Regenerative Agriculture

Building Soil Fertility Through Carbon Sequestration

Hacienda las Imagenes

During the past 40 years in Guanacaste I have acquired a pretty good understanding of environmental issues affecting a difficult region of Costa Rica.

We have been involved with regenerative agriculture for 20 years on a 1400 hectare property. Half of this area is in forest. The other half is in mixed use, pastures and forest with primarily native grasses.

We raise cattle, horses, grow trees, and farm grass. In order to feed animals sufficiently you have to be able to grow it efficiently. To achieve this, soil fertility has to be improved daily.

What we are observing, along with some reference work to reinforce what we are doing, is the basis for this presentation. This is not scientific research, but rather practical observations made over time.

Our micro climate has changed and is unique to the surrounding area.

- Biodiversity is increasing.
- More moisture is being retained for longer periods.
- Pastures are producing more grass in less time with improved ground cover.
- Cattle are healthier and have greater weight gains.
- As peripheral forests are increasing, there is more morning condensation.
- Springs are increasing in quantity and quality of water.

We understand the urgency of reducing excess atmospheric carbon dioxide. However, people don't generally consider the important part soil has in this effort. Some have misconceptions in regards to some key issues.

In an attempt to make this information more understandable I will try to simplify.

These issues are:

- The causes of excess atmospheric carbon dioxide and soil degradation.
- Where and how carbon can be most effectively sequestered.
- Loss of moisture in soils and desertification.
- Depleted nutrients in our food and increasing health problems.

The common solution is to build soil fertility.

The only way to significantly reduce atmospheric carbon dioxide is through photosynthesis. There is an agricultural solution. This will not require government action or the invention of new technologies.

At least half of our present carbon dioxide dilemma comes from unsustainable agricultural practices. This is something we can work to change now.

Live, carbon rich soils with a high percentage of organic material promote microbial activity and better absorption of moisture.

Topsoil with continuous ground cover can store significant amounts of carbon and retain 70% of its moisture. Dead compacted soil with little ground cover loses 100% of its moisture.

With continual ground cover, photosynthesis, and microbial activity a "liquid carbon pathway" enables carbon to be incorporated into the soil. (C.Jones, 2008)

This is light being absorbed by chlorophyll in green leaves combined with carbon dioxide and water to create carbohydrate sugars. This feeds the plant and microbial life connected to or in close proximity to the roots. The surplus is expelled through the roots of plants into the soil. Carbon is stored into the ground and oxygen released into the atmosphere.

The challenge is to put as much organic material into the soil for as long as possible with each growing season. 8% of the Earth's surface is agricultural, in cultivation or pasture lands. This does not include any forests, just areas that have already been disturbed. An increase of 1.6% organic material into these areas could get us back to preindustrial carbon dioxide levels. (A.Yeoman, Priority One)

Due to soils generally being in a degraded state, there is plenty of room to store carbon in the "soil bank".

This increase in organic material requires changes in the status quo and eliminating some bad habits we have acquired over the last 65 years.

With the advent of chemical farming we got on the fast track to lose stored carbon in the soil. It has become acceptable to use depleted soil as a neutral medium, to prop up a plant and use chemicals to feed it.

To say these chemicals are necessary to feed the increasing population could not be further from the truth.

If we continue on our present path, fewer people will be fed.

Sustainability is a term that is used a great deal but often misunderstood. To continue doing something year after year without ill effects is sustainable.

In order to sustain an agricultural activity the soil has to be alive, well aerated, spongy, nutrient rich, microbial active, and humus laden. Humus is 58% Carbon. Loss of moisture in the soil and desertification are synonymous with loss of carbon in the ground.

When it rains 1", there is 67,000 gallons of water falling on one hectare. On a 16 hectare pasture that is 1,000,000 gallons of water. Without live soil, this water and any remaining topsoil is washed away. How we absorb and retain moisture is critical to carbon sequestration as well as recharging ground water and avoiding desertification.

Tilled, burned, and overgrazed soil without ground cover loses all of its moisture and becomes hard packed. When ground cover is burned off, which is the primary demise of Guanacaste, there is no hope for any kind of increased fertility.

Soils have to be 100% covered 100% of the time.

Reducing excess atmospheric carbon dioxide through forests alone will not achieve the desired reductions in time. Grasslands, if managed correctly, will. Under-grazed or inefficiently grazed grasslands lack the maximum input of organic material possible.

When a pasture is grazed or mowed appropriately, a level of optimum growth and quality of forage can be maintained.

Each time the grass is being pruned back, there is an equivalent sloughing off or pruning of the roots. A reduction of forage above ground has a corresponding reduction of root mass below ground. This is organic material decomposing where you want it, accessible to the microbes attached or in close proximity to the roots. As new roots begin to spread out, they will take new routes creating new channels, increasing aeration, and water filtration.

The more you can graze a field determines the amount of organic material that can be put into the soil. This depends on holistic, intensively managed grazing. (A. Savory)

Keeping pastures in a growing vegetative state is how to build soil fertility and sequester the greatest amount of Carbon. This is biological carbon exuded from plant roots, processed by microorganisms into carbon rich humus.

Here in the tropics, rather than a one-time growth cycle to maturity and seeding, it is possible to achieve 20 times the organic material input in a given season.

A variety of forages on the surface facilitates a variety of microorganisms with different influences and benefits in the soil. (Ademir Calegari)

When there is only one kind of plant, there may be only one level of root penetration. With multiple forages there are many different penetrations that aid in the prevention of a hard packed level below the surface. This "biological tillage" helps to maintain aeration and filtration of moisture to greater depths.

Chemical inputs destroy the microbial activity that is essential to building soil fertility. A plant can only draw up moisture and nutrients in close proximity to its roots. Mycorrhizal fungi connect to the plant roots and receive carbon based sugars from photosynthesis. The fungi in return transport fertilization, moisture, minerals, and nutrients made available by bacterial activity.

The fine root hairs of the fungi extend great distances and help feed the plant that which would be otherwise inaccessible. The roots of these fungi (mycelium) connect to each other and create a "soil food web" that connects with other plants and trees. (E.R. Ingham)

This ability to connect individual plants below ground facilitates the transfer of nutrients between different species. When one sector or species is lacking, another can come to the rescue.

When you apply inorganic nitrogen, ammonia based, fertilizers you are essentially drowning the fungi in its own feces. A waste product of microbes is ammonia, fertilizer in a natural state supplied in appropriate increments. Inorganic nitrogen is overloading and killing microbial life.

Atmospheric nitrogen is the most abundant gas. All green plants fix nitrogen, not just legumes. As long as microbial activity is present and there is continual ground cover, access to nitrogen is limitless. (C.Jones). There are 18 tons of nitrogen in the atmosphere over every square meter of surface area.

When you apply inorganic phosphorous, it inhibits hormone production by plant roots. These hormones control root extension, lateral root development, and the production of root hairs. These hormones also help the colonization of microbial fungi. (Czarnecki 2014)

Soil already contains sufficient phosphorous, but is only available to plants if the right microbes are present.

When you apply herbicides and fungicides, you are killing the microbial life that enables increased soil fertility and carbon sequestration to occur.

When you apply pesticides, you are indiscriminately eliminating beneficial organisms as well. There are around 3000 "pests" that can damage crops and livestock. For each one of these, there are 3000 more beneficial organisms that are also being killed.

Since 1950, increasing agricultural chemical inputs parallel increasing health issues. Nutrients, not just the few indicated on the box, but the whole array that are necessary for good health are not being incorporated into the food we eat.

It is essential to have microbial activity drawing up nutrients deeper in the soil profile that the roots of plants cannot reach.

To summarize, here are some ways to destroy live soil:

- Fire
- Bare farmed ground
- Chemical fertilizers, pesticides, herbicides
- Over grazing
- Under grazing

Here are some ways to build live resilient soil:

- 100% ground cover 100% of the time
- Inputs of large amounts of organic material
- Uniform and consistent microbial activity
- Holistic, intensively managed grazing for pastures
- Perennial multi species green cover crops for farmed ground
- Maximizing a vegetative growing condition with each season

There is incredible simplicity in that so many seemingly overwhelming problems can be solved with biological solutions. We should look to nature and a 3.8 billon year successful track record whenever possible. (J. Benyhus biomimicry)

The needed transition from destructive agricultural practices to regenerative practices is essential to the reduction of atmospheric carbon dioxide, improving soil quality, increasing nutrient availability, and improving absorption of moisture.

5 to 20 tons of carbon dioxide per hectare per year can be stored in healthy soil. Every 100 tons of CO_2 removed from the atmosphere equals 27 tons of carbon sequestered biologically into the soil. (Allen,M.F. 2007 (Leake,J.R. 2004)

Maintaining forests, establishing corridors, and allowing secondary forest growth in unsuitable agricultural areas is essential.

The use of fire to clear areas each year must be stopped immediately. The primary objective is to put organic material into the soil not send it up in smoke. To stop these fires will positively affect water absorption and the recharging of aquifers.

Becoming carbon neutral was a good objective at 350ppm. Today, at 400ppm, we have to reduce existing atmospheric carbon dioxide. Beyond organic regenerative agriculture is our way out of a bad situation. Beyond organic is to begin connecting into natural processes rather than trying to control or destroy them. The term "organic" can often be a barrier rather than a bridge for many to get started in the right direction.

Regenerative agriculture is always building soil fertility rather than losing it. This is working in a sustainable way to store carbon, increase moisture content, and improve available nutrients.

If we can substantially reduce atmospheric carbon by sequestration into our soils it will give us time to work our way out of fossil fuels. (Rattan Lal) We can avoid desertification.

We will have a better chance adapting to and perhaps slowing up a changing climate.

More moisture can be retained within the terrestrial cycle rather than being washed out to sea. This will moderate weather and recharge depleted aquifers.

We can improve the nutrient value of our food and become healthier.

All of this is observable.

The longer a plant can stay in a growing state, the more organic material can be put into the soil and more carbon can be stored. The more carbon in the soil allows for more moisture to be retained. More moisture produces greater amounts of organic material facilitating increased microbial activity. Increased microbial activity builds fertile soil with stable stored carbon deep in the soil profile. The end product is humus.

When the plant to microbe cycle is functioning, it makes our work simple.

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