A Regenerative Approach to Agriculture

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How Does the Natural World Function

Natural ecosystems are self-organising, self-repairing entities that have the attribute of resilience by way of their inherent diversity. They are resistant to change and recover well from disturbances such as storms, droughts and fires. In the words of the great American ecologist Aldo Leopold, the biotic community behaves 'like a slowly augmented, revolving fund of life'. The natural tendency of communities of living organisms over time is to proliferation and diversity. Complex communities use approximately a third of the energy they receive from the sun, to maintain their structure and diversity. In natural ecosystems material lost to the forces of erosion and oxidation, are roughly matched by new material coming in from decaying rock and elements brought up from the rhizosphere by the plant community and associated biota.

The living organisms present in a natural ecosystem compete and cooperate for the maximum share of resources for themselves, and by their interactions with each other and the physical world, contrive to make the world a life-friendly place. Change is the one constant over three and a half billion years of life on earth. Species are adapting or becoming extinct all the time; it has been estimated that of all the species that ever lived, 99% are now extinct. The destruction of habitat from development of land for food production for the human species has accelerated the background rate of species turnover. The species extinction rate is now 1000 times the background rate.

The energy used for maintenance of structure and diversity can be viewed as 'work' done by the ecosystem to maintain itself. The physical structure of plants, comes from atmospheric CO_2 via the process of photosynthesis which is driven by energy from the sun. The cells of living organisms are rich in carbon. The breakdown and recycling of the plant community happens via grazing by herbivorous species, organic processes, fire, or in arid environments by oxidation and termite activity. Fungi, soil fauna and other micro-organisms are fundamental agents in the recycling of organic matter.

Early Agriculture and the Development of Tools

Before agriculture began around 10,000 years ago, human communities were in dispersed groups moving around, hunting and gathering. Populations were small and so impacts on ecosystems were modest. Their largest impact on ecosystems was probably from fire setting, and from hunting wild animals for food. They contrived to keep their own populations in proportion to their resources by social means or through low survival rates, accidents, disease, drought and predation.

Humans have developed a range of tools with which to alter ecosystems. Among these tools are technology (usually the first tool we reach for), fire, rest (via herding or fences), animal impact, grazing, living organisms; these are all influenced by money, labour and human creativity. Since the invention of engines and machines powered by fossil fuel (essentially this is prehistoric solar energy), our capacity to alter the environment has accelerated dramatically.

Human populations began to grow with increasing food supplies provided by agriculture. Natural capital (or biotic capital), in the landscape was converted into other forms of capital in the form of infrastructure, shelters, yards, storage for produce etc. Human labour and fire were the main sources of work to progress the ongoing conversion of natural capital. Eventually animals were domesticated and broken in to harness and used to accomplish more work. Because the human population was small and land plentiful, when land was exhausted, it was retired and over time, the process of plant succession restored the soil organic matter. It is the plant community and the associated biota that confers health and resilience on the soil and land community.

The development of tools and technology enabled humans to live in many different environments. Early farming communities had plenty of land and moved onto new land frequently. Over long time-frames ecosystems were simplified; effectively, people were harvesting the energy that complex ecosystems formerly used for the maintenance of structure and diversity. The premise of agriculture seems to have always been that there will always be a new paddock to farm. For many centuries this was true, but, as populations grew, the European societies began to run out of resources, especially wood. Many of the conflicts between tribal groups and then, emerging nations, were about trying to secure more land on which to produce food and fibre. When the technology for sailing and navigation was developed the Europeans began to colonise the New World. The America's, Africa, India and Australia were new lands to exploit and enabled the colonisers to put off the time when they needed to confront the issue of human population growth.

Developing and Failing Societies

The ecosystems of Europe and elsewhere were gradually converted for agriculture over several thousand years. Over the centuries several large and complex societies developed (e.g. the Mayan civilisation of South America, the Roman empire, the Pueblo Indians, Easter Island), and then failed as the resource base became depleted and disease and conflict adjusted the population.

Developing Australian Landscapes

The history of human settlement and land development in Australia has been very different. The aboriginal inhabitants were practicing hunting and gathering when the Europeans arrived in 1788. The tribal groups were diverse and the society complex, but nevertheless nomadic. The aboriginal race in Australia has a very long history in human time frames, at least 40,000 years. Since European settlement in Australia, huge areas of grassy box woodland, grassland, forest and shrublands have been converted for agriculture. Where rainfall is sufficient and considered reliable enough, mostly mixed grazing and crop-farming has been established.

Economics, Solution or Problem?

Human beings seem to have wonderful skill at addressing and sometimes solving immediate problems, but they lack the capacity to predict the long term consequences of their mostly technological solutions. So often we address the symptoms (short term), instead of the root cause of a problem. As society developed and money began to be used for trading the value of goods, the notion of profit arose as the principal motivation for actions. Although economic theory states that the market ensures that resources are always allocated to the most efficient use, it seems that economics generally ignores or defers the costs imposed by our production systems on the ecosystems that underpin all human endeavours. Our development of a staggering array of tools with which to divert a greater share of the product of photosynthesis into our mouths and pockets, has allowed us to keep putting off the time when we confront the real issues of human population, resource degradation, pollution and overuse.

The Human Population Dilemma

In relation to the total time of life on earth (3.5 billion years), human existence is only a very brief moment (approx. 1.8 million years). Similarly, the time of agriculture (approx. 10,000 years), in relation to the total existence of modern humans is less than one percent of the time humans like us have been present on earth. Because we have language and communication skills, and can reason, we have been able to alter vast areas to feed an ever increasing population. It is worthwhile looking at the timeline of human population development.

World population over time:

- 200 million A.D. 200 the height of the Roman Empire
- 400 million A.D. 1500
- 1 billion 1825 Coal use increasing, development of steam power

- 2 billion 1925 Oil use increasing, internal combustion engine
- 4 billion 1980
- 6.5 billion Present population

Note that it took thirteen centuries, from 200A.D. to A.D. 1500, for the population to double from the height of the Empire of Rome, and only eighty years to more than treble from two billion in 1925 to six and a half billion today.

Productivity, Yield, Carbon Losses and Energy Costs

The gross productivity of an ecosystem is the sum of all the respiration of the entire living community. This is maximised in complex, diverse communities. The **net** productivity is that portion surplus to the requirements for maintenance of structure and diversity of the community. We call it productivity, but it is really **net productivity** or **yield**. When we harvest more than the net productivity of the ecosystem we call it **income.** But we are really taking biological capital from the ecosystem which impacts on its capacity to maintain itself; so really it is a **liquidation of capital**. Agriculture has always proceeded in this manner and while there was low population and lots of surplus land to develop, it was not too problematic. Ironically, the human population has grown dramatically because we have been so effective at diverting the product of photosynthesis (it is now estimated that humans use more than fifty percent of the product of all the photosynthesis that occurs world wide, each year). In so doing, we have now become responsible for much of the ‘work’ the ecosystem used to do for itself; this is a heavy responsibility, as the value of oil continues to rise. We have become slaves to our own cleverness.

It has been estimated that our agricultural soils have lost up to seventy percent of the organic carbon present when European settlement began in Australia. Another measure of our impact is the increasing level of inputs needed to produce yields that give a profit after costs. As oil increases in price with scarcity, all inputs are increasing in value and the high inputs in modern production systems in a variable climate mean that the capacity to generate profits is to some extent being dictated by the value of the inputs. As time goes on it will become harder for farmers to generate profits due to escalating energy costs embedded in all inputs. We will need to learn from the ecosystem so our production systems work with rather than against the processes of nature.

In Australia, losses of soil carbon have not been confined to crop lands. From the moment fences began in the 1860's and it became possible to constantly stock paddocks with domestic animals, the diversity of the plant community has been simplified. A lot of timber was cleared, as well as a large area of regrowth following the control of fire in the landscape. The native perennial grasses and associated native forbs and edible shrubs would not tolerate constant defoliation and the indigenous plant populations faded into the background against the inexorable onward march of the army of exotic annual grasses and weeds. This loss of native diversity in grazed landscapes, represents the largest loss of soil carbon from Australian soils. The replacement of vast areas of native perennials by exotic annuals represents the greatest disturbance to catchment hydrology since Europeans began practicing agriculture in Australia. Loss of ground cover leading to wind and water erosion in all major droughts, as well as denudation caused by rabbit grazing from the 1890's are other significant sources of soil carbon loss.

Australian land development has come at the expense of the diversity of the native biotic community and the organic carbon in soils. The conversion of this natural capital has given us the complex society that we have come to expect and which is so comfortable and convenient.

Potential for Change

As mentioned above, Australian agricultural soils have lost at least seventy percent of the soil organic carbon that was present when Europeans arrived and began practicing agriculture. Of the total area that is used for agriculture in Australia, eighty five percent is grazed by livestock. The potential for restoring the level of organic carbon in our soils is large. But it will not be possible without changes in our own attitudes and management. Current information about the potential for changing soil organic carbon levels concerns the modest changes possible with change of practise from conventional cropping activities with multiple disturbances, to zero-till systems. Research has shown that using zero-till systems, soil C increases are marginal at best.

Pasture cropping and no-kill cropping are low cost, low risk cropping alternatives that can produce profits and environmental gains by increasing biodiversity and soil organic carbon levels, whilst delivering a reasonable profit. These systems rely on planting winter active cereals into summer active native perennials. The small disturbance and long rest provided by the winter cereal gives the opportunity for more native grass plants to establish during the life of the crop. This is a cropping system that seems to allow the community to retain the energy it needs to maintain its structure and diversity. Cropping systems like this would seem to be a good fit as we enter a lower energy future.

Potential for Change in Grazing Processes

Many Australian soil tests show soil organic carbon levels as low as 1%. Grazing management that allows recovery of plant communities between grazings, and where the community is proceeding toward complexity and a more perennial base, is likely to be increasing soil organic matter, and thus soil organic C. The EverGraze project, a partnership between the Future Farm Industries CRC, MLA, DPI and CMA's, will compare environmental (biodiversity, soil organic carbon) and production values between various grazing methods, from conservative set stocking to planned grazing. In NSW, various other 'carbon' projects are under way, managed by NSW DPI in collaboration with CSIRO and others, some of which is funded by the NSW Greenhouse Plan, to try and quantify what is occurring under a range of grazing management styles.

Little knowledge is available about what is happening to soil carbon in grazed landscapes. However, the French scientist Andre Voisin, was able to demonstrate that a grazing area managed for recovery of the plants between defoliations, was able to produce two to three times the biomass in a season, when compared to constantly-stocked pasture. This important work showed that controlling time in the grazing enterprise can lead to increasing biological capital and by extrapolation, increases in soil organic carbon. Where the community has been simplified to annuals, it is probable that soil organic C has been seriously depleted. Different management, using the power of the process of plant succession, whereby the plant community proceeds from simplicity to complexity, can be a low cost way to reverse the trend of soil carbon depletion.

Our own experiences with monitoring plant species in different pastures shows some interesting trends. The paddocks with the lowest species diversity and groundcover are the sown introduced perennial pastures. Recent species counts in such paddocks show only **seven** different species. The paddock next to the one just mentioned has a large saline drainage line running through it; the rest of its area has not been cropped for at least twenty years. The species count in the less disturbed paddock was **forty** nine species. Of these forty nine species, **fifteen** were **native perennial grasses.** It seems it is possible for our soils to become friendly again to the plants that evolved there.

Grazing management on both these paddocks has been the same since 1999. We use the planned grazing technique familiar to those who practice Holistic Management. In general terms this means that during the **growing season** plants are only grazed for up to three days and then allowed to fully recover before re-grazing. This recovery varies with the speed of growth depending on the time of the year; the recovery could be as short as thirty days or as long as 100 days or more. During the **dormant season** the available feed on the property is assessed (basically this is a feed budget), so we know how many stock we can carry to the next seasonal break. In every year we plan for 150 days of no growth plus a further 60 days in case the break is later. In effect we plan for dry conditions every year (some still prefer to call this 'drought').

It is this planning process, monitored to ensure we are making progress to the future resource base goals we have set ourselves, that is fundamental to the increase in diversity we want, and underpins our desire for full groundcover all the time.

The High Energy Cost of Modern Society has Consequences

The disturbing recent increases in atmospheric CO_2 and the rate of change of global temperature point to our way of living as being an accelerator in the process of climate change. Exploring management styles that can produce food and fibre whilst restoring soil organic C whilst also allowing the powerful process of plant succession to reinstate native perennial grasses would seem to be an imperative. Increasing soil organic carbon removes carbon from the atmosphere. Managing in a holistic sense so that all decisions consider the needs of the ecosystem as well as our own needs will be necessary if we are going to make any progress in sequestering C in our soils.

Cool, moist climates are more conducive to the increase of soil organic carbon than hot dry climates. The soils of the earth do not have an unlimited capacity to store carbon. Now is a moment in time when changed management with the potential to increase soil organic carbon levels can regenerate landscape function. Most of the organic C in soils is in what is known as the labile pool that is continually being recycled by decay and release to the growing plant community and associated biota. Some of the carbon exuded by root hairs as carbon-rich compounds, exhibits resistance to organic breakdown, from decades to hundreds, and even up to thousands of years. It seems logical that if cropping and grazing processes can be managed to produce more biomass and better soil cover, then that would lead to greater amounts of soil organic carbon being sequestered in our carbon-depleted soils.

The Living Systems of the World Run on Solar Energy

In the temperate zone (this is where the grasslands of the world are), natural ecosystems function on less than one percent of the total solar radiation that reaches the earth; most is reflected or dissipated as heat, only a small fraction is fixed by plants. Agricultural systems in the temperate zone produce slightly more annual biomass (approx. 3,500dry kg per ha), than natural ecosystems (2400kg). This is not surprising as agriculture usually occupies the best soils and has energy 'subsidies' of fertilizers, herbicides, cultivation and fossil fuel to enhance the 'work' done by the ecosystem. As the cost of oil rises with increasing scarcity, the value of the inputs can lead to increasing business risk, in an increasingly variable climate. When we spend money in a farming system, we are laying a debt on the biota, to deliver a return on the investment.

The Carbon Market

It is possible that someone may pay you for increasing carbon levels in soil. Markets have buyers and sellers. People usually invest in products that they have confidence in and that they judge to be secure. Values change with the perception of scarcity or abundance. Currently, those seeking to enter the carbon market are those businesses with high carbon emissions, or those who wish to invest in the carbon market for philanthropic reasons. Some businesses have a statutory obligation to offset a percentage of their current emissions (e.g. coal burning power plants). The theory behind this is that the cost of purchasing the offset increases the cost of the activity producing the emission of CO_2, and should become the driver of change to a lower emission activity. Currently, the difficulty of this process is that the cost of the offset is so low, that it has become a cheap way to pay a small price to go on producing emissions. This may change over time as people become better informed about energy options for our future power needs. In Australia some governments derive revenue from state-owned coal-fired power stations.

- The soil carbon market may pay for **measured increases in soil carbon**. The issue of permanence will need to be clarified. At the end of a contract, if the measurement shows a lower soil carbon figure, it is possible (perhaps even likely), that you may have to write a cheque for the difference, instead of receiving one.

- If payments are delivered for a **change of practice** from carbon-emitting to a **carbon-sequestering management practice**, there will be issues concerning how long the change of practice will need to be undertaken. It will be necessary for a range of management styles to be quantified as to the likely carbon effects, to give farmers the information necessary to enter the market with confidence.

Becoming the Change You Want

There are ways to sequester huge quantities of carbon in soils. We already know some of the ways this can be achieved. This can begin happening now and at very modest cost; all that is required is a change of attitude and management. Grazing that allows plants to recover fully from each grazing has the potential to increase the amount of biomass that a community of plants can produce in a season by between two and three times. The extra biomass is achieved by allowing the time for plants to fully express themselves whenever they are trying to grow.

However, this extra biomass is not all for us. Remember that we are managing for the whole community, not just ourselves, and the community needs a third of the fixed solar energy for maintenance of structure and diversity. Perennial plants that are quickly defoliated and allowed to recover, increase their basal area and have large root structures, enabling the addition of increasing volumes of organic carbon to soils. Conversely, plants that are constantly stocked, diminish in basal area and have small root systems and leaves.

Benefits Flow Regardless of Payments for Carbon

Even if farmers do not receive a direct payment for managing on the positive side of the carbon equation, both individuals and society will benefit. Soils high in carbon have better structure, higher water-holding capacity, enhanced infiltration capacity, the potential to increase species, a greater mass and diversity of soil biota, they are resistant to water and wind erosion, and salinity and the biota are more resilient. In the future it is likely that grazing and cropping styles that sequester carbon in soils may be used offset other agricultural emissions.

Which side of the Carbon Equation are you on?

A check-list to use as a guide to get a feel for which side of the carbon equation you are on, positive or negative. Items marked with an asterisk are those activities I believe can be activated with no cash input.

Carbon Positive Activities

- *100% groundcover
- *Improving soil structure
- *Increased infiltration capacity
- *Less erosion
- *Less salinity
- Planned grazing
- *Matching stock to carrying capacity
- *Increasing species
- *Increasing perenniality
- *Decreasing dependency on inputs
- *Less product leaving farm
- No-till cropping (marginal)
- *Lower fuel use
- *Lower water use
- *Lower electricity use
- Less burning
- Natural regeneration

Carbon Negative Activities

- High Overheads
- Set stocking
- Low groundcover
- Increasing salinity
- Increasing erosion
- Deteriorating soil structure
- Simplifying land community
- Increasing annual capital inputs
- Increasing product turn-off
- Conventional cultivation
- Increasing fossil fuel use
- Increasing water use
- Increasing electricity from grid
- *Burning

Ongoing Dilemmas for Human Society

- Current human population would not be possible without the huge energy input of fossil fuel, a finite resource.
- The increase in carbon dioxide emissions with our high energy way of life will threaten our very existence.
- The way current society is arranged (high energy cities and a constant need for electricity and a liquid fuel source to move things around the landscape), may not be possible in an energy constrained future.
- Some large natural processes (melting ice sheets and glaciers, softening permafrost in the tundra and increasing acidity in oceans), have built-in positive feedbacks that may ensure their continuation regardless of our efforts to mitigate our own emissions.
- Approximately one half of the people on earth are suffering from malnutrition and the population is increasing by about 100 million each year.
- Annual losses of productive land to road-making and urbanisation is between 10 million and 35 million hectares.
- Most new land that is being developed is from tropical forests, the lungs of the earth.
- Despite the application of 2.5 million tonnes of pesticides annually, 40% of world crops are lost to pests and weeds.

- Despite advances in low disturbance farming the world average soil loss on croplands is 30t/ha. This is about 30 times the replacement time and clearly unsustainable.
- If the external energy inputs are withdrawn or reduced, food volumes will fall.
- There is enormous inertia in large populations. China's one child per couple policy began in 1978 but will not begin to reduce the Chinese population until2040.
- Feeding grain to livestock is protein and energy inefficient, yet intensive feeding of livestock continues to increase. Equity of food distribution is a serious issue that must be confronted.

Different Decisions Different Results

What is Holistic management? It is blindingly simple, but requires some thought and effort.

1. How do you want to live based on your deeply held values?
2. What do you need to produce to be able to live like this?
3. What is the future resource base that will support the production into the long distant future?

Start making decisions towards all three parts of this holistic goal and monitor to ensure you are moving towards it.

How has our management altered since using the Holistic management decision-making framework?

- Planned grazing means paddocks are only grazed for six to ten days per year
- Concern about some cropping practices and groundcover issues led us away from cropping to a livestock-only business

- Capital in machinery was converted to fencing, water and livestock
- Annual budgets for fertilizer and chemical paid for much of the water and fencing, no external funding for development
- Matching stock numbers to carrying capacity has meant no feed costs during five years of drought
- Income more modest but low cost of production means profit is less risky
- Measured improvement in groundcover, soils feeling soft
- Measured increase in species, birds and native grasses beginning to come back gradually
- No burning
- Lower overheads
- Much less stress; feeling good about progress towards landscape goals

Conclusion

The 200 years of Australian land development for agriculture has had far-reaching consequences. Grazing and cropping practices have depleted Australian soil carbon by an estimated seventy percent in a very short time, leading to the simplification of the land community and a dependence upon an increasing array of inputs that are increasing in value due to the rising cost of oil. Australian society has benefitted from the conversion of natural capital.

Running inflexible, high-cost farming systems in a variable climate can increase business and environmental risk. It is now possible to make decisions that lead to flexible management of grazing and cropping processes that can be profitable, low-cost, low-risk and also deliver landscape regeneration.

Farmers who engage in generous management that regenerates land, have a reasonable expectation that society should reward them for delivering a necessary environmental service (carbon sequestration, increasing biodiversity, improved landscape function).

From a world perspective, it will not achieve much if carbon trading only serves to allow the big emitters to go on emitting without gradually changing to lower-emissions technology. This needs political will.