Plant functional strategies in patterned landscapes – responses to the environment and effects on ecosystem properties

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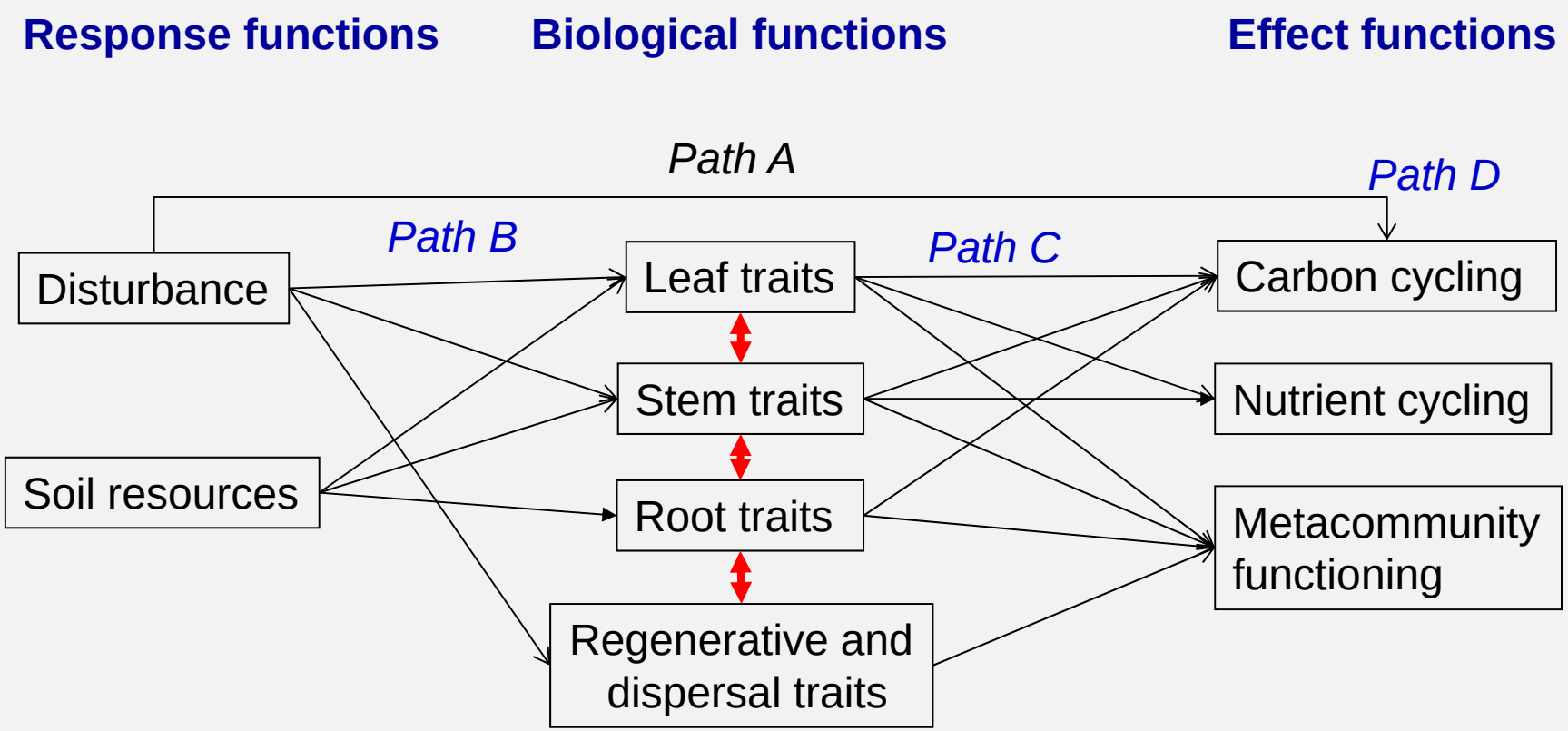
The response – effect framework



Path A: Trait-trait linkages

Path B: Responses to environment

Path C: Effects on ecosystem functions

Path D: Direct environmental effect

Lavorel & Garnier 2002, Suding et al. 2008

Functional Relevance of Plant Organs

Function

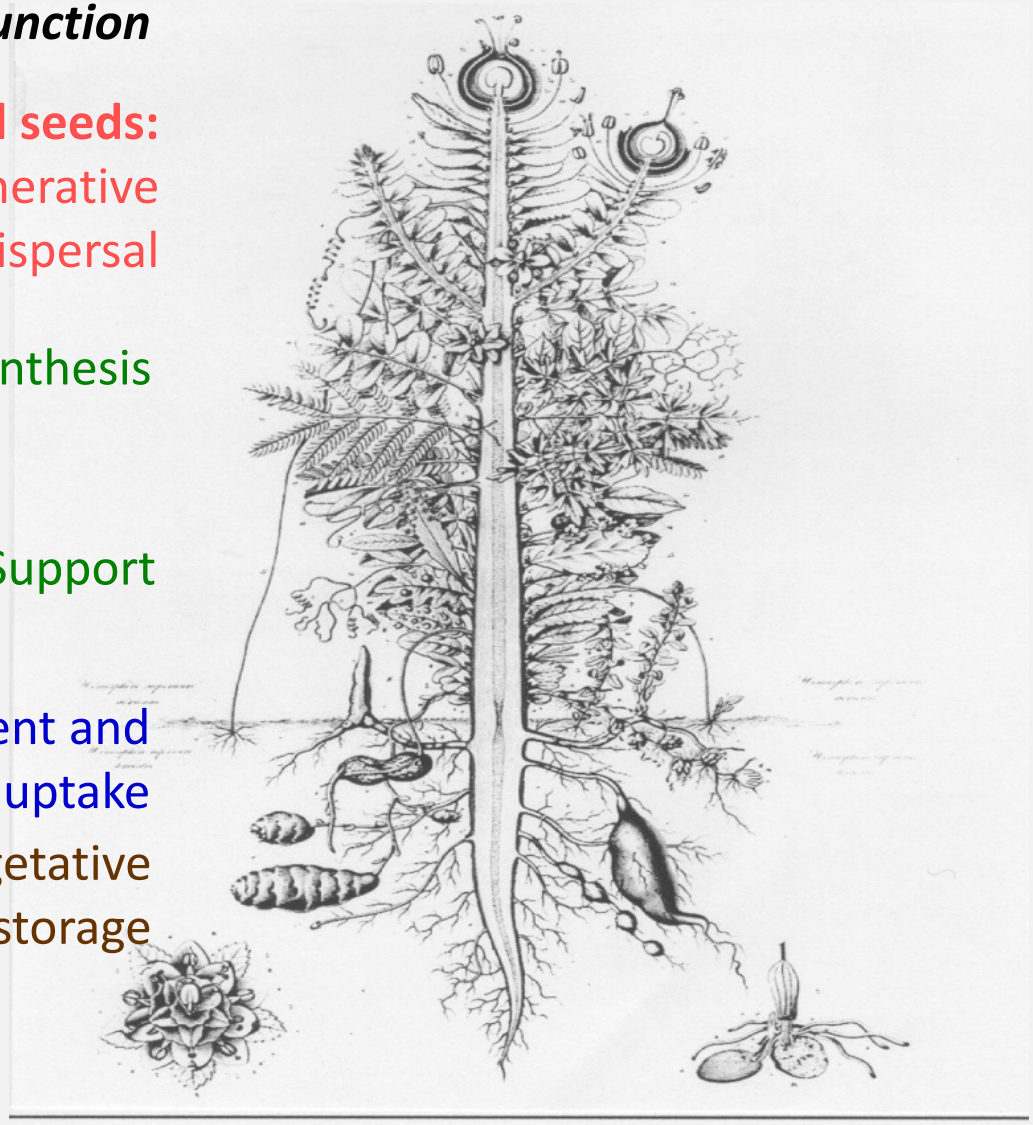
Flower and seeds: Pollination, generative reproduction, dispersal

Leaves: Photosynthesis

Stems: Support

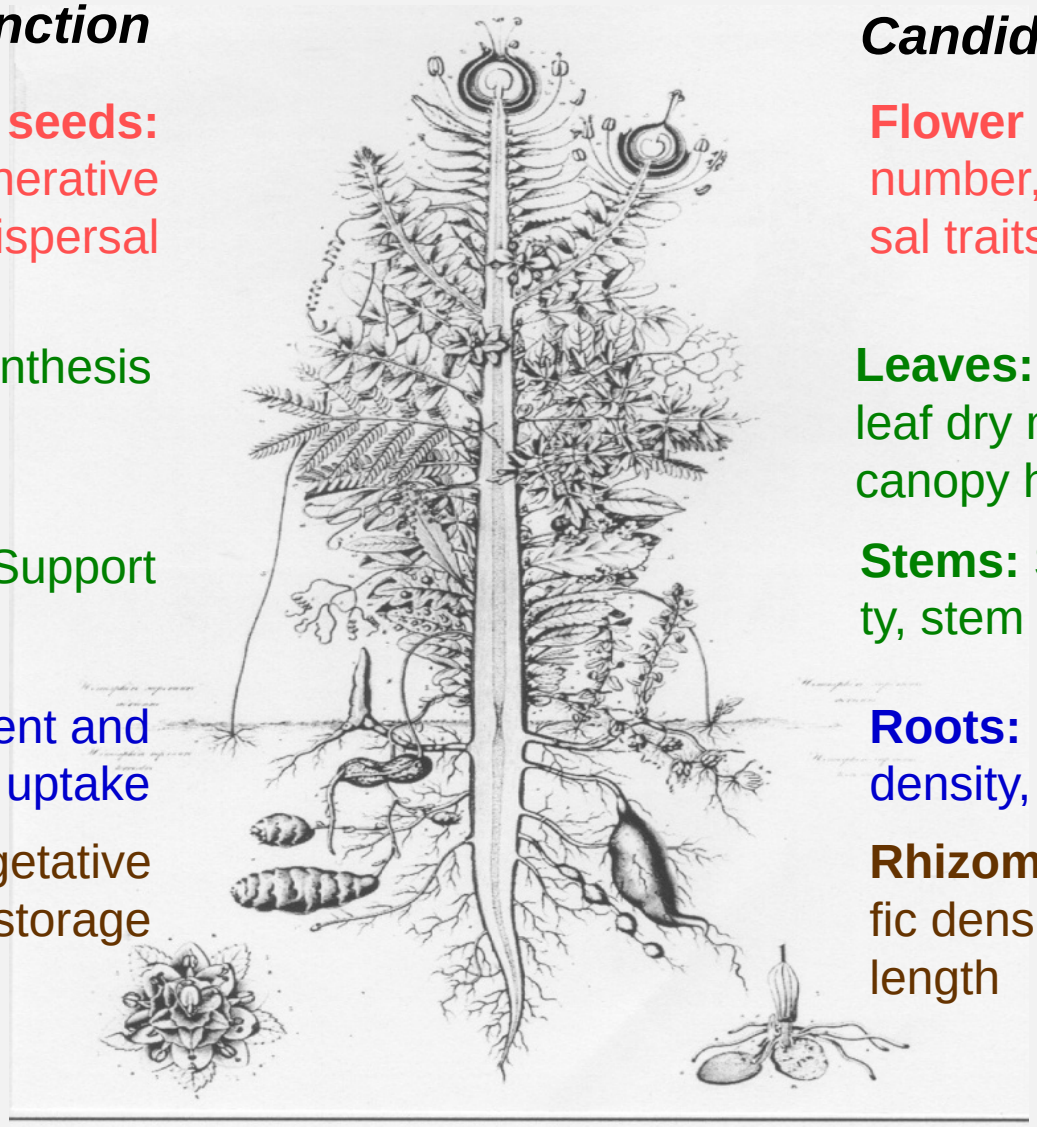
Roots: Nutrient and water uptake

Rhizomes: Vegetative reproduction, storage



Number-, Size-, Area- and Volume-related Traits

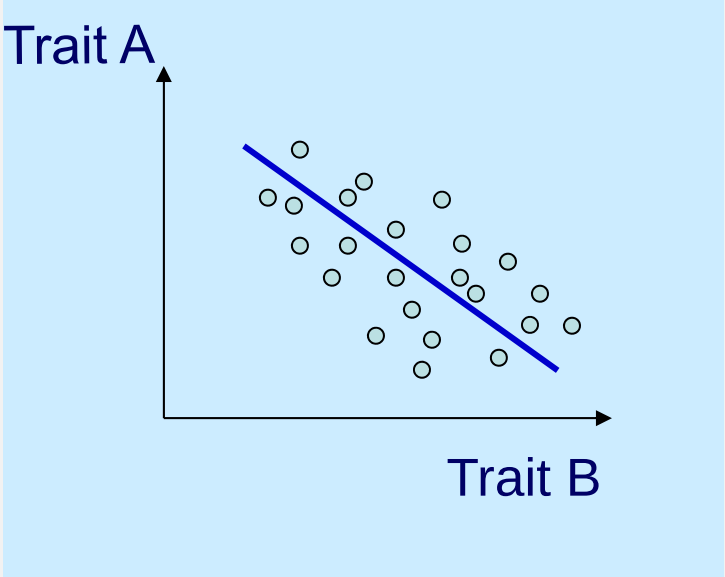
Function	*Candidate traits*
Flower and seeds: Pollination, generative reproduction, dispersal	**Flower and seeds:** Seed number, seed mass, dispersal traits, releasing height
Leaves: Photosynthesis	**Leaves:** Specific leaf area, leaf dry matter content, canopy height
Stems: Support	**Stems:** Stem specific density, stem specifc length
Roots: Nutrient and water uptake	**Roots:** Root specific density, Root specific length
Rhizomes: Vegetative reproduction, storage	**Rhizomes:** Rhizome specific density, Rhizome specific length



Kleyer et al. 2008 J. Ecol.

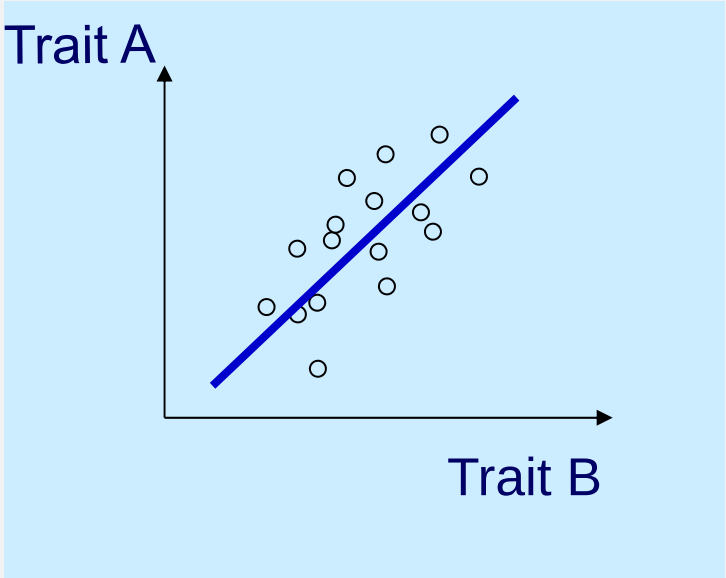
Scaling relationships

Negative scaling trade-off



Allocation to trait A represents costs for trait B

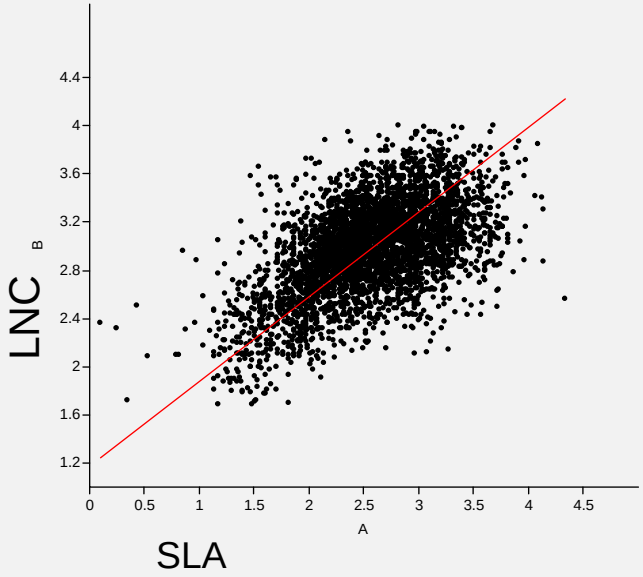
Positive scaling allometry



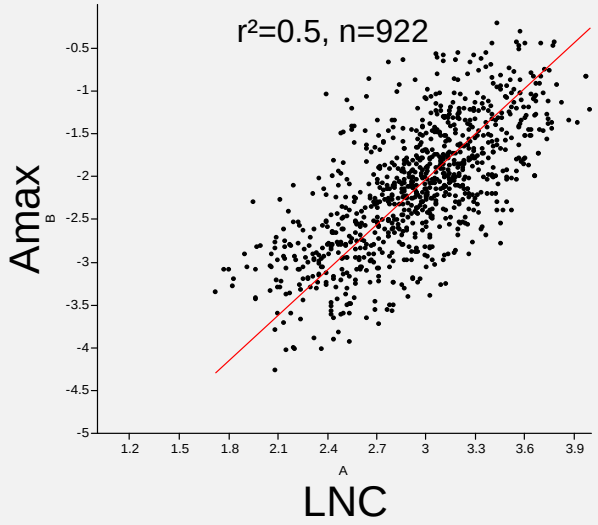
Allocation to trait A requires allocation to trait B

Note that trait-trait linkages are multivariate rather than bivariate

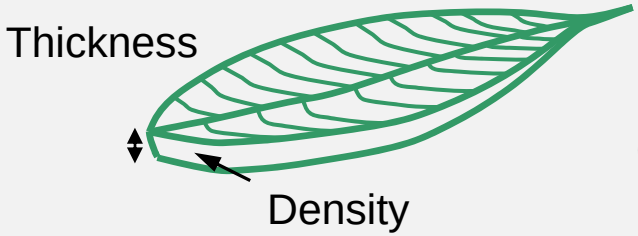
Positive and negative scaling: The leaf economics spectrum



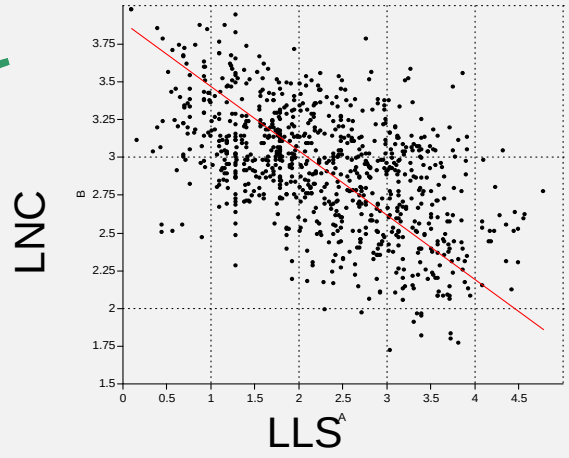
LNC=0.7+1.2*SLA, r^2=0.3, n=3918



Specific leaf area (SLA)
= leaf area/mass [$mm^2 mg^{-1}$]



Light interception *per* unit leaf mass



LNC=3.9-0.4*LLS, r^2=0.28, n=872

LNC: Leaf nitrogen content
SLA: Specific leaf area
Amax: Photosynthetic rate
LLS: Leaf life span

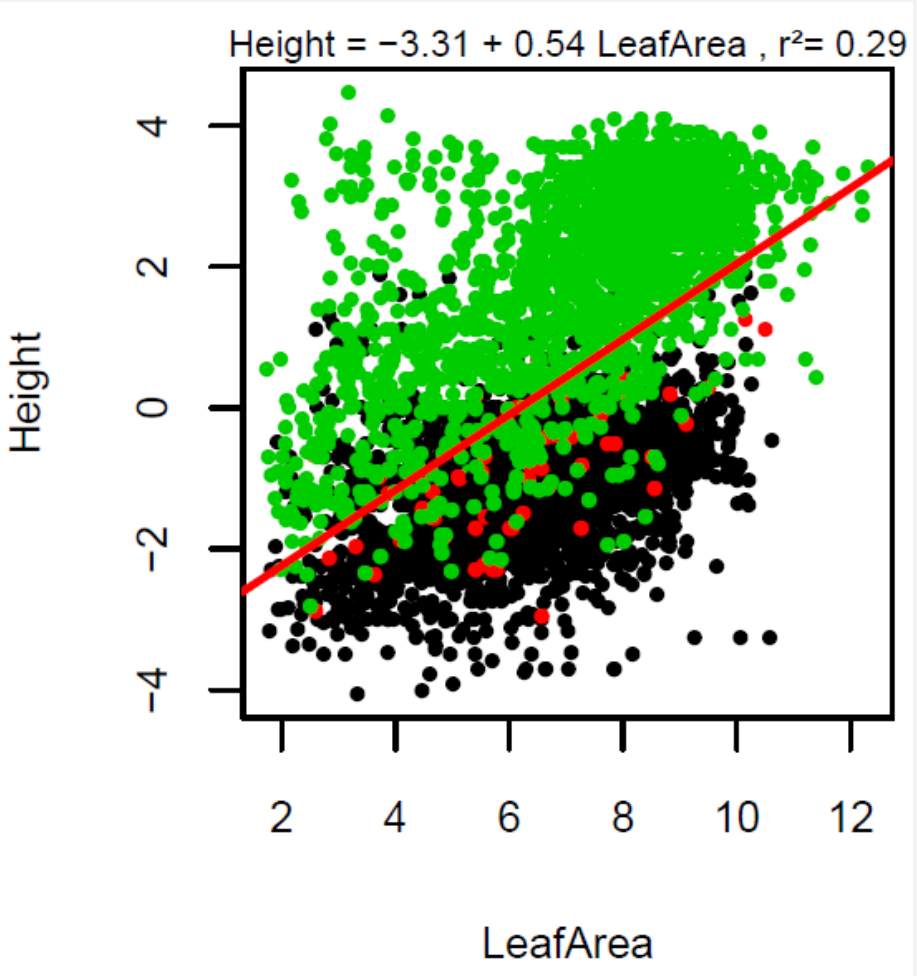
(each dot represents a species, data taken from TRY, a global plant trait database)

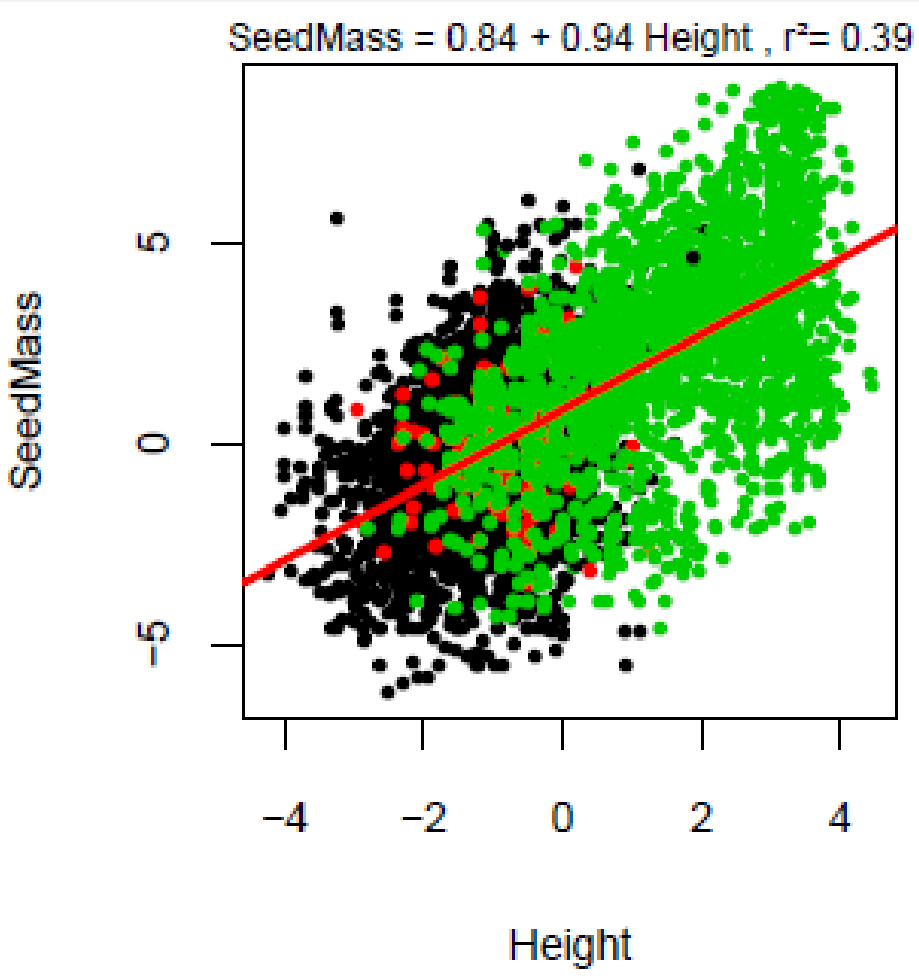
Slide from Eric Garnier

Wright *et al.* (2004) *Nature* 428: 821

Allometries and Trade-offs

TRY database (10000 species worldwide)



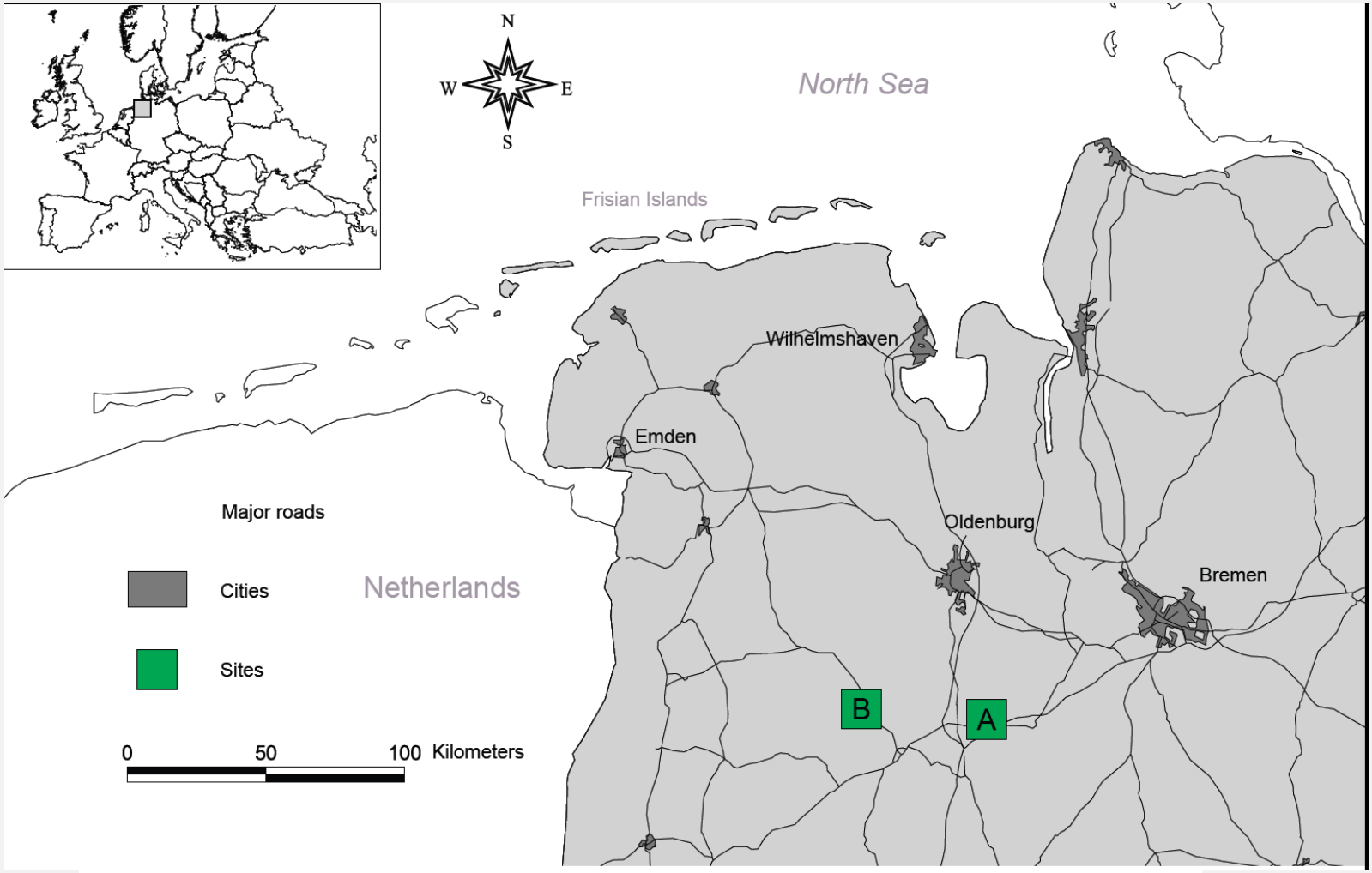


Leaf area and seed mass increase with plant canopy height

TRY Consortium in prep.

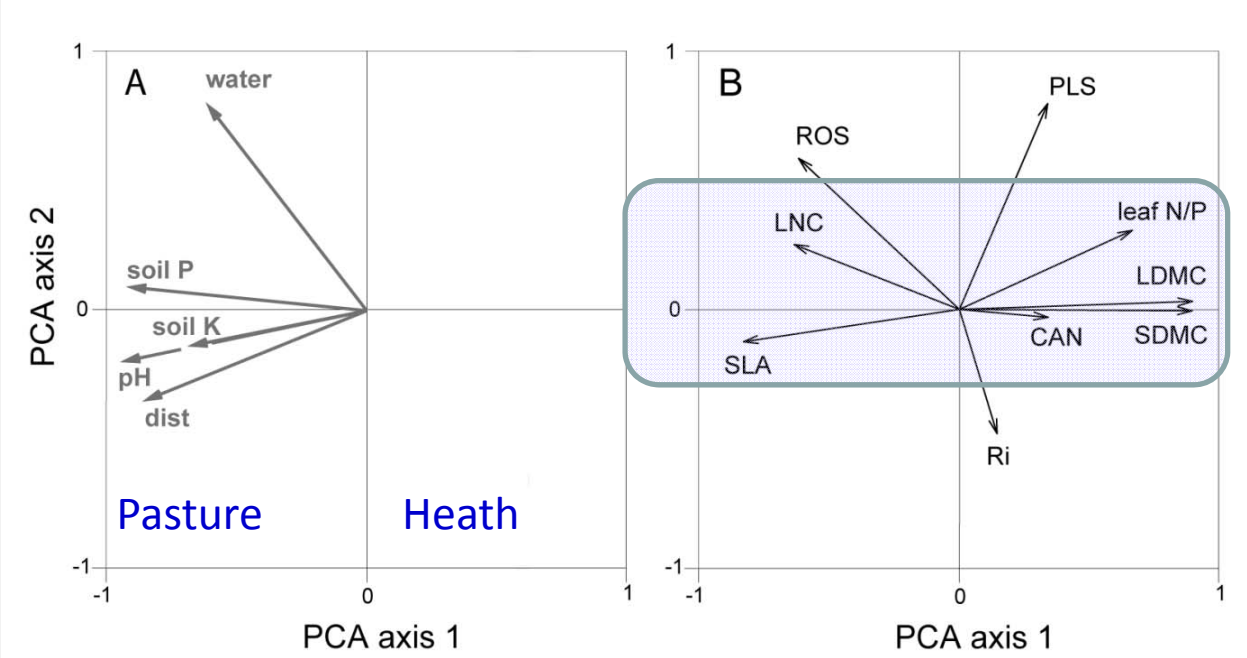
Pastures and heaths

Two study sites:
Pastures managed for dairy farming
Heathlands managed for conservation



29 plots on pastures, 40 plots on heathlands

Leaf economics spectrum responds to resources

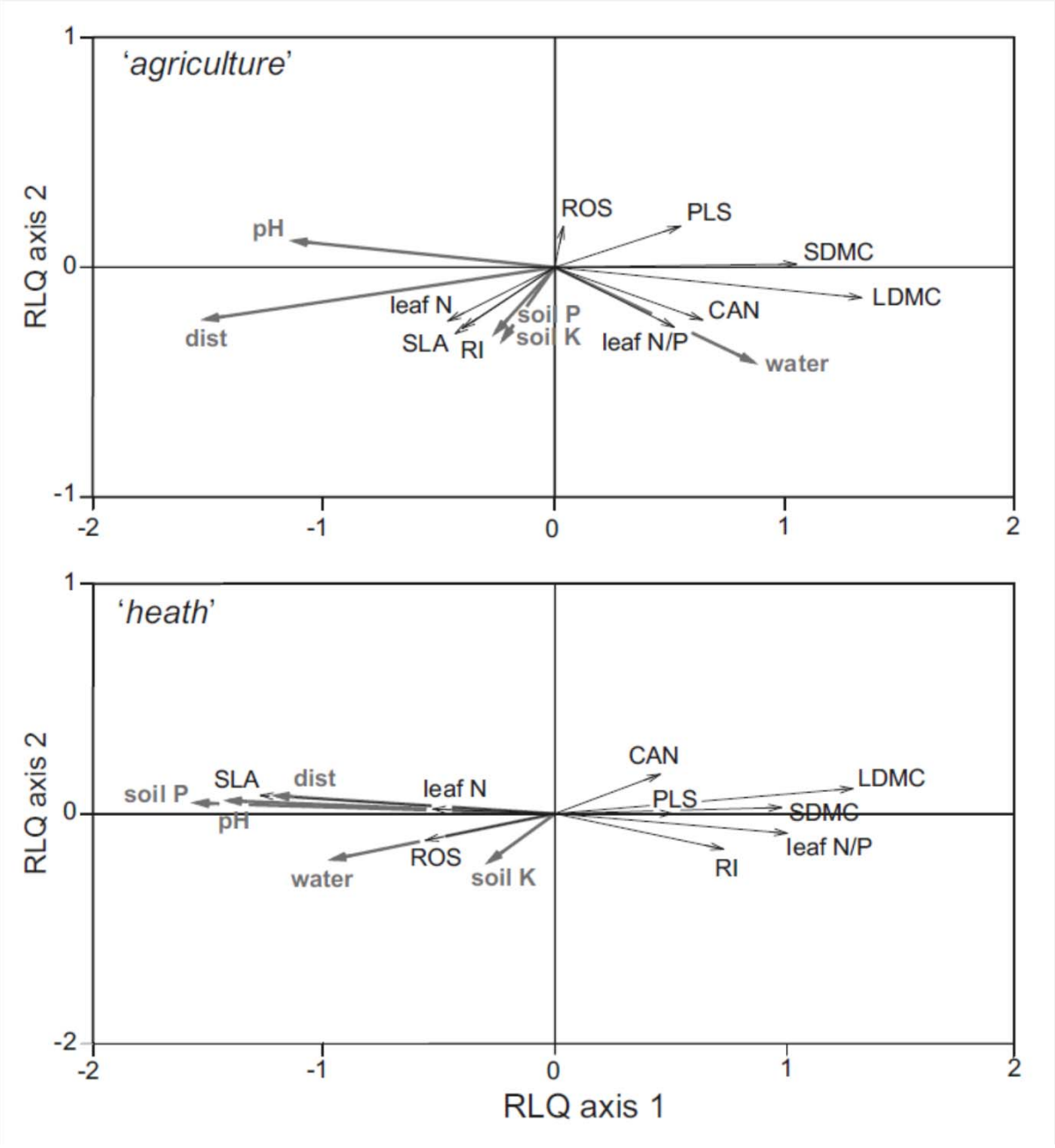


soil P: available P,
Soil K: available K,
Water: soil water holding capacity,
Dist: Land use intensity.

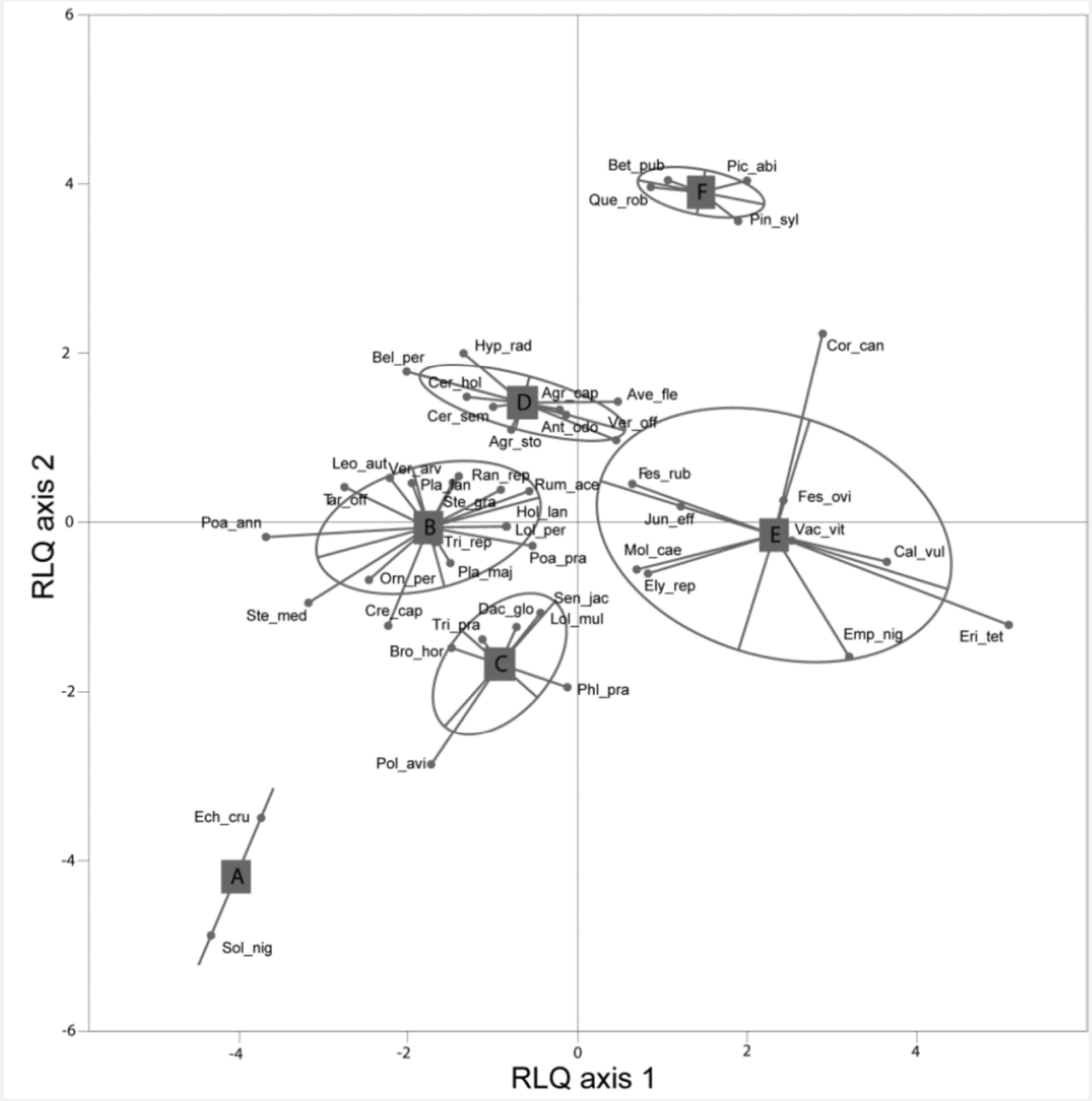
SLA: Specific leaf area,
Leaf N: Leaf N content,
ROS: Rosette,
PLS: Plant life span,
CAN: Plant canopy height,
RI: Reproductive allocation,
Leaf N/P: Leaf N:P ratio,
SDMC: Stem fresh:dry weight ratio,
LDMC: Leaf fresh:dry weight ratio

Lienin & Kleyer 2011 Agriculture, Ecosystems and Envrionments 145, 67–76

Consistency in trait - environment relationships



Functional response groups



The response-effect framework: Questions

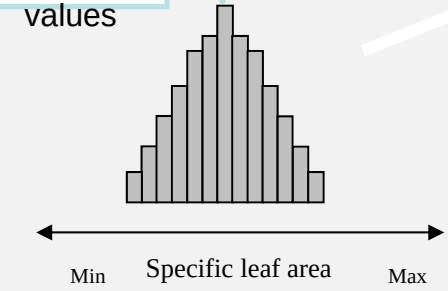
Soil resources

Disturbances

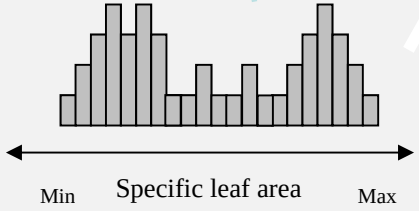
Non-consumable env. factors

Environment

Comunity avarage of SLA values



Comunity dispersion of SLA values



Species traits

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Biomass production

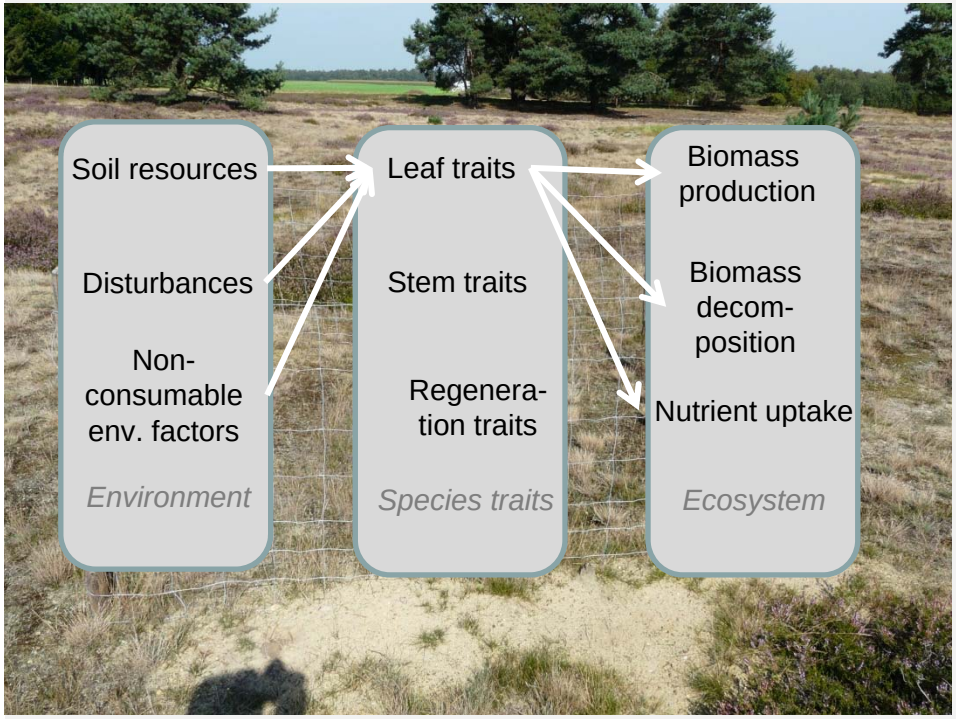
Biomass decomposition

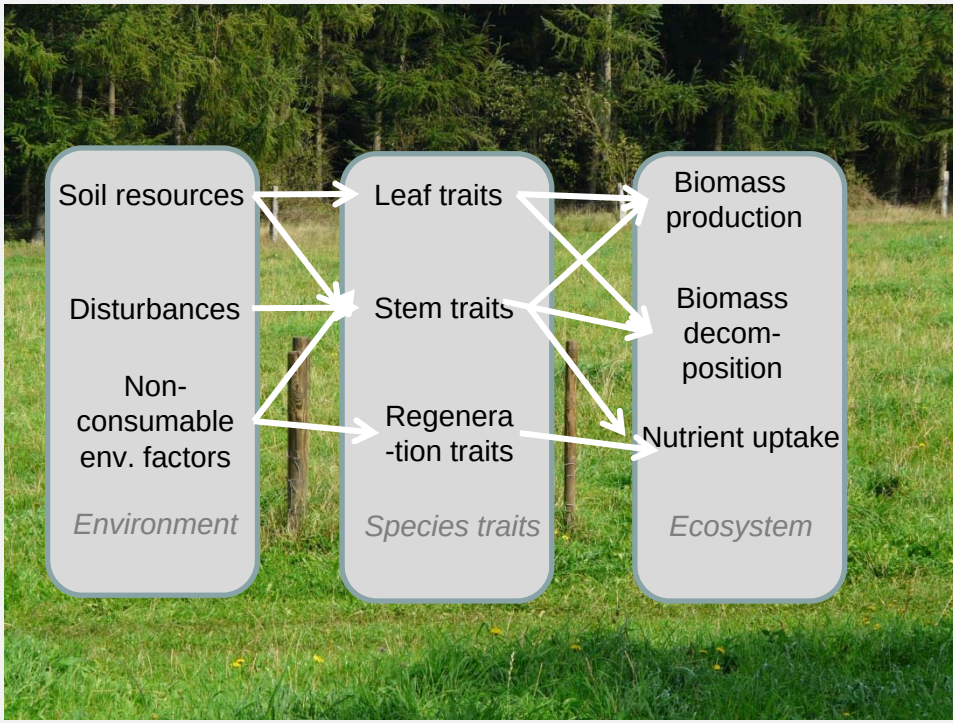
Nutrient uptake

Ecosystem

Do trait averages or trait diversity across all species in a community most strongly affect ecosystem properties?

The response-effect framework: Questions





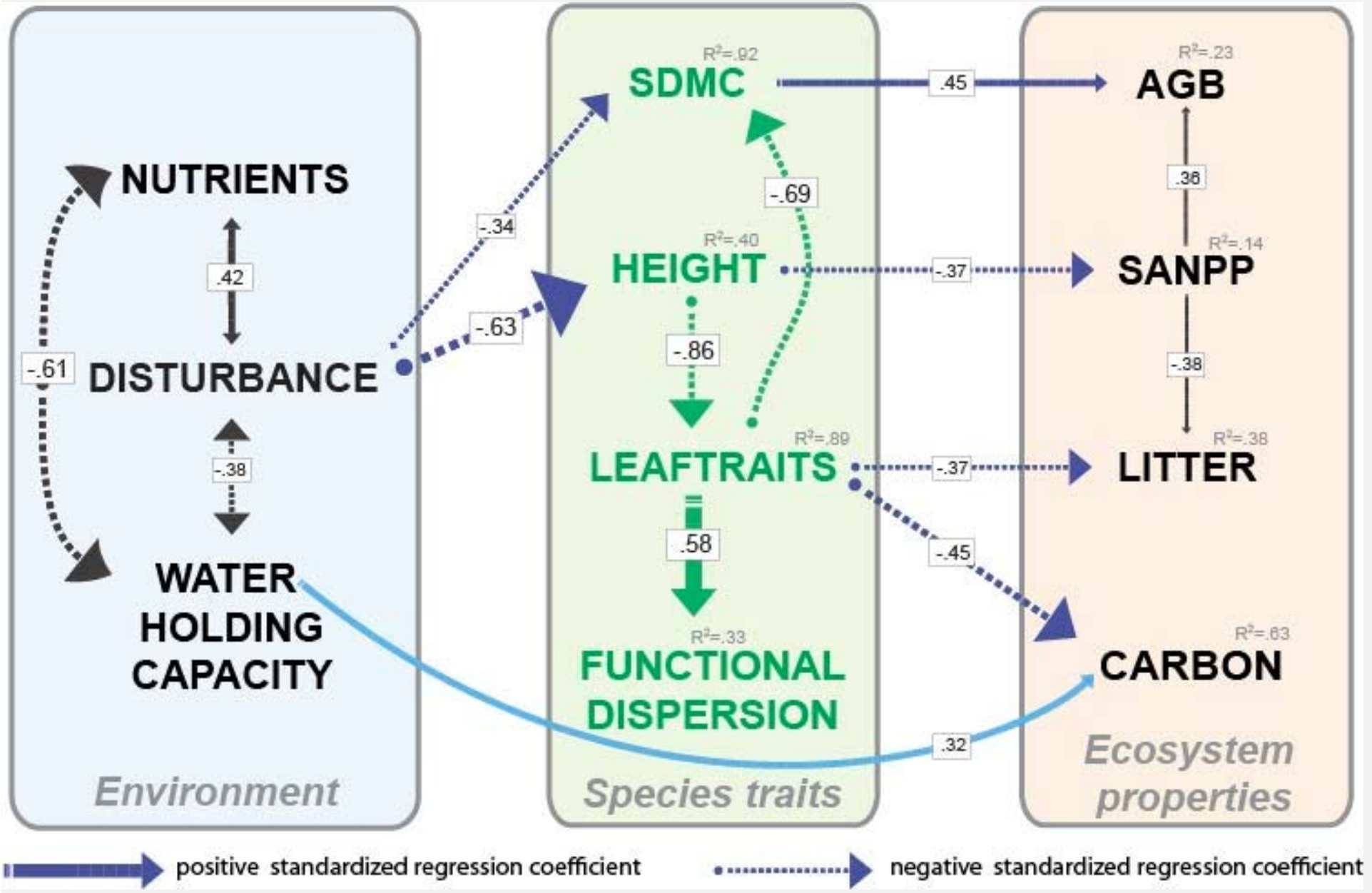
A few key traits or a diversity of traits?

Variables

Variables	Abbreviation	Unit	Mean `pastures´	Mean `heath´
Disturbance index	DISTURBANCE	relative[1]	1.45	0.37
Soil potassium content	Soil K	kg/ha[1]	64.78	92.00
Soil phosphorus content „Nutrients“	Soil P	kg/ha[1]	300.25	141.94
pH value	pH	log-scale	4.66	3.66
Soil water holding capacity	WHC	mm	119.92	95.58
Canopy height	HEIGHT	cm	28.26	22.63
Specific leaf area	SLA	mm^2/mg	24.10	12.18
Leaf dry matter content	LDMC	mg/g	299.46	512.70
Leaf nitrogen content „Leaftraits“	LNC	%	22.87	17.68
Leaf phosphorus content	LPC	%	2.72	1.30
Leaf C/N ratio	LC/N	ratio	19.81	28.36
Stem dry matter content	SDMC	mg/g	311.93	459.83
Functional dispersion of leaf traits	FDis	-	1.01	1.25
Aboveground biomass	AGB	g/m^2	409.76	494.54
Specific aboveground net primary productivity	SANPP	g/kg/month	0.07	0.07
Rate of litter mass loss	LITTER	%	21.94	18.84
Total soil organic carbon concentration	CARBON	t/ha	202.93	164.11

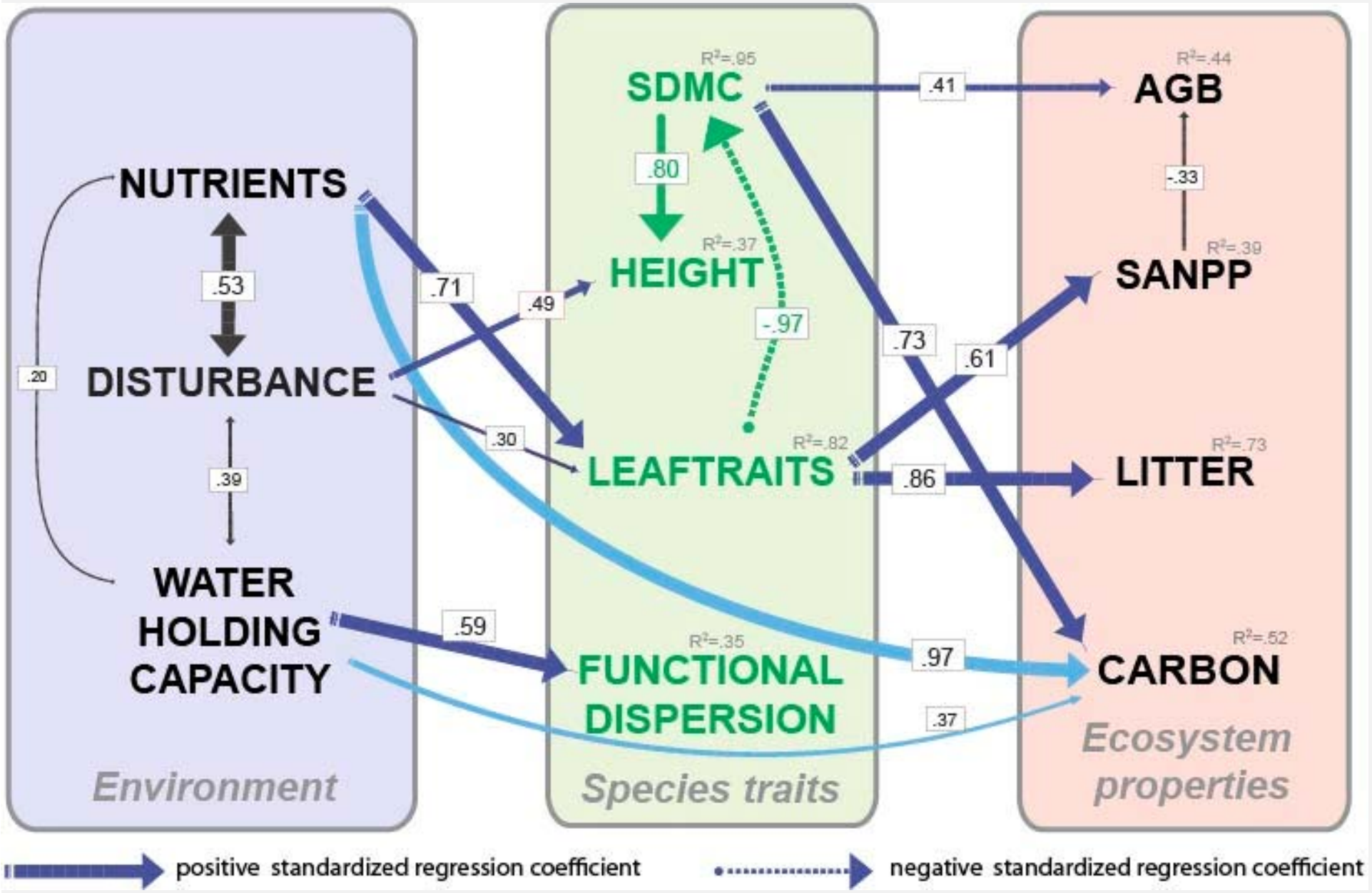
Fertilised Pastures

Lienin & Kleyer 2012 Basic and Applied Ecology 13, 301–311



Heath

Lienin & Kleyer 2012 Basic and Applied Ecology 13, 301–311



Discussion

How were trait-trait linkages organised?

Positive and negative scaling relationships between leaf and stem traits were consistent across landscapes, suggesting strong constraints of biological functions on response and effect functions.

How were response functions organised?

Growth traits responded to resources and disturbances: more resources and stronger disturbances lead to more acquisitive plants with higher leaf turnover.

How were environment-trait-ecosystem linkages organised?

Disturbance was main driver in pastures, soil resources in heaths, generating often opposite effects on ecosystem properties, particularly litter decomposition.

Above-ground net productivity was affected by the leaf economics spectrum and height, whereas standing biomass increased with investments in structural tissue.

Discussion

Do trait averages or trait diversity across all species in a community most strongly affect ecosystem properties?

Differences between community mean traits affect ecosystem properties more strongly than within-community trait dispersion, questioning the relevance of diversity-ecosystem functioning relationships at larger scales

Are response-effect relationships entirely context-dependent or can they be generalised across landscapes?

Changes in environmental drivers (resources vs. disturbance) can reverse trait – ecosystem relationships, emphasizing context in ecological research.

Generalisation is possible by addressing the diversity of pathways in landscapes.

Thank you for your attention

Thanks to the Landscape Ecology Group

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