Ecosystem services indicators for grassland-based livestock systems

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Multifunctionality of grassland-based livestock systems

Traditional grassland-based livestock systems provide several market and non-market services:

- Dairy and meat products
- Conservation of local breeds
- Semi-natural habitats and biodiversity conservation
- Landscape maintenance
- Risks prevention
- Recreation and ecotourism
- Cultural heritage

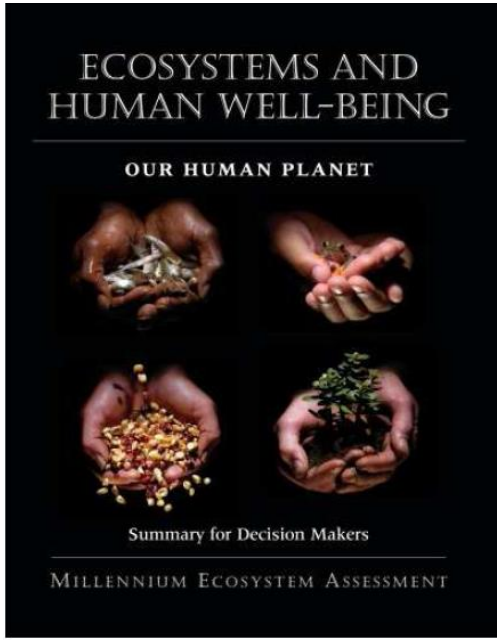
Aims and outline

To analyse the approaches used to evaluate the link between grassland based livestock systems and Ecosystem Services (ES)

- Definition and classification of ES
- ES and agro-ecosystems
- Methodological approaches
- Case studies
- Discussion and take home messages

Ecosystem services (ES)

Ecosystem Services are defined as the direct and indirect contributions of ecosystems to human well-being, many of which do not have a market value.



Different classification:

- Millennium Ecosystem Assessment – MEA 2005
- The Economics of Ecosystems and Biodiversity - TEEB 2010
- Common International Classification of Ecosystem Services - CICES

Millennium Ecosystem Assessment 2005

http://www.millenniumassessment.org

Provisioning	Food, freshwater, fibers, ornamental materials, biochemicals, natural medicines, genetic resources, energy resources.
Supporting	Nutrient cycling, photosynthesis, water cycling.
Regulating	Disease/pest regulation, biological control, pollination, erosion regulation, water regulation, purification and treatment, air quality regulation, climate regulation.
Cultural	Cultural diversity, spiritual and religious values, knowledge systems, educational values, inspirations, aesthetic values, social relations, sense of place, cultural heritage values, recreation.

TEEB 2010 The Economics of Ecosystems and Biodiversity www.teebweb.org

Provisioning	Food , Raw materials, Fresh water, Medical resources
Supporting	Habitat for species, Maintenance of genetic diversity
Regulating	Local climate and air quality, Carbon sequestration and storage, Moderation of extreme events, Waste-water treatment, Erosion prevention and maintenance of soil fertility, Pollination, Biological control
Cultural	Recreation and mental and physical health, Tourism, Aesthetic appreciation and inspiration for culture, art and design, Spiritual experience and sense of place

CICES Common International Classification of Ecosystem Services (version 4.3) https://cices.eu/

Section	Division	Group
Provisioning	Nutrition	Biomass
		Water
	Materials	Biomass.Fibre
		Water
	Energy	Biomass-based energy sources
		Mechanical energy
Regulation & Maintenance	Mediation of waste, toxics and other nuisances	Mediation by biota
		Mediation by ecosystems
	Mediation of flows	Mass flows
		Liquid flows
		Gaseous/air flows
	Maintenance of physical, chemical, biological conditions	Lifecycle maintenance, habitat and gene pool protection
		Pest and disease control
		Soil formation and composition
		Water conditions
		Atmospheric composition and climate regulation
Cultural	Physical and intellectual interactions with ecosystems and land-/seascapes	Physical and experiential interactions
		Intellectual and representational interactions
	Spiritual, symbolic and other interactions	Spiritual and/or emblematic

Agriculture and Ecosystem Services

"invisible services" "marketable" benefits
"invisible disservices" "Non-marketable" benefits

Climate
GH Gases
Pollutants
H_2O

Provisioning
Food
Genetic resources
Other goods

Not provisioning ES
Habitats and biodiversity
Natural hazards mitigation
Aesthetic quality
Touristic appeal
Cultural Identity
Etc…

Nutrients cycles Soil fertility Pollination Biological control Mitigation of natural hazards …

Supporting and Regulating

Agriculture and Ecosystem Services

“marketable” benefits

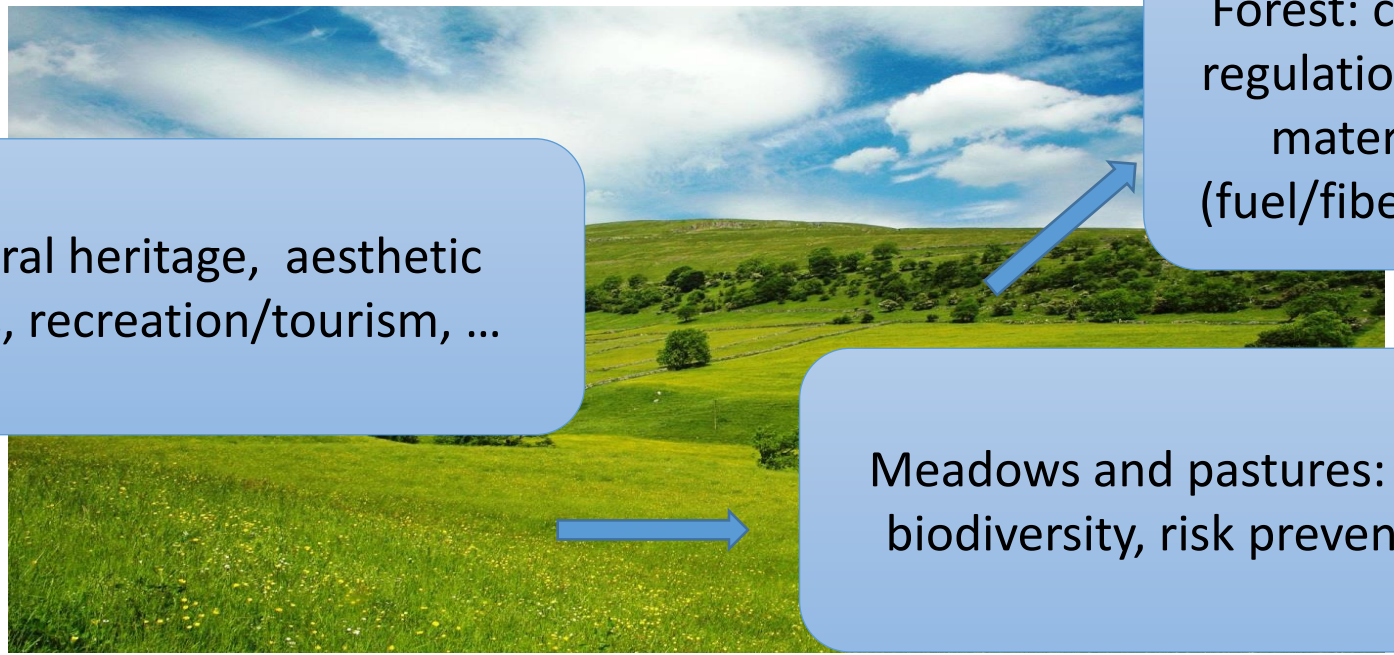
“invisible” disservices

Provisioning
Food

Climate
GH gases
Pollutants
H_2O

Nutrients balances
Ecological Footprint
Life Cycle Assessment LCA

Grassland based livestock systems



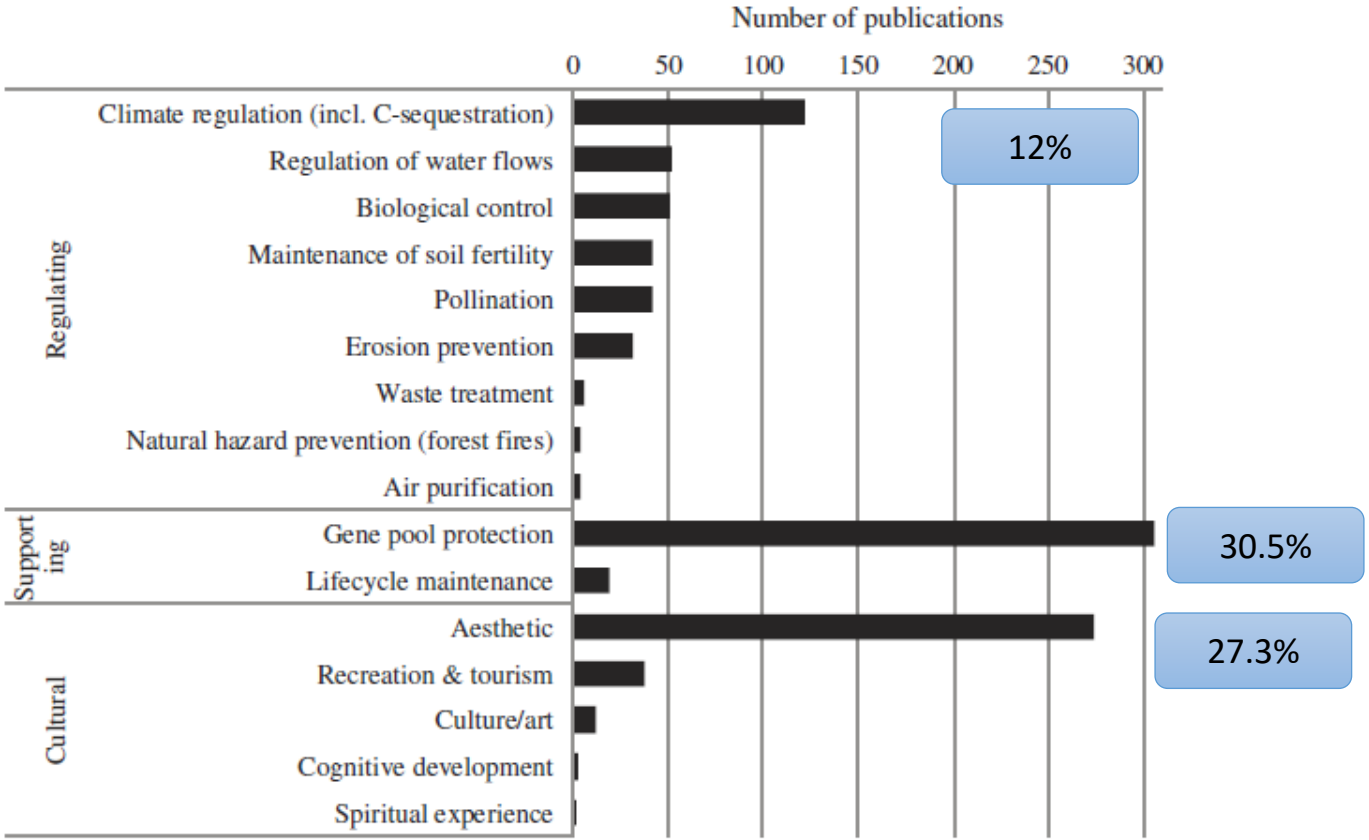
Forest: climate regulation, raw materials (fuel/fiber), etc.

Cultural heritage, aesthetic values, recreation/tourism, …

Meadows and pastures: forage; biodiversity, risk prevention….

High Nature Value Farmland (HNVF, EEA 2004)

The application of ES framework to European pasture-based livestock farming systems (Rodríguez-Ortega et al., 2014)



Ecosystem Services valuation

- Different functional units
- Different temporal and spatial scales
- Different perception by society
- No market price

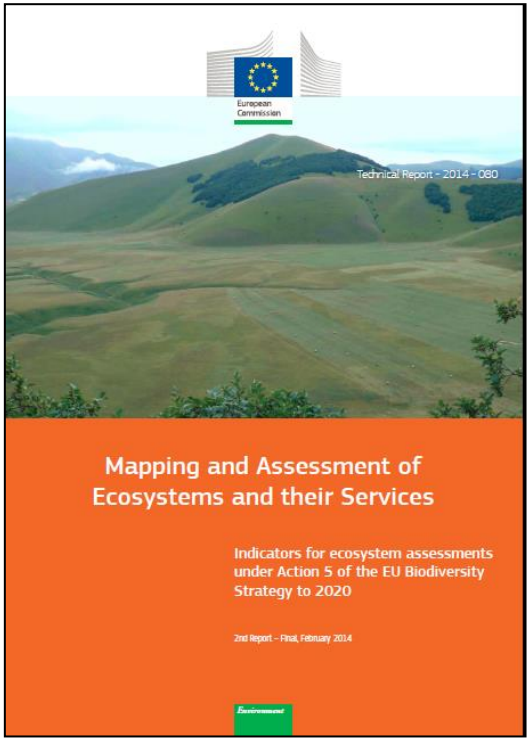
Methods:

1. Biophysical
2. Socio-cultural
3. Economic

Ecological evaluation of ES: Biophysical indicators

Wide range of indicators available.

- Number of indicators available on the CICES website for ES ONLY in GRASSLANDS AND CROPLAND: 68
- Indicators for assessing biodiversity:
  - direct indicators- almost all taxonomic groups have been proposed to assess species diversity or abundance
  - indicators based on management data
  - predicting indicators based on models



Socio-cultural evaluation of ES

Social evaluation approach	Characteristics	Specific techniques
Consultative methods	Structured processes of inquiry into people's perceptions and preferences.	Individual questionnaires In-depth interview
Deliberative and participatory methods	Group-based activities to identify people's relationships with ecosystems, conflicts between the beneficiaries of ES, and trade-offs between different management strategies, land uses or possible future scenarios	Focus Groups Delphy surveys Participatory rural appraisal Participatory scenario planning

Economic evaluation of ES

Economic evaluation approach		Characteristics	Specific techniques
Direct Market Value		Based upon current markets	Direct market analysis Production function analysis Replacement or avoided costs
Indirect Market Value	**Revealed-preference**	Infers values from human behavioural changes in real markets	Travel cost Hedonic pricing Factor Income
	Stated-preference	Estimated economic values through hypothetical markets	Contingent valuation Choice modelling
	Benefit transfer	Infers the value of ES based on previous estimations at another study site	Unit value Benefit function Meta-analysis function transfer

Case studies

- Biophysical approach → trade offs between different indicators: Berton, Marco, et al. "Environmental footprint of the integrated France–Italy beef production system assessed through a multi-indicator approach." *Agricultural Systems* 155 (2017): 33-42.

- Socio economic approach: Faccioni et al., 2017: “Socio-economic valuation of abandonment and intensification of Alpine agroecosystems and associated ecosystem services”

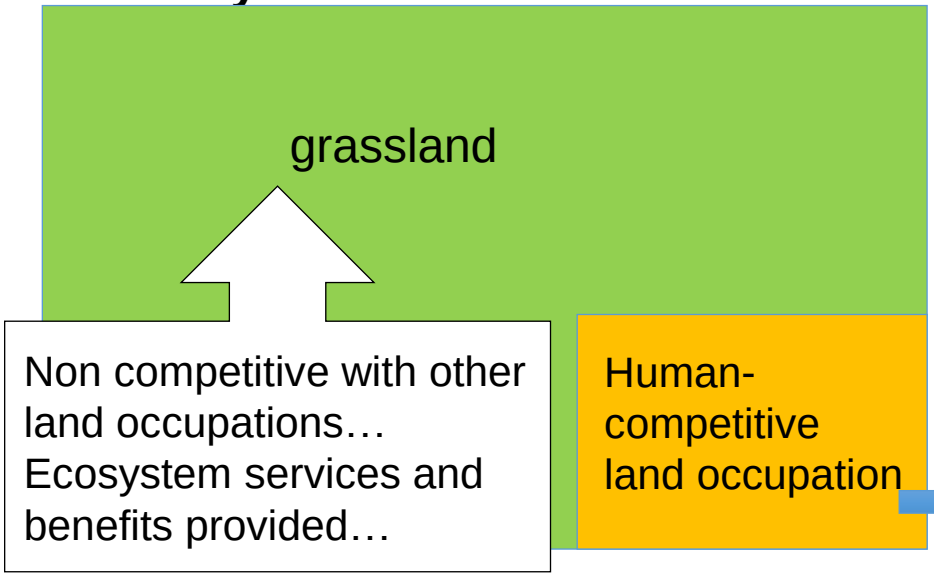
Environmental footprint of the integrated France–Italy beef production system assessed through a multi-indicator approach

The North-East Italy beef sector is included in a two-steps livestock farming system

- Geographically separated
- Based on different production systems and outputs

Grass *vs* crop land occupation for beef production

Integrated France-Italy beef sector:
19.2 m²/year



Land occupation per 1 kg BW

Pig sector
4.1 m²/year
(Gonzales-Garcia et al., 2015)
5.4 m²/year
(Basset-Mens and van der Werf, 2005)

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22nd Congress of the Animal Science and Production Association
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Socio-economic valuation of abandonment and intensification of Alpine agroecosystems and associated ecosystem services

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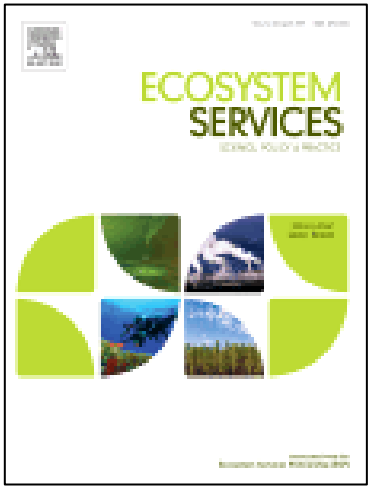
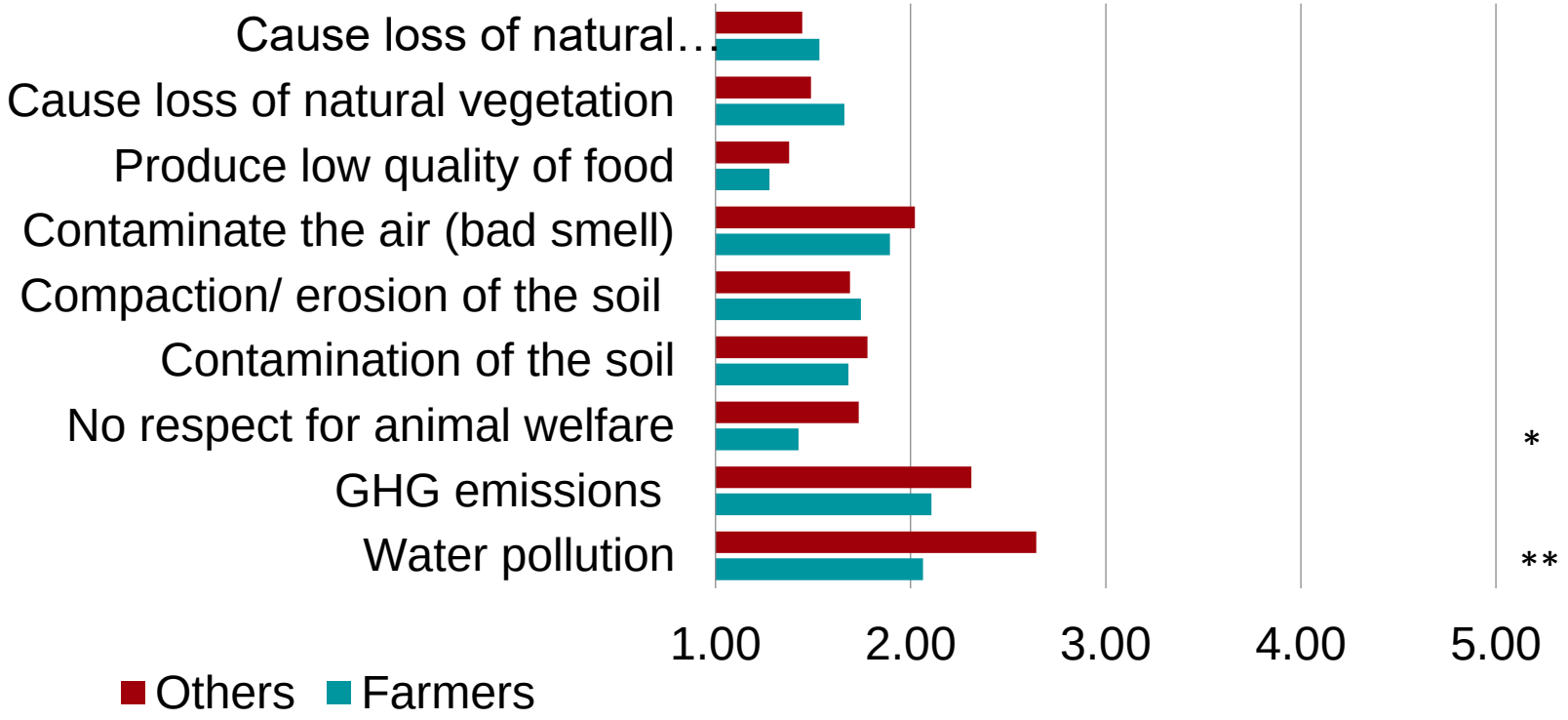


Aims

This study analysed the socio-cultural and economic values of a number of Ecosystem Services provided by the agroecosystems managed by Alpine livestock systems, in order:

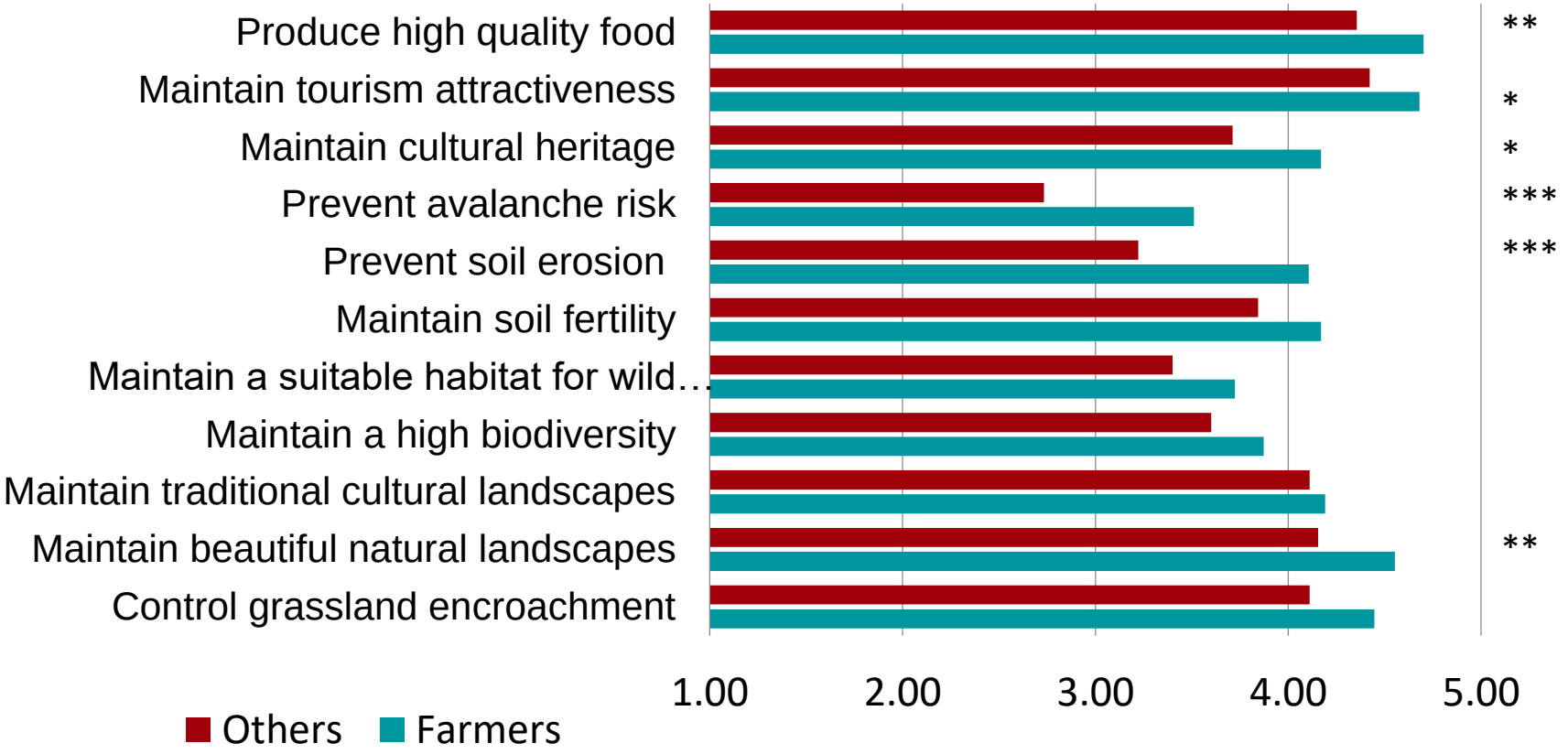
1. to understand how farmers and non-farmers, as local stakeholders, perceive the Ecosystem Services and Disservices linked to dairy cattle systems
2. to investigate how the general population values the different Ecosystem Services and disservices, and the trade-offs between them in monetary terms

Average levels of agreement and disagreement on negative aspects of the mountain dairy cattle systems

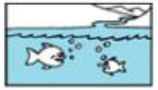
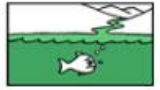


1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree. *=*p* <0.05, **= *p* <0.01

Average levels of agreement and disagreement on positive aspects of the mountain dairy cattle systems



1: strongly disagree, 2: disagree, 3: neutral, 4: agree, 5: strongly agree. *=p <0.05, **= p <0.01, ***= p < 0.001

	Policy A	Policy B	CURRENT Policy
	Summer farm abandonment and highland pasture encroachment. Concentration of permanent livestock and/or agricultural farms in the valleys (meadows converted to arable land).	Maintenance of highland pastures and possible increases in summer farms. Expansion of meadows in the valleys.	Increase of shrubs encroachment on pastures and reduction in summer farms use. Decrease of meadows and trend towards concentration of livestock and/or agricultural farms in the valleys.
Landscape			
Biodiversity	 Decrease in number of species	 Increase in number of species	 Light decrease in number of species
Water quality	 Rivers and lakes more polluted	 Clean rivers and lakes	 Rivers and lakes slightly polluted
Quality products	 9 cheeses (5 valley, 3 summer farms, 1 DOP)	 17 cheeses (9 valley,5 summer farms, 3 DOP)	 13 cheeses (7 valley, 4 summer farms, 2 DOP)
Annual cost	 10 euro	 50 euro	 30 euro
CHOICE	○ A	○ B	○ C

Willingness to pay (WTP) (€ per person per year) of the general population, and calculation of total economic value (TEV).

Ecosystem service	Value component of TEV	WTP (€)	WTP (%)
Landscape	Non consumptive direct use	35.1	22.0
Biodiversity	Non-use existence value	40.3	25.3
Water quality	Indirect use	79.3	49.8
Quality products	Consumptive direct use	4.6	2.9
Total economic value (TEV)		159.3	100.0

Discussion and take home messages

- The Ecosystem Service approach can offer an holistic view of the sustainability of grassland based livestock systems
- Different classification and approaches to valuate ES
- Factors to consider:
  - Objectives of the survey and use of data
  - Spatial and temporal scale
- Multiple trade-offs
- It is a multidisciplinary approach: which role for animal scientists?