Animal Welfare.
Worldwide.

Sustaining our Soils

An animal welfare solution for the environment and the climate

Authors:

Miguel Ángel Zhan Dai, FOUR PAWS | Dr Thainá Landim de Barros, FOUR PAWS | Dr Carolina Cardoso Nagib Nascimento, FOUR PAWS | Ana Rita Gato Soares, FOUR PAWS | Sophie Aylmer, FOUR PAWS | Daniela Haager, FOUR PAWS | Dr Andrea Beste, Büro für Bodenschutz & Ökologische Agrarkultur (Institute for Soil Conservation & Sustainable Agriculture) | Dr Anita Idel | Dr Marília B. Chiavegato, Ohio State University | Dr Mohamed Habibou Assouma, CIRAD – French Agricultural Research Centre for International Development | Dr Pierre Hiernaux, Pastoc, Pastoralisme Consei | Dr Jonathan Vayssières, CIRAD – French Agricultural Research Centre for International Development

Reviewed by:

Dr Marlene Kirchner, FOUR PAWS

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Glossary

Agroecology	As outlined by the FAO's 10 elements, it is a holistic agricultural approach integrating ecological principles and social factors. It optimises interactions within agroecosystems, emphasising sustainability, animal welfare, biodiversity and community involvement for resilient and efficient farming practices.
Animal farming	Rearing of farmed animals for use for food, fibres and other commodities also known as livestock farming.
Animal welfare conscious approach	An animal welfare conscious approach demands to take into consideration this wellbeing according the Five Domains Model, when planning and implementing relevant policies and measures.
Biochar	Type of charcoal produced from biomass, including crop residues or animal manure. It is primarily used in soils to improve their fertility, water retention and nutrient availability.
Carbon farming	Agricultural practices that aim to sequester carbon dioxide (CO_2) from the atmosphere into the soil, vegetation, or other carbon sinks.
Carrying capacity	Carrying capacity is defined as the maximum number of animals that can live on a certain area without causing degradation.
Excellent welfare states	This means that the risk for poor welfare is very low and animals most likely live a life worth living, encountering positive experiences and minimal negative experiences and with a positive mental state. This means a score in the range 80-100 according to Welfare Quality® (2009). Welfare Quality® assessment protocol for cattle. Welfare Quality® Consortium, Lelystad, Netherlands.
Extensive farming system	Low-input production system mostly relying on natural or seminatural grasslands.
Farmed animals	Terrestrial animals reared for food, fibres, and other commodities – e.g. cattle, pigs, sheep, goats, poultry, rabbits.
Five Domains Model	The Five Domains Model is a tool for guiding systematic and thorough assessments of animal welfare states. It describes animal welfare as a subjective mental state (5th domain), which in turn is influenced by the animal's nutrition, physical environment, health, and behavioural interactions. These are the four physical domains that affect one another in a dynamic and synergetic way. When caring for animals, it is necessary to consider all domains of welfare and their dynamic relationship in that moment and in time. The current mental state is the welfare state of the animal, at that moment.

Intensive farming system	Also known as factory farming, it is an industrial method of raising farmed animals intended to maximise production at minimal cost. The animals in these systems regularly suffer from most cruel practices and their basic needs are not met. On factory farms, animals are confined in small spaces and the animals are kept indoors and/or in cages for their entire life.
Loess	Sedimentary deposit made of windblown silt and fine particles, often yellowish in colour. It forms extensive blankets in regions with specific geological and climatic conditions, typically in areas once covered by glaciers.
Manure	Organic matter, mostly derived from animal faeces and urine, but normally also containing plant material (often straw), which has been used as bedding for animals and has absorbed the faeces and urine.
One Health	As defined by the OHHLEP, it is an integrated, unifying approach that aims to sustainably balance and optimise the health of people, animals and ecosystems. It recognises the health of humans, domestic and wild animals, plants and the wider environment (including ecosystems) are closely linked and interdependent.
Planetary Boundaries	Set of nine bio-physical limits of the Earth system that should be respected in order to maintain conditions favourable to further human development. Crossing the suggested limits would lead to a drastic change in human societies by disrupting some of the ecological bases underlying the current socioeconomic system. This concept was proposed for the first time in 2009 by a team of internationally renowned scientists lead by Dr Johan Rockström.
Siltation	Accumulation of sediment, primarily silt, in bodies of water. It occurs when soil erosion from land surfaces is carried by runoff or flowing water into water bodies, where it settles. It can lead to various environmental problems.
Slurry	Manure in liquid form, a mixture of excrements and urine of domestic animals, including possibly also water and/or a small amount of litter.
Soil organic carbon	Carbon stored within soil in the form of organic matter. It is derived from plant and animal residues that have undergone decomposition and become part of the soil's organic fraction. Soil organic carbon is a key component of soil fertility, structure, and overall health.
Stereotypies	A behaviour that repeats itself in a pattern that seldom changes and serves no obvious purpose.

Grazing animals and grasslands – coevolving for millions of years

Dr Anita Idel

Vast forest and grassland ecosystems dominate the vegetation on the global landmass. Both ecosystems are characterised by their permanence, but their growth dynamics are fundamentally different.

> **Grassland ecosystems have and always will be crucially impacted by their coevolutionary partners: for millions of years, they have developed alongside large grazing animals.[b]**

This coevolution proved to be beneficial for both partners. While understanding this coevolution could be essential to finding a solution for the current planetary crises, it has been critically understudied. Recent publications focusing on grasses emphasise a lack of data regarding the history, coevolutionary origin, quantity, quality and potentials of grasslands: *Nature published a mega study assessing grasses and trees in the context of climate*[111]; the UN Food and Agriculture Organisation (FAO) prepared a 'Global assessment of soil carbon in grasslands – From current stock estimates to sequestration potential'[112]; and *Science published a Special entitled 'The history and challenge of grassy biomes. Grassy biomes are twenty million years old but are undervalued and under threat today.'*[113]

Intensive agriculture has been leading to dramatic land use changes, with grasslands and forests being converted to arable lands. Despite that, no other plant community covers as much of the global landmass as grasses. Grasslands are the most successful biome, followed by forests. Grasses can grow where trees cannot grow due to a lack of nutrients or water, including above the timber line and in arid or semi-arid regions.[85,112,114,115,116,117,118] Worldwide, 70% of agricultural land is grassland, compared to 30% of arable land; in the EU the ratio is 40% to 60%.[119] As a consequence of the intensification of farming, the biological quality of grasslands has reduced dramatically – in particular on land area used for silage production.

Despite the enormous dissipation and diversity of permanent grasslands worldwide, we are still faced with a considerable lack and uncertainty of data on soil conditions, carbon inputs and soil, animal and vegetation properties at regional and global levels, amongst other factors that would allow for a better estimation of the importance of grasslands for carbon storage. This has been acknowledged favourably in reports of the FAO, already in 2014, and more recently in 2023.[112,120] It is, however, clear that permanent grassland contributes in a major way to soil fertility and humus build-up and therefore to the reduction of climate-relevant emissions.

Considering that year on year large amounts of above-ground biomass are removed by mowing machines, the success of permanent grasslands is even more impressive. For millions of years, biomass was exclusively removed through grazing.[c,112,113,121]

Grasses benefit from grazing. Since humans began populating the planet, they observed that grasses (Poaceae) continue to grow during the vegetation period when they are grazed. Beyond this specific biological feature, grazing triggers a growth impulse in the grasses: their photosynthetic capacity increases, they absorb more CO_2 from the

b Hereafter, grazing refers to the use of grasslands by large grazing animals.

c Mowing is a relatively new technique and has only been used on a large scale for a few decades.

atmosphere and use it to produce more biomass.[d] Ultimately, the global success of grasses is largely due to the fact that they have developed beyond merely tolerating grazing. They grow not despite, but because they are being grazed; they benefit from grazing.

Large grazing animals do not treat grasses and tree saplings differently: they graze them. But why does grazing trigger a growth impulse in grasses while it stops the growth in tree saplings?

The reasons for these completely opposite effects of grazing have nothing to do with the animals but with the plants. As grasses coevolved with large grazing animals, fundamentally different growth dynamics developed between grasses and other plants. Whether they are annuals or perennials – grasses share a similar basic building plan. Once a blade of grass has been grazed, it is level at the top and retains this torn-off edge. It will increase in length again from its base at the bottom. Plants such as tree saplings, on the other hand, grow from the shoot above ground. If they have but one shoot, they are unable to grow once they lose that shoot through grazing. This difference between grasses, the coevolutionary partner to grazing animals, and other plants is the reason why grazing conserves open spaces.[117]

Furthermore, in an attempt to avoid being eaten, many plants invest a huge amount of energy to defend themselves by growing thorns or spikes or by developing bitter substances.[122] Others avoid being grazed by growing flat and close to the soil. Grasses are unique in the way they grow: they tolerate large grazing animals and react with enhanced growth.[123,e]

d Contrary to the many effects of grazing – in particular on biodiversity and the exchange of microbes from saliva to cow pats on the soil – the growing impulse triggered through grazing which has developed over millions of years can be imitated through mowing.

e Grasses start to defend themselves only when they are grazed too often and/or too low and their regeneration and eventually their survival is threatened.[125] Possible defence against insect damage – with poisons or poison concentrations that are not relevant to large grazing animals – is not being dealt with here.

They do not expend energy to resist them, but use the available energy to (over)compensate for the loss of biomass.[124] Provided that moisture is available, the grass stems immediately regrow from the basal growth zone.[125]

Grasses have adapted to grazing animals so well that being grazed has turned into an advantage. Ultimately, coevolutionary adaptation has made grasses dependent on grazing: grassland will cease to exist if it remains permanently unused.

Even seventy years ago, Professor Ernst Klapp, a leading scientist in the field of grassland research, recognised the coevolution of grazing animals and grassland for its important contribution to soil building.[127] As he expected, the biological specificity of their coevolution was soon forgotten. As chemical synthetic fertiliser became widely available, more and more grassland was ploughed up for arable use and no longer periodically grazed. It is remarkable how rarely the uniqueness of grassland ecosystems is emphasised.[128,129,130] On the contrary, today the discussion mostly focuses on what happens when the coevolutionary partner for grasses is permanently absent because humans have eradicated grazing animals or are keeping them away through fences. As a result of this, shrubs spread and, if there is enough moisture circulating in the system, forests develop.[131] This anthropogenic process is usually characterised as natural succession.

Nevertheless, many authors consider grazing to be a disturbance. The accumulation of silicic acid or silicates in grasses is often seen as evidence that grasses also expend energy to defend themselves against being grazed. The fact that large grazing animals developed high-crowned (hypsodontic) teeth practically during the same period as grasses began to spread turf-like across wider areas, reinforced the interpretation of grazing as disturbance.[132,133] However, when grazing, the teeth of the coevolutionary partners withstand abrasion because their enamel is harder than these silicates.[134] Grasses primarily form silicates as a reaction to abiotic influences and not to protect themselves against herbivores. Particularly in dry conditions, silicates are advantageous to grasses.[f,122]

From steppes to 'bread baskets'

Permanent grassland ecosystems not only cover non-arable soils, but also soils which are too steep, too stony, too dry or too wet to be ploughed. They have also produced the most fertile soils and form the world's largest biome.[115]

Today, the most farmed soils, known as 'bread baskets', all have a common genesis: steppes. Whether in North America (prairies), in Ukraine, in Hungary (Puszta), in Romania (Bărăgan), in Kazakhstan, in Mongolia, in China (Manchuria), in the bays of Germany's lowlands, in Argentina and Uruguay (subtropical pampas), these most fertile soils were grazed over millennia, during and after the last glacial period – in a world without fences.[113,114,135,135] High, originally inanimate loess fractions provided a favourable condition for soil fertility.[114,136,137] But like all soils, they were enlivened by vegetation and that means from above: these soils grew through their use by grazing animals.[g]

f The first global-scale study linking leaf silica concentration in grasslands to climate, soil nutrients, and grazing mammalian herbivores concluded that exclusion of the latter did not elicit a consistent change in silicification.[122]

g Sustainable grazing is of great importance for biological diversity and it is also key to maintaining the basic resources needed for world food supplies: water quality, soil fertility and, related to that, the climate. In addition there is health, human health as well as animal health. Yet, the externalisation of costs as well as the economies of scale continue to dominate science and research. It remains advantageous to breed for high performance, high yields and industrialisation.[139,140]

Permanent grasslands can store more carbon than forests

Due to the lower water requirement of grasses compared to trees, permanent grasslands dominated in the low-precipitation glacial periods, which put plants with high water requirements at a disadvantage. It was getting colder and drier as a result, as glaciers increasingly bound the previously circulating water. In the current interglacial age, grassland ecosystems form the largest biome, the largest permaculture and the largest mixed culture.[115] The bite of the coevolutionary partner stimulates the photosynthesis performance. As a result, grasses react by increased biomass growth above ground and below ground (root system).

Grassland and forest ecosystems roughly cover a similarly sized land area. But worldwide, grasslands store more carbon than forest ecosystems: firstly, in the above-ground biomass; secondly, in the below-ground biomass; and thirdly, in the soil.[141,142,143]

Trees have an exogenic root system: they form associations with fungi (mycorrhizae) to increase their range and thus the availability of nutrients and water. In contrast, grasses are much younger in terms of evolutionary biology; they not only form more root than shoot biomass, but their root biomass is dominated by fine roots, and that means a vast amount of root tips.[144,145] This is essential for soil formation: 80% occurs through roots.[146]

Soil formation begins at the tip of the roots. Before these finally decompose, they give off carbon-rich exudates with which they feed soil microorganisms. Through these exudates, they influence the soil environment such as the pH value and thus promote the availability of nutrients.[147,148]

Despite these interactions, the dominating assumption still is that the quantity of root biomass is crucial for soil formation. In a meta-study[111], Terrer and colleagues evaluated 108 studies – each experimented with trees and grasses under augmented CO_2 partial pressure. As expected, they all grew more biomass. The question though was to which extent additional soil had been formed. Contrary to common expectation, grasses, and not trees, formed more soil. Thereby the authors challenged the current climate models.[h,149]

Trees mainly store carbon and nutrients in their own biomass and this – clearly visible to us – is mainly found above ground, in their wood. Grasses, however, store primarily in the soil instead of in their own biomass, which gives them decisive advantages in terms of nutrient availability. Humus consists of 58% carbon; it is the largest terrestrial carbon store on earth.[i,112] Globally, grassland soils store 50% more carbon than those of forests.[141,150,151]

It is important to note that despite lower carbon storage potential compared to permanent grasslands, forests play a vital role in the global environment. They represent the largest reservoir of plants and animals on land fostering most of the world's terrestrial biodiversity.[152,j] Additionally, they provide large parts of the world's drinking water and

h 'Overall, SOC stocks increase with eCO_2 in grasslands (8 ± 2 per cent) but not in forests (0 ± 2 per cent), even though plant biomass in grasslands increase less (9 ± 3 per cent) than in forests (23 ± 2 per cent).'[111] 'Ecosystem models do not reproduce this trade-off, which implies that projections of SOC may need to be revised.'[111]

i 'Soils store significant amounts of carbon as soil organic matter, globally about 2.3 times more than the carbon in atmospheric CO_2 and 3.5 times more than the carbon in all living terrestrial plants.[149] Global grasslands are important components of the terrestrial carbon cycle, storing [119,120,121] Gt C150 in vegetation biomass, about 343 Gt C in the top one meter of soil[141] and a potential soil sequestration rate of 0.5 tonnes C/ha per year.'[112,141,151]

j primarily in tropical forests[153]

are major contributors to climate change resilience by performing buffering functions, such as cooling effects and protecting local flora and fauna against extreme weather.[153]

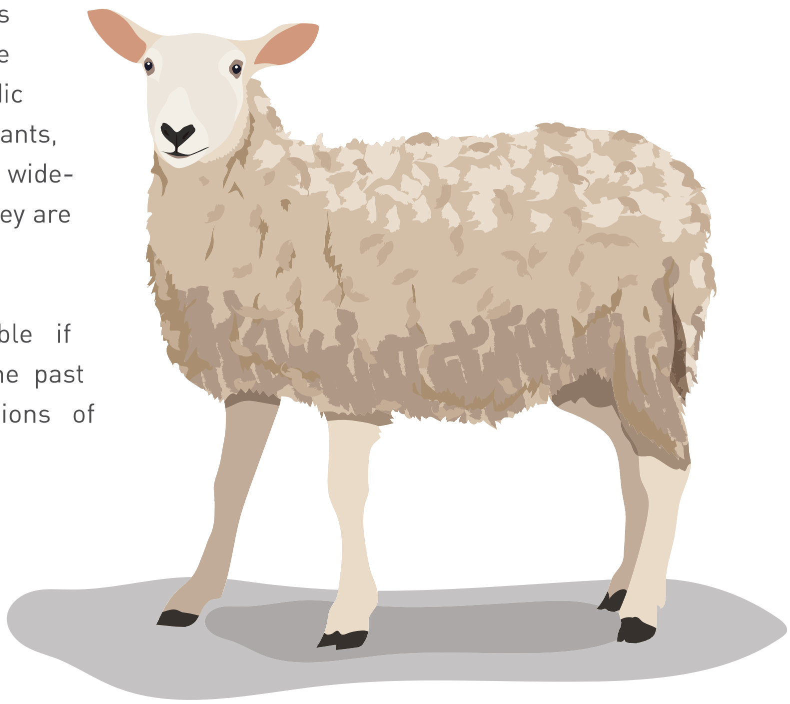
Grasslands are losing their coevolutionary partners

According to Manzano and colleagues[154], the number of large grazing animals in the transition period from Pleistocene to Holocene is vastly underestimated, threatening current sustainability efforts. This is because a more accurate estimate of the stocking density of large herbivores not only matters for biological diversity, but also has considerable significance for climate development.[155] By underestimating the amount of herbivores in the past, the importance they had on shaping and keeping the current landscapes is also underestimated, to the point, a further loss of large grazing animals in grasslands can destabilise the carbon content in soils, according to Naidu and colleagues.[156]

Three areas of research – bones, pollen/seeds and methane – contribute to the considerable underestimation of the number of large grazing animals in the past. Their bones were used to make fires[127] or were destroyed to make tools at new sites and often can no longer be found because calcium dissolves in acidic soil.[127] In comparison to other flowering plants, pollen and seeds from grasses are less widespread, because they only flower when they are not grazed.

A further underestimation is inevitable if the number of grazing ruminants in the past is inferred from the methane emissions of cattle today, which are fed intensively with silage from grasslands with extremely reduced biodiversity – such as monocultures. As with native prairies or pampas, diverse grass-herb-legume-mixes lead to much lower methane emissions.[159,160]

This underestimation puts even more into question the current confinement of most ruminants in intensive farms. Grasslands are losing their coevolutionary partners, losing a needed component of their development. This is further emphasised by looking at the broader ecosystem: one cow produces about one tonne of dung per month, which provides fodder to more than ten kg insect biomass as well as for bats, amphibians, reptiles and birds such as storks.[k] However, this is only possible if the cow is grazing, because the cowpat is unique and impossible to substitute.[161,162]



k 'It appears that an apparently efficient animal such as a cow leaves in its faeces enough food material in a year to support an insect population, mostly dipterous larvae, equal to at least one fifth of its own weight.'[161]