everything starts with GOOD SOIL

Soil fertility is the capacity to receive, store and transmit energy to support plant growth. These processes require healthy soils, self organizing systems with physical, chemical and biological components all functioning and in balance. Continuous use of acidic or salty synthetic fertilizers, insecticides, fungicides, and herbicides disrupts this delicate balance. Before we can hope to improve systems, however, we need to understand why they are the way they are, and then how science and practice can help to actively manage soil biology to improve and maintain soil fertility, and achieve more sustainable, healthy and productive farming systems.

In 1989 the American Society of Agronomy defined sustainable agriculture. Their definition states: "A sustainable agriculture is one that, over the long term, enhances environmental quality and the resource base on which agriculture depends; provides for basic human food and fiber needs; is economically viable; and enhances the quality of life for farmers and society as a whole." There are many components to sustainable agriculture but none is more important than the soil component, as this is the foundation of any farming system.

TABLE 1: SUSTAINABLE AGRICULTURE PRACTICES[2]

	Conventional	Biological
Basic Outlook	Control Nature	Work with natural system.
	Maximize Yield Short Term View	Build Soil Long Term View
Soil	Supports plant; supplies about a dozen elements	A complex system: physical, chemical and biological factors.
Fertilizers	Synthetic, soluble salts emphasize N-P-K and pH. Replace what crop removes.	Natural or low salt, some slow-release. Balance all elements in soil a balanced diet.
Crops	Oten monoculture. Grow for market and yield.	Soil building rotations. Grow for quality. Manage soluble nutrients,
Weeds	Chemical control	mechanical control or spot herbicides; smother crops.
Pests/Diseases	Chemical control, resistant varieties.	Natural control by good health, natural enemies and rotations.
Economics	High inputs. Moderate profitability.	Low inputs. High profitability.
Environment	Chemical pollution, degraded soil with high erosion risk.	Little pollution. Good soil with low erosion risk.

[1] Source: MF – 2263, Sustainable Agriculture, Kansas State University Agricultural Experiment Station and Cooperative Extension Service. In reviewing sustainable agricultural practices, it is important to compare conventional practices with biological practices. In chart one is a basic comparison of these practices.

[2] Source: The Biological Farmer, Zimmer, Gary F. 2000.

MYTHS ABOUT SUSTAINABLE AGRICULTURE[1]

ISN'T THIS WHAT MY GRANDPARENTS DID?

Sustainable agriculture seeks to combine some of the old wisdom of past practices, like crop rotation and green manure crops, with useful current technology.

YOU CAN'T MAKE MONEY IN SUSTAINABLE AGRICULTURE.

Studies from several states have reported that sustainable agriculture is as profitable as examples on the conventional end of the continuum.

SUSTAINABLE AGRICULTURE INCREASE SOIL EROSIONBECAUSE OF INCREASED USE OF TILLAGE.

Sustainable agriculture practitioners can meet conservation compliance guidelines, but they emphasize certain soil conservation methods over others. For example, continuous no-till does not work well for sustainable agricultural farmers, due to reliance on herbicide inputs in such a system. On the other hand, a tillage-rotation system, where no-till may be alternated with reduced-till and conventional-till practices is feasible.

overview of SOIL

Soils contain enormous numbers of diverse living organisms assembled in complex and varied communities. Soil biodiversity reflects the variability among living organisms in the soil - ranging from the myriad of invisible microbes, bacteria and fungi to the more familiar macro-fauna such as earthworms and termites. Plant roots can also be considered as soil organisms in view of their symbiotic relationships and interactions with other soil components. These diverse organisms interact with one another and with the various plants and animals in the ecosystem, forming a complex web of biological activity. Environmental factors, such as temperature, moisture and acidity, as well as anthropogenic actions, in particular, agricultural and forestry management practices, affect to different extents soil biological communities and their functions.

Soil organisms contribute a wide range of essential services to the sustainable functioning of all ecosystems. They act as the primary driving agents of nutrient cycling, regulating the dynamics of soil organic matter, soil carbon sequestration and greenhouse gas emissions; modifying soil physical structure and water regimes; enhancing the amount and efficiency of nutrient acquisition by the vegetation; and enhancing plant health. These services are not only critical to the functioning of natural ecosystems but constitute an important resource for sustainable agricultural systems.

Improvement in agricultural sustainability requires, alongside effective water and crop management, the optimal use and management of soil fertility and soil physical properties. Both rely on soil biological processes and soil biodiversity. This calls for the widespread adoption of management practices that enhance soil biological activity and thereby build up long-term soil productivity and health.

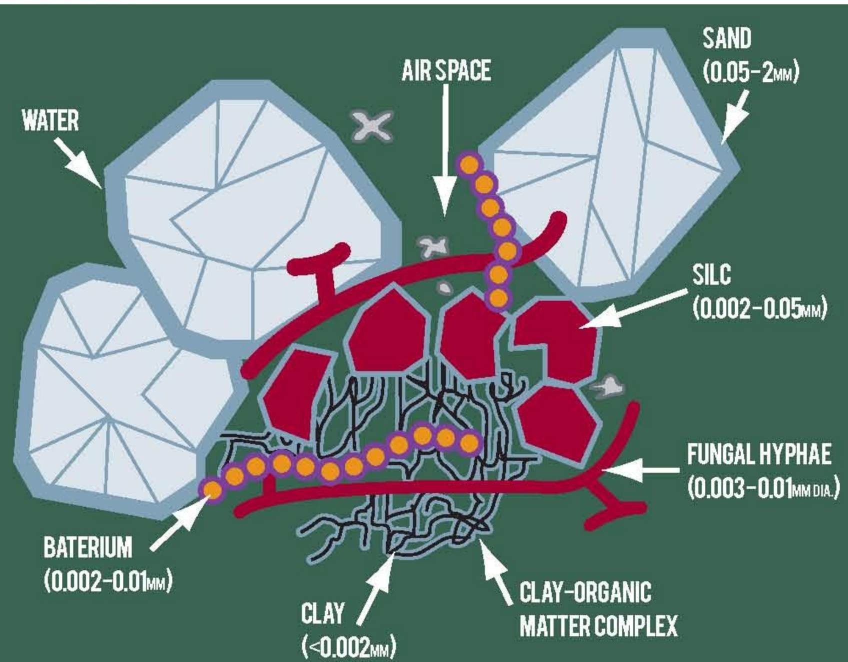
Adaptation and further development of soil biodiversity management into sustainable land management practices requires solutions that pay adequate consideration to the synergies between the soil ecosystem and its productive capacity and agro-ecosystem health. One practical example of holistic agricultural management systems that promote and enhance agro-ecosystem health, including biodiversity, biological cycles and soil biological activity is organic agriculture.

ORGANIC MATTER

Soils need to be able to support plant life and that requires more than just minerals. On average, good garden soil is 45 % mineral in nature and 5 % organic matter, as microbial organisms go thru their natural life cycle. As plants and animals die on the surface and are decayed by bacteria and fungi, they are ultimately converted into humus, a

ORGANIC MATTER AND SOIL COMPONENTS

- Compared to a bank account for plant nutrients.
- Soil containing 4% of organic matter in top 7" 80,000 lbs of organic matter/acre. This will contain 5.25% N, 4200 lbs/acre.
- Water retention: 1% or less OM can hold less than 10,000 gal of water. 3% OM 1 acre can hold 2-3" of rain.
- A study of soils in Michigan demonstrated potential crop-yield increases of about 12% for every 1% organic matter.
- In a Maryland, researchers saw an increase of 80 bushels of corn per acre when organic matter increased from 0.8% to 2%.



carbon rich, coffee colored organic material.

Humus consists of very long, hard to break chains of carbon molecules with a large surface area, these surfaces carry electrical charges, which attract and hold mineral particles. What's more, the molecular structure of the long chains resembles a sponge; lots of nooks and crannies that serve as veritable condominiums for soil microbes. These structures also provide for air and water to be held in the soil for the plant roots.

AIR & WATER

Minerals and humus make-up the solid phase of the soil, but plants require oxygen and water or which is known as the gases phase of soil. The voids between individual mineral and organic particles are filled by water and air.

Water moves between soil pores in one of two ways; by the pull of gravity or by the pull of individual water molecules on each other or as capillary action. Gravitational water moves freely through soils. Soils with large pores help to promote the flow of gravitational water. As water fills the pores, it displaces and pushes out air in front of it. When the water flows through, it allows new supply of air to move in. When gravitational water hits roots, which acts like sponges, it is absorbed.

PROFILES

Soils are exposed nonstop to the forces of weathering. Rain, for example, will cause some soil minerals and organic matter to leach out as the water moves down the through the soil profile. This material may hit an impervious barrier and become concentrated in a certain layer. The size of particles may cause a particular material to be concentrated or be filtered. Eventually, over time, distinct layers and zones of different materials are formed. This can be seen when digging thru the surface and exposing the various layers. A soil profile is a map of these layers.

COLOR

Color is an indicator of what is in your soil, as soil color is sometimes dependent on the soil's specific mineral and organic components. Weathering, oxidation, reduction actions of iron and manganese minerals, and the biochemistry of the decomposition of the organic matter are the primary factors influencing soil color.

Organic components in soil are very strong coloring agents and produce dark colored soil. When iron is a component of soil, it rusts, and soil particles are coated with red and yellowish tints. When manganese oxide is a major component of soil, its particles take on a purple-black hue. The presence of these colors usually indicates good drainage and aeration.

Gray soils can indicate a lack of organic material. They often indicate anaerobic conditions because the microbes that survive in such conditions often use iron in the soil, rendering it colorless. Color is a visual tool that an agronomist often utilizes to judge the health of the soil.

Comparison of soil with poor organic matter and good organic matter. There is an obvious color difference in these soil comparisons which make it easy to detect the good from the bad.

TEXTURE

Soil scientists describe the size of the soil particles in terms of texture. There are three categories of soil texture: sand, silt, and clay. All soils have a specific texture that enables one to judge its propensity to support a healthy soil food web and thus healthy plants.

STRUCTURE

Individual particulate size, or texture, is obviously an important characteristic of soils, but so is the actual shape these particles take when grouped together. This shape, or soil structure, depends on both the soils physical and chemical properties. Factors that influence soil structure are particle orientation, amount of clay and humus, shrinking and swelling due to weather, root forces, biological influences and human activity.

When you look at your soils, you don't see individual particles but rather aggregates of these particles. The biology in the soil produces the

HEALTHY SOILS FROM AGRICULTURE

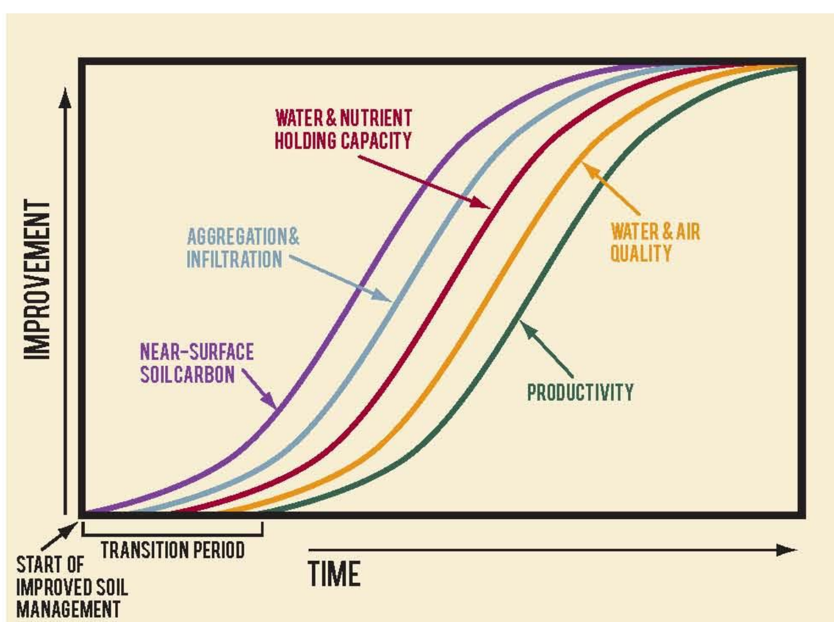
Capturing the benefits of soil biological activity for agricultural production requires adhering to the following ecological principles:

• Supply organic matter. Each type of soil organism occupies a different niche in the web of life and favors a different substrate and nutrient source. Most soil organisms rely on organic matter for food; thus a rich supply and varied source of organic matter will generally support a wider variety of organisms.

• Increase plant varieties. Crops should be mixed and their spatial-temporal distribution varied, to create a greater diversity of niches and resources that stimulate soil biodiversity. For example diverse habitats support complex mixes of soil organisms, and through crop rotation or inter-cropping, it is possible to encourage the presence of a wider variety of organisms, improve nutrient cycling and natural processes of pest and disease control.

• Protect the habitat of soil organisms. The activity of soil biodiversity can be stimulated by improving soil living conditions, such as aeration, temperature, moisture, and nutrient quantity and quality. In this regard, reduced soil tillage and minimized compaction - and refraining chemical use - are of particular note.

glues that bind the individual soil particles into aggregates. As they go about their day-to-day business, bacteria, fungi, and worms produce polysaccharides, sticky carbohydrates that act like glues, binding individual mineral and humic particles together into aggregates.



Graph showing the dramatic jump of improving soil management.