Signposting sustainable soil management

Declan McDonald, Specialist Productive Soils

Victoria
The Place To Be

DEPARTMENT OF PRIMARY INDUSTRIES | farm services

Soil Health at DPI Victoria

DPI and LWA-funded Soil Health Project 2006-10 ($4m)

Victorian Auditor-General's Report – tabled in Parliament 5th October, 2010

Main findings:

- Healthy soils support plant growth, decomposition and recycling processes, and resist erosion;
- Continued levels of agricultural productivity depend on good soil health;
- Loss of agricultural productivity from declining soil health would have substantial economic implications for Victoria;
- DSE, DPI and CMAs have implemented soil health programs effectively;
- Soil health responses are neither integrated, nor well coordinated; projects generally met their objectives individually, but they tended to focus on the delivery of outputs rather than achievement of outcomes.

Soil Health at DPI Victoria

Establishment of Specialist Productive Soils role to coordinate and integrate soil health activities across sectors:

		FSV			
GRAINS	**HORTICULTURE**	**MEAT & WOOL**	**DAIRY**	**COMMUNITY**	
	FFSR		**BRD**		
		CMAs (10)			
		LANDCARE			
		INDUSTRY			
BCG	**SFS**	**DAIRY AUS**	**HAL**	**MLA**	**GRDC**
		FARMERS AND FARMING ASSOCIATIONS			
		AGRIBUSINESS			
		UNIVERSITIES			

Sustainable Soil Management

- What it is
  - Managing the soil in such a way that the ability of future generations to meet their needs for food and fibre are not compromised by actions today;
- What it's not
  - Allowing the continuation of negative trends in soil condition indicators – soil pH, soil carbon, erosion by wind and water;
  - Treating the soil as a renewable or limitless resource
  - Only putting a dollar in if there is a guarantee of getting a dollar+ out
  - Soil sealing - building on our best soil

Sustainable Soil Management

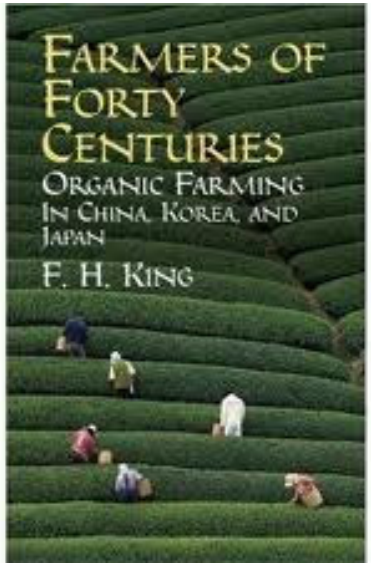
How do we measure it?

- Possible quantitative indicators include:
  - pH, chemical analysis, BD, Aggregate stability, P, SOC, etc.

- Additional qualitative indicators:
  - the effect of improved use of fertiliser and other chemical inputs,
  - improvements to stock health,
  - improvements in crop quality, yield or feed value
  - increased farmer satisfaction,
  - improvements to agro-ecological properties (tree cover, shelter belts, predator habitat, aesthetics).

Where have we come from?

The Natural History of Pliny - in the time of the ancient Greeks 2000 years ago, the use of manure was*'... of very ancient date. In the times of Homer even, the aged king is represented as thus enriching the land by the labour of his own hands'*.



- Dominion over nature
  - God blessed them and said to them, "Be fruitful and increase in number; fill the earth and subdue it. Rule over the fish of the sea and the birds of the air and over every living creature that moves on the ground."
- Mechanistic thinking - Hamilton
- Technological developments from the green revolution
- Focus on productivity
- Subsidised by fossil fuels and other high energy inputs

"A hundred times every day I remind myself that my inner and outer life are based on the labours of other men, living and dead, and that I must exert myself in order to give in the same measure as I have received and am still receiving..."

Where are we going?

- If you don't know where you are going, any road will get you there …
- Long view 50-100 years ahead
- What condition do we want in our soils in 2111?
    - High carbon, optimal biological function, well structured, chemically and minerally balanced;
- What will soil management look like then?
    - Controlled traffic; sophisticated nutrient selection, formulation and delivery; improved management of soil cover; sophisticated management of soil biological properties; sophisticated grazing management strategies;

What must we change?

"A new type of thinking is essential if mankind is to survive and move toward higher levels"

- Our thinking
  - Soil as a non-renewable resource – peak soil?
  - Ask not what the soil can give to you …
- Our use of fossil fuels – peak oil, peak P
    - Fertiliser, pesticides / herbicides / fungicides, fuel;
- Our use of nutrient inputs
- Scale of machinery

Big Rigs

The Versatile 1080 (affectionately know at Versatile as BIG ROY) was built in the late 70s as a prototype. It was a 26-ton, 600hp, eight-wheel-drive monster with a 19-litre Cummins engine in the rear and the 2,100-litre fuel tank in the front section.

The new tractor caused a sensation but soaring development costs and the fact that there were no implements big enough to challenge it's pulling power caused the cancellation of the BIG ROY program.

BIG ROY is still on display at the Manitoba Agricultural Museum in Austin, Manitoba, Canada.

Current situation

- Few agricultural soils are physically, chemically or biologically optimised to grow food and fibre and lack ideal levels of soil carbon, pH, nutrients and beneficial organisms
- The developments of high energy inputs transformed agriculture and allowed it to flourish on previously marginal land
- Such land was marginal because of low inherent fertility, limiting factors such as specific nutrients, acidity, poor structure, poor drainage etc.
- We have become expert at driving out-of-tune soils, that is, expert at producing food and fibre from unbalanced soils lacking in good health
- What does an in-tune soil look like?

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TOYOTA

An ecological approach

- Emerging awareness recognises that:
  - natural systems have limits
  - biology is central to the production of food and fibre
  - we can use better understanding of ecological processes to our advantage

- A shift to an ecologically-sympathetic approach is acceptable to farmers

- 95 - 98% based on proven science; research needed to address gaps in knowledge and management.

What does a functioning ecosystem need?

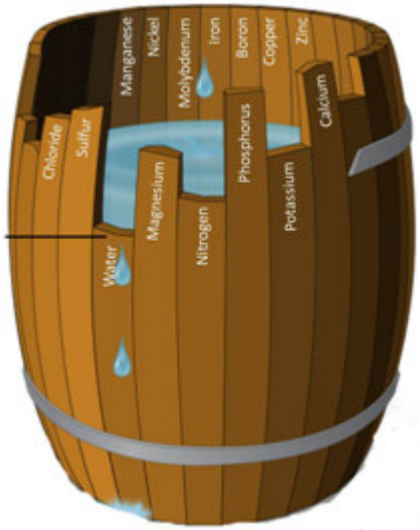
- A car as a composite of its physical, chemical and biological functions
  - Physical – steel frame, engine block, pistons, wiring
  - Chemical – petrol, combustion,
  - Biological – driver behaviour
- A cow as a composite of its physical, chemical and biological functions
  - Skeleton
  - Oxygen exchange
  - Rumen

- Soil as a composite of its physical, chemical and biological functions
  - Physical – soil texture, soil structure, soil strength
  - Chemical – soil pH, nutrient interactions, interactions with organic matter
  - Biological – nutrient cycling, disease suppression, plant / soil interactions

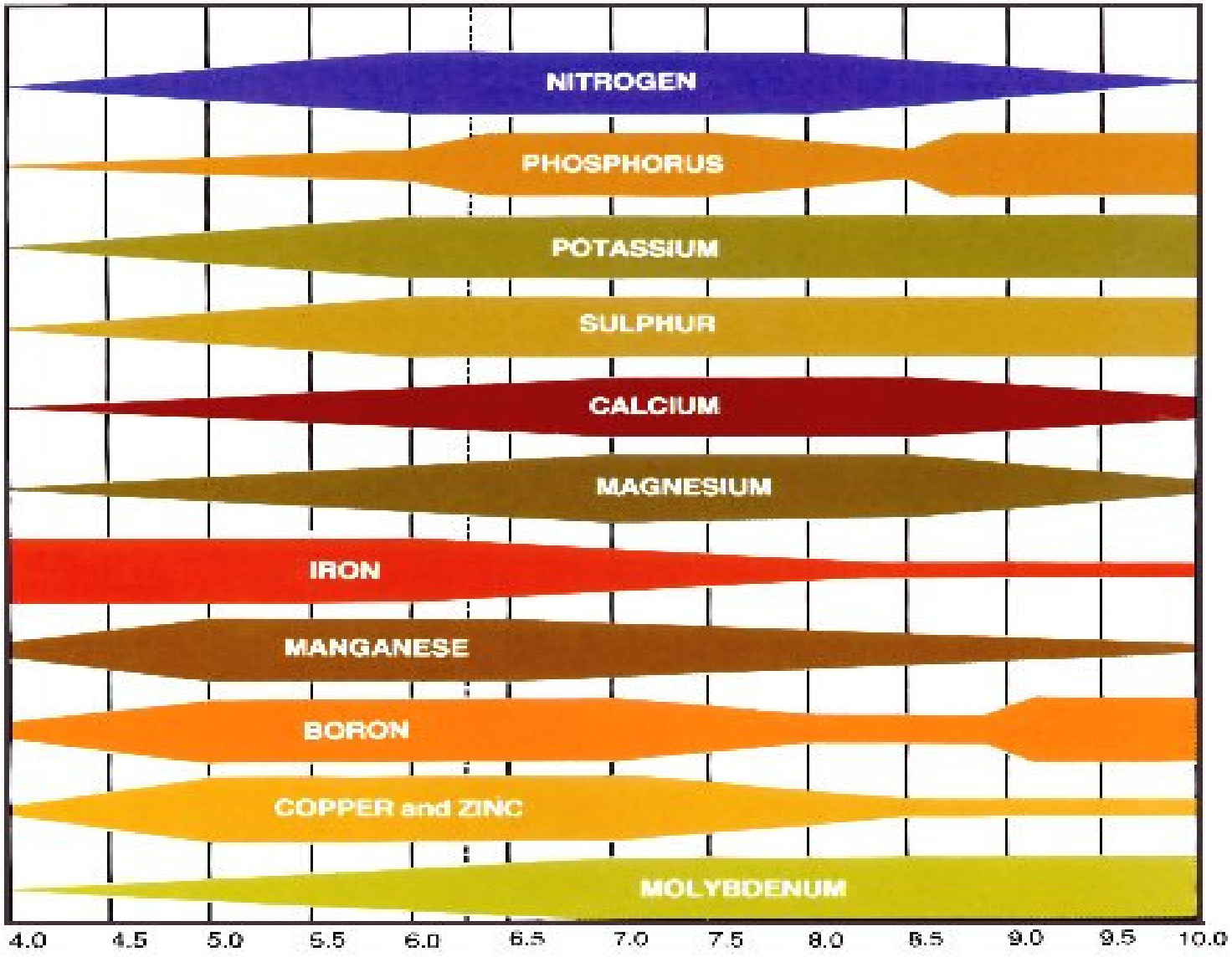
Optimising soils

- Nature's optimisation strategies – changes to the plant and soil
- Optimising the physical, chemical and biological elements in our soils
  - Sustainable soil management: how our soils are going to make the distance
  - Flight commemorating Kingsford-Smith's crossing of Pacific
- Major resistance to this idea due to the cost of optimising marginal land
  - How is a farmer on acid or sodic or calcareous soils going to optimise his / her chemical, physical or biological function without going broke?
- Will we as consumers allow the farmer to do this? What about the Cost of Living?
- Are my soils optimisable?
- What does it mean to optimise physical, chemical and biological elements?
- Are there really benefits to optimisation?
- What if I can't get my soils into optimal condition?
- Optimisation is a journey – not necessarily a destination

Chemical optimisation



- Ca 68%, Mg 12%, K 7%, Na 1%, H 12%;
- pH 6.3-6.8;
- Ca:Mg 7:1 - 5:1


NITROGEN
PHOSPHORUS
POTASSIUM
SULPHUR
CALCIUM
MAGNESIUM
IRON
MANGANESE
BORON
COPPER and ZINC
MOLYBDENUM
4.0
4.5
5.0
5.5
6.0
6.5
7.0
7.5
8.0
8.5
9.0
9.5
10.0

Chemical optimisation

Conflict in Soil Science

- Ca 68%, Mg 12%, K 7%, Na 1%, H 12% - standard for soil tests
- Base Cation Saturation Percentages (BCSP) vs. Sufficiency Level of Available Nutrients (SLAN)
- Many studies demonstrated that yield is not dependent on BCSP
- SLAN addresses plant nutrient needs and supplies only those elements which will result in a plant response
- Soil impediments – structure, texture, organic carbon, pH, low biological function, pest and disease pressure, drainage – can all be overcome with high energy solutions: fertilisers, biocides, tillage, irrigation etc.
- BCSP does not automatically produce a crop response but lays the foundation for system health
- Central practice in ecologically-focused agriculture

Chemical optimisation

- Main criticism is the cost of adjusting soils to meet the needs of modern production
- Changing pH and Ca:Mg on some soils would be cost prohibitive
- Improving Ca relations is a principal signpost to sustainable soil management
- Role of Ca in soils:
  - Soil structure; Stimulates root and shoot development; Increases mechanical strength of plant; Enzyme activator; Enzyme cofactor; Neutralises organic acids in plant; Reduces soil acidity; Stimulates microbial activity; Facilitates uptake of other nutrients; Controls ionic balance and membrane permeability.
- Focus on promoting Ca availability to the plant
- Use of plant tissue test to show levels of uptake
- Uptake is a measure of biological activity
- Major research needed to understand benefits to soil function and plant quality from Ca addition

Physical optimisation

- Soil texture – sand, silt and clay
- Soil structure
- Soil organic matter
- Optimisation of chemical profile supports improvements in soil physical attributes
- Optimisation of biological profile supports improvements in soil physical attributes

http://inhabitat.com

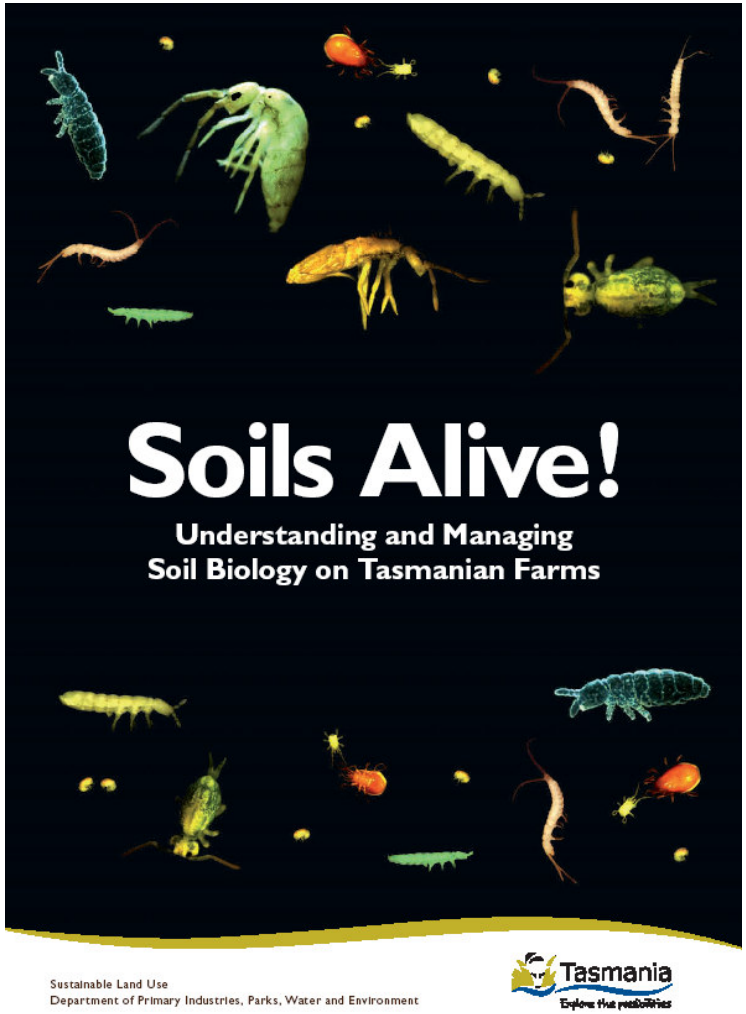
Biological optimisation

"Not everything that counts can be counted, and not everything that can be counted counts."

- Insufficient understanding
- No cause for analysis paralysis
- Farmers of 40 centuries understood the practice if not the process
- Current good awareness of biological processes e.g. carbon cycle, disease suppression, role of microorganisms in nutrient cycling and uptake, product quality, decomposition
- Practices should support diversity in the system – multi-species groundcover, rotations, diverse inputs etc.

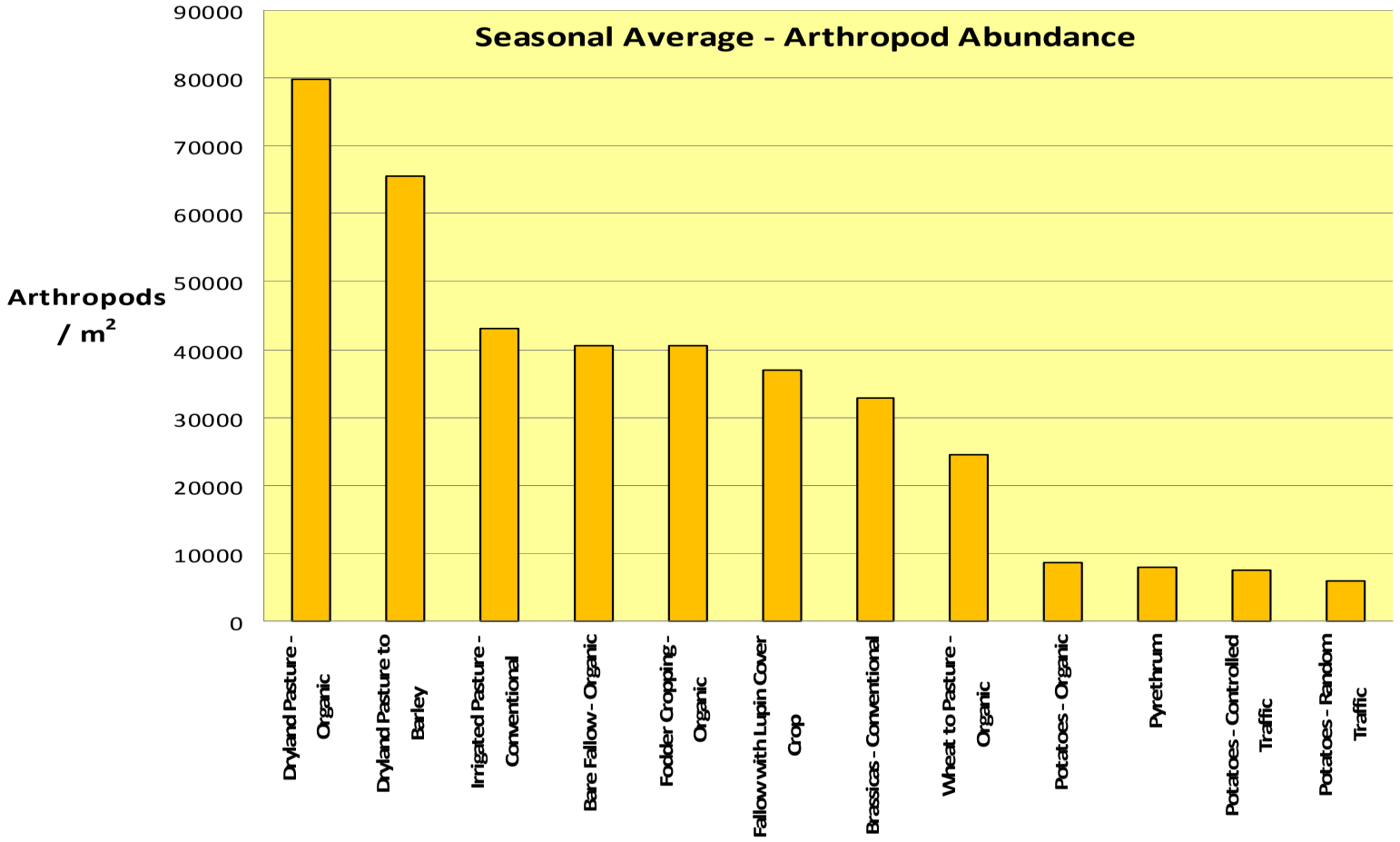
Biological optimisation

- Need for systems thinking
- Birds and Soil
- Soil and soil life
- Billions of organisms per gram of healthy soil
- Two tonnes of livestock per ha.
- Soils Alive! (McDonald and Rodgers, 2010)



Arthropod abundance on Tasmanian Ferrosols

(McDonald & Rodgers, 2010)



Productivity vs. Profitability

- Gifts of the Green Revolution
  - Pest and weed management
  - Productivity improvements
- Productivity paradigms
  - Continual increases in production
  - Continual improvements in efficiency
- Increased production vs. sustainable soil management
- ‘Sweet spot’ – potatoes, milk, etc.
- Profitability and sustainability

How do we apply these ideas to everyday farming?

"The only thing that interferes with my learning is my education."

- Givens:
  - Goal of sustainable soil management; Soil as an ecosystem; chemical, physical and biological function;
  - Nothing radical here; Subtle changes required.
- New learnings from old:
  - Management practices
    - » Tillage, groundcover, carbon management
  - Input management
    - » Fertiliser practice
    - » Biocide practice
  - Signposting sustainable soil management

Management Practices - Till as little as is necessary

- Tillage is not a dirty word
- Tillage can be good for:
  - Compaction
    - Machinery, stock, soil strength / poor structure, low organic matter
  - Air and water movement
    - Fresh or polluted air, ease of water movement into and through the soil
  - Rooting depth – Yeomans
    - Volumes of soil to be explored (length of rye grass roots), ability to make new topsoil
  - Decomposition
    - Lifeblood of the soil, cycle nutrients, promote biological diversity, build carbon
- Tillage can be bad for:
  - Soil life, soil carbon, soil structure, erosion
- Every time you till, you traffic
- Every time you traffic, you increase the need to till

Management practices – Maintain Groundcover

- Groundcover
  - Protects the surface of the soil
  - Provides habitat and food for soil organisms
  - Multispecies groundcover provides diversity and variety
  - Provides nutrients for following crop
  - Promotes biological function
  - Promotes carbon cycling and storage
  - Promotes deep rooting to break up hard pans and access deep nutrients
  - Provides varied feed for stock
  - Prevents water loss
  - Reduces pest and disease pressure
  - Regulates soil temperature variation

Management practices – Improve Grazing Management

- Grazing management
  - Diversity of pasture species
  - Grazing strategies
    - three-leaf stage
    - Set stocking
    - Mob grazing
    - Rotational grazing
  - Grazing to control weeds
  - Diversity of stock – cattle, chickens, sheep etc.
  - Gift of manure, urine, hair, saliva, feathers etc.

Management practices – Carbon, carbon, carbon

- Carbon management
  - Grow it
    - Stubble mgt; green manures; grazing management
    - To till or not to till?
    - Clive Kirkby's work on C sequestration - C,H,O,N,P,S
    - Green Manures: spray, crimp or turn in?
    - Legumes vs. cereals; Growing or senescing?
  - Make it / import it
    - Compost
  - Re-distribute it
    - Effluent management; Natural Sequence Farming

Management practices – Carbon, carbon, carbon

Compost

- Carbon pools – labile, humus, recalcitrant
- Humus has a CEC of up to 300 meq
- Greatly increases water holding capacity
- Greatly improves soil structure
- Dairy practice
- Adding nutrients in stable forms e.g. P, S,
- Too much work?

Effluent management

- C:N ratios of manures varies but all are potentially valuable: Poultry c.15:1; Cow c.18:1; Horse c. 25:1
- Natural Sequence Farming

Input management: Fertilisers – Wise Use of Powerful Tools

- Supporting system health or blunt weapons?
- Little research from an ecological perspective
- Abundant evidence of misuse
- Soil optimisation vs. Plant growth
- Growing body of scientific and anecdotal evidence of strengths / weaknesses
  - Soluble vs. insoluble
  - Salt indices, pH, additional nutrients
  - Biological stabilisation
  - Buffering
  - Application methods: dry, foliar, split, compost
  - Calcium
  - Complex interactions
  - Stock health implications

Input management: Biocides – Wise Use of Powerful Tools

- Why do plants get sick?
- Compared with running a health system on antibiotics …
- Pesticides, fungicides, herbicides
  - Collateral damage
    - Death or impairment of non-target species – macro and microorganisms and plants; reduced N fixation by blocking plant – rhizobium pathway
  - Necessary tools
    - Judicious use to avoid collateral damage and resistance
  - Harm reduction strategies
    - System health, soft chemicals, buffering, pH
  - Avoidance strategies
    - IPM, cultural practices

Signposting sustainable soil management

- Evidence of changing thinking
- System health is the ultimate expression of successful farming
- Agroecosystem management
- Pests and disease seldom attack healthy plants
- Healthy soil, healthy plants, healthy animals – Feed the Soil!
- All organisms have the same requirements for a healthy existence
- Do plants have immune systems? Physical responses and phytoalexins
- Importance of Ca, P, Mg and B – Ca / B relationship identified in ‘60s
- Brix as a measure of soluble carbohydrates in a plant
  - Thorsteinson (1960) bees, butterflies etc – high sugars; grasshoppers and leafhoppers – low sugars;
- Plant sap pH as an indicator of susceptibility of plant to pest / disease

Signposting sustainable soil management

- Sigatoka control on bananas – 10 day scheduled spraying of fungicide
- BCSP approach: Ca > 60% TEC *and* B > 1mg/L - significant reduction in Sigatoka pressure – average 5 sprays p.a. cf. 26 sprays p.a.
- pH and Ca for optimum plant health may be higher than for optimum yield (Fitzgerald *et al.* 2003 *Australian Journal of Experimental Agriculture)*
- Six of the ten largest growers in Qld using this system.
- Unpublished data from northern Tasmania:
  - BCSP approach: Ca > 65% and B ~ 2ppm resulted in onions being sprayed with fungicide once in four seasons cf. average of 7-10 times per season
- Significant reduction in mastitis and improved animal feeding, welfare and behaviour reported by dairy farmers using lower input model
- Milk effective in the control of powdery mildew (Peter Crisp PhD Thesis)
- Commercial crop production (sugar cane, barley and potatoes) using 10-20% of 'normal' N input

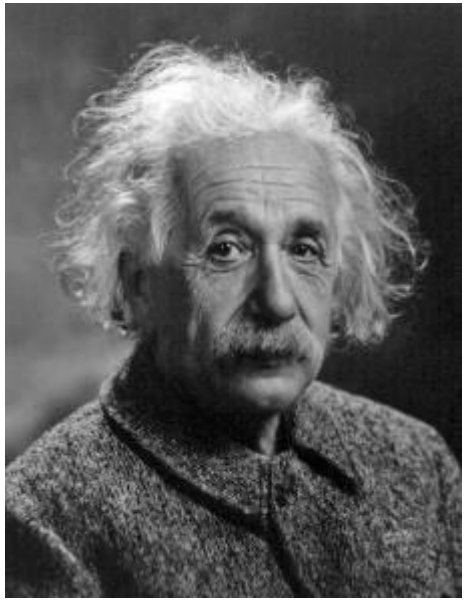
Summary

- The need for sustainable soil management
- Increased job satisfaction
- No mention of added bugs or other novel inputs
- Focus on more sophisticated use of conventional tools to promote soil health
  - Need to learn more about the tools we rely on
- Promote soil / plant / animal (system) health
- Optimise growing conditions for the long road ahead
- Maximise water infiltration, air movement, biological activity with appropriate tillage and groundcover
- Become a carbon farmer
- Invest in your most important asset
- Protect and grow your farm's productive capacity

"Anyone who has never made a mistake has never tried anything new."

"The only real valuable thing is intuition."

"The hardest thing in the world to understand is the income tax"



Thank you

Declan McDonald
Specialist Productive Soils
Farm Services Victoria
Declan.mcdonald@dpi.vic.gov.au