DELIVERING REGENERATION

CAROLINE GRINDROD

Caroline is a regenerative agriculture expert and founder of rootsofnature.co.uk

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The security threat to nations that hunger, inadequate access to water, and disease can create is well established.

There is a wide range of worthy humanitarian efforts and impressive initiatives across the planet seeking to prevent this melting pot of climate instability, biodiversity decline and rampant desertification from boiling over into a collapse of peace and security.

It is encouraging to see some international efforts seeking to address the root cause of issues rather than continuing to fire-fight the symptoms. There has been a distinct shift from directing resources to 'avert hunger' through the use of low-quality energy calories, to a wider view of food security and even 'nutritional security'.

In their 2012 report, the Committee for World Food Security set the benchmark as 'when all people, at all times, have physical, social and economic access to food which is safe and consumed in sufficient quantity and quality to meet their dietary needs and food preferences and is supported by an environment of adequate sanitation, health services and care, allowing for a healthy and active life'.

That is a huge step forward – but are we digging deep enough? I believe that the roots of true nutritional security starts in the soil.

Modern agriculture has a tendency to think of soil as a medium in which to grow a plant, but it is so much more.

Healthy soil is an entire ecosystem in its own right – alive with trillions of microscopic organisms working together as the soil food web.

In modern agriculture, we have also made the mistake of thinking of a plant as something we can isolate from the soil food web and grow in a lifeless medium as long as we feed it a few key nutrients: nitrogen, phosphorus and potassium.

What we have overlooked, to our detriment, is that a plant should be considered a holobiont. This is described, by Dr. Lynn Margulis in her 1991 book Symbiosis as a Source of Evolutionary Innovation, as an assemblage of a host and the many other species living in or around it, which together form a discrete ecological unit. The components of a holobiont are individual species or bionts, while the combined genome of all bionts is the hologenome.

Living soil is to a plant, what the gut is to a human.

Plant roots on their own are able to only take up a small percentage of the total nutrients stored in soil as they can only access nutrients in a plant-available form from the soluble pool. Plants have however developed a symbiotic way of achieving the dozens of nutrients they need to be healthy and grow optimally. Bacteria and fungi in the soil can access the inexhaustible pool of nutrients locked up in the

rock, sand, silt and clay of our soils. Through the use of enzymes and acids, they can solubilise minerals and take them into their biomass. Healthy, photosynthesising plants feed carbon-based exudates out through the tips of their roots to attract and feed these microorganisms and in turn their tiny predators. Through a combination of digestive secretions, death and decay, the previously unavailable range of nutrients held in the bodies of the organisms are delivered to the plant root in a form they can utilise.

Through a rapidly emerging world of plant research from a more holistic and biology focussed lens, we can understand that many of the diseases and vulnerabilities of our modern cropping systems stem from poor plant nutrition arising from dysfunctional soil health.

When a plant is unable to interact with a healthy soil food web it cannot optimally photosynthesise or synthesise nutrients into strong cell structures and waxy protective outer coatings. A plant's sap becomes highly attractive to pest insects with simple digestive systems and its physical structures are more easily attacked. Poorly plants are more easily affected by drought, flood, wind and frost - they lose their resilience. Only healthy plants with access to a wide spectrum of nutrients can make the phytochemicals that help them fight pests and diseases.

If plants are not able to take up the full spectrum of nutrients required for health and resilience, then the livestock that eat these plants, and the humans that eat the plants and animals, are subject to many of the same health vulnerabilities.

So what causes the loss of a functional soil food web and the resulting vulnerable and disease-prone plants and animals? Tillage, leaving soil bare and exposed, use of artificial fertilisers, use of pesticides, the use of antibiotics, a low diversity of species and overgrazing caused by badly managed livestock. Modern agriculture is at war with healthy soil.

The more we damage the soil food web, the more we must lean on energy-hungry and environmentally damaging artificial fertilisers, pesticides and animal medications, to treat the symptoms of poorly plants and livestock caused by poorly soils – and so it goes on, the costs of production go up, and the nutrient quality of our food plummets.

But the threat of food insecurity from a loss of biodiversity and badly managed soils doesn't stop there. A damaged soil is no longer held together with the biotic glues and structures that come from a symbiotic relationship with functional plants. These dead soils release stored carbon into the atmosphere contributing to global warming. Some estimates suggest that 133bn tonnes of carbon, or 8% of total global soil carbon stocks, may have been lost from the top two metres of the world's soil since the dawn of agriculture 12,000 years ago. (Sanderman et al, Feb 2018)

What's more, with global warming, we are also concerned with feed-backs that contribute to heating over and beyond the impact of greenhouse gases themselves.

Bare and degraded soils lead to desertification which in turn leads to a series of ever-warming effects on our planetary systems such as:

- Increased soil surface and air temperatures due to loss of transpiring plants. The soil surface can be 40 degrees cooler under the protection of green or a tall sward of grass.
- The tiny dust particles from bare degraded soil cause warming heat hazes that create humidity droughts.
- Large areas of bare soil cause heat domes that repel clouds and prevent rainfall.
- Methane oxidation through the hydroxyl ion pathway is reduced by the lack of moisture provided by plant transpiration and dimmed sunlight levels caused by dust hazes.
- The effectiveness of cooling radiation windows is compromised by heat domes and heat hazes.
- For every 1% loss of soil carbon, the soil can retain approximately two buckets of water less per square metre in the soil structure leading

to floods and drought. Some agricultural soils across the world have lost up to 50% of their original carbon stocks.

The World Atlas of Desertification shows that globally we are turning an area approximately half the size of the European Union to desert every year. The warming effect this has on our planet through these complex mechanisms is surely vast.

So it is clear that soil health is the very foundation of food security – so what can we do to reverse the alarming decline?

Currently, the setup of government bodies and their policies are too siloed and specialised so the responses they generate are mostly a mirror of this rational and mechanistic world view. Nature is however complex, intertwined and self-organising. The whole is greater than the sum of its parts.

As tempting as it may be to try and find blanket global solutions as a response to these wicked global threats, responses must mimic nature itself in order to benefit from the power of whole system cooling and stability. This requires a mindset shift and the use of systems or holistic thinking to find effective and adaptive solutions.

As the soil microbiologist, Walter Jehne, has shown, agroecological and regenerative ways of producing food offer opportunities to leverage the multiple benefits of growing and rearing nutrient-dense food from low input, climate-resilient systems that also cool our planet.

Every environment across the world is unique and supports a different range of habitats and potential agricultural options. The rich diversity of our global cultures has emerged under the particular influences of what food and fibre can be locally and sustainably produced.

For example, pastoral systems emerged from places where it was hard to grow crops and easier to rear livestock, while arable plant food systems emerged from regions of deep flat soils and high fertility. Each region's recipes, fashions and culture are shaped by the foods people ate and the lifestyle that was required to grow them. Epigenetics has meant that different people's health and nutritional requirements have co-evolved with their diet.

Agroecological regenerative systems use principles, not prescriptions. Below is an example of how we assess the health of the land and typical examples of guidelines we would use when designing a unique plan for the farm.

Water cycle – How effectively can you capture and retain your rainfall so that it is used by plants and animals for production?

Soil Health – How efficiently can plants and animals access nutrients, and how rapidly are these recycled so they can be made available again?

Photosynthesis – How optimal is the conversion of sunlight into food for the whole food web, including the livestock or plants you are directly managing?

Airflow – How can we better buffer the extremes of exposure to the elements to enhance plants and animals' production? How healthy are your soils' structures so that effective gas exchange can occur so plants can access the unlimited nitrogen and carbon available in our air?

Nature's dynamic networks – How complex and resilient are nature's interconnections in your landscape, so that pests are reduced, disease is minimised, and the growing season is long and stable?

Guidelines that help to achieve regenerative outcomes:

- Keep the soil covered with organic material
- Minimise repetitive soil disturbance
- Maximise diversity in crops, pasture plants and habitats
- Maintain a living plant in the soil all year round
- Integrate livestock or wild animals

With enough people working together we can start to impact local and even regional climate as well as reverse the collapse of biodiversity.

By teaching the principles of soil health and functional ecosystems, along with coaching in holistic thinking, we can support any farmer in the world develop their own way of producing a culturally appropriate healthy food on healthy soil in a way that builds community and cooperation.

This is the ultimate hopeful, proactive, simple and cost-effective approach to combating food instability and civil unrest.