Light Farming: Restoring carbon, organic nitrogen and biodiversity to agricultural soils

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Imagine there was a process that could remove carbon dioxide (CO_2) from the atmosphere, replace it with life-giving oxygen, support a robust soil microbiome, regenerate topsoil, enhance the nutrient density of food, restore water balance to the landscape and increase the profitability of agriculture?

Fortunately, there is.

It's called photosynthesis.

The power of photosynthesis

In the miracle of photosynthesis, a process that takes place in the chloroplasts of green leaves, carbon dioxide (CO_2) from the air and water (H_2O) from the soil, are combined to capture light energy and transform it to biochemical energy in the form of simple sugars.

These simple sugars - commonly referred to as 'photosynthate' - are the building blocks for life in and on the earth. Plants transform sugar to a great diversity of other carbon compounds, including starches, proteins, organic acids, cellulose, lignin, waxes and oils.

Fruits, vegetables, nuts, seeds and grains are 'packaged sunlight' derived from photosynthesis. The oxygen our cells and the cells of other living things utilise during aerobic respiration is also derived from photosynthesis.

We have a lot to thank green plants for!!

Significantly, many of the carbon compounds derived from the simple sugars formed during photosynthesis are also essential to the creation of well-structured topsoil from the lifeless mineral soil produced by the weathering of rocks.

Without photosynthesis there would be no soil.

Weathered rock minerals, yes … but fertile topsoil, no.

The plant-microbe bridge

It comes as a surprise to many to learn that over 95% of life on land resides in soil - and that most of the energy for this amazing world beneath our feet is derived from plant carbon.

Exudates from living roots are the most energy-rich of these carbon sources. In exchange for 'liquid carbon', microbes in the vicinity of plant roots - and microbes linked to plants via networks of beneficial fungi - increase the availability of the minerals and trace elements required to maintain the health and vitality of their hosts (1, 2). Microbial activity also drives the process of aggregation, enhancing soil structural stability, aeration, infiltration and water-holding capacity. All living things - above and below ground - benefit when the plant-microbe bridge is functioning effectively.

Sadly, many of today's farming methods have severely compromised soil microbial communities, significantly reducing the amount of liquid carbon transferred to and stabilised in soil. This creates negative feedbacks all along the line.

Over the last 150 years, many of the world's prime agricultural soils have lost between 30% and 75% of their carbon, adding billions of tonnes of CO_2 to the atmosphere (3). Losses of soil carbon significantly reduce the productive potential of the land and the profitability of farming. Soil degradation has intensified in recent decades, with around 30% of the world's cropland abandoned in the last 40 years due to soil decline (4). With the global population predicted to peak close to 10 billion by 2050, the need for soil restoration has never been more pressing.

Soil dysfunction also impacts on human and animal health. It is sobering to reflect that over the last seventy years, the level of every nutrient in almost every kind of food has fallen between 10 and 100%. An individual today would need to consume twice as much meat, three times as much fruit and four to five times as many vegetables to obtain the same amount of minerals and trace elements as available in those same foods in 1940.

Dr David Thomas (5, 6) provided a comprehensive analysis of historical changes in food composition from tables published by the Medical Research Council, Ministry of Agriculture, Fisheries and Foods and the Food Standards Agency. By comparing data available in 1940 with that in 1991, Thomas demonstrated a substantial loss in mineral and trace element content in every group of foods investigated.

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Mineral depletion in vegetables
1940 - 1991

Average of 27 kinds of vegetables

- Copper - declined by 76%
- Calcium - declined by 46%
- Iron - declined by 27%
- Magnesium - declined by 24%
- Potassium - declined by 16%

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Mineral depletion in meat
1940 - 1991

Average of 10 kinds of meat

- Copper - declined by 24%
- Calcium - declined by 41%
- Iron - declined by 54%
- Magnesium - declined by 10%
- Potassium - declined by 16%
- Phosphorus - declined by 28%

Source: Thomas, D.E. (2003). A study of the mineral depletion of foods available to us as a nation over the period 1940 to 1991. *Nutrition and Health*, 17: 85–115.

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The nutrient depletion summarised in Thomas's review represents a weighted average of mineral and trace element changes in 27 kinds of vegetables and 10 kinds of meat. Significant mineral and trace element depletion was also recorded in the 17 varieties of fruit and two dairy products tested over the same period (5).

The mineral depletion in meat and dairy reflects the fact that animals are consuming plants and/or grains that are themselves minerally depleted.

In addition to the overall decline in nutrient density, Thomas found significant changes in the ratios of minerals to one another. Given that there are critical ratios of minerals and trace elements for optimum physiological function, it is highly likely that these distorted ratios impact on animal and human health and well being (5).

Restoring nutrient density to food

It is commonly believed that the significant reduction in the nutrient density of today's chemically produced food is due to the 'dilution effect'. That is, as yield increases, mineral content falls. However, compromised nutrient levels are not observed in high-yielding vegetables, crops and pastures grown in healthy, biologically active soils. Indeed, the opposite applies.

Only in rare instances are minerals and trace elements completely absent from soil. Most of the 'deficiencies' observed in today's plants, animals and people are due to soil conditions not being conducive to nutrient uptake. The minerals are present, but simply not plant available. Adding inorganic elements to correct these so-called deficiencies is an inefficient practice. Rather, we need to address the biological causes of dysfunction.

"There can be no life without soil and no soil without life; they have evolved together"
(Charles E. Kellogg, USDA Yearbook of Agriculture, 1938).

The soil's ability to support nutrient dense, high vitality crops, pastures, fruit and vegetables requires the presence of a diverse array of soil microbes from a range of functional groups. The majority of microbes involved in nutrient acquisition are plant-dependent. That is, they respond to carbon compounds exuded by the roots of actively growing green plants.

Most plant-dependent microbes are negatively impacted by the use of 'cides' - herbicides, pesticides, insecticides and fungicides. The use of these chemicals reduces nutrient uptake, compromising the plant's immune response and often requiring even further use of chemicals.

In short, the functioning of the soil ecosystem is determined by the presence, diversity and photosynthetic rate of actively growing green plants - as well as the presence or absence of chemical toxins.

But who manages the plants - and the chemicals?

You guessed it … we do.

Fortunately, consumers are becoming increasingly aware that food is more than a commodity. Indeed, increased global awareness of the links between food quality, soil function and planetary health may well prove to be a significant driver for much-needed social and environmental change (7). It is up to us to restore soil integrity, fertility, structure and water-holding capacity - not by applying 'bandaids' to the symptoms, but by the way we manage our food production systems.

The soil carbon sink

Soil can function as a carbon **'source'** - adding carbon to the atmosphere - or a carbon **'sink'** - removing CO_2 from the atmosphere. The dynamics of the source-sink equation are largely determined by land management.

Over millennia a highly effective **carbon cycle** has evolved, in which the capture, storage, transfer, release and recapture of biochemical energy in the form of carbon compounds repeats over and over. The health of the soil - and the vitality of plants, animals and people - depends on the effective functioning of this cycle.

Technological developments since the Industrial Revolution have produced machinery capable of extracting vast quantities of fossil fuels from beneath the Earth's surface - as well as machinery capable of laying bare large tracts of grasslands and forests. Taken together, these factors have resulted in the release of increasing quantities of CO_2 to the atmosphere while simultaneously destroying the largest natural sink over which we have control. The decline in natural sink capacity has amplified the effects of anthropogenic emissions.

Carbon, nitrogen and water

When areas of intact vegetation are first cropped, good yields of high protein grain can usually be obtained without the addition of fertiliser. Over time, the replacement of a diverse ecosystem with single species crops, the use of excessive cultivation and the practice of maintaining a 'bare fallow' between cash crops, result in losses of soil carbon and the deterioration of soil health. In an effort to maintain yield, more and more fertiliser, particularly inorganic forms of nitrogen, are often applied.

Rather than applying 'more fertiliser' the solution to deteriorating soil function lies in the adoption of management practices that increase levels of stable soil carbon. Organic carbon, organic nitrogen and moisture-holding capacity always move together. When levels of soil carbon increase, so too do levels of organic nitrogen and the ability of the soil to infiltrate and store water.

Organic carbon holds between four and twenty times its own weight in water. In many environments, moisture availability (rather than nutrient availability) is the most limiting factor for production. Over time, improvements to soil carbon levels eliminate the need for inorganic fertilisers.

Increasing the level of stable soil carbon also has a positive effect on landscape function. Carbon is essential to the formation of the water-stable aggregates that enhance soil structure, which in turn reduces run-off and minimises erosion.

Carbon Conversion Efficiency (CCE)

Carbon Conversion Efficiency (CCE) is the percentage of carbon inputs (plant litter, animal manure, root exudates etc) biologically converted to stable soil carbon. For a range of physical, biological and chemical reasons, the conversion of carbon inputs into stable carbon is higher for root-derived materials than for above-ground biomass (8, 9).

An analysis of 10 stable isotope experiments undertaken in the field with roots grown in situ (i.e. no soil disturbance) found the stabilisation of root-derived carbon ranged from 18 to 91%, with an average of 46%, while the stabilisation of carbon derived from above-ground biomass ranged from 3 to 17% with an average of 8.3% (9). Overall, the stabilisation of root-derived carbon was five times higher than that from above-ground biomass (9). The authors suggested that the stabilisation of root-derived carbon could be even higher in perennial-based ecosystems than in the annual systems studied (9).

One reason root-derived materials make such a positive contribution to stable soil carbon pools is that in addition to providing a carbon source, the rhizosphere supports the free-living nitrogen fixing bacteria and beneficial fungi essential to stabilisation. Stable soil carbon is around 60% carbon and 6-8% nitrogen. Ideally, this nitrogen should come from the atmosphere. Well-aggregated soil is porous and has high rates of gaseous exchange. As soil carbon levels improve, soil structure improves and the conditions for associative biological N-fixation are enhanced, creating a positive feedback loop. When soil carbon is declining, the opposite applies. Populations of beneficial fungi fall, aggregate stability declines and the resulting poor structure limits gaseous exchange. This in turn reduces biological nitrogen fixation by free-living bacteria and hence the stabilisation of carbon.

Currently, many agricultural, horticultural, forestry and garden soils are a net carbon source. That is, these soils are losing more carbon than they are sequestering.

The potential for reversing the net movement of CO_2 to the atmosphere through improved plant and soil management is immense. Indeed, managing vegetative cover in ways that enhance the capacity of soil to sequester and store large volumes of atmospheric carbon in a stable form offers a practical and almost immediate solution to some of the most challenging issues currently facing humankind.

The key to successful sequestration is to get the basics right.

Five Principles for Soil Restoration

1. Green is good - and yearlong green is even better

Every year, photosynthesis draws down hundreds of billions of tonnes of CO_2 from the atmosphere. The impact of this drawdown was dramatically illustrated in a stunning visualisation released by NASA in 2014 (10). The movement of carbon from the atmosphere to soil - via green plants - represents the most powerful tool we have at our disposal for the restoration of soil function and reduction in atmospheric levels of CO_2.

While every green plant is a solar-powered carbon pump, it is the photosynthetic capacity and photosynthetic rate of living plants (rather than their biomass) that drive the biosequestration of stable soil carbon.

> ***Photosynthetic capacity***: the amount of light intercepted by green leaves in a given area. Determined by percentage canopy cover, plant height, leaf area, leaf shape and seasonal growth patterns. On agricultural land, photosynthetic capacity can be improved through the use of multi-species covers, companion cropping, multi-species pastures and strategic grazing. In parks and gardens plant diversity and mowing height are important factors. Bare soil has zero photosynthetic capacity. Bare soil is not only a net carbon source but is also vulnerable to erosion by wind and water.
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> ***Photosynthetic rate:*** the rate at which plants are able to convert light energy to sugars. Determined by many factors including light intensity, moisture, temperature, nutrient availability, plant species richness and the demand placed on hosts by microbial symbionts. Colonisation by mycorrhizal fungi and/or trichoderma can significantly increase photosynthetic rate. Plants photosynthesising at an elevated rate have a high sugar and mineral content, are less prone to pests and diseases and contribute to improved weight gains in livestock. Photosynthetic rate can be assessed by measuring Brix levels with a refractometer.

An increase of around 5% in global photosynthetic capacity and/or photosynthetic rate would be sufficient to counter the CO_2 flux from the burning of fossil fuels, provided the extra carbon was sequestered in soil in a stable form. This is do-able. On average, global cropland is bare for around half of every year (11). ***If you can see the soil it is losing carbon – and nitrogen!!***

Both photosynthetic capacity and photosynthetic rate are strongly impacted by management. Leading-edge ‘light farmers’ are developing innovative and highly productive ways to keep soil covered and alive, while producing nutrient dense food and high quality fibre.

One of the most significant findings to emerge in recent years has been the improvements to infiltration, water-holding capacity and drought resilience when bare fallows have been replaced with multi-species covers. This improvement has been particularly evident in lower rainfall regions and in dry years (12).

A healthy agricultural system is one that supports all forms of life. All too often, many of the life forms in soil have been considered dispensable. Or more correctly, have not been considered at all.

2. Microbes matter!!

The significance of the plant-microbe bridge in transferring and stabilising carbon in soil is becoming increasingly recognised, with the soil microbiome heralded as the next frontier in soils research.

One of the most important groups of plant-dependent soil-building microbes are mycorrhizal fungi. These extraordinary ecosystem engineers access water, protect their hosts from pests and diseases - and transport nutrients such as organic nitrogen, phosphorus, sulphur, potassium, calcium, magnesium, iron and trace elements including copper, cobalt, zinc, molybdenum, manganese and boron - in exchange for liquid carbon. Many of these elements are essential for resistance to pests and diseases and resilience to climatic extremes such as drought, waterlogging and frost.

When the mycorrhizal symbiosis is functioning effectively, 20-60% of the carbon fixed in green leaves can be channelled directly to soil mycelial networks, where a portion is combined with biologically fixed nitrogen and converted to stable humic compounds. The deeper in the soil profile this occurs, the better. Humic polymers formed by soil biota within the soil matrix improve soil structure, porosity, cation exchange capacity and plant growth.

Soil function is also strongly influenced by its structure. In order for soil to be well structured, it must be living. Life in the soil provides the glues and gums that enable soil particles to stick together into pea-sized lumps called aggregates. The spaces between the aggregates allow moisture to infiltrate more easily. Moisture absorbed into soil aggregates is protected from evaporation, so that soil remains moister for longer after rain or irrigation. This improves farm productivity and profit.

Well-structured soils are also less prone to erosion and compaction and function more effectively as bio-filters.

Sadly, many of the microbes important for soil function have gone missing in action. Can we get them back? Some producers have achieved large improvements in soil health in a relatively short time. What are these farmers doing differently?

They diversify.

3. Diversity is not dispensable!!!

Every plant exudes its own unique blend of sugars, enzymes, phenols, amino acids, nucleic acids, auxins, gibberellins and other biological compounds, many of which act as signals to soil microbes. Root exudates vary continuously over time, depending on the plant's immediate requirements. The greater the diversity of plants, the greater the diversity of microbes and the more robust the soil ecosystem.

The belief that monocultures and intensively managed systems are more profitable than diverse biologically-based systems does not hold up in practice. Monocultures need to be supported by high and often increasing levels of fertiliser, fungicide, insecticide and other chemicals that inhibit soil biological activity. The result is even greater expenditure on agrochemicals in an attempt to control the pest, weed, disease and fertility 'problems' that ensue.

The natural grasslands that once covered vast tracts of the Australian, North American, South American and sub-Saharan African continents - plus the ‘meadows’ of Europe - contained several hundred different kinds of grasses and forbs. These diverse grasslands and meadows were extremely productive prior to simplification through overgrazing and/or cultivation. The variation in plant root architecture in a range of North American prairie plants is illustrated in Fig. 2.

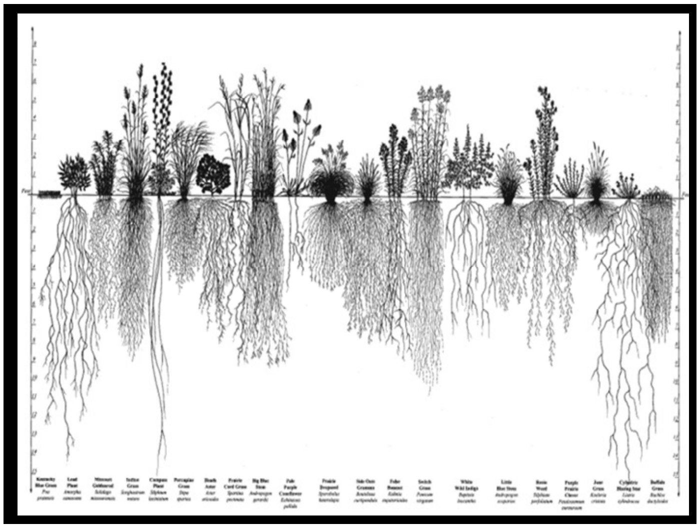

Fig. 2. Variation in root architecture of native American prairie plants, Illinois, USA (13).

Innovative farmers are experimenting with up to 60 to 70 different plant species to see which combinations perform best for soil restoration. Some grain and vegetable producers are setting aside up to 50% of their cash crop area for multi-species ‘soil primers’. They believe the benefits far outweigh the costs. It has been reported that two full seasons of a multi-species cover can perform miracles in terms of soil health.

However, it doesn’t need to be complicated. Something as simple as including one or two companions with a cash crop can make a world of difference. Indeed, it is becoming increasingly common to see peas with canola; clover or lentils with wheat; soybean, pigeon pea, faba beans, mungbeans or vetch with corn; flax with chickpeas; buckwheat and/or peas with potatoes … and so on. Monoculture will hopefully soon be a thing of the past.

In addition to improving soil function, companion plants provide habitat and food for insect predators. Recent research (14) has shown that as the diversity of insects in crops and pastures increases, the incidence of insect pests declines, hence avoiding the need for insecticides.

Plant production is often higher in diverse communities (15,16,17,18) with diversity reported to influence yield to a greater extent than fertiliser (15). A study on the effects of nitrogen applied at rates of 0, 100 and 200 kg N/ha/yr to 78 experimental grassland communities of increasing plant species richness (1, 2, 4, 8 or 16 species) found high plant diversity with zero fertiliser produced better yields than low diversity with 200 kg N/ha/yr (15).

Increased plant production in diverse communities is closely linked to the sequestration of both carbon and organic nitrogen (17,18,19, 20). It has been suggested that the high carbon storage capacity of remnant native prairie with '11+' plant species indicates there would be economic, ecological and environmental advantages to increasing the diversity of CRP plantings, from the current 5 or 6 species, despite the higher upfront costs (20).

Common myccorrhizal networks

An aspect of plant community structure that is gaining increased research attention is the presence of 'common mycorrhizal networks' (CMNs) in diverse pastures, crops and vegetable gardens. It has been found that plants in communities assist each other by linking together in vast underground super-highways through which they can exchange carbon, water and nutrients (21, 22). Common mycorrhizal networks increase plant resistance to pests and diseases (23) as well as enhancing plant vigour and improving soil health.

Beneficial saprotrophic fungi are also stimulated by plant diversity. The increased quantity and diversity of root-derived organic inputs, particularly exudates, enhances fungal biomass resulting in a significant shift in fungal-to-bacterial biomass ratios (24).

In my travels I've seen many examples of monocultures suffering severe water stress while diverse multi-species crops beside them remained green (Fig. 3).

Fig. 3. Triticale monoculture (left foreground) suffering severe water stress while triticale sown with other species (background and right) is powering. In addition to triticale, the 'cocktail crop' contained oats, tillage radish, sunflower, field peas, faba beans, chickpeas, proso millet and foxtail millet. Chinook Applied Research Association (CARA), Oyen, Alberta.

For a humorous insight into how diverse mixes of plants collaborate with soil life to rejuvenate soil and enhance drought tolerance, see reference 25 at the end of this document.

In mixed species plantings, warm-season grasses (such as sorghum and corn) are the most generous 'givers' to soil carbon pools, while broadleaf plants benefit the most from the increased availability of nutrients.

4. Limit chemical use

The mineral cycle improves significantly when soils are alive. It has been shown, for example, that mycorrhizal fungi can supply up to 90% of plants N and P requirements (26). In addition to including companions and multi-species covers in crop rotations, maintaining a living soil often requires that rates of high-analysis synthetic fertiliser and other chemicals be reduced, to enable microbes to do what microbes do best.

Profit is the difference between expenditure and income. In years to come we will perhaps wonder why it took so long to realise the futility of attempting to grow crops in dysfunctional soils, relying solely on increasingly expensive synthetic inputs.

No amount of NPK fertiliser can compensate for compacted, lifeless soil with low wettability and low water-holding capacity. Indeed, adding more chemical fertiliser often makes things worse. This is particularly so for inorganic nitrogen (N) and inorganic phosphorus (P). An often overlooked consequence of the application of high rates of N and P is that plants no longer need to channel liquid carbon to soil microbial communities in order to obtain these essential elements. Reduced carbon flow has a negative impact on soil aggregation - as well as limiting the energy available to the microbes involved in the acquisition of important minerals and trace elements. Lack of trace elements increases the susceptibility of plants and animals to pests and diseases.

Inorganic N: The use of high-analysis N fertiliser poses a significant cost to both farmers and the environment. Only 10 to 40% of applied N is taken up by plants, the remaining 60 to 90% being lost through a combination of volatilisation and leaching (27).

It is often assumed that nitrogen comes only from fertiliser or legumes. However, all green plants are capable of growing in association with nitrogen-fixing microbes. Even when N fertiliser is applied, plants obtain much of their N from microbial associations.

Farmers experimenting with ‘yearlong green’ farming techniques that incorporate high diversity are discovering that their soils develop the innate capacity to fix atmospheric nitrogen. However, if high rates of N fertiliser have been used for some time, it is important to wean off N slowly (27), as free-living nitrogen fixing bacteria require time to re-establish.

One of the many unintended consequences of the use of nitrogen fertiliser is the production of nitrous oxide in water-logged and/or compacted soils. Nitrous oxide is a greenhouse gas with almost 300 times the global-warming potential of carbon dioxide.

Inorganic P: The application of large quantities of water-soluble P, such as found in MAP, DAP or superphosphate, inhibits the production of strigolactone, an important plant hormone. Strigolactone increases root growth, root hair development and colonisation by mycorrhizal fungi, enabling plants to better access soil P (28). The long-term consequences of the inhibition of strigolactone include destabilisation of soil aggregates, increased soil compaction and mineral-deficient (eg low selenium) plants and animals.

In addition to having adverse effects on soil structure and the nutrient density of food, the application of inorganic water-soluble phosphorus is highly inefficient. At least 80% of applied P rapidly adsorbs to aluminium and iron oxides and/or forms calcium, aluminium, manganese or iron phosphates. In the absence of microbial activity, these forms of P are not plant available (28).

It is widely recognised that only 10-15% of fertiliser P is taken up by crops and pastures in the year of application. If P fertiliser has been applied for the previous 10 years, there will be sufficient for the next 100 years, irrespective of how much was in the soil to begin. Rather than continually adding P, it may prove more economical to incorporate P-scavenging plant species in cover and intercrop mixes as well as managing land in ways that support the soil microbes able to access ‘locked up’ soil P.

Mycorrhizal fungi are extremely important for increasing the availability of soil P. Their abundance can be significantly improved by the presence of perennial plants, the use of diverse cover crops, the inclusion of companions in cash crops and appropriate grazing management.

5. Animal integration

A multitude of animal species were in contact with soils prior to agricultural intensification. There is no doubt that soil function is improved by their presence. The re-integration of animals into cropland can be extremely beneficial - for both the soils and the animals. Grazing multi-species covers with domestic livestock, for example, helps recover seed costs and improves both soil and animal health.

The way livestock are managed has a significant impact on soil function. In actively growing perennial pastures, it is vitally important that *less than 50%* of the available green leaf be grazed at any one time (Fig.1). Retaining adequate leaf area reduces the impact of grazing on photosynthetic capacity and enables the rapid restoration of biomass to pre-grazed levels. Significantly more forage will be produced during the growing season - and more carbon sequestered in soil - if pastures are grazed 'tall' rather than 'short'. In addition to maintaining photosynthetic capacity though management of leaf area, the height of pasture has a significant effect on moisture retention, nutrient cycling and water quality.

Maintaining photosynthetic rate is also important. Higher Brix levels in pastures translate to improved feed conversion efficiency, higher average daily gain and enhanced milk production. It is quite possible that higher Brix levels also result in higher Carbon Conversion Efficiency (CCE), given that plant roots and their exudates represent the primary pathway for stable soil carbon sequestration (8, 9, 24).

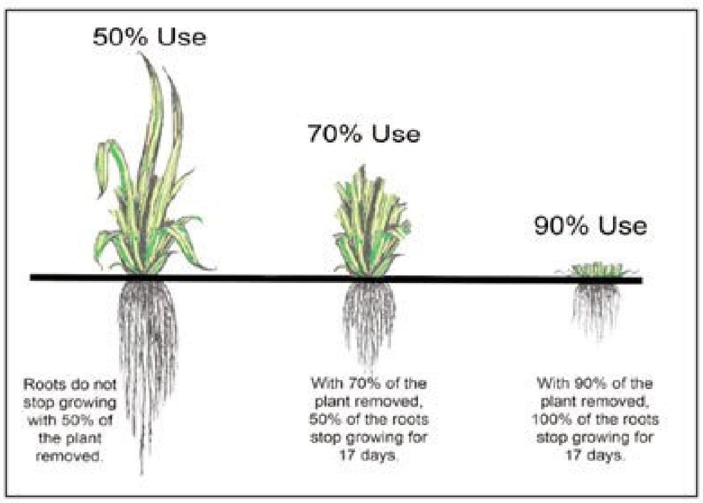

Fig.1. Growth of both tops and roots is significantly impaired if more than 50% of the green leaf is removed in a single grazing event (29).

Relationship between leaf area removed and impact on roots (30):

Up to 40% leaf area removed = no effect on root growth
50% leaf area removed = 2-4% root growth inhibition
60% leaf area removed = 50% root growth inhibition
70% leaf area removed = 78% root growth inhibition
80% leaf area removed = 100% root growth inhibition
90% leaf area removed = 100% root growth inhibition

Regenerative grazing can be extremely effective in restoring soil carbon levels at depth, particularly in perennial pastures. The deeper the carbon the more it is protected from oxidative and microbial decomposition. The 'sequestration of significance' is that which occurs below 30cm (31).

Conclusion

All food and fibre producers - whether of grain, beef, milk, lamb, wool, cotton, sugar, nuts, fruit, vegetables, flowers, hay, silage or timber - are first and foremost **'light farmers'**.

Sadly, the intensification of agricultural activity since the Industrial Revolution has resulted in significantly less photosynthetic capacity - that is, green groundcover - on the earth's surface, while also impacting on the photosynthetic rate of the groundcover that remains.

Our role, in the community of living things of which we are part, is to ensure that the way we manage green plants results in as much light energy as possible being transferred to, and maintained in, the soil battery - as stable soil carbon. Increasing the level of soil carbon improves farm productivity, restores landscape function, reduces the impact of anthropogenic emissions and increases resilience to climatic variability.

It is not so much a matter of 'how much' carbon can be sequestered by any particular method in any particular place, but rather, 'how many' soils are sequestering carbon. If <u>all</u> agricultural, garden and public lands were a net sink for carbon we could easily draw down sufficient CO_2 to counter emissions from the burning of fossil fuels.

Everyone benefits when soils are a net carbon sink. Through our food choices and farming and gardening practices we all have the opportunity to influence how soil is managed. Profitable agriculture, nutrient dense food, clean water and vibrant communities can be ours … if that is what we choose.

For our futures and the futures of our children and grandchildren, why not begin today to rewrite the story of soil??

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