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Building a Pasture Savings Account

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The Upper Midwest has some of the best grass growing conditions during our relatively short grazing season, but I frequently see pastures that lack the density and vigor that we expect. We plant the newest, best varieties but they just don't perform well. I've always wondered why.

I believe that the key might be soil organic matter (OM). Although it rarely makes up even 10% of mineral soils, this small fraction is critically important in the regulation of nutrients and water in soils. Both the amount and the quality of OM may be important.

Many of our rotational pastures are relatively young, recently converted from cropland. Research has shown that continuous, tillage-intensive cropping of land depletes soil organic matter. For most cropped land, this depletion goes unnoticed. Since we started growing corn in the Midwest, yields have steadily increased in response to hybridization, fertilizers, and weed control. Pastures and other perennial crops are different though. Growth is spread out over a much longer season and they rely more heavily on the innate capacity of the soil to supply water and nutrients.

Organic Matter Matters.
Why is OM important to pasture productivity? Along with clay, OM plays an important role in soil moisture holding capacity. Both clay and OM together are responsible for cation exchange capacity (CEC), which regulates how much the soil can retain of such important nutrients as phosphorus, potassium, and calcium. Unlike clay, OM is also a source of nitrogen which is released slowly as the OM is decomposed and transformed by soil microbes.

Soil OM also plays a key role in soil structure. Complex organic compounds formed when micro-organisms decompose plant residues are the glue which holds soil particles together. Soil aggregation or the formation of soil particles is the way in which the balance of air and water critical to plant life is maintained in the soil environment.

Patience is Key.
Getting back to our problem, what we need to know is how soil OM depletion affects pasture productivity and what it takes to restore soil quality following a long history of tillage. In a world where a 3-year study is long and 2 years is the standard, the kind of long-term research that is needed rarely gets done.

Fortunately, much of our published pasture research was done back when longer term research was done more routinely. Even in that era, the 24 year study I recently came across is unique. The paper, published by the British Grassland Society in 1979, documented changes in a pasture starting in the seeding year. This work provides some insights into restoring productivity to worn out land.

The operative word here is patience. The study suggests that, when tillage is stopped, the soil undergoes a transformation, feeding and restoring itself over 8 to 10 years, before it finally stabilizes and produces a consistent yield.

The study was planted in a field with a long cropping history. The pasture was seeded to ryegrass and white clover in 1954 and given a minimal annual application of 43 lb N, 19 lb P, and 53 lb K per acre throughout the study. From the first year, pasture yield declined for 8 years from 4.3 tons dry matter per acre to a low of 1.9 tons/a. Following year 8, yield rose again and stabilized by year 11 at about 3.6 tons/a. The authors documented that the bulk of these yield changes occurred in the April-June period. Yields for the rest of the season were variable and responded primarily to that year's rainfall patterns.

Early summer growth depends largely on the amount of moisture and nitrogen stored in the soil over winter and available to the plants as they begin to grow in the spring. If the soil does not have the inherent capacity to sustain good early season growth, overall yields are going to suffer. The study suggests that relatively small increases in organic matter can improve pasture performance. During the 8-year 'recovery' period, the authors documented an increase in OM from 2.4 to 3.4% and an increase in soil nitrogen content of 65 lb/a.

Not just any Organic Matter will do.
Organic matter is a complex and often poorly understood component of soils. There are three distinct types: the passive, slow, and active fractions (Walter Goldstein of Michael Fields Agricultural Institute talks about passive, active, and labile fractions). We can think of them in banking terms. At one end of the spectrum is plant residual material in the active fraction. It functions like a checking account, readily available as it is broken down by soil microbes and repeatedly replenished by seasonal crop growth.

At the other end of the spectrum is the extremely stable passive fraction or humus. This portion is like a retirement account or savings bonds. Humus is composed of compounds that are highly resistant to decomposition and are stored away for the long term. It does not appear to decline significantly even after many years of annual tillage.

The slow fraction is like a savings account. When plant residual is abundant, it is 'banked for later use' and becomes part of the slow fraction. Like a savings account, the slow fraction is used for 'lean times' when there's a low balance in the active fraction. It is this OM that makes available a consistent supply of water and nutrients to perennial plants through out the growing season. It is this fraction that is depleted in intensive tillage systems.

Restoring worn-out soils.
The key to improving pasture productivity may be rebuilding the OM savings account. Critical to this process are many insects, fungi, and microbes that live in the soil. In a single cubic inch of soil there can be over 10,000 individual organisms; in an average acre of soil there are 9000 pounds of soil dwelling critters. It is this soil ecosystem that mediates the amount and quality of OM. Our management affects how this ecosystem functions.

Like all living things, soil organisms need oxygen, water, nutrients, and energy to survive. Under tillage, oxygen and water become more plentiful; nutrients and energy become limiting factors in microbial population growth. The microbes respond by dipping into the banked organic matter for nutrients and energy to support increased growth. Over time, they use up this important organic matter fraction. The goal in restoring it is to increase plant biomass inputs without increasing decomposition rates.

The perennial nature of pastures takes us a long way in this direction. In addition, several studies have shown that regular, moderate amounts of nitrogen fertilizer will increase overall biomass production and promote increases in soil OM. In other words, short term nitrogen application for a 'young' pasture may help restore soil productivity in the long term. Returning plant biomass to the pasture in the form of residual and manure also adds to the organic matter bank. In this respect, there is no wasted forage in a pasture system. As long as it stays on the farm, even if it does not pass through a cow, it contributes to future production.

The term ‘grass farmer’ signifies the view that our profitability is as closely tied to managing pasture as it is to managing animals. We might also want to think about grass farming as being about managing the soil and those other living things under the soil surface. It is this basic resource and how we manage it that ultimately determines production and profitability.