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RE-THINKING SUSTAINABLE SOLUTIONS – INNOVATION INSPIRED BY NATURE

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ABSTRACT

Australian rural landscapes are facing a crisis from land degradation due to rising salinity levels, soil acidification and soil erosion. There is growing consensus amongst the businesses community, government departments and research organisations that the real solution to these problems and the broader sustainability dilemma comes by taking a 'whole of system' approach to agricultural and rangelands management. This article introduces two cutting-edge concepts – Biomimicry and Natural Sequence Farming – to illustrate how whole-system thinking can effectively and profitably address the challenges facing agriculture and rangelands.

SUSTAINABLE AGRICULTURE - THE NATURE OF THE CHALLENGE

Australian rural landscapes are facing a crisis from land degradation due to rising salinity levels, soil acidification and soil erosion. Traditional farming and agricultural methods in Australia have been derived from farming practices which have been developed for European soils and climates, but have caused significant damage to our rural environment (Williams and Saunders 2002). Three types of soil degradation - salinity, sodicity and acidity - have been estimated to cost the Australian economy $2.4 billion annually (CRC for Soil and Land Management 1999). This has had significant consequences for rural communities who ultimately rely on environmental health for their existence (Boulton 1999; Boulton 2003; Lake 2003).

In addition, climate scientists forecast that due to global warming there will be often less water for farmers in the coming decades. According to Dr Mike Howden of CSIRO Sustainable Ecosystems, "climate change may reduce the amount and quality of produce, as well as the reliability of production and the sustainability of the natural resource base on which agriculture depends. The need therefore becomes the development of agricultural systems that are more resilient and consistently productive." (CSIRO 2003)

WHOLE SYSTEM THINKING – THE ART OF DENYING TRADE-OFFS

The potential risks and existing ramifications of these issues only heighten the urgency of achieving rangelands-specific solutions that simultaneously improve resilience, significantly increase yield productivity *and* in an achievable timeframe that minimises environmental impact. The question then becomes: how?

The emerging consensus is that the real solution arises by taking a 'whole of system' approach to design of industrial and agricultural systems (Hargroves and Smith 2005). A 'system' describes how various elements of "something" interact and depend upon each other to create the characteristics of that particular thing (Hitchins 2003). We have heard of various forms of technological systems: computer systems, security systems, manufacturing systems. But systems get much, much more complex than our latest and greatest supercomputers. Natural and agricultural systems use processes that are some of the most complex on earth.

Consider the process of optimising an industrial system for energy or water-productivity. Common problem-solving pedagogy typically uses 'reduction analysis' to break-up a system into smaller components and optimise each component independently. Underlying this approach is the core economic assumption for design, that the more efficient one makes their system, the more it'll cost to make that increment of efficiency improvement. This is known as the 'law of diminishing returns.' Over the last 30 years however, much work has been done by businesses, governments, and research organisations to prove that this economic assumption is in fact a myth (DITR 2003; Hawken *et. al.* 1999). The empirical evidence argues that the greater degree to which the components of a system are optimised together through 'Whole System Design', the more such trade-offs are omitted and the 'law of expanding returns' applies, where bigger improvements in resource productivity can be made at much smaller cost than smaller improvements (Hawken *et al.* 1999). Hawken *et al*. use nature as an example of Whole System Design applied,

"For the past 3.8 billion years or so, nature has been running a successful design laboratory in which everything is continually improved and rigorously retested. The result, life, is what works. Whatever doesn't work gets recalled by the Manufacturer. Every naturalist knows that nature does not compromise; it optimises. A pelican, nearing perfection (for now) after some 90 million years of development, is not a compromise between a seagull and a crow. It is the best possible pelican. A pelican, however, is not optimised within a vacuum. It exists in an ecosystem, and each part of that ecosystem, in turn, is optimised in coevolution with the pelican. A change in the pelican or in any aspect of its ecosystem could have widespread ramifications throughout the system, because all its elements are coevolving to work optimally together." (Hawken *et al*, 1999)

The ability for agriculturalists and pastoralists to consider the whole of the system can lead to ways that both improve resource productivity and reduce costs by a Factor of 4 – 100 (von Weizsacker *et al.* 1997). But to be truly effective, we need to seek to be restorative of the planet rather than destructive. In the context of the loss of natural capital and the loss of resilience of many of the world's ecosystems, land development and management must be redesigned to not merely reduce its impact on the environment, but to be truly restorative of the natural and social capital. It is also not just ensuring that future generations can meet their needs, but that they have even more choices than the current generation in how they meet those needs.

This involves the complete reversal of the negative impacts of existing patterns of land use and development, improving human and environmental health, and increasing natural capital (i.e. increasing renewable resources, biodiversity, ecosystem services, and natural habitat). Restorative Whole System Design for sustainability approaches instead seek to reverse impacts, eliminate externalities and increase natural capital by supporting the biophysical functions provided for by nature to restore the health of the soil, air, water, biota and ecosystems.

The following case studies of Biomimicry and Natural Sequence Farming are approaches that apply Whole System Design to achieve truly remarkable, and sustainable, solutions.

BIOMIMICRY: INNOVATION INSPIRED BY NATURE

Nature manufactures in water, without toxins, without waste, using abundant raw materials and very little energy. Whatever waste is produced is food for another species. Nature banks on the diversity of poly-cultures rather than the vulnerability of mono-cultures. Nature computes using shape, not symbols. For over 3.8 billion years, natural systems have sustained by following biological designs, processes, and laws. What can we learn from Nature's R & D?

Biomimicry (from bios, meaning life, and mimesis, meaning to imitate) is a new science that studies nature's best ideas and then imitates these designs and industrial processes to solve human problems (Benyus, 1997). Biomimics look to nature for specific advice: How will we grow our food? How will we harness energy? How will we make our materials? Biomimicry removes the need for managing inefficiency – rather than attempting to mitigate and manage pollution and waste, it is designing out these inefficiencies from the beginning. The practice of this emerging form of design and process innovation uses a canon of nature's laws to guide solutions development: nature runs on sunlight; nature banks on diversity; nature uses only the energy it needs; nature demands local expertise; nature fits form to function; nature curbs excesses from within; nature recycles everything; nature taps the power of limits; nature rewards cooperation (Benyus 1997, p7).

The application of Biomimicry to land management and agriculture is yielding significant whole of system benefits. A notable example hails from Kansas in the United States, where The Land Institute (The Land Institute, 2006) are designing domestic plant communities that behave like prairies, but have predictable seed yields to be feasible for agriculture and sustainable food production (Benyus 1997, pp 11-58; Suzuki 2003). Their work is shifting from an annual *mono-culture* agricultural system (existing for the last 8-10 thousand years) to a perennial *poly-culture* agricultural system, based on the prairie grasslands (Benyus 1997, pp 11-58; Suzuki 2003). They realised that, when comparing mono-agricultural systems (such as wheat) to poly-agricultural systems (such as prairies), they found that prairies: don't experience net soil erosion or pest epidemics; they require no annual seed planting or cultivation; they use inputs (water and sun) as required (and available) and emits no un-usable waste; they recycle nutrients, reuse water and adapt to local conditions. They also discovered that the prairie is one of the most resilient ecosystems because of its perennial vegetation and diversity of species (Benyus 1997, pp 11-58; Suzuki 2003). The work now being undertaken by researchers at The Land Institute is the development of a balanced combination and consistency of perennial plants that produce enough edible goods to meet human demand (Benyus 1997, pp 11-58; Suzuki 2003). They are replacing conventional mono-cultural practice with Biomimicy-inspired wisdom from the prairie to achieve an increase in seed yield productivity through perennial agriculture, with no trade off on topsoil degradation.

NATURAL SEQUENCE FARMING

Before European settlement, many of the smaller waterways in Australia were discontinuous "chain of ponds" or pool-riffle systems which flowed intermittently. Loss of riparian vegetation, increased soil degradation and a reduction in soil stability has led to wide spread erosion of these waterways resulting in more deeply incised waterways which flow rapidly (Boulton 1999; Erskine 1999; Erskine and Webb 2003). As a result of these changes to waterways, when significant rainfall events occur, the water flows rapidly down the deeper eroded channels, adding further to the erosion and then is lost to the local system. Before these changes to the landscape, when the channels were shallow, rainfall events resulted in two significant effects:

1. Local flooding of the floodplain of water catchments was more common. This resulted in water and nutrient-rich sediments being spread over surrounding soil, hydrating the soil and supplying plant nutrients.
2. The freshwater "lens" around the waterway was re-hydrated. These in turn refills the aquifers connected to the waterway. This freshwater lens has the effect of sitting above any saline groundwater.

Natural Sequence Farming (NSF) provides a cost effective way to re-hydrate land and lift farming productivity whilst reducing farming costs significantly. By mimicking key fluvial and riparian features present in the Australian landscape before settlement, NSF re-engages a sequenced pattern of activities in nature that re-hydrates floodplains. It does this by reinstituting the ways water flowed through the landscape before erosion and changes to it. As NSF states, "Restoring the hydrology of the landscape to something closer to its original nature creates multiple benefits by: reducing water loss, restoring and replenishing aquifers, increasing water availability, enhancing water quality, combating water salinity, reducing erosion and turbidity, increasing groundcover, enhancing riparian zones, increasing biodiversity." There are now over 10 rangeland sites many with cattle grazing around Australia where these methods have been applied all with remarkable results.

In 2002, the then Deputy Prime Minister the Hon John Anderson directed a multi-disciplinary panel of experts led by the CSIRO to examine the application of NSF principles at "Tarwyn Park" in the Upper Hunter Valley. The Panel's report concluded that farmer, Peter Andrews, had established a successful and sustainable farming system at Tarwyn Park, and further recommended rigorous testing of NSF in different landscapes and with a variety of economic activities.

Further proof of the multiple benefits of NSF natural irrigation concepts has come from a 5 year application of NSF principles at the property of North Queensland Fruit & Vegetable Suppliers in the Burdekin Dry Tropics. The application of NSF principles and concepts has already resulted in increased water availability, produced significant water savings, restored the natural hydrological processes, and improved the resilience of the farm to the significant seasonal and longer term cyclical fluctuations in the availability of water common in the dry tropics. Applying these techniques has led to remarkable results:

- Increase on-farm surface / sub surface water storage so that even if it does not rain for two years the farm is drought proof
- This shift to utilising fresh surface flows has allowed a complete halt to the use of bore water pumping from aquifers (252 mega-litres per season) saving significant money and energy because now the farm no longer needs it. The bore water from the region was becoming increasingly salty. So this shift has significantly reduced salinity (down from 3300ppm to 800ppm) improving productive land capacity
- Aquifers have been recharged
- Losses to evaporation, improving water availability
- Reduce the quantity of water needed to support the same level of previous agricultural production (by 70%)
- Reduce the uncontrolled runoff during peak inflows
- Increase farm productivity with lower water inputs
- Reduced pesticide use (down by 85%), lessens impact on native and desirable species Reduced use of artificial fertiliser (down by more than 20%)
- Reduced herbicide use (down by 30%), community health, environmental residuals

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