What are sustainable agroecosystems?

food systems and food chains

What is a **food system**? This term refers to the entire process involved in making food accessible to all people. A food system, no matter its size, encompasses five sectors:

- How and where food is grown
- The processing of food
- The distribution of food
- Food consumption
- What happens to the waste created by the other four processes

You can look at food systems on a global level or focus on a household food system. There are also community food systems.

A food chain has elements that are similar to the food system.

A **food chain** is a linear sequence of organisms through which nutrients and energy pass as one organism eats another. The levels in the food chain are producers, primary consumers, higher-level consumers, and finally decomposers. These levels are used to describe ecosystem structure and dynamics. There is a single path through a food chain. Each organism in a food chain occupies a specific **trophic level** (energy level), its position in the food chain or food web.

In many ecosystems, the base, or foundation, of the food chain consists of photosynthetic organisms (plants or phytoplankton), which are called **producers**. The organisms that consume the producers are **herbivores** called **primary consumers**.

Secondary consumers are usually **carnivores** that eat the primary consumers. **Tertiary consumers** are carnivores that eat other carnivores.

Ecosystems

An ecosystem is a complex level of organization made up of living (biotic) elements, such as communities of organisms, and non-living (abiotic) elements, such as the physical surroundings.

The members of every ecosystem can be identified as being either a producer (autotroph), consumer (heterotroph) or decomposer. The relationships between these groups can be illustrated in food chains or food webs.

While producers are responsible for capturing energy and using this energy to convert inorganic materials into organic matter, decomposers break down organic matter into inorganic materials (such as mineral ions) that can be recycled within ecosystems by plants.

Communities within ecosystems are made up of populations. Interactions between these populations and their environment enable matter to be recycled and energy to flow through the ecosystem.

Higher-level consumers feed on the next lower trophic levels, and so on, up to the organisms at the top of the food chain.

One major factor that limits the number of steps in a food chain is energy. Energy is lost at each trophic level and between trophic levels. This energy takes the form of heat.

The linear model of ecosystems, the food chain, is a hypothetical and overly simplistic representation of ecosystem structure. A model that looks more like a web — which includes all the interactions between different species and their complex interconnected relationships with each other and with the environment — is a more accurate and descriptive model for ecosystems. A **food web** is a concept that accounts for the multiple trophic (feeding) interactions between each species.

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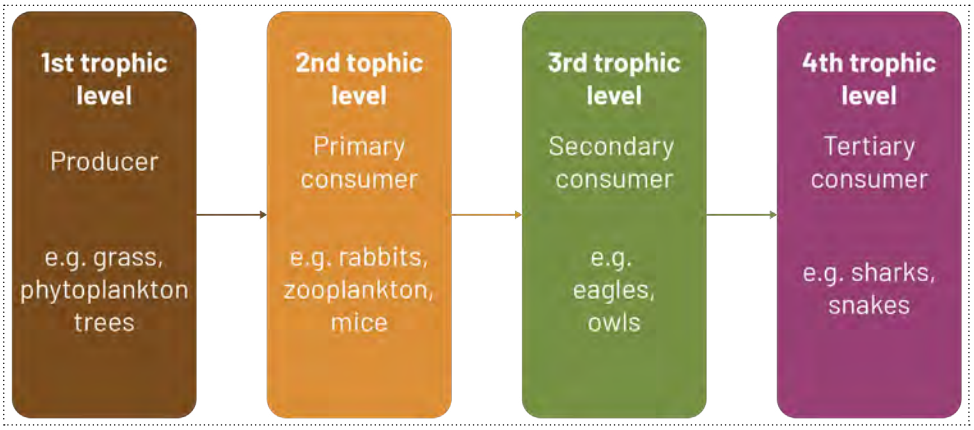
At what trophic level are humans in the food chain?



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How can farmers use understandings of ecological food chains and webs to influence the food system?

comparing natural ecosystems and agroecosystems

An ecosystem that has been modified for agricultural use is called an agroecosystem. **Agroecosystems** involve all the interactions between biotic and abiotic features in an agricultural area.

The term agroecosystem can be used to describe a broad range of environments, from individual fields to farms to entire ecozones. The agroecosystem is a central part of the food system.

Understanding how agroecosystems works is important to a better understanding of sustainability.

When humans create an agroecosystem, they change the energy flow. They change the species in the agroecosystem food web, adding some (like food crops or animals) and removing others (like rodents or large predators).

When farmers buy fertilizers or animal feeds, nutrients "flow" onto the farm. When farmers sell grain, meat or milk, nutrients flow off the farm. This is similar to flows in and out of chemical cycles.

Flows that involve products entering or leaving the farm are intentionally and carefully managed.

Other flows are unplanned — for example, when nitrate is lost from the soil by leaching to groundwater or when runoff waters take nutrients along with eroded topsoil to a nearby stream.

When crops are harvested and brought to the barn to feed animals, that is a nutrient flow, as is the return of animal manure to the land. Together these two flows are a true cycle, because nutrients return to the fields from which they came.

By learning about energy flow in ecosystems, we can better understand how to design agroecosystems to minimize energy loss, making them more efficient and therefore more sustainable.

In natural systems, waste products return to the trophic system. Plants or animals die and defecate, and decomposers break down these wastes and they become nutrients for plant growth or organic matter in the soil.

This can also happen in systems that humans are involved in. For example, in some food systems, food waste is composted and worked back into the agroecosystem. However, since so many people now live far away from the farms that their food comes from, food waste often ends up in landfills and most of the **biomass** — the biological waste from organisms — produced does not return to the soil as organic matter. Some believe that this is due to a disconnect between people and their food.

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To what extent do you think people are disconnected from the food they eat? Why do you think this?

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In what ways do you think a better understanding of ecosystems could strengthen the connection that people have to food, farmers and sustainability?

how dairy farmers manage resources

Sustainable development aims to meet current economic and social needs and ensure future generations can also meet theirs. Dairy farms are located in every province in Canada.

Many farms are multigenerational. To continue this tradition for future generations, dairy farmers carefully manage their farms' natural resources to ensure milk production is as efficient as possible. Part of the sustainability equation on a dairy farm means effectively managing soil, air and water quality.

Soil

Canadian dairy farms manage a unique combination of livestock and cropland requirements. Many dairy farmers grow their own feed to use on their farms and purchase nutrients to fertilize their soils.

They apply best management practices like crop rotation, growing forages and no-till to improve soil quality, reduce GHG emissions and improve biodiversity. Dairy farmers invest in research on cropping systems and ways to capture carbon in the soil on their dairy farms.

Air

The way farmers collect, store and apply manure can impact air quality. Dairy Farmers of Canada is continuing to invest in research to improve air quality and reduce emissions from dairy barns and manure pits with technologies like **biofiltration** (natural process of aerobic degradation of air contaminants through bacterial oxidization).

Manure management systems and using best management practices to apply manure can help improve air quality. Other technologies like **anaerobic digestion** — the process of degrading animal waste using microorganisms in the absence of oxygen to produce biogas — are also being developed and utilized.

Water

Canadian dairy farmers realize the importance of maintaining the safety of their production systems to protect water quality. ProAction™ is a multi-component, on-farm food safety program for the production of dairy. This initiative promotes best practices, including protecting water sources from bacterial contamination.

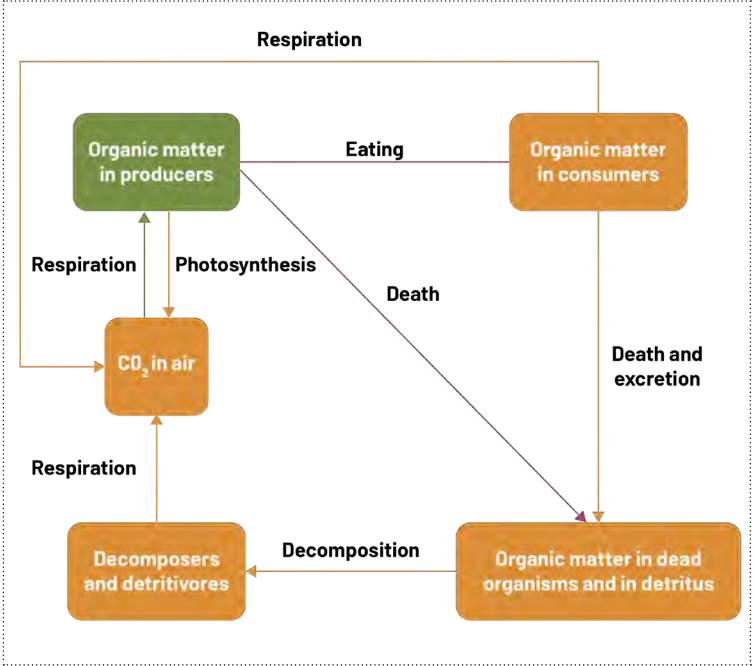
These practices include:

- Restricting cattle access to surface water and other natural areas
- Locating manure management systems in a way to prevent contamination of water
- Creating buffer strips between land and waterways

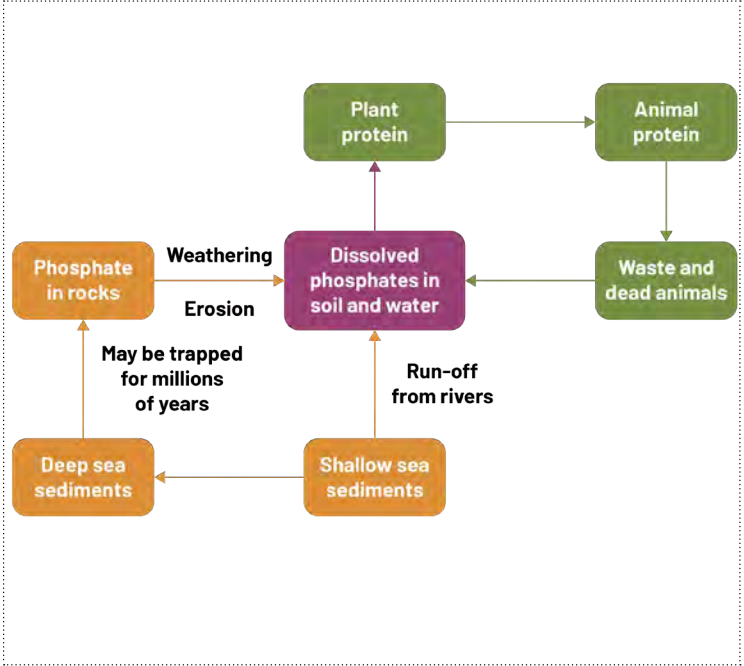
cycling of matter in ecosystems

Food chains and food webs describe how matter can be recycled through an ecosystem. The cycle of matter assists in maintaining a sustainable ecosystem. Consider the cycles of carbon, phosphorus and nitrogen.

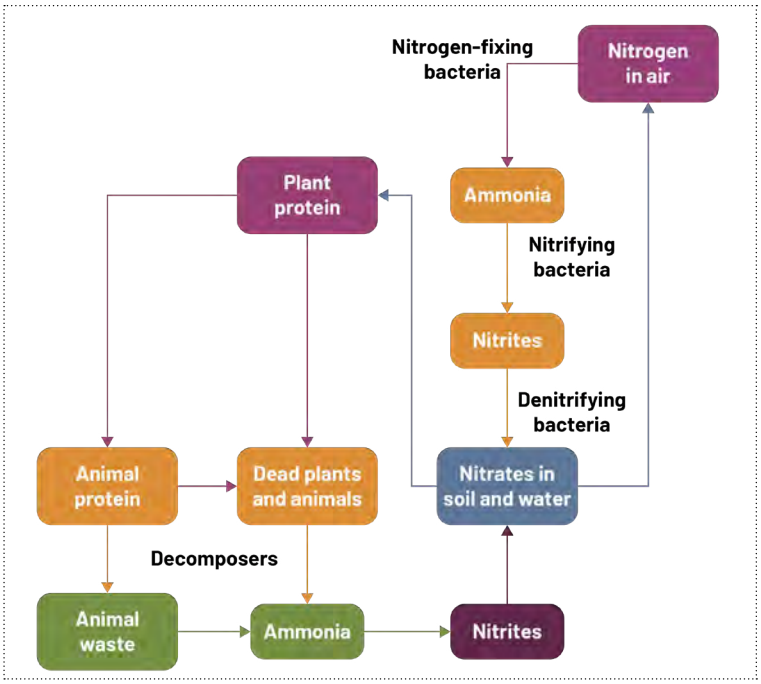
Carbon cycled within an ecosystem



Phosphorus cycled within an ecosystem



Nitrogen cycled within an ecosystem



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How can these three cycles apply to an agricultural ecosystem?

What about agroecosystems? Sustainable agricultural practices involve more efficient use of nutrient cycling on farms.

Nutrient cycling in agroecosystems

Soil carbon is dynamic. Changes in the amount of carbon stored in soil organic matter depend on the relative rates of carbon input from plant litter and carbon emitted as CO_2 via decomposition.

If carbon inputs are greater than carbon loss, then the amount stored increases; if carbon input is less than carbon loss, the amount of carbon stored decreases.

To increase stored carbon, practices must either:

- **Increase plant yield (photosynthesis)**
- **Increase the proportion of fixed carbon added to soil, or**
- **Slow the rate of organic matter decomposition.**

By managing soils for growing crops and raising livestock, the world's farmers are unconsciously conserving a soil carbon reservoir that is roughly equivalent to the total carbon that would be released after 100 years of fossil fuel burning at the current world rate. In recent years, the size of this immense carbon pool has changed very little.

Despite the apparent stability of this carbon reservoir, there is nothing permanent about any of the carbon which it contains, nor of the agricultural practices that promote this apparent stability.

Historically, when lands were first cropped, large amounts of carbon were lost because cultivation accelerated decay and removal of harvests meant less carbon was returned to soil. But today, farmers can rebuild some of the lost carbon through improved practices.

By increasing the amount of carbon stored in soils, these practices make soils more productive and resilient for use by future generations, while continuing to remove CO_2 from the air.

If land management practices are changed in ways that increase the soil organic carbon, CO_2 is effectively removed from the atmosphere and stored or 'sequestered' in the soil. The size of the 'sink' is increased.

Farm practices that contribute to the carbon sink are:

- **Reduction in tillage**
- **Restoring degraded land, improving pasture management**
- **Reducing fallow periods**
- **Adding animal manures to the soil**
- **Crop residue management**
- **Using legumes and/or grasses in crop rotations**
- **Converting marginal crop land to perennial grass or trees**
- **Using rotational grazing and high-intensity/short duration grazing**
- **Planting shrubs and trees as shelterbelts**
- **Restoring wetlands**

In addition to sequestering, or storing, carbon in the soil, these practices also increase soil productivity, enhance the quality of water running off or draining from agricultural land, and provide a more hospitable environment for wildlife inhabiting agricultural lands.

In Canada, one-quarter of a million farmers manage about 68 million hectares of land. Overall, these farmers have considerably improved the sustainability of their soil management practices on land used for crops and grazing.

Agriculture and Agri-Food Canada (2014). Carbon Dioxide. Online www.agr.gc.ca/eng/science-and-innovation/agricultural-practices/climate-change-and-agriculture/greenhouse-gases/carbon-dioxide/?id=1329321971040

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How are the practices identified by Agriculture and Agri-Food Canada part of the cycling of matter in agroecosystems?