STUDY GUIDE

2019

Agroecology

FORESTS ONTARIO

ONTARIO ENVIROTHON 2019

Acknowledgements

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2019 Learning Objectives

Key Topics

1. Understanding how ecosystems function and the services they provide.
2. Understanding the importance of good soil health, as the foundation of a healthy ecosystem.
3. Understanding agroecology on large and small farm operations, and the indicators of sustainable farming.
4. How sustainable and best management farming practices enhance and protect soil health, water quality and water quantity, biodiversity, manage insect pests, disease, and weeds.
5. Understand differences between local, regional, and national foods systems that are vital to grow food for an ever increasing world population; and the importance of each food system.
6. New technologies that help provide more efficient agriculture production.

Learning Objectives

1. Define agroecology. Undewrstanding the importance of moving toward these farming principals and systems to conserve natural resources, mitigate climate change, reduce erosion and protect water quality and quantity as well as promote pollination.
2. Basic knowledge of soil science including its physical, chemical and biological processes and its vital role in sustainable farming.
3. Comprehension of farming practices that build soil organic matter such as organic amendments, crop rotations, cover crops, conservation tillage, and management intensive grazing systems to improve soil health.
4. Understand best management practices that reduce water use such as conservation tillage, cover crops, plant selection, precision agriculture and sub-surface drip irrigation.
5. Knowledge of the role pollinators play in farming and methods to attract them.
6. Understand integrated pest management and biological pest control techniques used to prevent insect pest, disease, and weed problems.
7. Understand the role of new technology: using UAV's (unmanned aerial vehicle), precision agriculture and robotics to increase farm efficiency for food production.
8. Describe the economic, social, and environmental benefits of sustainable agriculture to local communities.

Tools and Recommended Resources

The following tools and recommended resources can better help you and your team prepare for the Envirothon program:

Identification Apps

ID pests, diseases, weeds, grasses and common plants

Federal Noxious Weeds Key
https://www.farms.com/agriculture-apps/education/federal-noxious-weeds-key

Mid-Atlantic Early Detection Network
https://www.farms.com/agriculture-apps/education/mid-atlantic-early-detection-network

Weed Alert Mobile App
https://www.farms.com/agriculture-apps/education/weed-alert-mobile-app

Palm ID Key
https://www.farms.com/agriculture-apps/education/palm-id-key

Educational apps and Resources

Glossary

Agriculture Glossary
https://www.farms.com/agriculture-apps/education/agriculture-glossary

Career Finder

Ag Career Finder
https://www.farms.com/agriculture-apps/education/ag-career-finder

Other

Agrifin
https://www.farms.com/agriculture-apps/education/agrifin

Grow Your Own
https://www.farms.com/agriculture-apps/education/grow-your-own

Green & Organic Agriculture
https://www.farms.com/agriculture-apps/education/green-and-organic-agriculture

1.0 Introduction to Agroecology

The food and agriculture industry has succeeded in supplying large volumes of food to global markets. However in doing so some agriculture techniques have been found to cause degradation of soil and aquatic ecosystems as well as emit high levels of Greenhouse Gas Emissions (GHGs) and contribute to ongoing **biodiversity** loss. In response to these important issues, scientists are trying to find a solution which will allow for food production while safe guarding environmental functions through the implementation of sustainable food systems. Some scientists and farmers believe that Agroecology is the solution to this growing issue.

Broadly speaking, agroecology is the application of ecological concepts and principles to agriculture. Agroecology as a system optimizes interactions between plants, animals, humans and the environment while safeguarding the social aspects of a sustainable and fair food system. It is believed that agroecology can deliver food security and ecosystem health, while still promoting economic stability. In saying this, agroecology is location and situation specific – there is not a "one size fits all" approach. Rather, it offers a set of principles to govern food and farming systems – approaches that can be locally-adapted and regionally applied.

With increasing pressure on ecosystems and biodiversity, the demand for sustainable farming practices has never been greater. Through this study guide students will be introduced to agroecology, its key principals and the benefits of agroecology.

1.1 Agroecology Principals

Agroecology is characterized by practices that focus on maximizing biodiversity and emphasize interaction and productivity across farms and local ecosystems. In many cases, these goals are accomplished without the use of **synthetic pesticides**, minimizing impacts associated with improper application, protecting wildlife habitat and **ecosystem services.**

Agroecology not only prioritizes environmentally sustainable approaches, but also develops socially equitable technologies that will ensure food security and ecosystem health, both locally and regionally. In 2012 the Food and Agriculture Organization of the United Nations (FAO) estimated that local, small-scale farming operations around the world produced more than 70% of food on the market. Recent studies have shown that applying agroecology principals in small-scale settings can produce up to two times more food in the next ten years (USC Canada, 2017; Fraser, 2012). Agroecological principles present a sustainable approach which can help to ensure farms continue to produce the high levels of diversity, integration, efficiency, resilience and productivity needed to adapt and feed the world, all while protecting and preserving ecosystem stability. Communities around the globe are benefiting from agroecology projects producing more affordable food that has a minimal impact on the environment, and ensures sustainability for future generations.

Socio-economic benefits of agroecology

- Increase income
- Maintain/create jobs
- Saving on chemicals
- Increase food security

Outcomes of diversified agroecological systems

- Similar/same crop yields as conventional farming
- Enhanced biodiversity on and off the farm

1.1.1 KEY ELEMENTS

The FAO has identified ten key elements of agroecology. These interdependent and interconnected elements are intended to be a guide for policymakers, practitioners, and stakeholders when considering and evaluating transitions in agricultural systems.

1. Diversity
2. Co-Creation and Sharing of Knowledge
3. Synergies
4. Efficiency
5. Recycling
6. Resilience
7. Human and Social Values
8. Culture and Food Traditions
9. Responsible governance
10. Circular and Solitary Economy

To view the complete list of principals with descriptions visit http://www.fao.org/agroecology/en

1.2 Innovations and Technology

Technological advancements are growing significantly each year, and with this comes change in the way we understand and approach challenges. In response to continued stress on aquatic and terrestrial ecosystems caused by competing demands, more emphasis has been placed on agroecology approaches and Best Management Practices (BMPs). Thus, food production can continue to become more sustainable and have less of a negative impact on the environment.

Examples include the following:

- Integrated Pest Management (IPM) and biological pest control techniques which reduce the use of pesticides and other potentially harmful chemicals.
- Social media, blogs (i.e Baute Bug Blog) and mobile apps which allow growers to identify weeds and insects in order to understand the best pest control techniques. Tools to help select the appropriate cover crops to build soil health or protect water quality are also available. These tools allow growers to share local knowledge and innovation.
- Development of knowledge-intensive resources (i.e. Midwest Cover Crop Council) that are specific to different landscapes which emphasize low-cost/affordable techniques that work with the local ecosystem, improving the local economy, society and environment.

2.0 Agroecology Principles in Soil Conservation

Soil contains a mixture of mineral and organic components that naturally hold a definite form, structure and composition. Soil ecosystems are incredibly biodiverse and are home to one quarter of all living organisms. It is this abundance of life which enables soil ecosystems to sequester more carbon than the atmosphere and vegetation (Soil Association, 2003). Carbon sequestration is the process through which carbon dioxide is removed from the atmosphere and is held in a liquid or solid form, in this case in soil ecosystems.

2.1 Components of soils

Soils may also be thought of as a porous media, like a sponge, containing both:

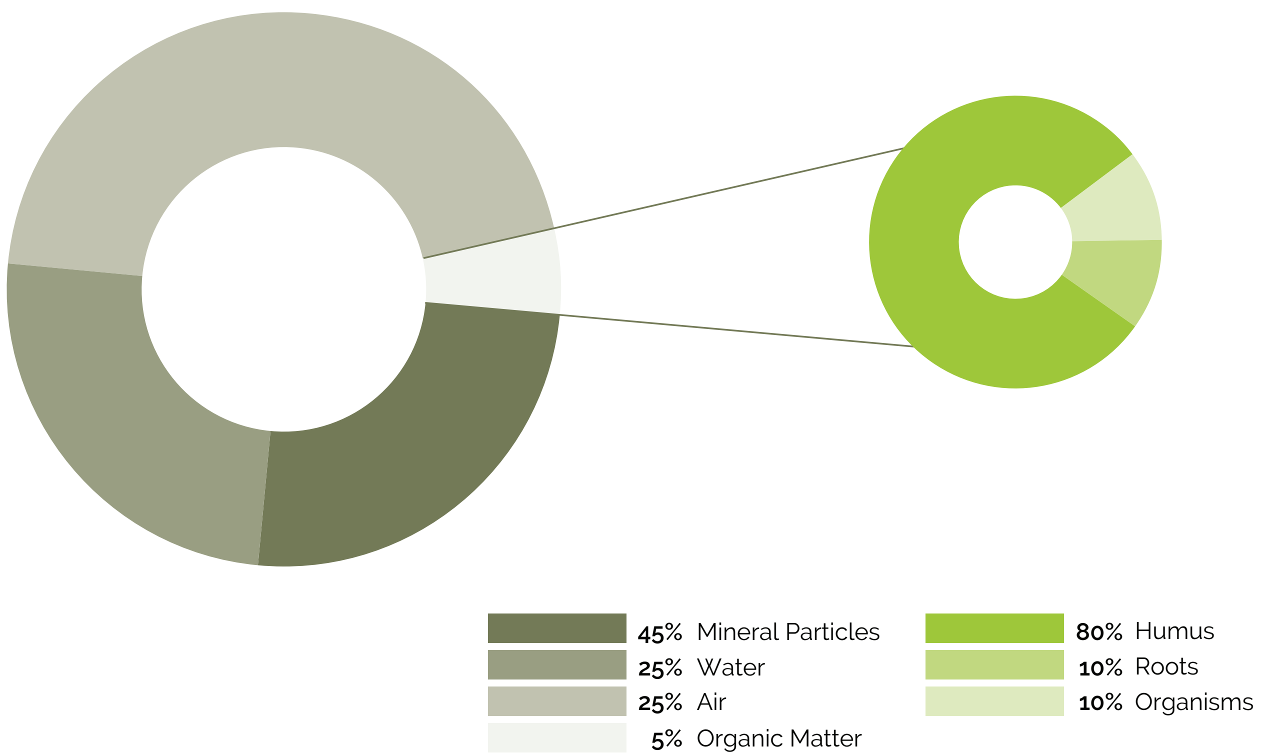
Solids the solid particles that make up the soil skeleton, including:

- Mineral grains
- Organic matter (both living and dead)

Voids the "empty" spaces between the solid particles that contain:

- Liquids ("water")
- Gases ("air")

Very generally, these components are considered to occur in the following proportions:



2.2 Soil Formation

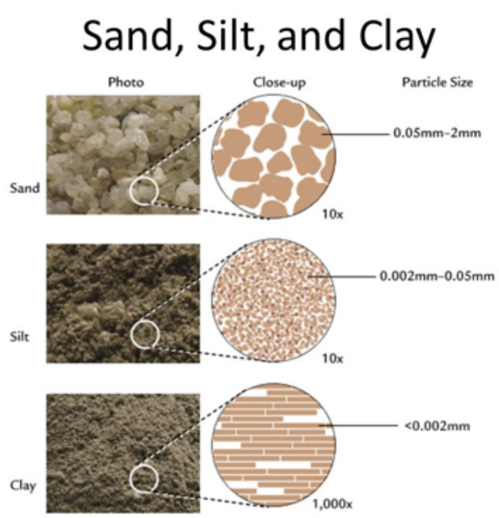
Soil formation is influenced by climate, topography, living organisms, and habitat structure as well as parent material decomposition over time. The conditions that affect soil differ from location to location and depend on the amount of time the material has been in place.

The five soil forming factors are:

1. Parent material
2. Climate
3. Living organisms
4. Landscape position
5. Time

2.3 Soil Texture

Mineral soils are composed of particles that are broadly categorized into three particle size classes: Sand, Silt, and Clay (refer to Figure 1). Particles less than 2mm in diameter are considered soil. Larger particles are considered coarse fragments. Depending on the proportions or percentages of each size class, a name is assigned to indicate the soil textural class. By determining the proportions or percentages of sand, silt and clay of samples in the field or laboratory, soils can be classified into various textural classes.



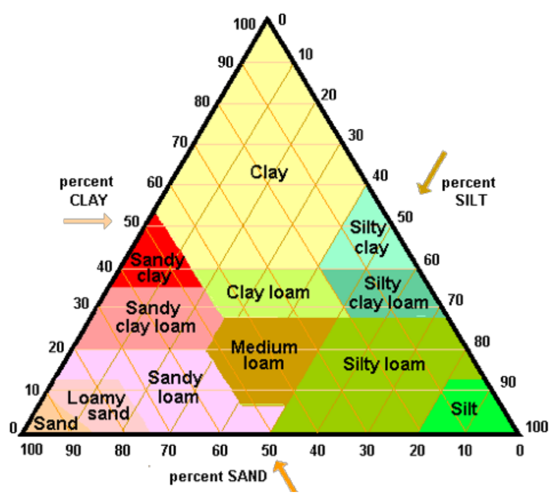


Figure 1 (Left). Soil is composed of ranging percentages of the following: Sand, Silt or Clay.

Source: Kathleen Halme, n.d.

Figure 2 (Right). USDA Texture Triangle used to determine the class names for various soils.

Source: USDA, n.d.

Soil Textural Triangle: This tool is used to determine soil textural class using the percentages of sand, silt, and clay in a mineral soil sample. The sum of the sand + silt + clay percentages must equal 100 percent. Therefore, knowing the percentages of any of the two size classes the triangle allows users to calculate the third percentage to determine the soil texture (refer to Figure 2).

How to use the Soil Texture Triangle: To start, locate the percentages of sand, silt and/or clay on their respective axes. The point at which the lines intersect will indicate the textural class name. When the intersecting line falls between textural classes then the name of the finer textural class is selected. For example, a mineral soil sample containing 40% clay, 30% sand and 30% silt will be classified as a clay rather than a clay loam (My Agriculture Information Bank, 2015).

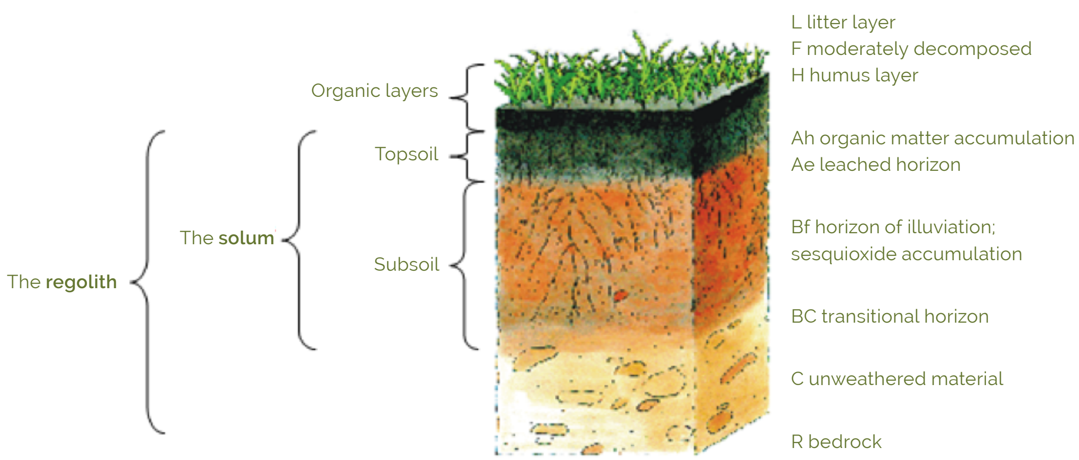
2.4 Soil Horizons

Through the interactions of the five soil-forming factors, soil constituents are reorganized into visibly, chemically, and/or physically distinct layers, referred to as horizons. Soils can be composed of both organic and mineral soil horizons. Organic horizons in poorly drained soils are classified as O horizons, while those in upland forests consist of L, F, H horizons. The master mineral soil horizons are A, B, C and R (Bedrock).

- The O horizon contains more than 30% organic matter. O horizons occur in areas that are saturated and anaerobic, such as wetlands, where decomposition is slowed leaving organic material developed mainly from bog vegetation to accumulate. The horizon contains organic matter in various degrees of decomposition including: highly decomposed, referred to as humic; moderately decomposed, referred to as mesic; and minimally decomposed, referred to as fibric. Because of their organic content, these horizons are typically black or dark brown in colour.
- The L, F, H horizons also contain more than 30% organic matter. These horizons occur in forested areas and are composed of leaf litter, twigs and woody debris. Similar to the O horizons these horizons represent a gradient of decomposition, L is undecomposed litter, F is partially decomposed folic material, and H, the humus is well decomposed organic materials with original structure still intact.
- The A horizon is a mineral horizon and is commonly referred to as topsoil as it forms at the surface. The A horizon is often buried by natural events and processes such as landslides and erosion. When the A horizon is buried, it is evident that there have been changes to the soil and landscape. A horizons can be dark coloured (Ah) due to the accumulation of organic matter or be light coloured (Ae) due to the eluviation (leaching) of organic matter such as iron or aluminum.
- The B horizon, also known as a mineral subsurface horizon, is situated in a zone of accumulation and is also known as the "illuviated" horizon. The materials that accumulate in this zone include organic matter, clay, soluble salts, and/or iron and aluminum. Minerals in the B horizon may be undergoing transformations such as chemical alteration of clay structure. Sometimes the B horizon will be exposed at the surface if processes such as erosion strip the horizon above it. This will typically occur when the landscape has been intensively modified.
- The C horizon consists of unweathered parent material that may include glacial till or lake sediments that have remained relatively unchanged throughout the soil forming processes. Some low intensity processes, such as the movement of soluble salts or oxidization and reduction of iron may occur.
- Lastly, the R layer is bedrock and is important when developing land use management plans.

Figure 3. Depiction of CDN soil horizons.

Source: Hazlet, n.d.



2.5 Soil Classification

The distinctive set of soil horizons that develop at any particular locations are the basis for classifying the soil. The first level within the classification system is the Order, which reflects the overall soil environment and the effects of the dominant soil-forming process. The Canadian System of Soil Classification currently includes 10 Orders illustrated in Figure 4.

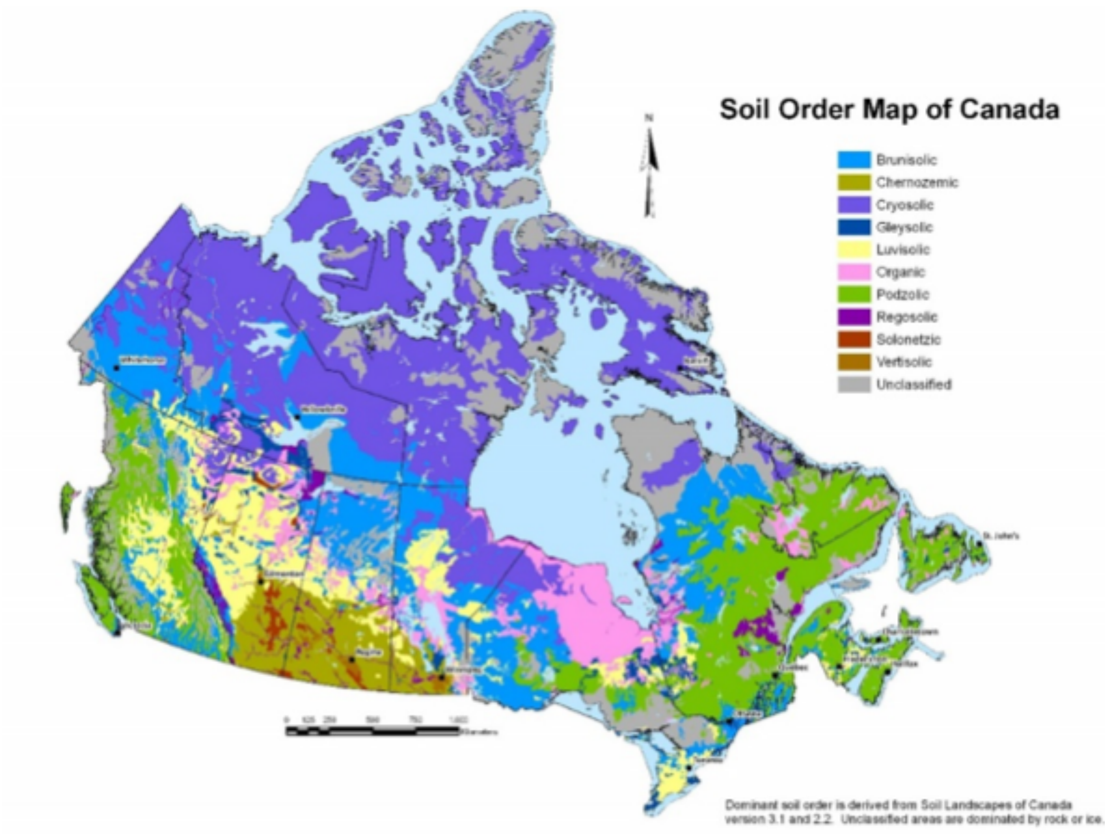


Figure 4. Soil orders in Canada.

Source: Soils of Canada, 2018.

2.6 Sustainable Soil Management

Soil degradation characterized by compaction, low soil organic matter (SOM), loss of structure, poor internal drainage, **salinization** and acidity can be attributed to poor agricultural practices. By looking to natural systems to inform agricultural practices, agroecology as a system of agriculture and land management, can potentially provide the answer to these global problems (Soil Association, 2003).

The following agroecological practices are examples of techniques which minimize soil degradation.

- **Conservation Tillage**: Tillage refers to the mechanical disruption of soils to incorporate crop residues, manage weeds, or loosen compaction; the process also accelerates the breakdown of organic matter. Tillage practices can expose bare soil to carbon loss as well as increase erosion and **runoff** rates. Conservation tillage ranges from limited tillage to no-till approaches that seek to balance trade-offs to achieve healthy soils.
- **Crop Rotation:** Growing different crops on an annual basis, intercropping (arranging multiple crops on a single field), or growing different crops in close proximity can improve, or maintain, soil health. The crop rotation process can also help to prevent the spread of diseases and pests, reduce erosion, support pollinators and other beneficial insects all while maintaining productivity.

- **Green Manure:** A green manure is a crop that is grown solely for the purpose of increasing soil fertility. Legumes, such as clovers, which can fix nitrogen from the air through their relationship with **rhizobia**, are common green manure crops. Once a green manure crop is incorporated into soils, nitrogen and other important minerals are released for the next crop. Green manures can also reduce run-off and soil erosion by maintaining permanent soil cover. Deep rooted green manure crops open up the soil as they grow, thus improving water infiltration. The addition of these green manure crops as organic matter further improves water penetration into the soil and builds SOM levels. With improved soil structure, green manures can reduce the leaching of nutrients; improve soil fertility while also reducing nutrient additions to ground water and streams. Green manure crops can also outcompete and suppress weeds, limiting the requirements for pesticides and other chemicals.
- **Compost:** Compost can be made on the farm from waste biomass generated by crop production, e.g. the straw left over from barley or the inedible roots and shoots of other crops. Nutrient losses through run off or leaching are much lower when compost is used compared with equivalent applications of fresh manure or slurry. Compost has also been shown to contain beneficial microorganisms that help protect crops from disease causing organisms (Soil Association, 2003).
- **Manure:** Manure can provide a valuable source of nutrients, but its application needs to be well managed to meet the needs of the land, structure of the soil, requirements of the crop and the nutrient availability within the manure. For instance, **slurry** can be improved by treating it in advance with a bacterial slurry additive to enhance soil biology.
- **Livestock**: Livestock are found in many agroecosystems and include many species and breeds raised in many different production systems. Agricultural productivity, income and resilience can be increased by including livestock with other components such as trees and crop plants. Good livestock management practices increase plant biodiversity in grasslands, which in turn enhances productivity, resilience, and other ecosystem services. (Livestock and Agroecology, FAO 2018) In addition to meat, milk and eggs, livestock can provide natural fertilizer, hides and skins. Livestock can be essential to livelihoods, nutrition and food security (FAO 2018).

Additional BMP's focused on safeguard and promote soil health have been developed by the Ontario Ministry of Agriculture and Rural Affairs (OMAFRA). Copies of these BMP's can be found online here.

2.7 How Agroecology can promote food supply

By applying agroecological methods, high yields for each crop in sequential rotations have been attained. Long term studies have also found that agroecological farming practices tend to improve soil health when compared to intensive practices and may produce comparable yields in some instances. Therefore, economic returns for crops produced using agroecological principals could be greater than intensive crops even when accounting for higher labour costs.

For more information about soils please refer to the Ontario Envirothon Soils Study Guide.

2.8 Case Study: Reducing Prairie Erosion Rates

The Government of Canada has been tracking soil erosion in the Prairies for over 30 years. Through the data collected, it was discovered that there have been significant improvements in soil health due to changes in land-use practices such as the reduction in summer **fallowing** and reduced tillage intensity. In particular, the adoption of no-till in cereal crops has had the greatest influence in reducing soil erosion due to the large portion of prairie lands devoted to cereal crop production.

The panel map in **Figure 5** shows the change in erosion risk from tillage in Alberta, Saskatchewan and Manitoba for the census years 1981, 1991 and 2011. This shift in agricultural practices from intensive tillage to no-till has occurred due to the improved understanding that the removal of crop residue leaves the subsoil exposed, making it vulnerable to erosion from wind and water (Agriculture and Agri-Food Canada, 2018). This is important to consider because the Prairie region accounts for over 85% of farmland in Canada, changes in the provinces significantly impact national averages as illustrates in this case study.

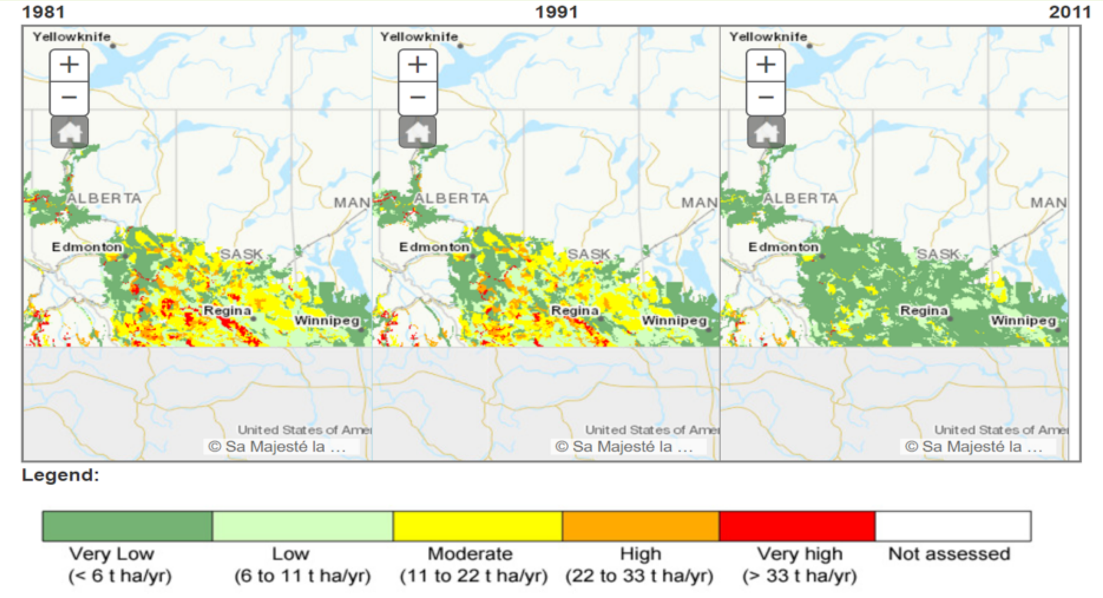


Figure 5. Soil Erosion Risk in the Prairies – Comparing 1981, 1991 and 2011. The index uses the same five-colour scheme as the indicator maps whereby dark green represents a desirable or healthy state and red represents least desirable or least healthy. The dark green areas represent a 'desired' class status, the light green represents a 'good' class status, the yellow areas represent a 'moderate' class status, the orange represents a 'poor' class status, and the the red represents an 'at risk' class status.

Source: Agriculture and Agri-Food Canada, 2018.

2.9 Hands-On Activity: Tea Bag Index Project

Summary

This activity requires using Lipton tea bags, specifically Green and Rooibos tea. Students will measure the decay of organic matter (plants) by burying them and then digging them up after three months. After being retrieved the bags are dried and cleaned, weighed and recorded to a minimum of two decimal places. Weight loss, decomposition rate and stabilization index will be calculated using the collected data from the excel sheet. Results can be sent to the Tea Bag Index Project, a global citizen science experiment. Students will learn that there is biological activity in the soils, and the intensity of this biological activity depends on environmental conditions and the nature of soil organic matter.

Materials Needed

- Lipton Rooibos Tea bags (93% rooibos)
- Lipton Green Tea bags (89% green tea)
- Permanent, waterproof marker
- Spade or spoon
- Sticks to indicate the place where the tea is buried
- Scale, which should be accurate on 0.01 grams or the Tea Bag Index flyer (TBI), which can be used as a scale and ordered via the TBI website
- Warm and sunny place for drying the tea bags
- Data sheet to fill in your report (link on pg.3)
- Microsoft Excel (to determine calculations)
- Internet browser to send results to data base

Student Learning Objectives

- After participating students should demonstrate knowledge of:
- The concept of decomposition and its relevance for soil fertility and our climate
- Why decomposition is affected by climate conditions
- Why different materials have different decomposition rates
- Why soil quality is important
- Why decomposition differs in different soil orders and in soils of different regions

Method:

1. Take an unused Lipton Green Tea (EAN 87 22700 05552 5) and Rooibos Tea (EAN 87 22700 18843 8) bag. Bury at least four sets of tea bags per site.
2. Print data sheets and use calculation sheet
3. Mark/number the tea bags on the white side of the label with a permanent black marker.
4. Before you bury the tea, measure the weight of each tea bag using scales (minimum 0.01 g accuracy) or the TBI flyer. Fill in the weight in the data form.
5. Bury the teabags in 8 cm-deep, separate holes while keeping the labels visible above the soil (e.g., in nearby forest, grassland or cropland).
6. Fill in the data sheet: Note the initial weight, date of burial, geographical position, environmental properties (e.g., grassland, forest, agricultural land, which plants are around the burial site), and experimental conditions of the site.
7. Recover the tea bags after approximately 90 days.
8. Remove adhered soil particles and dry in a sunny environment for at least 3 days.
9. Remove what is left of the label (the yellow/white square) but leave the string and weigh the bags using scales (minimum 0.01 g accuracy) or the TBI flyer.
10. Fill in the data form on the site containing: Date of recovery, weight after 90 days, and other additional observations.
11. Calculate weight loss as percentage of the start weight. Calculate your TBI by using the Excel sheet and compare the calculated parameters. Average per location or soil order and compare

Sample Excel Sheet

J4

	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
3	tea bag weight of the bag				0.1223											
4	hydrolysable fraction			Green tea	0.84											
5				Rooibos tea	0.55											
6																
7		Initial teabag weight		Final teabag weight		Initial tea weight		Final tea weight								
8	sample nai	Green	Rooibos	Green	Rooibos	Green	Rooibos	Green	Rooibos		Fr. Dec. green	S	ar	Fr. Rem Rooibos	days(t)	k
9	sample1	2.01788	2.19386			1.76638	1.94236	-0.2244	-0.2244		1.127039549	-0.33853	0.73887	-0.115529373		#NUM!
10	sample2															
11	sample3															
12	sample4															
13	sample5															
14	sample6															
15	sample7															
16	sample8															
17	sample9															
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25	sample17															
26	sample18															
27	sample19															
28	sample20															
29	sample21															
30	sample22															

Importance of Activity: Decomposition releases nutrients from the decaying organic matter into the soil that can be used by soil organisms and plants. It releases carbon dioxide into the atmosphere, which is a greenhouse gas that contributes to the effects of climate change. Therefore, as an experiment, it is important to relate soil quality and its relevance to climate change.

3.0 Agroecology Principles in Water Conservation & Quality

Agriculture is one of the most water consuming practices in the world, accounting for over 70% of global freshwater use (Global Agriculture, n.d). In Ontario agriculture is a significant user of water, but still falls behind municipal use and manufacturing (Loe, Kreutzwiser and Ivey, 2001). While the majority of water accessed is used to grow crops and livestock, a portion of the extracted water is also lost to runoff and evaporation. In Canada, over 90% of farms rely solely on precipitation for watering their crops – but this varies regionally according to climatic conditions (Farm and Food Care, 2014).

3.1 Agricultural Impacts on Water

If nutrients, in particular phosphorus or nitrogen, enter lakes or rivers in the form of runoff, they can cause excessive algae growth. This growth in turn results in reduced light and oxygen levels in aquatic ecosystems, conditions which can lead to dead zones along with mass mortality events for fish and other aquatic species. This process of nutrient loading is called **eutrophication**, and is an increasing issue around the world due to runoff and improperly treated sewage (Beketov et al., 2013). In addition to runoff nutrients can enter water systems through **tile drainage** and **seepage** into the groundwater, eventually reaching other water bodies. This, along with draining fields can have serious impacts on the **hydrology** of an area, altering the flow of groundwater, rivers and streams, causing **sediment loading** (Blann et al., 2009).

Pesticides also have the capacity to negatively impact aquatic systems. Although useful for protecting and producing large amounts of food, if improperly applied pesticides can have negative effects on surrounding water bodies and wildlife, as these chemicals dissolve and remain in the hydrological system for extended periods of time (Scholz et al., 2012).

3.2 Agroecology and Water Conservation

Water is an essential component for the production of food and sustaining healthy agricultural systems. It is known that water quality is a principal that is connected to agricultural practices around the world. For the successful development of crops and livestock, farmers depend greatly on adequate supply of good quality water. In agroecology there are many BMP's that can be implemented to conserve water. These practices include: residue management, cover crops, plant selection, precision agriculture and **sub-surface drip irrigation.**

Residue Management: This practice leaves the residue from the previous year's harvest on the land before and after planting the next year's crop. This reduces runoff and conserves water by retaining and holding moisture, better allowing plants to absorb it. This practice is widely used in agriculture for its many benefits including reductions in water use (Busari et al. 2015).

Cover crops: These are crops which are specifically selected to protect and improve the quality of agricultural soils, additionally they may have value for livestock grazing or animal feed. Cover crops improve the lands ability to absorb and hold water by retaining moisture in plant roots during times of drought and acting as a sponge in times of rainfall. Many different plant species can be used as cover crops, common ones include; barley, oats, and ryegrass (Florentin et al, 2010). Another common group of cover crops are legumes, including clover, vetch, or daikon radish. These plants are ideal because they form a large tap root that is able to penetrate deep into the soil creating space for air and water (Florentin et al, 2010).

Plant Selection: Plant selection is strategically choosing and planting species that will flourish in a particular area being grown. Selecting plants adapted for the local climate will facilitate crop production and reduce fertilizer and water requirements. Additionally farmers can use a technique known as companion planting where different crops are planted in close proximity to increase production through pest control, pollination or providing habitat to beneficial species.

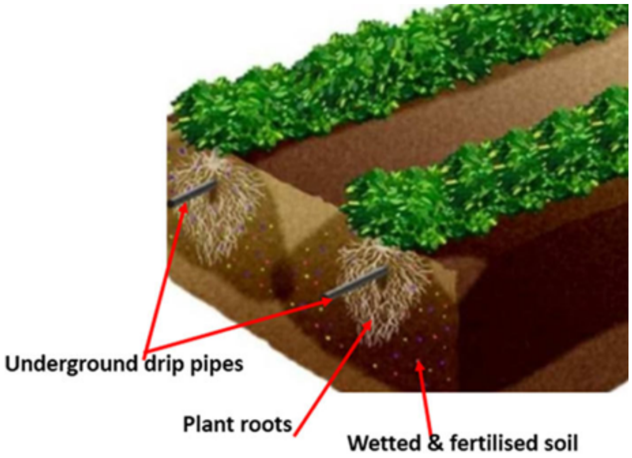
Precision agriculture: Precision agriculture is a highly advanced management concept that is based on observing, measuring and responding to variations in crops and productivity. Using Geographic Information Systems (GIS) and Global Positioning Systems (GPS), the goal of this practice is to predict, map and optimize the productivity of an operation. Farm maps can be created using a hand-held GPS, GPS within farming equipment or by using Unmanned Aerial Vehicles (UAVs) with mapping capabilities. UAVs are often used to get a 'bird's eye view' of conditions on the ground and can take photos that can assist with decision making. Precision agriculture helps farmers calculate the cost of inputs required to ensure crop success and can help reduce the overuse of water (Alberta Agriculture and Forestry, 2014). Precision agriculture can be used to precisely apply different rates of nutrients, to provide the precise amount of feed to livestock and to apply the correct amount of irrigated water at the right time and place.

Sub-surface drip irrigation: This system uses drip tubes or drip tape buried in the sub-surface of the ground to dispense a controlled amount of water and is an effective alternative to flood irrigation. Sub-surface drip irrigation reduces evaporation and runoff and can reduce water requirements on farms by 25- 50%. Although very effective for conserving water, this type of system is expensive to establish and requires ongoing maintenance (Reich, 2014).

With agriculture being one of the most consumptive activities by humans, it is important that water conservation is a priority in all farming operations. With agroecology practices becoming more widely recognized as a viable alternative to **intensive agriculture** more people are investing in these BMP's and using water responsibly.

Figure 7. A diagram of a sub-surface drip system.

Source: PoratoPro.com, 2014



For more information about Aquatics please refer to the Ontario Envirothon Aquatics Study Guide.

Figure 8. Farmer Al Kominek setting his drip pipe irrigation system near Dresden, Ontario, 2014.

3.4 Case Study: Heartnut Grove Inc. Family Farm

Background

Beginning in the 1920s, agricultural operations dominated the drought-prone Norfolk Sand Plain region of Southern Ontario, where tobacco was grown. One such farm is Heartnut Grove Inc.

Located outside of Dresden, Ontario, this farm falls within one of the most drought-prone regions in the province. Al Kominek, a farmer and sales representative with Heartnut Grove Inc., grows corn, soybeans and wheat. Throughout the year water inputs could be drastically reduced by lack of rain and evaporation, as a result Kominek would have to pay for higher quantities of water to irrigate his crop.

Solution

To solve this issue, Kominek installed a sub-surface drip irrigation system in 2014, a relatively uncommon practice in the region at the time. Sub-surface drip irrigation systems have been used for years in western Canada and in the Southern United States as they are effective at reducing evaporation through underground dispersal. Kominek created a nine-acre demonstration site, where he planted corn, soybeans and wheat to see the impacts of the irrigation system.

Results

As of 2015, the implementation of a sub-surface drip irrigation system was successful, creating a more productive season (almost twice as productive) when compared to the previous year which used an overhead irrigation method. Additionally the sub-surface drip irrigation system was successful at conserving water year-round. it is estimated the system will last a minimum of 15 years if properly maintained, making it an attractive option for farmers in drought prone regions.

3.5 Hands on Activity: Water Management

Source: National Agriculture in the Classroom, 2013

Summary

Students will discuss the limited amount of fresh water on earth. Identify how best management practices can reduce water consumption. They will also discuss the need for water conservation and protection related to population growth and agriculture, and compare and contrast methods of irrigation for water conservation.

Materials

- Water PowerPoint
- Map of local watershed (optional)
- Journey 2050: Water video

Activity

1. Open the *Water* PowerPoint.
2. **Slide 3:** Play the Journey 2050: Water video **(5:07)**.
   Engage students with the video by asking them to discover three things:
   - How is water used in agriculture?
   - What methods do farmers use to irrigate their crops?
   - What best practices can be implemented to use water more efficiently in agriculture? (Background and discussion prompts are outlined in the steps below and in the PowerPoint notes).
3. **How is water used in agriculture?**
   - **Slide 4:** Ask students, "What do farmers need to grow a crop?" Use the click animations on the PowerPoint slide to display open space, fertile soil, sunshine, correct climate and seeds. Once these items have been discussed, explain that there is one more item. Without it, the crop will fail completely. Ask students what this could be. (*water*)
   - What methods do farmers use to irrigate their crops? Describe these common methods:
   - **Slide 6:** Drip Irrigation—Using the picture, describe drip irrigation. Water is sent through plastic pipes that are laid along the crop rows. Tiny holes allow water to drip at the base of the plants. This method is most effective for fruit and vegetable crops.
   - **Slide 7:** Center-Pivot Irrigation—Using the picture, describe center-pivot irrigation. This is a large sprinkling system on wheels. A line of sprinklers pivots around a center point in a field. This method of irrigation is what creates green crop circles that can be seen from a plane.
   - **Slide 9:** Flood/Furrow Irrigation—Using the picture, describe flood or furrow irrigation. To utilize this method of irrigation, farmers dig furrows between their crop rows. Water is delivered to the top of each row using ditches or siphon hoses. The crop is irrigated as the water flows from the top to the bottom of each row.
   - **Slide 10:** Ask students, "Besides irrigation, what other ways do farmers use water?" Allow students to offer their answers. Guide the discussion, clarifying that irrigation accounts for the majority of water use in agriculture, but water is also needed to raise livestock and to clean and sterilize facilities such as milk barns or food processing plants to prevent food-borne illnesses.

4. **What best practices can be implemented to use water most efficiently in agriculture?**
    - **Slide 11:** Help students recall the definition of *best practice*. Next, apply the principle to water conservation and ask for ideas of how farmers can conserve water as they grow our food.
    - **Slide 12:** Refer to the video clip they viewed at the beginning of the lesson. It described a practice called *conservation tillage*. Explain that farmers will leave crop residue (materials such as stalks, stems and seeds) in their fields without plowing it under in the fall. In the spring, they use an air seeder (device that precisely plants the seeds at equal distances and proper depth in the soil and then covers them) to plant the next crop, eliminating the need to plow the soil. Conservation tillage improves water-use efficiency in crops.
    - **Slide 13**: Explain that a riparian area is a space between land and a waterway, ideally filled with native grasses, shrubs and trees. Landowners can improve water quality by preserving wetland and riparian areas, which have many benefits. These areas help filter nutrients that are collected as water runs over the land; help control water levels during floods; and provide habitat for animals. If possible, use a local riparian area as an example to help students understand.
    - **Slide 14:** Explain to students that some methods of irrigation are more efficient than others. Best practices in irrigation vary by farm and crop, but they will generally enable farmers to decrease water evaporation, deliver water more directly to plant roots (eliminating water loss to other locations or from runoff), and measure precise soil moisture for exact watering.
    - **Slide 15:** Ask students, "How can we protect and conserve water at home and in our schools and communities?" As students discuss answers, reinforce the concept that our actions affect our natural resources. Water conservation ideas include: turning off the water while brushing your teeth, using low flow toilets, using water bottles and refill stations, decreasing shower times, etc.

4.0 Agroecology Principles in Wildlife and Biodiversity Conservation

For the purpose of this study guide, wildlife is defined as: Undomesticated animals living in their natural environment.

Agriculture in Southern Ontario contributes significantly to the total crop production in Canada, around 25% (National Farmer Union, 2011). This region is also one of the most biodiverse areas in the country, however due to competing demands a decline in wildlife populations has been observed. As of January 30th, 2018; there were 237 species-at-risk listed across Ontario (Government of Ontario, 2018). These population declines are strongly linked to habitat loss and fragmentation from development and agricultural expansion.

Recently approximately 16 million acres of land in northern Ontario become available for agricultural use due to the warming temperatures allowing for extended growing seasons (Mentor Works, 2017). This means additional forests and lands could be cleared for production resulting in additional, significant, habitat loss.

Agroecological systems emphasize biodiversity and the interactions between **flora** and **fauna** on and off the farm. The avoidance of synthetic pesticides and fertilizer use protects wildlife habitat and populations adjacent to agricultural areas. Agroecology incorporates ecosystem services provided by wildlife to maintain productivity and crop yields. For example, the presence of birds and bats will provide a measure of natural pest control.

4.1 Benefits of Wildlife in Agroecology

Wildlife provides ecological services to each other including humans and our agricultural systems. Native vegetation works to filter contaminants before they enter the groundwater, prevents soil erosion and provides habitat for wildlife. The presence of wildlife around agricultural areas provides pollination, pest control and enhances the biodiversity of an area making it more resilient to external stressors. By implementing either wildlife friendly or **land sparing techniques**, areas of land not being used for crop production can become prime wildlife habitat for native species.

4.2 Birds

Many farms depend on synthetic pesticides to control pests and weeds; however, if incorrectly applied, these chemicals can pose a threat to the surrounding environment. To avoid or minimize the use of chemicals, farms can take advantage of biological controls already existing in nature. One such example would be to encourage the presence of native **insectivores** such as the Eastern song sparrow, swifts and swallows. These bird species can act as effective natural crop pest protection, reducing or eliminating the need for synthetic pesticides (Barbaro et al., 2016).

Figure 9 (Left), Adult eastern song sparrow, Melospiza melodia

Source: Schain, 2017

Figure 10 (Right), Honeybee, Apis spp. collecting pollen.

Source: NaturGuide, 2018.

4.3 Pollinators

Pollination is the key to the success of the food industry and is worth billions of dollars per year. Bees, specifically honey bees, are the primary pollinators in Ontario's agricultural sector. Bees, birds, and other pollinators impact 35% of the world's crop production, and are responsible for increasing yields in 87 of the top food crops, worldwide (FAO, 2018).

Despite their importance in our agricultural systems, bee populations are declining globally for a number of complex and interdependent reasons. These reasons include pesticide use, climate change and disease/parasitism. An important technique to support pollinators is to encourage natural vegetation close to farmlands. Farmers can create habitats that support pollinators through the implementation of naturalized borders with hedgerows and promote wild flowers, as well as **snags** and **downed-woody-debris** for colonization.

For more information about Wildlife please refer to the Ontario Envirothon Wildlife Study Guide.

4.4 Case Study: Hindmarsh Farm Ecological Restoration

Background

Hindmarsh Farm is located in the municipality of Central Huron, just south of Goderich. The property is 140 acres and includes a mix of working farmland, ponds, scrubland and hardwood forest.

Hindmarsh has been a working farm for more than 60 years, but recently there have been concerns for its future. The surrounding area is being rapidly developed, encroaching on Hindmarsh's borders, and its owners are now asking that the land be protected. The site was identified as having significant ecological, agricultural, and recreational features; such as Significant Woodland Habitat and Significant Wildlife Habitat (Ontario Farmland Trust, 2014).

Potential Solutions

- In 2009, the farm was protected by The Ontario Farmland Trust (OFT) easement that limits and restricts land uses that are not compatible with agriculture (subdivision development, aggregate extraction, etc.).
- In 2014, students from Goderich District Collegiate Institute planted over 100 trees around two of the wetlands on the property, in efforts to naturalize the area and create additional habitat.
- A trail in the woodlot was created by the property owner and has been maintained by the Maitland Trail Association.

Results

- Farm is currently used as an educational tool for the surrounding community, specifically the local schools, public also has access to the walking trails.
- No future development will occur on the site that is not compatible with agriculture, allowing for habitat and biodiversity enhancement and preservation.

Figure 11, Map of Southern Ontario with Huron County highlighted in red.

Source: Huron Stewardship Council, n.d.

4.5 Hands-On Activity: Land Use Planning

In this activity, the goal is to explore two land use planning practices: wildlife friendly and land sparing. Students will compare and contrast these two practices and determine which method they would implement and how they would implement this on their own farm. Don't forget to reference other agroecology practices which could be integrated as well.

Land Use Practices

Wildlife Friendly: the presence of narrow linear grasslands or tree buffers and planting of heterogeneity or low-intensity crops.

Figure 12 (Left), Wildlife friendly technique using treed hedgerow.

Source: Farming UK, 2018.

Figure 13 (Right), Land sparing technique incorporating forest patches.

Source: Sam Beebe, 2009.

Activity Situation

You own a small 50-acre farm in Southern Ontario specializing in organic crop production. You have noticed that the past few years a subdivision development has been moving closer to your property. At the same time, you have also noticed a decline in the number of Eastern Meadowlark birds, a threatened insectivore species in Ontario. The soil around your farm is fairly clayey and poorly drained, resulting in high moisture content. Using the image of the property provided and the soil information, complete the following objectives.

Figure 14 (Left), Aerial Imagery of Property.

Source: King, 2018

Figure 15 (Right), Eastern Meadowlark, Sturnella magna.

Source: Brookens, 2017.

Objectives

- Compare and contrast wildlife friendly and land sparing use practices using a pros and cons list.
- Determine which land use practice you would implement on your farm to benefit Eastern Meadowlarks, including the native vegetation species you will plant that will thrive in the saturated soil conditions.

5.0 Agroecology Principles in Forests and Forest Management

Agroforestry is a collective name for incorporating trees into agricultural operations by combining trees with the production of crops and livestock while benefitting the land. Integrating trees, animals, and crops together is called an agrosylvopastoral system. Agroforestry systems in North America include: woodlot management, plantations, windbreaks, silvopastoral, intercropping/alley-cropping, and trees planted on streambanks. Agroecology systems are ranked as being very sustainable as seen in Figure 16.

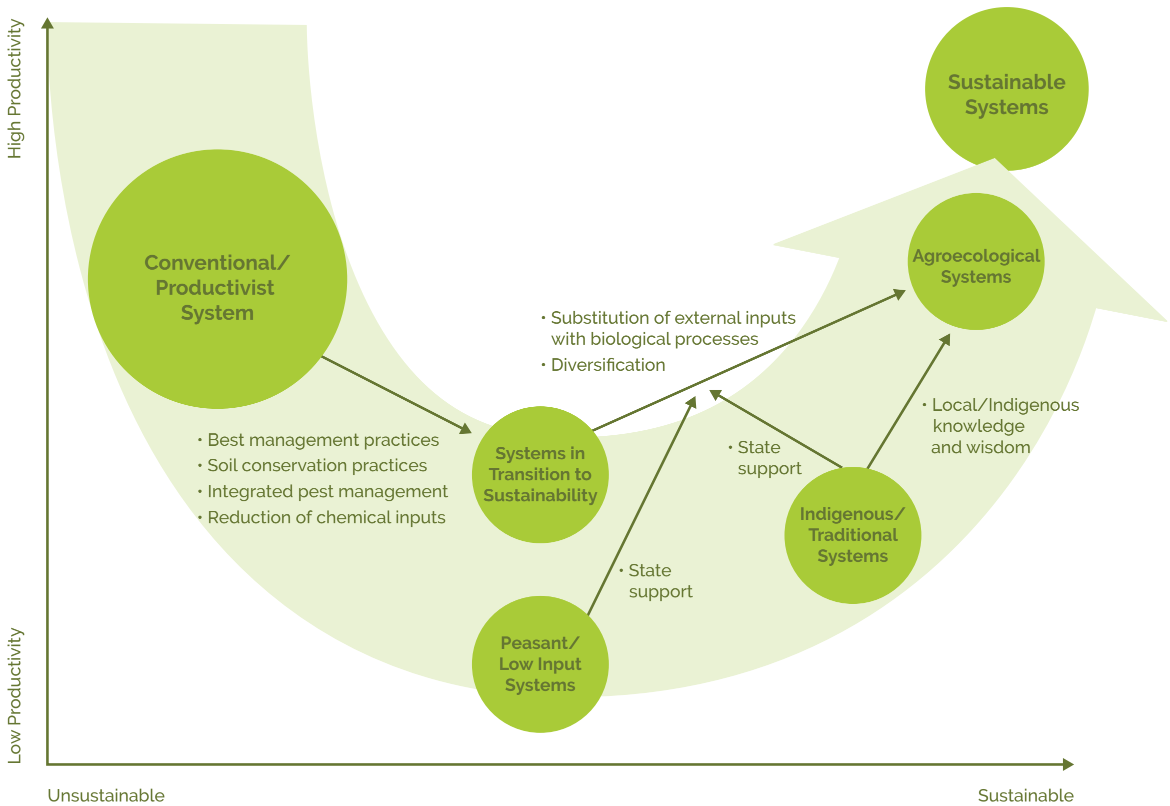


Figure 16. Diagram showing how Agroecology is a more sustainable approach.

Source: IAASTD Latin America and Caribbean Summary for Decision Makers, 2009

Benefits of Agroforestry Practices

Economics

1. Diversified farm income
2. Energy savings
3. Significant opportunities for generating products for farm use
4. Opportunities for farm labour
5. Possible tax incentive opportunities

Environmental

1. Decreased water and wind erosion
2. Improved soil quality/reduced erosion
3. Conservation of soil moisture
4. Improved nutrient cycling
5. Increased biodiversity
6. Increased health and resiliency of natural areas
7. Improved carbon sequestration
8. Reduced impacts of agriculture
9. Increased pollinator habitat

Barriers to using Agroforestry Systems:

1. Belief that trees will reduce productivity of lands
2. Trees may physically interfere with farming operations (i.e. machinery)
3. Increased biodiversity could include increase in pest species (Woodlot Management, 2007)

5.1 Woodlot Management

Woodlot management is an important component of agroecology, and as a result there are many practices to select from depending on overall goals for the property. For example, woodlot managers may desire a higher concentration of a specific tree species, such as Sugar maples to produce maple syrup and associated products. To ensure goals are met a comprehensive forest management plan is required. Best Management Practices Agroforestry Woodlot Management is an excellent book for property managers (see Figure 17). By planning early, additional agroforestry strategies can also be identified and implemented.

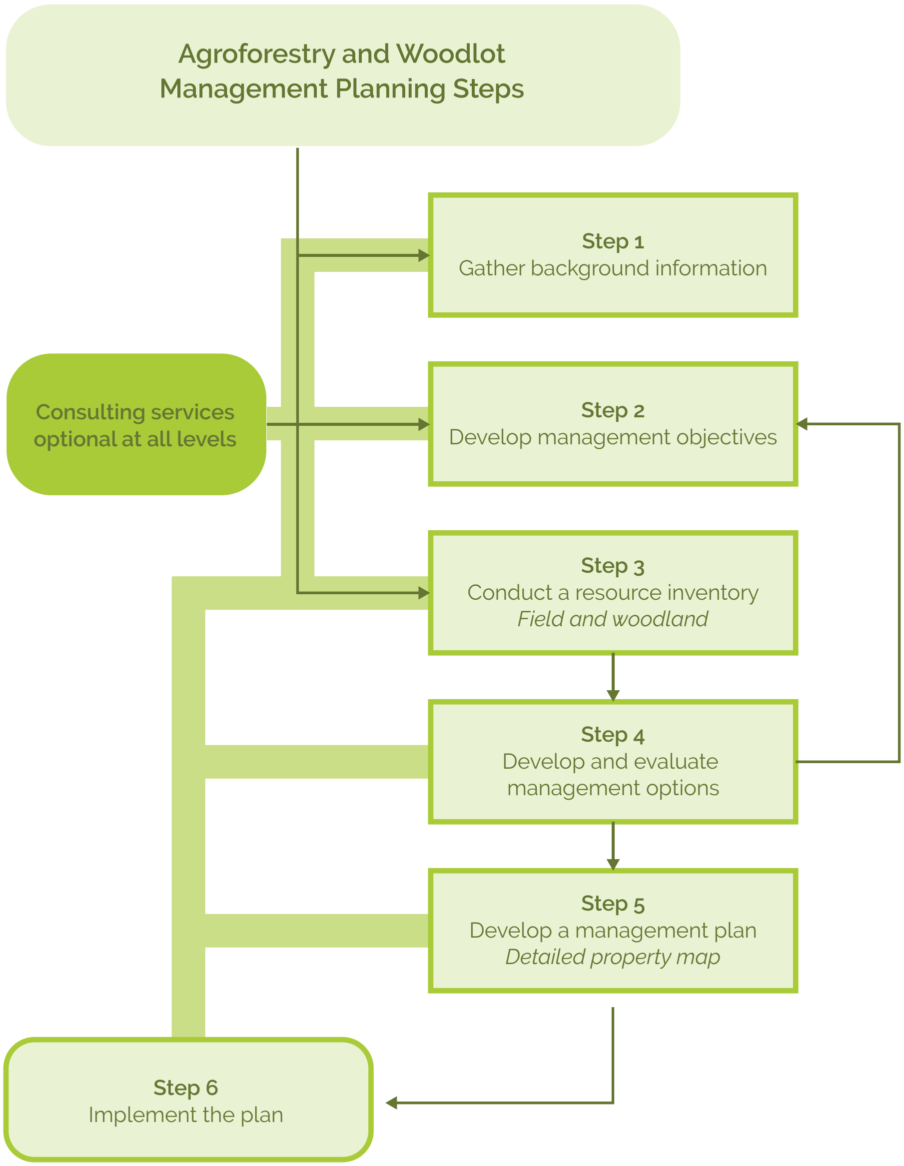


Figure 17. Six steps to carry out when planning a woodlot.

Source: Woodlot Management, 2007

Landowners can benefit from woodlots from direct and indirect sources (see Table 1). Well-managed woodlots benefits include timber sales, recreational opportunities as well as non-timber forest products (NFTP) such as mushrooms, medicines and fuelwood. While woodlots provide landowners with numerous benefits, these benefits can only be realized with the implementation of good forestry practices.

Table 1 & 2, Table Adapted from Woodlot Management, by Best Management Practices Agroforestry Series *Volume 1, 2007*

Direct Benefit	Marketable Products
Wood Product Processing	• Timber from woodlots and plantations • Veneer logs from timber harvests • Fuelwood from woodlots • Pulp from woodlots and plantation thinning • Modified **feedstuffs** to improve palatability and availability of nutrients
Non-Timber Forest Products	• Maple syrup and maple products • Cedar boughs for ornamental purposes • Ground Hemlock for medicinal purposes • Mushrooms and nuts for culinary needs • Forest herbs for alternative medicine
On-Farm Wood Products	• Fuelwood to offset energy costs • Fencing materials • Building materials for framing, siding pens, wagons, tools, home furniture-making

Indirect Benefit	Details
Income	• Use timber and NTFP sales from woodlots as insurance against low commodity pricing
Property Value	• Include timber when determining property value for real estate or equity purposes, especially when considering the non-farm real estate market
Social	• Improve mental health • Reduce air pollution and storm water runoff • Mitigate noise pollution and act as visual barrier
Labour Use	• Use farm labor force to produce maple syrup, fuelwood, fencing, and building materials during off seasons/when conditions are unsuitable for fieldwork
Land Use	• Create or maintain woodlots and plantations for wise land use – especially for marginal and fragile lands

5.2 Plantations

Intentionally planted woodlands are known as plantations. In Ontario, the most common plantations found in agricultural operations are single conifer species planted in rows, consisting of trees that are all the same age (aka Even-Aged). This type of planting is used to attain **crown closure** in the shortest timeframe possible.

Plantations can bring abundant rewards if properly managed to reduce mortality, maximize growth, and produce marketable products. These rewards can be best achieved through thinning, pruning, and general care. Plantations can be a tool used on fragile or **marginal lands** to stabilize soil and rehabilitate through forest cover. Today it is understood that increasing diversity of tree species has many benefits, including the generation of specialty products such as nuts, maple syrup, veneer hardwoods, and forest farming products.

According to *Best Management Practices for Agroforestry – Woodlot Management* are:

- A good source of revenues
- Wood and energy products for on-farm use
- Cover and protection from wind and water erosion
- A productive, alternative land use for marginal cropland
- Protection for lands associated with sensitive water sources
- Expanding and/or connecting forests and other natural areas
- A "sink" for carbon dioxide – to reduce atmospheric levels of greenhouse gases
- Landscape diversity
- Encouragement of succession from field to natural forest

5.3 Windbreaks

Windbreaks are linear clusters of trees or shrubs that are used to alter wind flow to protect people, soil health, property, and livestock while also enhancing biodiversity. Windbreaks in agroecology are also known as shelterbelts. Windbreaks can be used around agricultural fields, adjacent to roadsides, waterways, and around facilities with livestock. Windbreaks are used to guard against cold winds, drifting snow, odor from animals as well as dust and chemical drift. Windbreaks can improve soil quality by preventing wind erosion, reducing wind speed, and enhancing soils water holding capacity. Windbreaks can also reduce farm energy and can provide pollinator habitat depending on the species of trees and shrubs planted; this type of agroforestry is essential in the creation of wildlife corridors and in combating habitat fragmentation.

According to the United States Department of Agriculture's National Agroforestry Center, "planting 2.5% of tillable land in the America Great Plains with windbreaks could remove up to 80 million metric tons of carbon dioxide from the atmosphere over a period of twenty years" (Wright, 2002).

As with other aspects of agroecology, planning is critical to achieving success when planting a windbreak. Plans need to include an assessment of what plants are in the area and what species would be well suited to the planting site (Agriculture and Agri-Food Canada, 2015). Additionally care must be taken to select a design which will provide the most benefit. The design should consider the equipment that will be used to prepare the site, plant the trees and most importantly, consider a maintenance plan for once planting is complete.

Figure 18.
Cows Silvopasturing.
Source: *Chedzoy, 2011.*

5.4 Silvopastoral

Silvopastoral systems are characterized by the deliberate inclusion of trees in livestock pasture with the intent of providing shade, increasing biodiversity and potential economical return through the sale of timber products. Soil and crops can benefit from the livestock through the deposition of manure which provides a natural source of nutrients and increases soil organic matter. Silvopastoral systems can also mitigate climate change through the sequestrating of carbon through tree planting.

5.5 Intercropping/Alley-cropping

Intercropping, or alley cropping are, types of agrisilvicultural systems which feature multiple crops planted in spaced rows, allowing for cultivation of crops in the space between. In North America it is common for grains, nuts and legumes to be intercropped together; the grain becomes the nurse crop providing cover to help establish the legume. Careful measures must be taken when using this agroforestry practice to ensure trees provide the correct amount of sunlight and are compatible with the selected crops.

Pruning and maintenance is required to admit the desired level of shade. Row, forage, specialty, and biomass crops are usually used for intercropping species such as corn, wheat, barley, bluegrass, clover, alfalfa, dogwood, willows, and birches. By using trees to provide cover, the crops are less likely to require spraying for weeds and pests, they need less irrigation and experience decreased competition from other species of plants. One study in Ontario, Canada noted the benefits to farmers included: increased cash flow, diversified production, and improved growth and productivity of fruit trees. Intercropping most commonly incorporates fruit and nut trees in the overstory, and annual crops on the ground. Methods of intercropping in temperate systems allow for widely spaced rows of trees conducive to mechanized harvest (Gordon 1997).

5.6 Riparian Streambank Planting

Riparian streambank plantings, also known as riparian buffers, are strips of native plants or forest communities planted along waterways. Riparian zone plantings protect water quality, stabilize soil, mitigate flood water, provide critical wildlife habitat, and encourage diverse recreation opportunities.

Riparian buffers are an important agroecology tool because they prevent excess **sedimentation** as well as filter **non-point-source pollution** and nutrient loading which in turn helps prevent eutrophication. These buffers also provide shade to cool stream water, providing habitat to a variety of fish species which are sensitive to temperature increases.

For more information about Forestry please refer to the Ontario Envirothon Forestry Study Guide

5.8 Hands on Activity: Cultivating Mushrooms

Source: Fungi Perfecti, 2015

Summary

Through this activity students will learn a technique to cultivate mushrooms, an important non-wood product.

Materials Needed

- Healthy logs without fungi to be used as plug spawn inoculations (logs cut in late winter/early spring are preferred due to higher moisture content, thick-barked hardwood species are preferred)
- Plug spawn (type of mycelium fungi grown in wooden dowels),the preferred species for quick growth rate include King oyster, King trumpet, and French horn)
- 5/16-inch drill bit
- High speed drill
- Rubber mallet (to tap plugs into holes drilled in logs or stumps)
- Beeswax or a soy-based wax (e.g. cheese wax) for sealing logs or stumps
- Camping stove, electric hotplate or other method to melt wax
- Old metal coffee can or other container safe to melt wax in
- Small one inch paint brush (to apply the wax)
- Duct tape (not necessary, but can be helpful)

Student Learning Objectives

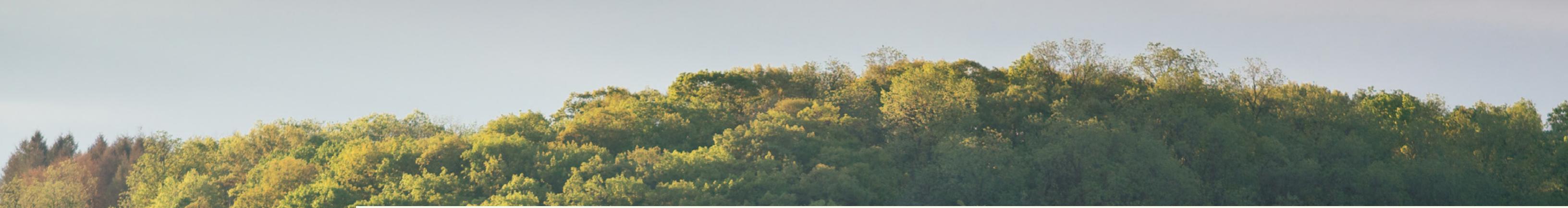
Students will be able to understand the following:

- How mycelium fungi grows and how it can take over a whole tree
- Mycelium's relevance to agroforestry
- How mushrooms can be cultivated for many years to come
- How the forest benefits from fungi decomposition
- Why moisture is important to grow mushrooms as a food source

Procedure

- Set up logs on a stand or safe area to drill 1 ¼” deep hole with 5/16” drill bit (use duct tape, stop at 1 1/4” up drill bit to ensure accuracy and consistency. Holes should be no more than 4” apart, in a “diamond or “checkerboard” pattern around log. With a three to four foot log there should be around 45 drilled holes.
- Plug spawn can now be inserted into the holes --> with clean hands, remove one dowel from the bag and place the bottom of it into a hole then use the mallet to tap the plug into the hole gently but firmly. The plug should fill the hole and just the top should be flush with the bark.
- Once all holes are plugged, start melting the wax. Use the paint brush to dip into the wax and seal the ends of the log then proceed to seal the dowels you have recently put into the log. This step is important as it ensures a higher rate of success. This step also helps prevents invasive parasites and competitive fungi. Use the wax to seal any ‘wounds’ and exposed inner layers of wood. However, be cautious not to cover the entire log in wax (because we need the moisture to grow the mushroom species).
- Once the logs are sealed, place the logs somewhere off the ground on pallets (other logs will do just fine). The logs should be intersected (lying across each other) to allow more space and moisture conservation. They should be placed in a shady and moist area under dense forest cover or shade cloth. It is recommended logs with different fungi species should not be placed close together because these will likely cause cross species competition.
- Water the logs once or twice every other week for 5-10 minutes until freezing temperatures or regular precipitation happens. Observe waxed ends of logs, looking for mottling in the wood that covers at least 65% of the end of the log. If mottling is at 65% or more, mushroom fruiting may be evident, if it is not evident it should be attempted. This can be done by shocking your log to start the fruiting - With the log in a container, pour very cold non-chlorinated water over the log until it floats. Weighting the log down is better but not necessary. Soak it for 24 hours. The colder you can keep it, the more mushrooms you’ll get. You can put the log and tray in the freezer or fridge at night for 8-12 hours (remember - the log needs light!) or set it outside for 1-3 days in winter. Freezing won’t hurt it. Empty the water, stand the log upright in a saucer. This fruiting usually happens around the 9-12 month mark or possibly sooner if using the preferred species listed above in materials. To speed up this process it is encouraging to soak the logs in water such as in a bath tub for 24 hours. You can bury the logs partially after fruiting occurs; eventually, with adequate moisture, eventually the whole log will be covered in mushrooms.

Congratulations– you have cultivated your first set of mushrooms!



6.0 Conclusion

Agroecological principals are effective tools that work to mimic local ecosystems. Agroecological principals consider the long-term health of soils, local wildlife and natural cycles and advocate for the selection of crops that are suitable to that area and its environmental constraints (Soil Association, 2003). Continued research into agroecological methods can improve our understanding of productive and profitable farming methods which minimize harmful impacts on rural communities, the environmental and human health.

It is important to remember that even though agroecological principles are broadly applicable, one size does not fit all. Different landscapes, soils, and climates will require unique blends of crops, animals (including livestock), and practices.

7.0 Glossary

A **Afforestation:** The planting of trees on sites that were formally used for agricultural production.

Anaerobic: The complete absence of gaseous or dissolved elemental oxygen in a given environment, can be a temporary condition.

B **Best Management Practices:** Methods or techniques found to be the most effective and practical means in achieving an objective.

Biodiversity: The variety of life on earth including genes, species and ecosystems. This can be measured in species diversity, genetic diversity or ecosystem diversity.

C **Crown Closure:** A measurement of canopy density of a forest, which is the crown (i.e. the top branches of the trees that can be seen from above) of trees combined together.

D **Down woody debris:** organic material that accumulate in a forest that are in various stages of decomposition

E **Ecosystem services:** Varied benefits that humans freely gain from the natural environment and properly-functioning ecosystems. Examples include the production of air and water, climate regulation, nutrient cycling and recreational values.

Erosion: The weathering away of land surface, particularly soil by running water, ice and wind. Ploughing up and down slopes can lead to gully formation, and light and friable soils can blow away in strong winds when exposed, usually in the spring.

Eutrophication: Excessive richness of nutrients in a lake or other body of water frequently due to runoff, which causes a dense growth of plant life and subsequent death of plant and animal species due to lack of oxygen.

Evaporation: The process of changing from a liquid to a gaseous state.

F **Fallowing:** Cultivated (i.e. tilled) land left intentionally idle during the growing season.

Fauna: The animals in an ecosystem.

Feedstuff(s): Anything used to create constituent nutrients of an animal ration.

Flora: The vegetation in an ecosystem.

Fragile Lands: Cropland that is prone to severe water erosion, wind erosion, compaction and flooding. They may still be productive but have a high risk of degradation.

H **Humus:** Soil made from decayed vegetable matter, containing valuable plant foods.

Hydrology: The movement, distribution, and quality of water in relation to land.

I **Insectivore:** An animal which feeds primarily on insects.

Intensive agriculture: Refers to farming systems which include the use of chemical fertilizers, pesticides and other inputs, genetically modified organisms (GMO's), heavy irrigation, intensive tillage, or concentrated monoculture production.

Integrated Pest Management (IPM): This is a broad-based approach to solving pest issues with minimal impacts to people and the environment including non-target species. IPM employs a combination of techniques such as biological controls, habitat manipulation, modification of cultural practices, and use of resistant varieties. Pesticides may also be used if monitoring indicates they are required.

Irrigation: Artificial application of water to the land, used to provide water for the growth of agricultural crops.

L **Land sparing Techniques:** The setting aside of land for biodiversity conservation

M **Marginal Lands:** Crop or pasture lands that, due to soil and landform features, are only marginally productive as farmland. Such lands are often too dense, stony, dry, wet, shallow or steep for conventional crops to be profitable for farming.

N

Non-Point Source Pollution: Pollution or contamination that cannot be traced to a single point of origin (i.e. there are multiple contributors; pollutant is diffuse over an extremely large area).

P

Pesticides: Refers to chemicals designed to destroy plants, fungal or animal pests.

R

Regolith: Layer of unconsolidated rocky material covering bedrock

Rhizobia: Beneficial bacterial that live in nodules on the roots of some plants.

Runoff: The draining away of water, or substances carried in it, from the surface of land, buildings or structures.

S

Salinization: The process of increasing salt content.

Sedimentation: The settlement of particles out of the water column along the bottom of the water body.

Sediment loading: An increased amount of suspended sediment present in the water body, to such a point that the depth and clarity of the water body is decreased.

Seepage: The slow escape of a gas or liquid out of a contained area.

Slurry: A mixture of manure and water, used as fertilizer.

Snags: A standing, dead or dying tree

Soil Degradation: The process by which the productive capability of soil is diminished (i.e. erosion salinization compaction, acidity).

Solum: The altered layer of soil above the parent material that includes the A (topsoil) and B (subsoil) horizons. The horizons of the solum have undergone the same soil forming conditions in contrast to the C horizon (unweathered parent material) which has been relatively unaffected by soil formation.

Sub-Surface Drip Irrigation: A variation on traditional drip irrigation where the dripline (tubing and drippers) is buried beneath the soil surface, rather than laid on the ground, supplying water directly to roots.

Synthetic Pesticide: A man-made substance which is not naturally occurring typically produced to imitate a naturally occurring product.

T

Tile drainage: A type of drainage system that removes excess water from soil below the surface and redirects the water to a nearby body of water.

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