Behind the Scores: Evaluating Sustainability Constructs and Farm Structural Factors in European Livestock Systems
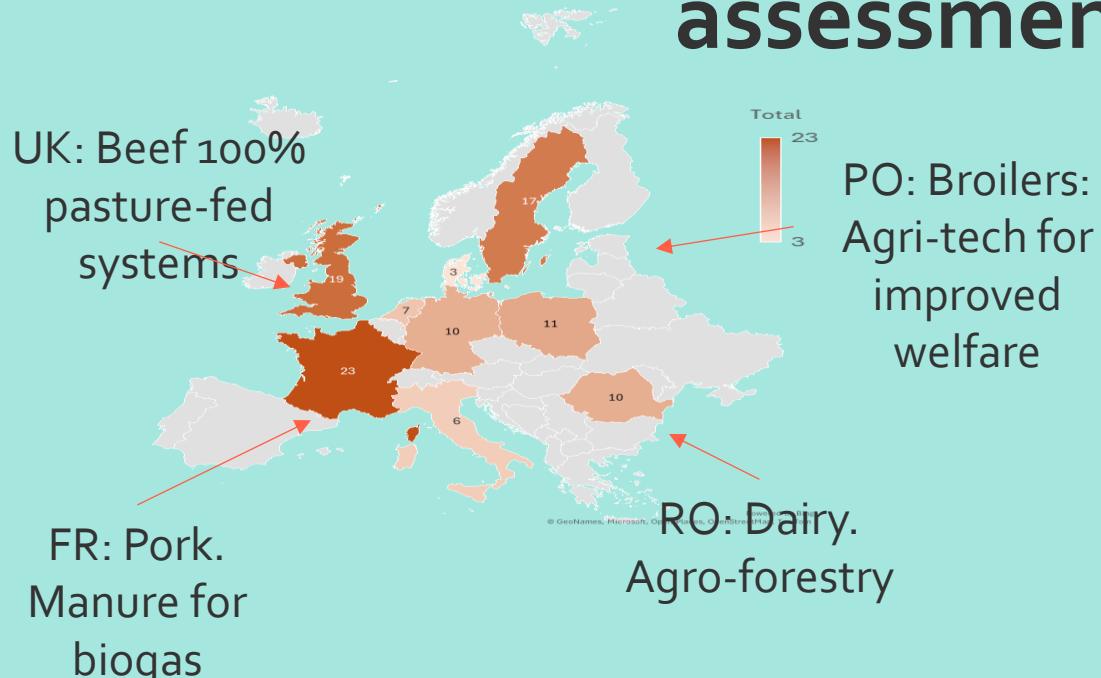
Jorge Campos González[a], Seval Cicek[c], Pietro Goglio[d], John Helming[c], Anna Hessle[e], Marc Muller[c], Simon Moakes[b], Annabel Oosterwijk[c], Simon Pelaracci[d], Nina Roehrig[a], Coen van Wagenberg[c], Laurence Smith[a,e]

[a] University of Reading, UK, [b] Aberystwyth University, UK, [c] Wageningen University, The Netherlands, [d] University of Perugia, Italy, [e] Swedish University of Agricultural Sciences, Sweden
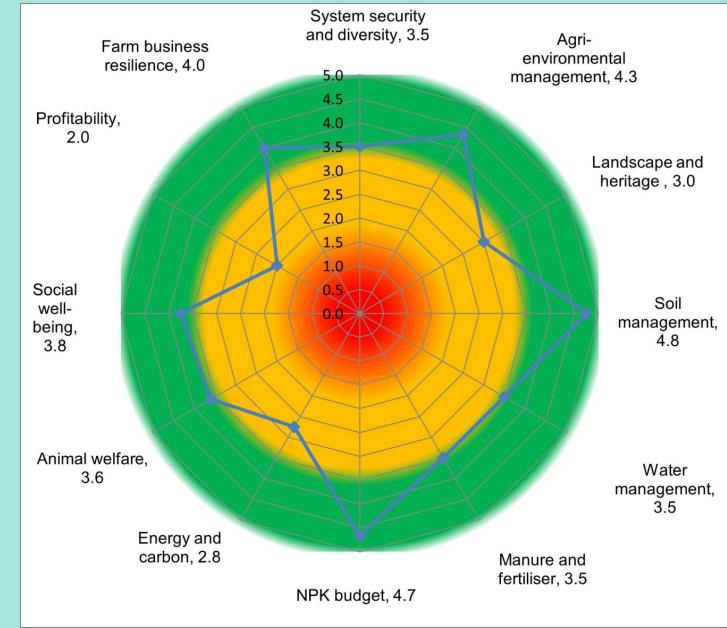
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Pathways
FOR SUSTAINABLE FOOD

Using the Public Good Tool (PGT) for sustainability assessments in PATHWAYS

UK: Beef 100% pasture-fed systems

PO: Broilers: Agri-tech for improved welfare

FR: Pork. Manure for biogas

RO: Dairy. Agro-forestry

System	Total	%
Beef	35	33%
Dairy	32	30%
Pork	12	11%
Poultry	27	25%
Total	**106**	**100%**

How reliable are our sustainability measures?

- *In a context of different variables contributing to a compound score or construct*

- *When our dataset compounds multiple locations and livestock types*

- *When we're interested in advanced statistical analysis to model "true" relationships rather than noise, to explore the extent to which structural farm features influence sustainability dimensions?*

Public Good Tool (PGT) Overview

Public Goods Tool v3.1

12 spurs — **186 scored questions**

~ 60 questions

| Category	Spurs	Scored
Env	• Agri-env management • Landscape & heritage • Soil management • Water management • Manure and fertiliser • NPK budget • Energy and carbon	**106**
Econ	• Profitability • Farm business resilience • System sec & diversity	**35**
Soc	• Animal welfare • Social well-being	**45**

+

- Farm core questions (initial data, UAA, farmer age, LU per ha)
- Livestock numbers (adult, young)
- Energy data (efficiency indicators, inputs vs outputs)
- Economic data (costs, actives, income sources)

Using PGT for multi-dimensional sustainability

PGT Assessment
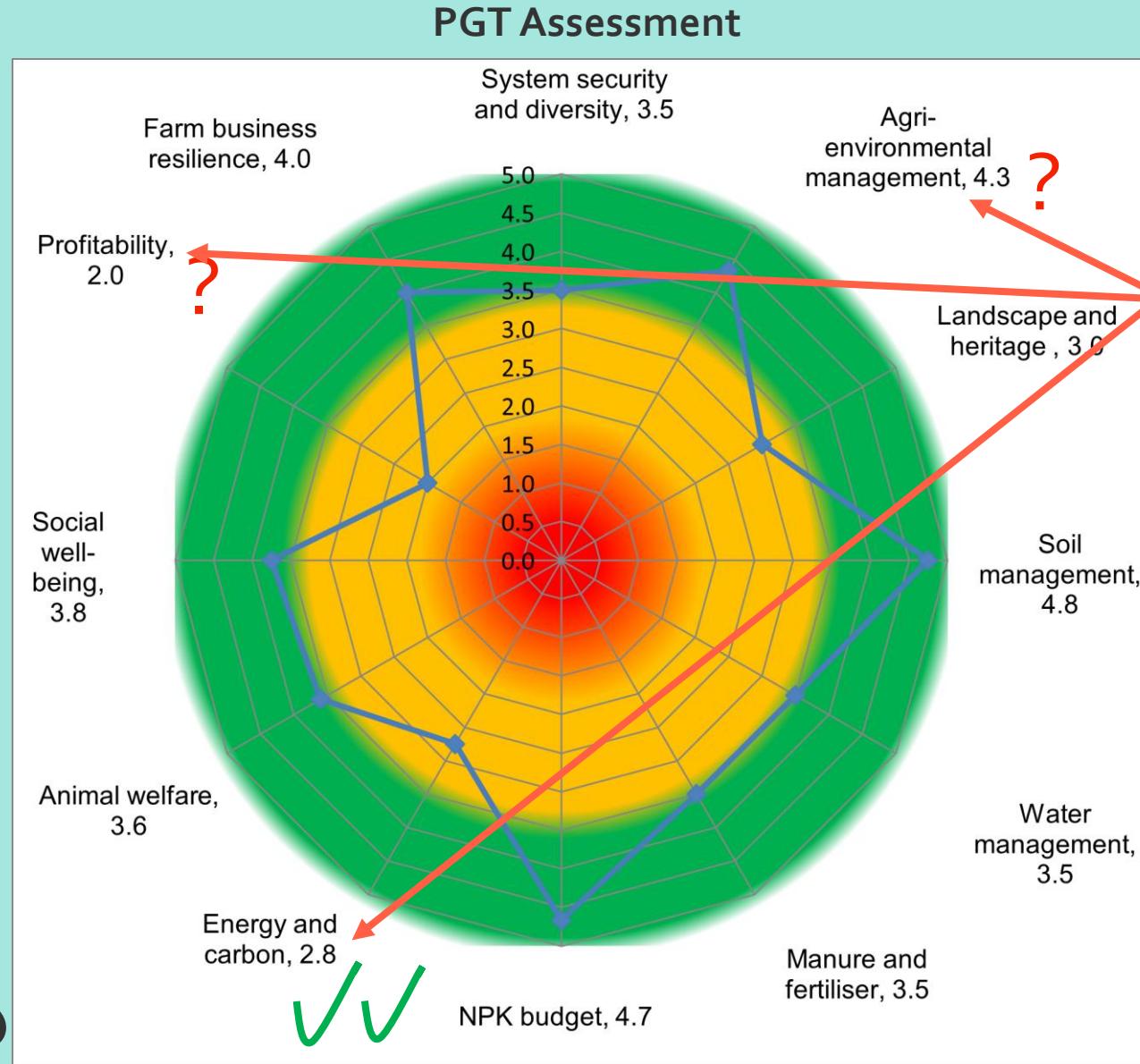
To what extend primary variables explain sustainability across multiple dimensions?

Percentage renewable energy used on farm, %
Percentage energy produced compared to energy consum
No. of full time workers (incl. owner, paid, unpaid)
Farm Net Income
Percentage cost of revenue (%)
Hourly earnings of owner(s)
% of local sales (<20 km)
% of regional sales
N
Number of plant species total, of which
Number of livestock breeds total, of which
Mortality rate young animals
Mortality rate adults
Do animals graze?
Proportion of short-term employed or hired staff
Proportion of family labour
Livestock MJ exported per MJ imported
Imported MJ energy per MJ in livestock and livestock pro
MJ of imported fossil fuels and nuclear per MJ in
livestock and livestock products exported

I. Behind the Scores: PATHWAYS & the use of the PGT to evaluate the sustainability of livestock innovations

Cronbach's Alpha (α)

Represents the internal consistency or reliability of a group of items (i) measuring a single construct or concept. $\alpha[0,1]$ (closer to 1 >> higher reliability).

$$\alpha = \frac{N}{N-1}\left(1 - \frac{\sum_{i=1}^{N} \sigma_i^2}{\sigma_T^2}\right)$$

The variance of each individual item i within the construct.

The variance of the total scores obtained by summing all N items.

N: The number of items or indicators within the construct being assessed.

Our 106 farms sample ➡️

IDHubFarm	(Intensity)	(Habitat)	Agri-Env Management Spur			
			(Management of arable land)	(Management pastureland)	(Management of other land)	(Pesticide use)
H1F1	3	3	5	3	4	5
H1F2	2	3	5	3	4	5
H1F3	4	4	4	3	4	5
H1F4	3	4	3	2	4	5

σ_T^2

=((6/(6-1))*(1-(9.15…/31.741)))

General criteria

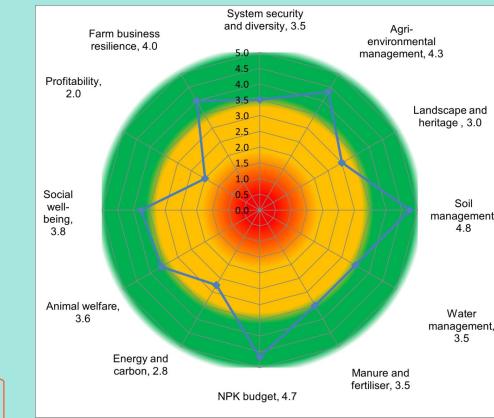$\alpha \geq 0.7 \;\rightarrow Good$

$0.5 \leq \alpha < 0.7 \;\rightarrow Moderate$

$\alpha < 0.5 \;\rightarrow Poor - Unacceptable$

Results: The overall α ($n = 106$)

Construct	Cronbach's Alpha	
Profitability	0.94	Good
NPK budget	0.87	
Agri-environmental management	0.85	
Manure and fertiliser	0.84	
Soil management	0.69	Moderate
Water management	0.62	
System security and diversity	0.52	
Social well-being	0.51	
Farm business resilience	0.50	Poor
Energy and carbon	0.44	
Landscape and heritage	0.42	
Animal welfare	0.33	

Some implications and recommendations for the Agri-Environmental Management construct

- Refine **pesticide-related items** (largest negative impact on "Alpha" if we remove it)

Question	Answer	Score
When using pesticides/other control measures, how do you decide on frequency and amounts to use?	No	1
	Yes, monitor impact	2
	Yes, monitor impact and act on results	3
	Yes, and target applications to minimise environmental impact	4

- **Split complex questions** (e.g., frequency) into two simpler, unambiguous items ("Frequency" and "amounts").

- **Replace subjective wording** ("monitor impact") with explicit criteria ("uses field scouting logs ≥ 3×/season")

Key takeaways - Reliability Check of PGT Spurs in PATHWAYS

- Why reliability first?
  - Cronbach's α exposed where PGT indicators truly hang together and where measurement noise hides real sustainability signals—vital before running regressions on structural drivers.

- What did we learn?
  - *Agri-Environmental Management* is already robust (α = 0.85) but dragged down by subjective pesticide questions.
  - Critical items identified
    - Pesticide-use wording ↓ reliability → clarify / simplify.

- Outcome for stakeholders: A tighter, evidence-based PGT will deliver more credible farm benchmarks, and less noisy further analytics.

II. Farm structural factors and sustainability dimensions

Methodology

- Using a Logistic regression approach, we explore the influence of structural farm features on sustainability dimensions, focusing on those with high or moderate reliability (e.g., Agri-Environmental Management and System Security and diversity)

➢ PGT original

   ➢ LU per ha

   ➢ Land Use (UAA & Number of land types)

➢ Building indicators based on the PGT original

   ➢ $Share\ subsidies\ on\ total\ income = \dfrac{Subsidies\ (Total)}{Total\ income}$

   ➢ $share\ labour\ cost\ on\ total\ cost = \dfrac{Labour\ costs,}{Total\ costs}$

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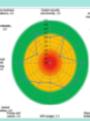
Logistic regression results: Comparing coefficients across spurs
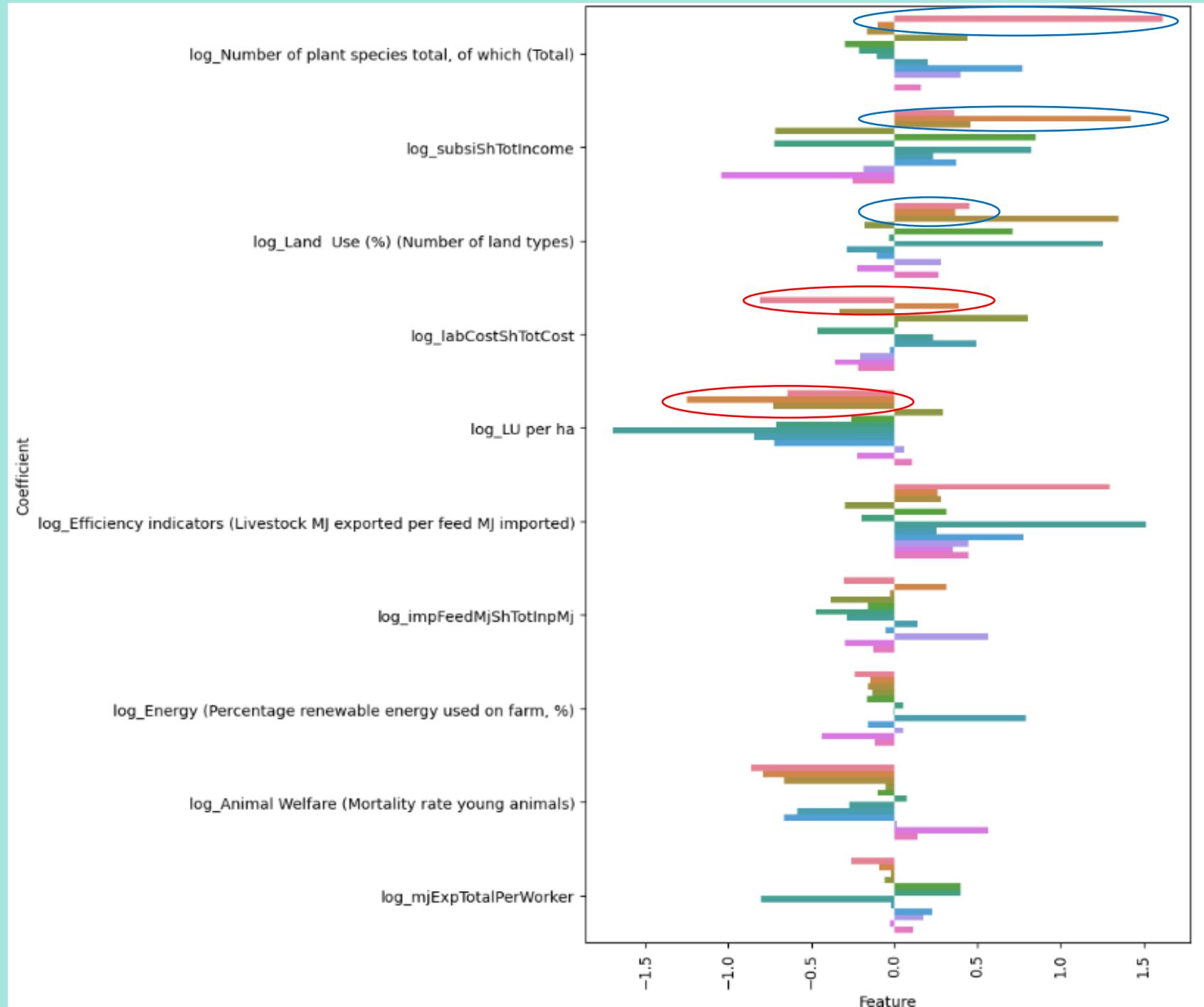
Logistic regression main insights

Agri-environmental management

↑ Subsidy share of income (β≈+1.75)

↓ Livestock density, LU/ha (β≈−1.59)

↑ Labour cost share (β≈+0.50)

Takeaway: Incentives and labour-intensive stewardship help; to consider managing stocking rates.

System security & diversity

↑ Subsidy share of income (β≈+1.03)

↓ Livestock density, LU/ha (β≈−1.14)

↓ Labour cost share (β≈−0.54)

Takeaway: Incentives help. Stocking rate is a negative driver.

Summary and recommendations

- Reliability problems to be addressed

- How structural factors influence (or predict) sustainability performance

- Importance of aligning sustainability constructs and underlying farm characteristics

- Recommendations include:
  - Refine indicators with low or negative reliability
  - Prioritise critical indicators with substantial positive impacts
  - Integrate structural farm variables directly into the PGT to strengthen sustainability insights

About Pathways

With the aim of reducing environmental impacts while addressing societal demands for safe, nutritious and affordable meat and dairy products, PATHWAYS is about identifying and increasing sustainable practices along the supply and production chains of the European livestock sector. Coordinated by the Swedish University of Agricultural Sciences (SLU) and comprising 28 partners from 12 countries, this 5-year (2021-2026) €9 million Horizon 2020 project contributes to the EU Farm-to-Fork Strategy which is at the heart of the EU Green Deal.

Get in touch

🌐 pathways-project.com

✉ media@pathways-project.com

🐦 @pathways_europe

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