Forage News

MISSISSIPPI STATE UNIVERSITY EXTENSION SERVICE

Soil Health: The Reality behind It in Grassland Ecosystems

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"Soil health" is a relatively new term in soils management. If you consider the three-way intersection of soil chemistry/ fertility, soil biology, and soil physics, you are looking at soil health. Because of the diversity of soils (Mississippi has over 200 different ones) the intersection will be different for each, and will vary due to management. A soil is not considered "sick": it has some issue that management may or may not alleviate. You are probably most familiar with the soil fertility measurements including pH, nutrients, organic matter, and lime requirement. Recommendations are offered with soil test results for any issues that may be identified. It is also important to consider the physical properties of soils which include texture, bulk density, penetration resistance, structure development, porosity, and aggregate stability. Compaction due to field traffic is the physical issue most seen in Mississippi soils.

Because of the increase in world population and food demand, we should understand that to produce the food we need today and in the future, there is a need to balance those complex systems instead of seeing agriculture as harmful. Food production on less acreage today cannot be possible without inputs that will increase yields such as improved varieties, efficient nutrient management practices, and improve harvest systems. Sustainability is based on balancing the equation of good production and not eliminating the positive aspects of it. Let's face the reality that there will be necessary changes in land-use and management to keep with the demand of global food supply.

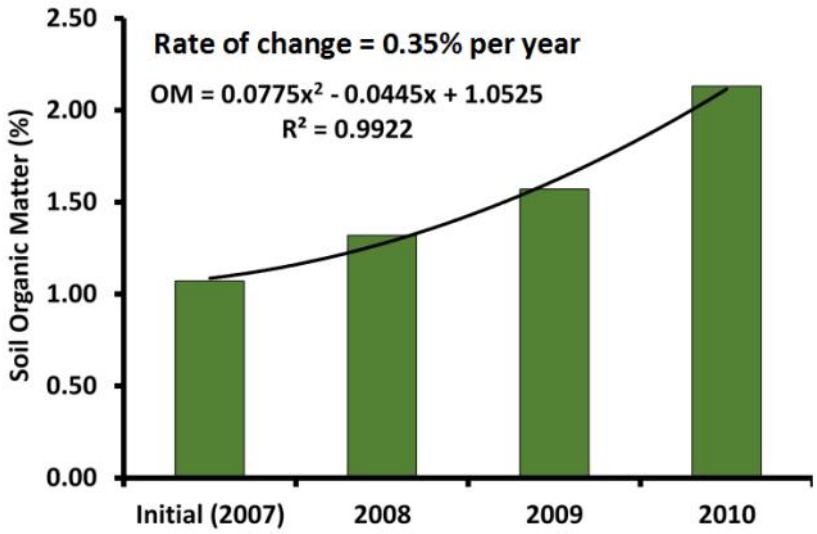

Figure 1. Changes in soil organic matter in a GA pasture dairy-based rotational grazing system over a three-year period. Adapted from Hancock, 2011. Original Source: Dr. Nick Hill, University of Georgia.

Soil is the fundamental unit for production agriculture, but at the same time a complex system that will require different considerations. Soil heath is not a one size fits all because of diverse soils, and some will need more management than others. Realize that soils do not change quickly, for example building organic matter (Fig. 1) in a soil in pasture without tillage. When discussing soil health, approach it from a quality soil management perspective. A grazing ecosystem

where proper grazing allow nutrient cycling, plants can provide carbon transformations (root exudates and root decomposition), stocking rates can help maintain soil structure by decreasing compaction, and proper use of pesticides can help keep the desirable species competitive. When these parameters are incorporated, it facilitates the interaction of soil organisms and plant productivity towards having better agricultural goods and services.

Soils have four major components with a variable percent of distribution: (1) water, (2) minerals, (3) organic matter and (4) air. The distribution of these components influences structure along with other factors (Table 1). Soil texture is the amount of sand, clay and silt, and for a given soil it is a fixed property with respect to practical time scales. Keep in mind that the proportion of soil particle sizes leads to types of soil such as fine, medium and coarse textured soils with distinctive soil physical and chemical properties that impact soil properties. For example, sandy soils tend to be lower in organic matter, lower pH, and higher capability of leaching potassium, lower cation-exchange capacity (CEC) and large pores that impede water retention. Clay soils tend to have higher organic matter, higher CEC, and larger quantity of small pores that increases water retention. The properties of silty soils tend to fall between the clay and sandy soils (Table 1).

Table 1. Characteristics of the three major soil types.

Property	Clay	Silt	Sand
Water holding capacity	High	Medium to high	Low
Ability to store plant nutrients	High	Medium to high	Poor
Nutrient supplying capacity	High	Medium to high	Low
Aeration	Poor	Medium	Good
Drainage capacity	Very slow	Slow to medium	High
Organic matter capacity	Medium to high	Medium	Low
Tendency to compaction	High	Medium	Low

Source: Brady and Well, 2008; Havlin et al., 2013.

We have seen decreased grassland productivity due to soil degradation, this could be related to mismanagement or adverse weather conditions. To regain the capacity and function of the soil, producers will have to management wisely with appropriate inputs which may include fertilizers, various pesticides to combat diseases, weeds and insects, and sometimes provide water to help desirable plant species get established. Keep in mind that some fungi and bacteria can act as pesticides as well. The concept of soil health is developed across a balance of nutrients and organic matter that could optimize forage production and microbial activity. It is important to note that organic matter accumulation is a very slow process (Fig. 1). Proper fertilizer use can increase forage biomass production and therefore, increase biological activity by increasing root mass production and root exudates as well increase biomass decomposition. When soils are depleted from those two components, there is a need to supply and replenish them in the soil and make the system more sustainable. For example, at a pH of 5.5 or lower, aluminum (Al) can become toxic to plants and reduce root mass, and also can reduce uptake of other nutrients such as phosphorous and potassium. Also, beneficial organisms such as earthworms cannot survive long-term in that environment. This is the case with most pastures across the southern USA. This means, a soil health program must have regular soil testing as a fundamental component to determine any lime and fertilizer needs for optimum levels for biomass production and strong root systems for putting carbon into the soil and thereby increase soil organic matter.

On occasion above ground residual biomass (commonly known as thatch) can also affect plants and nutrient availability by reducing microbial activity and organic matter decomposition. In cases where above ground residual biomass is very dense, the use of fire could be a good source to increase soil temperature and help release nutrients. This is a practice

that is recommended to use every 3-4 years in forage systems if too much biomass has accumulated. Organic carbon is the source of food for soil organisms, but we need to be careful what carbon form is available. Organic matter containing high levels of lignin (a complex polymer) is not easily decomposed. This means that choosing plant species with lower lignin levels will impact decomposition rates.

Don't think that soil health will magically appear if you only apply the general recommendations. A step-by-step process be followed to reduce inputs needed and improve soil health, making the system more self-sustainable. To manage the below ground environment, we also need to focus on the above ground production. The more biomass is removed from above ground, the smaller the root system in a plant will be and carbon sequestration will be limited. The reason for that is because plants with less leaf area above ground will need to allocate more carbohydrates to growth and recovery instead of storing those in the root and help the root system grow.

One of the prescribed recommendations is to have a diverse number of forage species**;** it will be very hard to meet all the nutrient requirements of those species and to promote long-term persistence due to interspecies competition. Although some species might be well adapted to one type of soil, others might not. Another issue when you look at a number of species is the cost of those mixes. They can have a large economic impact in the cost of establishment that is not being accounted for in the soil health model. My approach in this issue will be to have a system that maintains ground cover year long and sustain grazing. One way to improve soil quality will be to have mixed species of grasses and legumes that compatible with each other and adapted the soil and climatic conditions. Legumes can improve the quality of grasses since they can fix their own nitrogen. The use of pinpoint grazing systems that can close the gap and maintain a more uniform forage production and grazing sustainability thought the year should be the goal. Plants that are productive can sequester carbon [capturing carbon dioxide (CO_2) from the atmosphere], have strong root systems and provide a diverse environment for soil microbes. The key is not so much how many species are incorporates in the system, it is how much rest those pastures are receiving to allow recovery. By implementing this practice, plants can have a faster canopy closure to reduce weed invasion and competition. At the same time, it might maintain soil temperature to a level that could encourage biological activity.

Integrating grazing management as part of soil quality should be done under the concept of rotational grazing. This means allocating adequate number of livestock to the correct amount of land to allow uniform grazing and provide rest periods. Grazing to a 3- to 4-inche stubble height will leave sufficient leaf area to allow plants to recover faster. Although the concept of mob grazing is seen as theme to soil health, keep in mind that large concentration of animals in a small area can increase soil compaction. At the same time, trampling 50% of the biomass can be a competition for the regrowth of the desirable species and causing aggressive species, especially weeds, to become advantageous. Keep in mind that trampling 50% of the biomass requires long time for decomposition based on soil temperature and microbial activity. The amount of organic matter that is expected from this type of system can take many years to build.

Recently, we see a lot of emphasis on soil biological activity, which means organisms present in the soil. Again for those organisms to colonize the soil and to live in the environment, we need to look at pH, soil structure, aggregate stability, moisture, temperature, nutrient supply and carbon transformations. Most of the microbes in agricultural soil are heterotrophic aerobes (organisms that do not produce their own food) and only a few have the nitrogenase enzyme system to fix nitrogen (N). Therefore, most microbes cannot provide the N they need and none can provide their own phosphorus

(P), potassium (K) and sulfur (S). Fertile soils are the foundation for good crop production. Having a good ground cover with strong root system will develop habitats for soil microbe's diversity.

The relationships between soil community structure and function are very complex. Soil formation and reorganization is a process that takes a long time to happen. Soil quality (AKA "soil health") should be measurable physical, chemical and biological attributes that relate to soil capacity to sustain grassland production as affected by specific management practices. There is a need to focus on current nutrient levels, soil biodiversity and ecological functions that may co-exist in such complex system and generate scientific data to support this concept more than just relying on philosophical principles. At the present, there is a limited allocation of measurable soil functions that can explicitly assess soil health. Assessment of soil health across agricultural systems, soil types and climatic zones is very complex and hard to comprehend due to the number of factors involved (Fig. 2). This means that no single indicator can provide a clear picture of soil health.

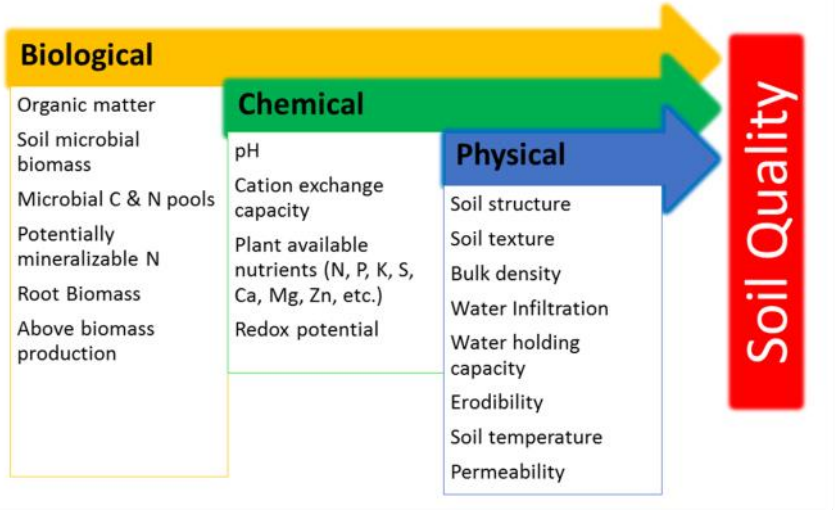

Figure 2. Potential factors that could be considered as indicators to link soil quality, soil fertility and land management practices to create a sustainable soil ecosystem.

The NRCS website indicates that "soil health can increase productivity and profitability immediately." Soil health is a slow process because it takes time to equilibrate pH, balance nutrient levels and most of all, building adequate levels of soil organic matter could take years depending on the soil type, texture, soil temperature, microbial activity, soil moisture, and forage species being used. It important to be realistic and cautious about immediate changes in soil health. It should be considered as a future benefit more than an instant impact. So, how can you develop a healthy pasture for future benefits? Concentrate on balancing the concept of rotational grazing with adequate resting periods (depending on the type of forage species), grazing to a 3 to 4 inches stubble height, increasing water infiltration, monitoring nutrient levels and fertilizing when needed, and allowing proper grazing to recycle nutrients more uniformly.

For upcoming forage related events visit:
http://forages.pss.msstate.edu/events.html

March 28, 2015—White Sand Field Day, Poplarville, MS
April 7, 2015 — Cool-season Forage Tour, Starkville, MS
April 14, 2015— North Mississippi Forage Field Day, Holly Springs, MS
May 15, 2015 — Alfalfa Field Day, Starkville, MS
June 19, 2015 — Warm-season Forage Tour, Starkville, MS