The Soil Solution

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Soil Health Addresses our Massive Problems

The UN has named 2015 **International Year of Soils** and we should surely embrace this initiative with open hearts and willing hands. It is an incredibly timely focus, in light of a series of serious challenges impacting our future and perhaps our very existence. Soil health directly affects plant, animal and human health. It also impacts topsoil erosion, water management and ocean pollution. Most importantly, it is now recognised that global warming is directly related to soil mismanagement. A global soil health initiative can literally save a planet threatened with a man-made fever.

The Top Five Threats to our Sustainability and Long-Term Survival

While in the UK recently, I met with a professor who shared some deeply concerning findings. He informed me that a recent survey of leading British scientists revealed that as many as **one in five** of the best thinkers in the country believe that we will be **extinct** as a species by the end of this century, or perhaps much earlier. This confronting information should serve to sponsor meaningful action from every one of us. There are five core threats that need to be urgently addressed and they all relate back to the soil. These include:

Loss of topsoil – at the current rate of topsoil loss, we have just **60 years**before the thin veil that sustains us is no more. This is a huge issue because we will hit the wall way before this six-decade deadline. What is driving this dramatic loss? Basically, it comes down to the massive decline in organic matter following the industrial, extractive experiment in agriculture. We have now lost more than two thirds of our humus. Humus is the soil glue that determines whether rivers run brown following rainstorms or if the winds tear dust from the fragile upper layers of our food-producing soils. Nature teaches us that you must **give to receive**. This universal law is at work in photosynthesis, the single most important process in nature. The plant pumps one third of the sugars it produces from photosynthesis back into the soil to feed the microbes, which in turn fix nitrogen, deliver minerals and protect against plant and soil pests. It is all about giving to receive.
However, this is not a lesson we have applied to our farmland. It is a fairly basic concept that when you remove crops from a field, you are extracting carbon and minerals and you can not just keep taking indefinitely. Unfortunately, this has been the dominant model in many soils for the past century. We have overtilled our soils, oxidised the humus and often ignored the replacement of key minerals that determine the health of humus-building microbes. We have burnt out humus with excess nitrogen at the rate of 100 kg of carbon per every 1 kg of nitrogen oversupplied. We have removed massive amounts of minerals and carbon with ever-increasing yields from our NPK-driven hybridised crops. In many areas we continue to burn crop residues. This senseless practice floods the atmosphere with CO_2, which should have been returned to the soil as humus. Burning also damages soil-life while scorching precious organic matter in the process. The loss of topsoil has been increasing for a century and now, with the challenge of climate extremes, it is accelerating at quite a pace. Soil health legislation is essential in all of the thirty countries I have visited in the past year and in the International Year of Soils, we all need to be pushing for a **Soil Restoration Bill** to formalise this urgent necessity.

1. **Ocean acidification** is another threat. The oceans have absorbed around half of the CO_2 that has billowed from our soils, smokestacks and cement makers over the past century. This is a planetary self-balancing mechanism, which has helped avoid a much higher global temperature increase. However, there has been a price to pay for this compensatory, carbon redistribution. The CO_2 becomes carbonic acid in the ocean and, as a result, our seas have become increasingly acidic. It is basic chemistry that creatures that make their outer shells from calcium struggle to do so in increasingly acidic conditions. This directly impacts coral, shellfish, phytoplankton, algae and krill, and their struggle for survival has already begun. The key understanding here is that their survival is actually our survival. 500 million of us are directly dependent on coral reefs. Algae and krill are the basic building block for all life in the

ocean. Phytoplankton produce 60% of the oxygen we breathe and we have already lost 40% of these creatures. It is a serious situation that is worsening by the month and our only response to date is to talk about reducing carbon emissions. Talk is all we have done. There has been very little action, because the latest figures show a 10% increase in global carbon emissions over this past year. This is the biggest single increase ever recorded, at a time when we are supposedly focusing on critically important reductions. There is a solution to this crisis and it rests in the soil.

2. **Ocean warming** is possibly the most urgent issue at present. Methane is a greenhouse gas that is 23 times more thickening (compared to CO2) of the heat-trapping blanket that warms our world. **Permafrost** is the phenomenon where ancient organic matter releases methane gas as the ice cover melts. There are currently huge, unanticipated outpourings of methane associated with the rapid thawing of Siberia. However, there is an even more threatening methane-driven phenomenon linked to the loss of ice in the arctic. The arctic oceans house mountains of methane and carbon sludge called **methane hydrates**. This material remains stable at the low temperatures and high pressure found at depths below 500 metres. However, it is now suggested that there will be no summer ice cover in this region within less than two years. This means that the arctic oceans, lacking the reflective effect of the ice cover, will warm much more rapidly. In a recent edition, the prestigious scientific journal Nature warned of a strong potential for a massive "methane burp" from this region within the next two or three years. They suggested that this "burp" could involve 50 gigatonnes of methane in one huge release. This is equivalent to 1150 gigatonnes of CO2. Here are some figures that help to put this huge release into perspective. The entire man-made contribution of CO2 to the atmosphere from industry, energy generation and transport since 1860 is 250 gigatonnes. The loss of two thirds of our humus through soil mismanagement represents another 476 gigatonnes. We may be set to see the equivalent of over 150% more CO2 than that combined total, released in one short time frame. It is a truly frightening scenario that highlights the screaming urgency of a call to action.

3. **Food security** and **feeding the billions** become increasingly serious concerns as climate change progresses. There is no country I have visited in the past 12 months that has not had serious issues linked to climate change. Brazil, with its biggest drought in 80 years; California, with a three-year killer drought; India, with a belated, substandard monsoon; and large areas of Asia, NZ and Australia impacted with unparalleled weather extremes. It is becoming increasingly likely that these climate-related issues could serve to trigger economic recession or **depression** and that is when the importance of **food security** becomes paramount. In uncertain economic times, you are absurdly vulnerable if you are a country like Qatar, with 6% of the food security of Japan, who produce just 40% of their own food requirements. Turmoil and international aggression come hand-in-hand with financial collapse – it is easy to shut down the imported food supply of another country when seeking to fast-track capitulation. Improving your food security becomes an urgent necessity in this brave new world. **Soil health** determines productive capacity. In fact, good soil and water are increasingly seen as "the new gold", in recognition of their expanding importance. **Warren Buffet** is buying up farms with good soil and water, the **Bush family** has acquired a slice of the largest aquifer in South America (around 500,000 acres of the massive Gurani aquifer which comprises 300 million acres) and the Chinese are buying up good farmland across the globe (in countries where it is allowable). The GMO companies have sold us the story that their GM varieties are the solution to feeding a growing world population. However, it is becoming increasingly obvious that these finely tuned hybrids require very specific and precise conditions to deliver their promise. They can be very productive when given the correct fertiliser, moisture requirements and climate conditions but they can really struggle in challenging conditions. In short, they do not have resilience and resilience is the single most important requirement in a world that is becoming considerably less predictable. The more mineralised and biologically active your soil, the greater the crop resilience. There are tens of thousands of examples of this phenomenon. In fact, the obvious validity of a soil health strategy could be clearly contrasted with the failings of the conventional approach in the face of changing conditions. The suicide of 300,000 Indian farmers is partially related to crop failures linked to this lack of resilience in GM crops. The reality is this: the billions are better fed with humus-rich, living soils that store precious moisture more efficiently and sustain crops that can adapt to and perform in changing conditions.

4. **Declining nutrition** in our food and **chemical contamination** of our fresh produce are two other closely-related issues impacting our sustainability. The industrial, extractive agriculture model has seen the constant removal of soil minerals and a loss of two thirds of the humus that helps to store and

deliver those minerals. It is common sense to recognise that, every time we take a crop from a field, we are removing a little of all 74 minerals that were originally present in those soils. We replace a handful of them, often in an unbalanced fashion, and we assault our soil life with a smorgasbord of farm chemicals, many of which are proven biocides. When we have bombed the microbe bridge between soil and plant there is a price to pay. The plant suffers, in that it has less access to the trace minerals that fuel immunity, and the animals and humans eating those plants are also compromised. It has been suggested that the food we now consume contains just **20%** of the nutrition found in the food consumed by our grandparents when they were children. The immune-compromised plant will always require more chemical intervention, and repeated studies have demonstrated the cumulative effect of chemical residues in our bodies. This serious scenario is all about minerals and microbes, and they, in turn, are housed by **humus**.

Humus Saves the World

It may seem like something of an oversell to claim that the sweet-smelling, chocolate brown substance that determines soil fertility could really pull us from the mire. The key understanding here involves a recognition that you can't make more carbon. The number of carbon molecules present on our planet has remained constant since the dawn of time. This carbon is either stored in the soil as humus, the carbon-based life forms, or the atmosphere as CO_2, and it cycles between these three. The problem is that a great deal of the carbon that used to be in the soil as humus (over two thirds) is now in the atmosphere, thickening the blanket and trapping more heat.

The very simple and obvious solution is to return some of that excessive atmospheric carbon back to the soil as stable humus. When we build organic matter (humus) in the soil we have effectively sequestered carbon from the atmosphere. This is a difficult concept to grasp for some people, but if you realise that you can't make more carbon, it becomes clear that if it is returned to the soil, it is also removed from the atmosphere. How effective is this strategy, you may be thinking, and could it be the solution? **Professor Rattan Lal** is, perhaps, the leading scientist driving this humus awareness. He has suggested that an increase in organic matter in the top six inches of the soil can effectively **counter 30% of man-made carbon emissions**. This is an extremely conservative estimate because carbon sequestration via humus-building happens at depths much greater than 6 inches. The roots of plants release glucose, created from photosynthesis, to feed the surrounding soil biology. Some of this glucose is converted to humus in the soil. In this context, root depth determines the depth and scale of carbon sequestration in the soil. The fact is that many plants have roots that extend much deeper than six inches. Recent studies, for example, have identified Australian native grasses with roots that extend well over a hundred feet down into the soil.

A review of recent climate change science reveals a common and depressing overuse of the term "**irreversibility**" in appraisals of our future. If we constrain ourselves to the concept of reducing carbon emissions as our sole action strategy, this negative appraisal may be justified. However, when humus-building is incorporated into that game plan, the story changes. A global increase of 1.6% organic matter is sufficient to reduce CO_2 levels in the atmosphere from 400 ppm to below 300 ppm, which effectively reverses global warming. The burning question remains – how do we do this within the short time frame involved?

How It Can Be Done: Ten Solutions That Must Become Government or Personal Policy

1. **Composting** becomes standard practice wherever it is possible. On every farm, every council and in every home garden, we compost or add compost. Composting involves the conversion of organic matter into stable humus, but it is much more than that. When we add compost to a soil it stimulates and regenerates the soil life responsible for building humus. We did not just add some stable humus to our soil with the compost inclusion, we triggered our existing soil life to build humus much more efficiently and rapidly. The single most important breakthrough in the science of composting is the finding that the inclusion of 6-10% of a high-clay soil to the compost facilitates the creation of a clay/humus crumb where the humus created lasts for much longer in the soil. In fact, it remains stable

in the soil for up to 35 years (compared to a bacterial-dominated compost, based on something like lawn clippings where this "active humus" is only stored in the soil for around 12 months).

2. **Mycorrhizal fungi (AMF)** become the most important creatures on the planet at this point in time. These endangered organisms, of which we have lost 90% in farmed soils, produce a sticky, carbon-based substance called **glomalin**. It is now understood that glomalin, in turn, triggers the formation of 30% of the stable carbon in our soils. This is massive – one soil organism could single-handedly turn things around! It is an inexpensive strategy to reintroduce these missing creatures to farmed soils. NTS, for example, has developed a mycorrhizal inoculum called**Platform®**, where AMF can be effectively reintroduced for as little as $10 AUD per acre. Recent research has also demonstrated that compost has a remarkable capacity to stimulate both existing mycorrhizal fungi and introduced AMF, so our first two solutions are inextricably intertwined (as are several of these proposed solutions).

3. **Protection of soil life**, and their humus home base, becomes an essential strategy. There is little point in reintroducing beneficial microbes with one hand and then promptly destroying the new population with the other. How did we lose **90%** of our AMF and seriously compromise cellulose-digesting, humus-building fungi in general? The use of unbuffered salt fertilisers dehydrates and kills many beneficials, overtillage slices and dices AMF and oxidises humus and we have often neglected to feed and nurture this important workforce. However, the single most destructive component of modern agriculture, in terms of soil life, has been **farm chemicals**. Some of the herbicides are more destructive than fungicides in removing beneficial fungi. Fungicides can sometimes take the good with the bad and nematicides are the most destructive of all chemicals. There needs to be legislation to regulate chemicals that are killing the microbes that may determine our long-term survival. In an extractive model, where the soil is viewed as an inert medium in which the plant stands, this has not been a concern. However, as the science floods in, we are thankfully recognising the critical importance of the soil as a living medium and change is underway.

4. A **carbon source** must be included with all **nitrogen** applications. If we investigate how we lost two thirds of our soil carbon, it becomes apparent that mismanagement of nitrogen is a major player. This is not just an issue relevant to loss of carbon – agriculture currently contributes 80% of the greenhouse gas, nitrous oxide, which is **310** times more potent than CO_2 in terms of its global warming side-effect. Here's how it works: nitrogen stimulates bacteria, because these creatures have more need for nitrogen than any other organism (17% of their body is nitrogen). The bacteria seek carbon after this nitrogen feeding frenzy to balance out their unique 5:1 carbon to nitrogen ratio. In the absence of applied carbon, they have no choice but to target **humus**. They would never choose to literally eat themselves out of house and home, but we give them no choice. The destruction of humus via the mismanagement of applied nitrogen is a major factor that can be easily addressed. This is no small thing. Research demonstrates that we lose 100 kg of carbon for every 1 kg of nitrogen applied over and above what is required by the plant at the time. Think of large applications of starter N, where a young seedling cannot possibly utilise that much nitrogen. We need to regulate N applications, to adopt foliar application of N (which can be dramatically more efficient) and to include a carbon source with every nitrogen application. The carbon source offers an alternative to eating humus. This might include molasses, manure or compost but the best choice is **NTS Soluble Humate Granules™**, a carbon-dense source of concentrated humic acid, that also stabilises and magnifies the nitrogen input.

5. **Tillage must be modified.** There is compelling research demonstrating the humus-building effect of no-till or minimum-till agriculture. Much of this comes from the **Rodale Institute** and their 25 years of in-depth research, quantifying humus-building dynamics. Every time we work the soil we disturb cellulose-digesting fungi and oxidise existing humus. I favour minimum-till over no-till, as there is evidence of mineral stratification that occurs over time in completely untouched soils. It makes sense that a combination of leaching and utilisation will see key minerals slowly move beyond the root zone. If we stir things up from time to time, this negative stratification effect can be countered.

6. **Green manure and cover crops** must become indispensable carbon-building tools for all of us. This is an integral component of a Nutrition Farming® approach, where we are always striving to feed the soil while converting plant material into humus. There is a rural myth among some growers that, in dryland

situations, these crops will steal moisture from the subsequent cash crop. This is not research-based. All of the evidence suggests that the increased moisture retention associated with this regular injection of organic matter more than compensates for the moisture removed in the production of the cover crops. There is compelling new US research that **cocktail cover crops** may be particularly beneficial. It has been found that certain combinations of plants, typically involving cereals, grasses, brassicas, legumes and chenopods, can trigger the release of phenolic compounds from these plant roots, which have been shown to stimulate rapid humus building. The brilliant American consultant, **Jerry Brunetti**, who sadly passed away in 2014, has included a particularly successful cocktail cover crop recipe in his parting gift, a wonderful new book entitled "The Farm as an Ecosystem". Cocktail cover crops sponsor microbial biodiversity because each species tends to favour and feed specific groups of root organisms. The more diverse the plant species, the more varied the soil life – and nature thrives on biodiversity. The brassicas in the mix can also discourage pathogens like nematodes and some diseases with their biochemical root exudates. Cocktail cover crops are also profoundly drought protective, in that the great mass of roots involved exudes a gel-like mucilage that can absorb ten thousand times its own dry weight in water. The trillions of bacteria around the roots also release a gel-like substance that provides them protection from predators but also serves to retain water. Brunetti cites a cocktail mix that has proven tremendously successful for North Dakota farmer, **Gabe Brown**, who has, in turn, been inspired by the innovative work of Brazilian agronomist, Dr Ademir Caligari. This mix includes at least a dozen of the following species: pearl millet, sorghum sundan grass, proso millet, buckwheat, sunn hemp, oilseed radish, turnips, pasha, ryegrass, canola, phacelea, cowpeas, soy beans, sugar beets, red clover, sweet clover, kale, rape, lentils, mung beans and subterranean clover. This mix includes the desired mix of legumes, grasses, cereals, brassicas and chenopods. It also involves cool season grasses and broad-leaved plants combined with warm season grasses and broad-leaved plants.

7. **Intelligent grazing** must be encouraged or incentivised to the point of legislative management. The dictionary definition of the word "science" is "adherence to natural laws and principles". Real science involves learning from the perfect blueprint of nature, rather than the futile attempt at improving upon nature that has characterised much of profit-based, scientific endeavour. In this context, we might examine nature to determine which soils on the planet have been most productive. The Great Plains in the US captured more carbon and produced more biomass than any other region on Earth. This amazing productive capacity was driven by huge herds of bison that moved into one area for a day, depositing massive amounts of urine and dung and creating a seedbed with their hooves for improved germination of the diverse range of seeds present in their dung. In effect, they facilitated a cocktail cover crop, or pasture crop in this case. The herds tended to graze down to about 4 inches before moving on, almost as though they were aware of the fact that the leaf is the solar panel that fuels photosynthesis. The plant pumps down 50% of its photosynthates (glucose) to the roots, and 60% of this carbon is exuded into the soil (30% of total glucose production). The whole carbon-building mechanics of the pasture are impacted by the length of the leaf, because the roots, which are being fed by the leaves, prune themselves back in accord with leaf size. If you have grazed down to a bowling green, the root mass has reduced accordingly and you no longer have a carbon-building pasture. Researchers like **Dr Christine Jones** in Australia have conclusively demonstrated that correctly managed pasture has the most carbon-sequestering capacity of any crop. Ruminants may yet be our savior, but only if we learn from nature and broadly adopt grazing practices where a post-grazing leaf length of 4 inches becomes the gold standard.

8. **CAM plants** involve something called Crassulacean Acid Metabolism, where their stomates remain open during the night, but close during daylight. This allows much more efficient photosynthesis and much better water utilisation (around 500% better). These plants thrive in hot, arid conditions, in low humus soils. Their role in these conditions is to maximise the benefits of minimal moisture, while pumping more sugars into the soil to build carbon in these barren soils. The good thing about these succulents is that they are absurdly easy to propagate. You simply break off a piece of plant and poke it into the soil. In suitable countries, the unemployed could plant trillions of these plants across areas that have been desertified by mankind's footprint. We could improve those soils while sequestering massive amounts of carbon from the atmosphere. One of the CAM plants, surprisingly, is Moringa, which is one of the most nutrient-dense food plants on the planet.

9. **Humates** become the most important of all farm inputs, from a humus-building perspective. Humic acid is the most powerful known stimulant of the cellulose-digesting fungi that build stable humus. It

also holds seven times its own weight in water, which, of course, benefits crops and soil organisms. Humates improve root growth and soil structure and buffer the dehydrating (biocidal) impact of salt fertilisers. These inputs are effectively cost neutral, so they remain a viable option even in subsistence farming. This "free" status is based upon the well-researched capacity of humates to magnify nutrient uptake by one third, via a phenomenon called "increased cell sensitisation". Soluble humic acid granules are combined with fertilisers at the rate of 5%. The cost of this inclusion is deducted from the fertiliser bill (i.e., a little less fertiliser is used to accommodate the cost of the humate additive). The proven 33% increase in fertiliser performance ensures that there is no risk factor associated with the small reduction in applied fertiliser. Soil, plants, animals, humans and the planet can all be beneficiaries of what is essentially a cost-free input.

10. **Biochar** is based upon the discovery of terra preta soils in the Amazon that seem to be self-generating and expanding. They feature humus-rich topsoil metres deep and they expand out beyond the villages from which they originated. It has been found that this remarkable fertility appears to originate from charcoal that was added to the soil from cooking fires. On the basis of this finding, the concept of manufacturing biochar as a humus-building soil additive has attracted considerable interest and associated research funds. I have been concerned that we had only really embraced half of the story. The amazing terra preta soils must surely involve specific microbes in a synergy with charcoal. We trialled a variety of task-specific organisms and broad-spectrum inoculums, like compost tea, in conjunction with biochar. However, we could not identify the specific synergy that turns biochar from inert carbon into a profound soil-building mechanism. Recently, I have had meetings with microbiologists who claim that the key synergist may be **mycorrhizal fungi**. This was a species we never researched but it seems highly likely that this is the key. Mycorrhizal fungi produce glomalin, which is responsible for 30% of soil humus. If these creatures were to move into hyperdrive, in the presence of biochar, it would explain the rapid soil-building phenomenon that is terra preta (black earth).

In Conclusion

2015 is the **International Year of Soils**. This UN initiative encourages a timely focus upon the importance of the thin veil of topsoil that sustains us all in so many ways. The soil glue that stabilises topsoil is humus. We have lost two thirds of our humus as a result of industrial, extractive agriculture and it is now time to address that issue. The words "human" and "humus" mean the same thing. They mean "of and for the earth". If our core purpose is to nurture and sustain the precious soil that supports us, then we have strayed a little on our path. It is not too late to recognise that mistake and move forward to make this critically important year the turning point.

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