



Plant functional traits and nutrient gradients on grassland

Jürgen Schellberg

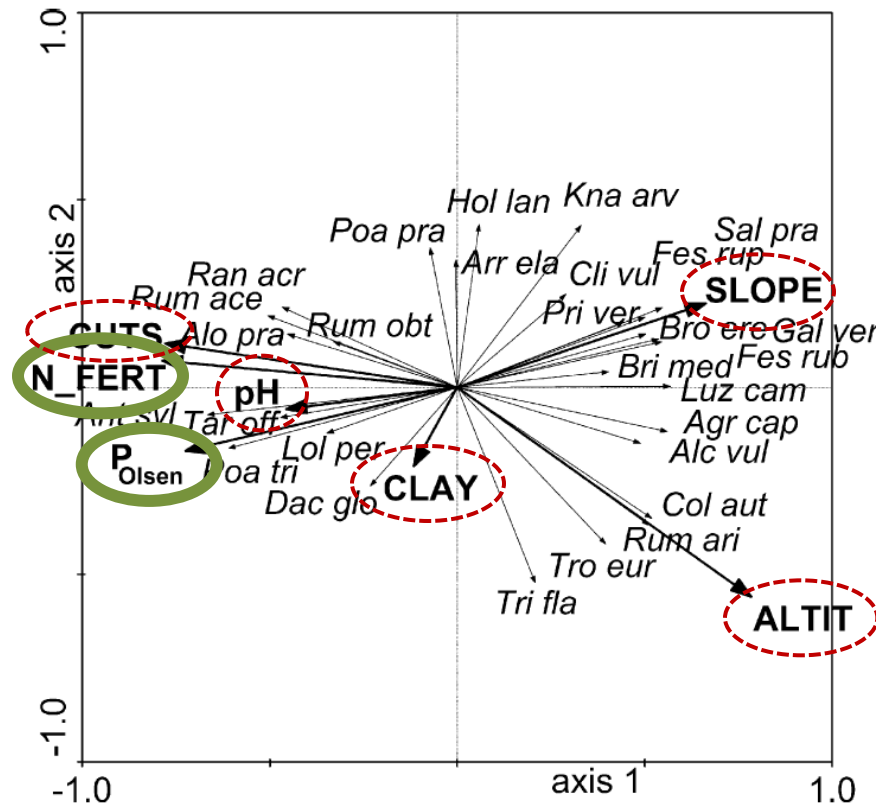
Institute of Crop Science and Resource Conservation
University of Bonn
Germany

Laise Pontes da Silveira

Agronomic Institute of Paraná
Ponta Grossa
Brazil

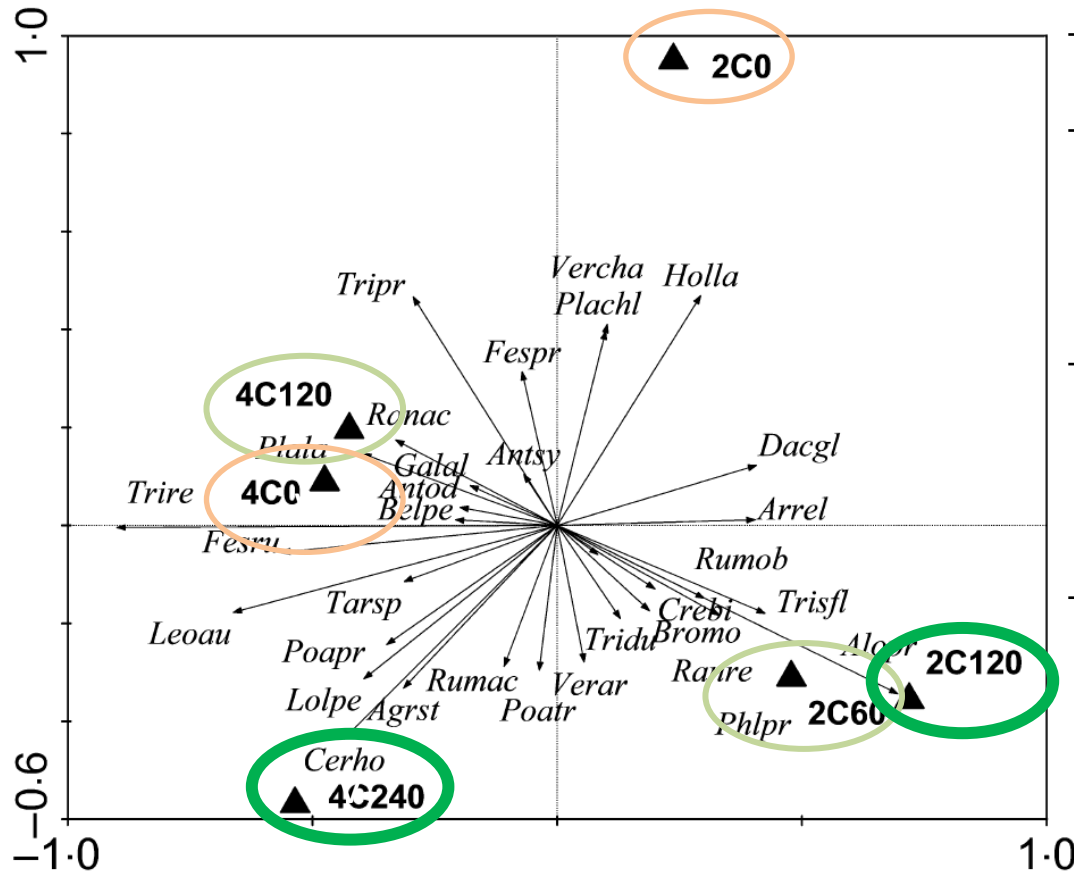


Environmental factors



Ordination plot of vascular plant species and explanatory variables along the first two axes of RDA constrained with the seven significant variables of the variation partitioning model. Only those 28 species with a fit-range above 20% are shown. The axes are scaled in standard deviation units. The data were obtained from 56 mown meadows in the Italian Alps.

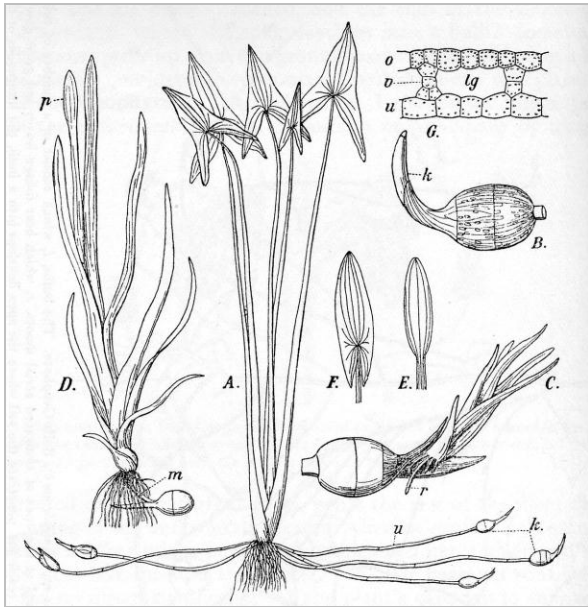
Marini, et al. (2007) *Agriculture, Ecosystems and Environment*.



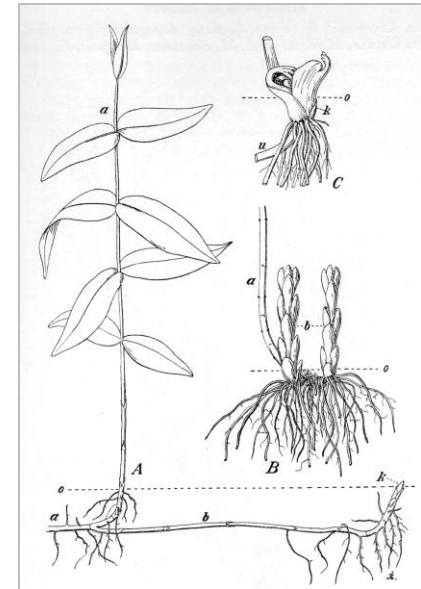
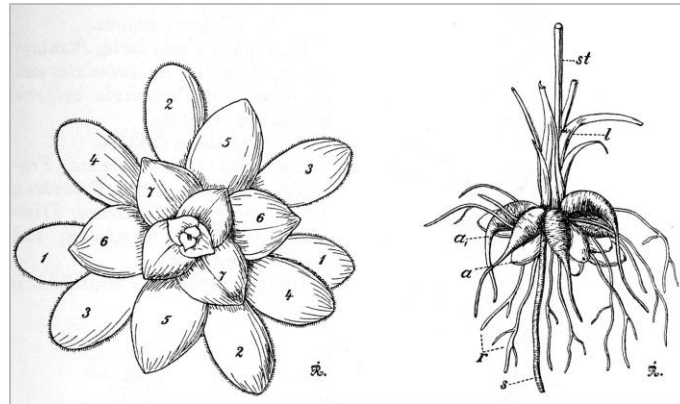
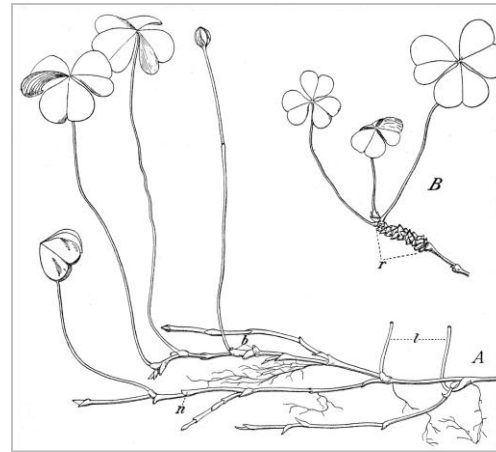
	No of cuts	N fertilizer [kg Nha ⁻¹ year ⁻¹]
2C0	2	0
2C60	2	60
2C120	2	120
4C0	4	0
4C120	4	120
4C240	4	240

Ordination diagram derived from RDA of plant species composition data in a 20 years experiment on permanent grassland at Rengen / Germany.

Pavlu et al. (2011) Grass and Forage Science



Christen Raunkiaer
1860-1938
Plant life forms (1937)



Plant functional traits can be defined as

- morphological
- physiological
- phenological
- biochemical

properties ...

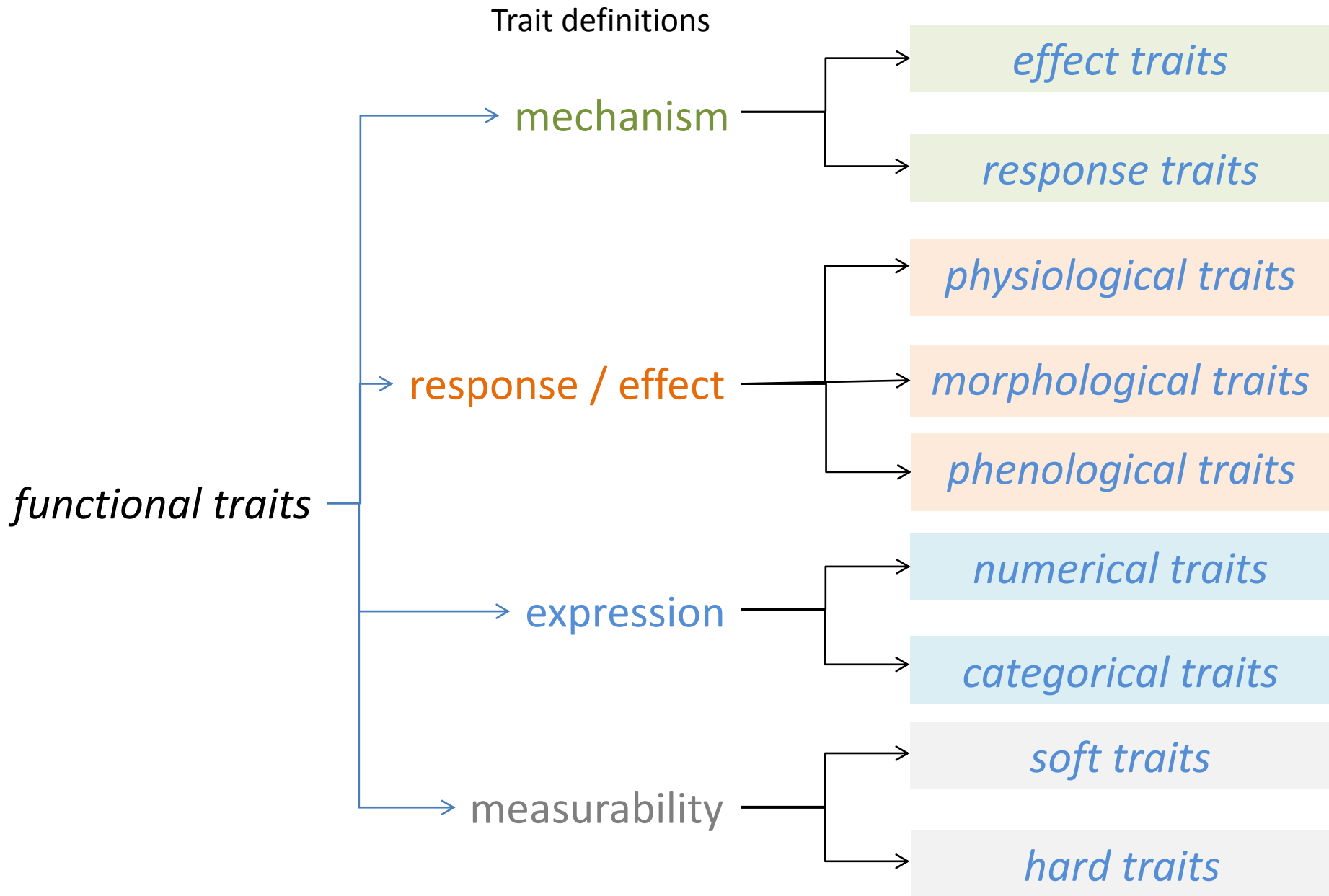
...which affect fitness indirectly via their impact on growth, reproduction and survival, the three components of individual performance (Violle et al. 2007).

Why we look at functional traits?

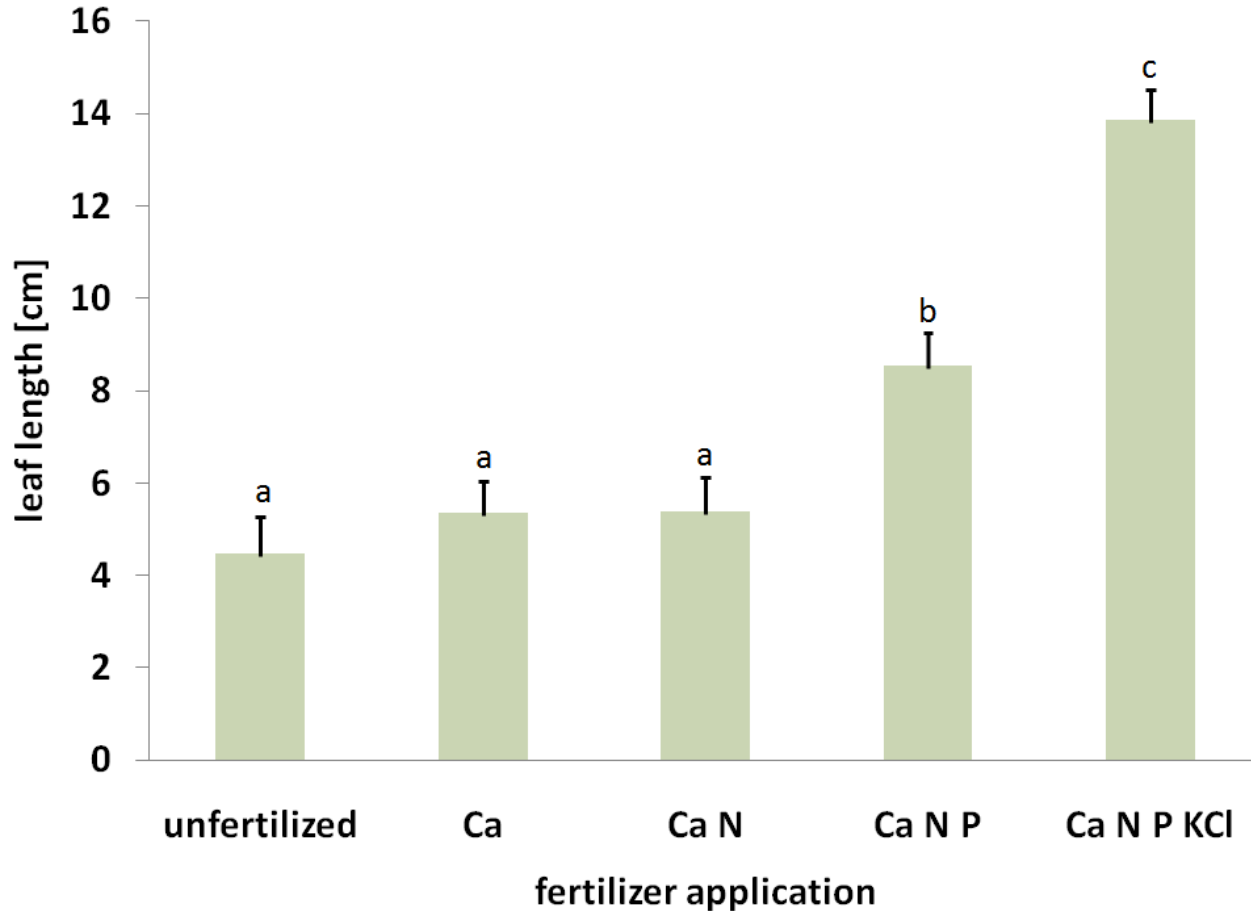
...ecologists have placed increasing emphasis on the use of phylogenetic classifications of organisms when describing the structure and functioning of ecosystems. Some feel that classical taxonomy will have to give way to functional classifications. (Smith, 1998)

GCTE:

...it will not be feasible to develop models for every ecosystem of the globe nor represent every species within those ecosystems. Thus, the concept that the complexity of the models can be reduced by treating a smaller number of 'functional types' (FT's) is central...; it has often been argued that the essential dynamics of ecosystems can be captured by grouping species into a limited number of FTs. (Steffen et al., 1992)

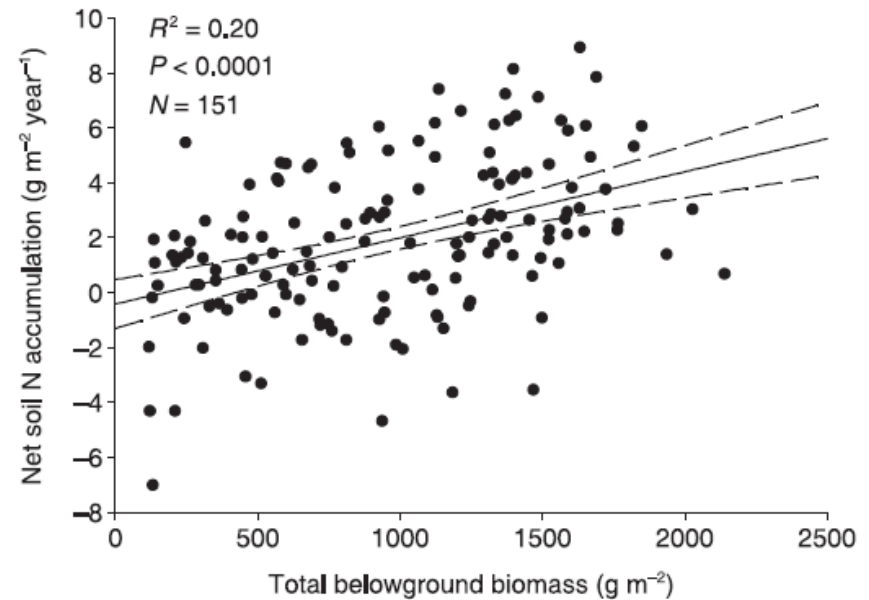
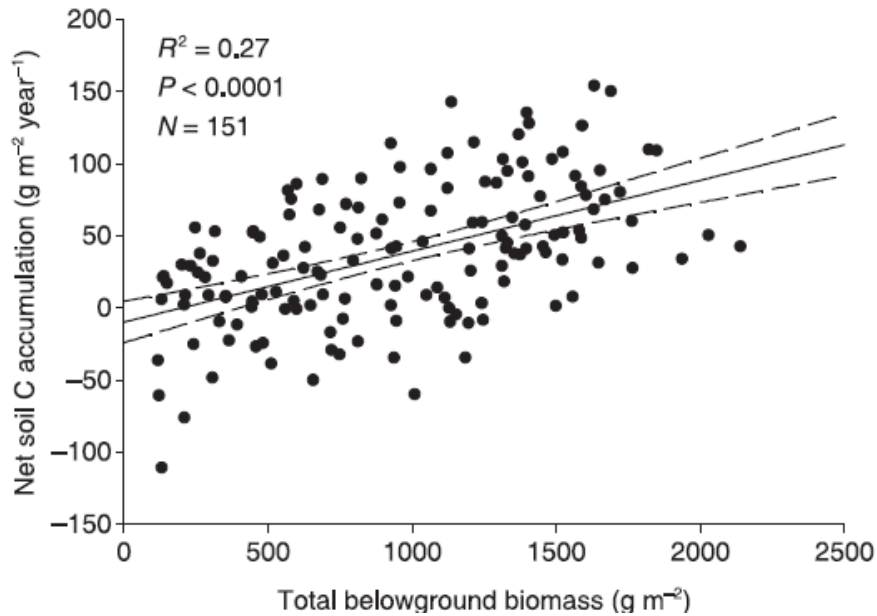


Response traits – an example



Effect of long-term fertilizer application on average leaf length per plant in *Plantago lanceolata* (L.) in the Rengen Grassland experiment (since 1941) (unpublished data, date of observation: July 2011)

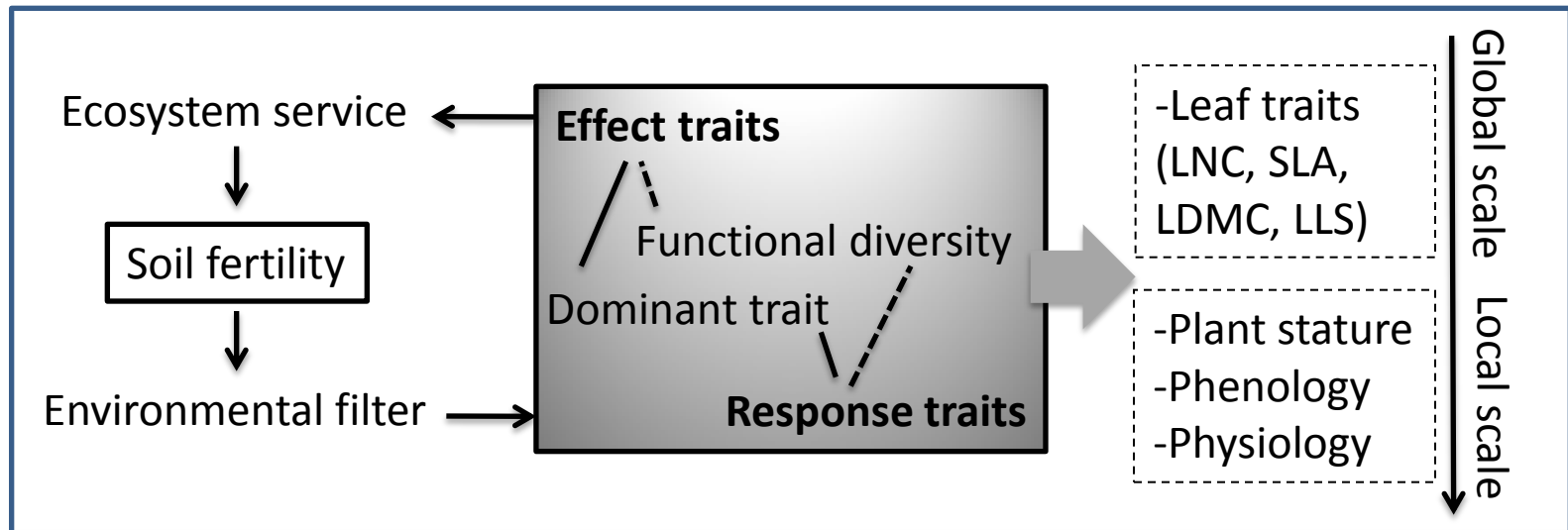
Effect traits - an example



Dependence of net soil C (left), and N (right), accumulation between 0 and 60 cm soil-depth on total plant below-ground biomass as measured in 2006. Regressions have d.f. = 1.151. Dashed lines represent 95% confidence bands.

Fornara and Tilman, 2008

Simplified presentation of the trait approach and its maintenance as an ecosystem service with soil fertility as the environmental filter

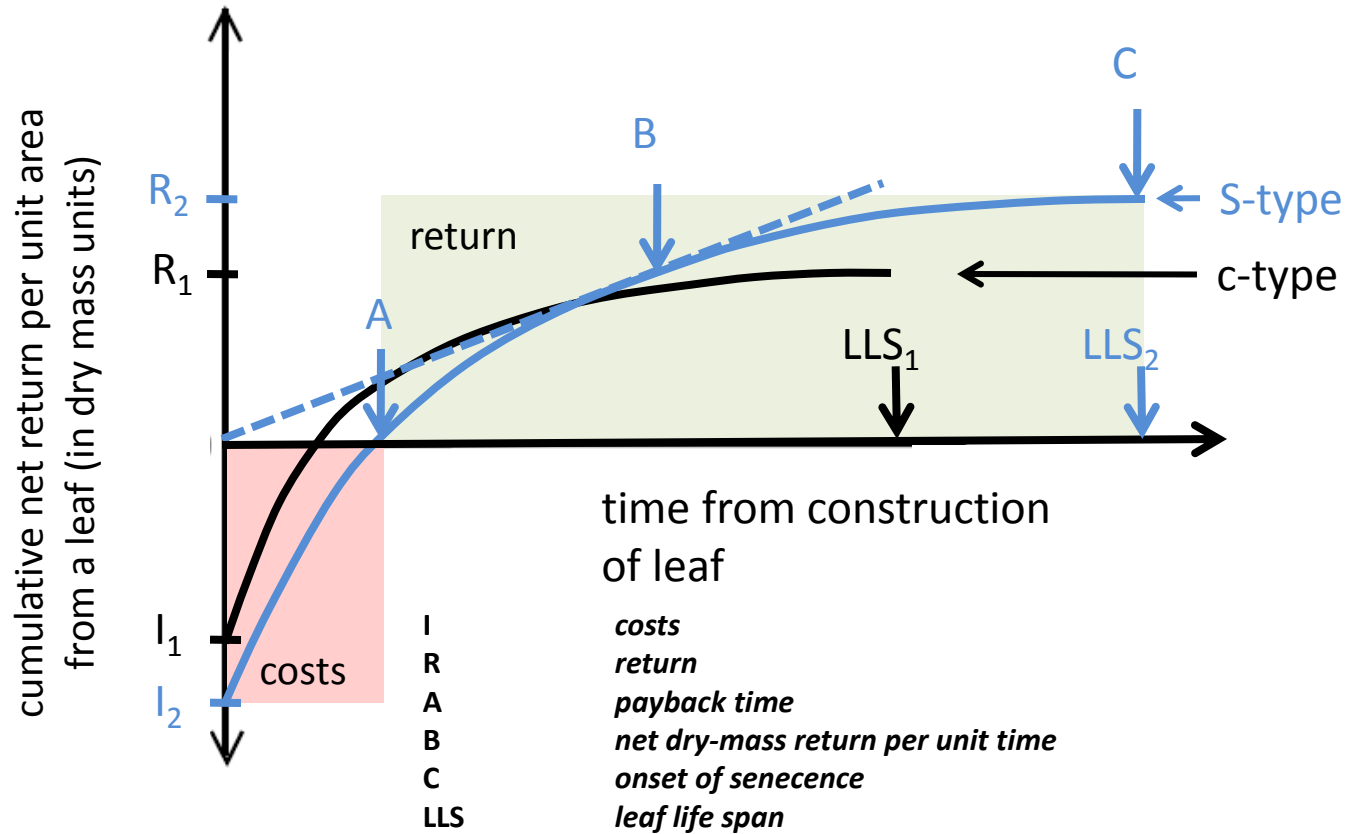


Evaluation of C-, S-, and R-types in relation to their functional traits

functional trait	C-type	S-type	R-type
relative growth rate	+++	-	+
soil cover	+++		
leaf area development	+++		
leaf form	laminar		
leaf inclination	prostrate		
specific leaf area	++	-	++
leaf N content	+++	-	++
photosynthetic rate	++	-	+++
rate of translokation to growing tissues	+++		++
C accumulation at low resource level	-	+	
efficient internal recycling of C	-	+	-
investment into structural biomass	-	+	-
leaf live span	-	+	-
development from seeds	-	+	++
monokarpy			+++
polykarpy		++	-

C: competitive, S: stress tolerant, R: ruderal

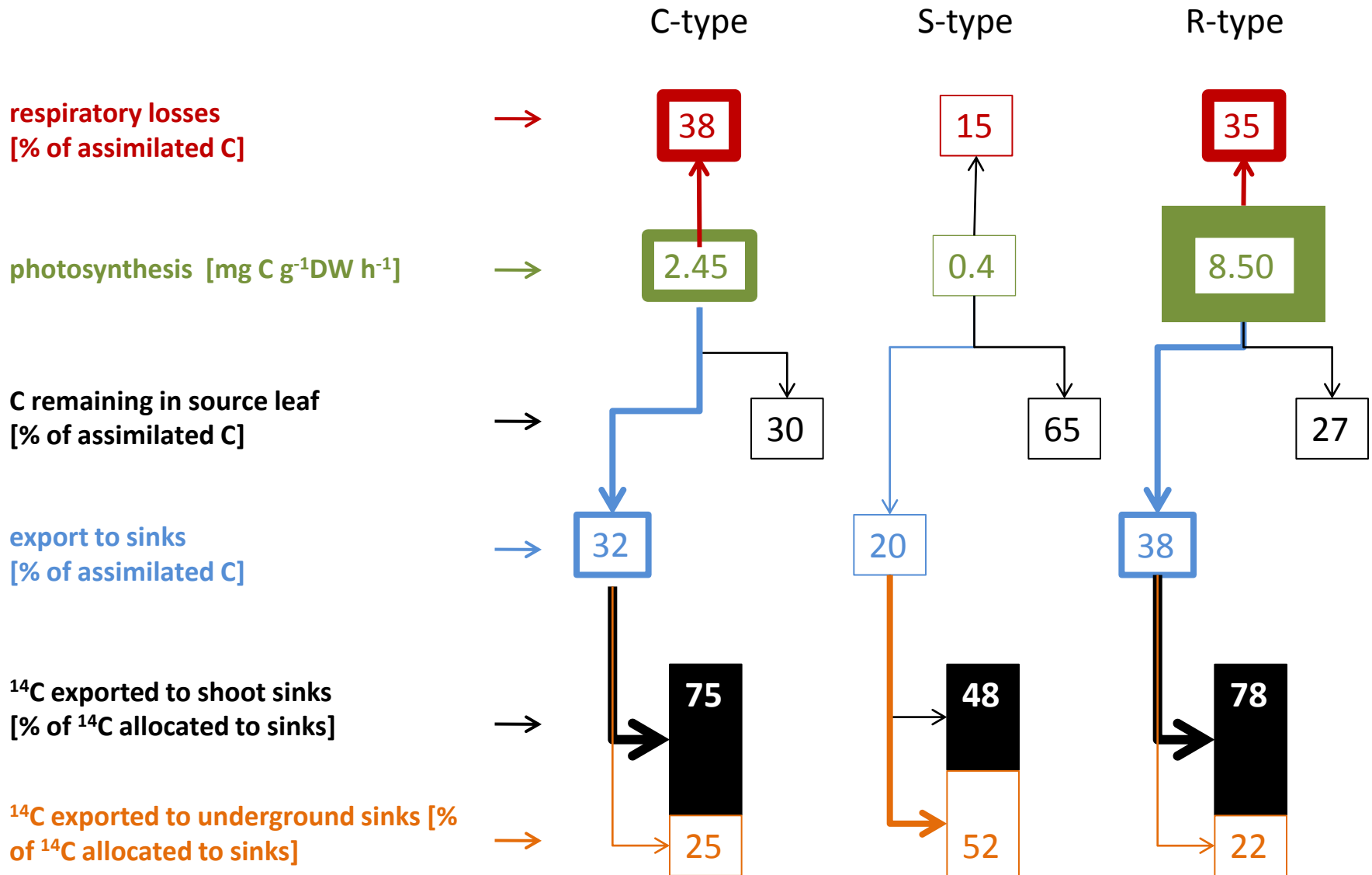
A theory of construction costs and net return of leaves – C type versus S type



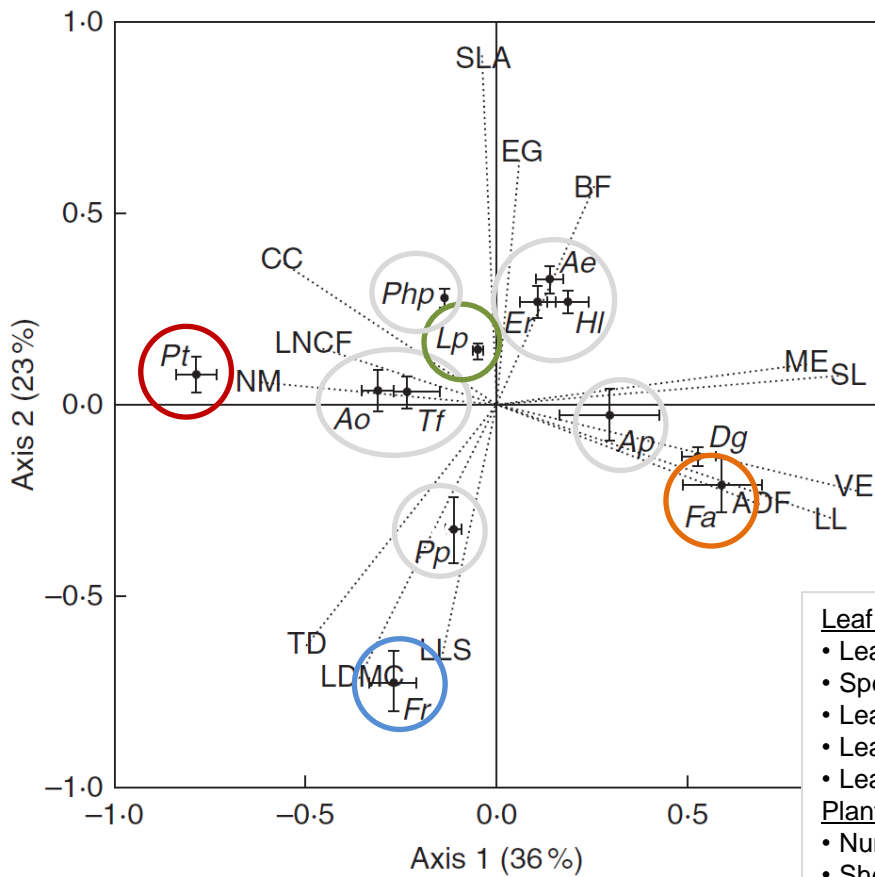
Kikuzawa 1995, *Vegetatio* 121, 89-100

Mark Westoby et al., 2002. *Ann. Rev. Ecol. Syst.* 33, 25–59

C assimilation, -translocation und -loss in C-, S- und R-types



Data source: P'yankov et al., 2000. Russian Journal of Plant Physiology, 47,(1), 5-13.



Species:

Ap	Alopecurus pratensis
Ao	Anthoxanthum odoratum
Ae	Arrhenatherum elatius
Dg	Dactylis glomerata
Er	Elytrigia repens
Fa	Festuca arundinacea
Fr	Festuca rubra
Hl	Holcus lanatus
Lp	Lolium perenne
Php	Phleum pratense
Pp	Poa pratensis
Pt	Poa trivialis
Tf	Trisetum flavescens

Leaf traits

- Leaf dry matter content
- Specific leaf area
- Leaf length
- Leaf lifespan
- Leaf N content per unit fresh matter

LDMC	mg d.wt g ⁻¹ f. wt
SLA	m ² kg ⁻¹
LL	mm
LLS	degree day, °Cd
LNCF	mg g ⁻¹

Plant traits

- Number of mature leaves
- Sheath length
- Vegetative plant height elongated
- Mature plant height elongated ME
- Plant cellular content
- Plant cellulose and lignin content

NM	tiller ⁻¹
SL	mm
VE	mm
CC	g kg ⁻¹
ADF	g kg ⁻¹

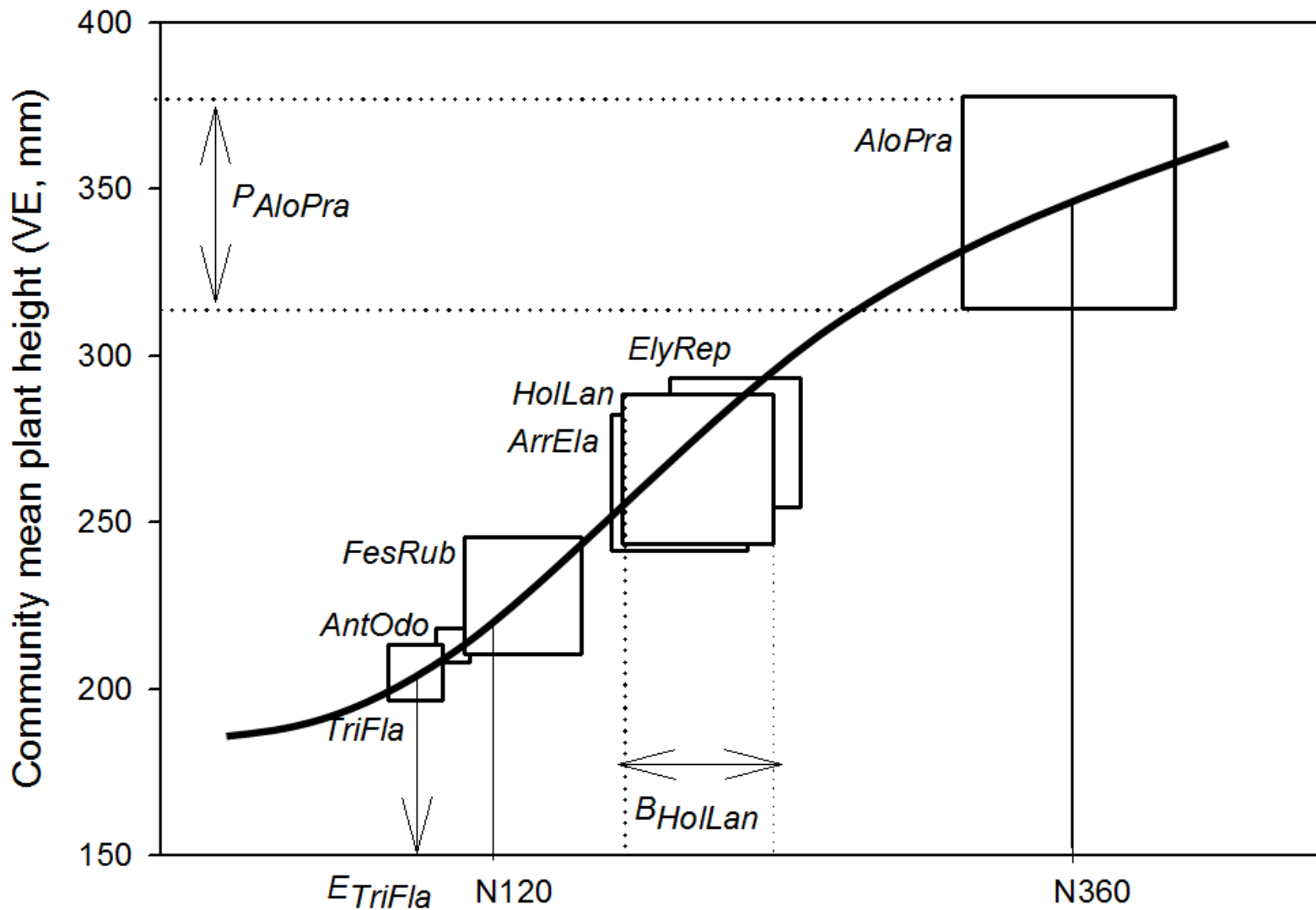
Morphological traits

- Earliness of growth
- Beginning of flowering period
- Tiller density

EG	–
BF	degree day, °Cd
TD	m ⁻²

Principal components analysis between traits measured under high N supply and low cutting frequency. (result of a principle component analysis)

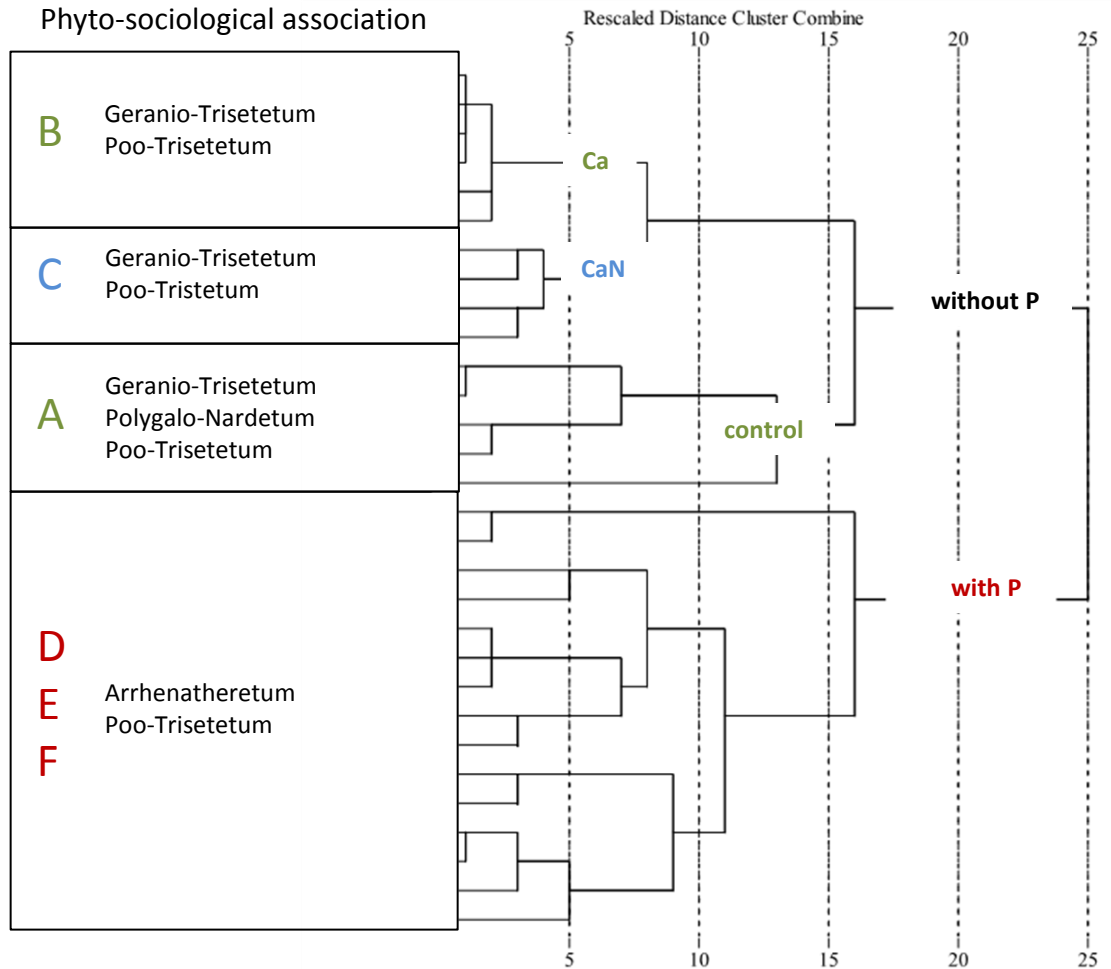
Pontes da S. et al. 2011 Annals of Botany



Trait-based quantification of species niche position and breadth along resources gradient (N supply, 120 and 360 kg N ha⁻¹ year⁻¹, denoted N120 and N360, respectively).

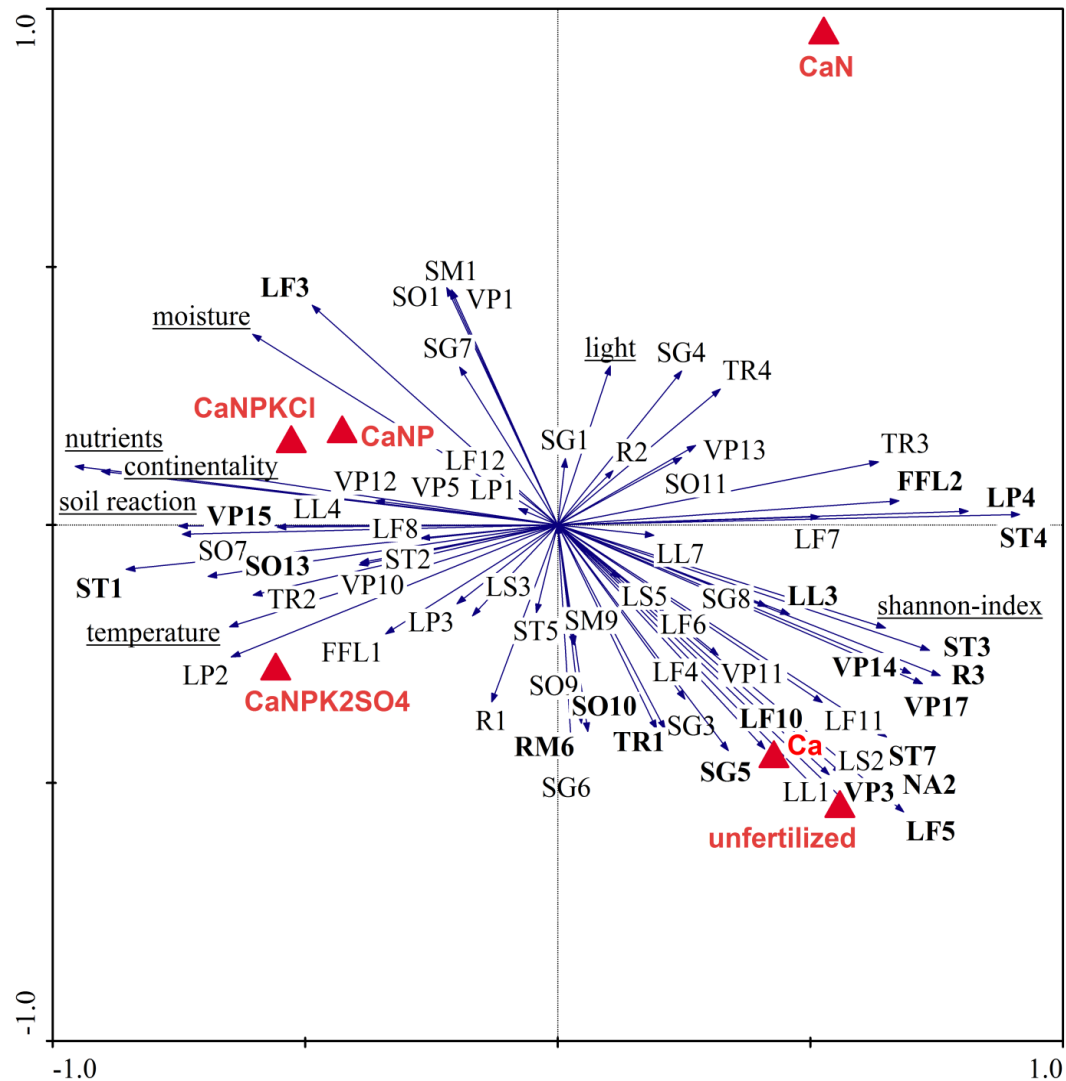


The Rengen Grassland Experiment



Dendrogram of experimental plots in the Rengen Grassland Experiment clustered based on combinations of their categorical plant functional traits (four years average of data, 2005-2008).

Results of the RDA on trait response to fertilizer application in the RGE (2005 – 2008 average)



Links across disciplines

- Better understanding of the link between **species composition** on grassland and the **trait syndrome** as influenced by nutrient supply and its consequences for ecosystem services is needed.
- Management strongly influences plant species composition, but, the underlying **functions** are rarely understood.
- Functional traits related to **feeding value** are directly related to the abundance of species and their growth strategy under given environmental conditions.
- The functional relations between **plant traits and animal traits** (claw size, form of dentition, bite frequency) can best be investigated in interdisciplinary studies.

Thanks for your attention !

trait costs response traits stress
numerical traits functional classification leaf economic spectrum
functional traits species richness trait benefits
ruderals functional diversity
trait syndromes
surviv
e
categorical traits functional groups physiological traits
functional type fitness plant community
biodiversity hard traits
morphological traits agroecosystem niche dimension
effect traits heritable trait ecosystem processes
plant strategy competitive ability
coexistence trait variation
functional dendrogram