Science Societies

Beef—it's what's for dinner, thanks to carbon

How this critical element connects every step of livestock production

By Alan Franzluebbers

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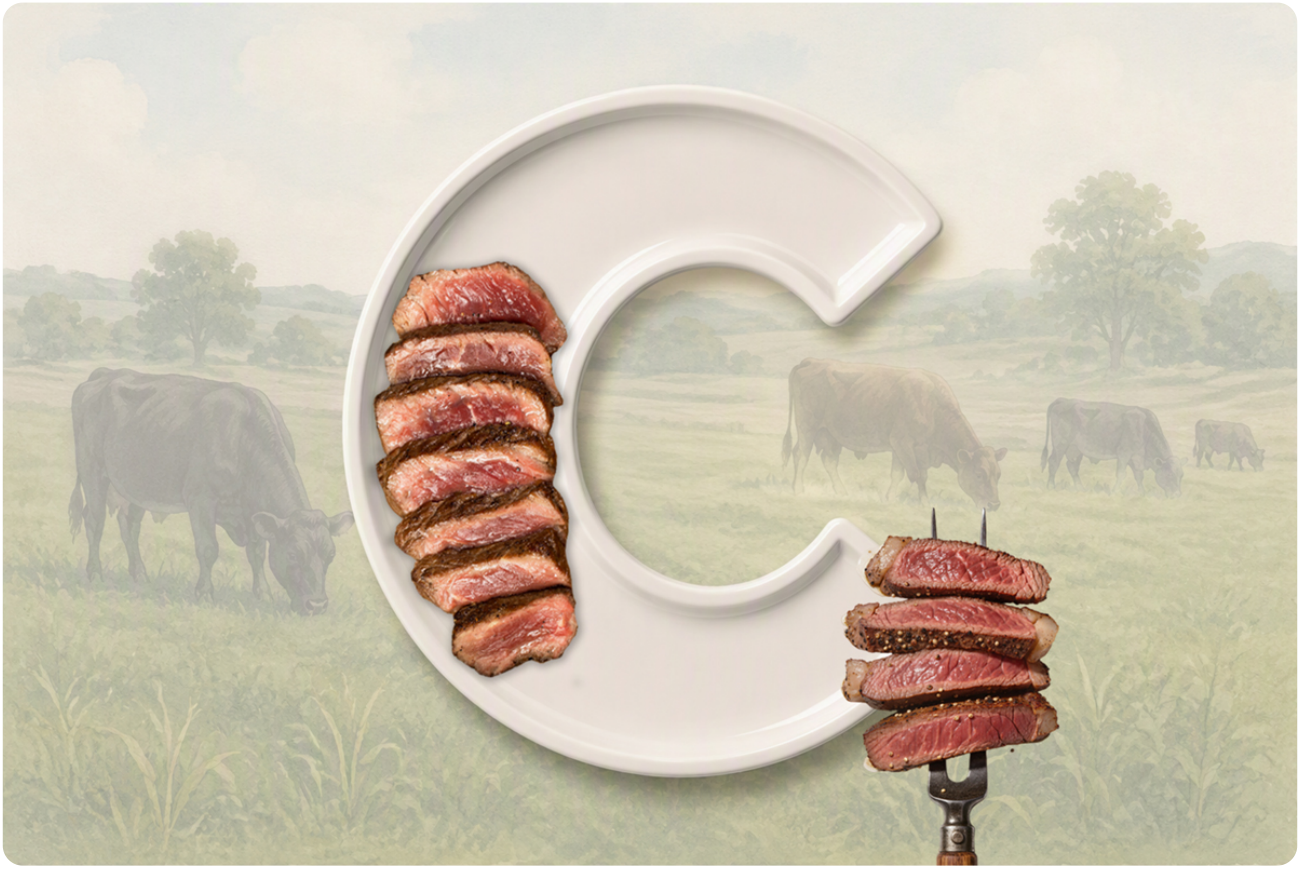

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Life as we know it wouldn't be possible without carbon. Despite this, do you ever actively think about this critical element? Carbon is in almost everything on our planet, including what we eat. In this article, we will dive into how carbon is involved in every step of livestock production.

This article is adapted from a series that originally was published in *The Carolina Cattle Connection*. It is a part of our Down to Earth series, which breaks down and explains food, farming, and environmental sciences for readers of all backgrounds, including those without formal scientific training.

Life is precious! And yet, we as people on this planet consider it normal and go about our business from day to day, year to year, generation to generation. This routine is good because then we can focus on the reasons why we love to work, play, and enjoy each other. But do you ever think about the building blocks that make this life possible?

Carbon is in the grass that feeds our cattle.

Take carbon, for example. How much of your day do you spend thinking about carbon? Probably not much, if at all (unless you're a scientist or farmer). But when you think about it, everything living contains carbon! Carbon is not in pure water, but carbon is in fruit juice, tonic water, sodas, in your morning coffee, in your afternoon tea, and your evening cocktail. We cannot live without carbon—it is even in us, in our bones, our muscles, our blood.

Carbon is in protein too! Carbon is in the food we eat, whether meat, dairy, eggs, leafy greens, or rice. Carbon is in the grass that feeds our cattle. Carbon is in the air—plants couldn't grow if it wasn't. Carbon is in the soil that nourishes the grasses and forbs that feed the rumen of beef cattle, turning carbon in plants into tasty beef products.

Food, cattle, and the carbon cycle

People cannot live without consuming food. Food starts with the production and harvest of plants. Those plants might be the leafy spinach or collards that you grow in the winter, carrots or turnips that we pull from the ground, or forage grasses that need to be converted by rumen organisms like cattle into protein-rich milk and meat. Therefore, we might consider the cycle of life beginning with the sun that shines on the diversity of plants throughout the world, which we harvest for food, shelter, and medicine. Life can only continue though if the carbon contained in this variety of grasses, flowering plants, vegetables, and trees returns to the soil where a mostly hidden community of organisms live. Those organisms are the small insects, spiders, earthworms, and microorganisms (bacteria, archaea, protozoa, and fungi) that consume dead plant and animal remains and return much of the carbon back to the atmosphere as carbon dioxide.

Plants are capable of living because of the energy in sunlight, the air that contains carbon dioxide, the water that falls to the ground from rainfall, and the soil that supports rooting and a valuable supply of nutrients. We as people cannot live without plants.

Plants provide the chemically bound energy needed for all animals to live. We rely on plants for an abundance and diversity of foods. We rely on plants for wood and fibers to house and clothe us. We rely on plants for medicinal compounds that stimulate our brains, that activate our muscles, that allow us to reflect on our place in nature…

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Photosynthesis is one of the miraculous features of life that is provided to us daily. Photosynthesis is the process of capturing carbon dioxide from the air and converting this inorganic carbon from the air into organic carbon compounds, starting as simple sugars.

Different plants have mechanisms to convert these simple sugars into more biochemically diverse substances, such as complex carbohydrates, proteins, fatty acids, hormones, and many more. For example, grasses consumed by cattle can contain a variety of these organic compounds. A key feature of grasses and forbs (herbaceous plants that are not grass-like nor woody) is their high concentration of cellulose and other structural carbohydrates like hemicellulose. These compounds are found in plant cell

walls, giving them strength and rigidity to withstand the harshness of the environment in which they grow.

People are not able to digest these structural carbohydrates, but cattle can because of microorganisms present within the rumen. These rumen microorganisms are provided an anaerobic environment (i.e., an environment without oxygen that allows for fermentation), which facilitates the breakdown of structural carbohydrates into volatile fatty acids, microbial protein, and B vitamins that the cattle can use to gain energy and grow.

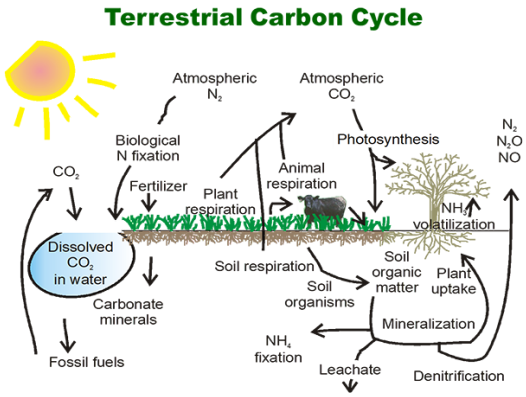
Cattle, agriculture, and greenhouse gases

Microorganisms in the rumen of cattle thrive without oxygen and they are provided this environment daily. Because of the fermentative environment in which they live, these organisms release methane as a product of their respiration rather than carbon dioxide. Although carbon dioxide is the most abundant greenhouse gas, methane has nearly 30 times greater heat-trapping capacity than does carbon dioxide. Therefore, cattle production is often targeted in the discussion of global warming due to this emission of methane.

However, methane is a relatively short-lived greenhouse gas with a lifetime of about 10 years in the atmosphere, whereas carbon dioxide has a lifetime of 120 years. Nitrous oxide is an even more potent greenhouse gas with the heat-trapping capacity of about 300 times greater than carbon dioxide. It has an average lifetime in the atmosphere of about 130 years. Nitrous oxide is released to the atmosphere typically following large applications of nitrogen-containing inorganic and organic fertilizers to soil. All food systems play a role in carbon

emissions, which is something that agricultural specialists are trying to mitigate in order to keep feeding future generations of people.

The cycle of life continues when plants and animals die, and they are consumed by soil microorganisms. The biochemical energy contained in dead tissues is used as food for their growth by the bacteria, fungi, and actinomycetes living in soil. Much of the carbon contained in these organic compounds of now dead plants and animals is converted to carbon dioxide and returned to the atmosphere where future plants can use it for growth. Carbon is cycled from the atmosphere to plants to animals to people to feces to soil microorganisms and back to the atmosphere. This is the simple flow, and yet nature is complex, and there are many other pathways that are occurring simultaneously. For example, plants, animals, and people get their energy for growth and respire some of the food carbon (i.e., carbohydrates) back to the atmosphere as carbon dioxide even before soil microorganisms complete the final phase. Also, carbon dioxide can be transformed into carbonate minerals in the presence of water, leading to large reservoirs of carbon that accumulate deep in the soil profile or in the ocean.



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people to feces to soil microorganisms and back to the atmosphere.

In summary, cattle and carbon are natural pairings of life. Carbon is in cattle, carbon is in you, and carbon is in our environment. Life is a balance from all the elements that sustain it. Disruptions of the carbon cycle, therefore, can disrupt life.

One of the pressing issues of concern today is the rising carbon dioxide concentration in the atmosphere. Elevated carbon dioxide in the atmosphere creates an invisible blanket (greenhouse effect) that blocks energy from the sun radiating back to the cosmos. If we had no atmosphere, Earth would be very cold and uninhabitable. Because we have a delicate balance of water vapor and carbon dioxide in the atmosphere, Earth is a blessed planet that is full of life. But the greenhouse effect is threatening our existence with rising temperature because of too much carbon dioxide in the atmosphere. Nature tries to keep balance but is being challenged by our choices. The issue is that we are burning fossil fuels that are natural but were buried away millions of years ago. The carbon contained in these burned fuels is being returned to the atmosphere at a much more rapid rate than current plant communities can utilize. Indeed, we need to grow more plants!

Dig deeper

Dr. Alan Franzluebbers is a Research Ecologist with the Plant Science Research Unit of the USDA-ARS on the campus of North Carolina State University (NC State) in Raleigh, NC. He was the 2025 President of the American Forage and Grassland Council and is a member of the Amazing Grazing team at NC State, conducting soil and plant research throughout North Carolina and surrounding states. He is also a member of the Center for Environmental Farming Systems, a collaboration of NC

State University, North Carolina A&T State University, and the North Carolina Department of Agriculture and Consumer Services.

Read more from Alan about how soil carbon affects life on Earth in this series in *Crops & Soils* magazine.

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