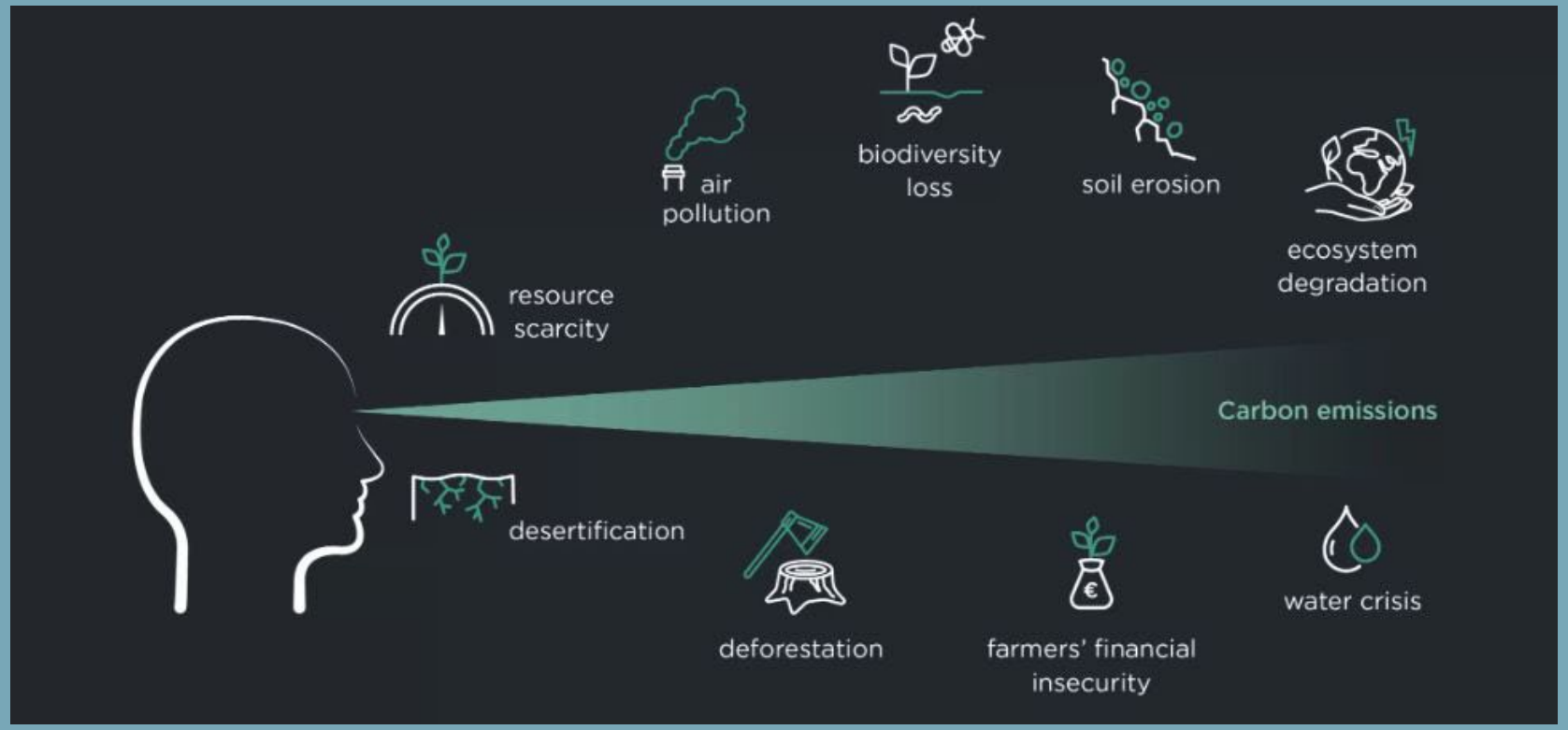
# Multicriteria performance of five grass-based cattle farms along a gradient of stocking rate

Bertrand DUMONT, Frédéric JOLY, Cian BLAIX, Juliette M.G. BLOOR,

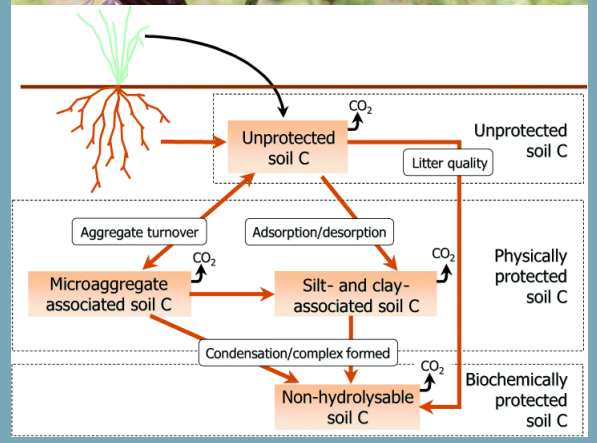
Michael S. CORSON, Olivier HUGUENIN-ELIE, Hayo M.G. VAN DER WERF

Reducing greenhouse gas emissions is undeniably important. But becoming overly fixated on this one metric can lead to carbon tunnel vision — in which organizations become overly fixated on one goal




➔ Need to account for multiple dimensions

# Grass-based farming systems also benefit society by providing services other than animal products *(Rodriguez-Ortega et al., 2014; Bengtsson et al., 2019)*


Modelling studies indicate that C sequestration alone in managed grasslands cannot compensate for the climate change impact of current ruminant emissions *(Wang et al., 2023; Keel et al., 2024),* which calls for decreasing the number of ruminants

# Huge management effects on the environmental benefits/impacts of cattle farms

How does grazing intensity influence the diversity of plants and insects in a species-rich upland grassland on basalt soils?

B. Dumont*, A. Farruggia*, J.-P. Garel†, P. Bachelard‡, E. Boitier‡ and M. Frain§

Agriculture, Ecosystems and Environment 241 (2017) 1–10

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Agriculture, Ecosystems and Environment

journal homepage: www.elsevier.com/locate/agee

A biodiversity-friendly rotational grazing system enhancing flower-visiting insect assemblages while maintaining animal and grassland productivity

Simone Ravetto Enri[a], Massimiliano Probo[a], Anne Farruggia[b,*], Laurent Lanore[b], André Blanchetete[c], Bertrand Dumont[b]

Article

https://doi.org/10.1038/s41467-024-48049-y

## Effects of management practices on the ecosystem-service multifunctionality of temperate grasslands

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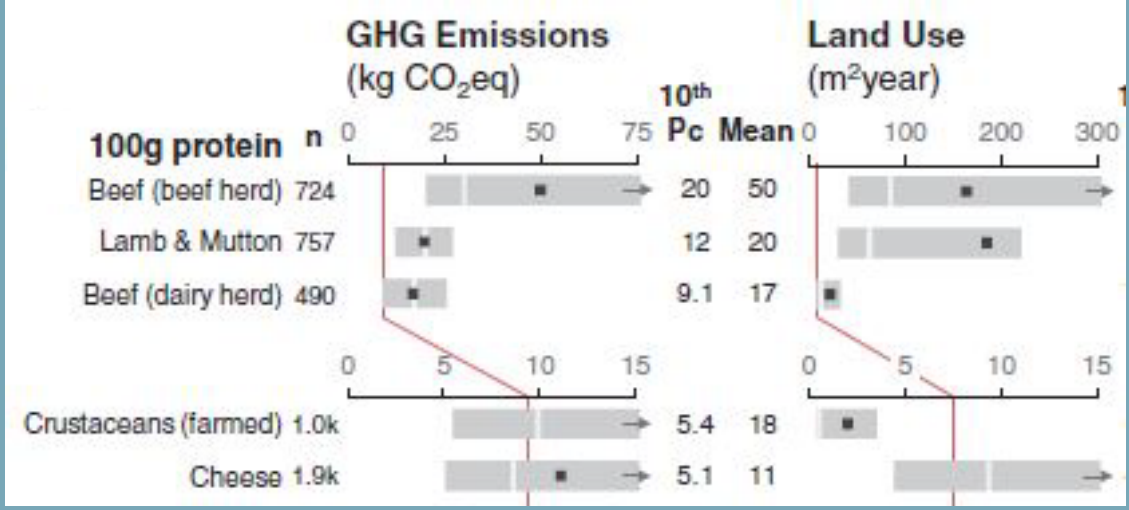
Franziska J. Richter[1], Matthias Suter[2], Andreas Lüscher[2], Nina Buchmann[1], Nadja El Benni[3], Rafaela Feola Conz[4], Martin Hartmann[4], Pierrick Jan[5] & Valentin H. Klaus[1,2]

RESEARCH

SUSTAINABILITY

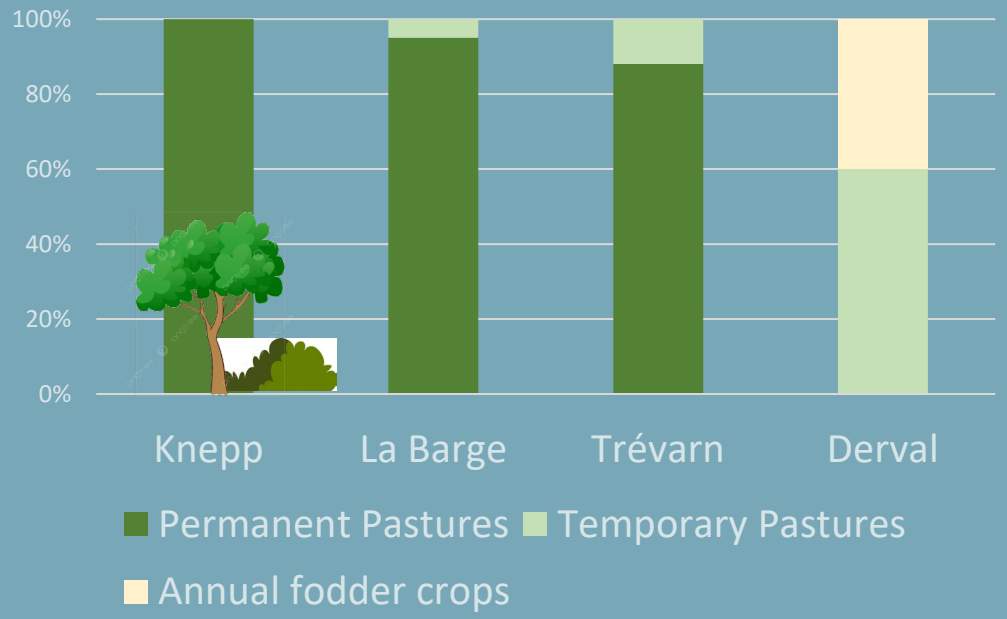
## Reducing food's environmental impacts through producers and consumers

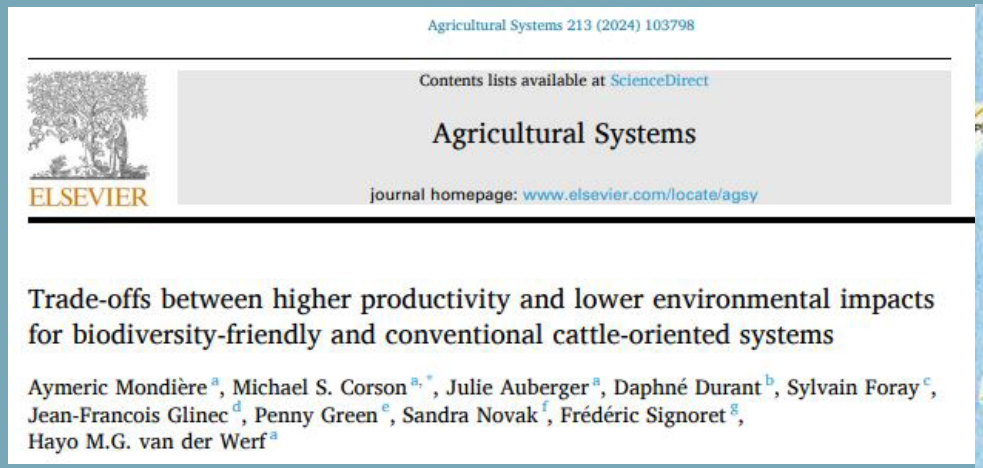
J. Poore[1,2*] and T. Nemecek[3]




# Among the promising « how? », we analysed sustainable options for cattle farms along a wide gradient of stocking rate in Atlantic lowlands

1 **Knepp** (rewilding) 0.18 LU/ha → 2 **La Barge** (Paysans de Nature) 0.53 LU/ha → 3 **Trévarn** (Agroecology) 0.79 LU/ha → 4 **Derval** (Conventional) 1.30 LU/ha



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ELSEVIER

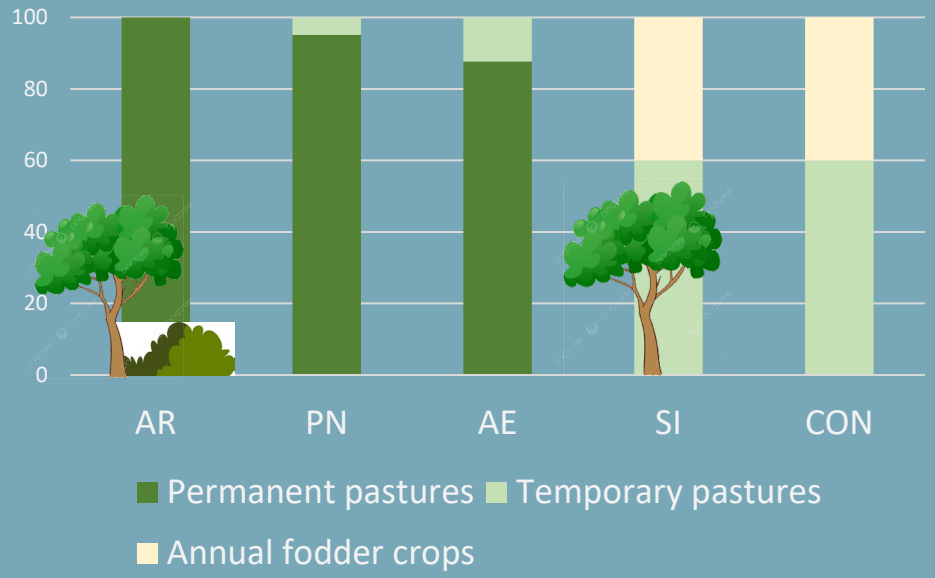
Trade-offs between higher productivity and lower environmental impacts for biodiversity-friendly and conventional cattle-oriented systems

Aymeric Mondière [a], Michael S. Corson [a,*], Julie Auberger [a], Daphné Durant [b], Sylvain Foray [c], Jean-Francois Glinec [d], Penny Green [e], Sandra Novak [f], Frédéric Signoret [g], Hayo M.G. van der Werf [a]

# A fifth farm was modelled to assess a sustainable intensification option

Sustainable intensification aims to increase the productivity of agricultural land to limit further loss of « undisturbed natural ecosystems » *(Pretty, 1997)*

A farm was modelled that produces the same amount of HE protein as the agroecological farm, with the same size and productivity/ha of agricultural area as the conventional farm




➔ 48 ha needed to produce the required amount of protein, while 44 ha (48% of area) are uncultivated and evolve gradually towards climax vegetation

# LCA allowed calculating environmental impacts in the five farms

| Options for animal production | Agricultural Rewilding (Knepp) | Paysans de Nature (La Barge) | Agroecological (Trévarn) | Sustainable Intensification | Conventional (Derval) |
|---|---|---|---|---|---|
| Human edible protein kg/ha.yr | 5.0 | 11.0 | 110.6 | 124.5* | 238.6 |
| Gross climate change $kgCO_2eq/ha.yr$ | 562 | 2553 | 4488 | 4671 | 8949 |
| Soil C sequestration | | | | | |
| C stored in woody biomass | | | | | |
| Net climate change $kgCO_2eq/ha.yr$ | | | | | |

* 238.8 kg / ha.yr in the agricultural area of SI farm (42%)

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| Soil C sequestration | -3615 | -2780 | -2087 | -2168 | -654 |
| C stored in woody biomass | -3056 | 0 | 0 | -2268** | 0 |
| Net climate change $kgCO_2eq/ha.yr$ | | | | | |

* 238.8 kg / ha.yr in the agricultural area of SI farm (42%)  ** in the area « returned » to nature

# LCA allowed calculating environmental impacts in the five farms

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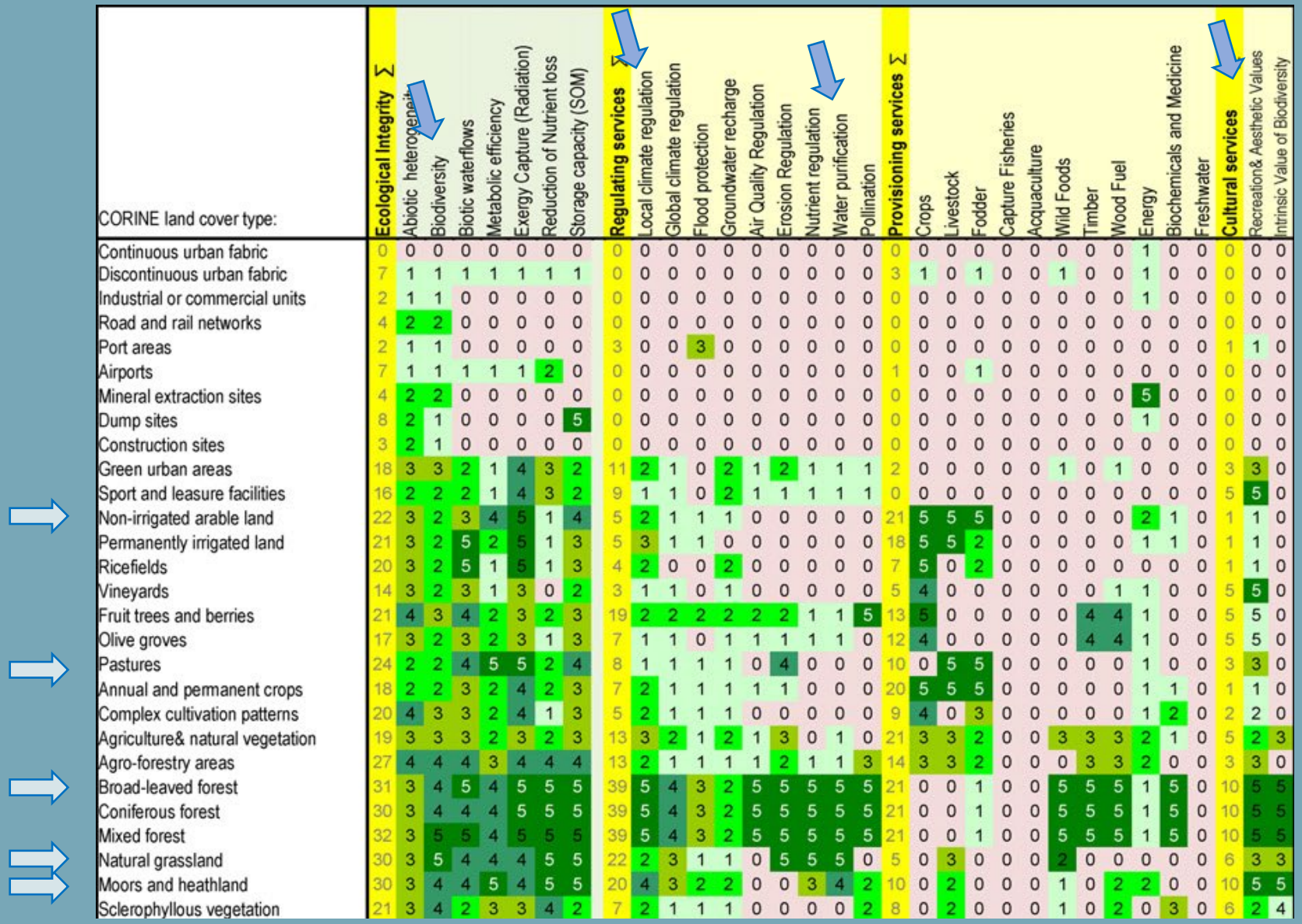
| C stored in woody biomass | -3056 | 0 | 0 | -2268** | 0 |
| Net climate change $kgCO_2eq/ha.yr$ | -6109 | -227 | 2401 | 234 | 8295 |

*Dumont et al. submitted*

➔ Two climate neutral options: land sharing at low SR (0.53 LU/ha), or land sparing while growing trees to compensate for higher GHG emissions

# Land use matrices provide ecosystem services and biodiversity indicators



| CORINE land cover type: | Ecological Integrity Σ | Abiotic heterogeneity | Biodiversity | Biotic waterflows | Metabolic efficiency | Exergy Capture (Radiation) | Reduction of Nutrient loss | Storage capacity (SOM) | Regulating services Σ | Local climate regulation | Global climate regulation | Flood protection | Groundwater recharge | Air Quality Regulation | Erosion Regulation | Nutrient regulation | Water purification | Pollination | Provisioning services Σ | Crops | Livestock | Fodder | Capture Fisheries | Acquaculture | Wild Foods | Timber | Wood Fuel | Energy | Biochemicals and Medicine | Freshwater | Cultural services | Recreation& Aesthetic Values | Intrinsic Value of Biodiversity |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Continuous urban fabric | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Discontinuous urban fabric | 7 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 3 | 1 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Industrial or commercial units | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Road and rail networks | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Port areas | 2 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 3 | 0 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Airports | 7 | 1 | 1 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Mineral extraction sites | 4 | 2 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 |
| Dump sites | 8 | 2 | 1 | 0 | 0 | 0 | 0 | 5 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 0 | 0 | 0 |
| Construction sites | 3 | 2 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Green urban areas | 18 | 3 | 3 | 2 | 1 | 4 | 3 | 2 | 11 | 2 | 1 | 0 | 2 | 1 | 2 | 1 | 1 | 1 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 1 | 0 | 0 | 0 | 3 | 3 | 0 |
| Sport and leasure facilities | 16 | 2 | 2 | 2 | 1 | 4 | 3 | 2 | 9 | 1 | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 5 | 5 | 0 |
| Non-irrigated arable land | 22 | 3 | 2 | 3 | 4 | 5 | 1 | 4 | 5 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 21 | 5 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 2 | 1 | 0 | 1 | 1 | 0 |
| Permanently irrigated land | 21 | 3 | 2 | 5 | 2 | 5 | 1 | 3 | 5 | 3 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 0 | 18 | 5 | 5 | 2 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| Ricefields | 20 | 3 | 2 | 5 | 1 | 5 | 1 | 3 | 4 | 2 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 7 | 5 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 |
| Vineyards | 14 | 3 | 2 | 3 | 1 | 3 | 0 | 2 | 3 | 1 | 1 | 0 | 1 | 0 | 0 | 0 | 0 | 0 | 5 | 4 | 0 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 0 | 5 | 5 | 0 |
| Fruit trees and berries | 21 | 4 | 3 | 4 | 2 | 3 | 2 | 3 | 19 | 2 | 2 | 2 | 2 | 2 | 2 | 1 | 1 | 5 | 13 | 5 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 0 | 0 | 5 | 5 | 0 |
| Olive groves | 17 | 3 | 2 | 3 | 2 | 3 | 1 | 3 | 7 | 1 | 1 | 0 | 1 | 1 | 1 | 1 | 1 | 0 | 12 | 4 | 0 | 0 | 0 | 0 | 0 | 4 | 4 | 1 | 0 | 0 | 5 | 5 | 0 |
| Pastures | 24 | 2 | 2 | 4 | 5 | 5 | 2 | 4 | 8 | 1 | 1 | 1 | 1 | 0 | 4 | 0 | 0 | 0 | 10 | 0 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 3 | 3 | 0 |
| Annual and permanent crops | 18 | 2 | 2 | 3 | 2 | 4 | 2 | 3 | 7 | 2 | 1 | 1 | 1 | 1 | 1 | 0 | 0 | 0 | 20 | 5 | 5 | 5 | 0 | 0 | 0 | 0 | 0 | 1 | 1 | 0 | 1 | 1 | 0 |
| Complex cultivation patterns | 20 | 4 | 3 | 3 | 2 | 4 | 1 | 3 | 5 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 0 | 9 | 4 | 0 | 3 | 0 | 0 | 0 | 0 | 0 | 1 | 2 | 0 | 2 | 2 | 0 |
| Agriculture& natural vegetation | 19 | 3 | 3 | 3 | 2 | 3 | 2 | 3 | 13 | 3 | 2 | 1 | 2 | 1 | 3 | 0 | 1 | 0 | 21 | 3 | 3 | 2 | 0 | 0 | 3 | 3 | 3 | 2 | 1 | 0 | 5 | 2 | 3 |
| Agro-forestry areas | 27 | 4 | 4 | 4 | 3 | 4 | 4 | 4 | 13 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 1 | 3 | 14 | 3 | 3 | 2 | 0 | 0 | 0 | 3 | 3 | 2 | 0 | 0 | 3 | 3 | 0 |
| Broad-leaved forest | 31 | 3 | 4 | 5 | 4 | 5 | 5 | 5 | 39 | 5 | 4 | 3 | 2 | 5 | 5 | 5 | 5 | 5 | 21 | 0 | 0 | 1 | 0 | 0 | 5 | 5 | 5 | 1 | 5 | 0 | 10 | 5 | 5 |
| Coniferous forest | 30 | 3 | 4 | 4 | 4 | 5 | 5 | 5 | 39 | 5 | 4 | 3 | 2 | 5 | 5 | 5 | 5 | 5 | 21 | 0 | 0 | 1 | 0 | 0 | 5 | 5 | 5 | 1 | 5 | 0 | 10 | 5 | 5 |
| Mixed forest | 32 | 3 | 5 | 5 | 4 | 5 | 5 | 5 | 39 | 5 | 4 | 3 | 2 | 5 | 5 | 5 | 5 | 5 | 21 | 0 | 0 | 1 | 0 | 0 | 5 | 5 | 5 | 1 | 5 | 0 | 10 | 5 | 5 |
| Natural grassland | 30 | 3 | 5 | 4 | 4 | 4 | 5 | 5 | 22 | 2 | 3 | 1 | 1 | 0 | 5 | 5 | 5 | 0 | 5 | 0 | 3 | 0 | 0 | 0 | 2 | 0 | 0 | 0 | 0 | 0 | 6 | 3 | 3 |
| Moors and heathland | 30 | 3 | 4 | 4 | 5 | 4 | 5 | 5 | 20 | 4 | 3 | 2 | 2 | 0 | 0 | 3 | 4 | 2 | 10 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 2 | 0 | 0 | 10 | 5 | 5 |
| Sclerophyllous vegetation | 21 | 3 | 4 | 2 | 3 | 3 | 4 | 2 | 7 | 2 | 1 | 1 | 1 | 0 | 0 | 0 | 0 | 2 | 8 | 0 | 2 | 0 | 0 | 0 | 1 | 0 | 2 | 0 | 3 | 0 | 6 | 2 | 4 |

Ecosystem services in columns

- Ecological integrity
- Regulating services
- Cultural services

Does not account for land management

scale for assessing capacities:

- 0 = no relevant capacity
- 1 = low relevant capacity
- 2 = relevant capacity
- 3 = medium relevant capacity
- 4 = high relevant capacity
- 5 = very high relevant capacity

*Burkhard et al. 2012, 2014*

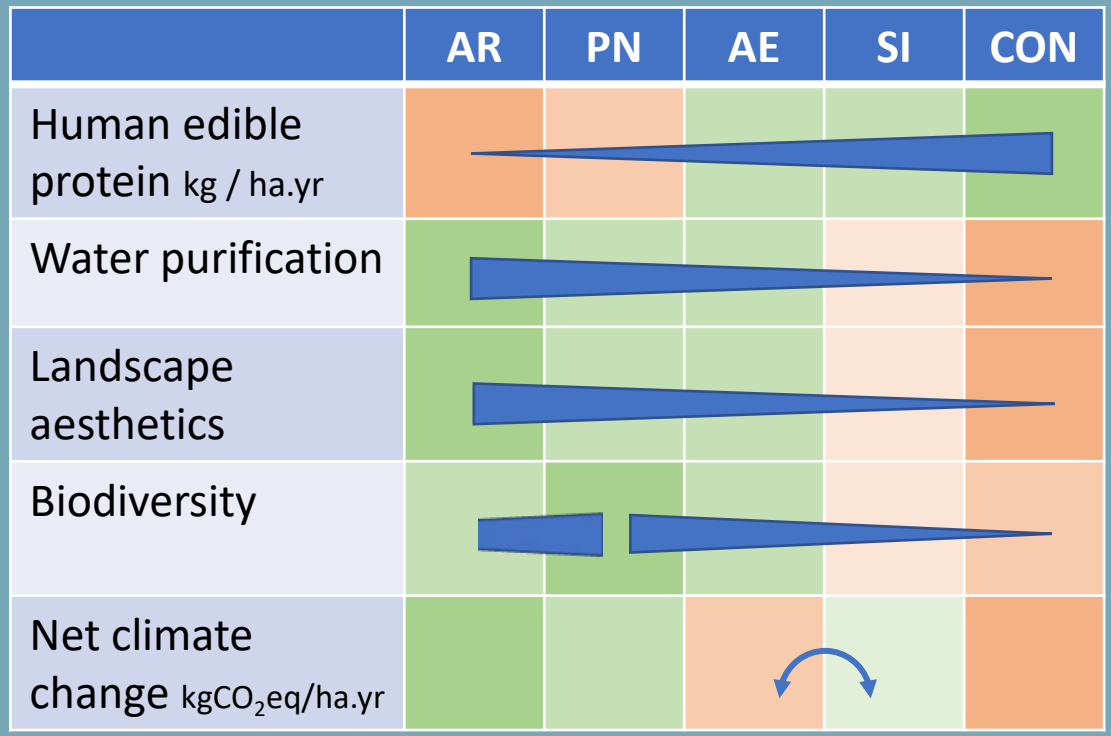
# Land use matrices provide ecosystem services and biodiversity indicators

| Options for animal production | Agricultural Rewilding (Knepp) | Paysans de Nature (La Barge) | Agroecological (Trévarn) | Sustainable Intensification | Conventional (Derval) |
|---|---|---|---|---|---|
| Water purification | 3.7 | 2.9 | 2.6 | 2.4 | 0.0 |
| Landscape aesthetics | 4.3 | 3.9 | 3.6 | 2.9 | 1.0 |
| Biodiversity | 4.3 | 4.9 | 4.6 | 3.0 | 2.0 |

*Dumont et al. submitted*

- ➔ Water purification benefits from the presence of permanent grasslands and trees and goes down to 0 when land use is based on crop, leys and fertilized pastures
- ➔ While the AR, PN and AE farms differed greatly in their C storage, they differed little in lanscape aesthetics and biodiversity scores (permanent grasslands)

# Which option represents the best compromise?




We applied an ES-multifunctionality method proposed by Manning *et al.* (2018)

Perspective | Published: 16 February 2018

**Redefining ecosystem multifunctionality**

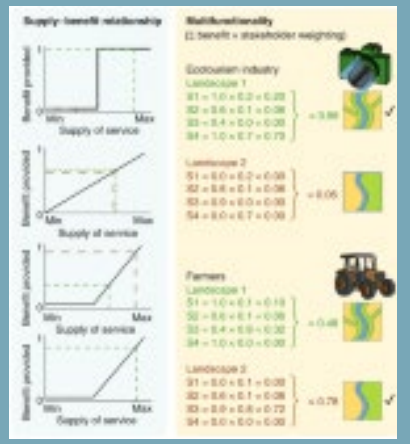
Peter Manning, Fons van der Plas, Santiago Soliveres, Eric Allan, Fernando T. Maestre, Mark J. Whittingham & Markus Fischer

*Nature Ecology & Evolution* **2**, 427–436 (2018) | Cite this article

# Valuing the overall supply of ESs from contrasting human perspectives

It requires:

- ➔ functional relationships between the supply of each ES and the benefits it provides to humans
- ➔ weighing ES by their relative importance to stakeholder groups



*Manning et al. 2018*

| Weight | Ecotourism sector | Environmental agency | Farmers | Researchers |
|---|---|---|---|---|
| Edible protein | 0.00 | 0.00 | 0.70 | 0.32 |
| C sequestration | 0.10 | 0.30 | 0.10 | 0.19 |
| Water purificat° | 0.20 | 0.60 | 0.10 | 0.10 |
| Land aesthetics | 0.50 | 0.00 | 0.00 | 0.16 |
| Biodiversity | 0.20 | 0.10 | 0.10 | 0.23 |

# Valuing the overall supply of ESs from contrasting human perspectives

Integrating stakeholder perceptions (≠ weight for the 5 dimensions) modified ES-multifunctionality scores and farm rankings

➔ How to establish a constructive dialogue?

➔ How to account for the diversity of narratives?

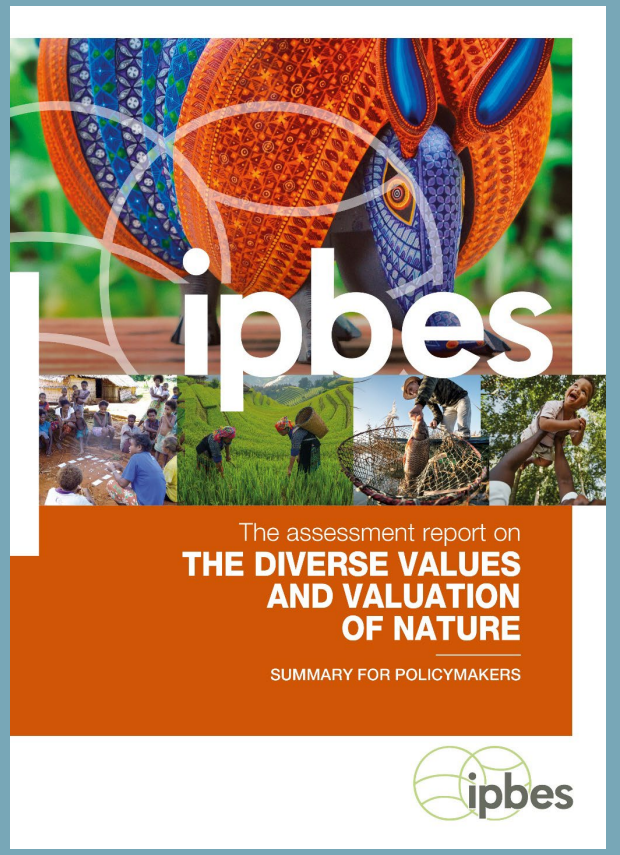

*Dumont et al. submitted*

# Conclusion

- Tools for participants to share their knowledge and values, and exercise their analytical skills *(Dernat et al., 2023)*

- Need for a more pluralistic perspective of multifunctionality that accounts for stakeholder values to establish a dialogue with farmers about how to move towards environmental targets

- Monocriteria assessments only reveal a small part of the story when analysing sustainable options for the future of animal production systems



# Thank you for your attention!

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