Why Regenerative Agriculture?

By Courtney White*

Abstract. Regenerative agriculture is both an attitude and a suite of practices that restores and maintains soil health and fertility, supports biodiversity, protects watersheds, and improves ecological and economic resilience. It focuses on creating the conditions for *life* above and below ground and takes its cues from nature, which has a very long track record of successfully growing things. By re-carbonizing soils via photosynthesis and biology, particularly on degraded land, regenerative agriculture can also sequester increasing quantities of atmospheric carbon (CO_2) underground, making it a low-cost "shovel-ready" solution to climate change. Its multiple co-benefits, including the production of healthy, nutritious food, means it will be a critical component of our response to rising climate instability.

> One of the buzzwords today is "sustainable." Everybody wants to be sustainable. My question is why in the world would we want to sustain a degraded resource? We need to work on regenerating our soils, not sustaining them.
>
> Gabe Brown, farmer and regenerative agriculture pioneer

Introduction

Is topsoil a renewable or nonrenewable resource? This question came to mind some years ago after reading *Dirt: the Erosion of Civilizations* by David Montgomery (2012), a professor of geology at the University of Washington. Although ostensibly a history of dirt, it is actually a book about the failure of societies to avoid repeating mistakes that hastened the demise of past civilizations. Dirt is created by the weathering of

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solid rock over time, usually accumulating at the rate of about *one inch per thousand years*. The top layer becomes biologically active with the presence of green plants and soil microbes. Unfortunately, we are eroding our topsoil at the alarming rate of an *inch per decade*, wrote Montgomery (2012), mostly as a consequence of poor agricultural practices. This imbalance has created a crisis for a simple reason: there is no substitute for dirt. Oil and natural gas can be replaced by other energy sources, preferably renewable ones, but nothing else can do what dirt does. In addition to being the medium in which our food grows, dirt stores drinking water, recycles dead material into new life, circulates essential nutrients, and stores carbon. Montgomery (2012) called it our most underappreciated and yet essential natural resource. If we wash it away, we pay the consequences.

This is not a new phenomenon, of course. As the Sumerians, Greeks, Romans, Mayans, Chinese, and early settlers in America could tell you, dirt matters. Time and again over the course of human history, social and political conflicts are exacerbated when there are more people to feed than can be supported by the land. Civilizations do not disappear overnight and they do not choose to fail. More often, they falter and then decline as their soil washes away over generations. Rome did not so much collapse as it crumbled, wrote Montgomery (2012), wearing away as erosion sapped its food-growing capacity.

Erosion is not just ancient history. In America today, millions of tons of topsoil are eroded annually from farm fields in the Mississippi River basin into the Gulf of Mexico. America's farms lose enough soil every year to fill a pickup truck for every family in the country. Worldwide today, an estimated 36 billion tons of soil are lost annually as a result of various land-degrading practices, a rate that has increased by 2.5 percent between 2000 and 2012, mainly due to clearing forests for agriculture (Borrelli et al. 2017). Until the last decades of the 20th century, clearing new land compensated for loss of productive agricultural land to erosion. According to the Global Land Assessment of Degradation published by the U.N. Food and Agricultural Organization (FAO), nearly 2 billion hectares worldwide (4.8 billion acres) have been degraded since the 1950s, representing nearly 25 percent of the world's, cropland, pastures, and woodlands

(Future Directions International 2011). Meanwhile, the world's population is expected to increase by 2 billion people by 2050, from 7.7 billion today to 9.7 billion (UN DESA 2019). This will place increasing stress on our arable land to provide sufficient food.

Land is critical to other ecosystem services, including the maintenance of biodiversity. IPBES (2019a) is a landmark report compiled by 145 experts from 50 nations, based on 15,000 scientific and governmental sources. It concluded that 1 million animal and plant species are now threatened with extinction and that biodiversity is declining around the world at accelerating rates unprecedented in human history. As noted by Sir Robert Watson, Chairperson of the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services, upon issuing the report:

> The health of ecosystems on which we and all other species depend is deteriorating more rapidly than ever. We are eroding the very foundations of our economies, livelihoods, food security, health, and quality of life worldwide. (IPBES 2019b)

Since agriculture is one of the primary activities that is reducing biodiversity, a summary of the IPBES (2019b) report concludes:

- More than a third of the world's land surface and nearly 75 percent of freshwater resources are now devoted to crop or livestock production.
- The value of crop production has increased by about 300 percent since 1970; raw timber harvest rose by 45 percent; and 60 billion tons of renewable and nonrenewable resources are now extracted globally every year, nearly double since 1980.
- Land degradation has reduced the productivity of nearly 25 percent of the global land surface; global crops are at significant risk from pollinator loss; and 100–300 million people are at increased risk of floods and hurricanes because of loss of coastal habitats.

Technology will not save us. It cannot create more dirt, only nature can. This is the big lesson of dirt, Montgomery (2012) observed: when you depend on a resource that is difficult to renew quickly, eventually you wind up in serious trouble. Modern society fosters the notion that technology will provide solutions to almost any problem, but no matter how fervently we believe in its power to improve our lives, technology simply cannot solve the problem of consuming a natural resource faster than we regenerate it.

> A common lesson of the ancient empires of the Old and New Worlds is that even innovative adaptations cannot make up for a lack of fertile soil to sustain increased productivity. As long as people take care of their land, the land can sustain them. (Montgomery 2012)

Creation

What if dirt—or more accurately *soil*—could be created quickly and by natural means? In fact, it is already happening and that is where regenerative agriculture comes in.

First, I want to take a quick detour to Charles Darwin. In his last book, published shortly before his death in 1882, Darwin focused on the lowly earthworm and the role it played in the mystery of soil formation. Conducting experiments in the backyard of his house over many years, Darwin discovered that topsoil can be expanded (deepened) in only a matter of years, largely as a result of the digestive work of earthworms. His thesis that soil was biologically alive with creatures transforming inert subsoil into rich topsoil by eating and excreting was rather revolutionary for its day, though his book was largely overlooked. Nearly a century would pass before we began to truly appreciate nature's innate capacity to create topsoil biologically.

Worms are important, but the real key to building topsoil is carbon. The process by which atmospheric carbon dioxide (CO_2) gets converted into soil carbon has been going on for at least a billion years and all it requires is sunlight, green plants, water, nutrients, and soil microbes. One of the first researchers to recognize the significance of this equation for its regenerative implications was Dr. Christine Jones, an independent soil scientist in Australia. According to Jones (2007), there are four basic steps:

- *Photosynthesis*: This is the process by which energy in sunlight is transformed into biochemical energy in the form of a simple sugar called glucose via green plants—which use CO_2 from the air and water from the soil, releasing oxygen as a byproduct. The chemical reaction: $CO_2 + H_2O + \text{energy} = CH_2O + O_2$.
- *Resynthesis*: Through a complex sequence of chemical reactions, glucose is resynthesized into a wide variety of carbon compounds, including carbohydrates (such as cellulose and starch), proteins, organic acids, waxes, and oils (including hydrocarbons), all of which serve as "fuel" for life on Earth.
- *Exudation*: Carbon compounds can be exuded directly into soil by plant roots to nurture microbes and other organisms. This process is essential to the creation of soil from the lifeless mineral dirt. The amount of increase in organic carbon is governed by the volume of plant roots per unit of soil and their rate of growth. More active green leaves mean more roots, which mean more carbon exuded.
- *Humification*: This refers to the creation of humus, a chemically stable type of organic matter composed of large, complex molecules made up of carbon, nitrogen, minerals, and soil particles. Visually, humus is the dark, rich layer of topsoil that people generally associate with stable wetlands, healthy rangelands, and productive farmland. Once carbon is safely stored as humus it has a high resistance to decomposition and therefore can remain intact and stable for hundreds or thousands of years.

The key to creating humus is a class of microbes called mycorrhizal fungi, which get their energy in liquid form as soluble carbon directly from actively growing plant roots. In turn, these fungi facilitate the transport of essential nutrients, such as phosphorus, zinc, and nitrogen, into plant roots in exchange for carbon. When mycorrhizal fungi are functioning properly, a great deal of the carbon that enters the leaves of plants can be channeled directly into soil as soluble carbon—which is why people get excited about the prospect of storing excess CO_2 in the soil as one remedy for global warming. Not only is it possible on a practical level, all it requires are the processes that create life—and creating life is something that the Earth does very well.

Healthy soils have a 6–8 percent fraction of carbon in them, typically. If undisturbed or restored to health, soils not only continue to hold their carbon but can "soak up" even more from the atmosphere, which is very good news for fighting global warming. Soil is one of the great carbon pools on the planet, along with the atmosphere, oceans, and vegetation. Thanks to the miracle of photosynthesis, carbon can be safely stored underground in plant roots and as part of the natural, biological soil-building process (Cho 2018).

An important co-benefit of increasing the carbon content of soils is its improved capacity to hold water. It is estimated that a 1 percent increase in organic matter can add as much as 16,000 gallons of water storage capacity per acre [about 144,000 liters per hectare] (Sullivan 2002). This is accomplished by increasing the porosity of the soil through improved soil structure as humus is formed. Carbon, in the form of a sticky protein called *glomalin*, attaches to loose minerals and can bind them together into aggregates, creating micro-pockets that fill with moisture that has infiltrated from the ground surface. Over time, these soil aggregates bind to other aggregates and if undisturbed can form underground "reservoirs" of water. This is very useful for surviving drought and will be increasingly important in many arid and semi-arid regions as dry times become the norm under climate change.

Improved soil structure also mitigates floods—another significant element of climate instability. The experience of Gabe Brown (2018) is illustrative. An innovative farmer in North Dakota, Brown transformed his family's conventionally managed, eroded, worn-out land into a biologically rich, healthy, and productive operation by turning *dirt into soil* with regenerative agriculture.

> When we purchased the farm in 1991, the infiltration rate on our cropland was only ½-inch per hour. That meant when a big storm came along, dumping two or three inches of rain, most of the water left the farm in a hurry usually taking a bunch of topsoil with it.

After raising the carbon fraction of his soil from 2 percent to 5 with regenerative practices, including year-round cover crops, this situation changed dramatically.

> By 2009, the infiltration rate had risen to more than *ten inches* per hour thanks to well-aggregated soils due to mycorrhizal fungi and soil biology.

As Brown discovered, there is an important requirement for successfully regenerating topsoil: *we must not till*. Turning over the ground with a plow every year exposes soil to wind and water erosion and releases large amounts of carbon dioxide into the atmosphere that was previously stored safely. Tilling breaks up (pulverizes) soil aggregates, destroys critical fungal networks, and can result in bare or compacted soil that creates a hostile environment for microbes, earthworms, and other forms of life. When life departs, erosion soon follows.

Transition

Dirt is *chemistry*—individual particles, minerals, and other elements, including calcium, phosphorus, and potassium. Soil is *biology*—bacteria, fungi, protozoa, nematodes, earthworms, reproduction, growth, life. Getting plants to grow in dirt is chiefly a matter of getting the chemistry right and applying it mechanically according to a calculated prescription. Getting plants to grow in soil, by contrast, is a matter of getting the biology right. If the ground is devoid of micro-organisms, for instance, you need to foster the conditions for their return.

There is where regenerative agriculture comes in. Perhaps the best way to explain its potential for building topsoil is to walk through the transition of a farm from industrial production to a regenerative one, as Brown did. The vast majority of farmers in the United States grow just a few crops, such as corn and soybeans, in an annual rotation using lots of killing chemicals—herbicides, insecticides, and fungicides—and artificial fertilizers. They usually leave their fields bare for six months between the harvest and spring planting (when they are likely to use GMO seed, but that is another story).

The first step in the regenerative transition is to stop using the synthetic chemicals, which are also killing beneficial insects and important soil microbes and fungi. This step is the essence of certified *organic* agriculture. Life returns quickly to the land. Gabe Brown likes to joke that he could never go fishing because there were no earthworms on his farm under conventional management. When he stopped using chemicals, however, earthworms appeared! It was a sign the land had begun the healing process.

The next step in the transition is a big one: stop using the plow. Stop killing life in the soil by turning it over every spring. Go "no-till." This is a difficult step for many farmers because plowing the land is an almost religious belief. Most organic farms continue to till, for example. The mental leap required to go no-till is much harder than the physical one. The next step is to keep fields covered with plants year-round, which boosts the biology underground. It can be cover crops or winter crops—whatever it takes to help plant roots and soil microbes collaborate as nature intended.

The next step is to diversify a farm's crops as much as possible, mimicking what happens in the natural world. There is a reason why nature *loves* polycultures—everything is working symbiotically. The next step is to stop artificial fertilizer use. The return of life and health to the soil via the previous steps means natural fertility will return as well. The last step is also a big one—integrate livestock into the operation by rotating cattle, pigs, and chickens through the crop fields and pastures. Grazing keeps the weeds under control and animal manure adds natural fertilizer to the soil. This transition can happen *anywhere*. Brown (2018) wrote:

> I follow five principles that were developed by nature, over eons of time. They are the same anyplace in the world where the sun shines and plants grow. Gardeners, farmers, and ranchers around the world are using these principles to grow nutrient-rich, deep topsoil with healthy watersheds.

Here are Brown's "five principles" for creating topsoil:

1. **Limit disturbance**. Limit mechanical, chemical, and physical disturbance of the soil. Tillage destroys soil structure. It is constantly tearing apart the "house" that nature builds to protect the living organisms in the soil that create natural soil fertility.

2. **Armor**. Keep the soil covered at all times. Bare soil is an anomaly—nature always works to cover the soil. Providing a natural "coat of armor" protects the soil from wind and water erosion while providing food and habitat for macro- and micro organisms.
3. **Diversity**. Strive for diversity of both plant and animal species. Grasses, forbs, legumes, and shrubs all live and thrive in harmony with each other. Some have shallow roots, some deep, some fibrous, some tap. Some are high-carbon, some are low-carbon, some are legumes. Each of them plays a role in maintaining soil health.
4. **Living roots**. Maintain a living root in the soil as long as possible throughout the year. When you see green growing plants any time of year it is a sign of living roots. Those living roots are feeding soil biology by providing its basic food source: carbon. This biology, in turn, fuels the nutrient cycle that feeds plants.
5. **Integrate animals**. Nature does not function without animals. The grazing of plants stimulates the plants to pump more carbon into the soil. This drives nutrient cycling by feeding biology. If you want a healthy functioning ecosystem on your farm or ranch, you must provide a home and habitat for not only farm animals but pollinators, predator insects, earthworms, and all of the microbiology that drive ecosystem function.

Brown's last point is critical and generally misunderstood by farmers and consumers alike. *The role of animals in regenerative agriculture is essential to building topsoil.* Consider the symbiotic relationships between herds of bison and native plants that existed for millennia on the Great Plains. The vast herds traveled across the land in annual migrations, never lingering in one place for long. They took what they needed from the plant community and kept going, leaving behind natural fertilizer in the form of manure and urine. The removal of plant foliage by grazing stimulates root activity, which, in turn, stimulates carbon exchange with soil microbes as the plants seek additional nutrients. The disturbance caused by thousands of hooves to the soil surface facilitates seed-to-soil contact and creates mini-water-collecting divots. All of this makes a significant contribution to soil formation. This process occurs everywhere, not just the Great Plains—the grass-grazer relationship is a natural one that can be found worldwide (Frank et al. 1998).

Regenerative ranchers and farmers mimic the behavior of wild herbivores by grouping their livestock—cattle, sheep, or goats—into a single herd and carefully controlling the timing, intensity, and frequency of the herd's impact on the land (usually with solar-powered electric fencing). "Timing" refers not only to the season of the year but how many days the herd spends in a specific pasture or paddock (often only seven-to-ten days per year). "Intensity" indicates the size of the herd for that period of time. "Frequency" measures how long the paddock is rested from grazing before the herd returns. This style of management is called adaptive multi-paddock (AMP), though it goes by other names as well: planned, short-duration, management-intensive, pulse, and cell grazing. All of them are based on the ideas of biologist Allan Savory, who developed his innovative model after years of observing migrating wildlife in southern Africa.

In a study led by a rangeland ecologist at Texas A&M University that compared AMP grazed plots to those grazed under conventional management, Dr. Richard Teague et al. (2016) concluded that AMP grazing test plots sequestered 2.7 metric tons *more* carbon per hectare than plots that were continuously grazed.

> Incorporating forages and ruminants into regeneratively managed agroecosystems can elevate soil organic [carbon], improve soil ecological function by minimizing the damage of tillage and inorganic fertilizers and biocides, and enhance biodiversity and wildlife habitat.

(The sequestered 2.7 metric tons from one hectare are equivalent to one-sixth of a U.S. individual's annual greenhouse gas contribution.)

The role of animal agriculture in climate change has been highly politicized recently with many well-meaning people advocating meatless diets as a way to reduce or eliminate the contribution of livestock to greenhouse gas emissions. However, this viewpoint does not take into account the larger picture of how ecosystems function. *It is simply not possible to sequester the necessary amounts of carbon dioxide in* *the soil to slow global warming without utilizing grazing animals, particularly since grasslands are one of the largest terrestrial biomes on the planet.* Cattle are not the problem—our management of them is. In fact, as Gabe Brown (2018) puts it, livestock are part of the solution:

> I thoroughly enjoy debating with vegetarians and vegans as to the importance of animals on the landscape. My contention is that if they are truly concerned about the health of ecosystems, they have to recognize the benefits that grazing ruminants provide, even if they choose not to partake of eating meat.

Food

One of the significant co-benefits of increasing topsoil via regenerative agriculture is the production of healthy, nutrient-dense food, including the potential for intensification—a useful prospect for a world trying to feed billions of people under the stress of climate change and resource depletion.

This potential hit home for me during a visit to Singing Frogs Farm (singingfrogsfarm.com), owned and operated by Paul and Elizabeth Kaiser and located on seven acres near Sebastopol, in northern California. I went to the farm because I was intrigued by the Kaisers' success at pioneering an innovative practice called *year-round farming*. I knew the operation was organic, no-till, and pollinator-friendly (they planted lots of hedgerows). I knew they sold their crops through a community-supported agriculture model, which meant they were local. I knew the farm was very profitable too. Paul was on record saying they grossed over $100,000 per crop-acre per year. In comparison, a typical organic farm in California grosses between $12,000 and $20,000 per crop-acre.

I also knew that the Kaisers considered themselves to be *carbon farmers*, having successfully elevated the carbon content of their soil from 2 to 6 percent (measured at a depth of 12 inches). They do it primarily via their composting and no-till practices. The key is the microbial population in the soil, which tripled under the Kaisers' stewardship. Everything flowed from this vibrant underground world they had fostered—crops, profits, and a high quality of life for themselves and their children.

What I did not know much about was year-round farming itself. In the Kaisers' model, vegetable seeds are sown in a greenhouse and then the seedlings are nurtured to a transplantable age. When a crop is harvested in the field, a young plant takes its place, often within hours. This way, the farm never stops producing food—and does so without growing weeds or using cover crops and commercial fertilizers. Instead, the Kaisers produce a great deal of compost on-farm and spread it along each row of crops on the top of the ground, rather than mix it with soil as is normally done. It is all done by hand by the Kaisers and their four full-time year-round employees.

To say this approach to farming is paradigm-busting is a huge understatement. When the Kaisers began farming in 2007, they followed the conventional model of growing one or two crops each year and then let the land idle until the following spring. However, two developments changed their mind during the first year on Singing Frogs: first, lots of mechanical things kept breaking down, which frustrated them immensely, and second, closing down the farm at the end of the growing season and reopening it again in the spring required an immense amount of time, energy, and more heavy machinery. The Kaisers decided there had to be a better way. The answer was to become a "knowledge-intensive" farm and work smarter, not harder. This led to two radical changes during the second growing season: (1) replace the machines with people; and (2) never stop farming.

Conclusion

Building topsoil quickly and producing lots of healthy food is not a pipe dream. It is a practicality, thanks to regenerative agriculture. It is possible because it is based on the same biological components that create and maintain life on the planet: photosynthesis, carbon, plant roots, water, and microbes. By building topsoil naturally we create the potential to put many hopeful, proactive solutions into operation, including the restoration of land health, intensified production of local food, expansion of watershed-based collaboratives, and the exploration of regenerative economic strategies. Perhaps the wise king of the province of Brobdingnag, as imagined by Jonathan Swift ([1726] 1918: 198–199), put it best:

> Whoever could make two ears of corn, or two blades of grass, to grow upon a spot of ground where only one grew before, would deserve better of mankind, and do more essential service to his country, than the whole race of politicians put together.

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