EU CAP Network Focus Group

'Regenerative agriculture for soil health'

Mini Paper 1

The role of animal husbandry in regenerative agriculture and the potential of livestock grazing to restore soil and ecosystem functioning

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September 2024

Funded by the European Union

Introduction

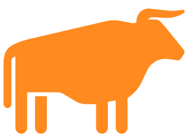
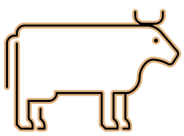
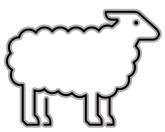
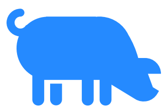
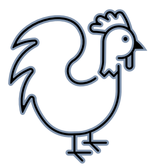
The emergence of the animal kingdom approximately 500 million years ago marked a key juncture in Earth's ecosystem development, fostering countless symbiotic relationships essential for ecosystem stability and climate regulation, such as those between grasses and ruminants. However, human activity, particularly since the 19th century, has significantly altered ecosystems through industrialization, leading to intensive livestock farming practices focused primarily on food production. In this context, animals lost their traditional role in the landscape. Regenerative agriculture aims to restore this balance by redefining the role of animals, utilizing them not only for production but also as agents for restoring soil fertility and ecosystem functions. Achieving this transition requires a nuanced and context-specific approach tailored to individual farm businesses, necessitating a shift in mindset and the exploration of new insights and inspirations. However, the processes itself always starts with a different way of thinking which in turn requires new insights and inspirations which are discussed in this mini paper.

Figure 1: Black Alentejano pig breed grazing on a fodder beet field in Portugal. Here is used Adaptive Multi Paddock Grazing in which a high livestock density grazes for short durations between long periods of forage rest to catalyze accelerated grass growth and soil health enhancement. Photo: Monte Silveira farm (Portugal), Source : Diogo Pinho

1. Animal husbandry in regenerative agriculture

Animals play essential roles in sustainable ecosystem management, particularly when managed through regenerative grazing practices. Livestock like cattle, sheep, and goats, when moved frequently across pastures, prevent overgrazing, promote grass growth, and enrich the soil with essential nutrients through manure and urine distribution. Moreover, animal manure serves as a valuable resource, enhancing soil structure and nutrient availability. Integrating animals with crop production further enhances sustainability by improving soil fertility, reducing erosion, and promoting carbon sequestration. Additionally, animals contribute to weed and pest control, foster biodiversity, and create diverse habitats within agricultural landscapes.

Table 1: Overview of the most commonly found livestock in regenerative systems and their contribution and examples of regenerative farms. Source: European Commission

				
Due to their versatility, **cattle** are by far the most abundant livestock found	Through responsible management, **dairy cows** provide a	Examples of **Sheep and Goats** in regenerative agriculture, either for	Traditionally a herded grazer, **pigs** contribute to soil health and nutrient	**Poultry** are prevalent in various agricultural systems such as free-

in regenerative agricultural practices Cattle contribute significantly to soil health, biodiversity, and carbon sequestration, playing a key role in sustainable food production within regenerative systems.	sustainable source of high-quality milk, supporting ecosystem health within regenerative systems. Examples of utilising dairy cows for building soil health in a way as with cattle are increasingly found if logistics allow.	dairy or meat production, are abundantly found in silvopastoral systems (e.g. vineyards, almond plantations or Christmas trees) but also in rotational grazing systems on grasslands. Due to their smaller body size as compared to cattle, small ruminants are aftersought in grazing cover crops during winter on heavy soils.	cycling through natural behaviours such as rooting and scratching. By integrating pigs into these systems, farmers enhance ecosystem resilience and promote sustainable agriculture, leveraging their foraging habits to manage weeds, pests, and organic matter, fostering regenerative practices.	range, integrated crop-livestock, agroforestry, and orchards. Their scratching and pecking behaviours are ideal for chemical-free control of pests and diseases (including fungi), weed management, and soil aeration.
https://liivimaalihaveis.ee/	https://www.kugelsüdhanghof.de	www.poetgaard.dk	https://freixodomeio.pt/	https://www.facebook.com/Appel.Eier

In landscapes re-integrated, grazing animals play crucial roles in sustainable food production, land restoration, and climate change mitigation. They serve as both habitat constructors and farm production sectors, contributing to healthier soils, increased biodiversity, and long-term agricultural sustainability. Contextual, site-specific pasture management is crucial to harnessing these services effectively, tailored to local needs and ecosystem functioning principles.

Figure 2: Regenerative Grazing (holistically planned) with two species. Source : Christine Bajohr

2. Regenerative grazing for ecosystem functioning in practice

Various grazing concepts like Rotational Grazing, Adaptive Multi Paddock Grazing (AMP), Mob Grazing, Management Intensive Grazing, and Holistic Planned Grazing (HPG) involve moving ruminant herds quickly between pastures. While they share similarities, differences exist in implementation and goals. Fixed rotational grazing lacks adaptability, unlike AMP and HPG, which tailor management to diverse contexts. Successful pasture management always depends on the manager's ability to adapt to environmental conditions, seasons, and growing periods. Converting to regenerative management typically starts with understanding living systems and assessing the farm environment. A successful pasture manager invests time in planning, monitoring, and flexibility. Gradual regeneration through targeted animal herd use can reduce the need for additional measures like reseeding or fertilizing. Positive development varies depending on the initial situation and objectives. Rapid yield increases may occur in desolate conditions, but restoring biodiversity in intensively used systems takes several years and requires comprehensive, coordinated measures across the entire farm.

Below listed are key criteria for successfully implementing regenerative grazing to improve soil health:

2.1. Successful planning

Creating a comprehensive long-term plan that considers social, ecological, and economic aspects is crucial for successful regenerative grazing practices. Seasonally adapted grazing plans within this framework cater to individual needs and circumstances. Effective planning, considering factors like weather extremes and invasive species, is essential for buffering unexpected events and achieving anticipated goals like soil cover and biodiversity. Detailed goal setting, including baseline assessment of soil properties and farm events, is critical. Plant growth rates and recovery phases between grazing vary with weather and season, affecting grazing management. Site factors ultimately dictate the rate and pattern of change, influencing successional developments. With experience and knowledge, optimizing pasture utilization, promoting soil and pasture health, and ensuring long-term agricultural sustainability become attainable goals.

2.2. Adaptation to non-growing seasons and harsh weather conditions

Figure 3: Bale grazing during winter is an option to keep livestock outside. Source : Airi Külvet

In regions with suitable climate and geography, winter grazing or bale grazing systems are viable options for livestock management. Bale grazing involves strategically placing hay or silage bales in pastures, allowing animals to consume feed while depositing manure, enriching soil fertility and pasture health. This method, often integrated into rotational grazing systems, provides supplemental feed during limited forage availability, such as droughts, while enhancing soil and pasture quality. Winter pasture grazing requires careful planning, including rotation, water supply, and shelter considerations, to ensure livestock welfare and sustainable land management.

2.3. Adapting the production to site conditions

From a regenerative perspective, adapting the agricultural system to local conditions is more sustainable and economically promising. This involves selecting suitable animal species and breeds that thrive in the given environment while considering animal welfare. For instance, high-performance dairy breeds may not be ideal for year-round grazing due to their energy requirements. Herd adaptability to varying weather conditions and feed quality in pasture systems is essential.

Figure 4: Planning to be at the right time at the right place with the right behaviour of the herd. Source : Christine Bajohr

Planning must account for the herd's impact and needs, including grazing behavior, feed intake, excrement concentration, and interactions with the environment. Incorporating additional species like poultry or horses can enhance impact by leveraging diverse needs. Diverse age groups within the herd can influence soil impact and grazing outcomes positively. Herd size and stocking density should align with available forage, preventing underuse, overuse, or soil damage. Adjustments in herd size may be necessary based on seasonal forage changes, market demands, or pasture health considerations.

2.4. Adaptation to environmental challenges and needs

Effective grazing management relies on precise timing, duration, and adequate recovery periods. Timing is crucial for carbon sequestration, aiming to sustain vegetative growth. Rapid regrowth phases necessitate swift herd movement to prevent plant population weakening, while slower growth or drought requires extended rest periods. Planning must consider factors like season, temperature, soil quality, and precipitation.

The length of stay on a pasture decreases with higher stocking density. Overgrazing or rapid return to grazed areas risks ecosystem degradation, soil decline, and reduced water holding capacity. Attention to timing is vital, considering the needs and reproductive cycles of plants, soil life, insects, and wildlife.

However, exceptions exist. Disruptive events, like temporary overgrazing, can reset systems stuck on the regenerative pathway, fostering greater species diversity. Flexibility in grazing management allows for adaptive responses to changing environmental conditions, promoting resilient ecosystems.

Find more information in an informative video on regenerative grazing in Estonian conditions.

3. Effects of best grazing practices on soil health and biodiversity

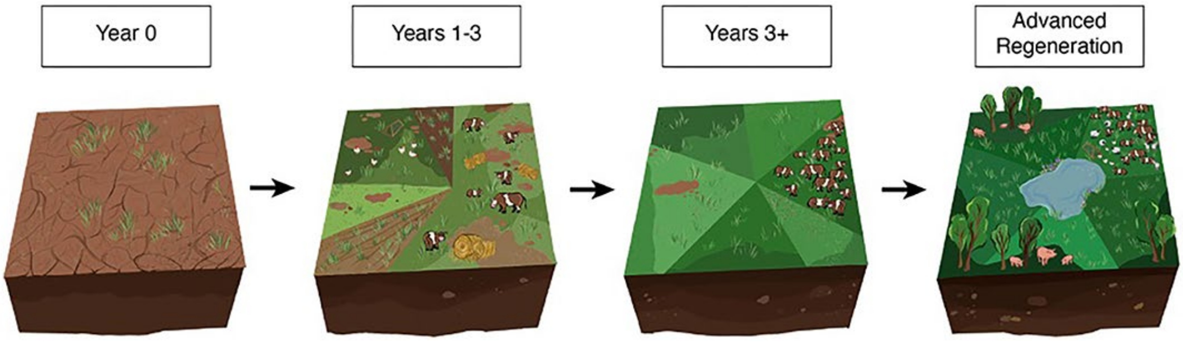


Figure 5: The regeneration process employed by White Oak Pastures, USA, illustrating the effects of rotational grazing on degraded cropland, Source : Rowntree et al., 2020

In principle, grazing is possible in all agricultural systems if care is taken to match the appropriate livestock for the task. Thus, for the desired effects to be achieved, it is critical to use livestock according to the current needs of the existing ecosystem in coexistence with production requirements. If farm animals are seen as tools for regenerating ecosystems, a ruminant herd could be compared to the famous "Swiss army knife" due to its multifunctional use in grasslands.

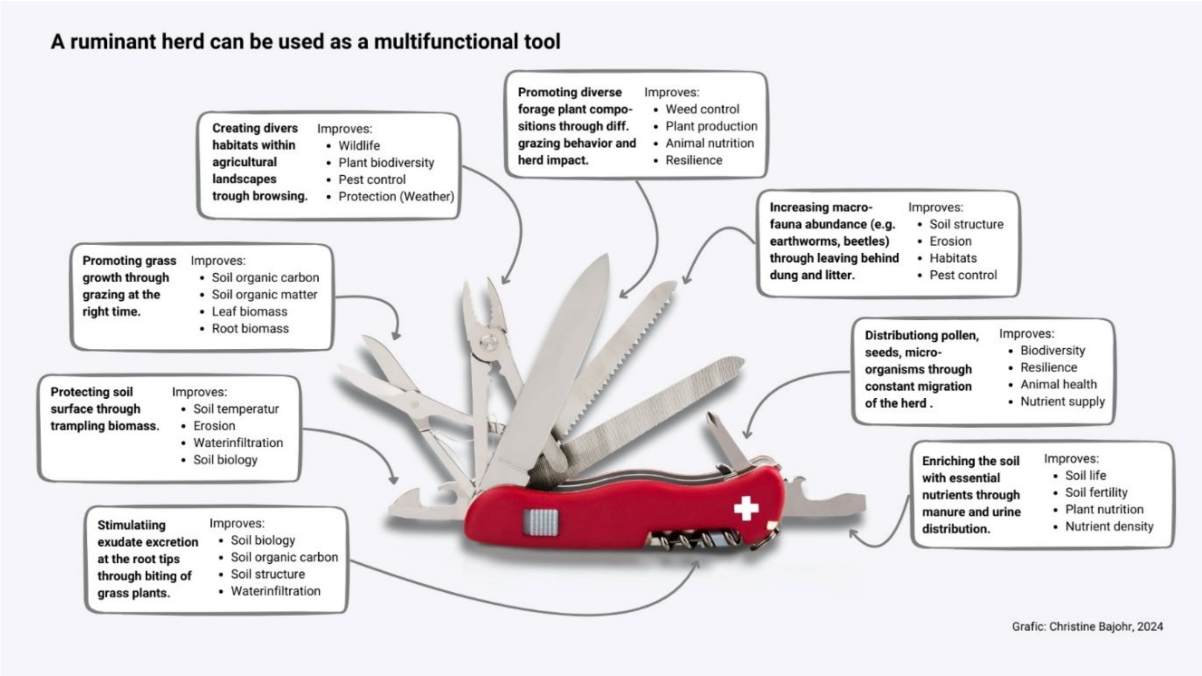


Figure 6: Allegoric depiction of ruminants as multi-functional tools in restoring, boosting, and maintaining soil health and ecosystem functioning. Source: Christine Bajohr

Grazing, and in particular rotational regenerative grazing has a variety of effects on soil health and biodiversity-related aspects. Those can be assessed individually, or in the context of holistic ecosystem multifunctionality, giving insights into the complexity of ecosystem-related interactions, thereby acknowledging differences resulting from spatio-temporal variation. In the following subsections, we introduce some of the scientifically reported direct effects of grazing on soil health and biodiversity

3.1 Direct effects of regenerative grazing on soil health

3.1.1 Above- and belowground biomass

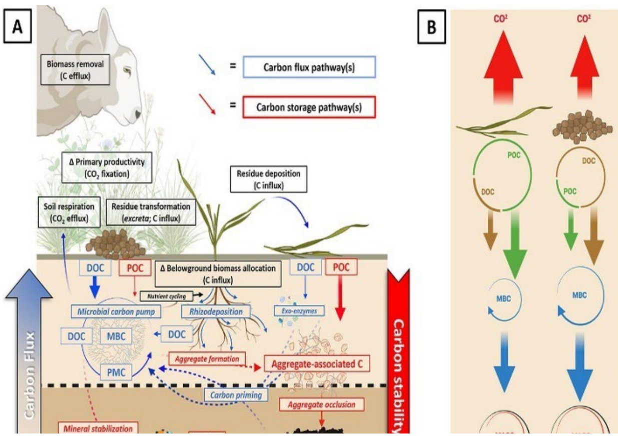


Figure 7: Pathways for carbon storage and decomposition under intensive regenerative grazing. Source : Brewer et al., 2023

Regenerative grazing impacts both above- and below-ground biomass in grasses, with plants prioritizing new aboveground growth for photosynthesis or more root biomass during drought or nutrient scarcity. This approach has shown a reported 30% increase in forage production (Díaz de Otálora et al., 2021), but differences in biomass yields depend on various factors, with limited studies quantifying these differences. Additionally, regenerative grazing promotes diverse forage plant compositions, including tap-rooted plants like plantain, which aid in nitrous oxide reduction, soil aeration, water infiltration, carbon retention, nutrient retention, and erosion prevention (Pijlman et al., 2019; Kell, 2011; Vannoppen et al., 2017).

3.1.2. Soil organic matter input

Grazing, unlike mowing, returns carbon and nutrients to the soil through animal excreta by about 50-70% (Gilmullina et al., 2020). This input includes altered compounds and lower carbon-to-nutrient ratios. Also, leaf litter after senescence adds organic matter to the soil through trampling or bioturbation. Intensive defoliation with long rest periods increases root growth, further enhancing organic matter input into the soil through various root processes (Nielsen et al., 2021; van Veelen et al., 2018; Sanaullah et al., 2009).

3.1.3. Soil carbon stabilisation and storage

In general, soil organic carbon (SOC) is preserved through three primary processes: protection from decomposition under low-oxygen conditions, binding to stable minerals like iron or aluminum oxides, and microbial remains, which constitute 50-80% of the stable soil carbon pool (Buckeridge et al., 2020). Regenerative grazing has been shown to increase stable SOC levels in surface soil by up to 12% over the mid to long term (Hewins et al., 2018; Díaz de Otálora et al., 2021) and enhance physico-chemically stabilized mineral-associated organic carbon in the subsoil layer (Brewer et al., 2023). However, the efficacy of SOC retention depends on climate, soil type, and the presence of stress or disturbances (Abdalla et al., 2018; Zhao et al., 2020; Yang et al., 2020). Overgrazing in conventional systems, for instance, can disrupt carbon sequestration in soil, affecting its long-term carbon storage capacity.

3.1.4. Soil microbial community structure

In healthy soil, diverse microbial communities, including archaea, bacteria, and fungi, play a crucial role in carbon and nutrient cycling, mediating approximately 90% of soil functions (Mhuireach et al., 2022). Grazing has consistently shown positive effects on soil microbial diversity and communities across various biomes and climates. It enhances soil productivity and functions by increasing microbial diversity compared to non-grazed ecosystems (Xun et al., 2018). Grazing animals also promote the presence of endophytic microbes, which benefit plants by aiding in nutrient mobilisation and uptake, ultimately promoting plant growth (Yang et al., 2021; Rana et al., 2020). Particularly, endophytic microorganisms are crucial for successful agriculture. Regenerative and multi-species rotational grazing hold significant potential for positively impacting soil microbial communities and enhancing soil health and functioning.

3.1.5. Physicochemical traits

Rotational regenerative grazing significantly impacts physico-chemical soil properties. Teutscherová et al. (2021) observed lower bulk density, improved soil aggregation, and higher water retention on rotationally grazed farms compared to continuous grazing. These improvements were linked to increased macrofauna abundance, particularly earthworms and beetles, which enhance soil structure through bioturbation. Additionally, Galindo et al. (2020) found that rotational grazing enhances soil quality by increasing β-glucosidase activity, available nutrients, soil pH, carbon content, sulphur content, and microbial decomposition, thereby improving nutrient cycling and productivity.

3.2 Direct effect on biodiversity

Figure 8: Naturally developed mixture of grasses, herbs, and clover following rotational grazing, Source : Claudia Nielsen

Biodiversity, including species richness and diversity indices, is a key metric for assessing the effectiveness of Regenerative Grazing Management (ReGM), according to the Savory Institute (2019). Regenerative farmers prioritise biodiversity for the ecological and economic sustainability of their farms (Stinner et al., 1997). However, comprehensive data on the impacts of intensive, infrequent grazing on various organisms are lacking (Carter et al., 2014). Achieving high livestock production and biodiversity conservation simultaneously may entail trade-offs (Lawrence, 2019). Morris et al. (2021) found higher soil microbiota diversity under regenerative rotational grazing, but vegetation responses varied. Grazing-induced structural changes benefited certain bird species, providing better foraging and nesting sites, but intensive stocking practices could reduce food resources for some birds during winter and drought (Morris et al., 2021). Despite mixed findings, European studies have generally shown positive impacts on plant biodiversity under regenerative grazing (Enri et al., 2017; Austrheim et al., 2001; Bugalho et al., 2011; DeGabriel et al., 2011).

3.3. Additional direct effects and benefits

Regenerative rotational grazing practices offer numerous environmental and non-environmental benefits, including improved soil and water management, enhanced animal welfare, and biodiversity conservation, ultimately contributing to agricultural sustainability. These practices can mitigate soil erosion and runoff, increase water availability for plants, and promote soil structure improvement. They also contribute to livestock health and welfare by reducing stress levels, improving body condition scores, and providing access to diverse forage species. Additionally, managed intensive grazing reduces the risk of accidents and injuries for farmers and agricultural workers. Rotational grazing further enhances positive landscape-level impacts. Furthermore, integrating livestock into grazing rotations promotes nutrient cycling, enhances soil fertility, and reduces reliance on synthetic fertilizers, thereby minimizing nutrient runoff into water bodies.

4. Economic performance

The economic performance of every production system is dependent on a plethora of direct and indirect effects. This is not different for regenerative grazing practices. Until now, only few studies have examined the economic performance of regenerative grazing as compared to no-livestock regenerative systems, or traditional cut and carry forage systems with up to 5 annual cuts and synthetic fertilisers or manure return.

A study on the economic performance of marginal livestock farms in the UK (Clark and Scanlon, 2019) revealed that, reducing output to a level where stock is sustained solely on naturally available grass, without artificial fertilisers, can increase profits or reduce losses due to significant savings in variable costs. This approach not only benefits financially but also alleviates environmental pressure on the land, especially in cases of overgrazing. The findings challenge the common belief among marginal farmers that increasing production leads to greater profitability, which was found across all farms examined, regardless of ownership, location within protected landscapes, or size.

In another study, using a life cycle analysis to compare regenerative to conventional sheep farming in Australia (Colley et al., 2019), it was found that regenerative grazing had the potential to improve their performance by offsetting fossil fuels.

Figure 9: Shropshire sheep in the vineyard, Source : Nikolas Schoof

Further, in another long-term study (Ogilvy et al., 2018) it was found that the average profit levels of the regenerative graziers were consistently higher (12 out of 14 years) compared to average conventional livestock (sheep and beef) farms and showed less variability over the study period. In particular, the economic performance was significantly better in years with adverse environmental conditions, like drought.

Thus, since less can be more, boosting the economic performance in livestock systems applying regenerative grazing practices is based on the following pillars:

- Reducing variable costs (including synthetic fertilisers and fossil fuels) by adjusting output levels to match the farm's natural grass availability.
- Streamlining fixed costs by maximising the utilisation of fixed assets, such as machinery sharing and resource cooperation with neighbouring farmers.
- Enhancing the value of meat products to improve price received. Integrating environmental stewardship into farm management, potentially increasing product value and eligibility for public payments tied to delivering public goods.
- Exploring diversification opportunities to expand the business portfolio. This shift entails moving from a production-focused model to one centred on profit margins. Case studies underscore the importance of exploring diverse options to boost farm business viability and profitability, necessitating a heightened emphasis on comprehensive business planning.

5. Challenges

Primarily, economic valuation and political trends present challenges for farmers applying regenerative livestock grazing. Traditional economic metrics may not fully capture its long-term benefits, hindering its economic viability. Additionally, political priorities often favour short-term gains over long-term sustainability, leading to policies that discourage livestock farming in general, including regenerative practices. In this context, subsidies and support systems until now tended to favour either classical conventional or certified organic agriculture, creating financial barriers for farmers interested in adopting regenerative approaches without additional certification and audit. Overcoming these challenges requires broader recognition of the benefits related to regenerative livestock grazing and policy frameworks that incentivise sustainable land management.

1. Valuation: Despite producing sustainable, high-quality products with added ecosystem service benefits, primary producers often receive inadequate remuneration due to insufficient valuation of regenerative practices.
2. Implementation: The diverse environmental variables across different farm settings make it challenging to offer standardized guidance, requiring a nuanced approach tailored to each farm's unique context. Understanding the delayed effects of management measures further complicates implementation, demanding a shift in mindset and the development of skills to balance ecological, social, and economic needs.
3. Workload: While sustainable management practices and diversification efforts improve landscape health and farm viability, they can also entail increased paperwork, establishment costs, and workload. Additionally, the initial investment in fencing may appear daunting, although modern fencing systems offer efficient solutions that require minimal time investment.

Livestock: production or tool?
The dual role of livestock in regenerative grazing, serving both production and habitat construction, poses challenges. Balancing grazing intensity for habitat diversity and production goals is complex. Managing livestock to avoid negative impacts on sensitive habitats requires careful planning and monitoring. Integrating livestock into habitat construction efforts may demand additional resources and expertise, posing logistical and financial hurdles for farmers. Thus, while livestock are valuable for habitat creation, their dual role presents management challenges in regenerative grazing systems.

6. Conclusion

Ecosystems are now under unprecedented pressure, with climate change probably being the most worrying. Regenerative grazing can be an instrument for adapting to climate change by strengthening the resilience of ecosystems. In particular, the improvement of carbon and water cycles, the promotion of soil fungi and grass stands with a deeper root system are practical examples that can make a positive contribution to adaptation in agricultural systems.

Regenerating an agricultural system is a dynamic and ongoing process in which no final state can be achieved. There are no universal or single regenerative practices. Instead, there are different approaches and methods, some of which are combined in different ways to initiate regeneration within a specific context. Both the goals and the results are always context-dependent in terms of climatic, ecological, economic and similar conditions.

To effectively utilise the potential of regenerative strategies, it is helpful to look into the original concept of nature and favour the use of animals, especially if less or even no fossil fuels are to be used in agriculture in the future. Where livestock farming has already been abandoned, cooperation could be entered into with livestock farming partners or livestock could be rented during the summer.

7. Research Needs

While the regenerative agricultural concept gains popularity globally, only few data exist on its spread in Europe. Currently, neither EUROSTAT nor FADN datasets give insights into the geographical distribution of regenerative grazing practices. More on-farm research is needed:

1. Understanding the complex interaction between grazers and grasslands requires comprehensive research efforts. Grazing outcomes vary greatly based on initial conditions, implementation methods, and subsequent feedback mechanisms, influencing management decisions. With climate change exacerbating weather extremes and seasonal shifts, there is a pressing need for studies investigating grazing effects across diverse climatic contexts.
2. Furthermore, research should delve into the impacts on resources and ecosystem processes, including carbon sequestration, biodiversity, soil fertility, and water storage capacity. Long-term studies are crucial to validate the positive effects of regenerative grazing, informing future climate assessments.
3. Additionally, assessing nutrient use efficiencies, nutrient losses, and greenhouse gas emissions from regenerative grazing systems compared to traditional husbandry practices is essential for a comprehensive understanding of their potential.
4. Further, understanding the full scope of regenerative grazing requires assessing its economic performance, alongside environmental impacts. Conducting life cycle assessments (LCAs) can provide insights into the overall sustainability of regenerative grazing systems, considering factors such as resource use, emissions, and economic viability. By integrating economic analyses with environmental assessments, researchers can better evaluate the holistic benefits and trade-offs associated with regenerative grazing practices.
5. In this context, assessing the enviro-economic performance of regenerative grazing systems is essential for informing stakeholders and policymakers, thus encouraging adoption by farmers in the case of incentivisation.
6. Additionally, assessing the farm-specific work distribution over the year (e.g., Madelrieux et Dedieu, 2007), is key to identify bottlenecks in the transition to regenerative grazing systems and solutions.
7. Assessing the occurrence and distribution of practices regenerative grazing in Europe, e.g. via Citizen Science.

7. Ideas for innovation

1. Affordable monitoring apps with integrated satellite-supported recording of biomass, biodiversity, energy flow, humidity/precipitation, and other data.
2. Techniques and methods to extend the grazing period in different regions (Baltic countries, Nordic countries, arid regions).
3. Easier access to knowledge and valuable information's in one's native language.
4. Regenerative peer-to-peer exchange networks and support from experienced mentors over the first 1-3 years of the transformation process to facilitate the transformation process towards regenerative management.
5. Livestock-pooling platforms and networks.

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