Ökosystemleistungen mit der landwirtschaftlichen Nutztierhaltung

Johannes Isselstein
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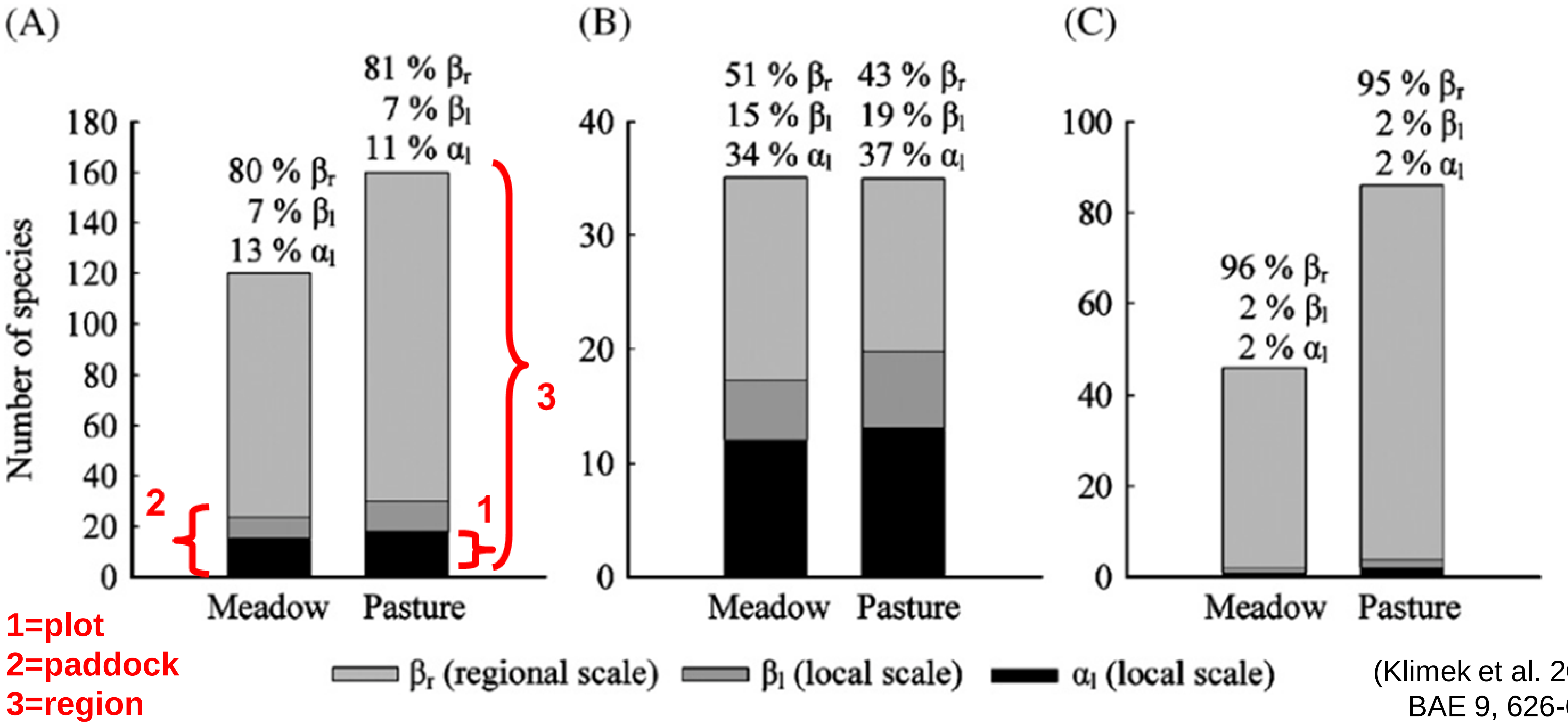
Hülsenberger Gespräche 2024

Monet / La Prarie fleurie

View of Lake Lucerne (Wikimedia Commons)



(Klimek et al. 2008, BAE 9, 626-634)

Scale dependency of the plant species richness of meadows and pastures (n=60) in the district of Northeim, Lower Saxony, (A)=all species, (B)=common species, (C)=rare species, region

Starting point / Hypotheses

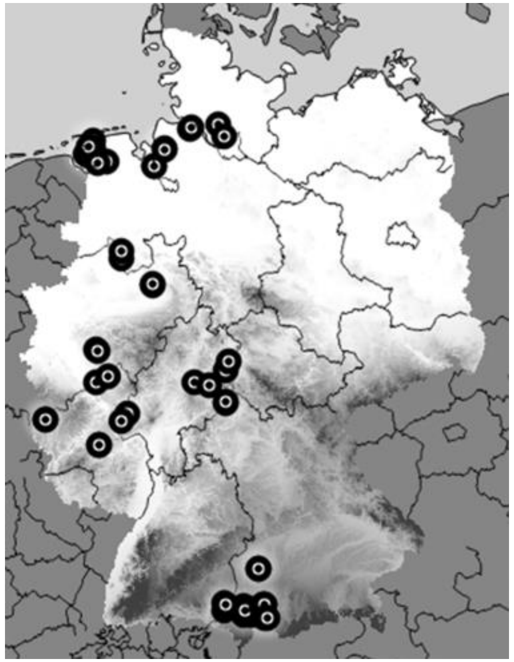
i. **The provision of grassland related ecosystem services is scale dependent**

ii. **Heterogeneity at landscape scale is important to ensure the continuous provision of ecosystem services**

iii. **Heterogeneity is due to spatial variability in the trophic conditions and to different grassland management / utilization (interaction)**

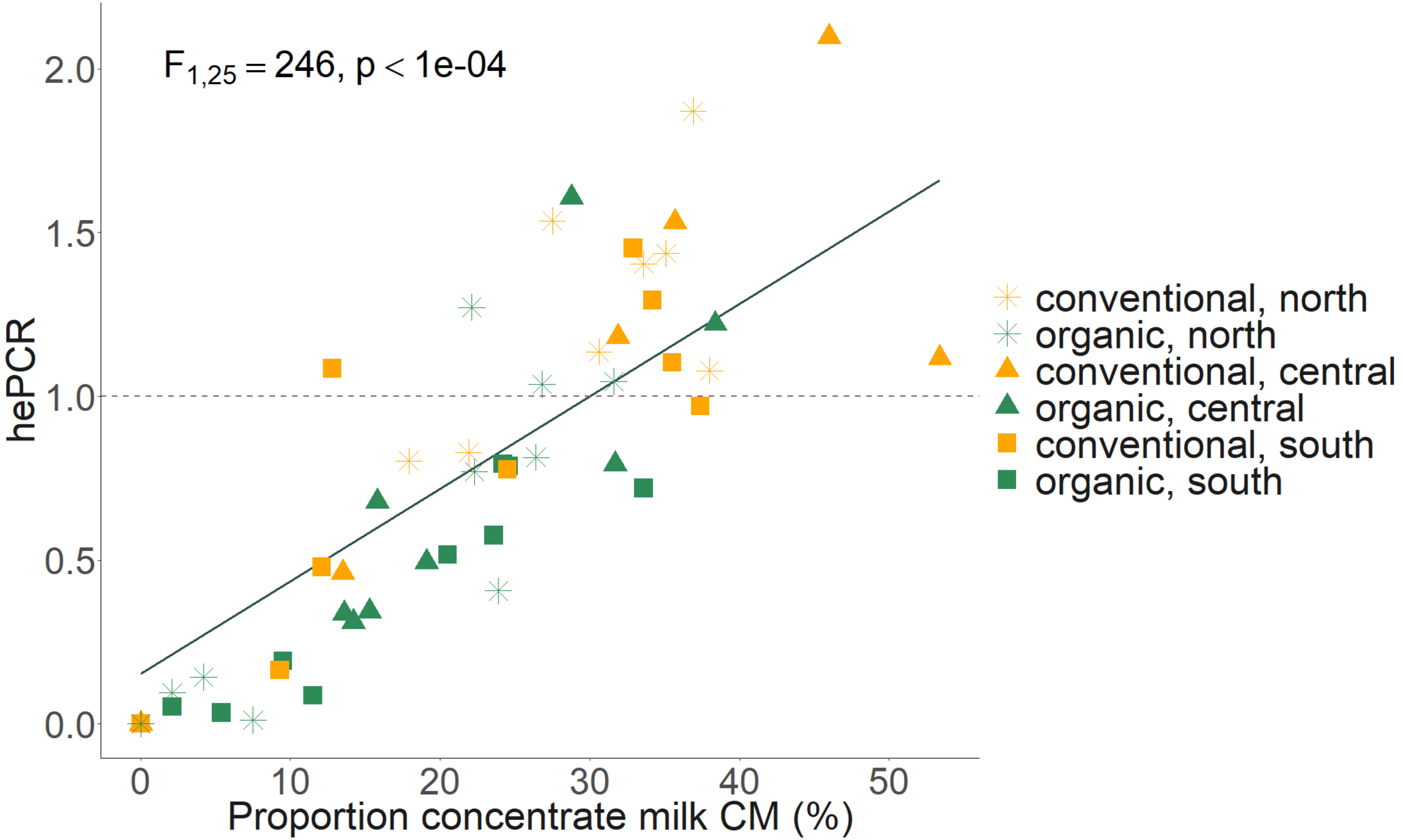
iv. **There is room for targeted management and livestock husbandry to support ecosystem services at large**

Grassland based production systems

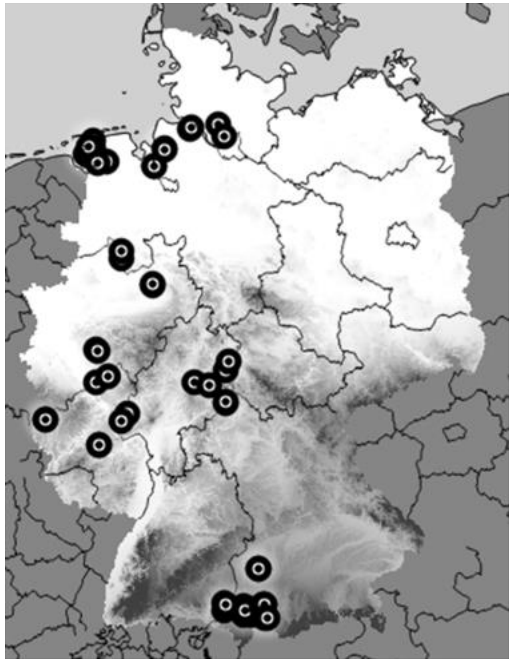


Dairy farms in Germany

- 3 regions
- 2 farming systems
- 2 concentrate levels



Relationship between concentrate feeding of dairy cows and the human edible protein con-version ration (hePCR) of dairy farms in Germany (Bettin et al. 2023, AEE, Wild et al. in prep.)



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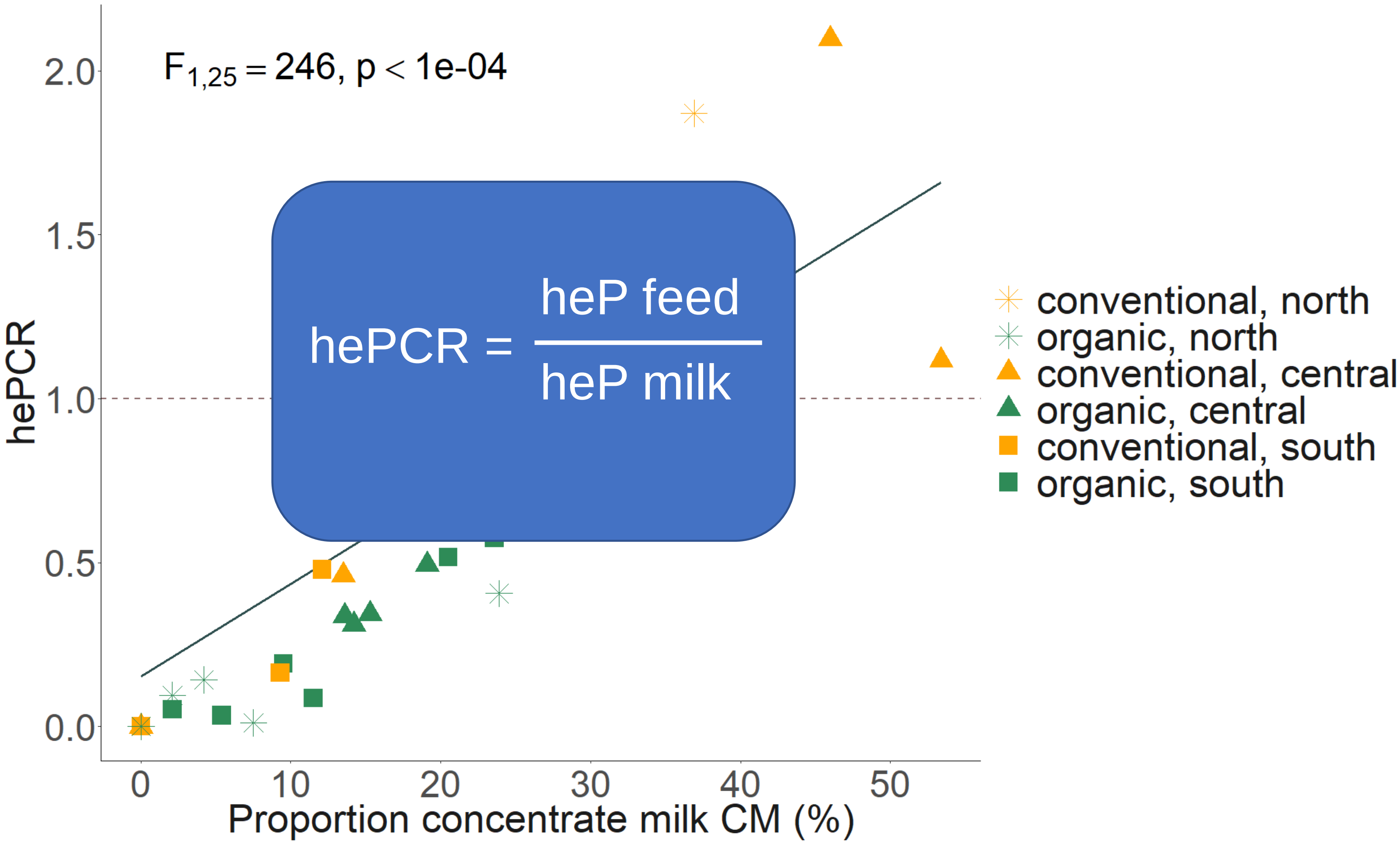

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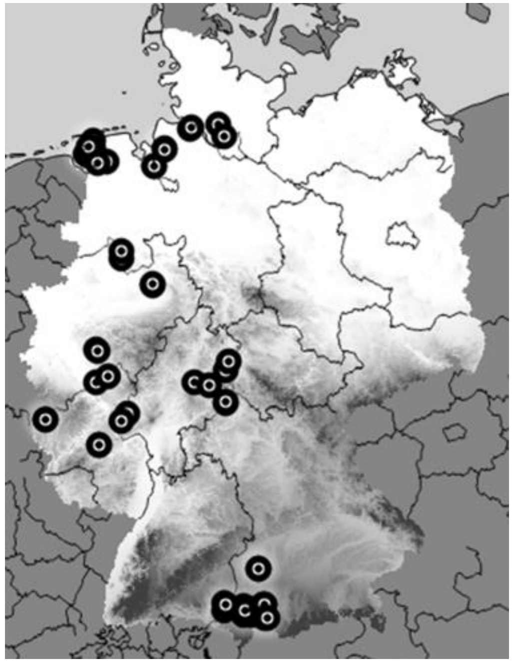

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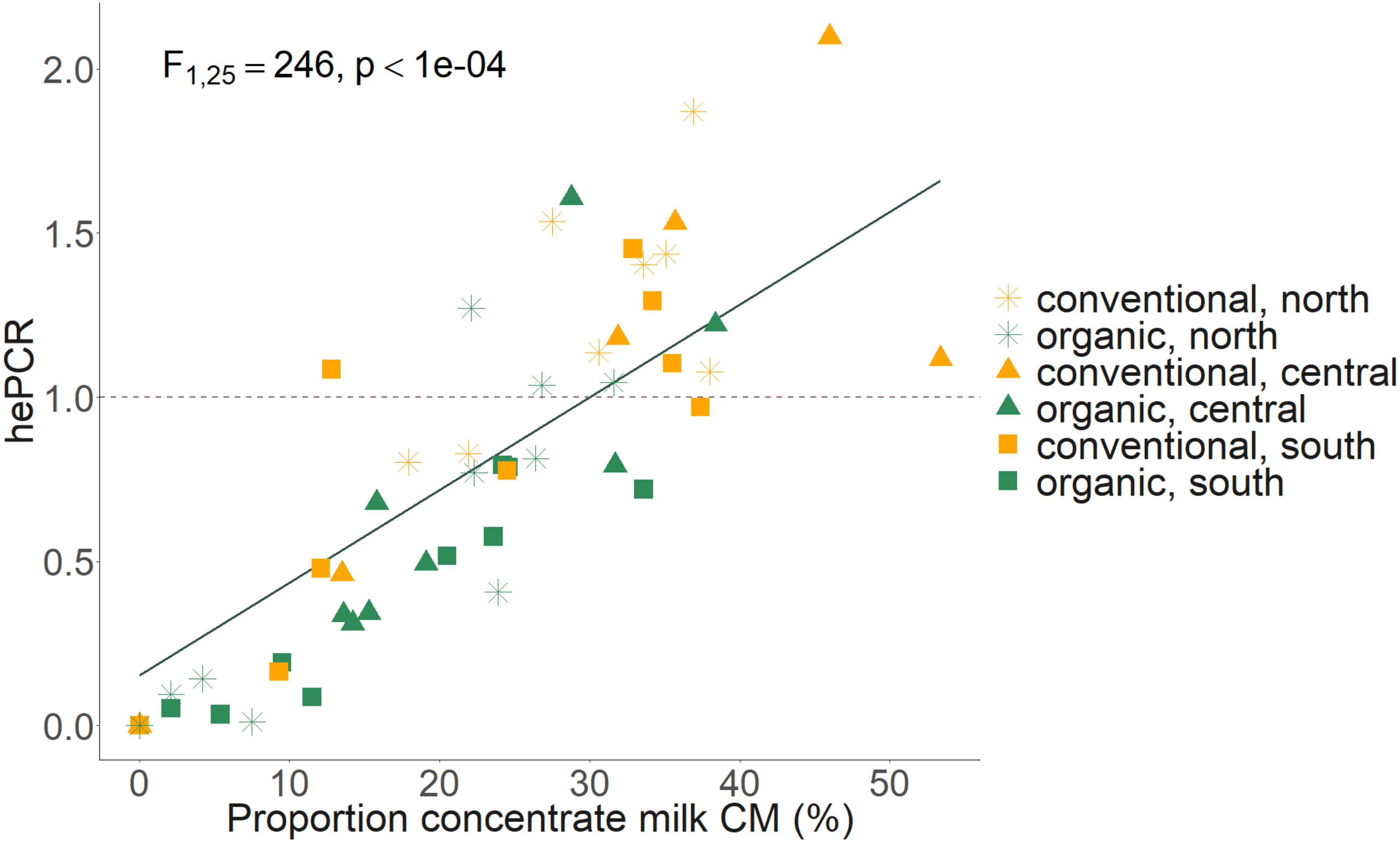

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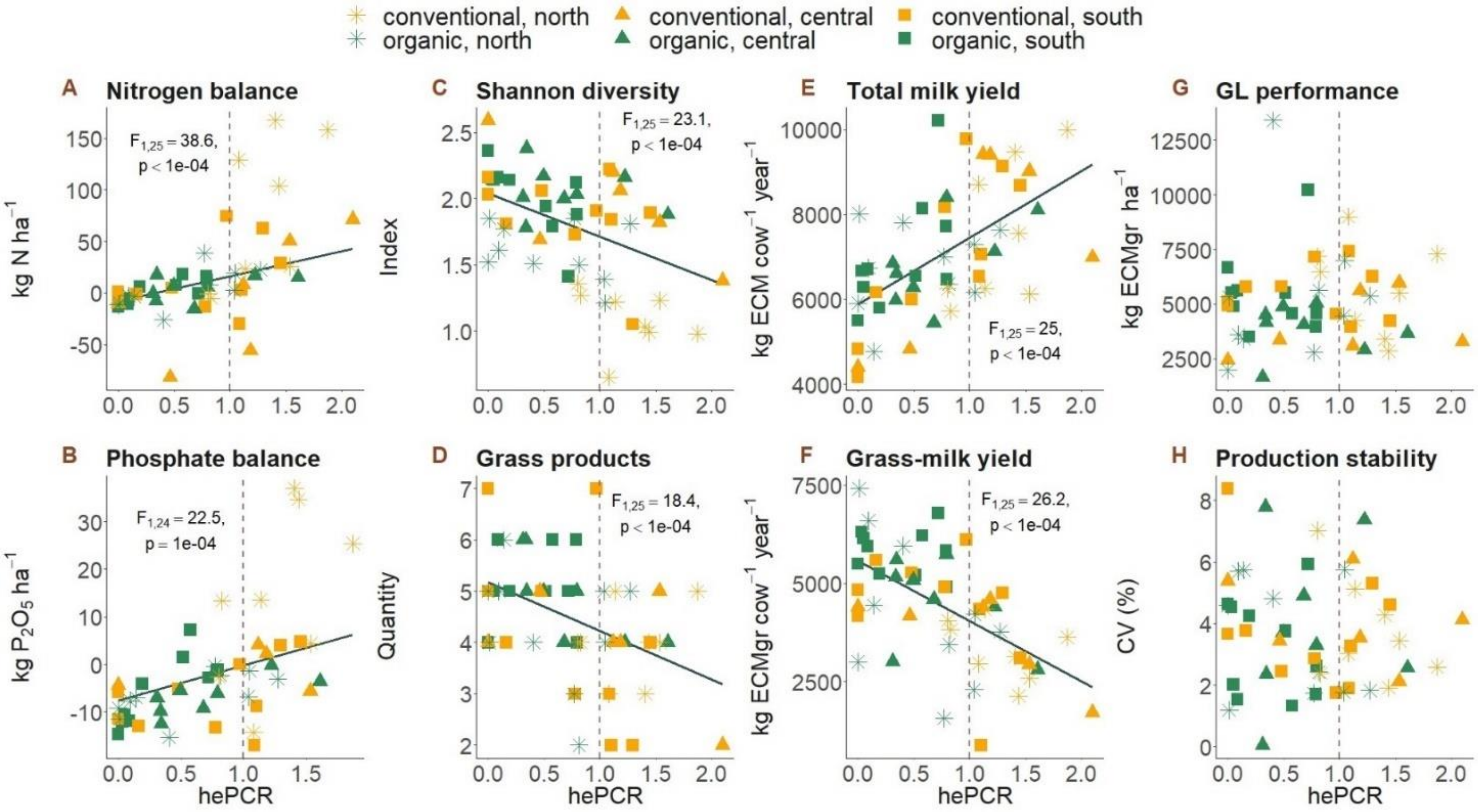
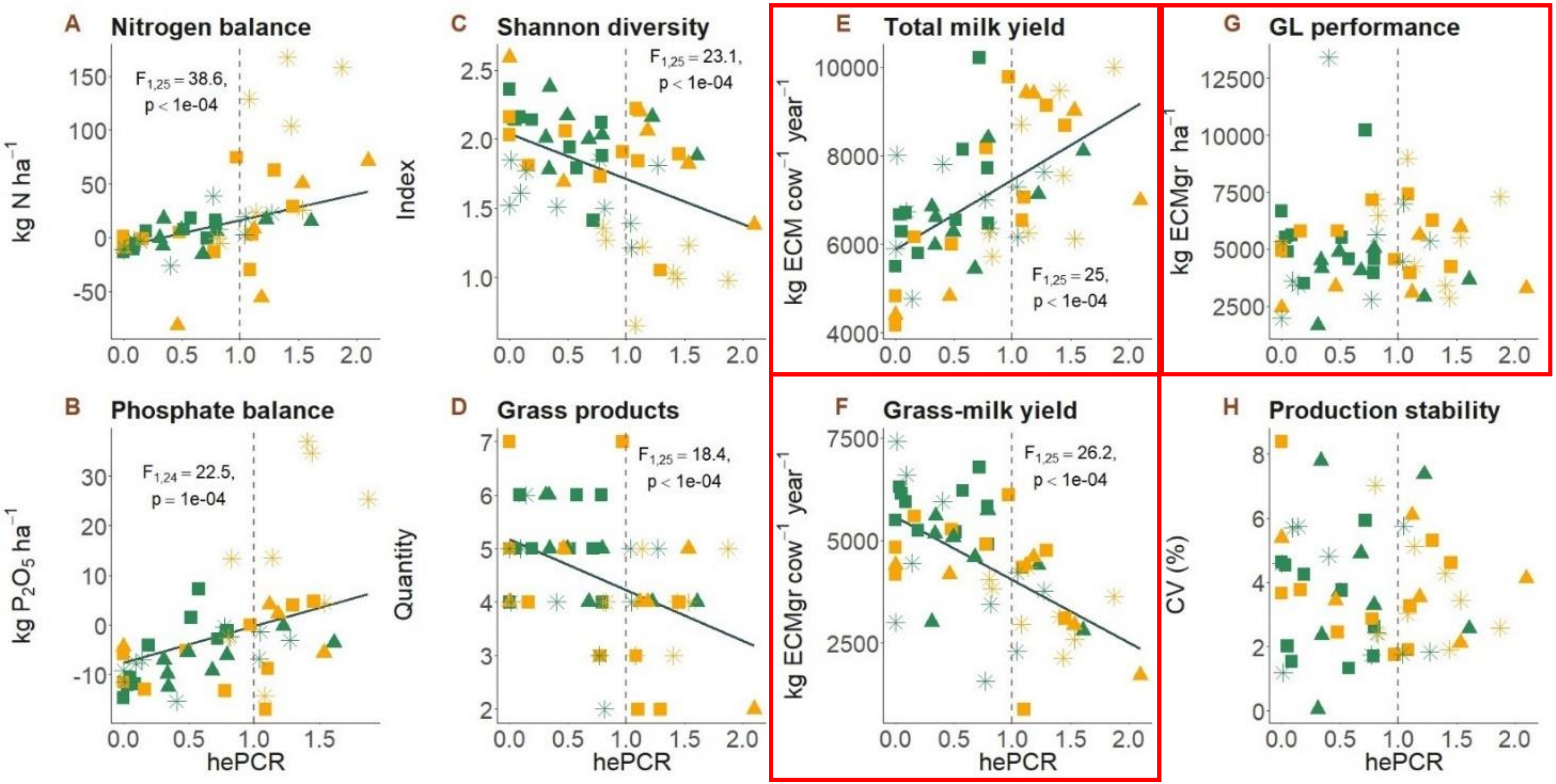


Relationship between hePCR and some ecosystem services of dairy farming in Germany

(Wild et al. in prep.)

Milchleistung



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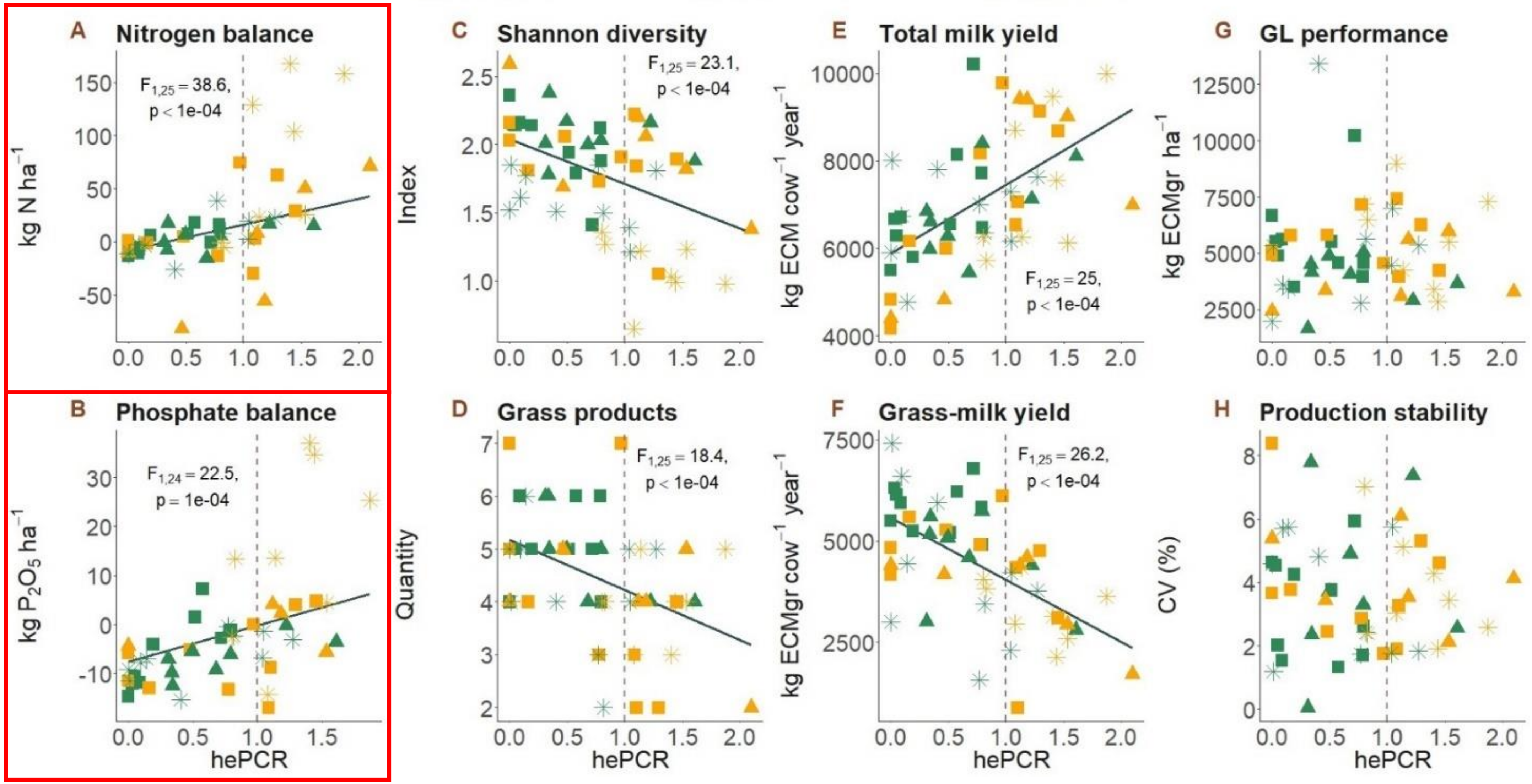
Stoffbilanz



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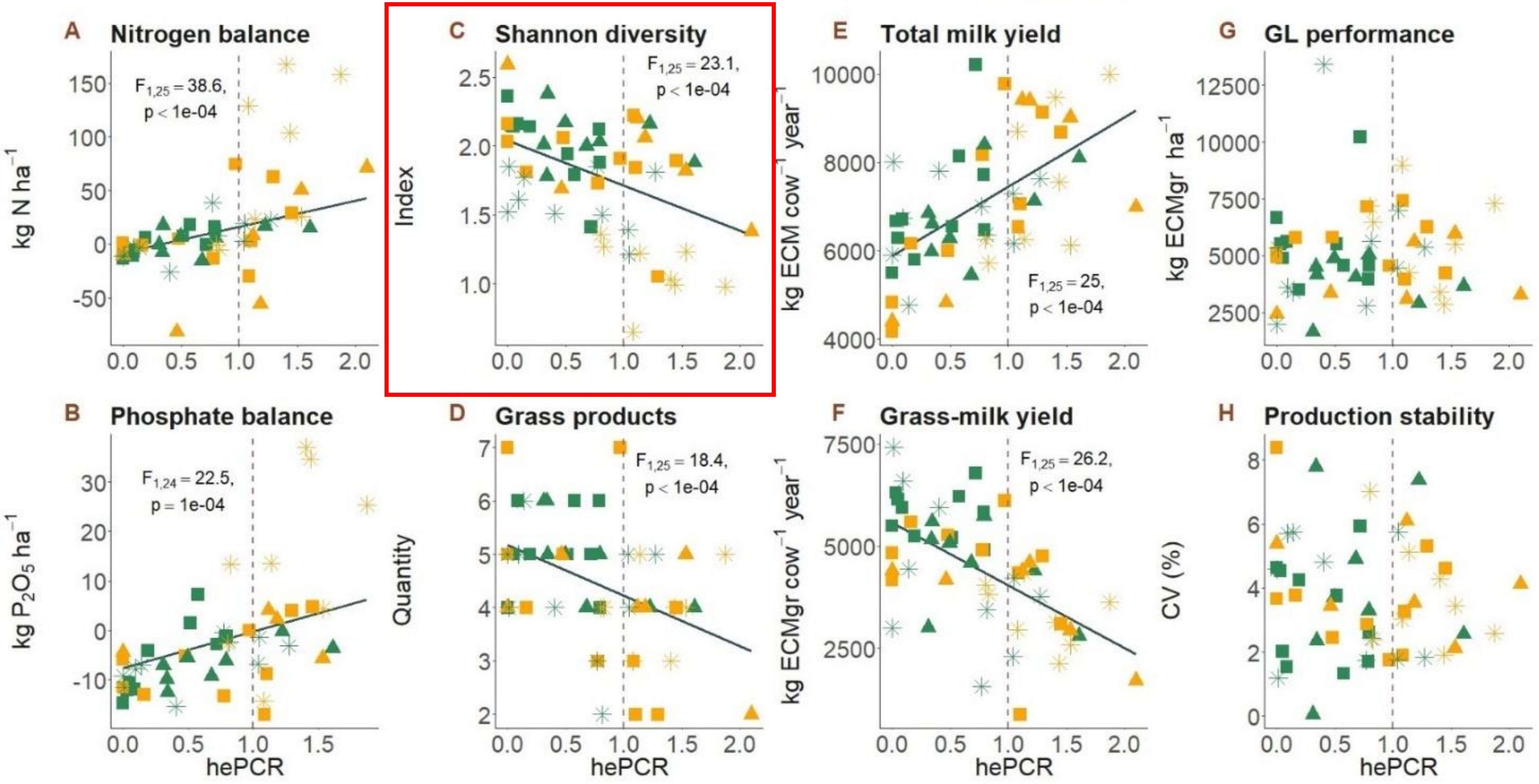
Diversität



Relationship between hePCR and some ecosystem services of dairy farming in Germany

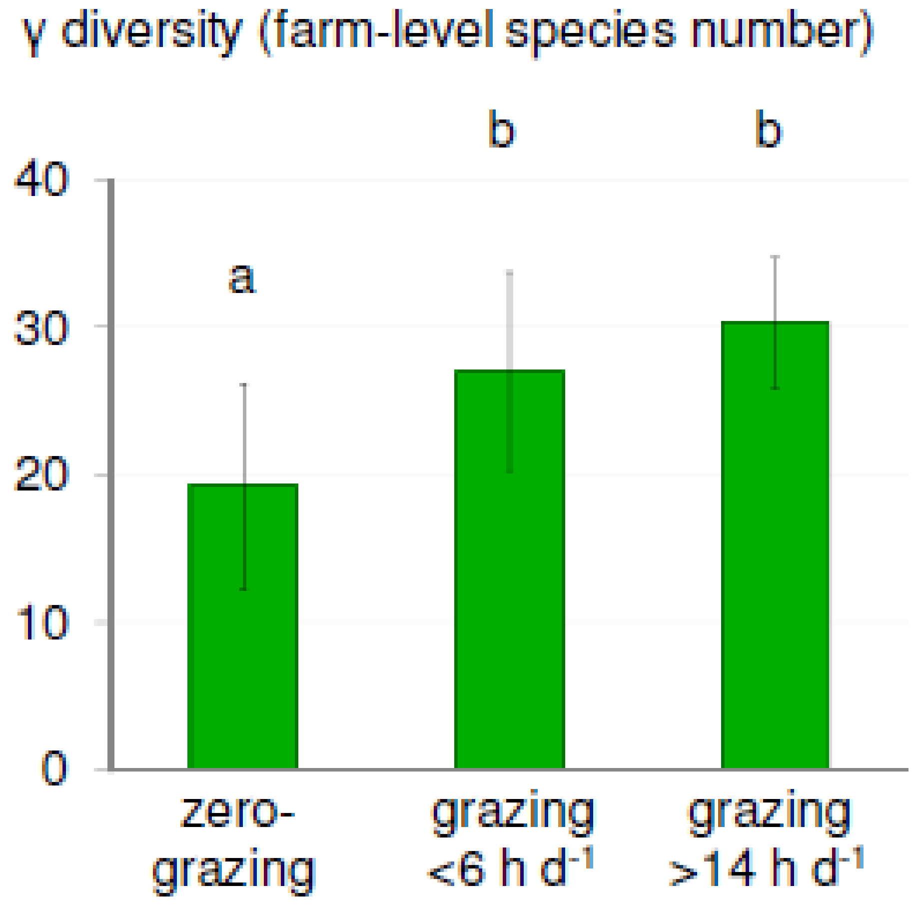
(Wild et al. in prep.)

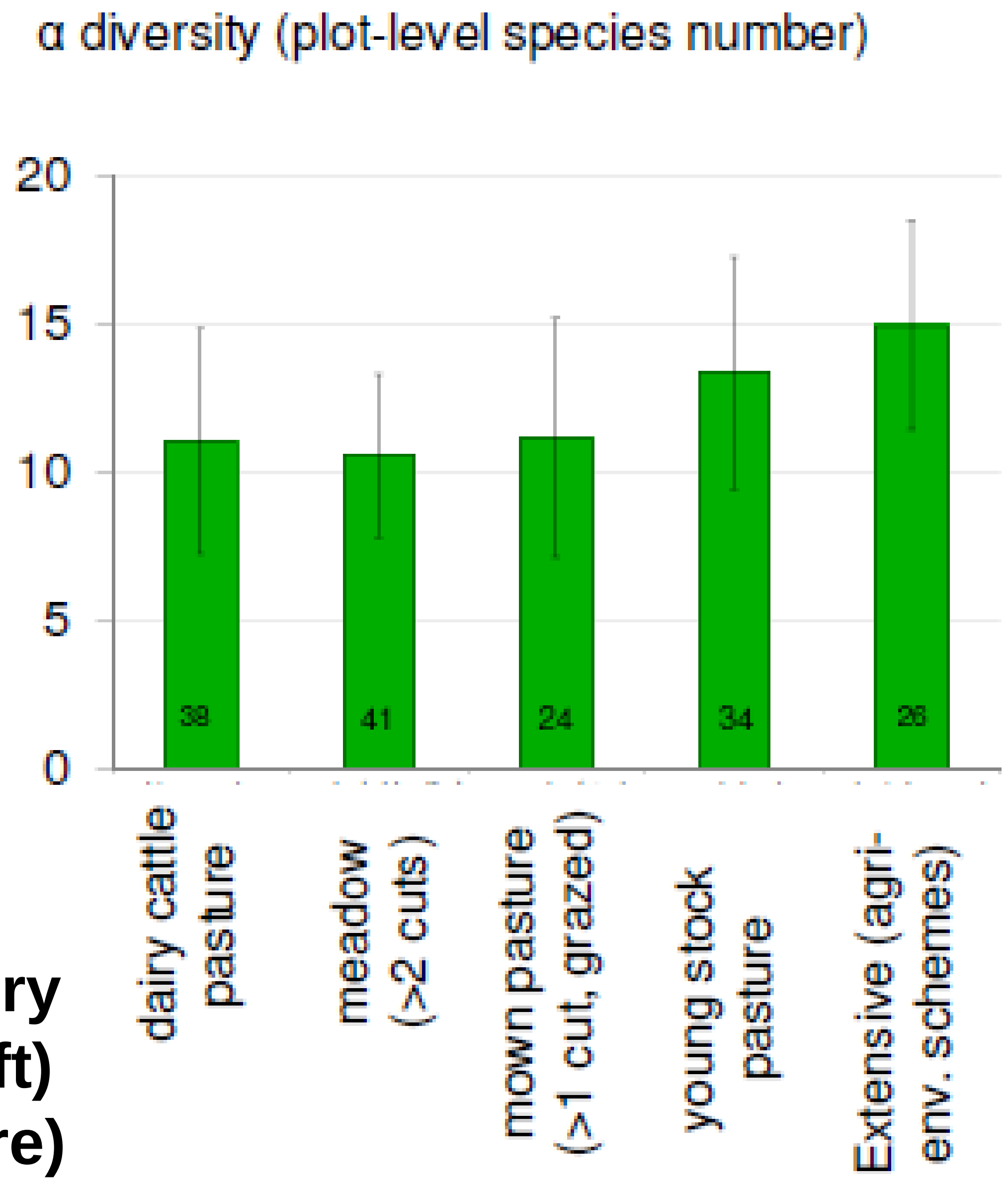
Plant species richness and management of grasslands of dairy and beef cattle farms in southern Lower Saxony, Germany, number of grassland sites for dairy n=120 and for beef n=120

	Beef			Dairy			
Diversity	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	*p*-level
Species/25m²	19	7	40	16	5	35	***
Species/Farm	50	31	79	47	34	71	n.s.

	Beef			Dairy			
Management	**Mean**	**Min**	**Max**	**Mean**	**Min**	**Max**	*p*-level
N-input kg/ha	71	0	339	167	0	468	***
Soil-P mg/100g	7.1	1	31	7.3	1	27	n.s.
Soil-K mg/100g	10.4	1	63	9.3	2	77	n.s.

(Stroh et al., GSE, 2009)

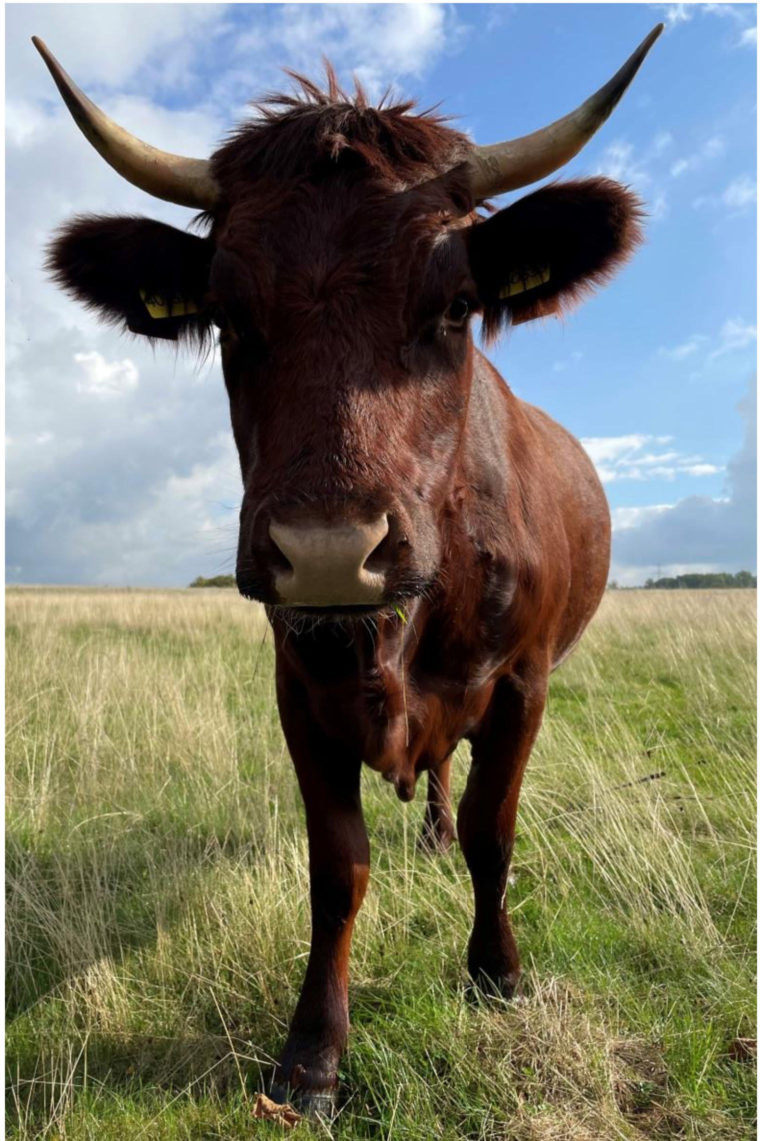




Plant species richness of grasslands of dairy farms (n=60) in NW-Germany in relation (left) to the grazing practice (daily time on pasture) and (right) to the grassland management

(Breitsameter & Isselstein, GSE 2015)

Grazing and grazers behaviour and grassland services



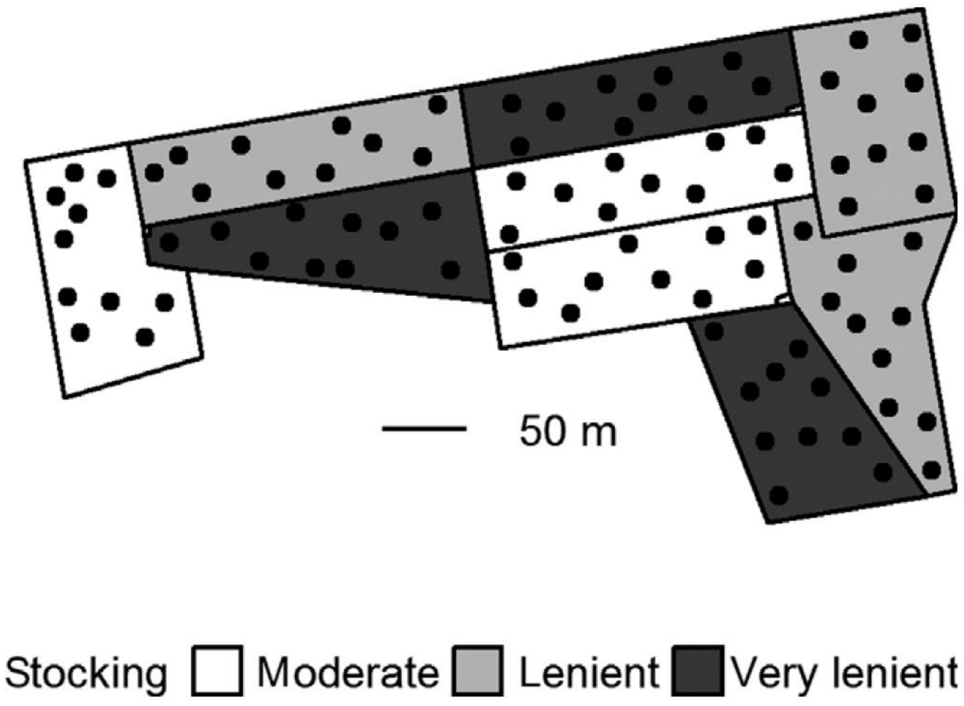
View of Lake Lucerne (Wikimedia Commons)

Park-like pasture landscape, Lake Lucerne, etching by Peter Birmann (around 1800)

Experimental design / treatments

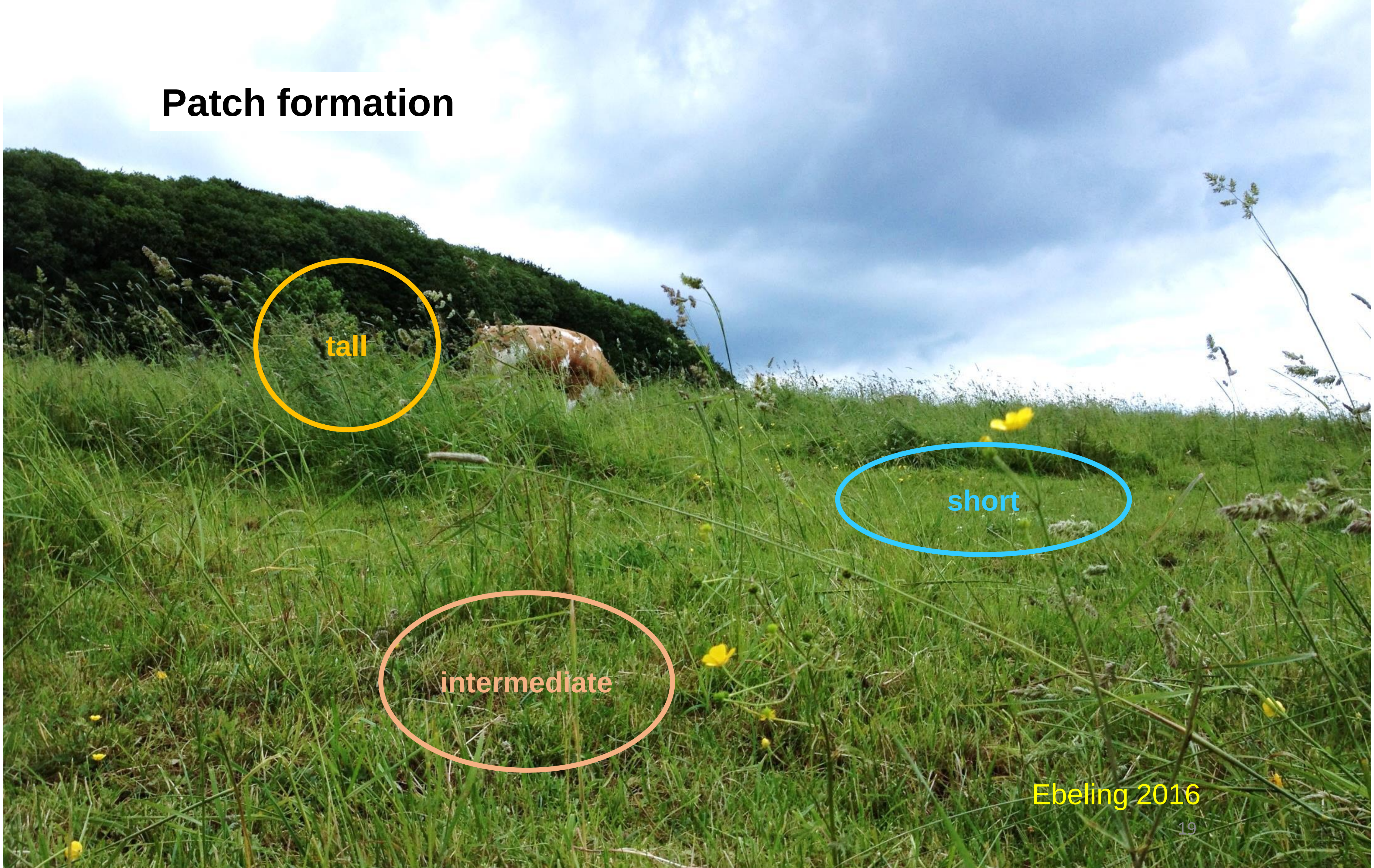
Grazing intensity	Target compressed sward height (cm)	Long-term average stocking rate (kg ha^{-1} y^{-1})
Moderate	6	645
Lenient	12	360
Very lenient	18	245

Replication number 3

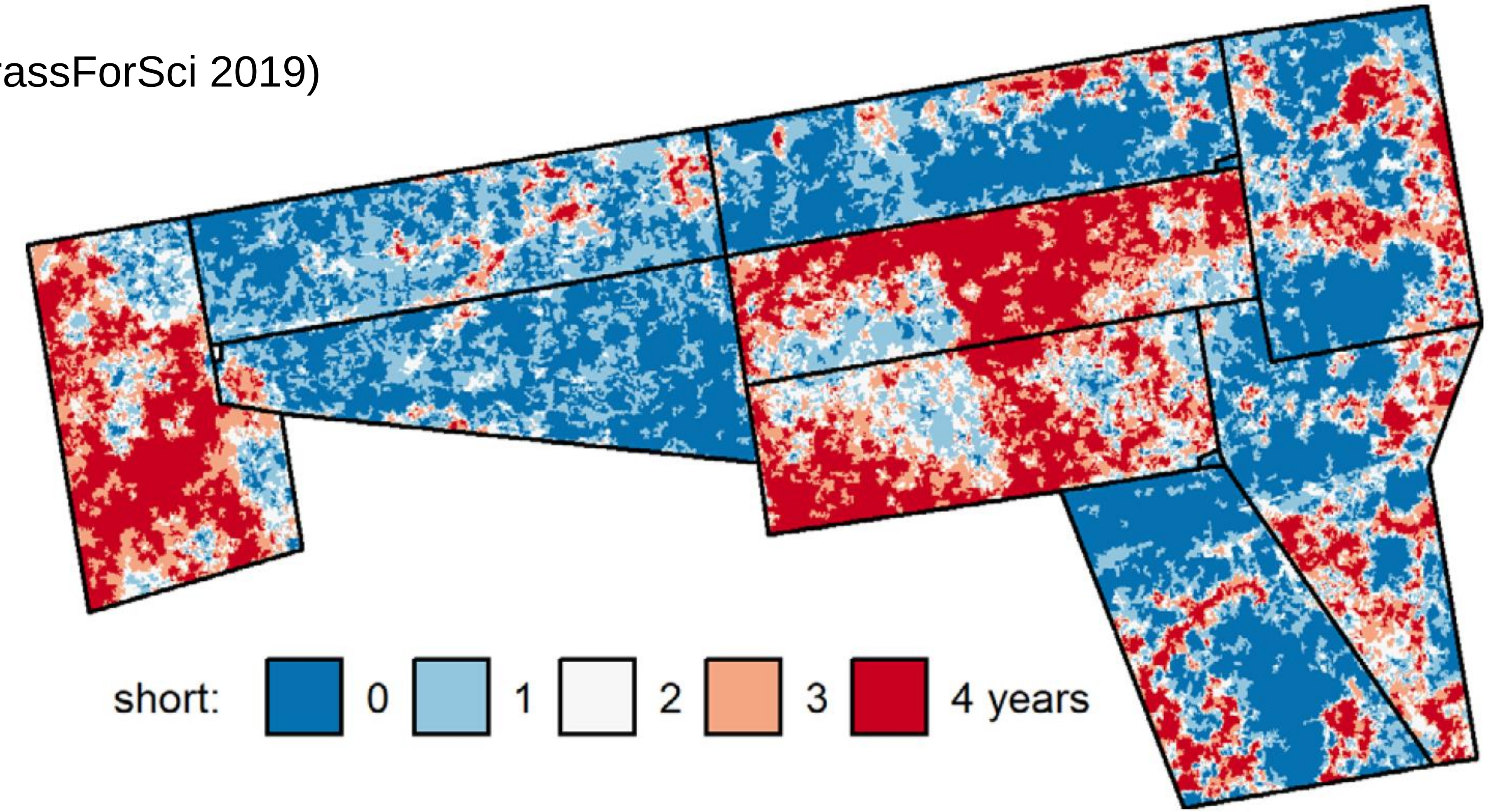


The long-term grazing experiment FORBIOBEN: Studying the effect of cattle grazing intensity on grassland ecosystem services
(Isselstein et al., GrassForSci 2007)

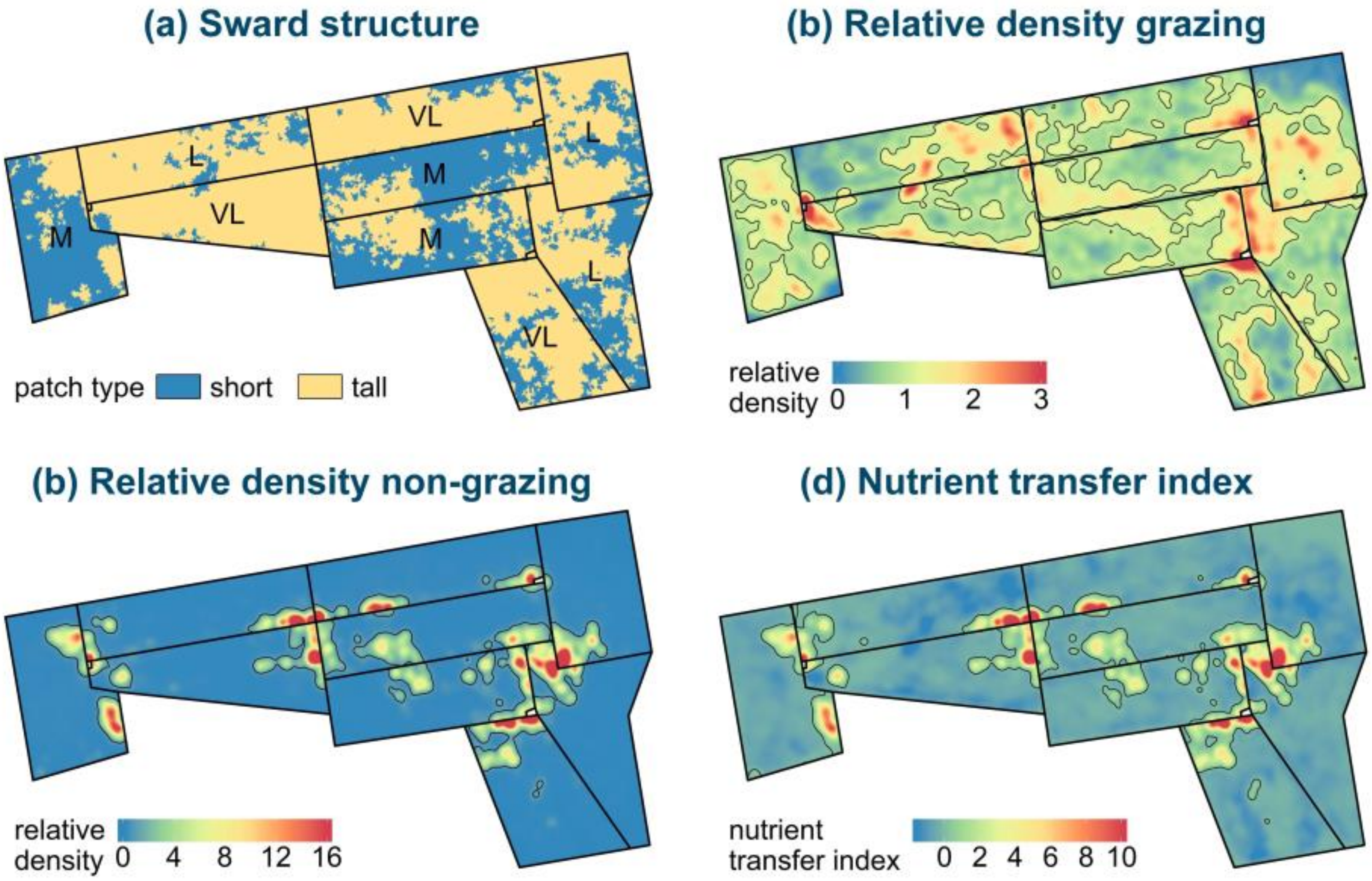
Patch formation



(Tonn et al., GrassForSci 2019)

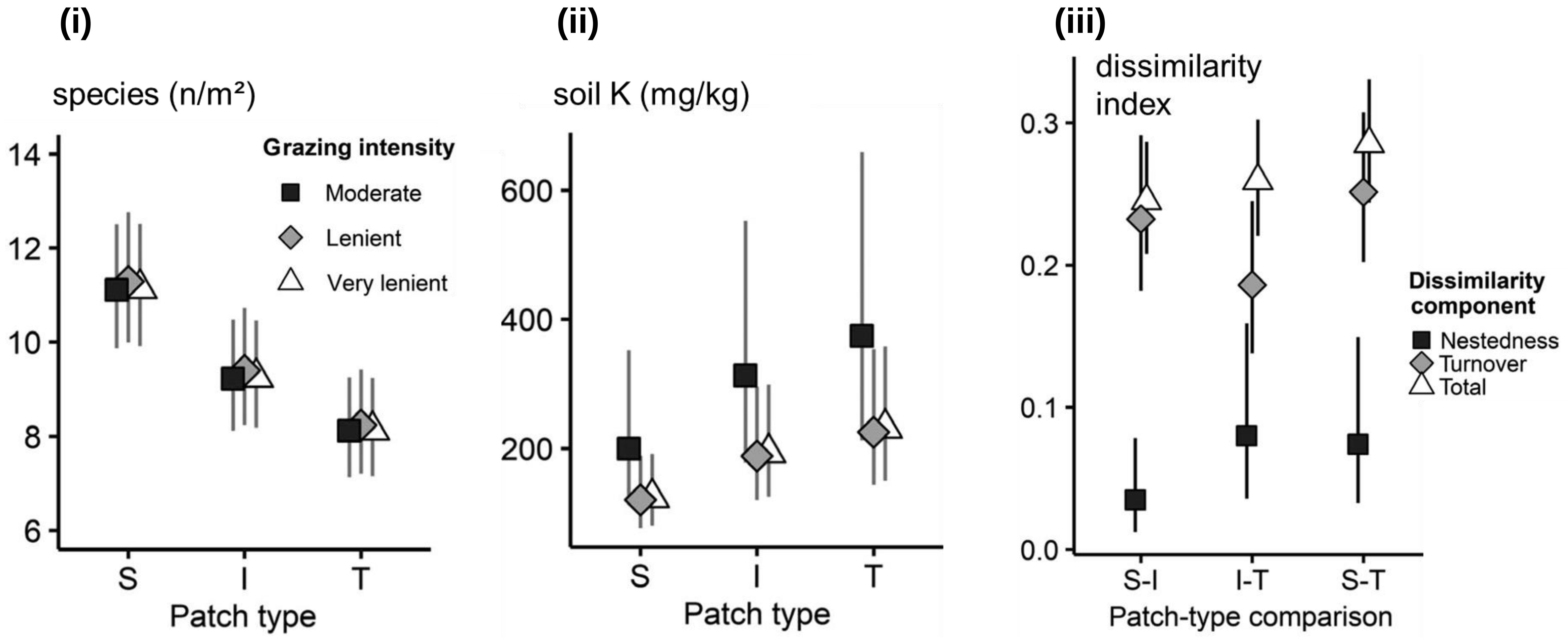


Temporal stability of patch structure: Number of times an area was classified as a short patch (as opposed to tall patch) based on aerial images from the years 2005, 2010, 2013 and 2015; 0: always classified as tall, 4: always classified as short

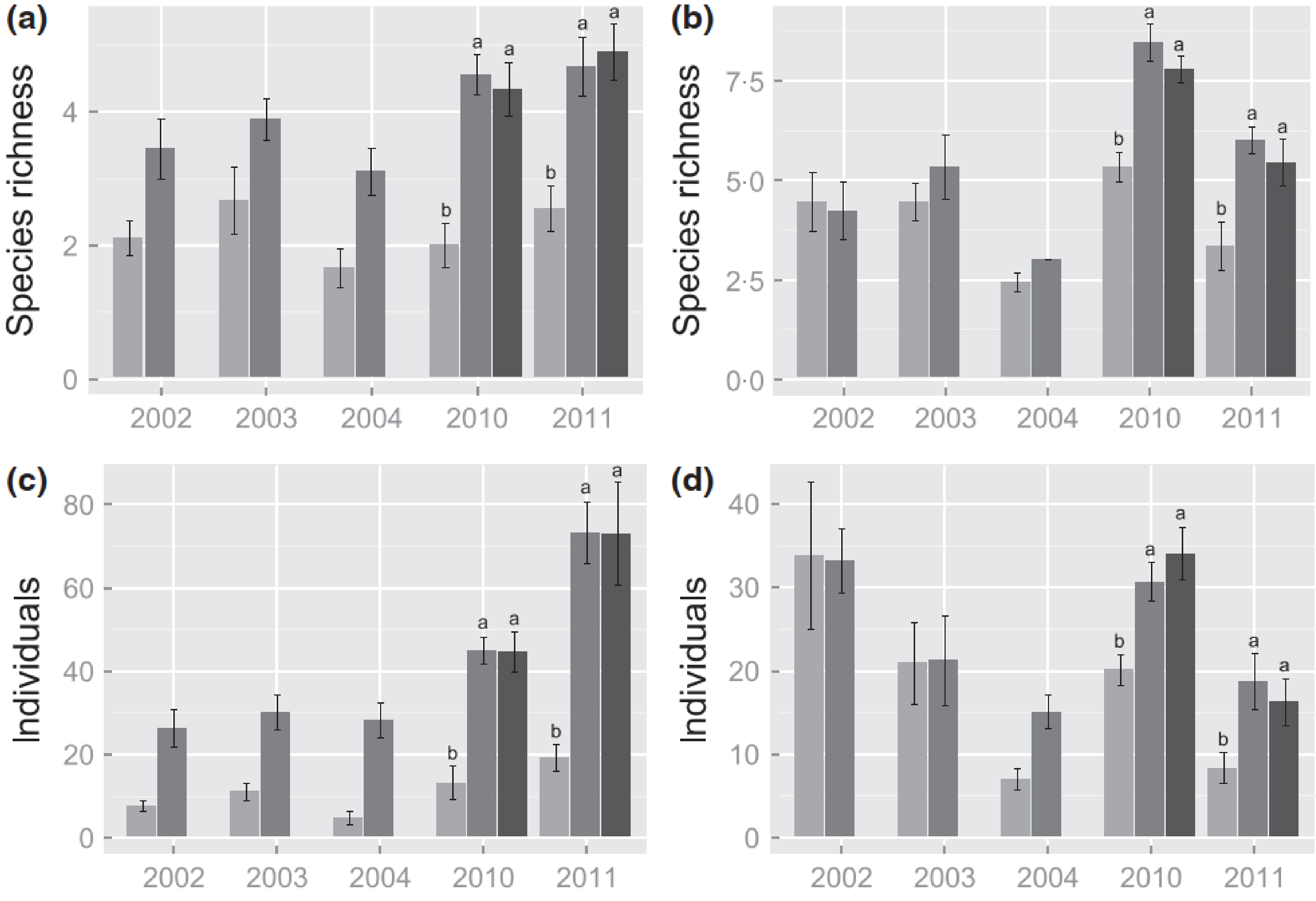


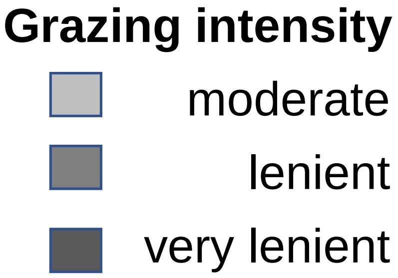
(a) Sward structure, (b, c) relative density grazing and non-grazing behaviour, (d) nutrient transfer index

(Tonn et al., JApplEcol 2019)



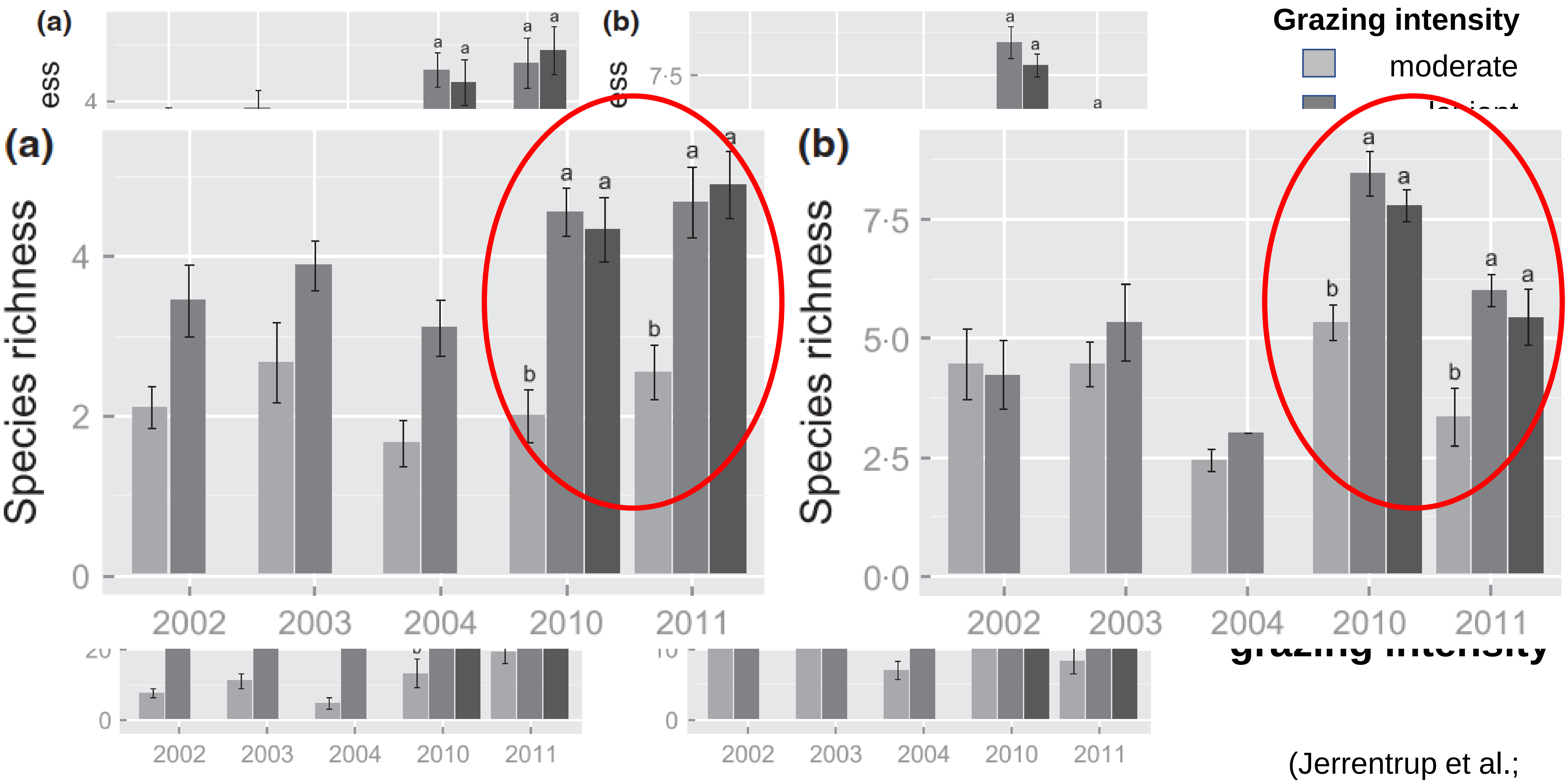
Effect of grazing intensity and patch type (S: short, I: intermediate, T: tall) on (i) plant diversity and (ii) soil nutrients and (iii) pairwise dissimilarity in vegetation composition between patch types: short (S), intermediate (I) and tall (T) (Tonn et al., JApplEcol 2019)





Mean species richness and abundance (a, c) of grasshoppers and (b, d) butterflies in relation to the grazing intensity

(Jerrentrup et al.; JApplEcol, 2014)



(Jerrentrup et al.;
JApplEcol, 2014)

Targeted grazing management

Digital technologies and their application in grassland production systems

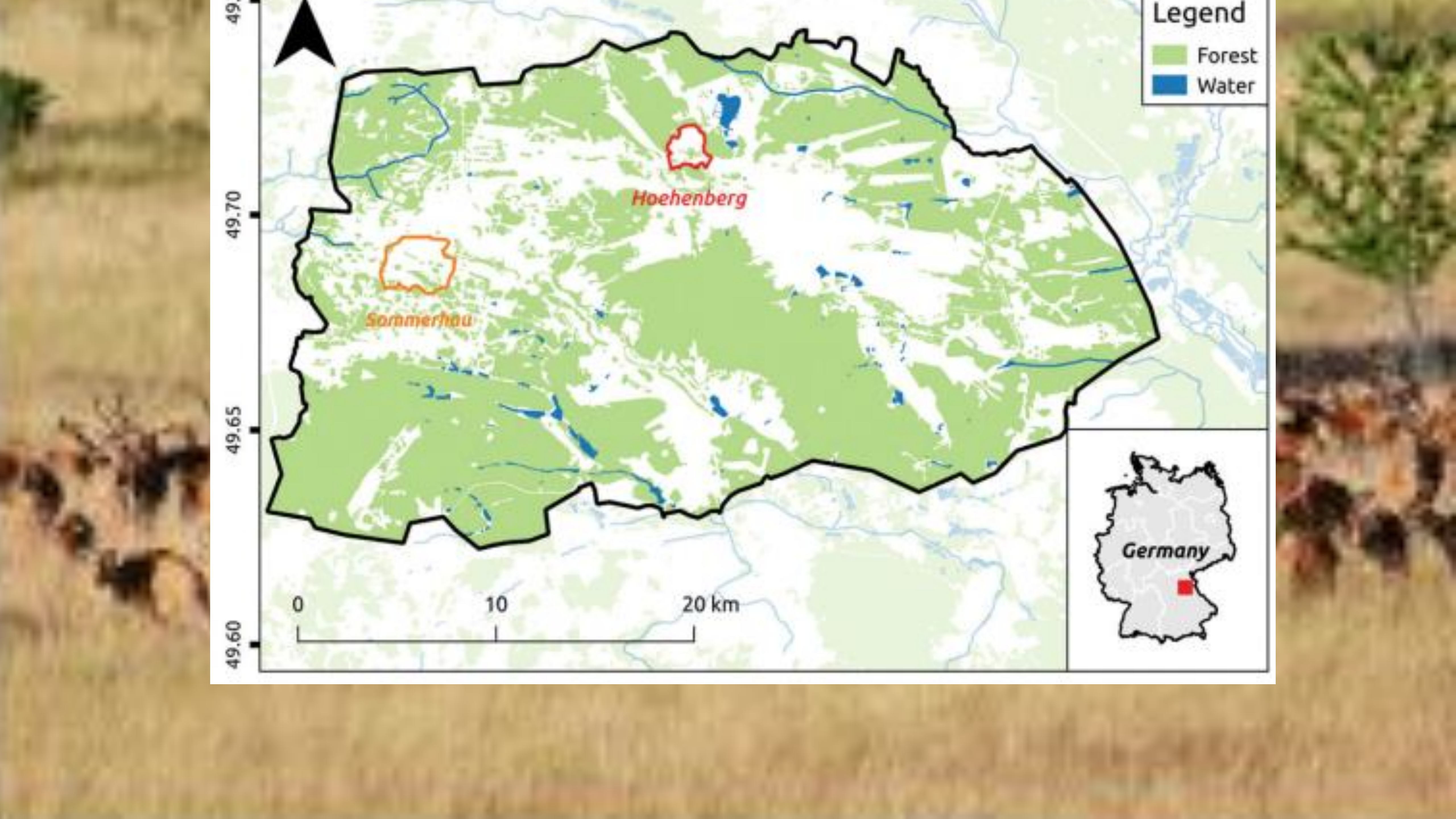
System component	Target / Variable	Technology / Sensors	Service
Soil	vegetation cover	RGB, structure from motion thermal imagery, remote sensing	erosion, surface runoff prevention
	soil moisture, evaporation	thermal imagery	water retention
	soil temperature	thermal imagery	soil biota activity
Grass sward	herbage mass, sward height	RGB, structure from motion, LiDAR, hyperspectral imagery	production, feed supply
	herbage quality	RGB, hyper- and multispectral imagery, NIRS	production, feed supply
	botanical/functional composition	RGB, hyperspectral	species diversity, invasive species, legume abundance
Livestock	walking	GPS tracker, pedometer	animal well being, -health
	grazing	bite recorder, GPS tracker	animal well being-, health, feed supply
	lying, ruminating	GPS tracker	animal well being-, health
	rumen disease	rumen pH sensor	animal well being-, health

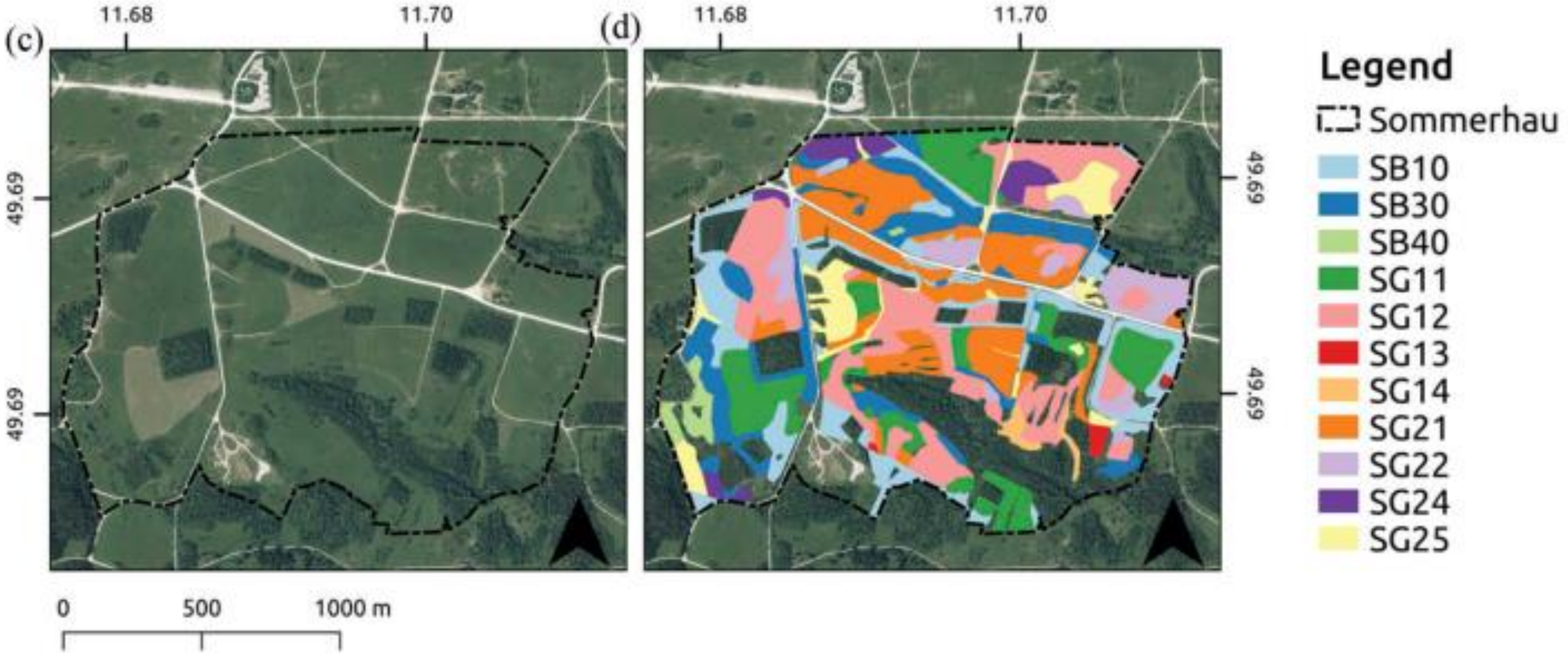
Digital technologies and their application in grassland production systems

System component	Target / Variable	Technology / Sensors	Service
Landscape	landscape structure, biodiverse spots, landscape elements	RGB, hyper-, multispectral imagery, LiDAR	biodiversity, nature conservation, cultural service
Society	documentation, traceability, certification of production processes	automatic information system, monitoring, archiving production processes	improved provision of non-marketable services
Decision making	management decisions at all components of production process	decision support systems, -tools, artificial intelligence, machine-, deep learning, archiving data	improved knowledge, information based production decisions

The example of the military training area Grafenwöhr

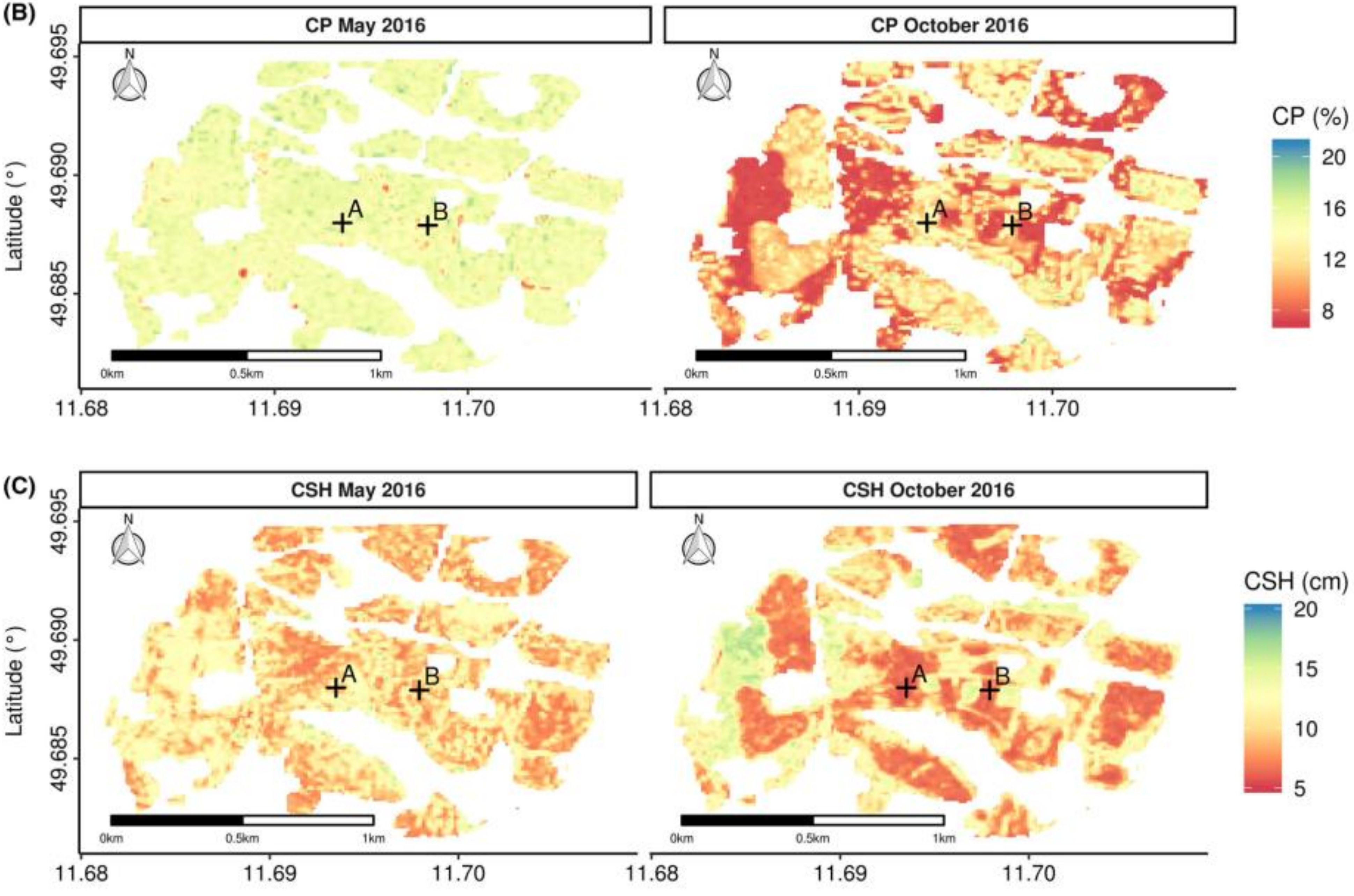
Classification of the vegetation and of herbage quality


Legend
Forest
Water
Hoehenberg
Sommerhau
49.70
49.65
49.60
0
10
20 km
Germany



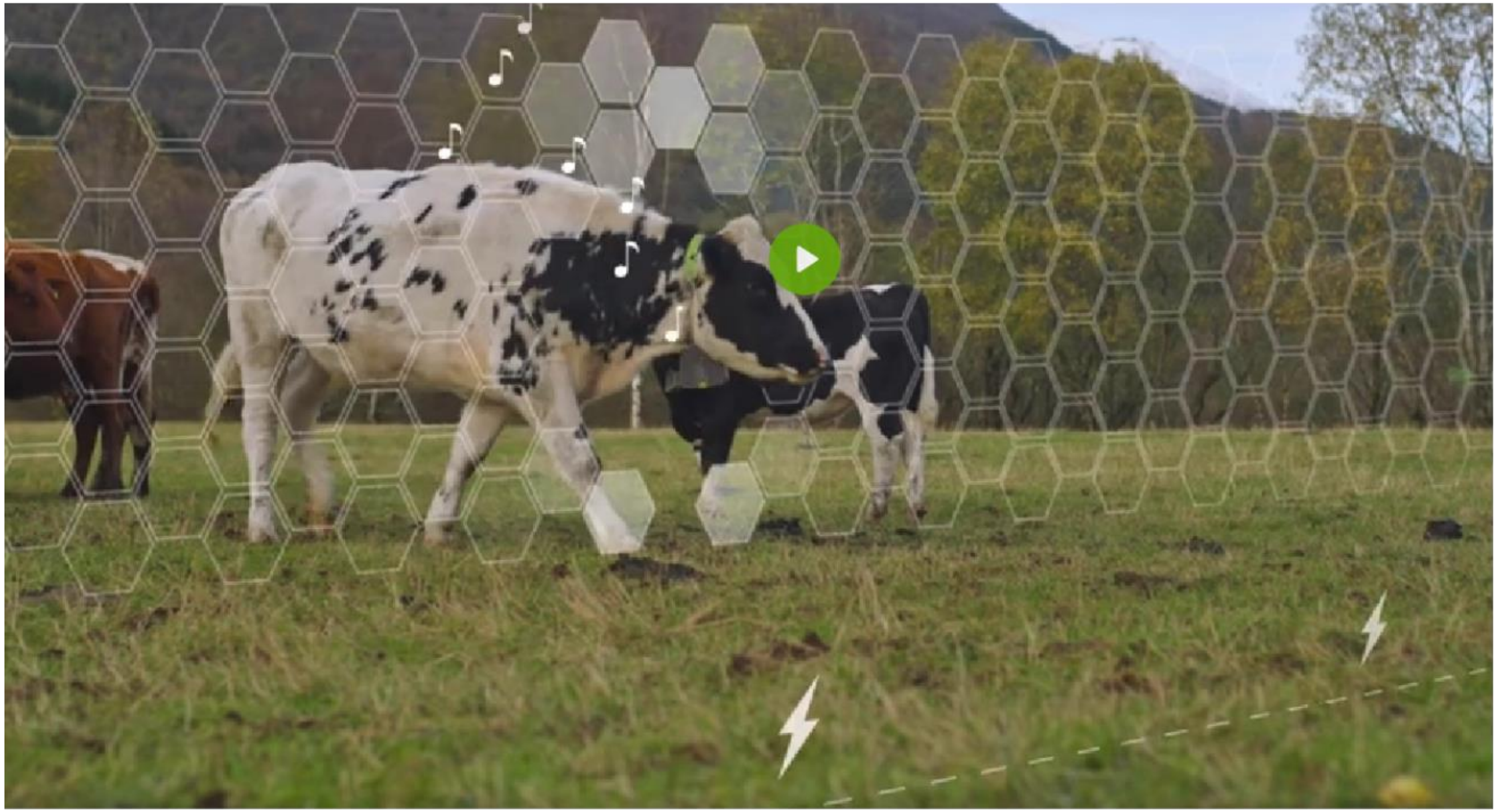
Area Sommerhau: Classification of semi-natural grasslands into different types

(Raab et al. 2018)

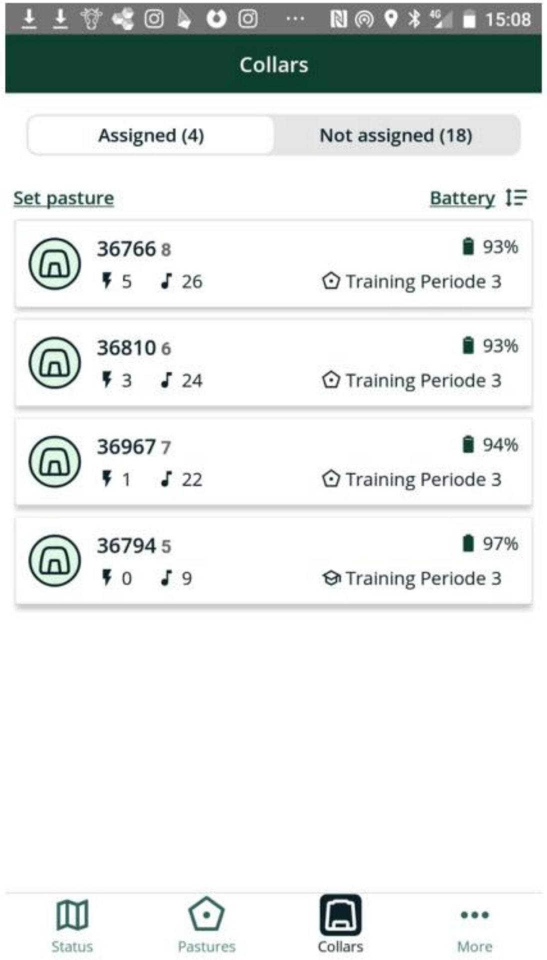


Sward height and forage crude protein content of the grassland in the Sommerhau area
(Raab et al. 2020)

Virtual Fencing Technology

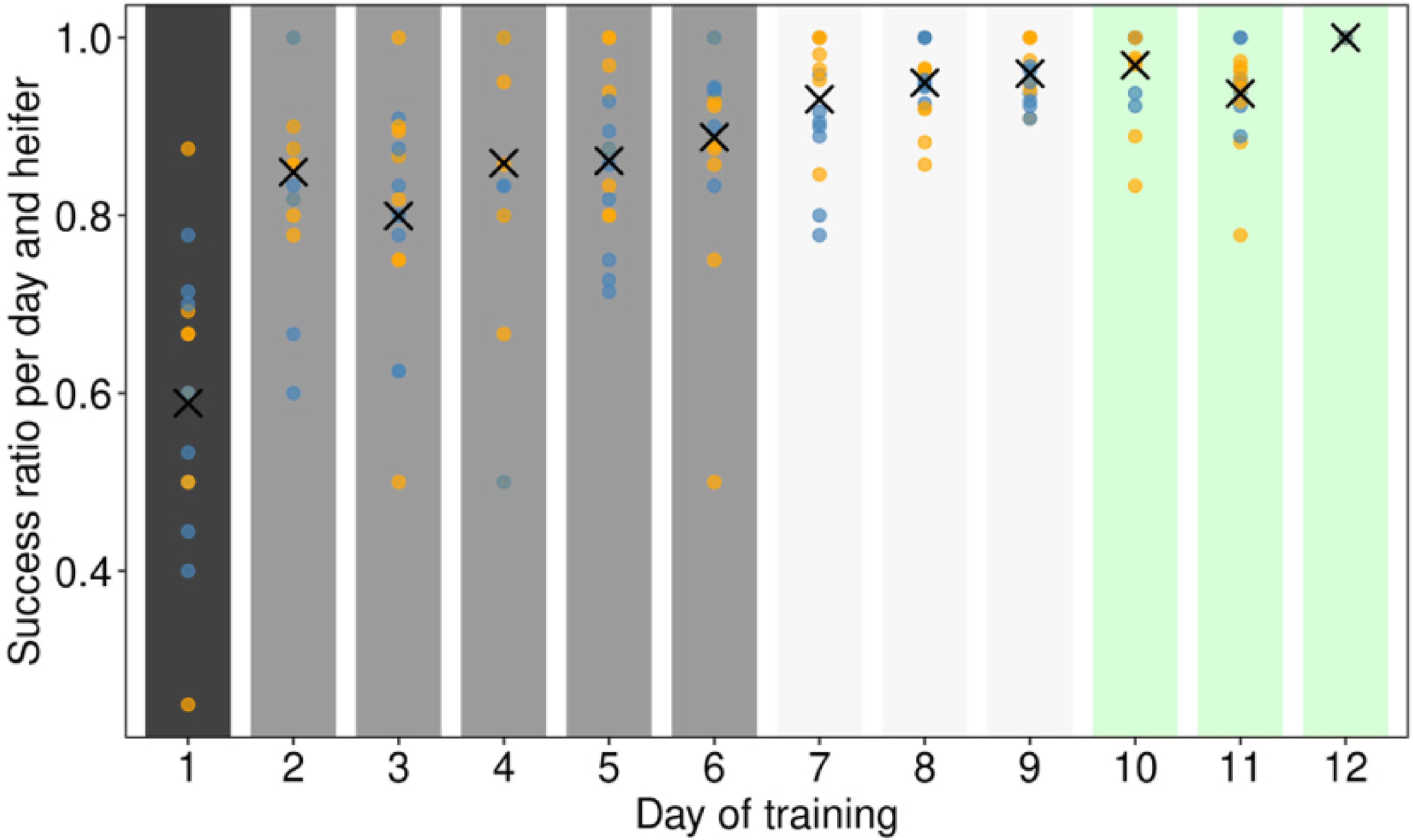


https://www.nofence.no

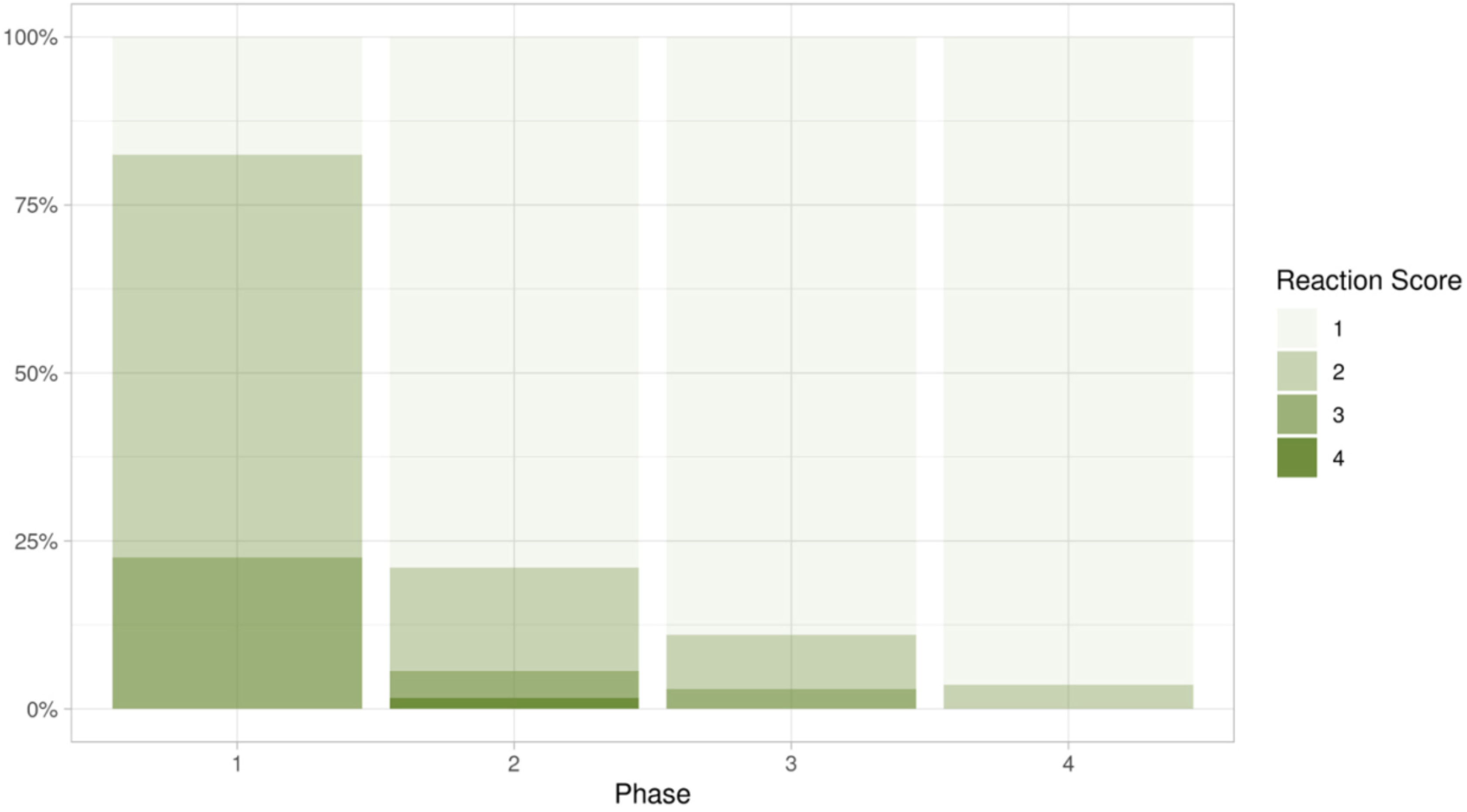


nofence: Virtuelles Zäunungssystem


Hamidi 2022
virtueller Zaun



Daily success ratio of two groups of heifers (yellow/blue) virtually fenced on pasture over a 12 day training period (Hamidi et al. Animal 2022, ApplAnimBehavScie 2024)



(1) Heifer continues to graze or walk slowly (< 3 steps) while turning

around; away from the VF line; causing the signal to stop

(2) Head shaking, walking (> 3 steps), jumping (only with front legs);

away from the VF line; causing the signal to stop

(3) Running (trot or canter); jumping; bucking away from the VF line, causing the signal to stop

(4) Breaking through the VF line

Response types of heifers when coming into contact to the virtual fence over three phases of a 12 day training period (Hamidi et al. ApplAnimBehavScie 2024)

Virtual fencing in rotational grazing at a practically relevant scale?

Hypotheses:

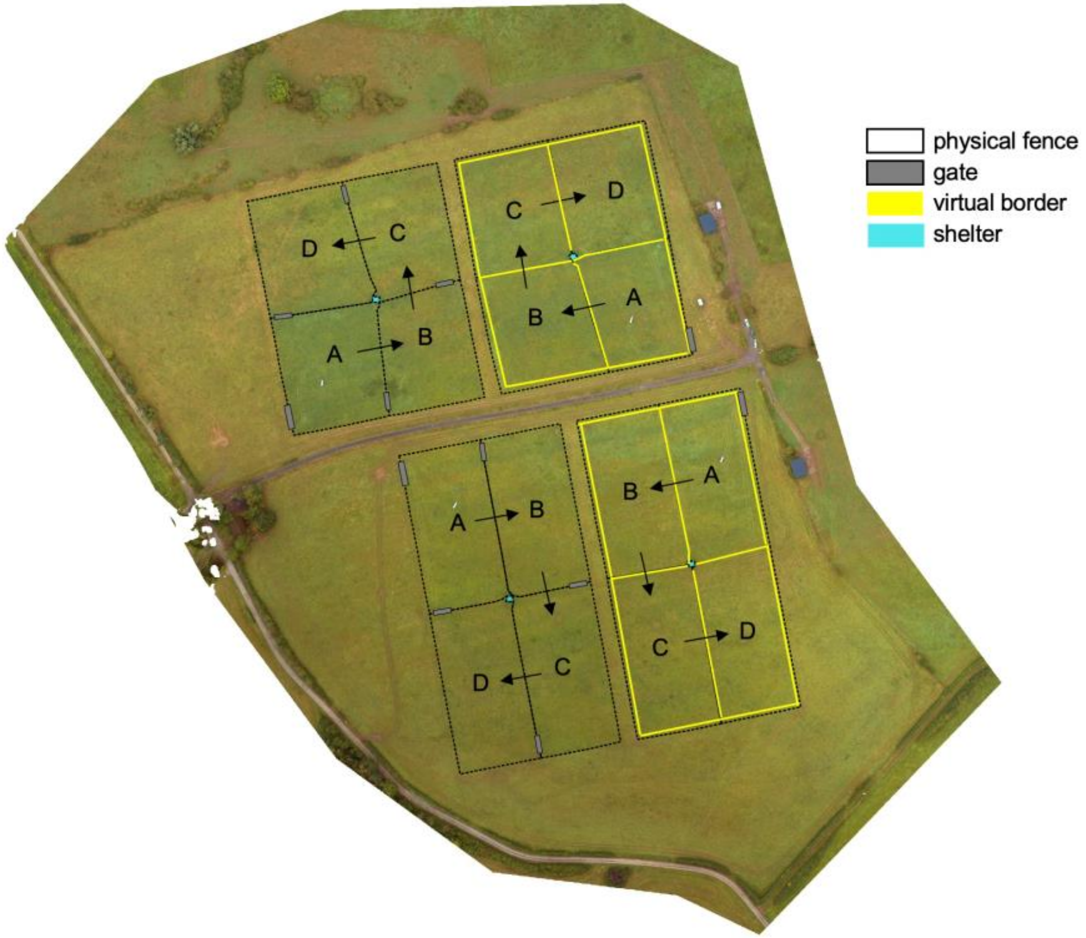
VF is unsuitable for rotational grazing.

VF causes elevated stress levels in grazing animals

VF negatively affects animal performance.

VF negatively affects herbage digestibility.

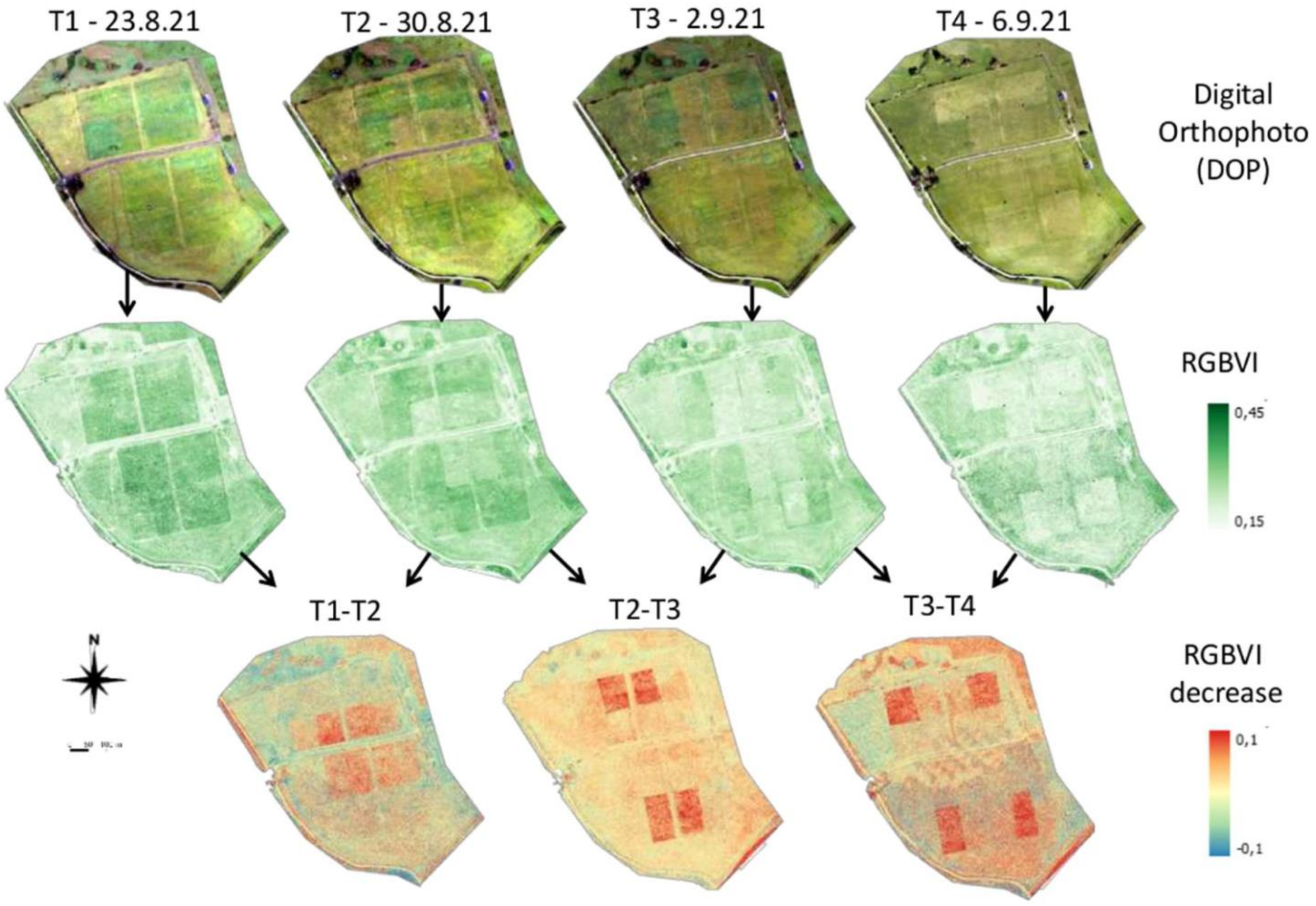
Grinnell 2022



- rotational grazing with virtual fencing trial in 2021
- 32 heifers in 2x2 groups
- virtual (VF) vs. physical (PF) fence
- 2 grazing periods
- 8 animals in a 2ha pasture, subdivided into 4 paddocks
- 3-4 days of grazing, then rotation

- Animals equipped with sensors:
  - Nofence virtual fencing collars
    - GPS positions, activity, signals
  - CowManager animal monitoring
    - animal behavior tracking
  - IceTag pedometer
    - step count, lying, standing time
- Animal observations (2 hours per group and day)

Grinnell et al. submitted



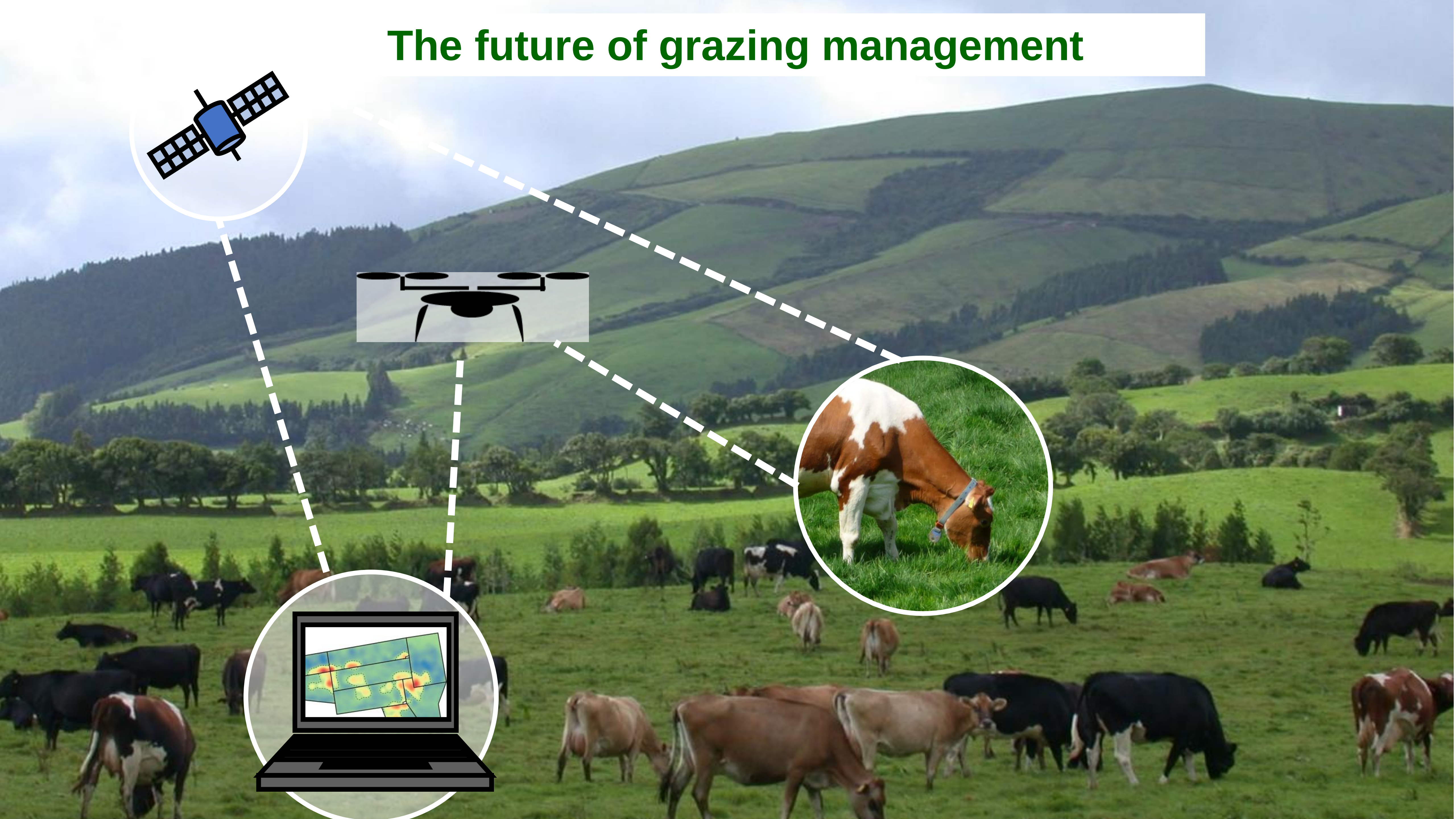
Changes in the herbage on offer in a rotational grazing system using UAV based remote sensing (RGBVI)

(Hamidi, Hütt, Grinnell et al. 2023)

Results of a systematic review on virtual fencing

Indicator	n Studies	Mean PF	Mean VF	Test Statistic	t-Test df	Test p	Effect size
Liveweight gain [kg/d]	PF: 5 VF: 7	1.04	0.589	1.17	10	0.27	0.684 (neglibile)
Lying time [h/d]	PF: 5 VF: 6	9.24	9.28	17.5		0.721	
Steps [#/h]	PF: 4 VF: 4	159	179	-0.194	3	0.339	-0.574 (moderate)
Lying bouts [#/d]	PF: 3 VF: 4	10.1	10	7.5		0.721	
FCM [ng/g]	PF: 3 VF: 3	19.2	17	7.69	2	0.0165	4.44 (large)

Wilms et al. JAnimSci 2024


The future of grazing management

Conclusions

i. **The provision of grassland related ecosystem services is scale dependent**

ii. **Heterogeneity at landscape scale is important to ensure the continuous provision of ecosystem services**

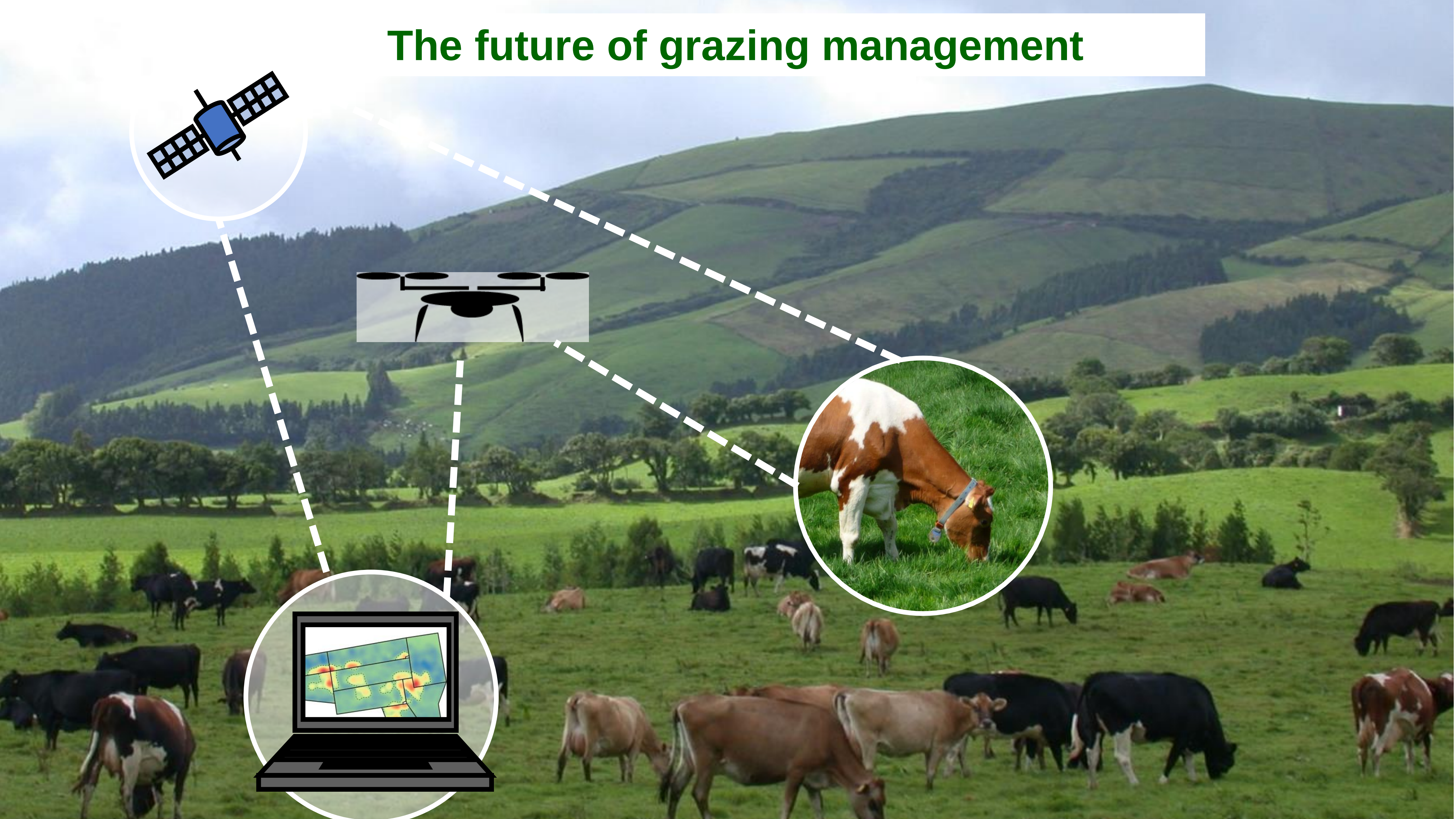
iii. **Heterogeneity is due to spatial variability in the trophic conditions and to different grassland management / utilization (interaction)**

iv. **The more the feed requirements of the livestock vary at the farm level, the more different can the grassland utilization be**

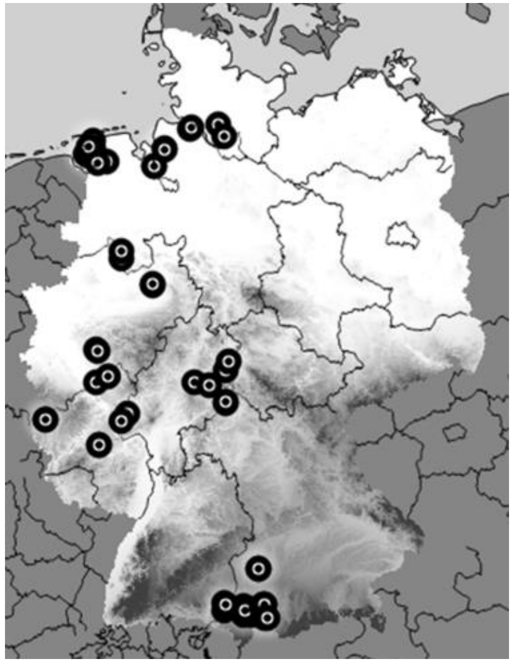
v. **Smart grassland farming technologies will markedly improve grazing and therewith the provision of ES at a landscape scale**

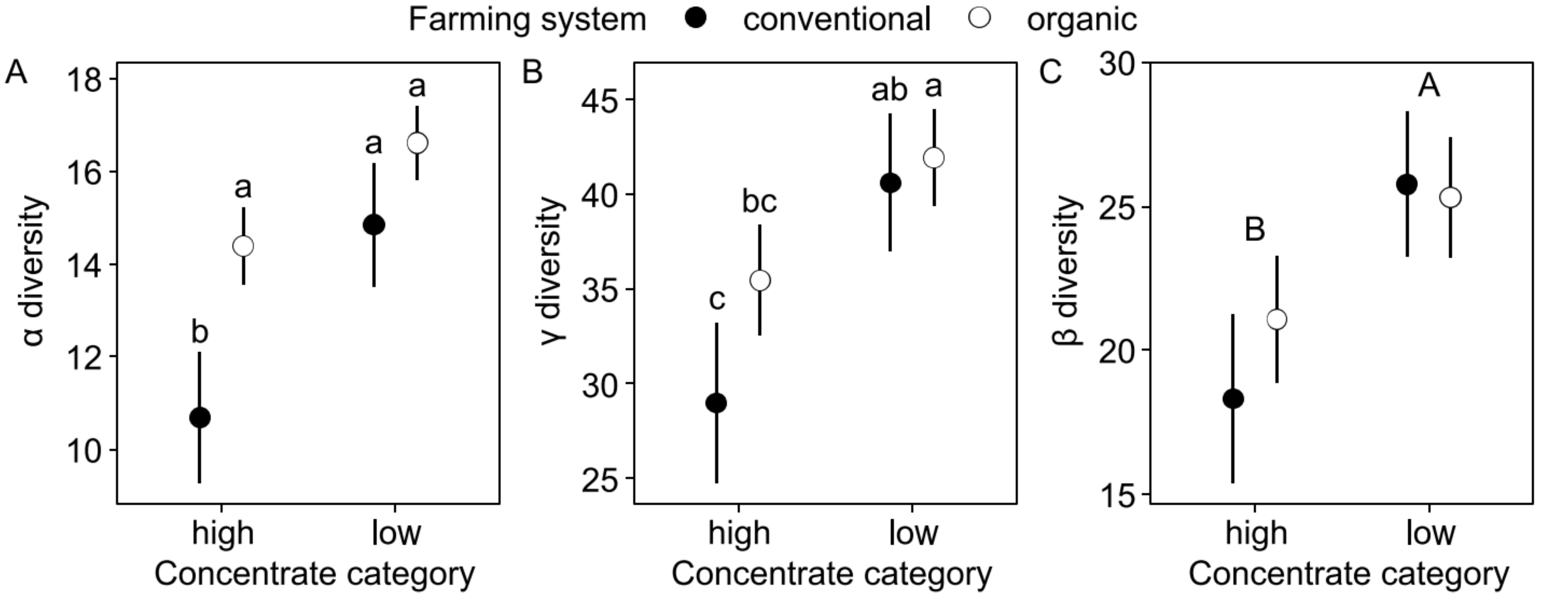

off to new shores………………..
Jurij Korolev

The future of grazing management



	hePCR category	mean	SD	Min	Max	Intercept at hePCR=1[1)]
Concentrate intensity g concentrate feed kg ECM^{-1}	PI	215	46	93	306	177
	PE	102	70	0	243	
Concentrate milk proportion %	PI	33	8	13	53	30
	PE	15	11	0	37	
N balance kg N ha^{-1}	PI	43	60	-56	167	16
	PE	-1	23	-82	75	
P balance kg P_2O_5 ha^{-1}	PI	12	38	-17	156	-0.3
	PE	-7	8	-35	13	
Shannon diversity index	PI	1.5	0.5	0.7	2.2	1.7
	PE	1.9	0.3	1.3	2.6	
Grass products quantity	PI	3.8	1.0	2	5	4.2
	PE	4.8	1.1	2	7	
MY total kg ECM cow $^{-1}$ year^{-1}	PI	7932	1268	6122	10002	7456
	PE	6562	1396	4166	10217	
MY grass kg ECMgr cow^{-1} year^{-1}	PI	3313	1090	877	4761	4038
	PE	5061	1227	1562	7418	
GL performance kg ECMgr ha GL^{-1} year^{-1}	PI	5033	1779	2853	9010	--
	PE	5104	2234	1658	13415	
Milk production stability CV, %	PI	3.72	1.65	1.77	7.37	--
	PE	3.69	1.97	0.05	8.39	





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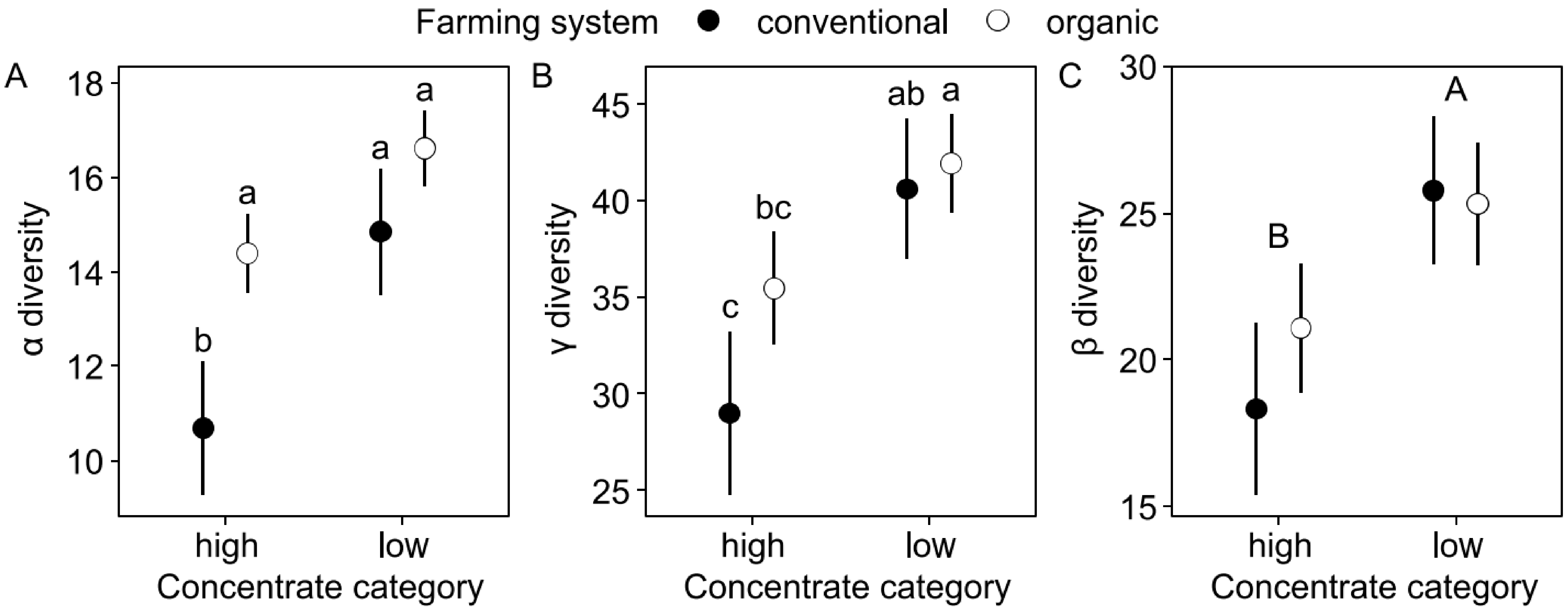
Bettin et al., AEE 2023

Effect of the level of concentrate feeding and farming system on different scales of the diversity of higher plants Germany



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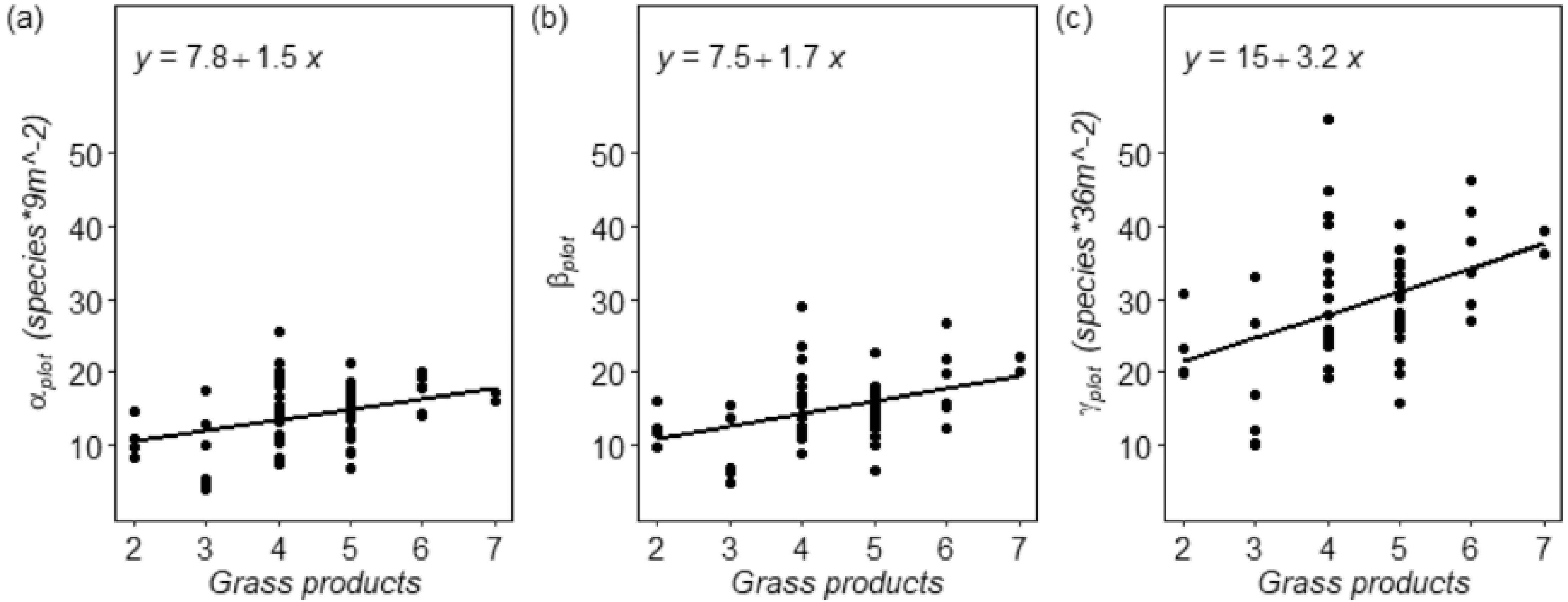
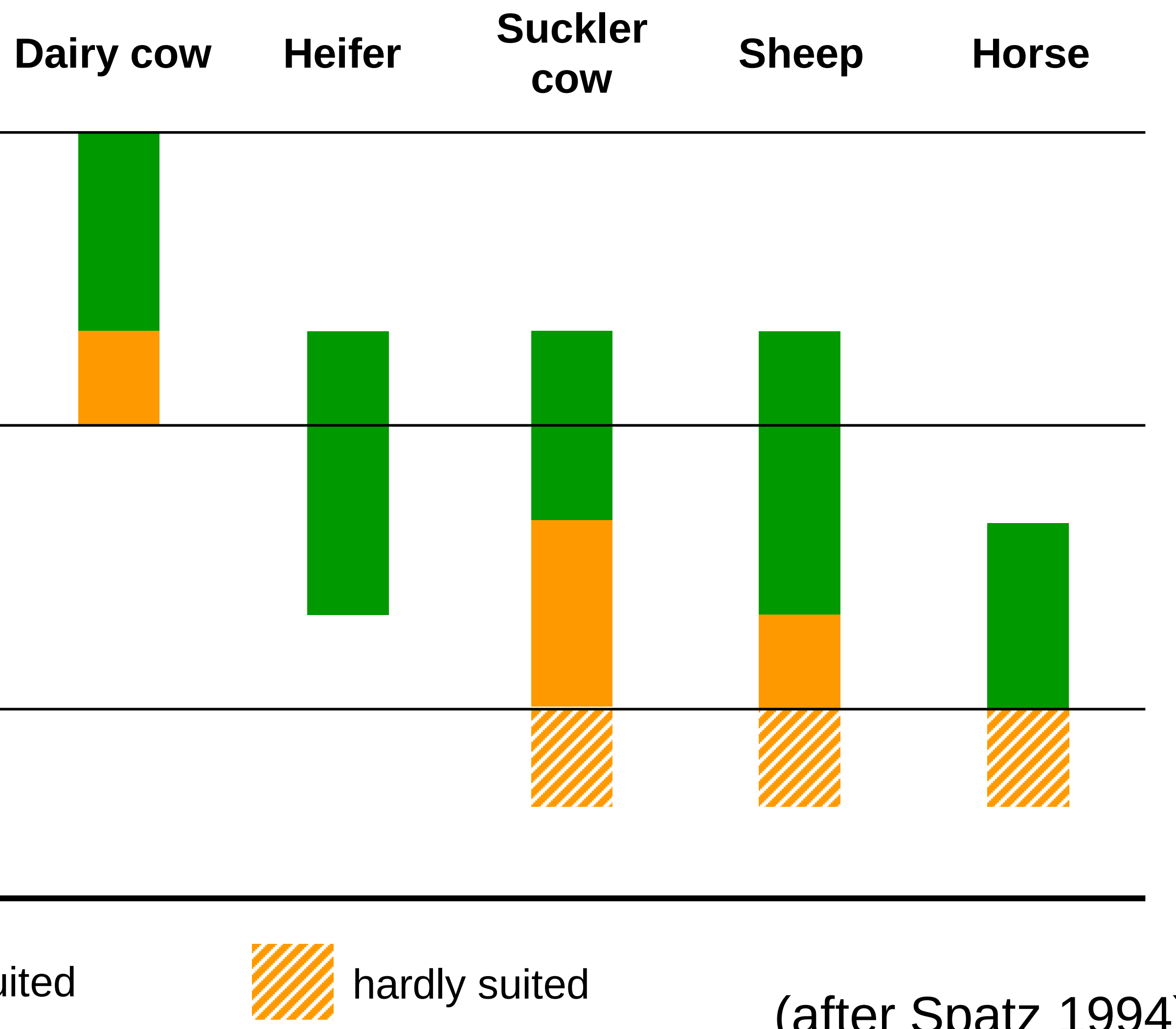


Bettin et al., AEE 2023

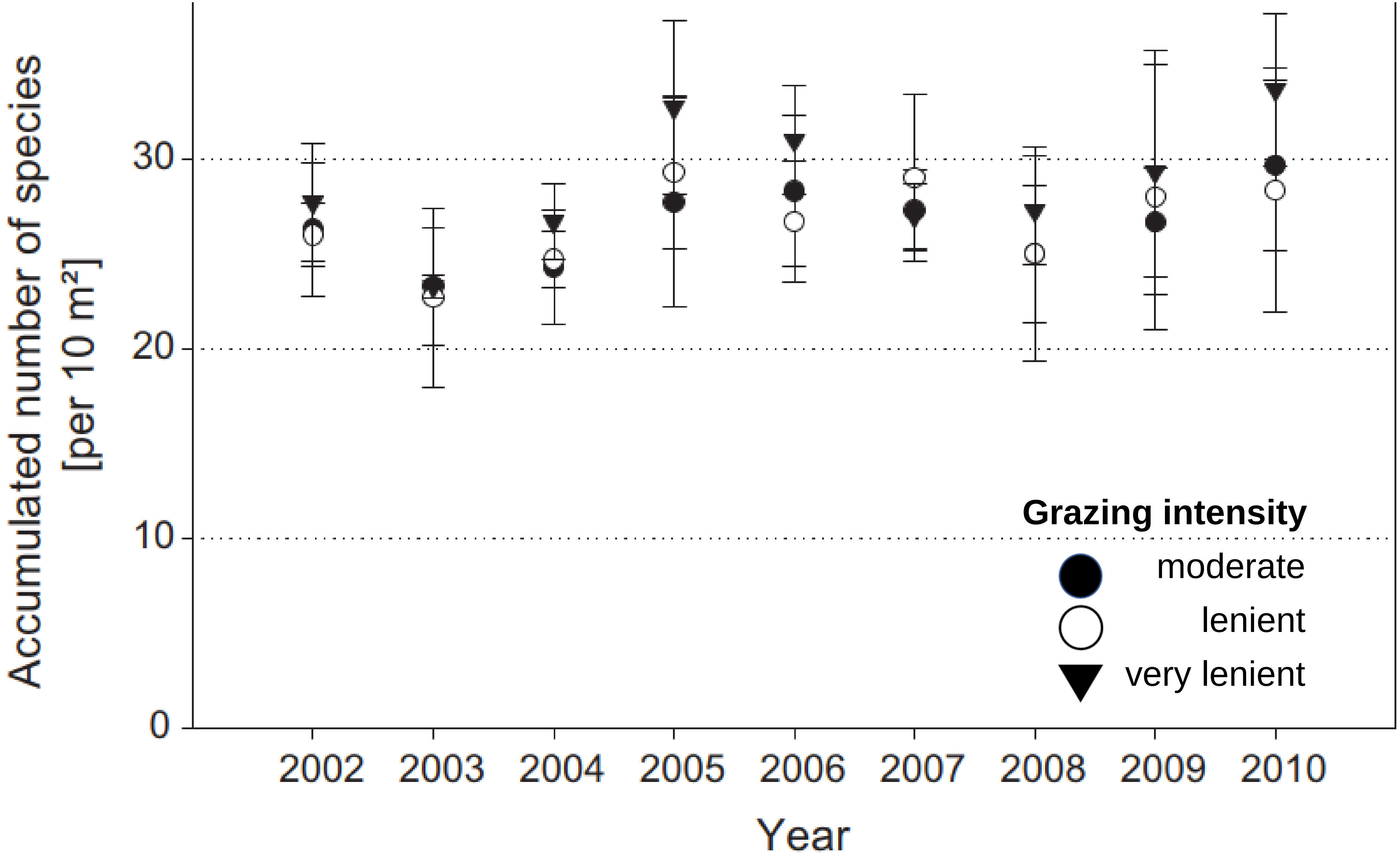
Plant diversity at plot and farm level of dairy farms in relation to the number of grass products produced on farm (silage, hay, grazed grass on intensively or extensively managed paddocks, hay of sites under AES,…..)

Herbage quality and potential feed for livestock

Harvesting date	crude fibre	cr. protein
	(g kg^{-1} DM)	
1st decade of May	<180	>200
2nd decade of May	180-220	160-220
3rd decade of May	200-240	140-200
1st decade of June	220-226	120-160
2nd decade of June	260-320	100-140
3rd decade of June	280-340	80-120
1st decade of July	300-320	60-100
2nd decade of July	300-360	60-100



(after Spatz 1994)



(Wrage et al. AEE, 2012)

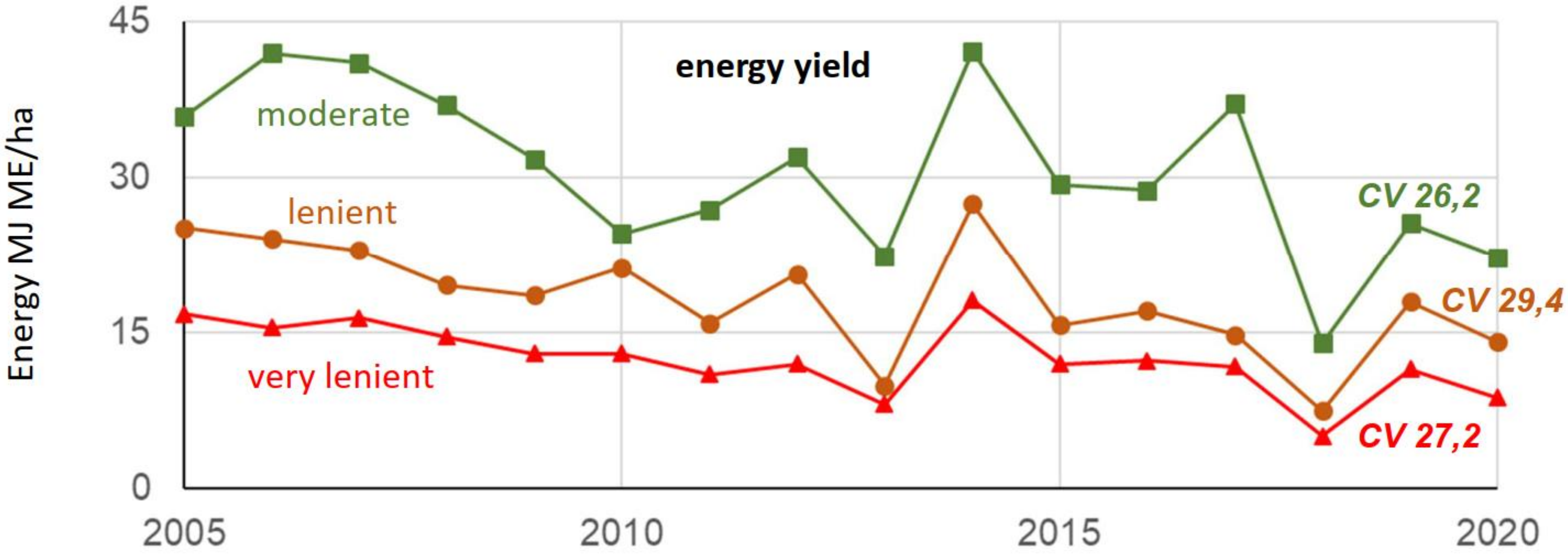
Species number in relation to grazing intensity

Importance of ecosystem services provided from grasslands depending on the grassland type

Ecosystem service	Cultivated grassland	Permanent grassland	temporary grassland	semi-natural grassland
Herbage provision	+++*)	++	+++	+
Soil-C/C-sequestration	++	+++	+	+
Nitrogen emission	++	+++	++	+
Water provision	++	+++	++	++
Biodiv./Genet. resources	+	++	-	+++

+) importance/priority: ‘+++’ highest, ‘++’ moderate to high, ‘+’ low, ‘-‘ no

(Isselstein & Komainda, Eucarpia 2021)



Grazing intensity and pasture performance in a long-term grazing experiment (Grinnell et al., AnimProdSci 2023)