

5.2: Beef Farm Ecosystem Products and Services Reading

The United States is the world's largest producer of beef. While there are many variations among the farms and ranches that raise beef cattle, we'll describe a "typical" beef operation in the Great Plains. Raising beef animals is a complicated process that often involves multiple stages and, usually, multiple farms (although a few beef farms and ranches keep and raise their animals from birth until maturity). When a beef animal is born, it is typically raised in a pasture with its mother until it is weaned off milk. Both animals will graze primarily on grass at this point. Once a calf is old enough, it will be moved to a "backgrounding operation" where it will still consume a diet of mostly grasses but also a smaller amount of corn and other grains. Once they reach 350-400 kg (800-900 lbs.), most beef animals are moved to large feedlot (or feedyard) operations in which they consume a diet of mostly corn grain until they are fully grown at 600 kg (or roughly 1300 lbs.).

Where does our beef come from?

Here are some pictures that show what you would see in a walk through the different stages of beef production. A beef animal will spend about 3-6 months at each stage.

Stage 1: Cow/calf. The top picture is a cow/calf operation in Nebraska. For the first six months, the calves stay with their mothers until they are old enough that they no longer need milk. As the calf grows older, it will increasingly start to graze on grass.

Stage 2: Backgrounding. The second picture shows a backgrounding operation in North Dakota with weaned animals that are 6-12 months old. These animals are fed a diet that consists mostly of grasses but also has a smaller amount of corn and other grains. If pasture is not available (e.g. during the winter months), backgrounded beef animals will be fed a diet that is mostly hay (dried grasses). For the purposes of this exercise, we will focus primarily on this kind of operation.

Stage 3: Feedlot. While some beef animals are grass-fed on a pasture, most beef animals end at a feedlot (bottom picture). Typically, a beef animal will spend 4-6 months here, consuming a diet that consists mostly of corn grain but also includes some other grains



Figure 1 Source: University of Nebraska–Lincoln



Figure 2 Source: NDSU Agriculture



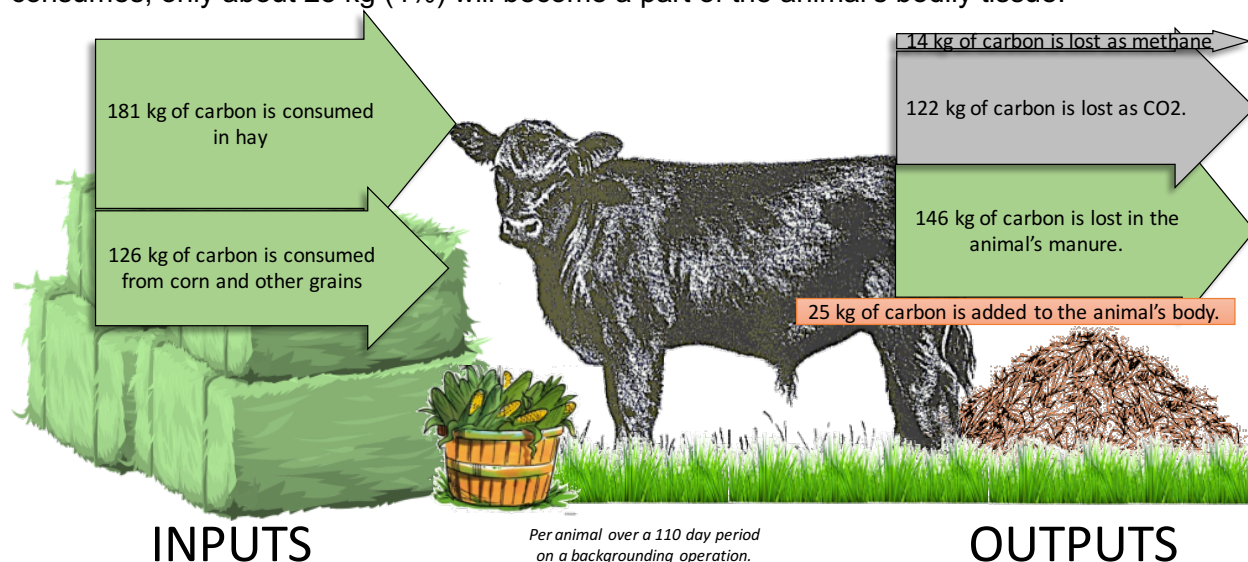
Figure 3 Source: NDSU Agriculture

and hay.

Carbon Pools and Fluxes in the Backgrounding Operation

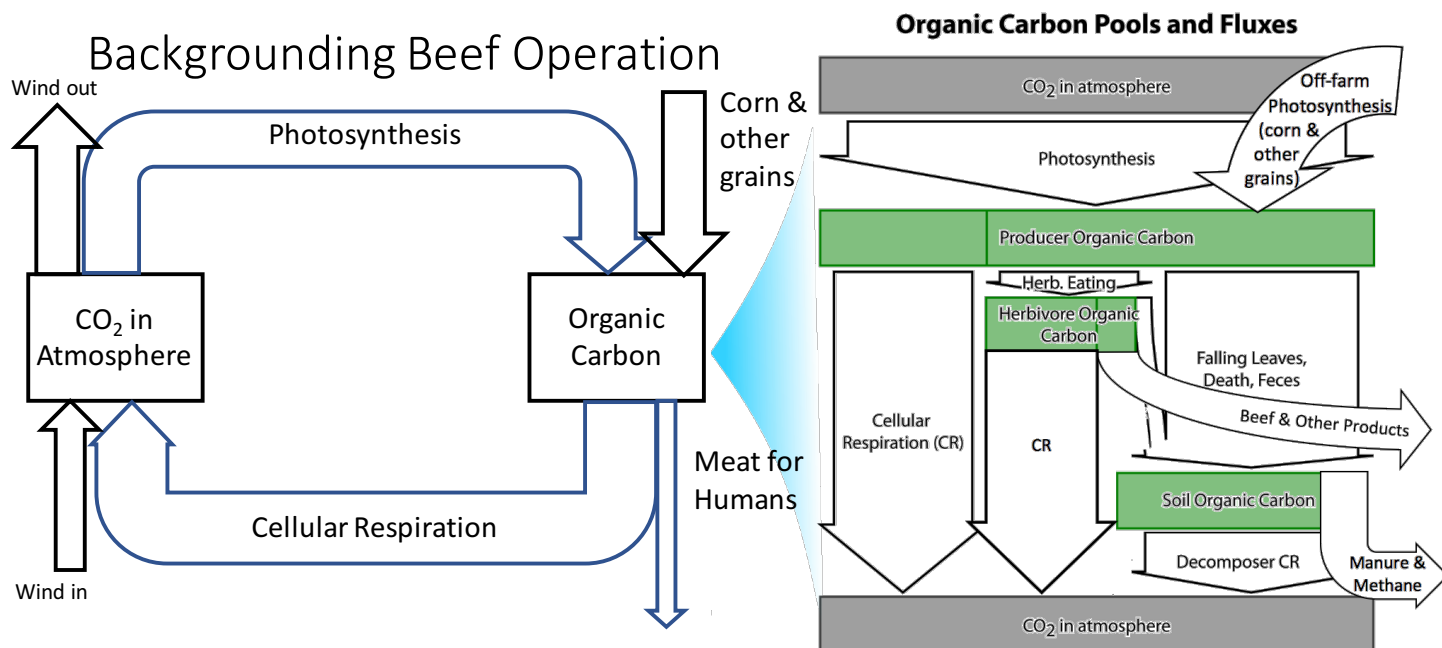
The pictures of the beef farms above show some evidence of carbon pools and fluxes. Can you identify them? Other pools and fluxes are invisible, but still essential to the functioning of the ecosystem. Let's review the main pools and fluxes.

Carbon pools. The visible carbon pools are mostly *organic carbon pools*, including producers (all the grass and other plants), consumers (all the beef animals), and decomposers (fungi and bacteria). There is a lot of organic carbon in these visible pools. For example, young beef animals will consume an average of 306 kg of carbon atoms each in their feed while they are on a backgrounding farm. All of that carbon has to go somewhere. About 40% of those carbon atoms will be expired as CO₂ that they breathe out, and another 4% is lost as methane (or CH₄, which the animal expels through burps and flatulence). Almost 50% of those carbon atoms will be excreted in their manure. Of the 306 kg of carbon atoms that each animal consumes, only about 25 kg (4%) will become a part of the animal's bodily tissue.



But there is even more carbon sequestered in carbon pools that we can't see in the photos. Much of this is *soil organic carbon*—all the plant roots, dead plants, and animals, bacteria, and fungi in the soil. An 80-acre (32-hectare) farm has over 2,000,000 kilograms of carbon in the soil! There is also *carbon dioxide* that is dispersed in the air and dissolved in the bodies of water that may be present on this farm. Each year, these 80 acres will sequester roughly 10,000 kg of carbon atoms in the organic matter in the soil (assuming the soil in this pasture is left undisturbed and is not plowed to plant field crops). Some of these carbon atoms will be a part of the roots of the grasses and alfalfa on this farm, some will come from the manure that the animals leave, and some will come from dead organisms.

Carbon fluxes. Carbon is also constantly moving among the pools of this farm. A few of those fluxes are visible, such as when animals eat the leaves of plants or animals are moved away from the farm. But many other fluxes are invisible, such as photosynthesis in the leaves of plants and cellular respiration in the cells of producers, consumers, and decomposers.



The diagram here shows the main pools and fluxes for this farm. The fluxes aren't balanced, though. The young beef cattle are not very efficient at converting the feed they consume into organic mass in their bodies. In fact, it takes an average of six kilograms of feed to produce one kilogram of beef.

Most of the carbon consumed in the feed is exhaled as CO_2 or lost in their manure. Some of that carbon is lost as methane, some may be transported off of the farm to be used as fertilizer for other fields, and some is sequestered in the soil of the pastures as organic carbon. In most cases, a farm like this will add more carbon to the environment than it will take away.

Altogether, the 40 animals on this farm will move over 12,000 kg of carbon atoms per year into meat, gases, and manure. In addition, the use of farm machinery and vehicles (which release CO_2 when they combust fuel) and other human activities makes it almost certain that more carbon atoms will be moved into the carbon pools of this farm than will be taken from it.

Ecosystem Products and Services from the Farm

Human management. Humans directly manage most of the aspects of this farm ecosystem. They determine its boundaries and attempt to control the species that are found (or not found) within this ecosystem.

- Humans will eliminate predators that pose an immediate threat to the cattle on this farm (or largely eliminated these predators decades ago).
- Humans will plant specific species that most benefit the cattle and will often eliminate plant species that are not beneficial to the purposes of the farm (i.e. weeds).
- Humans will control when and how often the cattle get access to different areas of this ecosystem to ensure proper plant cover and nutrient management.

These management practices help to ensure that the kind of biodiversity present in this managed ecosystem ensures that as much of a product (beef) can be produced as possible.

Farm Products & Ecosystem Services. This farm provides two key products:

- *Food:* The farm mainly provides nutrient-dense food for humans in the form of beef. These products also provide income for the people who sell it. In addition to food, leftover parts of beef cattle are used for a wide variety of purposes, including pharmaceuticals, cosmetics, leather, glue, and more.
- *Fertilizer:* Cattle produce a lot of manure that is rich in the nutrients that plants need for growth and productivity. Most of the manure produced by livestock is used to fertilize the fields that produce the food needed to feed humans and animals. While most of the mass of a plant comes from carbon dioxide in the air and water in the soil, plants also need nitrogen and phosphorus that are found in the manure to be productive.

Other ecosystem services. The farm also provides other services. It provides habitat for many different plants and animals that do not directly affect the productivity of the beef animals, including birds and predatory insects that eat mosquitoes and other harmful insects (particularly if the farmer participates in the Conservation Reserve Program, in which they set aside a portion of the farm specifically for wildlife habitat); evaporation from pasture cools the air; the farm, if well managed, can be scenic and pleasant to experience.

Tradeoffs: What services does the farm NOT provide? When we manage ecosystems to produce some products and services, it always means that we get less of others. Here are some other products and services that humans could get from this farm, but do not.

- *Habitat:* While this farm does provide some habitat for plants and animals, many species are intentionally excluded from this land. The biodiversity of this land would be higher if it were not as intensely managed by humans.
- *Carbon sequestration:* Because this land is used to produce beef, the amount of carbon emissions usually exceeds the amount of carbon sequestered.
- *Water:* this farm ecosystem has a much greater potential for causing groundwater or surface water pollution compared to the native habitat it displaced.
- *Space for living and recreation:* Because the farm is used for food production, it cannot be used for homes or for most kinds of outdoor recreation.

Digging Deeper: Where You Can Learn More about Farms and Their Ecosystem Services

To learn more about farms and the ecosystem services that they provide:

- To get a brief overview of how beef is produced in the United States, visit <https://www.ers.usda.gov/topics/animal-products/cattle-beef/background/>
- For a detailed look at how beef feedlots are managed, visit <https://store.extension.iastate.edu/Product/Beef-Feedlot-Systems-Manual>
- To see how beef management could be changed to sequester more carbon dioxide, visit <http://www.dasnr.okstate.edu/Members/donald-stotts-40okstate.edu/carbon-sequestration-a-positive-aspect-of-beef-cattle-grazing-grasslands/>
- While beef is a nutrient-dense food, it is not an efficient way to produce food, and most of the carbon atoms consumed by a beef animal are lost as manure or CO₂. While the amount of beef that could be raised on this land could feed 364 Americans, this same farm could feed 1461 Americans with 40 dairy cows. If planted in corn, it could feed 2228

Americans per year.¹ To read more about research on how beef consumption can affect land use and your carbon footprint, visit

https://www.washingtonpost.com/lifestyle/food/heres-how-much-giving-up-beef-helps--or-doesnt-help--the-planet/2017/07/20/03bb5ba2-6d60-11e7-b9e2-2056e768a7e5_story.html?utm_term=.028f2476b68e

¹ Based on Americans' average annual consumption rates of 25.2 kg of beef, 285.8 kg of dairy, and 159.4 kg of corn.