Ecosystem services provided by semi-natural and improved grasslands
– *synergies, trade-offs and bundles*

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Grasslands in agricultural production

Natural - grassland biomes
(created by fire and wildlife grazing)

Semi-natural - long history of traditional management, HNV-farmland, high biodiversity

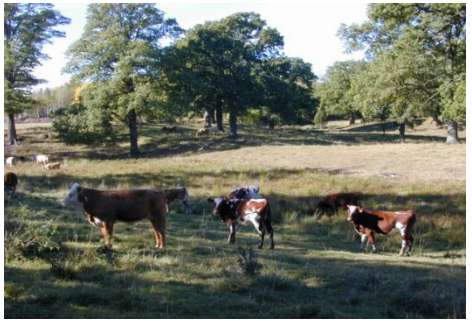
Improved - resulting from technological capital-intensive management, including artificial fertilization, plowing, sowing, and high density of livestock.

Traditionally low-intensively managed grasslands are appreciated all over the world

High biodiversity

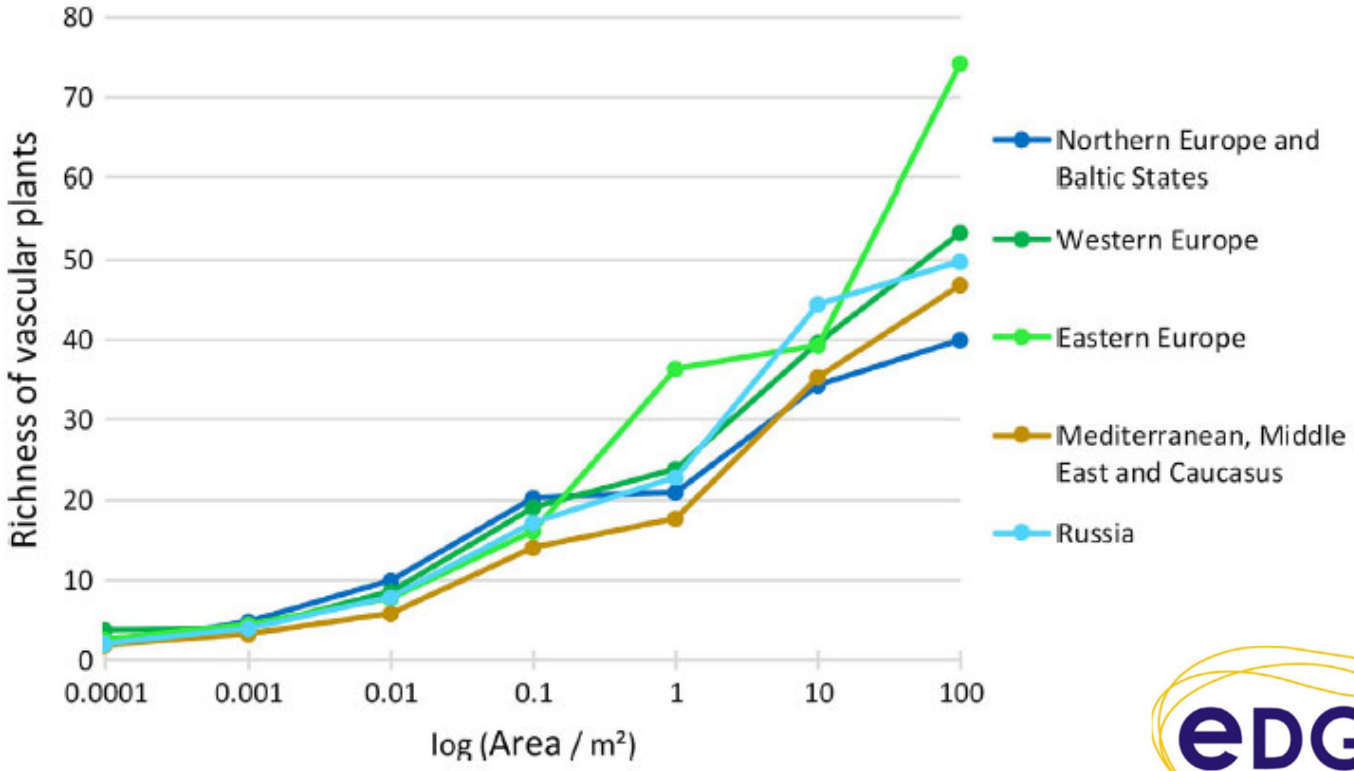
Dahesa, Spain

Rangeland, Africa



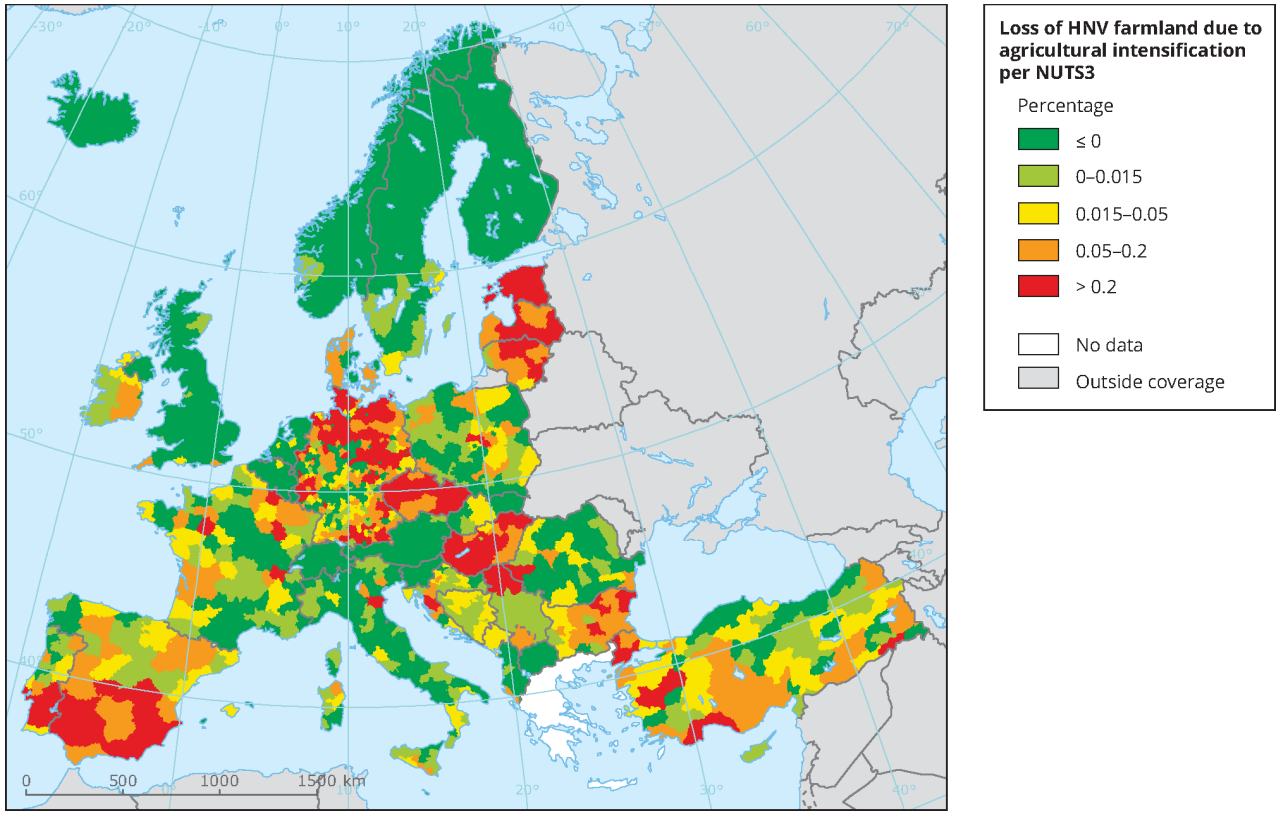
Semi-natural grassland, Europe

Milpa, South America



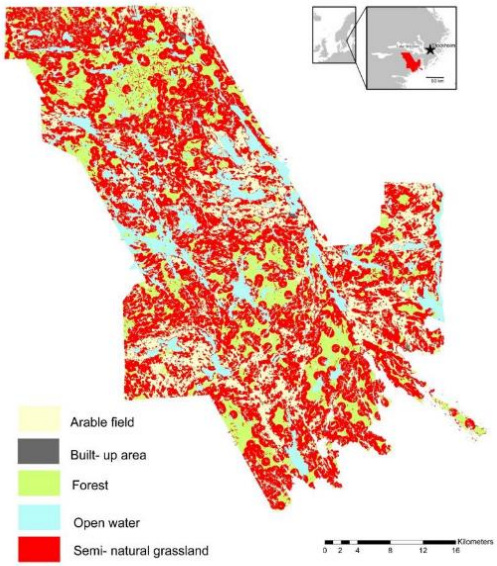
Dengler et al. 2020

The Eurasian Dry Grassland Group

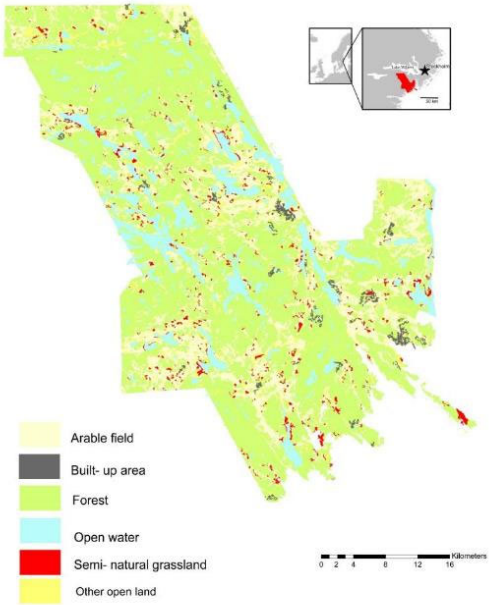


Loss of HNV farmland in EU the last 50 years

Grassland extent 1901



Grassland extent 2012

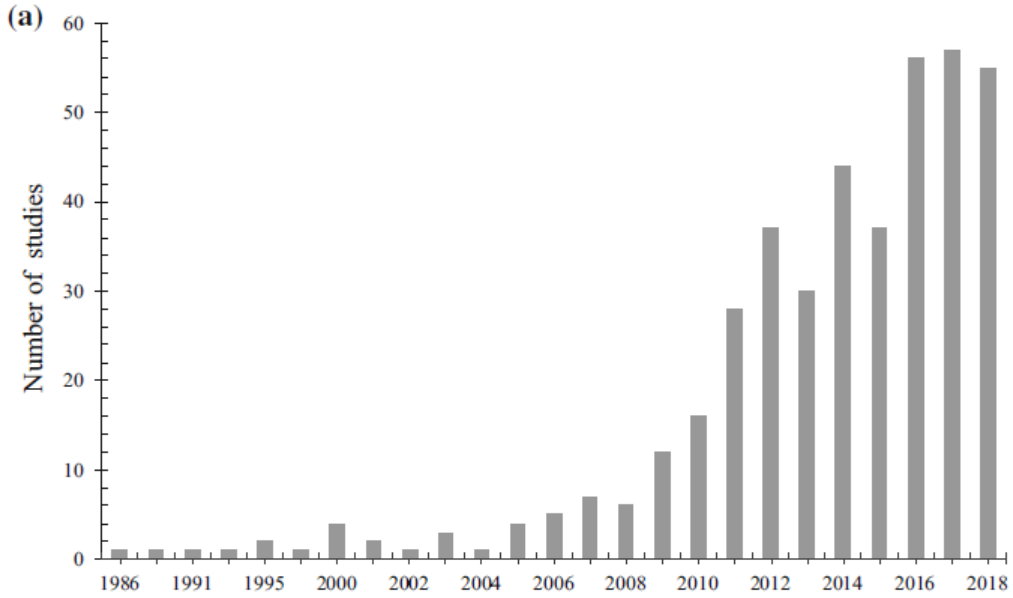


Cousins et al. 2015

Ecosystem services (ES) from grasslands

…still understudied compared to other systems – forests, lakes, urban areas

ES studies on grasslands – a systematic review



Zhao et al. 2020

ES studies on grasslands – a systematic review

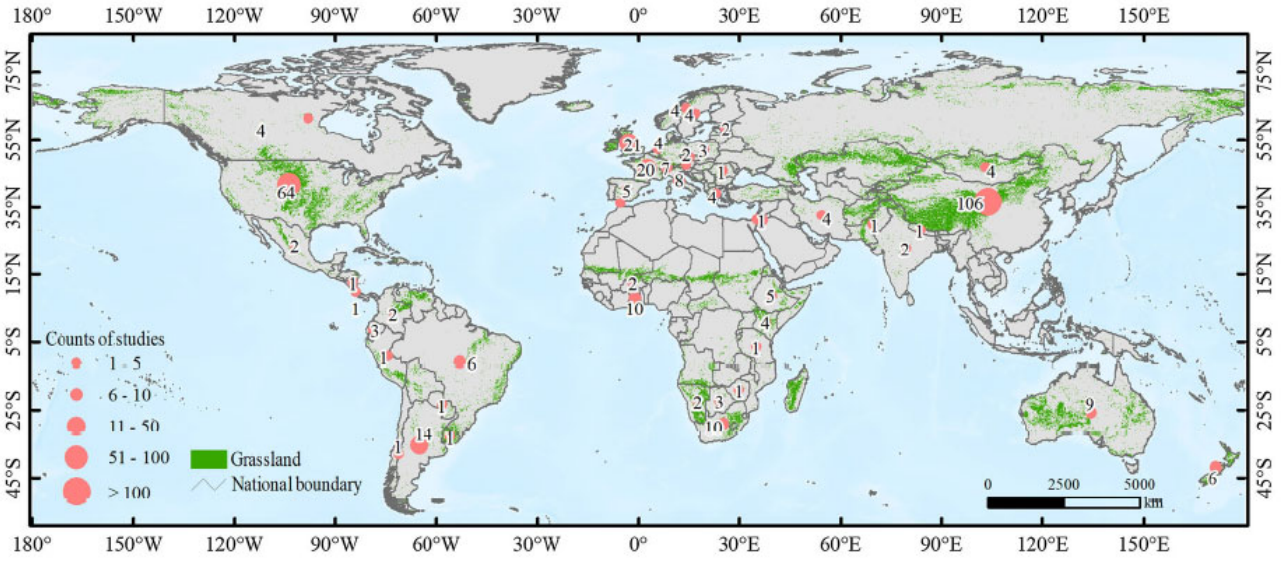
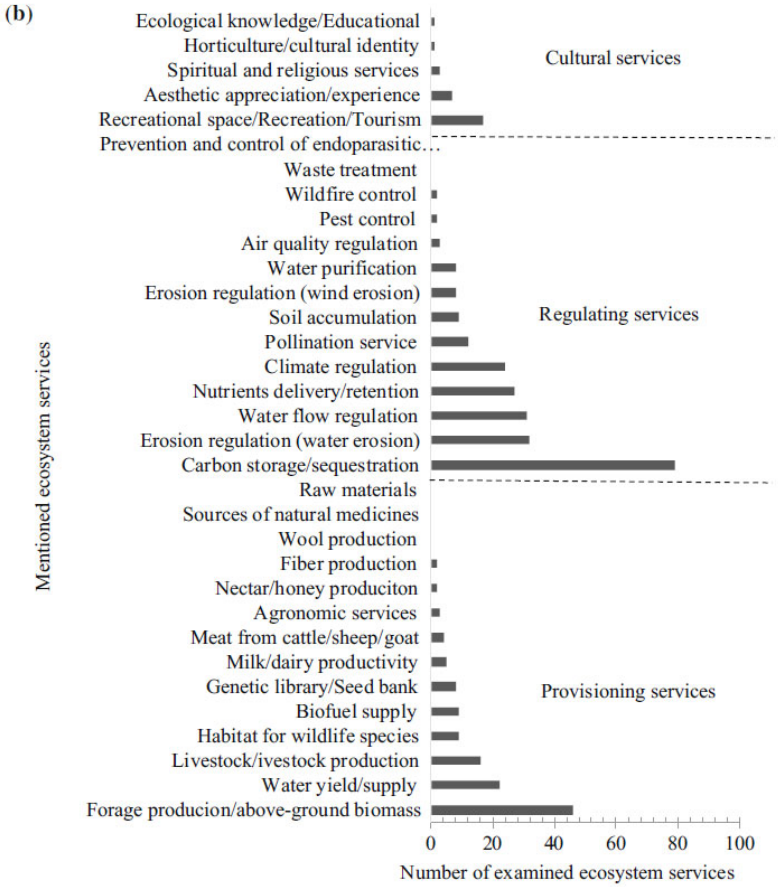


Fig. 4 Global distribution of studies on grassland ecosystem services. *Note* the grassland was extracted from CCI-LC (Climate Change Initiative-Land Cover) products generated by the European Space Agency CCI projects (http://maps.elie.ucl.ac.be/CCI)

Zhao et al. 2020



Zhao et al. 2020

Aim

Review the utility of the ES framework for sustainable grassland management in Europe

- Semi-natural grasslands (SNG) and improved grasslands (IG) - differences and similarities in ES generation between the grassland types
- Present synergies, trade-offs and bundles in the grassland types
- Discuss supply and demand of ES
- Discuss how managing ES may increase the sustainability of future livestock farming systems in Europe

Semi-natural grassland (SNG) (Sweden),

Improved grasslands (IG) (Spain)

Data Compilation

Data available did not allow us to perform meta-analysis

We used the IPBES confidence matrix to estimate the confidence of evidence

ipbes
Science and Policy for People and Nature

Use of confidence terms

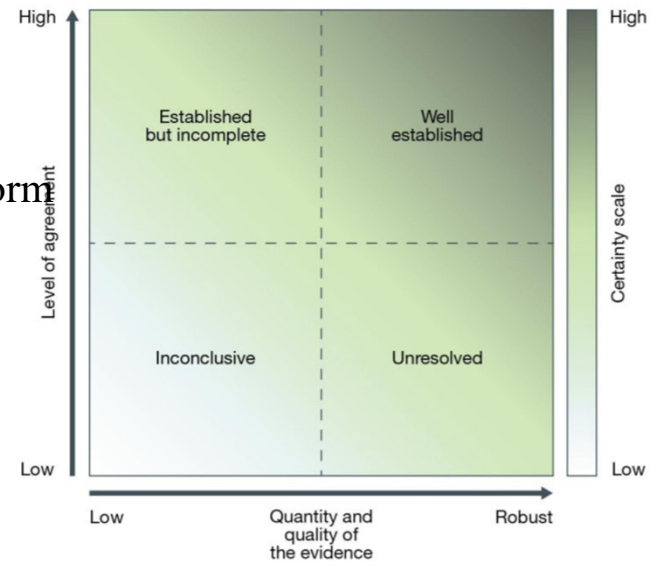


Figure SPM.A2: The four-box model for the qualitative communication of confidence. Confidence increases towards the top-right corner as suggested by the increasing strength of shading. Source: modified from Moss and Schneider (2000).[1]

Well established: comprehensive meta-analysis or other synthesis or multiple independent studies that agree.

Established but incomplete: general agreement although only a limited number of studies exist; no comprehensive synthesis and/or the studies that exist address the question imprecisely.

Unresolved: multiple independent studies exist but conclusions do not agree.

Inconclusive: limited evidence, recognizing major knowledge gaps.

12 services most commonly investigated

in semi-natural and improved grasslands

- 3 provisioning
- 7 regulating
- 2 cultural

Ecosystem services	Confidence term	Comments	Reference
Plant biomass production (Fodder production)	WE	Generally high production in IG than SNG	Zisenis et al. 2011
Wild products	EI	SNG are better providers than IG, mostly due to historical ecological knowledge and values	Sucholas et al. 2017, Torralba et al. 2018, Vári et al. 2020
Habitat provision (Maintaining nursery population and habitats)	WE, IC	SNG are better providers, but few studies are conducted in IG	Dengler et al. 2020, Wilson et al 2012,
Pollination (Pollination of crops and wildflowers)	WE, IC	Few studies directly relate SNG and IG to crop production. SNG important for pollination in the landscape	Werling et al. 2014, Taki et al 2010
Biological control (Pest control for increase crop production)	EI	Few studies directly relate SNG and IG to crop production.	Jonsson et al 2014,
Carbon capture (Carbon sequestration through photosynthesis)	IC,UR	Carbon capture is generally higher in IG, but results are inconclusive and site dependent	Sollenberger et al. 2019, Chang et al. 2021
Carbon storage (Carbon sink in the soil)	WE	Carbon storage is higher in SNG	Dlamini et al. 2016, Sollenberger et al. 2019
Erosion control (reducing run-off and stabilizing soil)	IC	Long-term permanent vegetation in SNG may prevent run-off and stabilizing soils, in contrast to IG	Pligrim et al. 2010, Fu et al. 2011
Water quantity (Infiltration and storage capacity)	UR	Potentially important but site dependent	Sollenberger et al. 2019, Posthumus et al. 2010, Guo et al. 2020
Water quality (Cleaning water through infiltration)	EI, IC	Potentially provided by SNG but could be decreased in IG	Cadman et al. 2013, Sollenberger et al. 2019
Tourism/recreation (Possibilities for recreation)	EI, IC	Clearly linked to high levels of biodiversity and multifunctionality of SNG, but less clear with IG	Hönigova et al. 2012, Martino&Muenzel 2018,
Cultural heritage (Historical activities, legacies and biological values)	WE	Cultural heritage is highly related to SNG but not to IG	Fischer et al. 2008, Lindborg et al. 2008, Bullock et al 2011

Provisioning ecosystem services from grasslands

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Regulating ecosystem services from grasslands

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Cultural
ecosystem services
from grasslands

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Synergies, trade-offs and bundles

- **Synergies** - synergetic relationship between two or several ES

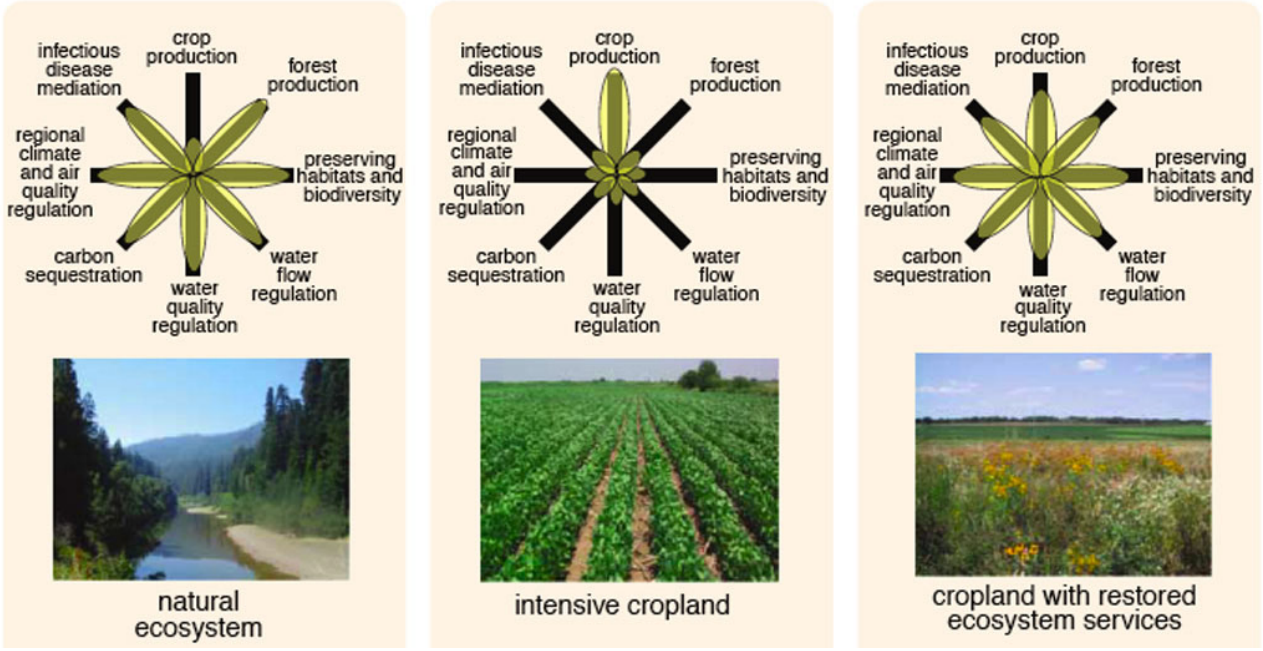
- **Trade-offs** - antagonistic relationship between two or several ES

- **Bundles** - associations among a set of services that occur together across space and time.

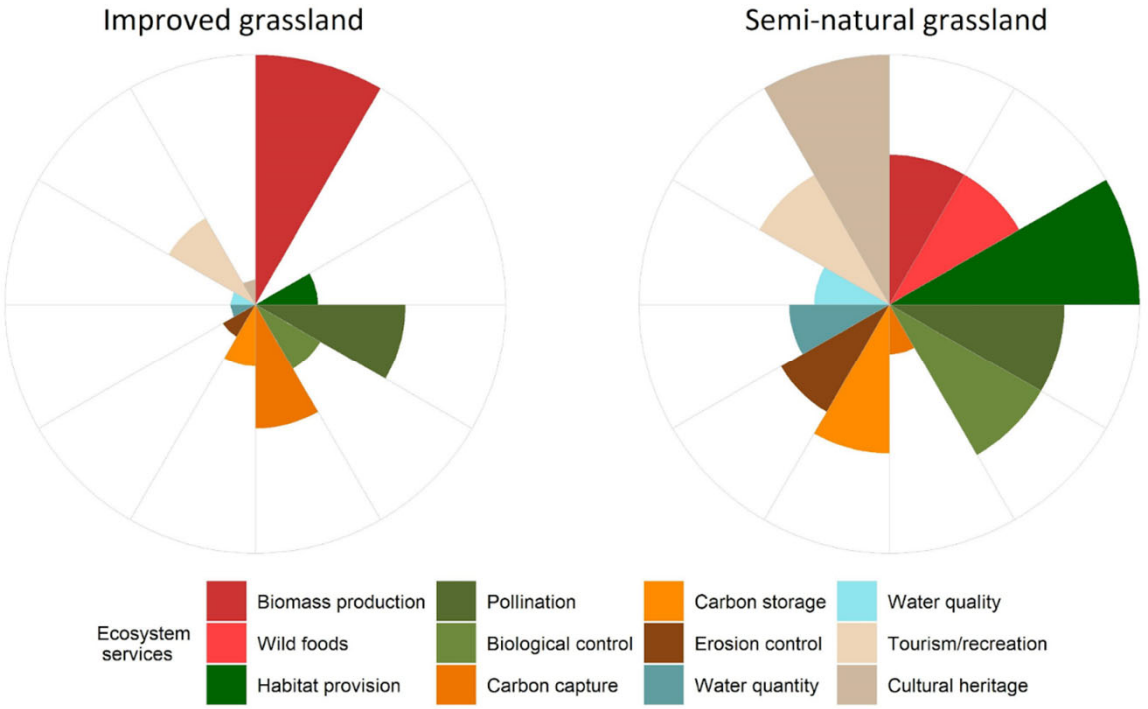
Bundles of services are often sought for in decision-making - could improve the management actions to favor as many ES as possible

Raudsepp-Hearne et al. 2010

Farmland and Ecosystem services

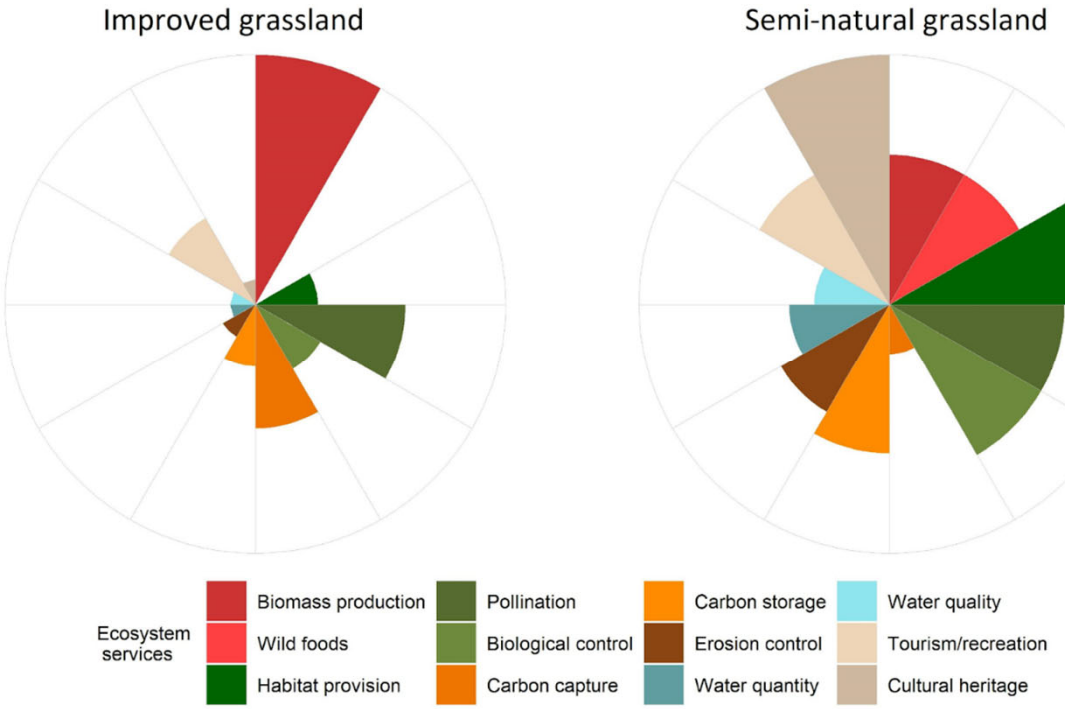


Foley et al. 2005



Most important ecosystem services generated from improved grasslands and semi-natural grasslands

Biomass production
Biological control
Carbon capture



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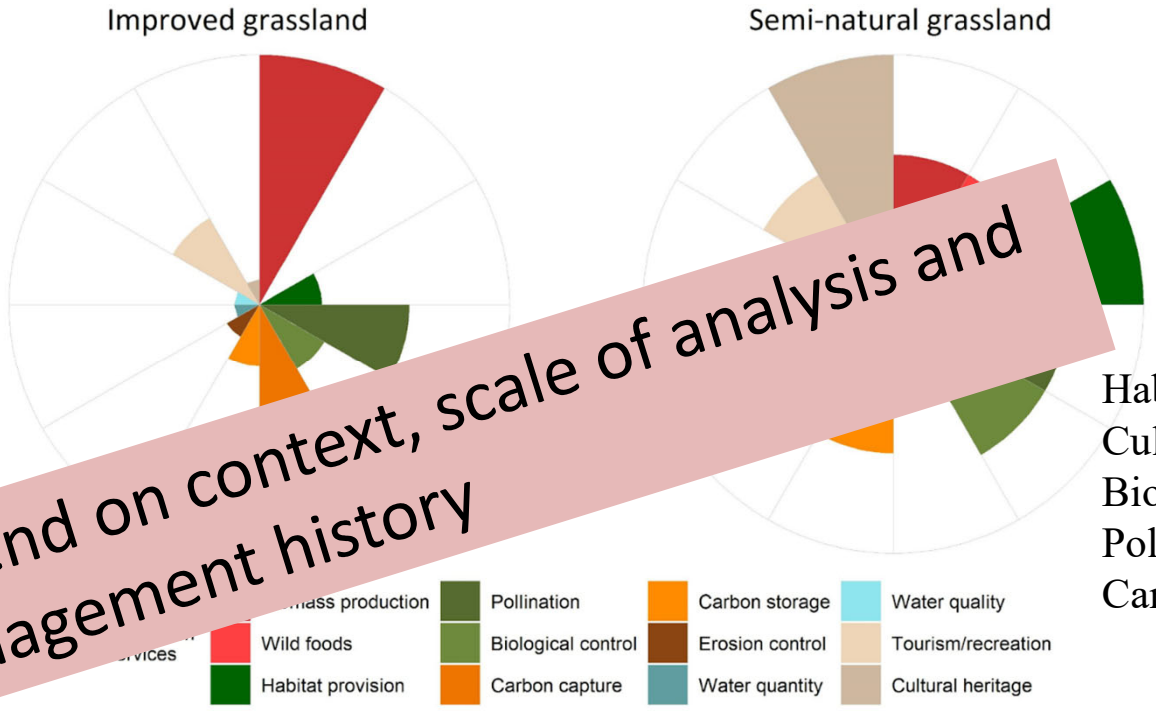

Depend on context, scale of analysis and management history

Habitat provision
Cultural heritage
Biological control
Pollination
Carbon capture

Most important ecosystem services generated from improved grasslands and semi-natural grasslands

Stakeholder perspective

- Supply - the capacity of an ecosystem to produce a service
- Demand - the amount and type of services demanded by people, (including potential future demands)
- Important to consider in ES management - The benefits depend on how different actors in society perceive or attach value to an ES

Lamarque et al. 2011, Yahdjian et al. 2015

Stakeholder perspective

Perception of ES depends on the policies, formal and informal institutions, knowledge, power relationships (the access to ES) and individually held values (Horcea-Milcu et al. 2016)
Differences in perceptions often related to discrepancies between the demands and actual supply of ES (Dingkuhn et al. 2020)
- Main source to tensions and conflicts around ES (Bernues et al. 2016)

Example: Farmers have a greater knowledge of and demand for ES than non-farmers, particularly regulating services e.g. water quality, soil fertility, erosion control, and biodiversity. Non-farmers have a higher demand for cultural ES that are often discussed in bundles, such as recreation and tourism, aesthetic value of the landscape and spiritual, educational and cultural values (Bernués et al. 2016)

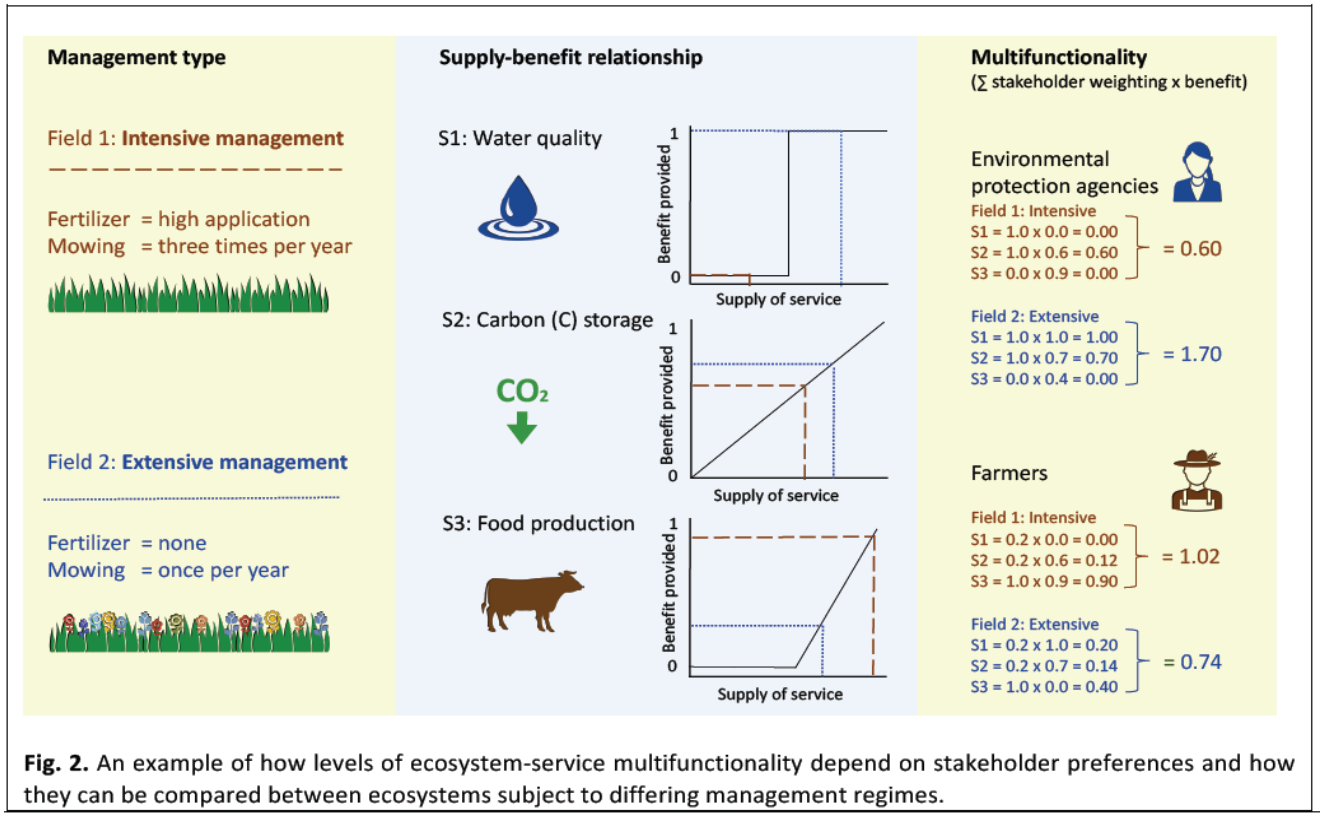

Fig. 2. An example of how levels of ecosystem-service multifunctionality depend on stakeholder preferences and how they can be compared between ecosystems subject to differing management regimes.

Manning et al. 2018, Nature

Stakeholder perspective

Farm economy

Many ES are public goods – no market price – no economic incentives for farmers to produce them – e.g. SNG with high aesthetic and recreational value vs IG with higher productivity levels.
Market failure - policies and support for grasslands that underpin the delivery of important ES, i.e. SNG.

Suggestions:

- Current agro-environmental policies - replaced by more targeted policies e.g. Payments for Ecosystem Services (PES)
- Focusing on biodiversity and bundles of ES like e.g. habitat provision, pollination and biological control can lead to delivered higher bundles of ES (Rodríguez Ortega et al. 2016)

Stakeholder perspective

Farm economy

….. Suggestions

- Transfer social demands into farmers' economies through value chains - link food products and services to grasslands through value-added products labelling (Ripoll-Bosch & Schoenmaker, 2021).
- Concerns for animal welfare, environment, biodiversity are future trends with regard to meat consumption and eat "less but better" meat (Resare-Sahlin et al. 2020)
- Expand the farm-to-fork frame to a wider one "landscape-to-fork", leading to more circular the production system.

Conclusions

- Management of grasslands strongly determines their capacity to deliver multiple ES
  - Improved grasslands (IG) are "designed" to maximize food production and not other ES
  - Semi-natural grasslands (SNG) have more balanced provision of different ES

- ES generation depends strongly on size of grassland, landscape context, scale of analysis and management history.

- The stakeholders perceptions and interests for ES vary across regions, socio-economic and policy contexts, and cultural backgrounds, reflecting the demand of ES.

Conclusions

- Focus on managing bundles of services, e.g. “water-biomass production-erosion control” or “habitat provision-pollination-biological control”, could increase multiple ES supply and facilitate management of both SNG and IG grasslands.

- Application of the ES concept to grasslands should be used in an informed way in decision-making for management and payment of non-market services.

Stockholm University

Thank you!