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# Carbon sequestration in Australian Grasslands:
## *Technical and Policy Issues*

Roger M. Gifford
CSIRO Plant Industry,
Canberra, ACT
Australia

roger.gifford@csiro.au

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# Australia carbon GHG emissions policy

- Government-commissioned Garnaut Climate Change Review
  - Final Report Sep 2008
  - It was major report proposing a “cap & trade” emission trading scheme
  - Australia's equivalent to the British Stern Report
  - Included a chapter on the potential of land use and land use change, with estimates for C-sequestration into Australian rangelands

- Government’s Carbon Pollution Reduction Scheme white paper
  - White paper Dec 2008
  - Similar to the Garnaut proposal
  - Known as CPRS

# Australian GHG emission policy: Cap & Trade Emission Scheme currently going through parliament (**CPRS**)

2008-2009

The Parliament of the Commonwealth of Australia

HOUSE OF REPRESENTATIVES

**EXPOSURE DRAFT (10/03/2009)**

Carbon Pollution Reduction Scheme Bill 2009

***A Bill for an Act to reduce pollution caused by emissions of carbon dioxide and other greenhouse gases, and for other purposes***

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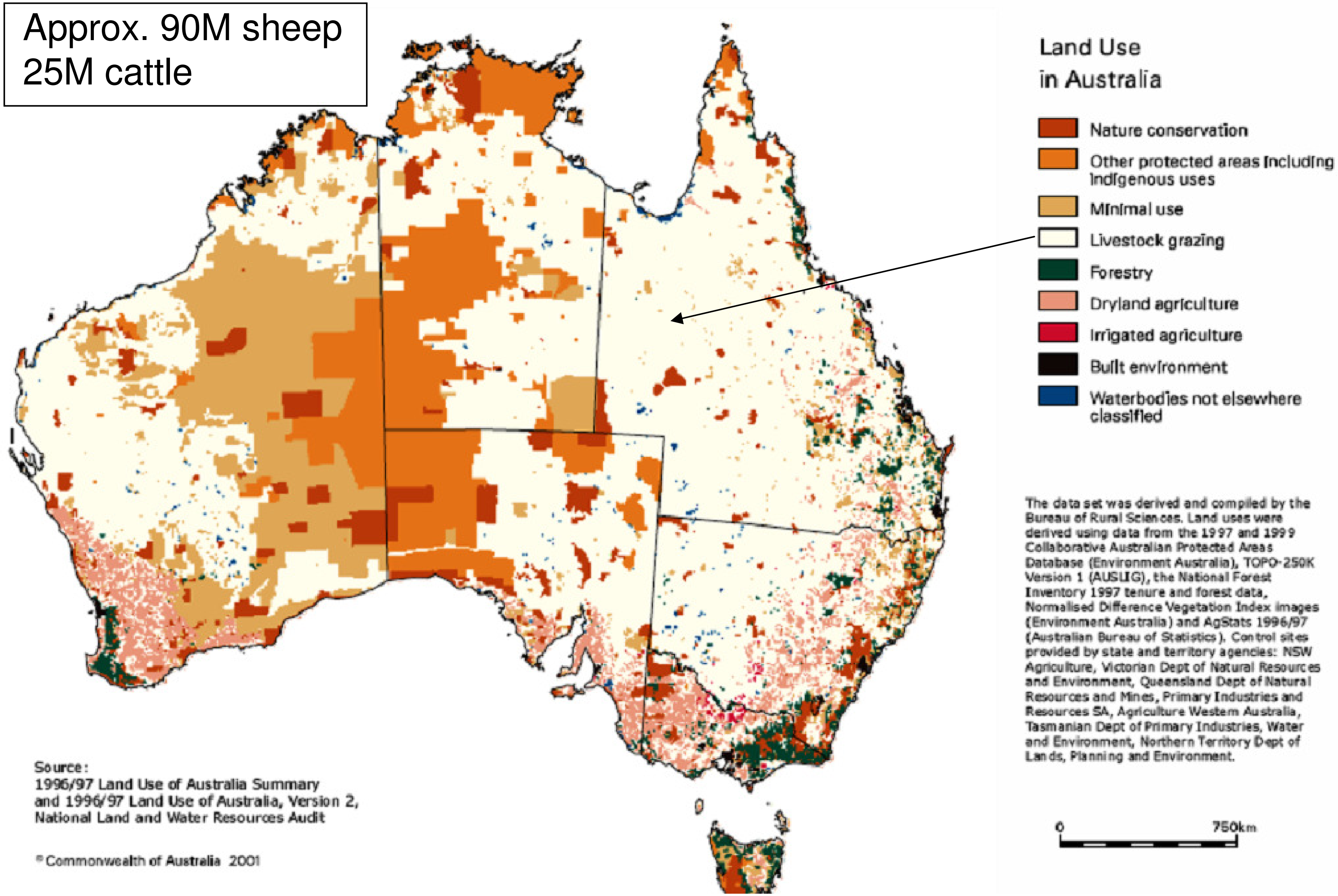
# Key features of the Australian CPRS

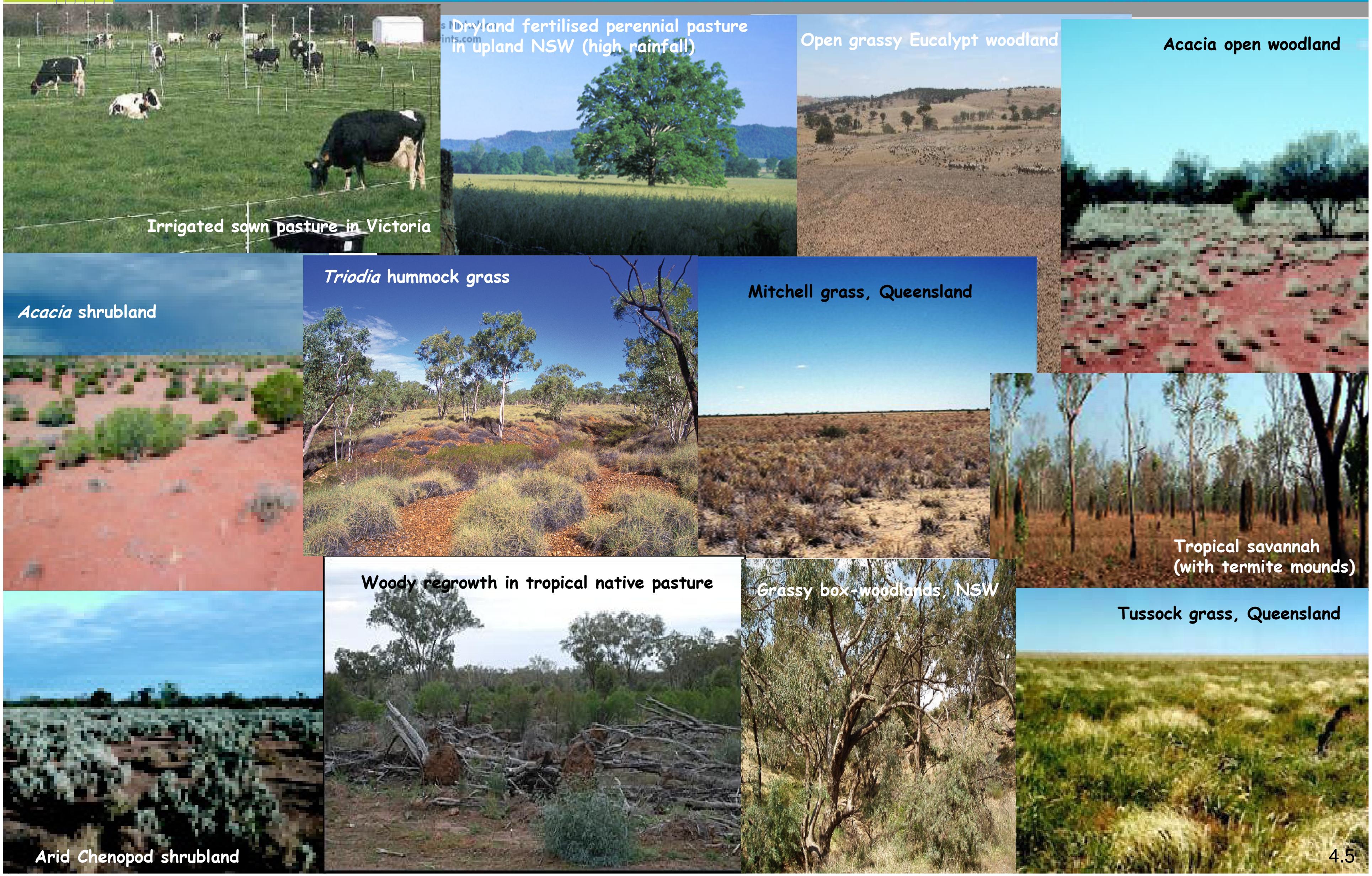
- Proposed cap & trade scheme to start July 1, 2010.  Total number of emission permits set each year by the assigned emissions cap
- 2020 national emission cap to be between 5% (min) and 15% (max) less than the 2000 emission (depending on Copenhagen agreements)
- Tradeable emission permits to be auctioned to upstream point-of-compliance liable entities (like power stations, refineries, fuel importers, landfill owners, etc)
- Reforestation is included in the form of approved reforestation projects with biosequestration being paid for in the form of free emission permits that are transferrable
- The Opposition and the Greens are making it's passage through parliament difficult
- Agricultural and grazing emissions and sinks are not included at first (too complicated and uncertain) but negotiations will start in 2013 for a possible 2015 start in some form.

# The pasture lands of Australia

Approx. 90M sheep
25M cattle



# Wide types of grazing land in Australia



# Area of grazing land in Australia ($x10^6$ ha)

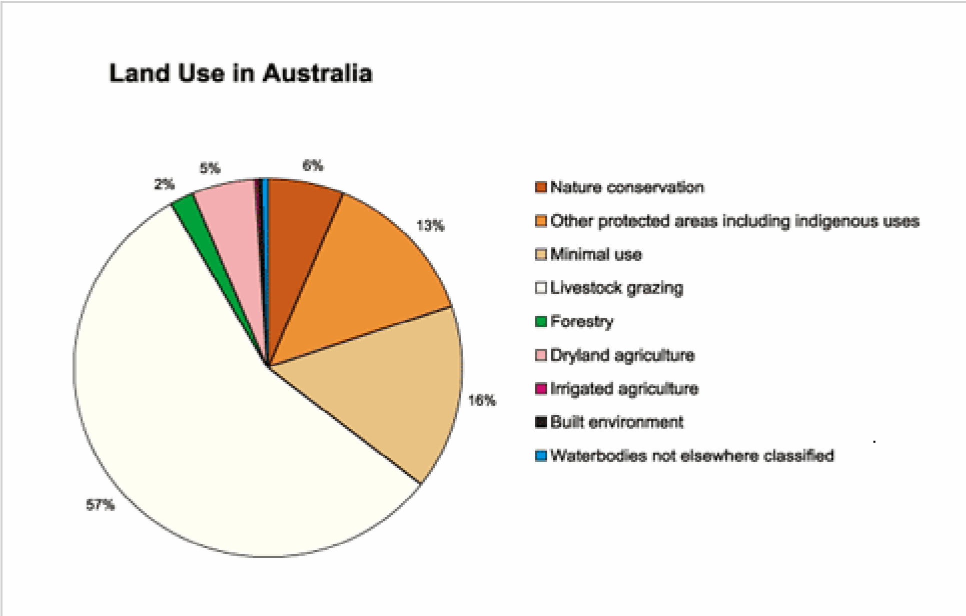
Source: Australian Bureau of Statistics

| | $x10^6$ ha | % |
|---|---|---|
| Australian total land area | 769 | 100% |
| Grazed natural vegetation | 419 | 54% |
| Improved pasture as leys in crop rotation | 24 | 3% |
| Irrigated agriculture (includes some grazing) | 3 | 0.3% |

Key points:

1) Over half of Australia is grazed, but mostly in semiarid areas with very low stocking rates on “native” vegetation.

2) Much of the native grazing lands have substantial woody vegetation that contains a substantial fraction of the ecosystem C stock



# What is the existing C stock in Australian grazing lands? Only two estimates available.

| | Area Mha | Live aboveground C-stock (Gt C) | Below ground C-stock (Gt C) | Total C-stock (Gt C) |
|---|---|---|---|---|
| Gifford (1992) | 443 | 14.5 | 29.9 | |
| Barrett (2009) | 441 | 9.9 | 26.5 | |
| Mean | | 12.2 | 28.2 | 40.4 |
| Mean C density (t/ha) | | 27.6 | 63.8 | |

c.f. Aust national annual GHG annual emissions:

from Energy/industry sector 0.117 Gt $C_{eq}$ $yr^{-1}$

from Land sector 0.035 Gt $C_{eq}$ $yr^{-1}$

As a result a lot of enthusiasm exists for sinking more C into soil, especially in the vast grazing lands, to offset Australian GHG emissions.

**But what would it take to increase it?**

*Soil-C is too restrictive*

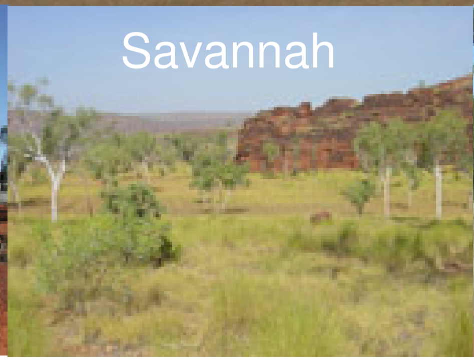
# Whole-ecosystem GHG emissions should be considered rather than just soil C because:

Why? 1) Ruminant digestive-methane is an important emission and interacts with grazing intensity and herbage quality (ie with pasture management)

2) Trees and shrubs are abundant in many Australian grazed systems. These contain a lot of carbon both above ground and below ground in roots, which go deeper than grass roots and decay slower.

3) Tree & shrub management for grazing involves fire, which emits GHGs

4) Methane emissions, grazing intensity, woody increase are interactive




- Woody plant density is a managed part of the ecosystem, which these days is subject to legislation

# Garnaut's estimates of C sequestration rates (slide 1)

*(Garnaut Review Final Report Chapter 22)*

- Following the Chicago Climate Exchange rulebook, Garnaut assumed that pasture C stocks could be built up in the soil by:

*"3. Project involves rangeland management practices that include use of **all** of the following tools through the adoption of a formal grazing plan:*

*a. Light or Moderate Stocking rates;*
*b. Sustainable Livestock Distribution which includes:*
*i. Rotational grazing*
*ii. Seasonal use. "*

(www.chicagoclimatex.com/docs/offsets/CCX_Rulebook_Chapter09_OffsetsAndEarlyActionCredits.pdf#page=142)

# Garnaut's estimates of C sequestration rates (slide 2)

*(Garnaut Review Final Report Chapter 22)*

Based on Chicago Climate Exchange rules for degraded rangelands Garnaut suggested, apparently assuming that all Australian grazing lands were degraded, and that degradation equated to overgrazing, that there is a soil bio-sequestration potential in the Australian rangelands of

**286 Mt $CO_{2eq}$ per year (78 MtC) for 20-50 years**

via such reduced grazing practices.

For the 358Mha that he referred to as grazing land this averages 0.27 tC $ha^{-1}$ $yr^{-1}$.

Questions arise from this.

1) Are all Australian grazing lands degraded/overgrazed?

2) What would be the value of animal production forgone? What's the costs?

3) Does reduced stock grazing necessarily increase rangeland soil C-stocks?

4) How reliable is the estimate of the technical bio-sequestration potential?

# Rationale for reduced grazing intensity increasing C-stocks

- The level of ecosystem carbon stocks express a balance between:

Inputs from new plant growth (primary plant production)

and

Outputs such as decomposition and via removal of agricultural products

That is the basis on which it is assumed that reducing herbivory from domestic stock grazing will increase soil carbon stocks. But ….

the "Chicago rules" do not seem to take into account several phenomena that make reality much less simple and unpredictable such as ………………….

# …..1. woody plant thickening due to grazing pressure - a widespread phenomenon in tropical rangelands

Woody plant thickening at Conkerberry Paddock at Kidman Springs. This is a red soil site in relatively good condition

1973

1989

2000

Woody component has:

- High above ground C stocks
- High deep soil C

http://www.savanna.org.au/vs/thickening_vegetation_red_soils.html

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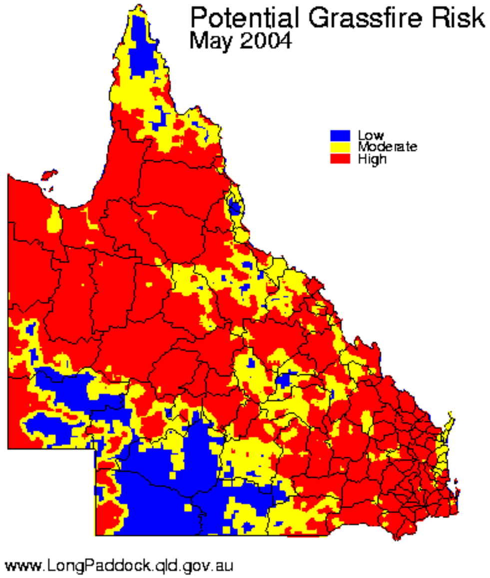
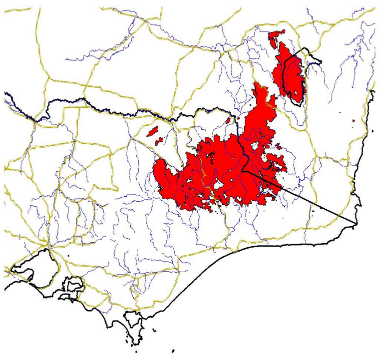
# In order to continue grazing, woody regrowth has to be bulldozed or burned …..

# …… 2. wildfire is part of the system in Australia loss of stored C; methane; black carbon




Fire Scar Area from Jan/Feb 2003 bushfires



Black-carbon from burning

Atmospheric soot –
A powerful atmospheric warmer

Soil-char –
A very long-lived C-sink

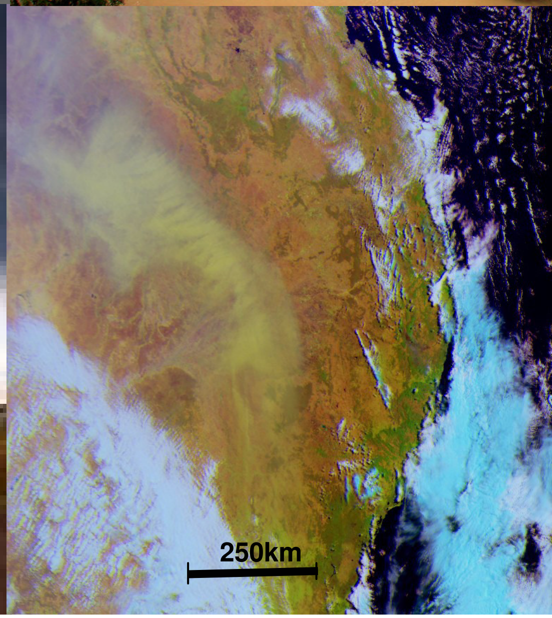
## ….3. native and feral herbivory – reduced domestic grazing partly compensated by increased unmanaged-herbivory








# …..4. floods & dust storms – vast quantities of surface soil (high SOC) shifted around




…poses soil-C ownership and permanence issues.

Compensation via ocean iron fert-ilisation effect

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Conclusion

There are are complex phenomena going on in Australian rangelands that interact with a reduced grazing regime to produce ill-understood and essentially unquantified effects.

## Influence of grazing intensity on rangeland C-stocks

- Degradation v overgrazing. They are not synonyms. Much confusion.

  There are several forms of degradation – bare ground, compaction, acidification, “scrub” growth ….. etc

- Overgrazing can increase ecosystem C stocks (woody thickening) or decrease C stocks (denudation, scalding)

- Very little data on the impact of changed grazing intensity on soil C stocks.

  **Ash, Howden and McIvor** (1995) Used paired-site contrasts in N Australia and a survey of opinion on areas of desirable, deteriorated and degraded pastures in N Australia to conclude that if deteriorated and degraded land could be returned to desirable condition 460 MtC could be sequestered in the soil, which if achieved over 50 yr would average about **9 Mt C $yr^{-1}$**.

  **Conant and Paustian** (2002) found only 22 suitable published paired-site examples world wide, none in Australian semi-arid or arid rangelands.

  Based on a regression of the difference in soil stocks in heavily v moderately grazed paired sites – mostly in USA, Canada and UK, one in China and in the alpine pastures of the Snowy Mountains in Australia, Conant and Paustian made some tentative estimates.

  For Austral/Pacific region, a GLASOD (Global Assessment of Soil Degradation) opinion survey indicated that 11.2% was overgrazed (97% of which was “lightly” overgrazed).

  If this overgrazing ceased it was estimated that the potential sequestration rate would be **4.4MtC $yr^{-1}$** (cf Garnaut estimated potential of 78 Mt C $yr^{-1}$.)

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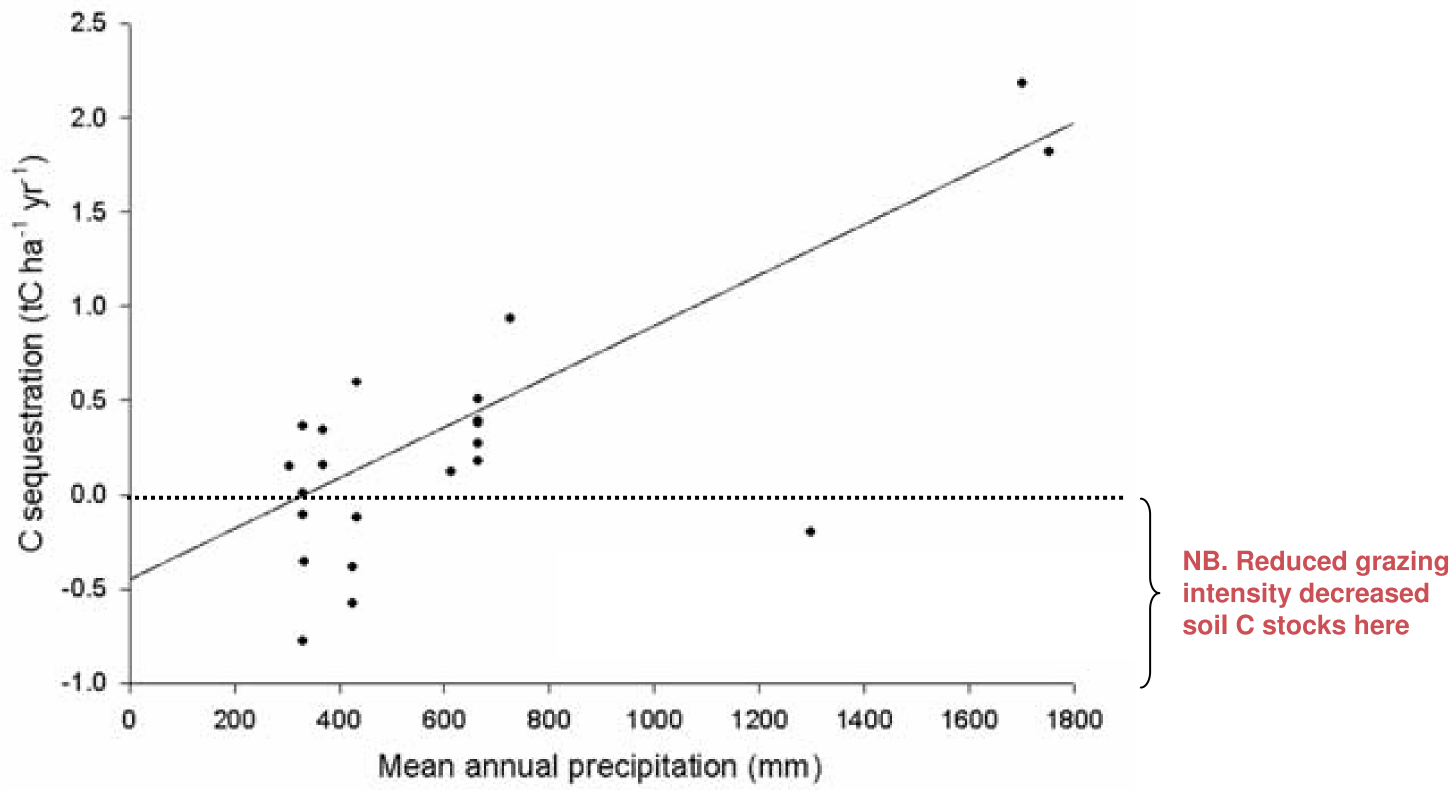
## Conant RT, Paustian K (2002). *Global Biogeochemical Cycles* 16(4) 1143
## Available world data is limited

The rate of increase in soil C stocks when heavy grazing is changed to moderate grazing intensity for diverse pastures worldwide expressed as a function of mean annual rainfall. $R^2$=0.29; P<0.01




Conclusion: This is a very weak (maybe irrelevant) basis for estimating C-sequestration potential from grazing management in Australia.

Given that:

- The very small number of available data-points

- In the range of rainfall that is relevant to Australia, almost half the data-points showed *decreased* soil C following reduced grazing pressure

- The analysis dealt only with soil C rather than whole ecosystem GHG sources and sinks

- The analysis does not address the large and complex effects of woody thickening, wildfire, unmanaged herbivory, and lateral transport of topsoil by wind and water….

….the analysis of Conant and Paustian must be regarded as only a small stepping stone in attempting to estimate the technical potential for managing Australia grazing lands to reduce GHG emissions.

However, from both analyses, it is clear that the Garnaut Review figure, based on the CCX algorithm, is much too high.

# The question of C-saturation: how long could C-stocks keep increasing?

There are two types of saturation.

1) For a step change in the balance between C input (NPP, litter fall) and C loss (death and decomposition, removal), the soil and above ground C-stocks will increase to a new steady state level.

2) With progressively larger C input rates to the soil, there comes a stage when the steady state soil C stocks do not increase further despite faster inputs.

Thus there are limits to how long changed management can increase C-stocks.

Importantly, once a new steady state is reached, it requires continued management to hold it at the elevated level of C-stocks.

Any C-biosequestration scheme involving financial incentives must accommodate **two phases** for the incentives:

Phase 1) to increase the C-stock in the ecosystem
Phase 2) to *maintain* that increased C-stock forever more.

# Risks and barriers to using C-trading for C-sequestration into rangelands

- **Harmonising a short term market mechanism** for $CO_2$ emission reduction with a long term ecological process of C sequestration having chaotic episodic elements**.**
  - Only phase 1 (C-build-up) has been under discussion to date.
  - Maintenance the elevated C-stocks is yet to be included – it involves costs.
  - Cannot verify that a change occurred for a couple of decades at least:
    - should people be paid until the increase in stocks is positively verified?

- **Establishing baseline** stocks and flows for C-trading
  - No hope if the baseline year is in the past - other than by deeming
  - Single year very problematic in highly variable environment – need a multiyear baseline
  - Need baseline fluxes as well as baseline stocks
  - Need to specify what the baseline grazing regime was to define regime-change

- **Factoring out natural change in C stocks**
  - Normal climate variability effects on C-stocks
  - Global change effects on C-stocks ($CO_2$ fertilising effect, warming effect, etc).

- **Opportunity for scams**
  - Replete with opportunity for financial (loopholes) and technical (sampling, timing, etc) scams especially if financial remuneration starts before on-site verification is technically possible.

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## Risks and barriers continued

- **Hydrological implications**
  Trees change run-off, soil water levels, ground water.
  Water also subject to trading

- **Change of C by erosion**
  Land can gain or lose C by water and wind erosion
  Huge quantities of C can be shifted by major floods or dust storms
  Eroded material may or may not be oxidised faster
  In the ocean eroded material fosters ocean C sequestration via iron fertilization.

- **Kyoto Lands and other regulations**
  What is the status of lands already designated as Kyoto-compliant?
  If already committed to a government-mandated land-plan can you also C-trade the purported C-benefits or is the agreement in the baseline?

- **Leasehold v freehold; change of leaser or owner**
  Who benefits; who is eternally burdened?

- **Costs to the grazier**
  Reduced stocking - loss of production
  Cost of verification of baseline and increased C-stocks
  Insurance against C-stock loss (fire)
  Opportunity cost of sequestered minerals

# Opportunity cost of sequestered minerals

Given that soil organic matter has a C:N:P ratio of about 10 : 1 : 0.2, each tonne of sequestered SOC contains ~100kg N and 20 kg P.

These minerals, when sequestered, are unavailable for plant growth and represent a forgone production opportunity (ie an opportunity cost).

At recent fertiliser prices, in addition to the value of the carbon (currently about $US8/t on the Chicago Exchange), the associated N & P are worth about $200-$300/t.

This is the appropriate cost basis to compare soil C sequestration with alternative methods of reducing GHG emissions.

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# Overall conclusions

- The Australian GHG cap & trade scheme plan would exclude emissions from pastoralism at first but include afforestation.
- This is wise because sources and sinks of GHGs are extremely complex in native rangelands owing to variable episodic weather effects, woody plant dynamics, competing non-managed herbivory, recurring wild fire, major lateral soil-C transport by dust storms and widespread flood.
- The best bet lies in increasing woody plant density on grazing lands (i.e. afforestation) at the expense of animal productivity. Use of woody belts may provide advantages, but needs more researching.
- The available data on grazed-ecosystem C stocks, fluxes and effects of grazing options are far too poor for designing a market-based scheme at present.
- There are numerous imponderables and practical hurdles to be addressed for successful and equitable implementation.
- The costs of sequestering carbon may far exceed the value of the carbon as set by other mitigation options under a cap & trade approach. But in some places combining C-sequestration with other objectives like biodiversity conservation, aboriginal employment, and erosion and sediment control may be worthwhile.

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# Thank you

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