Soil carbon markets: science or snake oil?

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Indicative costs/income of soil carbon markets

- Cost of sampling ranges widely: $30-175 per core, min 9 samples for 2021 Soil Carbon ERF
- Can be paid in ACCUs as they are earnt (type of loan), range from 15-30% ACCUs earnt
- **Total cost of sampling soil carbon ranges from $15/ha to $60/ha** ($3/ha may be stretch goal)
- Returns assuming 0-0.8 t C ha/yr, soil carbon returns = $0-24/ha/year
- Anecdotal evidence suggest large range of returns across farms, -$250K to >$2M
- **Productivity benefits of improved SOC worth more than carbon income** (at carbon price of $20/ACCU; $126-200/ha/year due to additional N mineralisation; Meyer et al. 2015; Harrison et al. 2015)

All values in Australian dollars assuming carbon spot price of $AU30/tonne CO2-equivalent;
https://www.researchgate.net/publication/274075525_Improving_greenhouse_gas_emissions_intensities_of_subtropical_and_tropical_beef_farming_systems_using_Leucaena_leucocephala;
https://piccc.org.au/research/wfsam/subproject/soil-carbon.html

1. Soil carbon markets focus on ‘permanence’, but short-term carbon offers the greatest fertility benefits

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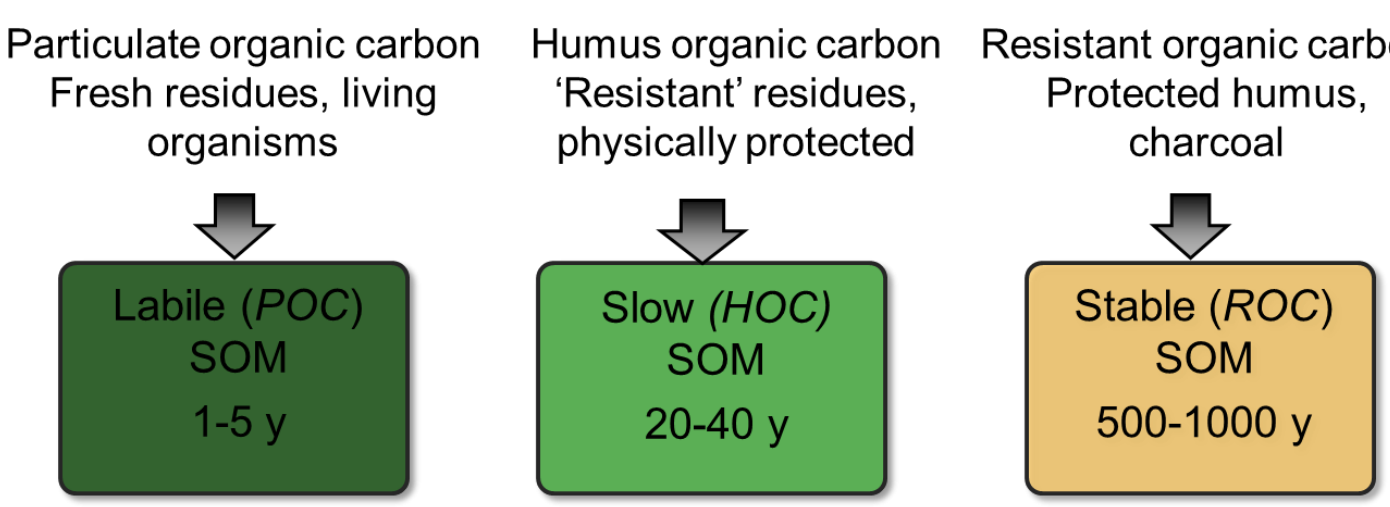

- Carbon markets focus on 'permanence' e.g. contract periods of 25 or 100 years
- ROC lasts longest but has little value in terms of soil fertility and plant growth
- Particulate organic carbon (POC) and humus have greater value in terms of fertility, but degrade much quicker
- In the short term, interventions mainly change POC – but this is easily lost: to be 'permanent', POC must be continually added as older POC degrades

https://www.agric.wa.gov.au/measuring-and-assessing-soils/what-soil-organic-carbon

Typical soil organic carbon levels

- Desert and degraded soils < 0.5% organic C
- Higher soil C can develop in areas supporting wetland ecology, flood deposition, fire ecology and human activity
- Fire-derived forms of carbon are present in most soils as unweathered charcoal (can be up to 50%)
- Peat soils and mollisols can have organic carbon >50%
- Soil carbon in Australia is lower than in many other places
- **In general, most agricultural soils 0.5-4% organic C**

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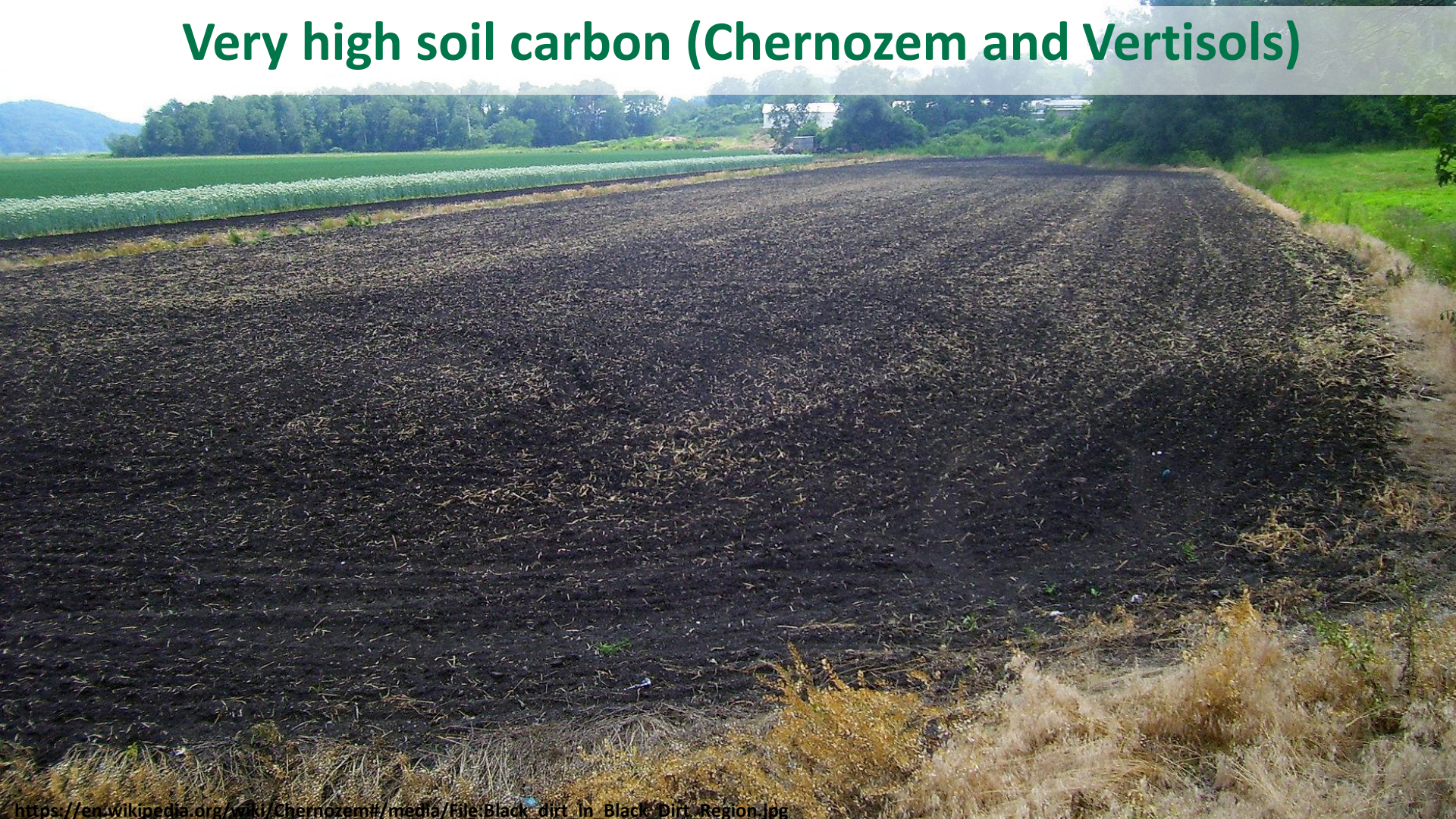
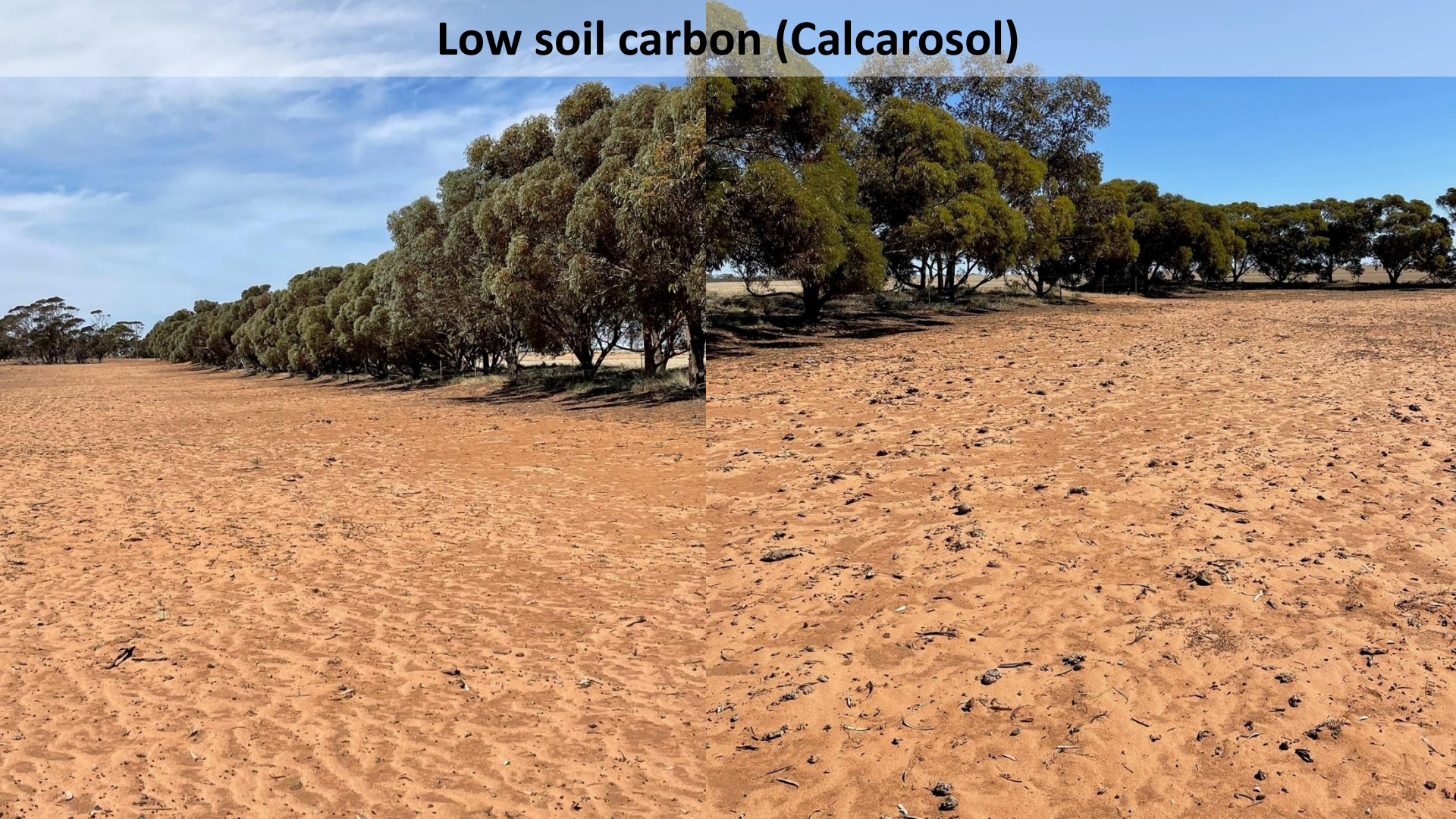
Very high soil carbon (Chernozem and Vertisols)



https://en.wikipedia.org/wiki/Chernozem#/media/File:Black_dirt_in_Black_Dirt_Region.jpg

Low soil carbon (Calcarosol)



2. Practices that improve soil organic matter are to be encouraged

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Benefits of improved soil organic matter

- **Greenhouse gas emissions:** a 1% gain in soil organic carbon represents 133 t CO2-e/ha of emissions
- **Drought resilience:** Humus holds 7 times its weight in water. For every 1% gain in soil organic carbon, soils can hold an extra 144,000 litres of water.
- **Chemistry:** Higher SOM improves capacity to store and supply essential nutrients (N, P, K etc) and can retain toxic elements
- **Physical:** Higher SOM improves soil structure, reduces erosion, improves water infiltration, improves habitat for microbiota
- **Biological:** Source of carbon and nutrients for soil organisms, enhancing biodiversity
- **The above often improve productivity and in some cases profitability**

1.Charman, P.E.V, Roper, M.M. (2000). Soil Organic Matter. In: Soils: Their Properties and Management. (Eds. P.E.V. Charman and B.W. Murphy) pp. 260-270. 2nd Ed. Oxford University Press.
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What practices improve soil organic matter?

- Retain crop stubble: after crop is harvested. Avoid burning stubble. Leave stubble anchored.
- Improve seasonal ground cover for a longer proportion of the year:
  - Reduce excessive stocking rates
  - Strategic addition of nutrients (noting that adding N can increase nitrous oxide in some contexts)
  - Reduce surface erosion (wind or water)
  - Pasture species diversity and deeper roots may have some benefit
- Convert from annual crops to perennial pastures
- Reduce cultivation
- Savanna fire management methods: burn early in dry season when fires are cooler and patchy, consider burning less area
- Inter-row crops: for tree crops and vines
- Organic amendments: e.g. biochar spreading or feeding to livestock
- Clay delving: can reduce non-wetting sands but only where existing soil texture is suboptimal
- New irrigation: begin irrigation on previously rainfed field

Win-win-win? Biochar as a feed supplement to reduce enteric methane, improve liveweight gain, improve soil carbon

To build soil organic carbon, we need to build soil organic matter

- In general, soil carbon is not built up as an individual *element*. It is built up as part of a *bundle*.
- To build soil carbon, we generally need to add N, P, K, S (Kirkby et al. 2013).
- "Nutrient addition at least doubled fine-fraction C sequestration in all soils irrespective of the initial fine-fraction or clay content"
- If any nutrient is lacking, SOC sequestration will be constrained and can fall.
- **Improving soil nutrient balance can improve soil organic matter and carbon**

Kirkby CA, Kirkegaard JA, Richardson AR, Wade, LJ, Blanchard C, Batten G. Stable soil organic matter: a comparison of C: N:P: S ratios in Australian and other world soils. Geoderma, 163 (2011), pp. 197-208

Kirkby CA, Richardson AE, Wade LJ, Batten GD, Blanchard C, Kirkegaard JA, 2013. Carbon-nutrient stoichiometry to increase soil carbon sequestration. Soil Biology and Biochemistry 60, 77-86.

Poultry manure	5:1
Humus	10:1
Cow manure	17:1
Legume hay	17:1
Green compost	17.1
Lucerne	18:1
Field pea	19:1
Lupins	22:1
Grass clippings	15-25:1
Medic	30:1
Oat hay	30:1
Faba bean	40:1
Canola	51:1
Wheat stubble	80-120:1
Newspaper	170-800:1
Sawdust	200-700:1

More N for microbes and easier to break down

https://agriculture.vic.gov.au/__data/assets/pdf_file/0006/857607/Soil-Carbon-Snapshot-updated-May-2022.pdf

N immobilisation

https://agriculture.vic.gov.au/__data/assets/pdf_file/0006/857607/Soil-Carbon-Snapshot-updated-May-2022.pdf

3. Carbon markets attempt to decouple effects of climate from those in management

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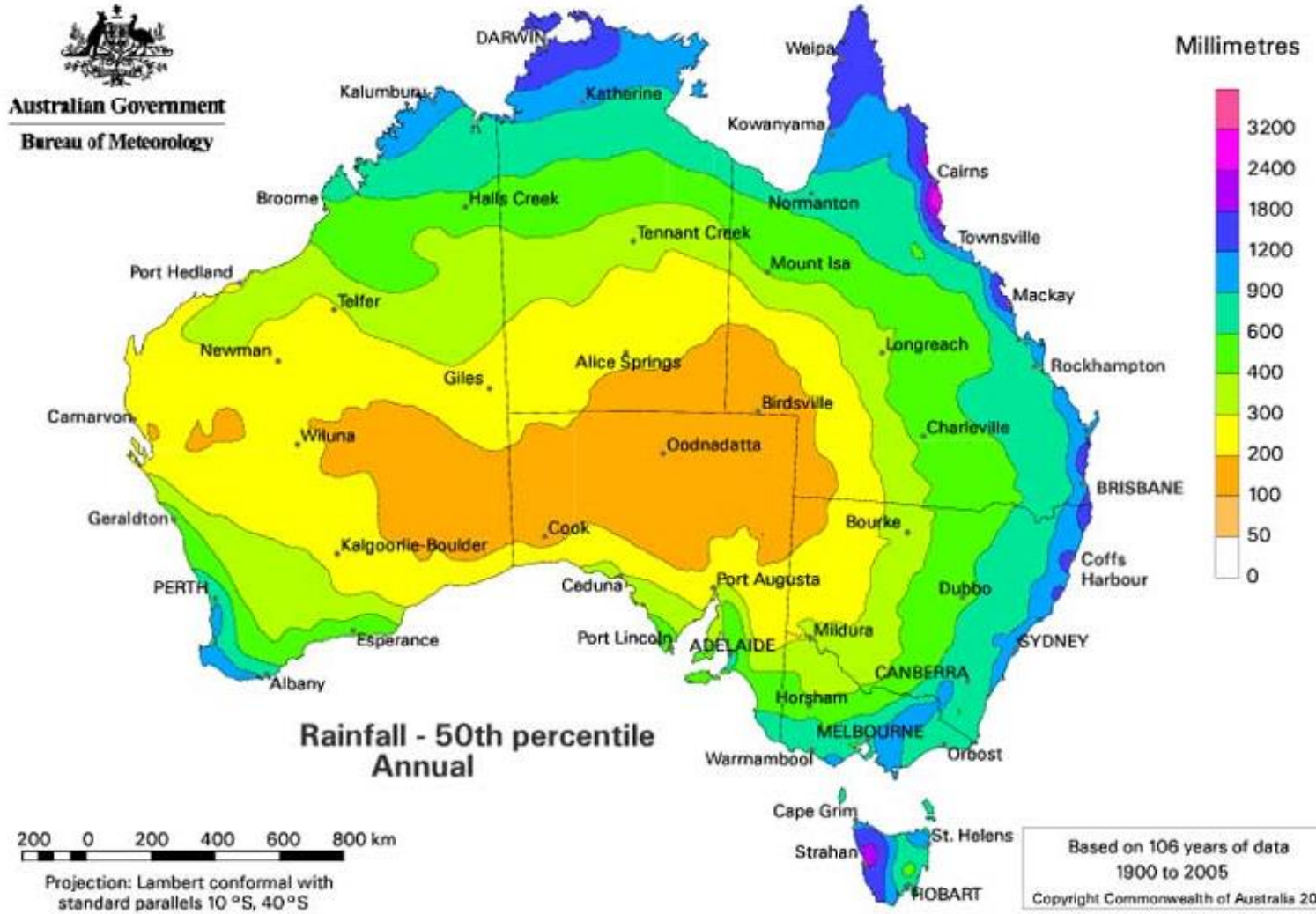
Australian Government
Bureau of Meteorology
DARWIN
Weipa
Kalumburu
Katherine
Kowanyama
Cairns
Broome
Halls Creek
Normanton
Tennant Creek
Townsville
Mount Isa
Port Hedland
Telfer
Mackay
Newman
Longreach
Alice Springs
Giles
Rockhampton
Birdsville
Carnarvon
Charleville
Wiluna
Oodnadatta
BRISBANE
Geraldton
Bourke
Cook
Kalgoorlie-Boulder
Coffs Harbour
Ceduna
Port Augusta
Dubbo
PERTH
Mildura
Esperance
Port Lincoln
ADELAIDE
SYDNEY
CANBERRA
Albany
Horsham
MELBOURNE
Warrnambool
Orbost
Cape Grim
St. Helens
Strahan
HOBART
Millimetres
3200
2400
1800
1200
900
600
400
300
200
100
50
0
Rainfall - 50th percentile
Annual
200 0 200 400 600 800 km
Projection: Lambert conformal with
standard parallels 10 °S, 40 °S
Based on 106 years of data
1900 to 2005
Copyright Commonwealth of Australia 2007
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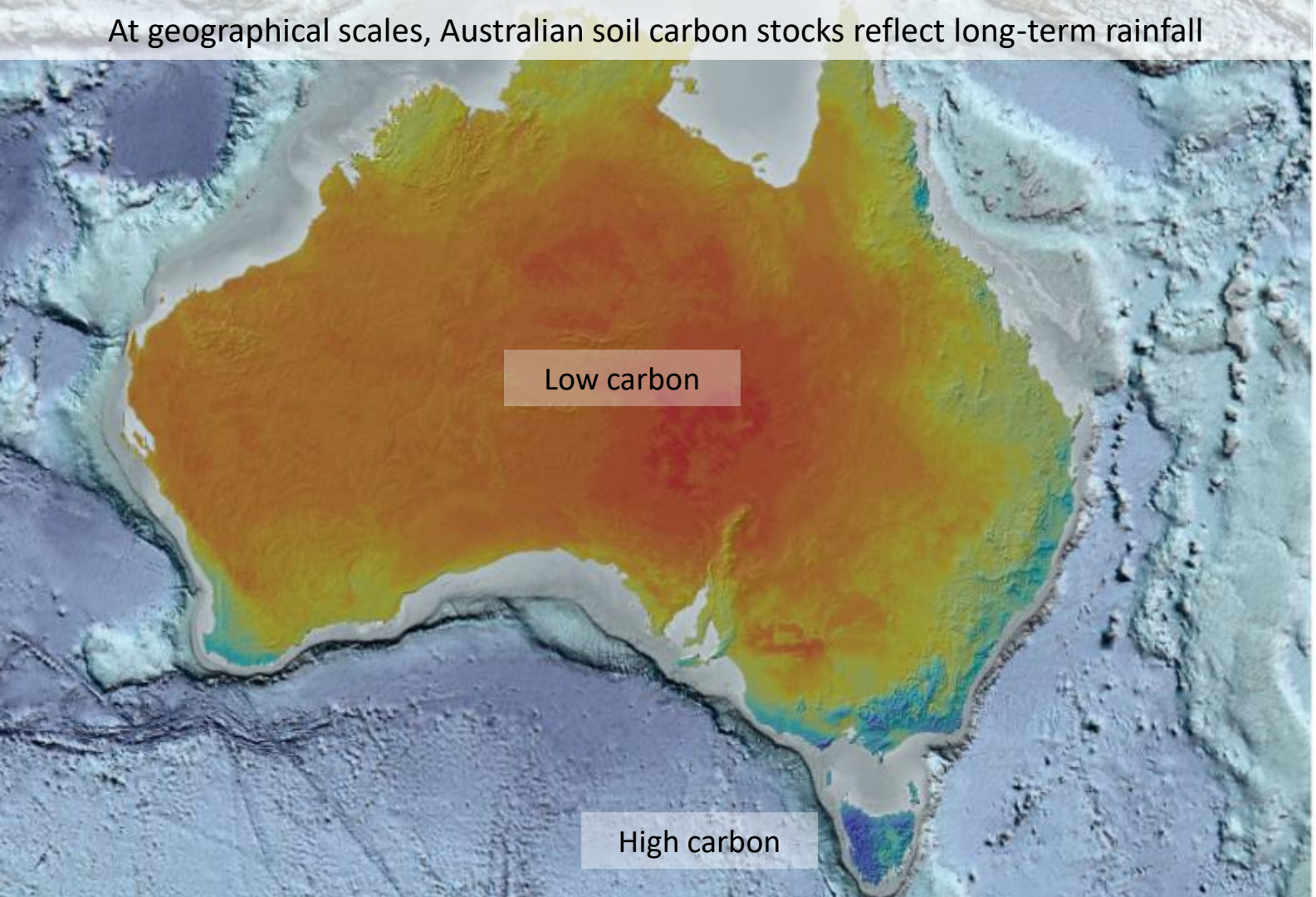
At geographical scales, Australian soil carbon stocks reflect long-term rainfall



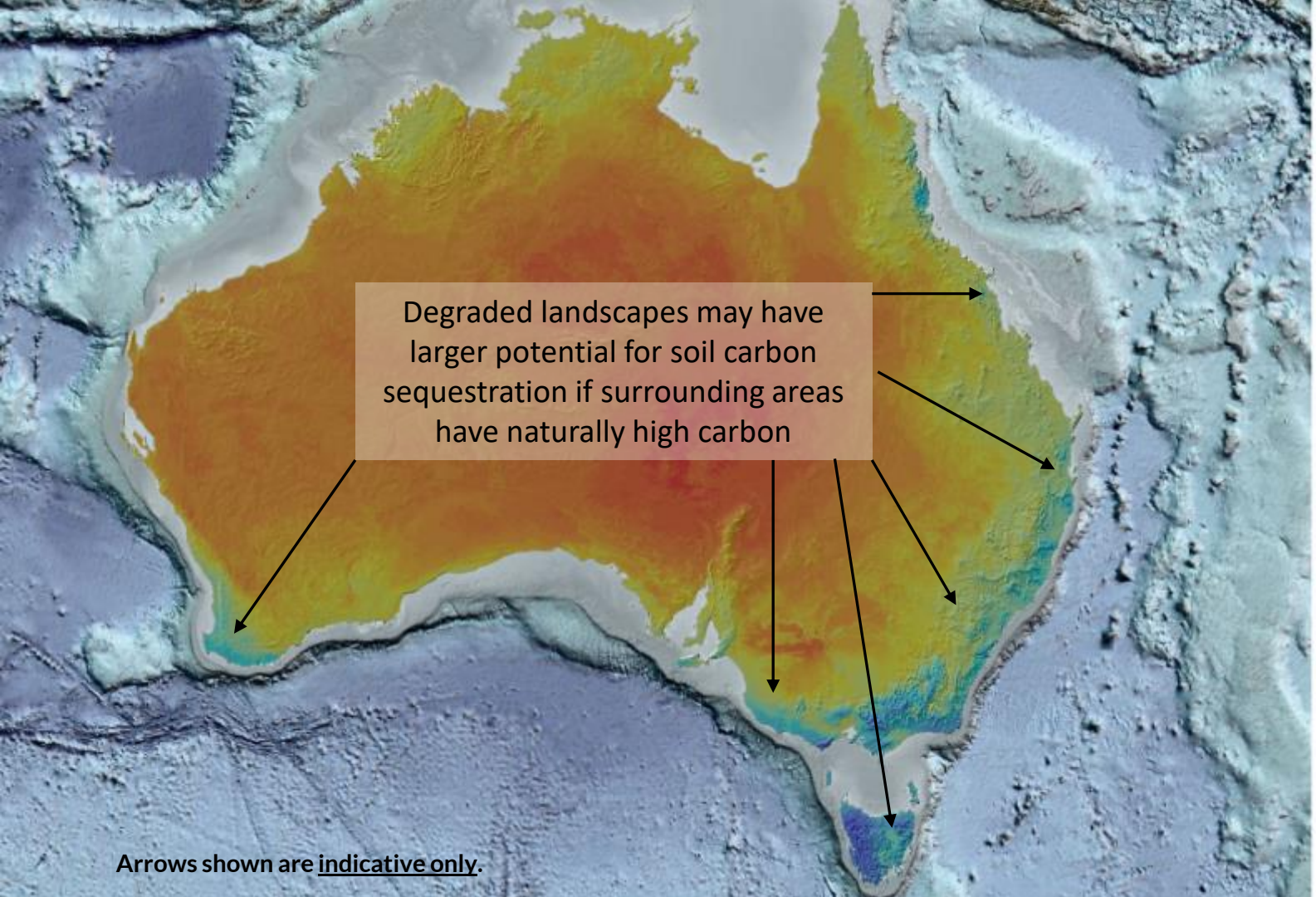
The 2010 baseline map of organic carbon in Australian soil will help Australia track changes in soil carbon stocks and assist with strategies to reduce greenhouse gas emissions through soils.

www.csiro.au/soilcarbonmap

Tonnes of soil carbon per hectare

230

5



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230

5

4. Soil organic carbon is ephemeral

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Low carbon landscape


High carbon landscape

5. For SOC “permanence”, practice changes must also be “permanent”

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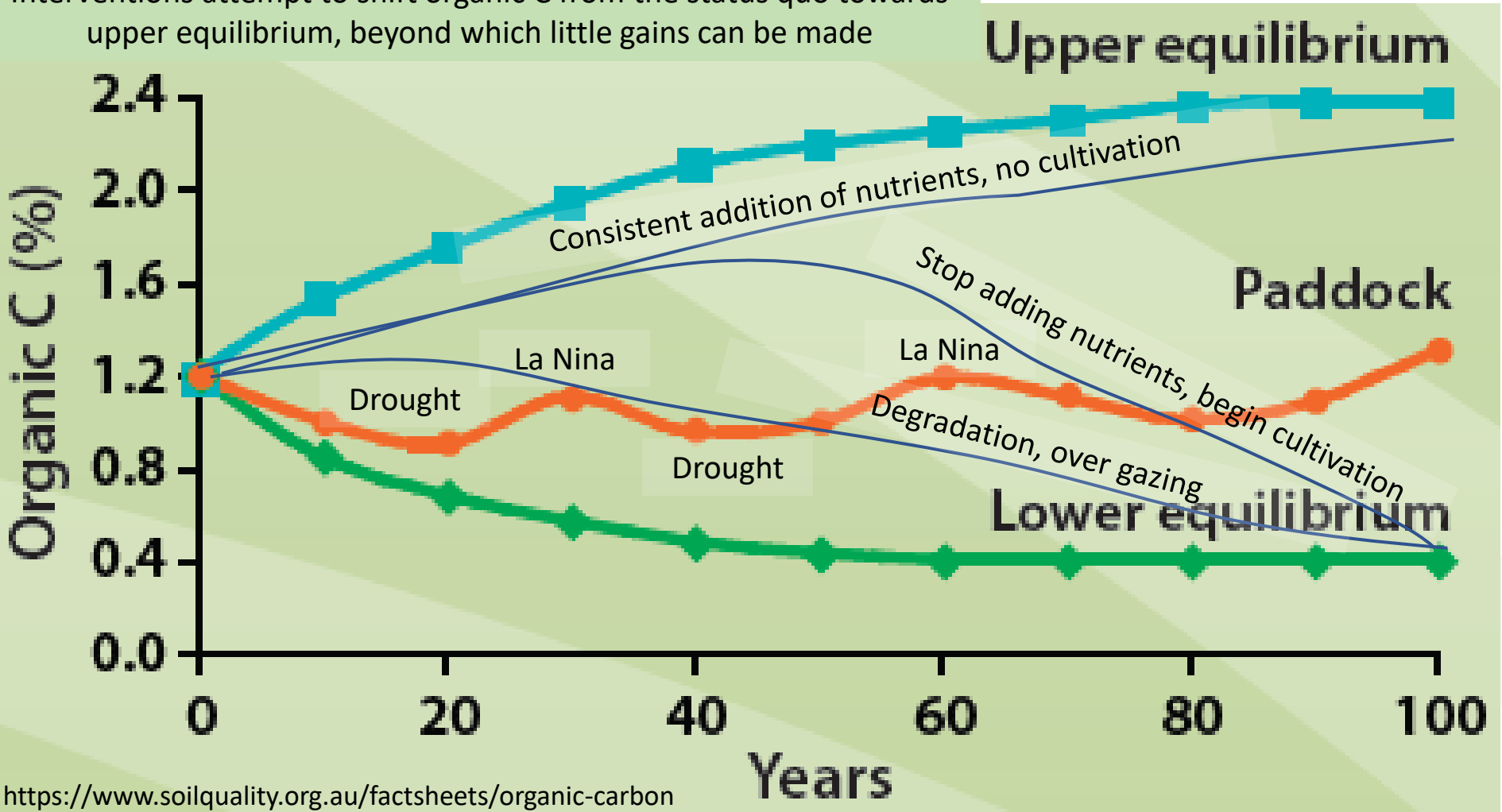
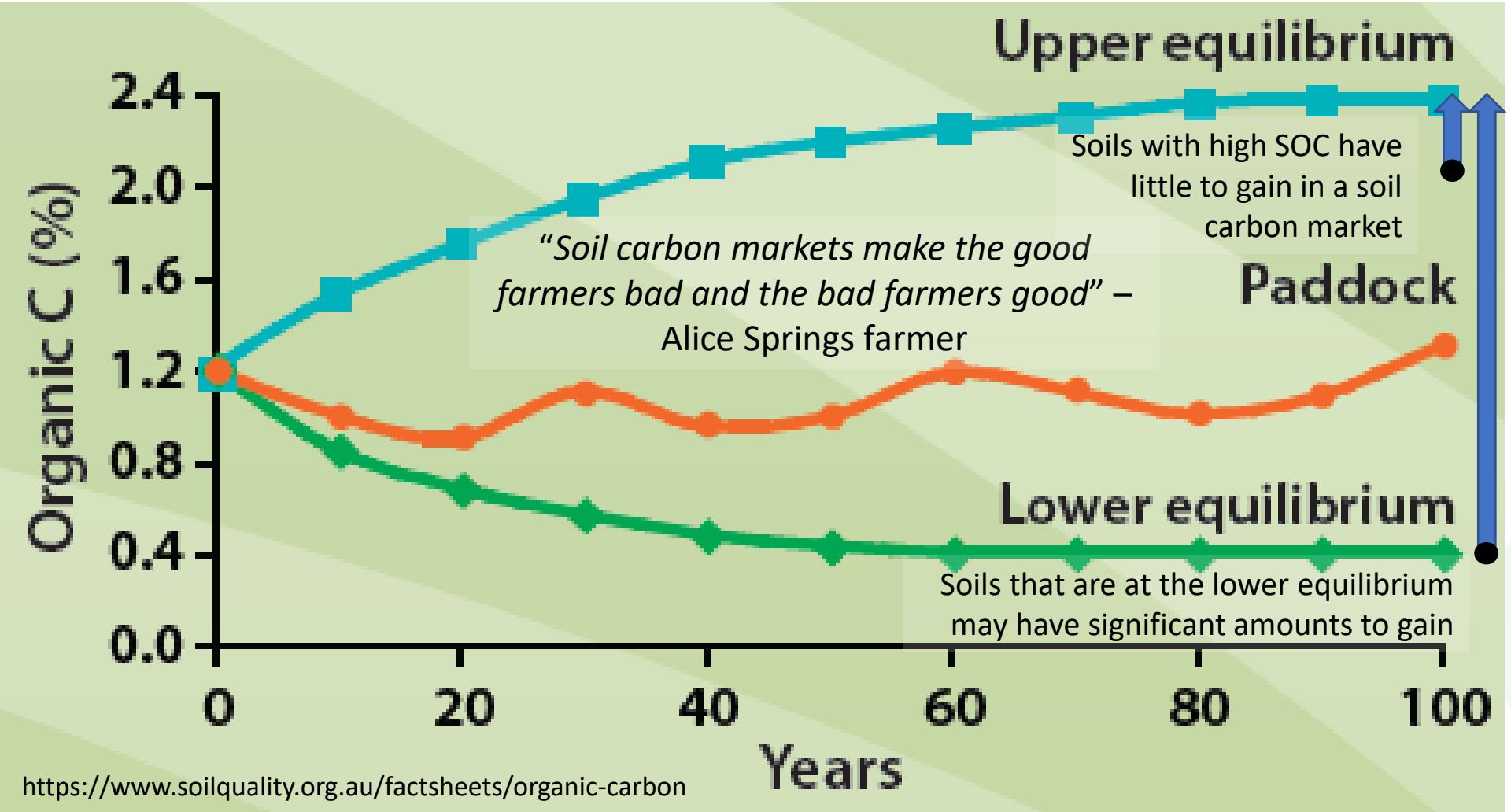
Interventions attempt to shift organic C from the status quo towards upper equilibrium, beyond which little gains can be made



https://www.soilquality.org.au/factsheets/organic-carbon



https://www.soilquality.org.au/factsheets/organic-carbon

6. Climate change generally reduces ability to sequester carbon

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realcommercial
Rural

Carbon sequestration to plummet by 2050

New research is bad news for soil carbon markets

ENDURED WARMING

Soil carbon markets face hot threat from climate change

ATTN: WOOLGROWERS

University of Tasmania modelling showed that soil carbon rates of change slowed by 55-133% by 2050 due to warmer temperatures, greater soil respiration, lower pasture growth

7. Divergent aspirations: individual livelihoods vs societal public good

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The contentious issue of “additionality”

- **Additionality** means that the rate of change of SOC relative to some baseline is greater than what it would have been in the absence of a management intervention

- **Many farmers are concerned with additionality** as it does not reward historical good management practice prior to enrolment in a carbon market

- **Soils with high SOC have little room to improve**, but lots of opportunity to lose SOC (droughts, bushfires, erosion, lack of maintained good management…)

- BUT the government pays land managers based on additionality to **incentivise them to adopt practices that improve SOC**, because the government’s goal is reduced global warming

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Rethinking soil carbon payment mechanisms

- Potentially more sensible to have a scheme that issues payments for carbon *stocks* rather than carbon *fluxes* – ie payment for environmental stewardship
- Payments could be made to landholders with carbon stocks that are high compared with regional thresholds e.g. >75th percentile carbon stocks
- If stocks fall to less than 75th percentile, payments cease
- This would ensure that landholders are paid for historical good management practice prior to a carbon market
- Also ensure that regions with higher stocks do not decline, releasing CO_2 into the atmosphere
- Would avoid issues associated with additionality, as absolute stocks are easier to measure than a change in stocks relative to an arbitrary baseline

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Soil carbon markets: science or snake-oil?

- *Practices* that build soil organic matter are **to be encouraged**
- At continental scales, SOC stocks follow long-term rainfall
- The extent to which SOC can be improved depends on timing of the baseline, paddock history, addition of nutrients…
- SOC can be **easily gained but easily lost** (e.g. drought)
- Current costs of participation in soil carbon markets in Australia **are high**
- Financial returns from soil carbon markets **vary widely**
- Carbon credits that are sold can no longer be claimed in farm GHG balance. This may conflict with aims for carbon neutral product.
- Productivity benefits of soil organic matter outweigh carbon market income
- Some costs associated with acquiring ACCUs are tax deductible but proceeds of ACCUs are assessable income
- Whether soil carbon markets are science or snake-oil depends on motivations and values of the individual

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