Life cycle and ecosystem services assessments provide opposite evaluations of the food and non-food contributions of livestock farming systems

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Introduction (1/3): reminder of LCA and ES environmental evaluation frameworks

	Life Cycle Assessment (LCA)	Ecosystem Services (ES)
Birth date	~1970	~2000
Origin	Industry	Ecology and economics
Quantification approach	Inventory of flows of energy and materials along product lifecycle	Supply of a service, typically per ha per year
Environmental impact	Rather negative (e.g. CO2-eq. Emissions & acidification)	Positive (e.g. water purification, pollination)
Tools	Many : databases and software (Ecoinvent and SIMAPRO)	No commercial user-friendly tools
Functional unit	Typically kg of product	ha of (agro)ecosystem
Food or non-food	Food	Food and Non-Food

=> Different worlds with few connections! (VanderWilde and Newell, 2021)

Introduction (2/3): Reminder of ES types (Haines-Young and Potschin, 2018):

- **Provisioning ES: supply of physical goods such as cereal, forage or animal products**
- **Regulating ES: processes regulating biophysical cycles such as water regulation, erosion prevention**
- **Cultural ES: contribution to mental and cognitive well-being (e.g. through landscape aesthetics) (not studied here because it is usually assessed at landscape scale)**

Food

Non-Food

Introduction (3/3):

- **Ruminant meat (i.e. food) has more detrimental effect than monogastric meat according to Life Cycle Assessment (de Vries and de Boer, 2010; Flachowsky et al., 2017; Poore and Nemecek, 2018): e.g. CO_2-eq. emissions, land occupation and energy consumption**

  -> reasons: ruminants have lower feed efficiency & fecundity and generate enteric CH_4 emissions

- **Ruminant systems are likely to supply higher levels of regulating ecosystem services (i.e. non-food) than monogastric systems because of grassland involved in their production (Burkhard et al., 2012; Dumont et al., 2018; Schils et al., 2022)**

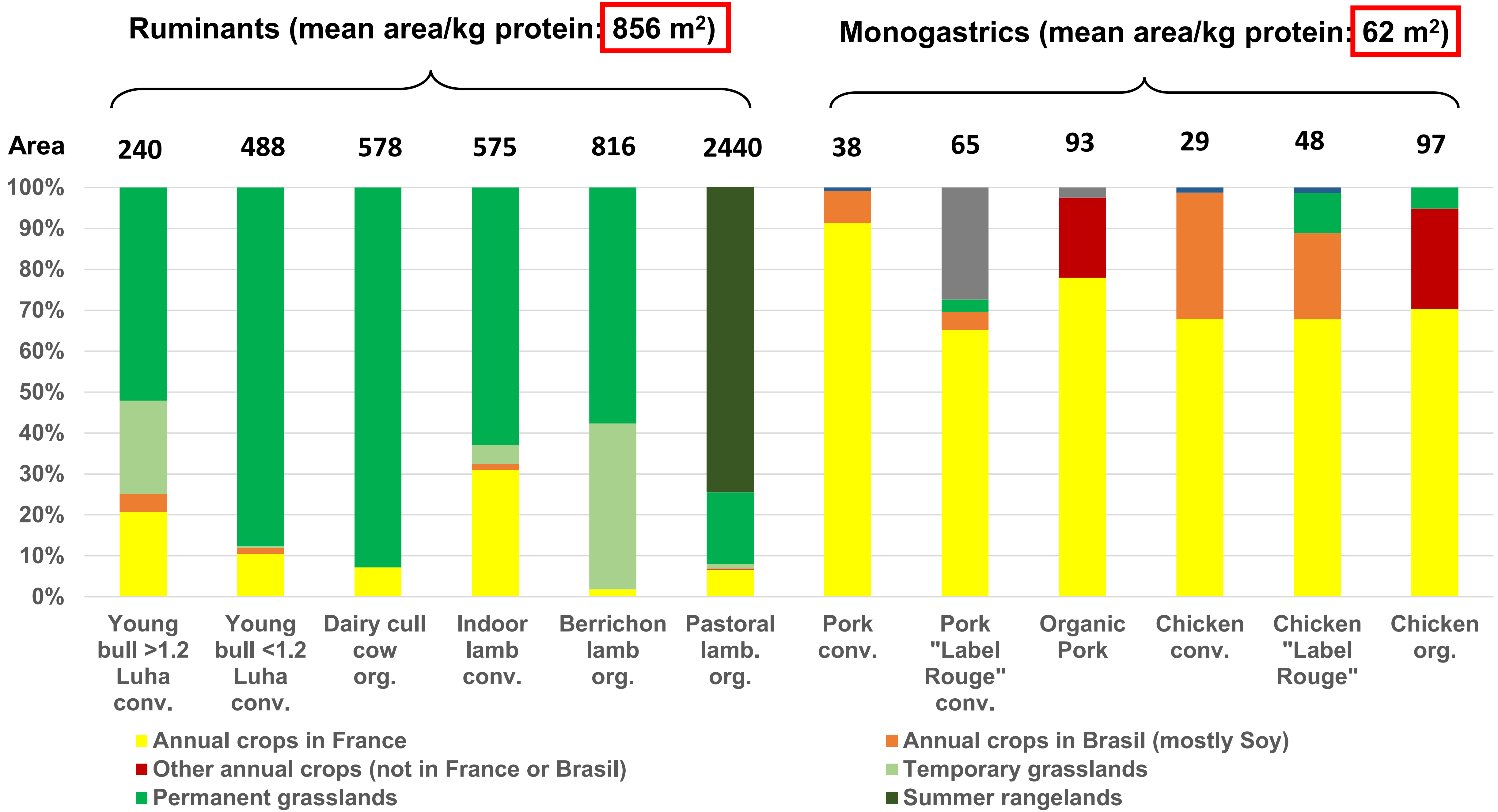
Monogastric feed basis

Ruminant feeding component

Our goal -> Apply simultaneoulsy LCA and ESA on a range of contrasting livestock farming systems including ruminant and monogastric species to assess food and non-food contributions

Method

- Conduct combined LCA and ES assessment on 1 kg of human edible protein (HEP) produced by constrasting animal-production systems, including ruminants and monogastrics
- LCA from the database Agribalyse inventory data and Environmental Footprint Method (EF 3.0)
- Establish land cover profile from Agribalyse inventory data (e.g. % of cropland, grassland)
- Assess scores of regulating ES from land cover profile (following Rugani et al. 2019)



-> More land used in ruminant systems

-> More grassland in ruminant systems

ES scores (literature review)

Land Use type	Erosion control	Pollination	Nursery (habitat quality)	Soil Quality	Water Quality	Carbon Stock	mean RES score
Annual crops conv. FR	0.5	0.5	1.0	0.0	1.0	2.0	0.83
Annual crops legume conv. FR	1.0	0.5	1.5	1.0	0.0	2.0	1.00
Temporary grassland without clover org. FR	2.0	1.5	3.5	3.0	2.5	1.8	2.38
Permanent grassland org. FR	2.0	2.5	4.0	3.5	3.0	2.5	2.92
Moutain grazed rangeland - FR	2.5	3.5	4.5	4.0	4.0	1.5	3.33
Forest - GLO	4.75	2.5	4.5	4.5	5	4	4.21

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Scores used to calculate a weighted average for each system (weighted by area)

Joly et al. revision under review

Comparison between animal types and correlation between LCA and ES

Indicator	LCA or ES	Type of contribution	Animal type				Coefficient of correlation between LCA and reg. ES	
			Rumi-nant	Mono-gastric				
Acidification (mol H+ eq)	LCA	Food	3.5	0.9	***			0.83***
Climate change (kg CO_2 eq)	LCA	Food	280	32	***			0.84***
Eutrophication, freshwater (kg P eq)	LCA	Food	1.5E-02	6.9E-03	***			0.79***
Land use (Pt)	LCA	Food	3.1E+04	4.3E+03	***			0.75***
Ozone depletion (kg CFC11 eq)	LCA	Food	4.3E-06	1.8E-06	***			0.77***
Resource use, fossils (MJ)	LCA	Food	351	189	***			0.68***
Water use (m3 depriv.)	LCA	Food	45	33	ns			0.40^{ns}
Land occupation (m2)	LCA	Food	856	62	***			0.75**
Mean regulating ES (score)	ES	Non-Food	2.4	1.2	***			

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-> Higher LCA impact for ruminants (known result)

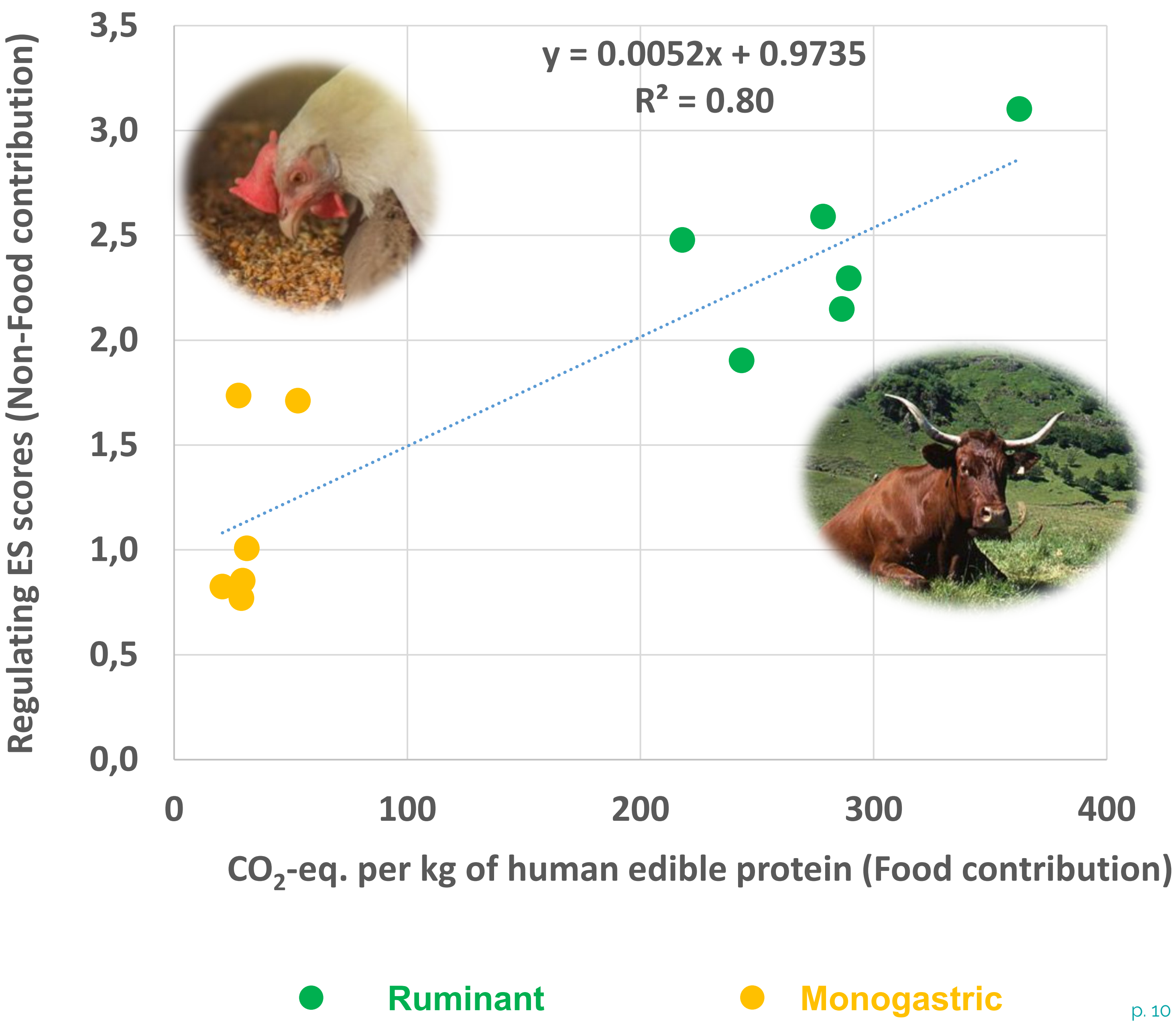
-> Higher regulating ES scores for ruminants (confirmed result)

-> The higher the regulating score, the higher the LCA impact (new!)

CO_2-eq. emissions and regulating ES

-> The more a system provides regulating ES, the highest its CO_2-eq. emissions

-> LCA and ES provide opposite assessments of Food and Non-Food contribution



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Conclusion

- Using LCA inventory data and data-base help conduct ES assessment and connect LCA and ES « worlds »
- LCA and ES metrics of Food and Non-Food contributions express clear antagonisms
- Relying only on widely applied LCA hides positive Non-Food contributions of grass-based extensive systems
- Should we separate Food and Non-Food areas or should we reduce antagonisms? (land sharing or land sparing debate)
- Introduce semi-natural infrastructure in monogastric systems or improve productivity of grass based-systems (e.g. through increased feed efficiency and higher forage quality) could reduce antagonisms

Thank you for your attention, questions?

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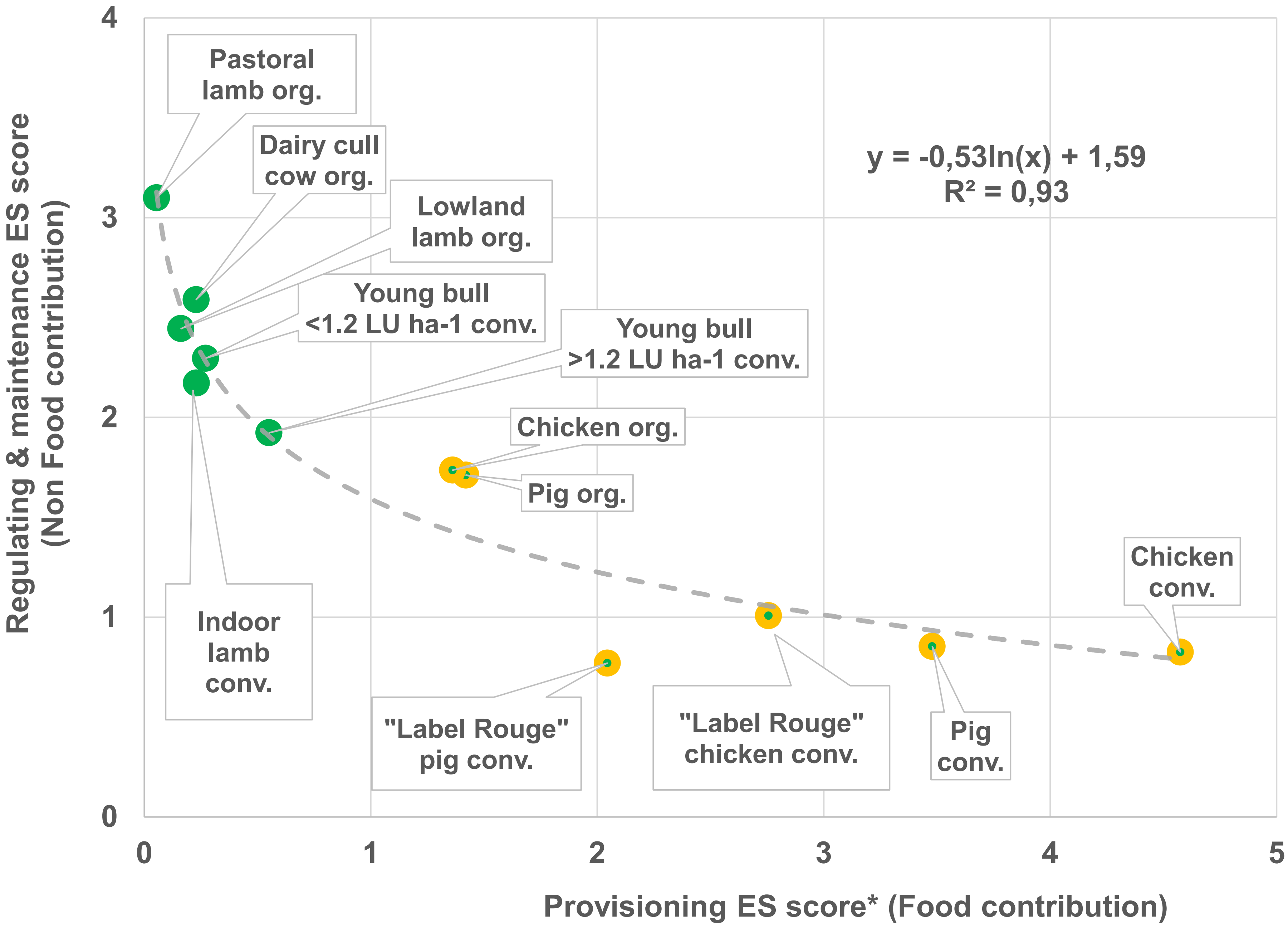
funding:

Correlation between ES types

-> Clear trade-off between Food and Non-Food contribution



● Ruminant

● Monogastric

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*~inverse of area used