LEARNING EXPERIENCE FOUR

Guiding Question: What are sustainable agroecosystems?

This **Learning Source** provides starting points and information to investigate:

- Food systems, food chains and food webs
- Trophic levels
- Natural ecosystems and agroecosystems
- Resource management
- Cycling of matter and nutrients

Build Competencies: Policy influences

Students analyze agroecosystem cycles and the effect of agricultural practices and food trends on the cycle.

This handout includes activities that support competencies and numeracy, and weblinks to online resources that can support student learning.

Assess

Look for evidence of understanding of the following concepts:

- Ecosystems
- Food chains and webs
- Trophic levels
- Producers and consumers
- Energy flows and matter cycles
- Influence of human activities

For a formative assessment, have students revisit how dairy farmers manage resources in the **Learning Source**. Agroecology integrates agriculture with the qualities of natural ecosystems, including efficiency (recycling and reusing resources), self-sufficiency (natural inputs), diversity (biodiversity of species and their interactions) and resilience. Create a **case study** of dairy farms, identifying how they address these four qualities in sustainable agroecosystems or select another industry from the links in the **Build Competencies** source.

Additional information and discussion questions are provided in the carousel slide for this guiding question in the sustainability MATTERS section of the LEARN webpage.

Click on the carousel slide to open and explore the following content.

- An introduction to **sustainable agricultural ecosystems**
- Information and a research-based article about **feeding livestock**

Additional Research or Background Sources

Consult teacher or student background sources such as the examples that follow to further explore, enrich or expand activities for this guiding question. Student research sources are also provided in **Build Competencies** handouts.

Food Secure Canada states that a healthy environment is the basis of a resilient and sustainable agroecosystem in their discussion paper *Environment and Agriculture*, found at **https://foodsecurecanada.org/resources-news/newsletters/6-environment-and-agriculture**.

The Food and Agriculture Organization of the United Nations provides *The 10 Elements of Agroecology: Guiding the Transition to Sustainable Food and Agriculture Systems* at **www.fao.org/3/i9037en/I9037EN.pdf**. This publication can provide some background for discussions with students. The 10 elements include:

- Diversity; synergies; efficiency; resilience; recycling; co-creation and sharing of knowledge (describing common characteristics of agroecological systems, foundational practices and innovation approaches)

- Human and social values; culture and food traditions (context features)
- Responsible governance; circular and solidarity economy (enabling environment

A perspective on **agroecology**, an approach to food production that uses — and creates — social, cultural, economic and environmental knowledge to promote food sovereignty, social justice, economic sustainability, and healthy agricultural ecosystems is provided on the National Farmers Union website at **www.nfu.ca/campaigns/agroecology/**. The resources on this webpage can provide background to agricultural practices and approaches that include Indigenous perspectives.

An international perspective on *Agricultural Ecosystems* from the World Business Council for Sustainable Development, including information and perspectives on sustainability and climate, water, land, soil and nutrients and future challenges, can be found at **http://cmsdata.iucn.org/downloads/agriculturalecosystems_2.pdf**.

This publication provides an overview of the three pillars of sustainable agriculture that can be useful to share with students.

Environmental	**Social**	**Economic**
• Support biodiversity and ecosystem services • Sustain productive agriculture, avoiding encroachment onto natural ecosystems • Manage natural resources well	• Foster healthy populations with the greatest chances of realizing their development potential • Improve livelihoods by providing food, feed, fibre and fuel of high quality	• Provide income to rural communities • Increase the value of agricultural produce throughout the value chain

Find an information snapshot about carbon sequestration as a sustainable agricultural practice from Agriculture in the Classroom Canada at **https://aitc-canada.ca/en-ca/learn-about-agriculture/category/farming-the-environment/carbon-sequestration**.

Another information snapshot about the use of fertilizers and their impact on soil nutrients can be found at **https://aitc-canada.ca/en-ca/learn-about-agriculture/fertilizer-use**. An information snapshot about organic soil management, that includes references to nutrient cycling, can be accessed at **https://aitc-canada.ca/en-ca/learn-about-agriculture/organic-soil-management**. Find the complete list of information snapshots at **https://aitc-canada.ca/en-ca/learn-about-agriculture**.

Find Science 9, Science 20 and Biology 20 learning outcomes supported by this learning experience on the following pages.

Use this activity to compare food chains and food webs in natural ecosystems to the human food chain in agricultural ecosystems. Encourage students to apply understandings of nutrient sources to agricultural ecosystems.

Analyze biotic and abiotic factors in agricultural ecosystems and make connections between the biogeochemical cycles of nitrogen, carbon, oxygen and water in agricultural contexts.

Encourage students to focus on energy flows in agroecosystems through trophic levels and assess the impact of human activities on natural ecosystems.

After completing activities in this learning experience, have students do further investigations into sustainability practices applied by Alberta farmers that influence biogeochemical cycles and promote healthy agroecosystems.

> EXTEND LEARNING

Have students work in small groups or as a class to complete a **4Cs analysis**, focused on the concept of agroecosystems.

Challenge students to think about sustainable practices that are involved in agroecosystems and how these practices may be reflected in the aspects of the food system they are familiar with.

The 4Cs chart asks students to consider connections, concepts, challenges and changes involved with a topic. Each area on the 4Cs chart is sparked with a focusing question.

Create and display or have students develop a 4Cs chart such as the example below. Include the headings and focusing questions in each square of the chart. Students can complete the 4C chart on a group poster or use sticky notes to brainstorm ideas in groups, then post them on a class 4C poster.

CONNECTIONS	**CONCEPTS**
What connections can you make between what you have learned about agroecosystems and your own life or other learning? (*Consider connections such as those to food that is accessible and consumed; between natural and agricultural ecosystems; between natural and human food chains and webs; between human activities and energy flows and biogeochemical cycles*)	What key concepts or ideas do you think are important from the information on agroecosystems? (*Encourage students to identify concepts, ideas and examples that connect to the bigger picture of sustainability*)
CHALLENGES	**CHANGES**
What are the challenges involved in implementing agroecosystem and sustainability practices? (*Encourage students to consider the three pillars of sustainability - environmental, social and economic; have them pose questions about the economic costs involved in sustainability practices, the extent to which farmers' livelihoods should be protected; the balance between amount of food and quality of food; the cost and accessibility of food; the impact on natural ecosystems and cycles*)	What change in thinking did you have? What have you learned? (*Ask students to think about what they have learned that they did previously know; how their learning has influenced their thinking about the food production system and/or sustainability*)

Learning Experience Four: Learning Outcomes and Competency Map

project AGRICULTURE Activity	GRADE 9 SCIENCE	SCIENCE 20	BIOLOGY 20
	CONCEPTUAL KNOWLEDGE	**CONCEPTUAL KNOWLEDGE**	**CONCEPTUAL KNOWLEDGE**
LEARNING SOURCE **What are sustainable agroecosystems?** **[CONTINUED ON NEXT PAGE]**	**Unit C: Environmental Chemistry** 1. Investigate and describe, in general terms, the role of different substances in the environment in supporting or harming humans and other living things • Describe and illustrate processes by which chemicals are introduced to the environment or their concentrations are changed (e.g., dilution in streams, biomagnification through food chains) • Identify questions that may need to be addressed in deciding what substances – in what amounts – can be safely released into the environment (e.g., identify questions and considerations that may be important in determining how much phosphate can be released into river water without significant harm to living things) 2. Identify processes for measuring the quantity of different substances in the environment and for monitoring air and water quality • Identify substrates and nutrient sources for living things within a variety of environments • Identify chemical factors in an environment that might affect the health and distribution of living things in that environment (e.g., available oxygen, pH, dissolved nutrients in soil) 3. Analyze and evaluate mechanisms affecting the distribution of potentially harmful substances within an environment • Identify and evaluate information and evidence related to an issue in which environmental chemistry plays a major role (e.g., evaluate evidence that the use of insecticides to control mosquitoes has an effect/has no effect on bird populations)	**Unit D: Changes in Living Systems** 20–D1.1k Investigate and analyze an aquatic or a terrestrial local ecosystem, distinguish between biotic and abiotic factors, describe how these factors affect population size and • Infer the abiotic effects on life; e.g., light, nutrients, water, temperature • Infer biotic interactions; e.g., predator-prey relationships, competition, symbiotic relationships • Infer the influence of biota on the local environment; e.g., microclimates, soil, nutrients 20–D2.1k Outline the biogeochemical cycles of nitrogen, carbon, oxygen and water and, in general terms, describe their interconnectedness, building on knowledge of the hydrologic cycle from Science 10, Unit D 20–D2.2k Describe artificial and natural factors that affect the biogeochemical cycles: • Nitrogen cycle; e.g., automobile, agricultural and industrial contributions to NOx combining with water to produce nitric acid, nitrogen in manure and fertilizers • Carbon cycle; e.g., emissions of carbon oxides from extraction, distribution and combustion of fossil fuels, releases associated with deforestation and cement industries • Water cycle; e.g., extraction of ground water, dams for hydro-electricity and irrigation 20–D2.3k Analyze and describe how energy flows in an ecosystem, using the concepts of conservation of energy (second law of thermodynamics); energy input and output through trophic levels, food webs, chains and pyramids; and specific examples of autotrophs and heterotrophs 20–D2.4k Explain why population size and biomass are both directly related to the trophic level of the species and explain how trophic levels can be described in terms of pyramids of numbers, biomass or energy	**Unit A: Energy and Matter Exchange in the Biosphere** 20–A1.3k Explain the structure of ecosystem trophic levels, using models such as food chains and food webs 20–A1.4k Explain, quantitatively, the flow of energy and the exchange of matter in aquatic and terrestrial ecosystems, using models such as pyramids of numbers, biomass and energy 20–A1.1sts Explain that the process of scientific investigation includes analyzing evidence and providing explanations based upon scientific theories and concepts (NS5f) [ICT C6–4.2] • Explain, in terms of energy flow, the advantage of vegetarianism in densely populated countries 20–A2.1k Explain and summarize the biogeochemical cycling of carbon, oxygen, nitrogen and phosphorus and relate this to general reuse of all matter in the biosphere 20–A2.1sts Explain that science and technology have both intended and unintended consequences for humans and the environment (SEC3) [ICT F3–4.1] • Discuss the influence of human activities on the biogeochemical cycling of phosphorus, sulfur, iron and nitrogen: – fertilizer applications – waste and sewage disposal – acid deposition – persistent organic pollutants • Discuss the use of water by society, the impact such use has on water quality and quantity in ecosystems, and the need for water purification and conservation: – manufacturing and processing – agricultural systems 20–A3.2sts Explain that science and technology have both intended and unintended consequences for humans and the environment (SEC3) [ICT F3–4.1] • Describe how human activities can have a disrupting influence on the balance in the biosphere of photosynthetic and cellular respiratory activities: – fossil fuel combustion – depletion of stratospheric ozone – forest destruction

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[CONTINUED] **LEARNING SOURCE** **What are sustainable agroecosystems?**	**Unit C: Environmental Chemistry** Work collaboratively in carrying out investigations and in generating and evaluating ideas (e.g., assume responsibility for their share of work in preparing for investigations and in gathering and recording evidence; consider alternative ideas and approaches suggested by members of the group) Demonstrate sensitivity and responsibility in pursuing a balance between the needs of humans and a sustainable environment (e.g., show respect for all forms of life; modify their behaviour in light of an issue related to conservation and protection of the environment; recognize that the materials people use may have environmental consequences when people dispose of them)	**Unit D: Changes in Living Systems** 20–D2.1sts Explain that science and technology have both intended and unintended consequences for humans and the environment (SEC3) [ICT F2–4.8, F3–4.1] • Assess whether the efforts to reduce human impact on biogeochemical cycles are viable, taking into consideration a variety of perspectives (considerations for deep-well and deep-ocean injection of wastes, for example, include properties of waste, concentration, uncertainty, environmental concerns, risks and benefits to human health and organisms, costs) • Evaluate the influence of society, and the impact of a variety of technologies, on the nitrogen cycle • Discuss the use of water by society, the impact such use has on water quality and quantity in ecosystems, and the need for water purification and conservation, considering such things as manufacturing, the oil industry, agricultural systems, the mining industry and domestic daily water consumption	**Unit B: Ecosystems and Population Change** 20–B1.1k Define species, population, community and ecosystem and explain the interrelationships among them 20–B1.3k Identify biotic and abiotic characteristics and explain their influence in an aquatic and a terrestrial ecosystem in the local region; e.g., stream, lake, prairie, boreal forest, vacant lot, sports field 20–B1.4k Explain how limiting factors influence organism distribution and range; e.g., • Abiotic factors: soil, relative humidity, moisture, ambient temperature, sunlight, nutrients, oxygen • Biotic factors: competitors, predators and parasites
	PROCEDURAL KNOWLEDGE	**PROCEDURAL KNOWLEDGE**	**PROCEDURAL KNOWLEDGE**
BUILD COMPETENCIES **Ecosystem cycles**  [CONTINUED ON NEXT PAGE]	**Unit C: Environmental Chemistry** Conduct investigations into the relationships between and among observations, and gather and record qualitative and quantitative data • Identify data and information that are relevant to the issue • Select and integrate information that is relevant to the issue (e.g., demonstrate proficiency in uploading and downloading text, image, audio and video files) Analyze qualitative and quantitative data, and develop and assess possible explanations • Apply given criteria for evaluating evidence and sources of information (e.g., use scatterplot data in evaluating how strong a relationship exists between two variables; evaluate claims of environmental impacts, based on the scope and relevance of supporting evidence) • Identify new questions and problems that arise from what was learned	**Unit D: Changes in Living Systems** 20–D1.1s Formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues • Design an experiment and identify specific variables to investigate relationships between biotic and abiotic elements of a micro-ecosystem (IP–NS2) 20–D2.1s Formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues • Predict disruptions in the nitrogen cycle that are caused by human activities (IP–NS3) 20–D2.2s Conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information • Draw, by hand or using technology, annotated diagrams of energy flow in food chains, webs and pyramids (PR–NS4)	**Unit A: Energy and Matter Exchange in the Biosphere** 20–A1.2s Conduct investigations into relationships among observable variables and use a broad range of tools and techniques to gather and record data and information • Draw, by hand or using technology, annotated diagrams of food chains, food webs and ecological pyramids (PR–NS4). 20–A2.1s Formulate questions about observed relationships and plan investigations of questions, ideas, problems and issues • Predict disruptions in the nitrogen and phosphorus cycles that are caused by human activities (IP–NS3) [ICT C6–4.1] 20–A2.4s Work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results • Work cooperatively in a group to investigate the influence of human activities on the biogeochemical cycles and use appropriate multimedia to present the information to a group (CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.2, F2–4.7, P3–4.1]

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[CONTINUED] **BUILD COMPETENCIES** Ecosystem cycles 	**Unit C: Environmental Chemistry** Work collaboratively on problems; and use appropriate language and formats to communicate ideas, procedures and results • Work cooperatively with team members to develop and carry out a plan, and troubleshoot problems as they arise	**Unit D: Changes in Living Systems** 20–D2.4s work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results • Work cooperatively in a group to investigate the influence of human activities on the biogeochemical cycles and, using appropriate multimedia, present the findings (CT–SEC1, CT–SEC2) [ICT P3–4.1] 20–D3.5k Describe how factors including space, accumulation of wastes (e.g., salinization of soil), competition, technological innovations, irrigation practices (e.g., Hohokam farmers) and the availability of food impact the size of populations 20–D3.4s Work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results	**Unit A: Energy and Matter Exchange in the Biosphere** 20–A3.4s Work collaboratively in addressing problems and apply the skills and conventions of science in communicating information and ideas and in assessing results • Work cooperatively as a group to investigate, synthesize and present information on the effects of changes to stratospheric ozone levels on society, agriculture, plants and animals (CT–SEC1, CT–SEC2, CT–SEC3) [ICT C1–4.4, C7–4.2, F2–4.7 **Unit B: Ecosystems and Population Change** 20–B1.1s Formulate questions about observed relationships; plan investigations of questions, ideas, problems and issues; and define and delimit problems to facilitate investigation • Hypothesize the role of biotic and abiotic factors in ecosystems; e.g., competition and chinooks (IP–NS3) [ICT C6–4.1] 20–B1.3s Analyze data and apply mathematical and conceptual models to develop and assess possible solutions • Analyze the interrelationship of biotic and abiotic characteristics that make up the ecosystem studied (AI–NS2, AI–NS3, AI–NS6)