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The utilization of carbon in the agri sector, brown coal in particular

Brown Coal Innovation Australia
Carbon to Products Seminar – pathway to a sustainable future

Federation University, Churchill
7th February, 2018

- **Is present agriculture sustainable?**
- The carbon in soil story
- Relevant research

Over 50 years ago, Paul Ehrlich's book, 'The Population Bomb', sold 3m copies

- To quote Ehrlich: "The battle to feed humanity is over. In the 1970s and 1980s, hundreds of millions of people will starve to death in spite of any crash programs embarked upon now. At this late date, nothing can prevent a substantial increase in the world death rate".
- "The average age of death in the U.S. by 1980 will fall to 42 years old".
- "We are in the midst of a 'new ice age'".
- Ehrlich failed for the same reason Malthus failed in the 17th century:
  - Human ingenuity has always been successful in overcoming crises that once seemed inevitable. In this case, the "Green revolution".

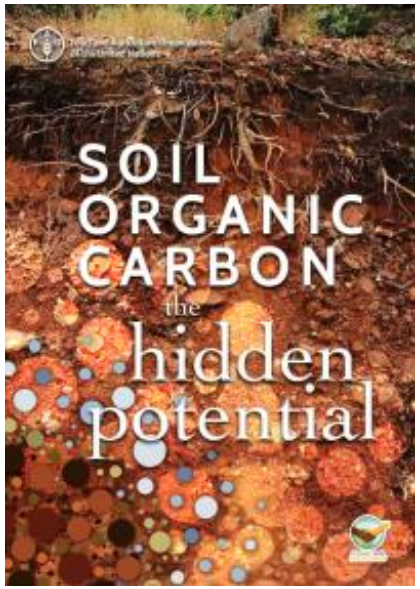
BUT is it sustainable?

- In Gippsland, the early measurements of soil carbon by Strzelecki were three times current levels.
- Given the critical role of soil carbon in agricultural productivity, we can guess that this trend is **NOT** sustainable.

Since industrialization, we have lost 2/3 of the soil organic carbon – a global challenge

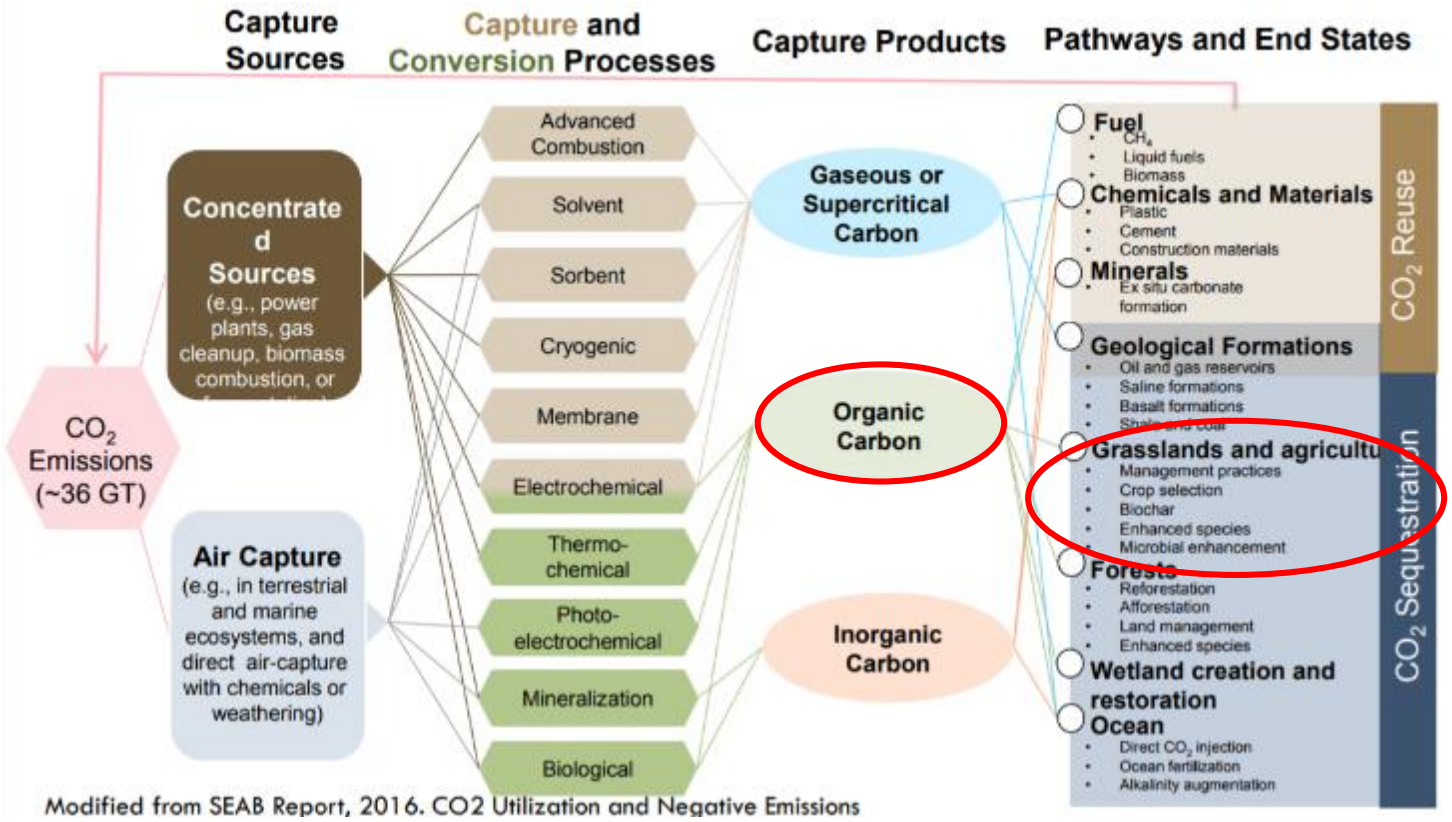
- And the decline is continuing

Food and Agriculture Organization of the United Nations



Global symposium on soil organic carbon
Rome March 2017

Soil Carbon: not just about agricultural productivity, but also about negative emissions



Source: http://rei.rutgers.edu/images/PDF/presentations/RS119_Benson-RutgersProspectsforCO2CaptureandStorage2017.pdf

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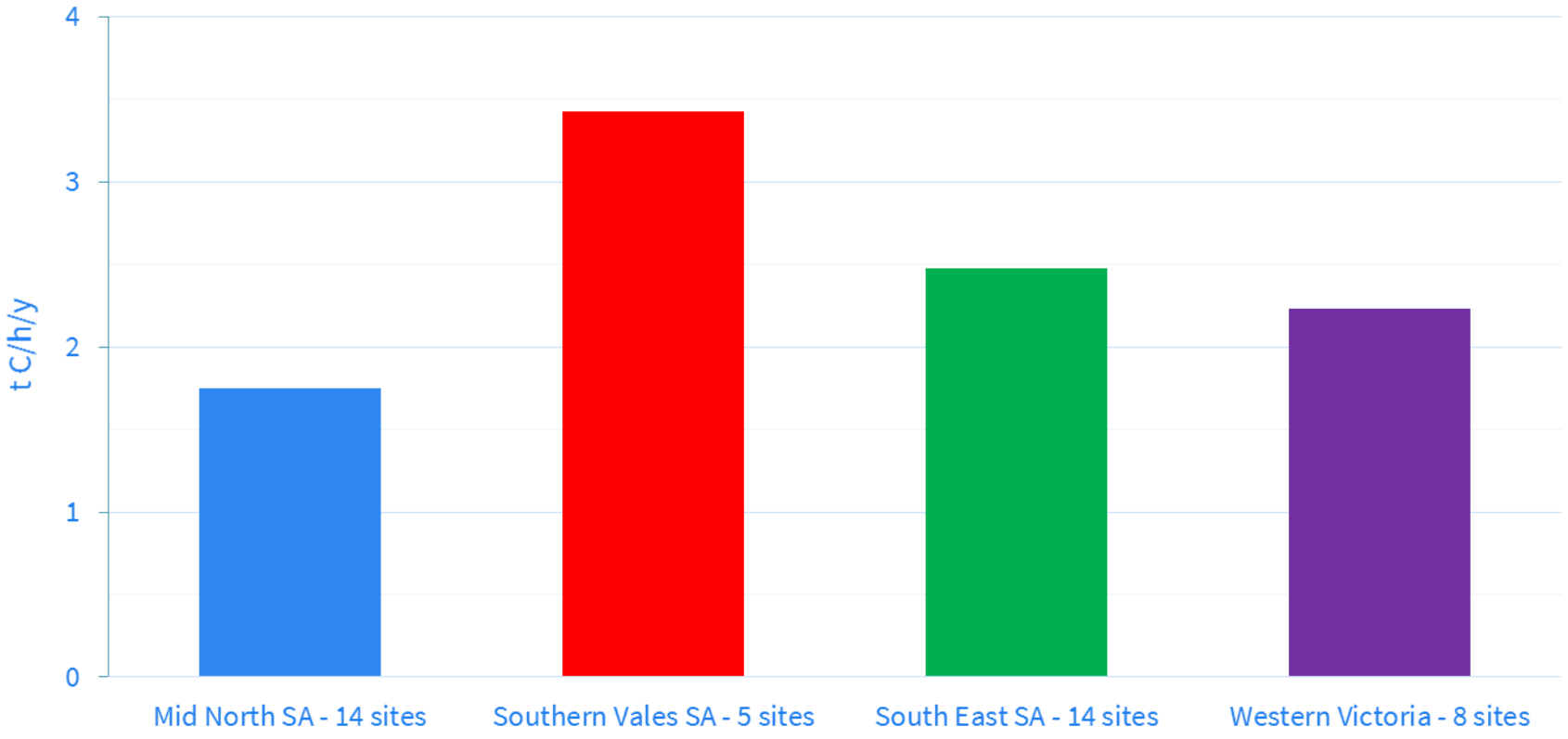
Results around the world are significant when all steps are combined

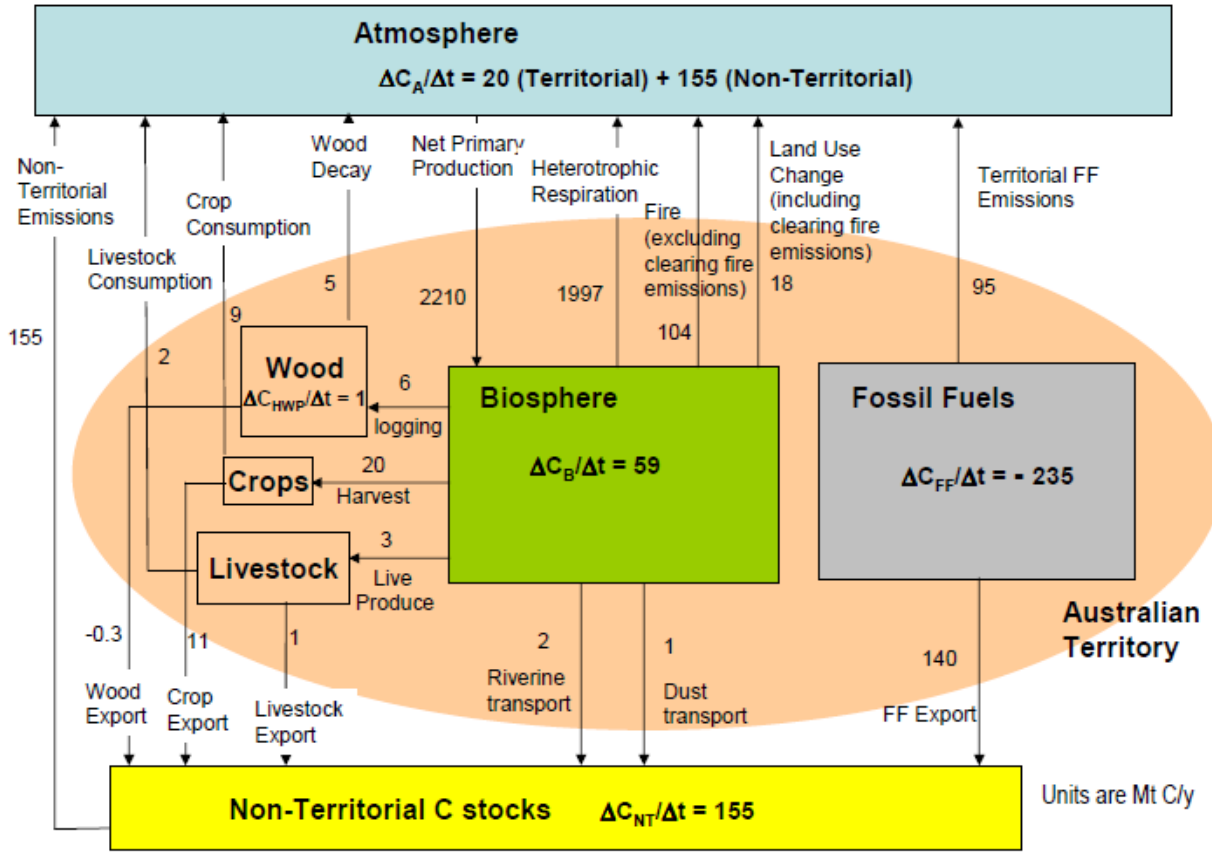
- Numbers from single modifications of practice: (Australian Government Emissions Reduction Scheme) t C/h/y

	Ineligible land	Marginal benefit	Some benefit	More benefit
Sustainable intensification	0	0.03	0.16	0.45
Stubble retention	0	0.02	0.08	0.20
Conversion to pasture	0	0.06	0.12	0.23

But when all elements or regenerative farming are practiced, results are much higher t C/h/y



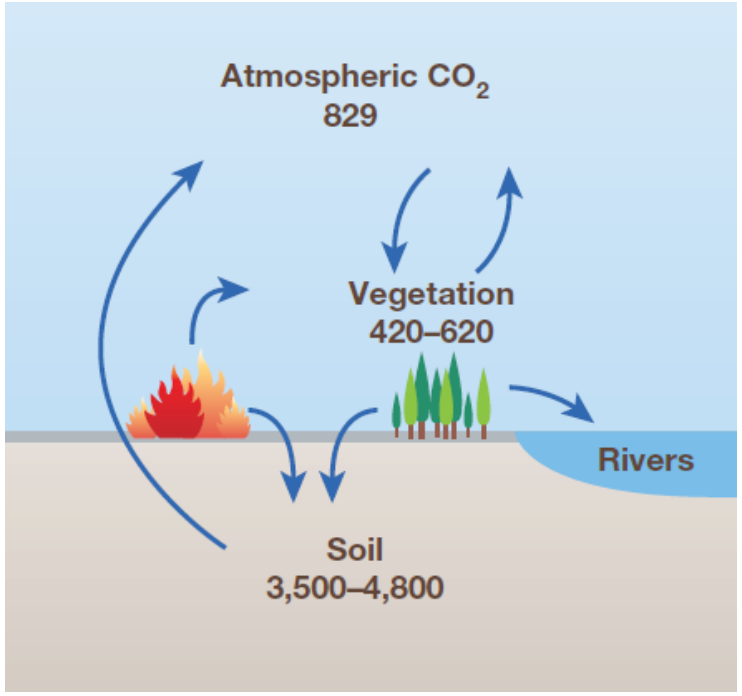
The numbers, even for Australia suggest we are dealing with Gt/y processes



Source: Haverd V, Raupach MR, Briggs PR, Davis SJ, Law RM, Meyer CP, Peters GP, Pickett-Heaps C, Sherman B. The Australian terrestrial carbon budget. Biogeosciences. 2013 Feb 7;10(2).

Global figures are compellingly large

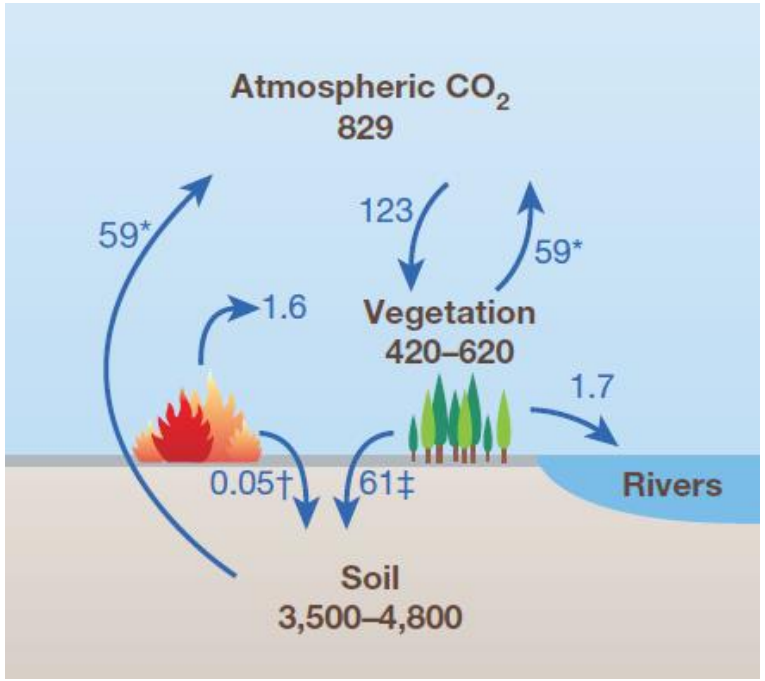
- Soil organic carbon is greater than the atmosphere and vegetation combined



Source: Lehmann J, Kleber M. The contentious nature of soil organic matter. Nature. 2015 Dec 3;528(7580):60-8.

Fluxes are also massive

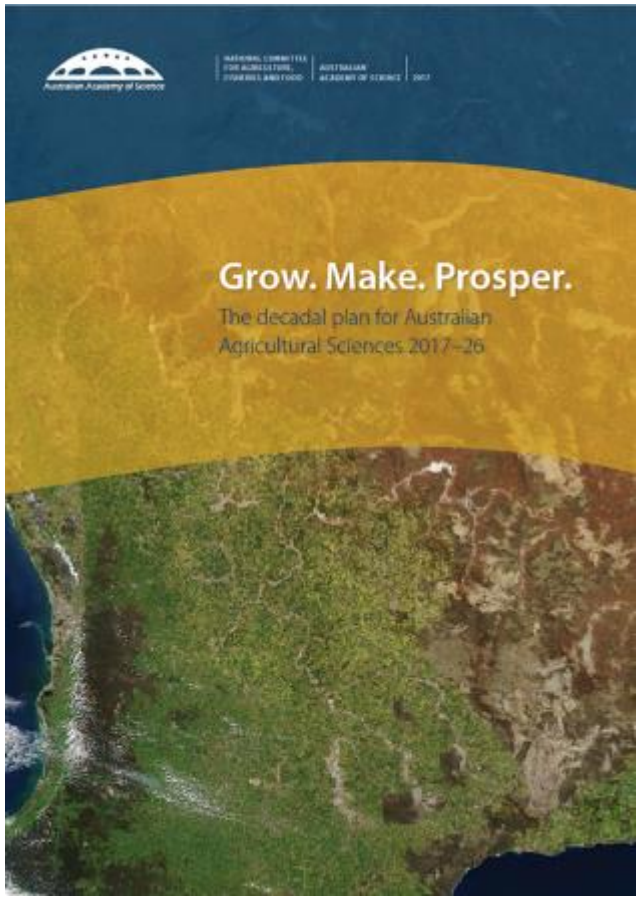
Fluxes (in blue) are also much greater than the 10 Gt c/y of anthropogenic emissions



Atmosphere to vegetation (photosynthesis)	123 Gt C/y
Vegetation to atmosphere (respiration)	59 Gt C/y
Vegetation to soil (production of living matter)	61 Gt C/y
Soil to atmosphere (losses by herbivore and De-composition of organic debris by soil biota)	59 Gt C/y
NETT accumulation of organic carbon in soil	±1 Gt C/y

Source: Lehmann J, Kleber M. The contentious nature of soil organic matter. Nature. 2015 Dec 3;528(7580):60-8.

But we are very, very far from a reasonably full understanding of the science

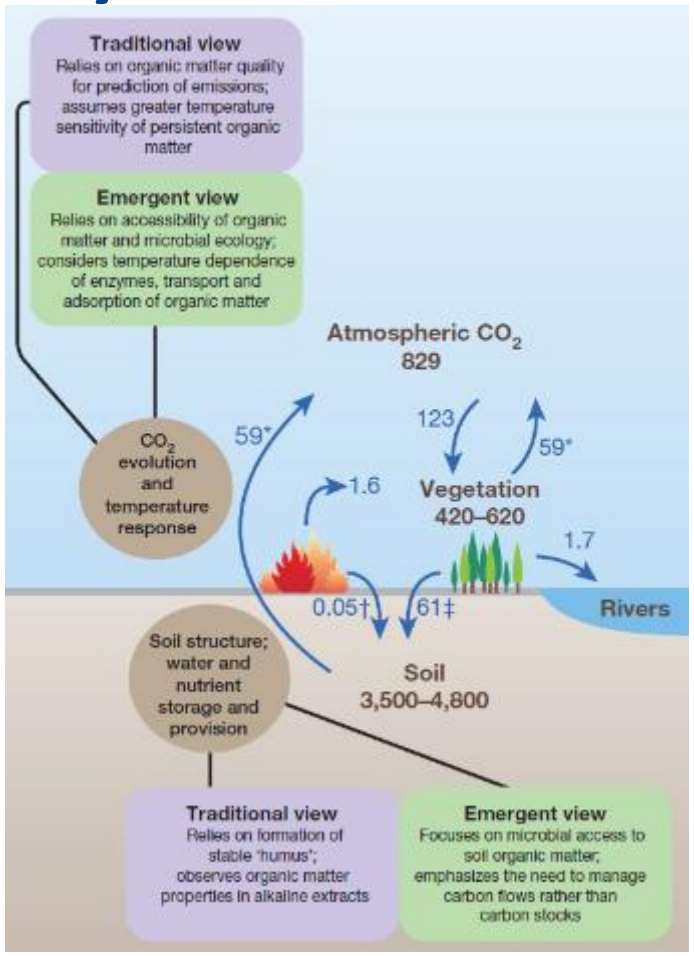


Soils are the most complicated biomaterial on the planet, it is not surprising that, in contrast to the huge amounts of information available with regard to above-ground plant performance, knowledge concerning the physical and biological soil–plant interface is still very patchy.

A healthy soil is incredibly complex: "One cm^3 of healthy soil contains 1 billion bacteria of between 20,000 and 30,000 species, several metres of fungal hyphae, several thousand protozoa and a few dozen nematodes" (US DoE).

Source: https://www.science.org.au/support/analysis/decadal-plans-science/decadal-plan-agricultural-sciences-2017-2026

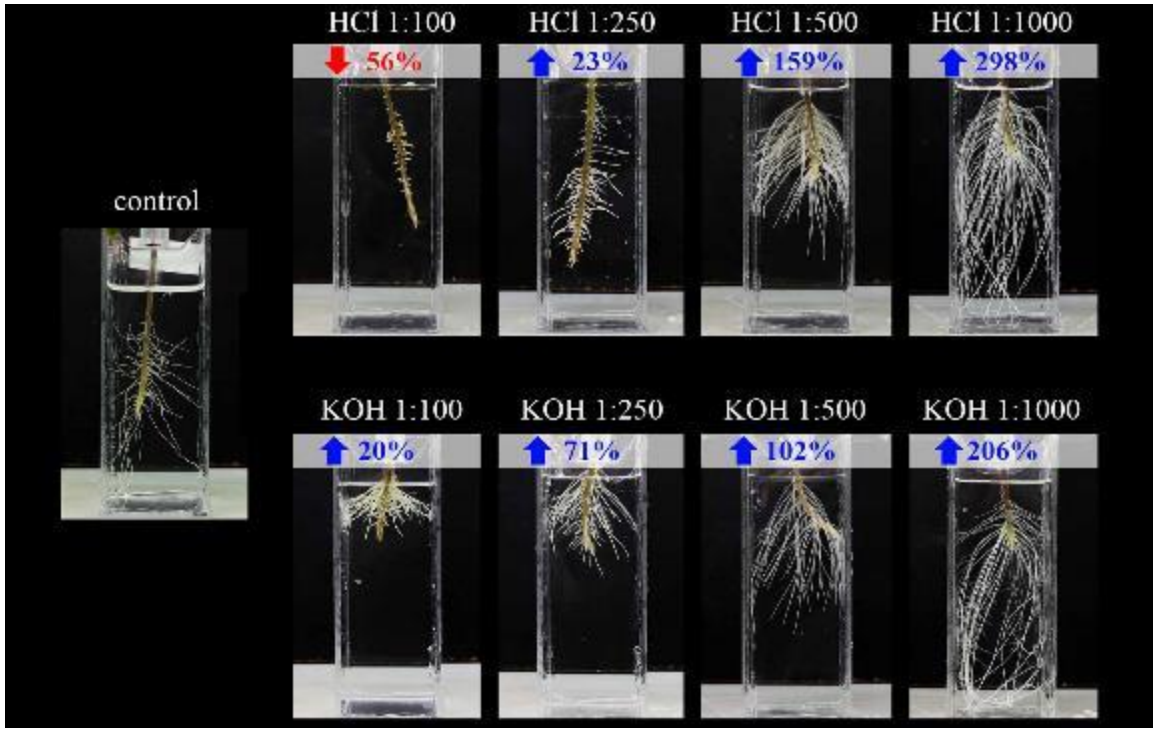
There are significant discrepancies in the science at a system level



Source: Lehmann J, Kleber M. The contentious nature of soil organic matter. Nature. 2015 Dec 3;528(7580):60-8.

There is a mountain of information on detailed aspects: much of it entertaining but not useful!

- Bio-stimulant effect on root growth



Popular opinion now sees soil carbon as the answer to emission reduction and lignite could be an important part of this….

Our best shot at cooling the planet might be right under our feet

Jason Hickel

Studies suggest that regenerating soil by turning our backs on industrial farming holds the key to tackling climate change

Source: https://www.theguardian.com/global-development-professionals-network/2016/sep/10/soil-our-best-shot-at-cooling-the-planet-might-be-right-under-our-feet

Regenerative farming could be our largest sink for CO_2 and simultaneously, sustainable agriculture

Chemical farming wipes out most of the biology, so the soil shifts from a living system to a largely lifeless inorganic system on life support.

Regenerative farming encourages the micro-organisms to restore soil C

- It does however require all three steps:
  - No plough
  - Retain cover
  - Grow cover crops
- And it can take some years for the soil to recover and yields to exceed previous performance
- Off-farm carbonaceous inputs also effective – a boost for the LV

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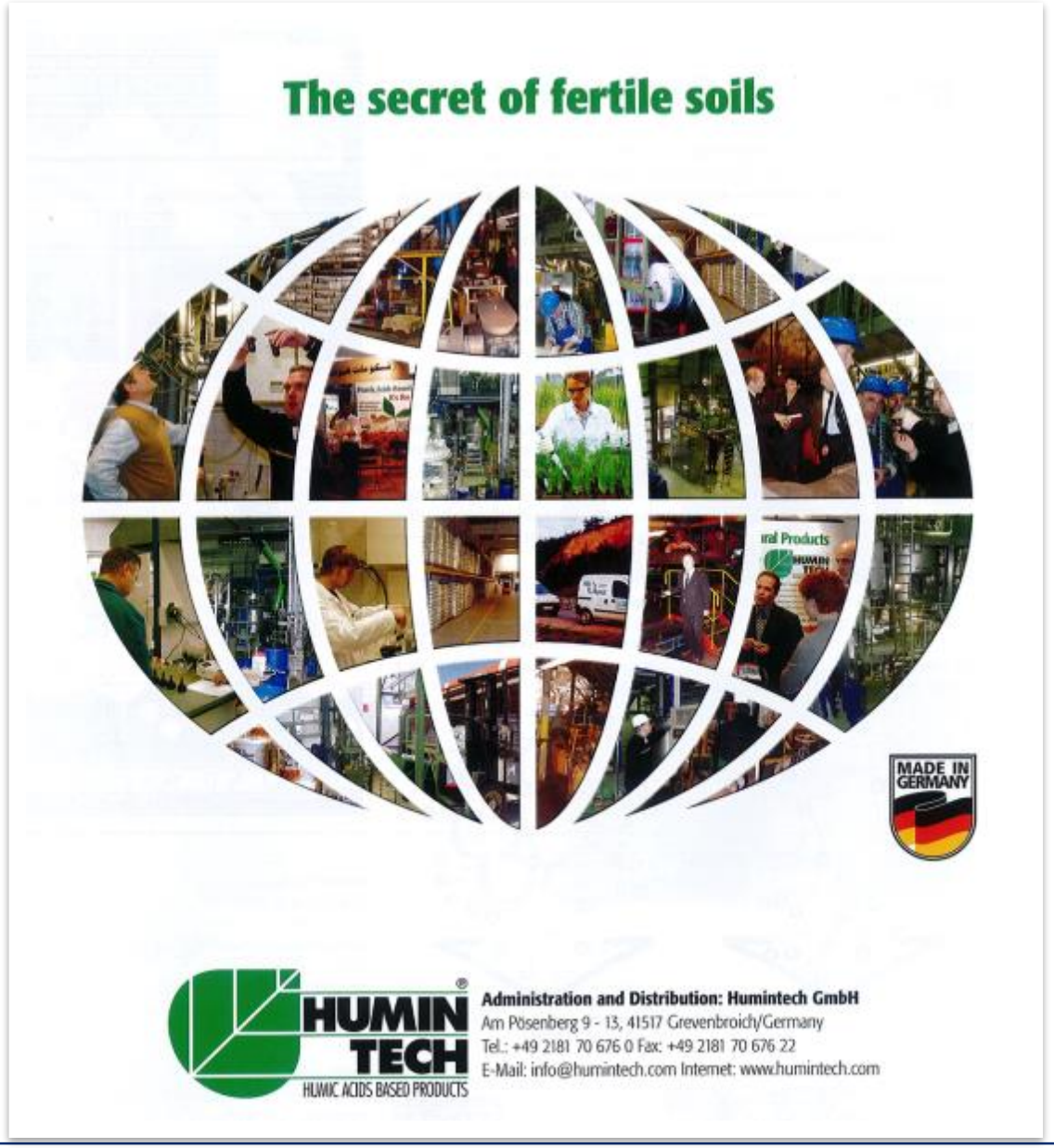
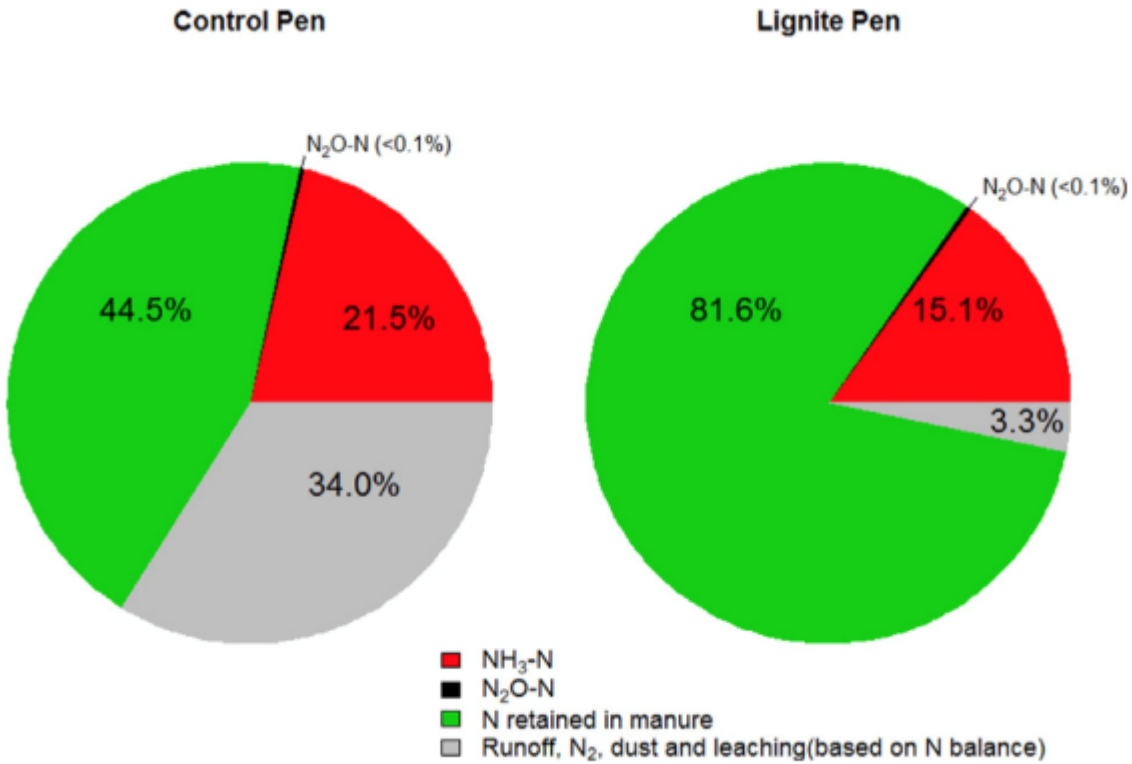
A lot of research started here at Grevenbroich – also a good example of enterprise

THE UNIVERSITY OF MELBOURNE



Use of lignite in beef cattle pens



Source: Science of the Total Environment 565 (2016) 148–154. Sun J, Bai M, Shen J, Griffith DW, Denmead OT, Hill J, Lam SK, Mosier AR, Chen D.

Use of humic substances in fish farming

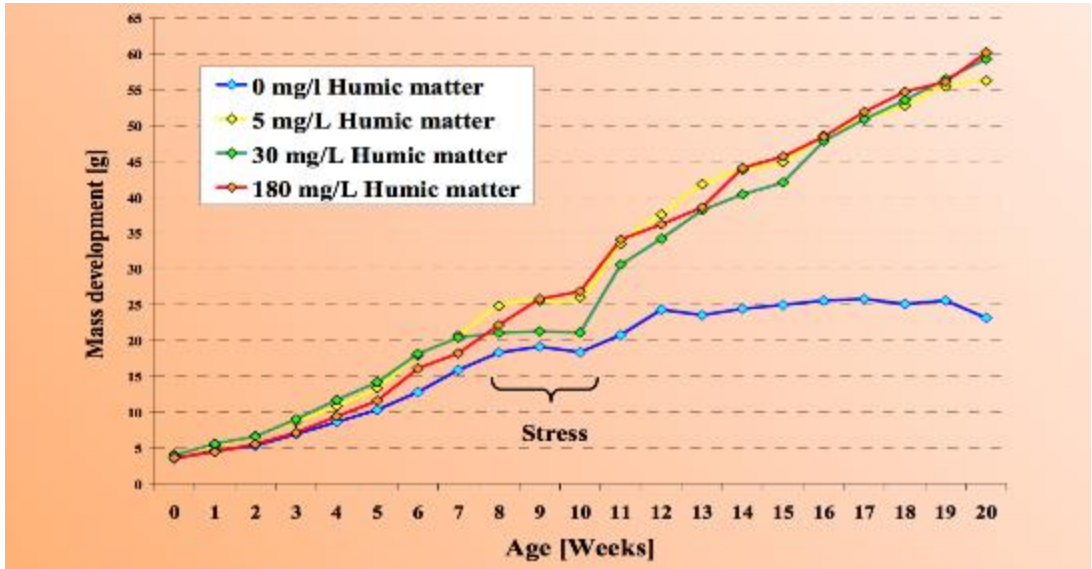


Fig.1. Growth of juvenile Swordtail (*Xiphophorus helleri*) in HS-containing water after chronical handling stress. Exposure of young swordtail to increasing concentrations of synthetic humic substances (HS1500) significantly effected the physiological. Any exposure enhanced the body mass development of the swordtail compared to the control. No dose-dependent effect of HS on growth was detectable. After a two week period of stressful handling, the HS-exposed fish recovered quickly whereas growth stagnated in the control fish. The examination of gills, fins, and skins revealed no infestation with ectoparasites. We assume that the growth promoting effect of HS1500 was due to an overall stimulation in metabolism.

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In summary, we need an integrated approach

- After centuries of intensive agriculture, soils globally are depleted. Australia is no exception.
- Present practices are not sustainable, especially the over and inefficient use of fertilizers in intensive agriculture.
- Contamination of soils from extractive industries is wide spread and also not sustainable.
- Soils contain 3 times as much C as the atmosphere. If managed properly, they could be a very significant long term sink for CO2.

In summary, … (2)

- Soils and their impact on the environment depend on complex interplays between physics (water and structure in particular), chemistry and biology (plant and microbiomes).
- Soils are the most complicated biomaterial on the planet, we have huge amounts of information available on above-ground plant performance, much less about the physical and biological soil–plant interface.
- Numerous trials have been undertaken to improve soil carbon but there is still no clear agreement on why benefits are so variable.
- Only a multi-disciplinary approach has any real chance of bridging the gaps.

In summary, … (3)

- We need the combination of:
  - Expertise in soil nutrients, particularly N, fertilisers and greenhouse gases from agriculture
  - Soil biome and soil molecular biology
  - Agronomy
  - Plant-soil interaction and nutrient efficiency
  - Smart fertilisers e.g. controlled release and new inhibitors/promoters
  - Integrated approach to soil modifiers e.g. lignite as part of compost
  - Sensors and automation of monitoring
  - New distribution techniques

Thank you