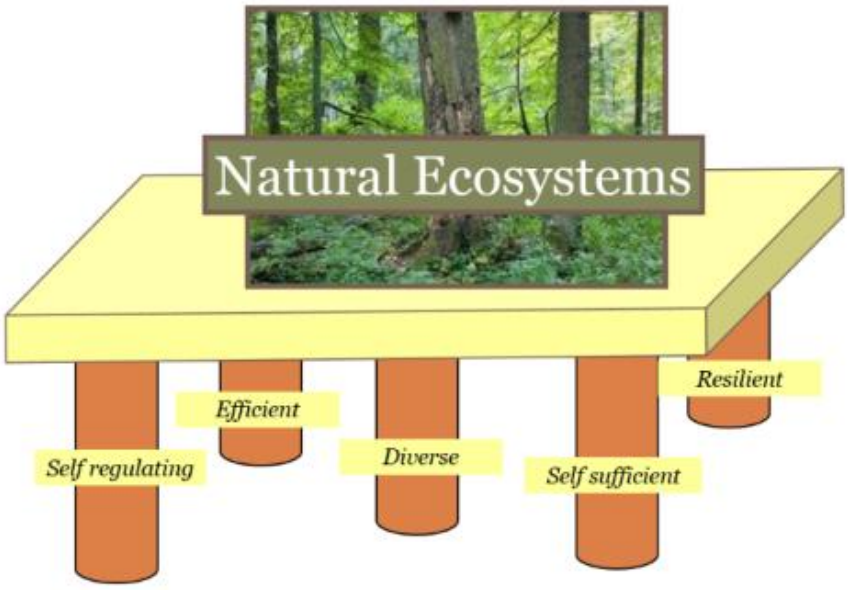
Chapter 12 Soil Management Using Ecological Principles and Soil Health Management - *Dr. Harold van Es, Cornell University*

Understanding Agroecology

Agroecology is the application of ecological science to the study, design and management of sustainable agroecosystems. Agroecology enhances agricultural systems by mimicking natural processes which in turn encourages beneficial biological interactions, synergies and efficiencies within the system. An agroecological system recycles nutrients, energy and carbon in favor of external inputs whenever possible. Agroecology provides a framework for approaching agricultural management that is much more knowledge intensive.



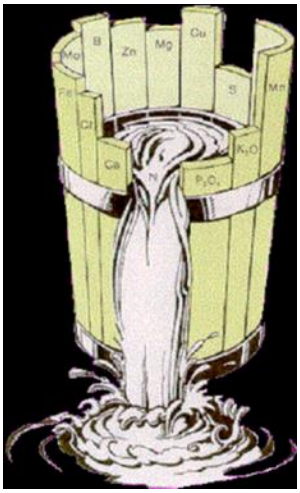
Natural ecosystems have evolved over the years into sustainable systems built on the basis of five fundamental characteristics, represented in the graph at _____.

Natural ecosystems are:

- Efficient – in terms of energy, nutrients, water, and carbon. All contribute to the cycle of inputs – there is little to no waste as one organisms waste in this system might be another organisms' resource.
- Diverse – biological diversity leads to check and balances above and below the soil level.
- Self- sufficient – few external inputs are required – primarily sunlight, rain and air. This is very different than traditional agricultural systems.
- Self-regulating – the diversity of the ecological communities promotes a dynamic balance of organisms. It would be uncommon to see a severe pest problem in this type of system.
- Resilient – these systems are able to bounce back after disturbances. For example, natural ecosystems tend to bounce back more quickly than agricultural land if there is damage from extreme weather.

Transforming agricultural systems

Is it possible to create agricultural systems that demonstrate some or all of the characteristics of a natural ecosystem? Agricultural systems often react to limiting factors – many of us have seen the illustration at left. The water barrel with short staves illustrates the limiting factor concept. Rather than repairing the individual stave, which is a reactive management strategy, perhaps we need to buy a new barrel! For example, if nutrients are deficient– rather than just adding fertilizer we should determine WHY the deficiency exists.



The "Limiting Factor Concept":

Natural ecosystems exhibit more pro-active "management" strategies which allow these systems to be more efficient and resilient. An example of this is the evolution of mycorrhizae in forests – this natural management strategy enhances mutualism and promotes synergy with other organisms.

The goal of pro-active, long-term management is to:

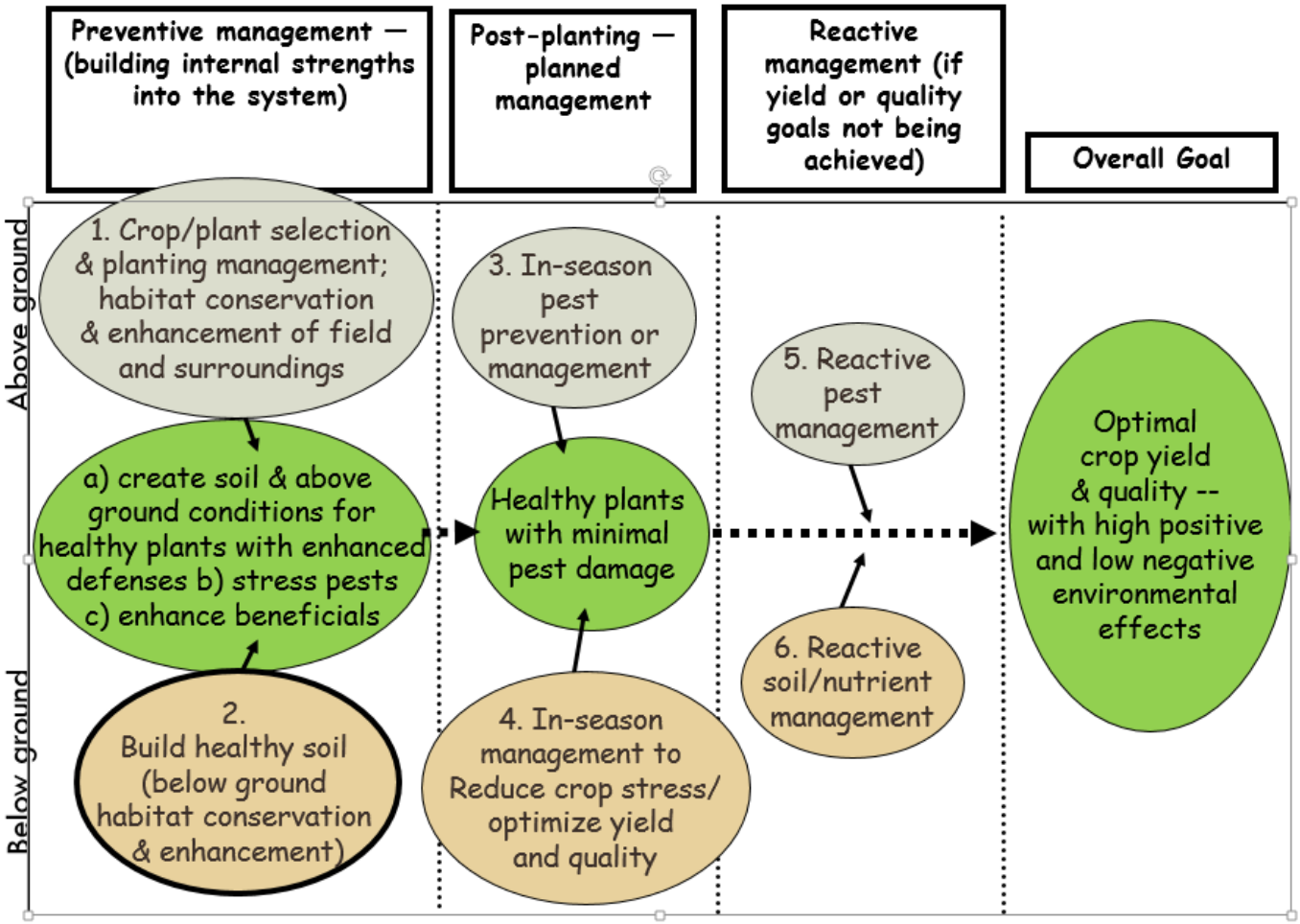
- Enhance mutualism and synergies
- Stress pests
- Enhance beneficials
- Create soil & above ground conditions to promote the growth of healthy crops with enhanced defenses

A whole system approach to soil and crop management at the field level

The chart below illustrates the strategy for long term preventive management. By properly assessing the soil – i.e. evaluating and amending pH, adding OM, reducing compaction - the soil will be healthier.

Above ground preventive management strategies include choosing resistant crop cultivars and then planting them with care. These strategies will enhance the overall success of the plant.

The second level (in-season management) would be a commitment to Integrated Pest Management (IPM) practices and the use of regular tissue testing. The commitment to these types of crop monitoring techniques allows you to grow healthy plants with minimal damage.



The third level of management (reactive management) may be needed if a pest or fertility issue needs more immediate attention. This type of management should be a final strategy to insure crop health and reduce the impact of the problem on the plant.

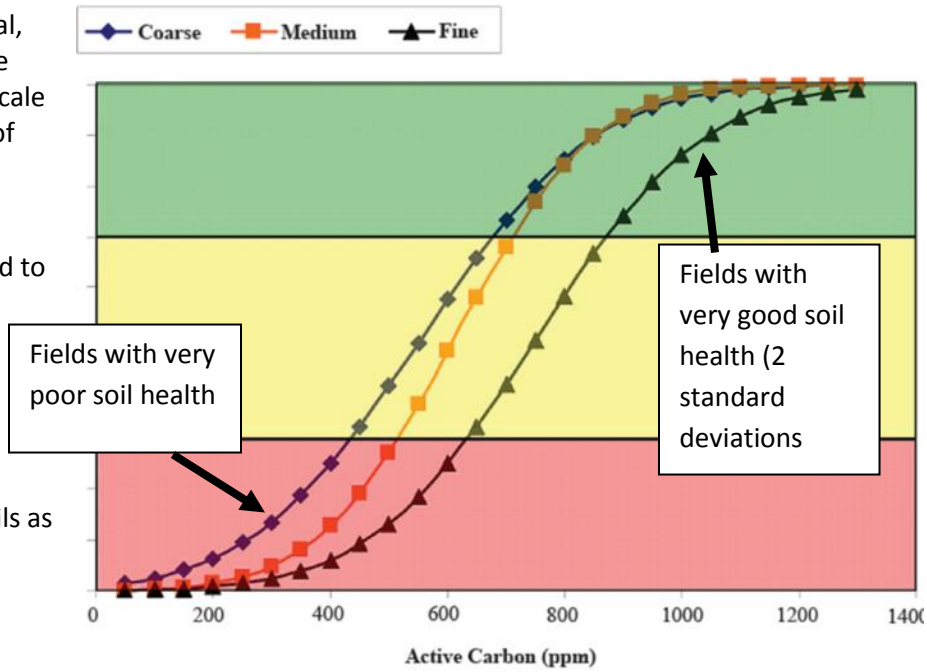
Historically we have focused on reactive management, but research and experience indicate that agriculture needs to move toward a more ecological model of management.

Some examples of ecological management models include:

- Many types of compost have been shown to suppress root disease when used in a potting mix.
- Lower early season Nitrogen levels decrease viability and competitiveness of small seeded weeds.
- Flea beetle pressure and damage to cabbage is more severe on compacted soil.
- Root rot severity of vegetable crops is decreased when crops are grown in cover crop rotation where the cover crops are sufficiently decomposed.
- Many cover crops suppress plant parasitic nematodes.

Pro-active soil management

The Cornell Soil Health Test (CSHT) is a tool that provides farmers the information needed to proactively manage their soil. As has been discussed elsewhere in this manual, the physical, chemical and biological indicators are measured and reported on a rating scale that alerts the farmer to limitations of that unique plot of soil.



The CSHT rating scale has been developed using soil typically devoted to annual agronomic or vegetable crop production systems. The CSHT needs to incorporate the existing information into a rating scale that is appropriate for perennial berry production. This will require more data from berry soils as the rating scale is developed using a frequency distribution of data from many soils.

Perennial system soils often have different values of active carbon and organic matter and can frequently require lower pH. Samples are needed from berry fields that will represent a range of conditions - especially from soils that don't perform well and those that do perform well. Additionally more time needs to be devoted to interpretation of the information.

Summary

Ecological management is a type of proactive management that builds resilience in the cropping system. Reactive management may be necessary to optimize the situation, but BOTH proactive and reactive management techniques are critical. Soil testing remains one of the most important components of ecological soil management but the CSHT needs to be refined for perennial crops to best inform berry growers. Remember, organic matter content is important – but it really isn't everything to a soil.

Additional Resources

1. Hoorman, J., Aziz,I., Reeder, R., Sundermeier, A., and Islam, R. 2011. Soil Terminology and Definitions, OSU Factsheet SAG-11, 8 pp.

GLOSSARY

Term	Definition
active carbon	*the portion of total soil organic carbon (matter) that is relatively easily metabolized or utilized by microorganisms.*
anaerobic	*living without air, as opposed to aerobic.*
anion	*an ion with more electrons than protons, giving it a net negative charge.*
anoxia	*areas of sea water, fresh water or groundwater that are depleted of dissolved oxygen. Anoxic conditions are in a general a more severe condition of hypoxia. The US Geological Survey defines anoxic waters as those with dissolved oxygen concentration of less than .5 milligrams per liter.*
base saturation	*The proportion of acids and bases on the cation exchange complex.*
biochar	*name for charcoal when it is used for particular purposes, especially as a soil amendment. Biochar, a stable solid, rich in carbon, which can endure in soil for thousands of years, increases soil fertility and agricultural productivity, and provides protection against some foliar and soil-borne diseases.*
cation	*is an ion with fewer electrons than protons, giving it a positive charge*
cation exchange capacity (CEC)	*the maximum quantity of total cations, of any class, that a soil is capable of holding, at a given pH value, available for exchange with the soil solution. CEC is used as a measure of fertility, nutrient retention capacity, and the capacity to protect groundwater from cation contamination.*
clay	*a fine-grained soil that combines one or more clay minerals with traces of metal oxides and organic matter.*
compaction	*the process in which a stress applied to a soil causes densification as air is displaced from the pores between the soil grains. Normally, compaction is the result of heavy machinery compressing the soil, but it can also occur due to the passage of (e.g.) animal feet.*
denitrification	*a microbially facilitated process of nitrate reduction (performed by a large group of heterotrophic facultative anaerobic bacteria) that may ultimately produce molecular nitrogen (N2) through a series of intermediate gaseous nitrogen oxide products.*
dynamic soil quality	*those soil qualities that change over relatively short periods of time (months to years) in response to land use or management practice changes. Dynamic properties include organic matter, soil structure, infiltration rate, bulk density, and water and nutrient holding capacity.*
erosion	*the process by which soil and rock are removed from the Earth's surface by exogenic processes such as wind or water flow, and then transported and deposited in other locations*
estuary	*a partly enclosed coastal body of brackish water with one or more rivers or streams flowing into it, and with a free connection to the open sea. Estuaries form a transition zone between river environments and maritime environments and are subject to both marine influences, such as tides, waves, and the influx of saline water; and riverine influences, such as flows of fresh water and sediment.*
eutrophication	*an ecosystem response to the addition of artificial or natural substances, such as nitrates and phosphates, through fertilizers or sewage, to an aquatic system.*
evapotranspiration	*the sum of evaporation and plant transpiration from the Earth's land and ocean surface to the atmosphere. Evaporation accounts for the movement of water to the air from sources such as the soil, canopy interception, and water bodies. Evapotranspiration is an important part of the water cycle.*