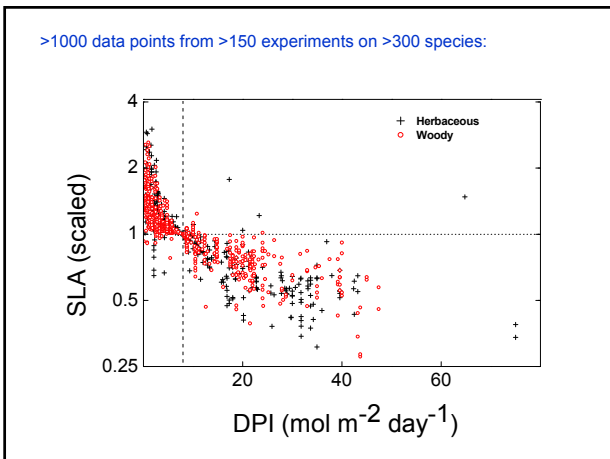
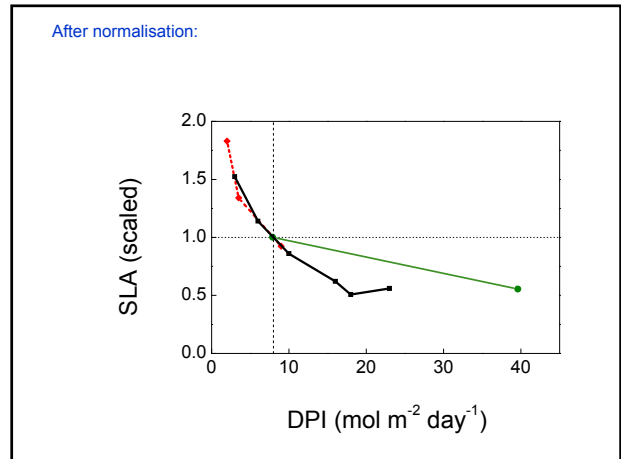
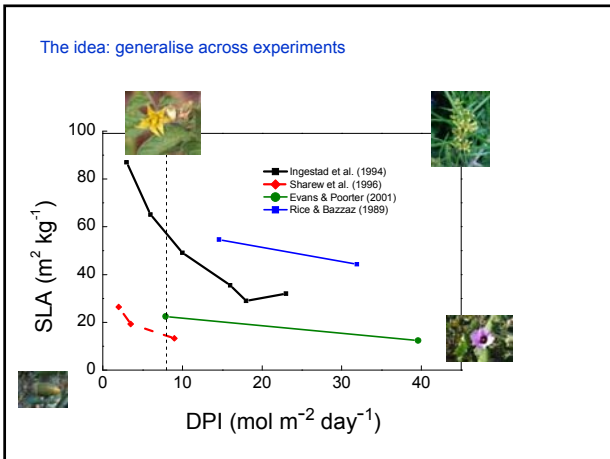
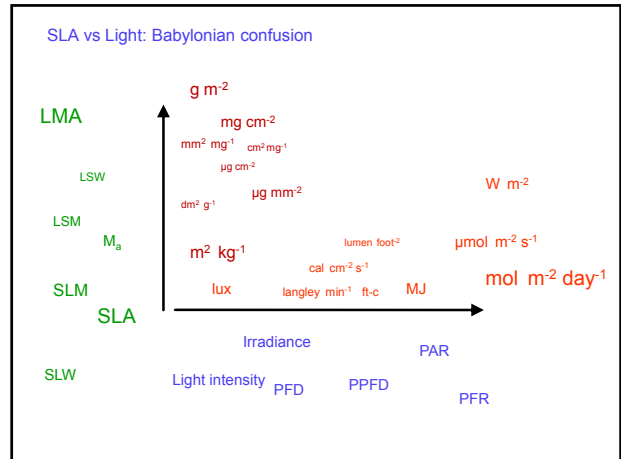
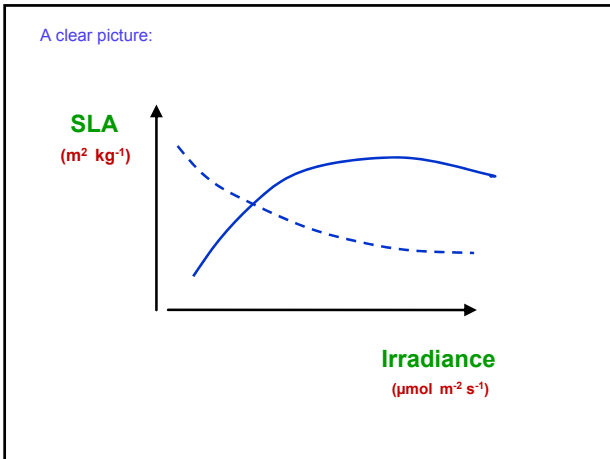
The Mitscherlich curve

A short-term response curve:



$$A_C = V_{\text{CMAX}} \cdot \frac{C - \Gamma_*}{C + K_C(1 + O/K_O)} - R_d$$

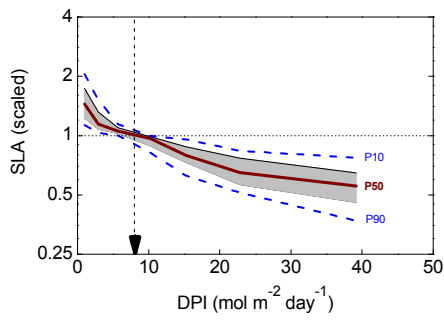
$$A_J = J \cdot \frac{C - \Gamma_*}{4C + 8\Gamma_*} - R_d$$



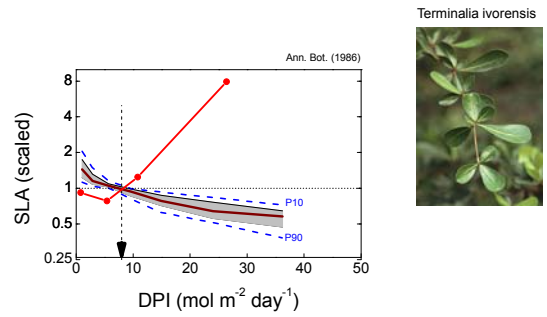
Can we make any generalisations?

- ▶ Is the response positive or negative?
- ▶ Is the response linear or not?
- ▶ What are the 'normal limits' ?

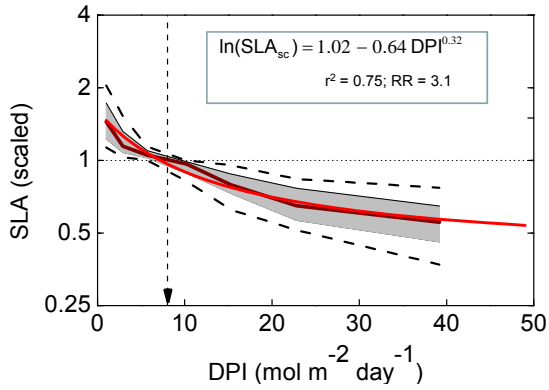
Median and the interquartile range for 7 light classes:



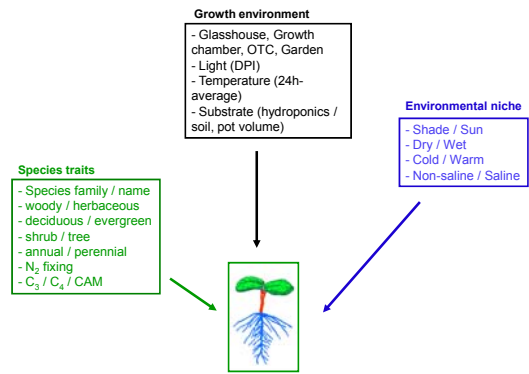
A tropical outlier:



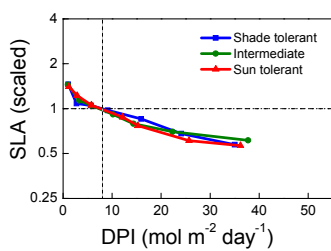
An overall non-linear equation:



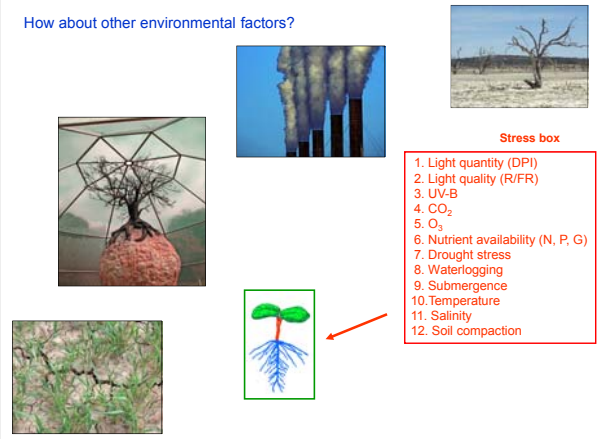
Are there differences between subgroups?



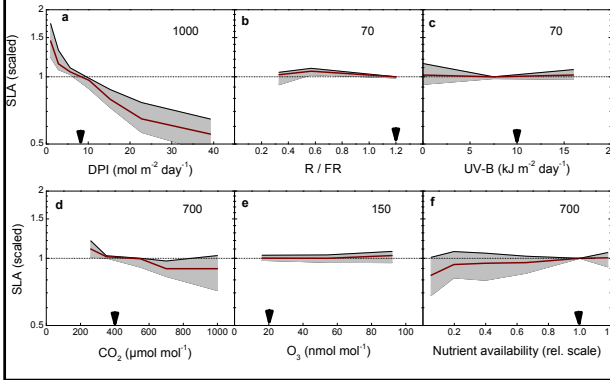
Are there differences in plasticity within subgroups?



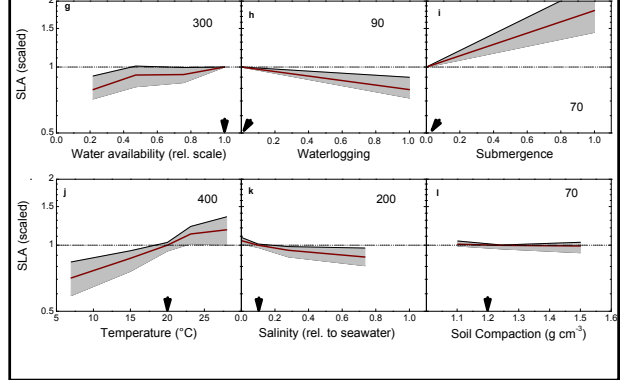
How about other environmental factors?



SLA responses to light, gases, and nutrients:



SLA responses to water, temperature, salinity and soil compaction:



Response Ratios:

	Range		RR
Irradiance	1–50	mol m ⁻² day ⁻¹	3.1
CO ₂	200–1200	μmol mol ⁻¹	1.4
Salinity	0–100	% seawater	1.2
Waterlogging	- - +		1.1
Compaction	1.0–1.6	g cm ⁻³	1.1

R: FR	0.2–1.2	mol mol ⁻¹	1.0
UV-B	1–20	kJ m ⁻² day ⁻¹	1.0
O ₃	5–100	nmol mol ⁻¹	1.0

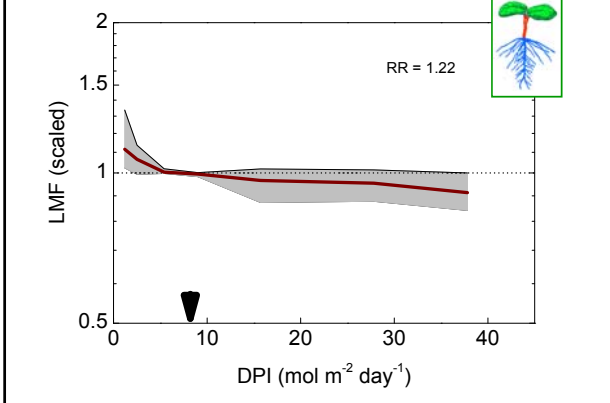
Nutrients	0.05–1	rel. units	1.1
Water (Drought)	0.05–1	rel. units	1.3
Submergence	- - +		1.8
Temperature	5–35	°C	2.3



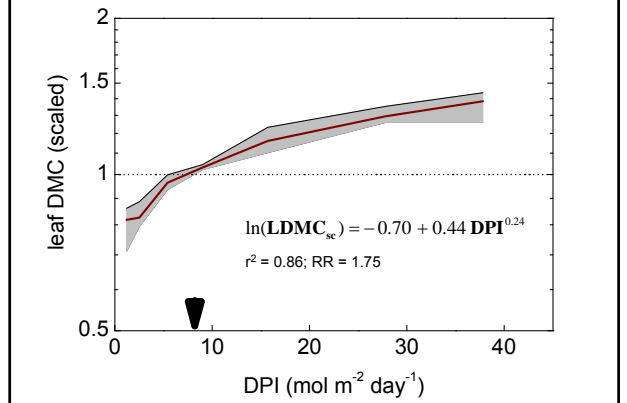
The matrix has a 3rd dimension:

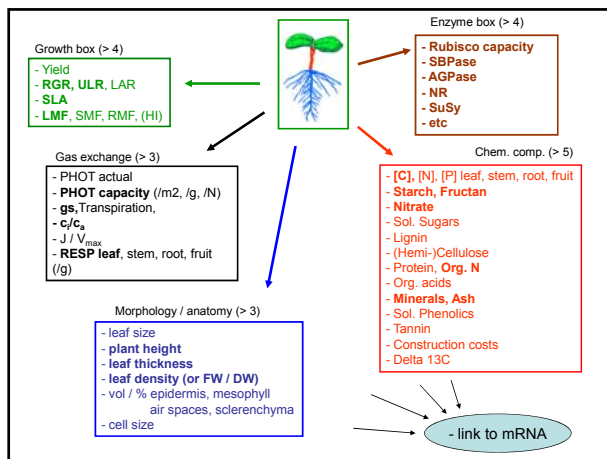
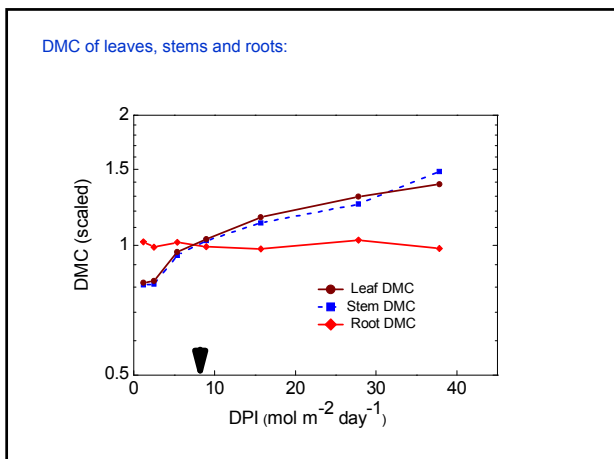
Env. Factor	SLA	Trait 2	Trait 3	Trait 4	...	Trait n
1	✓	✗	✗	✗	✗	✗
2	✓	✗	✗	✗	✗	✗
3	✓	✗	✗	✗	✗	✗
4	✓	✗	✗	✗	✗	✗
5	✓	✗	✗	✗	✗	✗
6	✓	✗	✗	✗	✗	✗
...	✓	✗	✗	✗	✗	✗
12	✓	✗	✗	✗	✗	✗

Allocation of biomass:



There are many other relevant plant traits:





Current status:

Collated Database:

- # of experiments > 1000
- # of species > 800
- # of env. factors 12
- # of variables 9

Conclusions:

This approach :

- ▶ Is able to summarise data across many experiments and species
- ▶ Yields quantitative response curves
- ▶ As well as normal limits
- ▶ Is applicable to (almost all) environmental factors
- ▶ Is applicable to all plant traits
- ▶ Useful for modeling

More info:

- www.metaphenomics.org

- Poorter H, Niinemets Ü, Poorter L, Wright I, Villar R. (2009) Causes and consequences of variation in leaf mass per area (LMA): a meta-analysis. *New Phytol.* 182: 565-588.

- Poorter H, Niinemets Ü, Walter A, Fiorani F, Schurr U. (2010) A method to construct dose-response curves for a wide range of environmental factors and plant traits by means of a meta-analysis of phenotypic data. *J. Exp. Bot.*, in press.

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