

Learning Journey: Ecological Processes

There are four Ecological Processes. These natural system processes are the foundation of every ecosystem and every farm system.

Energy Flow: Harness the power of the sun: boost photosynthesis year round.

The Water Cycle: Transform total precipitation into effective precipitation. Rain is only useful to us when the soil can infiltrate and hold it and plants can use it - otherwise it becomes a detriment as runoff and erosion.

The Mineral Cycle: Fuel nutrient exchange between the soil, atmosphere, plants and animals.

Community Dynamics/Diversity: Build resilience through diversity by focusing on functional groups. Greater diversity above ground supports greater diversity below ground.

This learning journey is a curated collection of educational resources, designed to help you acquire knowledge and skills about the ecosystem processes.

The Ecological Processes

What Are Ecological Processes?

Regenerative land management focuses on understanding and utilizing the natural processes that occur between the soil and its surrounding biotic (living) and abiotic (non-living) environments. These interactions work together to enhance the soil's overall function. By observing and respecting these ecological processes, regenerative practices aim to guide land management in a way that promotes long-term soil health and resilience. The four ecological processes are the energy cycle, the water cycle, the mineral/nutrient cycle, and community dynamics.

What Is the Energy Cycle?

The energy cycle refers to the movement and transformation of energy as it flows through organisms and the environment, starting with the sun, which provides the essential energy for life on Earth. Solar energy drives photosynthesis in plants, allowing them to generate sugars that other organisms consume for energy. When organisms die, their nutrients return to the soil through decomposition, where they are recycled and used by other organisms. Soil organisms remain active

for over nine months a year, while many summer annuals photosynthesize for just four months, producing exudates that feed these organisms. Photosynthesis peaks when plants are in their vegetative state, between germination and flowering. By maximizing photosynthesis through strategies like extended crop rotations, cover cropping, and incorporating perennial forages, energy use can be optimized, boosting farm profitability. Remember, when plants aren't growing, energy isn't flowing.

What Is the Water Cycle?

The water cycle is the continuous movement of water on, above, and below the Earth's surface, playing a crucial role in redistributing water to sustain ecosystems, agriculture, and human life. The main stages include evaporation, condensation, precipitation, and collection. Within the smaller water cycle, processes like infiltration, where soil absorbs water, and transpiration, where water is transported through plants, are also essential. Optimizing water infiltration is key, as the amount of precipitation matters less than how much water the soil can absorb and make available to crops. Healthy soil, which acts like a sponge and resists compaction with a "chocolate cake" texture, allows for better water retention. Conversely, sandy soils, though they drain well, may become compacted without enough organic material. Soil health and groundwater availability are directly connected, making them inseparable in sustainable land management.

What Is the Mineral/Nutrient Cycle?

The mineral cycle is the process by which essential nutrients like nitrogen, phosphorus, potassium, calcium, and magnesium move through the ecosystem, playing a vital role in plant growth, soil fertility, and overall ecosystem health. This cycle involves the exchange of minerals between soil, plants, animals, and microorganisms, ensuring that nutrients are continuously available. Optimizing access to these nutrients and minimizing loss, such as through leaching, is crucial for farm prosperity. Tools like tissue and forage analyses can help identify nutrient deficiencies, while soil tests reveal the mineral composition. Additionally, testing for microbial activity provides insights into the mechanisms that make nutrients accessible to plants. As soil carbon is lost at a similar rate in both drought and heavy rain, the key difference lies in carbon input, which is harder to achieve in dry conditions, highlighting the interconnectedness of the carbon and water cycles. Incorporating deep-rooted plants can gradually increase soil carbon over time, reinforcing the long-term benefits of good soil management.

What Are Community Dynamics?

Community dynamics significantly contribute to regenerating soil by shaping the interactions among various organisms, including plants, animals, fungi, bacteria, and other soil microorganisms. These interactions are essential for building and maintaining healthy soil ecosystems, which are crucial for soil regeneration. Maximizing diversity by mimicking natural systems enhances resilience; the stacking effect of polyculture protects soil, prevents erosion, stabilizes temperature, and increases biological activity. By letting nature do the heavy lifting, we can work with natural processes as much as possible.

Promoting plant species diversity—such as incorporating both annual and perennial plants, as well as warm and cool-season varieties—is essential. In regenerative organic agriculture, the goal is to keep living roots in the ground year-round with maximum ground coverage. Additionally, implementing windbreaks, hedgerows, and riparian areas, particularly with trees and shrubs arranged in a multi-story setup, helps protect against wind erosion and enhances the small water cycle. Reincorporating livestock and wildlife, akin to the roles buffalo once played, along with a diverse array of plant species, including forbs, broadleaf plants, herbaceous varieties, and legumes, fosters a robust ecosystem that enhances overall soil health.

Conclusion

Ecological processes are essential in regenerative organic agriculture because they directly contribute to soil health, crop productivity, and sustainability. Understanding and leveraging ecological processes are crucial for creating sustainable, productive, and resilient agricultural systems that benefit farmers, the environment, and society as a whole.

Understanding Ecosystems

What Is an Ecosystem?

An ecosystem is a geographic area where living organisms (plants, animals, and microorganisms) and nonliving components (rocks, temperature, and humidity) interact and depend on each other. Changes in any factor, like temperature, can impact the entire ecosystem. Ecosystems can range in size from large landscapes to small tide pools.

What Is an Agricultural Ecosystem?

Agricultural ecosystems are human-designed and managed environments for growing crops and raising animals. They are simpler than natural ecosystems, with limited types of plants and animals. Farmers control or eliminate other plants or animals, like weeds or pests, to maintain the ecosystem. Soil, microbes, and organic matter play crucial roles in supporting these agricultural systems.

Agricultural ecosystems require the same essentials as natural ecosystems, such as nutrients, energy sources, moisture, suitable habitat, and gas exchange. They feature similar interactions between living (biotic) and nonliving (abiotic) components. These interactions between biotic and abiotic elements are crucial for the health of agricultural ecosystems.

Components Of An Ecosystem?

Biotic Factors: All living components such as animal, plants, and the microorganisms like fungi, etc.

- **Producer:** Organisms that produce food for themselves and other organisms.

- Consumer: Organisms that depend on other organisms for food.
- Decomposer: Organisms that break down remains and waste, releasing simple inorganic molecules back into the environment.

Abiotic Factors: Non-living or physical components like air, weather, water, temperature, humidity, altitude, the pH level of soil, type of soil, etc.

- Edaphic Factor: Refers to the soil and ground surface characteristics, including texture, nutrient composition, and density, which determine the types of plant species that can grow there.
- Climate Factor: Components such as water, sunlight, humidity, climate, temperature, and pH.
- Topographic Factor: Includes surface exposure, altitude, slope, etc.

Ecological Processes as a Foundation for Regenerative Organic Agriculture

1. Energy Flow

Carbon dioxide --> carbohydrates --> root exudates --> organic matter --> energy.

Photosynthesis is the pathway that carbon follows out of the atmosphere, through the plant and into the soil where it feeds microbes and builds soil structure. A healthy landscape is an unending flow of energy. Carbon flows constantly from the atmosphere through plants, into soils and into higher order animals. It structures soils, feeds food webs and is released again and again. The speed this process takes and the effect it has are intrinsically linked to land and water. The influence of the landscape on the cycling of energy should not be underestimated.

2. Water Cycle

A healthy landscape is a moderator of environmental stressors. It soaks up, filters and stores water. It cools temperatures, creates rain and can withstand both flood and drought. The influence of the landscape on the water cycle and of the water cycle on the landscape is so important.

3. Mineral Cycle

A healthy landscape is a repository of nutrients. It moves them in and out of available forms. Stores them in the short and long term and houses mechanisms that makes them available to plants when needed. The influence of soil biology on the cycling of nutrients should not be underestimated.

4. Diversity

Biodiversity is a tool for resilience. Every actor has a part to play; most have more than one. Built in redundancy and the capacity to adapt are the built in safety mechanisms of the natural world. The higher our biodiversity, the more rapidly and efficiently we can pivot. Without biodiversity, we soon run out of options.

Ecological Process - Energy Flow

Energy Drives Living Systems

It takes growing plants to create energy flow in living systems. The more sunlight we are capturing, the better for our cash crops and the quality of the land being stewarded. Energy flow begins with sunlight being captured by plants through the process of photosynthesis. In this document, we will look at two areas where land managers can influence energy flow into their systems by increasing photosynthesis:

- extending the growing season (i.e. the number of days/year when plants are photosynthesizing) by using cover crops
- increasing the photosynthetic capacity of individual plants.

Maximizing Photosynthesis Through Ground Coverage

Often when we think of our growing season, we think of the four months or so it takes to produce our cash crop. The reality is that plants in nature are growing in the spring and fall as well. We've all seen green grass poking through the snow as the first hints of spring arrival. Here are some finer points on the issue:

- Soil organisms work 9+ months a year, many summer annuals photosynthesize (and produce the exudates that feed soil microbes) for less than 4 months a year.
 - Keeping the soil life well fed keeps the (eco)system running.
- Primary photosynthesis happens in the plants during their vegetative state.
 - This is the period between germination and flowering where the plant is busy photosynthesizing and accumulating the resources needed for flowering and reproduction.
- Maximized photosynthesis is a driver for profitability.
 - Increasing the system's overall health creates compounding health benefits for plants and microbes and drives higher yields.
- Planting fall/winter cover crops is a great way to extend the photosynthetic days in your fields.
- Intercropping and Polycropping: Use timing to ensure cash crop is above the other plants to gain more light and the intercrop to gain more days spent photosynthesizing.
- Ensure forage crops are not overgrazed.
 - Overgrazing hurts the plant, setting back its health and in effect, its photosynthetic ability.
- Maximum energy can be utilized through rotation strategy and crop coverage.
 - Increasing the overall health of the plants also increases the photosynthesis.

Maximizing Photosynthesis of the Individual Plants

Did you know that it is common for plants to operate at between 15%-20% photosynthetic capacity? Did you also know that this can be increased to 60% by applying a number of management

strategies? Although creating the right environment for increased photosynthesis is a multifaceted issue, there are some considerations to make:

- Are the plants receiving enough CO₂ (carbon in soil)?
 - More CO₂ for the plant increases photosynthesis ability.
- Is there adequate water?
 - Both the plants and the microorganisms in the soil need water.
- Is there enough usable manganese for the plants?
 - *“Managing manganese is a critical requirement for maximizing photosynthetic efficiency”* – John Kempf
 - Plants primarily need manganese to photosynthesize.
- If manganese levels are good, how are the magnesium, iron and nitrogen levels?
 - These are secondary nutrients used by the plant to photosynthesize.

All the principles of regenerative agriculture play a role in creating healthy plants which can have cascading effects on photosynthesis. In a holistic practice, what is done in one area affects the whole system.

Ecological Process - The Water Cycle

The Water Cycle

Just like the nutrient cycle, the water cycle has no beginning nor end, and there is no starting or stopping point. The main objective for a farm is to capture as much water as possible and effectively utilise it to promote plant growth and soil health. So how does water cycle through the planet? Water cycles through evaporation, precipitation, infiltration, and transpiration, and these naturally occurring steps will be described in this section.

What Does a Non-Functioning Water Cycle Look Like?

Precipitation falls and meets scattered plants and exposed soil. If the precipitation cannot infiltrate the soil, it displaces it and leaves a trail of erosion, as well as pollutes downstream waterways. With less water able to soak into the soil, this makes the soil more susceptible to drought conditions. Compact soil also traps CO₂ and prevents oxygen uptake.

What Does a Functioning Water Cycle Look Like?

Solar energy is the main player in evaporation. Bodies of water like oceans, lakes and rivers are constantly exposed under the sun, and the solar heat turns these liquids into gases in the atmosphere. Soil also experiences evaporation when water escapes from pores in the ground.

The moist air that is created through evaporation, plus water that travels through plants into the atmosphere (transpiration), rises to higher levels in the atmosphere. This air condenses in cooler temperatures, creating clouds that are saturated with water droplets. Once the cloud is sufficiently saturated and cooled, the clouds break and water droplets begin to fall in the form of precipitation. Snow and rain fall on the ground, and plants protect the soil by absorbing the impact of precipitation. Rain droplets gently seep into the ground. Any water that is not absorbed by the soil becomes surface runoff, which eventually leads to a freshwater body. Then, water in the soil feeds springs and creeks to keep water cycling through greater bodies. As the water enters the soil, it is consumed by plant roots and microbes for metabolism. The roots develop huge networks underground between fungi and their own root hairs to maximise surface area and optimise absorption.

When Plants Cover Soil:

- Soil temperature decreases
- Evaporation reduces
- Soil gains greater resilience to drought
- Soil aggregates better to permit more gas exchange
- Microbe networks below ground are protected

Conclusion

In a functional water cycle, water transformation and utilisation is maximised in a continuous flow for all life on the planet. This ecological process is crucial for creating a regenerative organic farming system and for restoring soil health.

The Water Cycle Rehydrating the Land: Shifting the Focus From Rainfall to Retention and Soil Health

The Small Water Cycle

The small water cycle, also known as the short/local water cycle, demonstrates how moisture circulates locally across land. It begins with evapotranspiration (the combined process of evaporation [water changing from liquid to vapor from soil and surfaces] and transpiration [water vapor releasing from plant leaves]), where water evaporates from soil and plants, ascending into the atmosphere as vapor. This vapor then condenses to form clouds, resulting in precipitation, such as rain, which returns moisture to the land. This ongoing interplay of evapotranspiration and precipitation facilitates a continuous exchange of water between the land and atmosphere, sustaining moisture levels within the region over time.

The Importance of the Small Water Cycle

The small water cycle, driven by the evapotranspiration process over land, is essential for local precipitation patterns and ecosystem stability. Human activities, like intensive agriculture, disrupt this cycle, leading to reduced soil absorbency, increased temperatures, and irregular rainfall. When there is insufficient water in the soil, the sun's energy, which would normally facilitate evapotranspiration, instead raises the temperature of the air and land, contributing to altered precipitation patterns. To address these challenges, initiatives closely tied to efforts to rebuild soil health and restore natural water management systems are essential.

Rebuilding Soil Health to Restore Natural Water Management

The small water cycle is disrupted due to degraded soil health, where rainfall evaporates into the atmosphere instead of infiltrating the compacted, carbon-deficient soil. Healthy soils are rich in organic matter, have good structure, and are full of microbial life, allowing them to retain moisture and support plant growth. For plants to grow and transpire water back into the atmosphere—where it can fall again as local rain—soils must be healthy and carbon-rich. This improves water infiltration, enhances the small water cycle, retains more water in cooler soil, generates greater local rainfall, reduces fire intensity, and helps create essential cloud cover. Restoring degraded soil will bring local temperature and rainfall benefits and positively impact the wider climate. By redesigning cropping and grazing practices to repair small water cycles, both farmers and the natural environment will benefit.

Effective Precipitation > Rainfall Volume

People often focus on rainfall volume, but the true concern is effective precipitation. Without effective precipitation, rain struggles to nourish plants or replenish groundwater. Soil, like a sponge, should absorb water, but if it's as impenetrable as a brick wall (compacted), even heavy rainfall won't hydrate it. So, it's not just about rain falling from the sky; it's about the soil's ability to embrace and make the most of every drop. And that all ties back to the importance of maintaining healthy soils.

All About the Small Water Cycle

The Necessity of Water

It is difficult to imagine a world without water. Nearly everything we do is reliant on water – from our own bodies and all the life around us to processing and production systems. As we work towards land stewardship and regenerative practices, we discover that we have a lot of work to do in restoring the water cycle. In this document, we will explore the more “localized” version of the water cycle known as the “small water cycle”.

The Small Water Cycle

The small water cycle is a feedback loop. Groundwater is absorbed by the roots of plants, trees and shrubs, transpired into the air and returned back to the land again in the form of rain. Water moves through plants via transpiration culminating in evaporation from aerial parts, such as leaves, stems and flowers. We will look at three areas that affect this process: the soil, the plants and the trees.

Soil and the Small Water Cycle

An important factor in the small water cycle is the soil's ability to hold water. Good soil is like a sponge and is resistant to compaction (displaying a "chocolate cake-like" texture). Water infiltration is optimized and runoff is minimized. This also helps create healthy groundwater, which in turn improves plant health and the entire water cycle.

Plants and the Small Water Cycle

"An imbalance in plant nutrition creates a need for more water" – John Kempf

Healthy plants simply operate in a more efficient and resilient manner than unhealthy plants. This, in turn, both reduces the plants' need for water and increases transpiration. Maximizing plant coverage through intercropping and poly-cropping will also enhance this process.

Trees and the Small Water Cycle

First Nations knowledge keepers have a saying: "The trees can call the rains to them". Science has begun to catch up with this ancestral knowledge. We now know that trees, particularly multi story arrangements, slow down the air which gives water droplets a higher chance of forming.

To Conclude

As we integrate regenerative knowledge and practices into traditional farming, we begin to get a sense of the overlapping nature of the principles and processes. At the end of the day, this is the nature of holistic practice.

Ecological Process - The Mineral Cycle

What Are Nutrients?

The nutrient cycle is all about the transfer of nutrients between living organisms and nonliving materials. There are two types of nutrients. Non-mineral nutrients are found in air and water, and these are hydrogen, oxygen, and carbon. Mineral nutrients can be found in the soil as macro- (nitrogen, phosphorus, potassium, calcium, magnesium, sulfur) and micro- (boron, copper, iron, manganese, chlorine, zinc, molybdenum) nutrients. These are the elements that plants absorb through their roots. All nutrients that are essential for plant metabolism come from mineral rocks, rainfall, and the atmosphere.

How Do Nutrients Cycle?

The atmosphere contains nitrogen, oxygen, hydrogen, and carbon in the form of gas and water - these are deposited into the soil through rain and wind. Dead and decaying plants and animals degrade into the soil, releasing carbon and other nutrients. Rocks in the environment and bedrock break down and deposit calcium and other minerals into the soil. Livestock contribute to nutrient cycling via manure, urine, and trampling plant materials. Plants take up nutrients with the help of microbes, and they release oxygen back into the atmosphere through photosynthesis.

Optimal Nutrient Cycling

Optimal nutrient cycling depends on plant diversity and soil cover. Plant diversity contributes to nutrient cycling by having roots of different lengths penetrate deeper soil, thereby allowing microbes to descend deeper and aggregate soil better. Different plants also interact and exchange with different microbes that accumulate unique minerals. Soil cover promotes nutrient cycling by protecting the soil from erosion, degradation, and nutrient leaching. If the soil is not covered, it is susceptible to run off, where the soil is eroded and crucial nutrients are stripped out of the ground.

How Does Livestock Cycle Nutrients?

Livestock are key players in cycling nutrients in the environment. They walk through the fields, trampling and crushing plant matter as they go. They tug up on plants, which stimulates massive releases of sugars into the soil so that microbes exchange nutrients for sugar. Livestock, specifically ruminants, chew up plant material, and the carbon matter sits in their rumen which breaks apart cell walls made of cellulose. The rumen continues to degrade the plant material until the animals regurgitate and deposit it back into the field. Livestock defecate and urinate, returning the consumed minerals back into the soil.

Conclusion

Nutrients are all around us, being utilized by every organism. If the nutrient cycle is failing in one area, then it affects all aspects of the cycle, and all living things are impacted. Knowing the principles and mechanics of the nutrient cycle is important in preserving its integrity, and using this knowledge will improve the health of your soil and inevitably, increase your crop yield.

Ecological Process - Community Dynamics / Diversity

Community dynamics, in ecological process terms, encompass the interactions and relationships among diverse organisms within an ecosystem, shaping its structure, function, and resilience. Community dynamics, or diversity, captures the essence of the saying, "It takes a village to raise an ecosystem," emphasizing the teamwork needed for supporting the well-being of an ecosystem. As plants, animals, insects, and microorganisms interact and change over time, they create a web of connections that support the health and resilience of the ecosystem.

This interconnectedness acts like a safety net, helping ecosystems stay strong against diseases and other environmental pressures (bad weather), while also building up positive effects over time. By nurturing a variety of plants—from grasses and flowers to trees and annual species—we keep the flow of nutrients and energy running smoothly, which in turn helps to maintain a rich array of life.

Community dynamics describes the continual changes in ecological communities. Alterations in one part of the ecosystem cascade through all others. Moreover, it emphasizes the importance of having plants, animals, fungi, and microorganisms at all developmental stages, as this balance between growth and decay is crucial for maintaining a healthy ecosystem.

Observation Is Key

Observation is crucial for understanding your community dynamics. By closely studying factors like soil, terrain, and biodiversity, you gain insights to tailor management decisions, optimizing productivity while conserving ecosystem health. You don't need to be an expert to recognize changes in bird diversity — observations can start as easily as noticing birds or different species you haven't seen before. Take notes and learn as you go, refining your observations over time.

Ecological Succession

Ecological succession, the gradual change of ecosystems, influences community dynamics — the interactions among species.

“As succession moves forward, community dynamics usually improve. Higher successional communities typically have more diversity, deeper roots, more ground cover, and more functional groups of plants” (Moseley, n.d., para. 9).

This understanding guides regenerative agriculture practices, helping farmers restore biodiversity and promote ecosystem resilience for sustainable land management.

Example

An example of community dynamics and ecological succession within regenerative agriculture is displayed in 'The Biggest Little Farm' documentary.

Learn More With These Related Links

- [Farm Ecosystem Web](#) (Educational Guide)

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Thank you for participating in this Learning Journey on Canadian Organic Growers' Regenerative Organic Hub. We hope you were inspired and found practical information and tools that will support you on your regenerative organic journey.

We invite you to click below and use our contact form to ask us any questions you may have, or comment on your Hub experience. This form is also the place to let us know if you would like to get involved with COG, including as part of our next cohort of Regenerative Organic Oats (ROO) program participants.