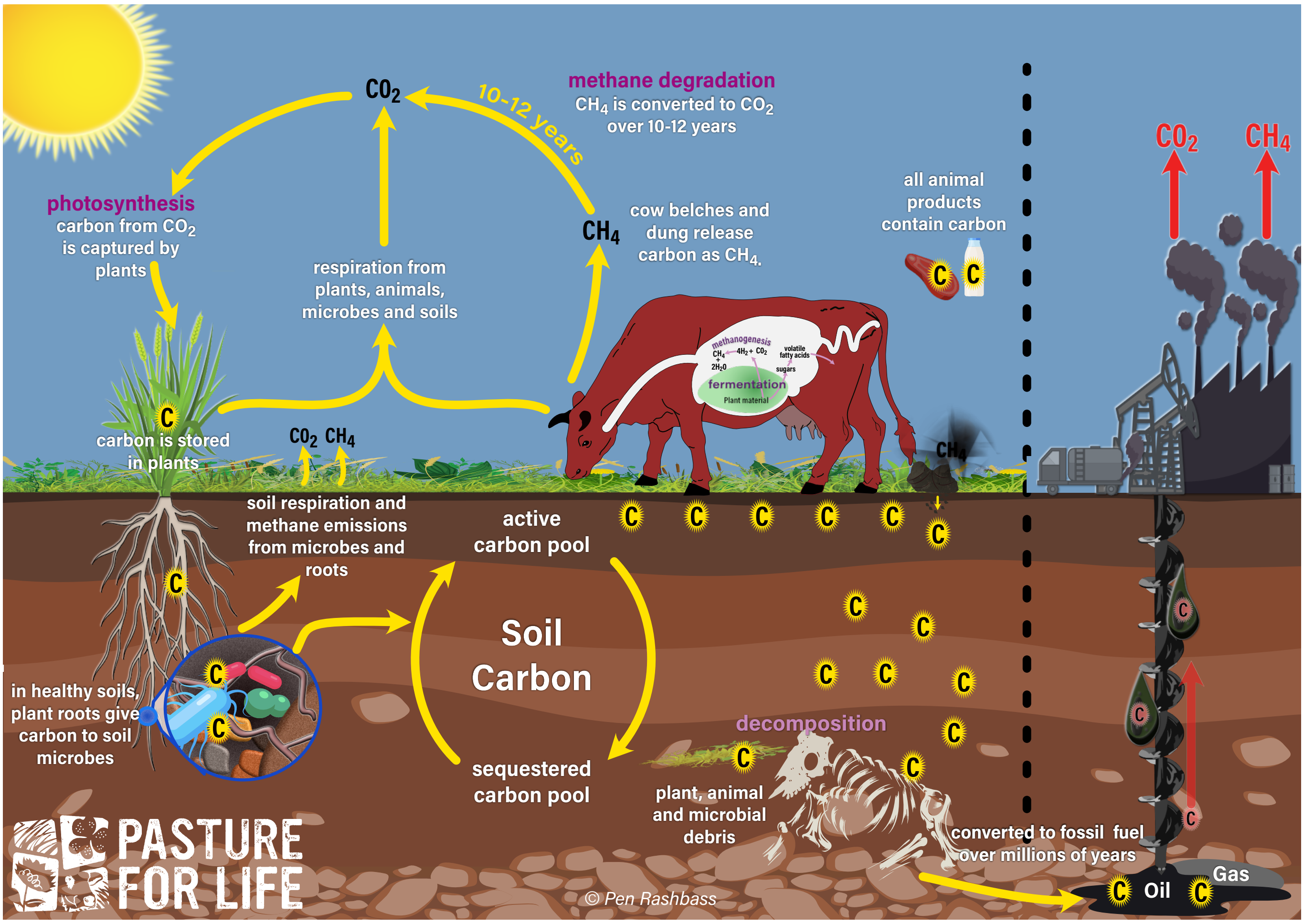
PASTURE FOR LIFE

Ruminants and the Natural Carbon Cycle



Overview

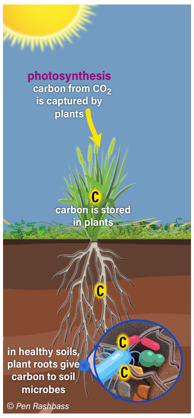
Planet Earth is a closed system that does not gain or lose carbon. Instead, carbon molecules move between the atmosphere, plants, animals, microbes, soil, minerals and oceans using a natural cycle known as the **carbon cycle**.

Where carbon is within the cycle determines the state of our climate and the health of our soils. Increasing carbon storage in soils is vital for:

- agricultural productivity and strong healthy plants
- reducing soil erosion and improving water holding capacity
- increasing resilience against droughts and floods
- combating climate change by pulling carbon out of the atmosphere
- environmental health, increasing biodiversity both below and above ground

Agricultural land takes up ~70% of the total UK land area – about 17 million Ha (65,600 sq miles) and ~ ⅔ of this is pastoral land[1]. Farming ruminants enables UK farmers to make use of this natural resource and provides nutritious food from land that otherwise would not be suitable for food production. Even small increases in soil carbon in our pastures can play a significant role in helping us combat climate change whilst also ensuring we create a secure national, self-sustainable and resilient food production system.

How we manage our livestock, land and our use of fossil fuel all impact on where carbon is within the cycle. **Well-managed grazing can have a positive impact on soil carbon storage and soil health[2].** In contrast, overgrazing can lead to negative consequences.



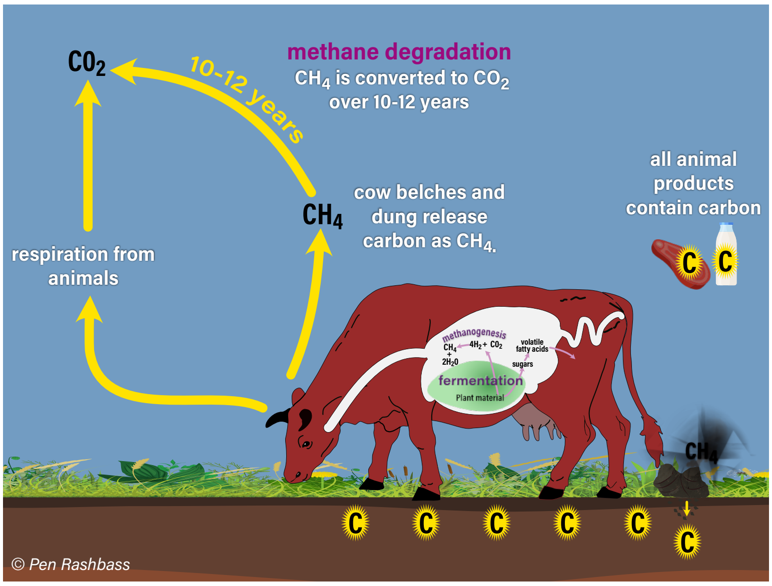
Photosynthesis is Nature's way of capturing carbon from the air.

It is a multi-step process by which plants make glucose (a simple sugar) and oxygen from carbon dioxide.

Plants then use this glucose as a basic building block to form a range of other constituents including more complex sugars, carbohydrates, amino acids, proteins, fats, oils, hormones, vitamins, structural compounds, defence compounds, protective compounds, and root exudates.

Plants provide food (carbon compounds) for grazing livestock.

Healthy, growing plants may release up to 10 - 50% of their carbon into the soil as "exudates"[3]. These feed the soil biology and drive the living processes in the soil.



Ruminants need to produce methane

Animals, including cattle, cannot digest plant fibres. However, tiny microbes living in the rumen of cows, sheep and other ruminants are able to ferment this fibrous material into simpler sugars and other nutrients that are then made available to the animal.

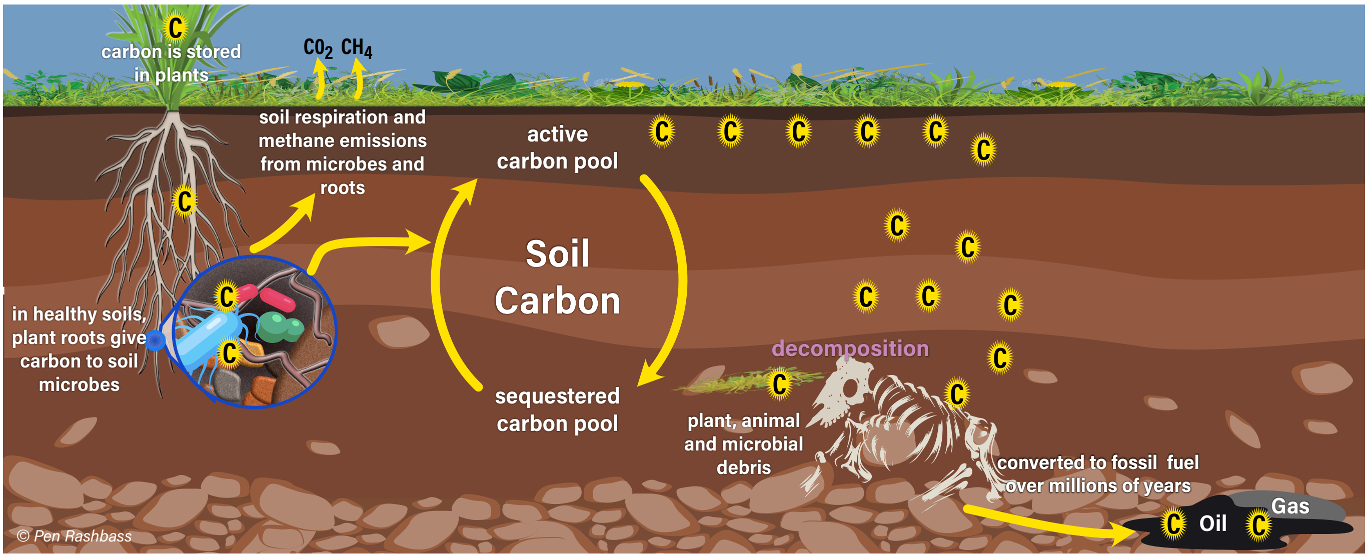
This symbiotic relationship between the rumen microbes and their host animal is crucial for ruminant survival. It provides them with the energy and nutrients they need for all essential functions including growth, milk production and a strong immune system.

It is this rumen fermentation that enables these large animals to thrive on grasses and other pasture plants. Hydrogen (H) atoms are released as a waste product of fermentation. However, too much hydrogen in the rumen is dangerous for the animal and can lead to serious health issues and even death. Nature's solution is to bind the H to carbon (C) to form methane (CH_4) using special microbes called "methanogens" in a process known as "methanogenesis". Ruminants then burp out this CH_4 to keep their rumen healthy.

There are many factors that determine the amount of CH_4 that a ruminant belches out. These include her genetics, her health status, the type of microbes present in her rumen and the type of food she eats. For example, plants high in natural condensed tannins may directly reduce rumen methane production[4], while a diverse diet of different pasture plants can improve overall animal health[5].

On well-managed, healthy pastures using optimal grazing systems, most carbon from healthy dung is taken up by the soil microbes and invertebrates and only a small proportion is released as CH_4 into the atmosphere. However, recent preliminary research has indicated that if cow excrement is kept in a mix of urine and water (as can happen in slurry pits), then the proportion of CH_4 emitted from her excrement compared to that burped out can increase dramatically[6].

Once CH_4 is in the atmosphere, it is more powerful at trapping heat than CO_2[7]. However, CH_4 naturally converts into CO_2 over a period of about 12 – 20 years[8]. This is in comparison with CO_2 from fossil fuels that remains in the atmosphere between 300 – 1000 years[9]. Because of this natural breakdown of CH_4, a herd or flock that is kept the same size and managed the same way for 12 – 20 years or more will not introduce additional CH_4 into the atmosphere.



Carbon cycling is part of a healthy soil ecosystem.

Healthy pastures capture more carbon by growing deeper root systems, supporting more soil organisms, building up organic matter and improving soil structure and function.

A healthy soil teems with a diverse community of microbes – including bacteria and fungi, invertebrates and other animals that make up the "soil food web".

Microbes use the carbon compounds released by plant roots to produce further microbes ("microbial biomass"), CO_2 which is released back into the atmosphere and other carbon-containing byproducts including biotic (biological) "glues". The carbon-rich microbial biomass and glues contribute to the formation of soil organic matter (SOM) which is important for soil health and fertility.

The biotic glues bind soil particles together to form soil aggregates that improve soil structure. The spaces between these aggregates form an extensive interconnected network of pores that help increase both soil aeration and its water-holding capacity, Both these create a more favourable environment for plant growth and for beneficial microbial populations to thrive.

As the microbes, plant and animal debris decompose they release carbon and other nutrients back into the soil.

There are several different "carbon pools" in the soil[10]. These cycle ("turnover") at different rates.

- the "active/labile pool" has a rapid turnover (days – years) – It is readily available for soil microbes and is highly responsive to management. This pool is vital for a healthy soil to function properly
- the "slow pool" has an intermediate turnover (years – decades) – It is partially protected and moderately stable
- the "passive pool" is long term storage (centuries to millennia) – It is highly protected and very stable

Stabilised pools effectively remove carbon from the atmosphere for long periods and mitigate against climate change. The active pool also keeps carbon in the soil (and out of the atmosphere) and is critical for a healthy soil. However, climate scientists are often hesitant to rely too heavily on this pool for carbon mitigation strategies because it is highly responsive to management decisions and is very sensitive to temperature, moisture and soil disturbance.

Good grazing management increases soil carbon and improves soil health

Ruminants can either improve or decrease soil carbon levels depending on how their grazing is managed.

To have a beneficial effect on soil health, optimal grazing management aims to enhance the ability of the pasture plants to photosynthesise throughout the year and also to improve nutrient cycling. It

- is always adaptive to the current local conditions
- leaves sufficient time between grazing periods for pasture plants to recover and rest
- encourages plant diversity
- stimulates new leaf and deeper root growth[11]. Increased leaf area on healthy plants increases the ability of plants to synthesise and enables them to take more carbon out of the atmosphere.

In contrast, overgrazing continually removes pasture vegetation and does not let plants recover properly. This causes reduced plant cover, decreased plant diversity, lower rates of photosynthesis and shorter roots, fewer soil aggregates, increased soil compaction, higher rates of soil erosion plus anaerobic soils that release more CH_4 into the atmosphere. All these reduce the carbon storage capacity of the land.

Our management decisions are key to ensure effective carbon storage – we must not blame the animal

Carbon calculators are tools that estimate the amount of greenhouse gas emissions associated with an activity or product. They are used to help governments, organisations, businesses and individuals make policy decisions. There are significant limitations when these tools are used for the agricultural sector because they vastly oversimplify the situation. Focusing primarily on carbon calculators can lead to misguided policies that negatively affect farmers, agricultural systems and the environment.

Carbon calculators work best for linear systems such as business or household energy usage. They are currently incapable of properly assessing the complete carbon cycle because they ignore the role that grasslands and good management play in increasing soil carbon storage and improving other ecological systems that reduce a farm's "global warming potential". CO_2 produced by respiration from any animal is not included in carbon calculators because, it is considered part of the natural carbon cycle. However, estimations of CH_4 emissions from livestock are included (even though this too is part of the natural cycle). Most these CH_4 emission estimations are inaccurate because they rely on simplistic mathematical averages that do not properly reflect actual measurements taken from real farming situations. This is especially true for optimally managed pastoral systems.

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