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Easy winnings? The economics of soil carbon sequestration in agricultural soils

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CSIRO

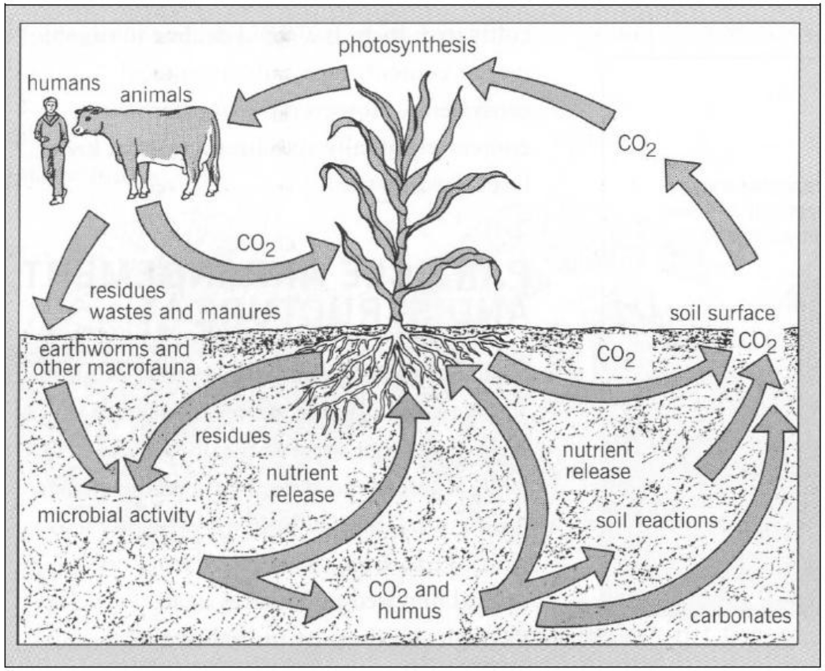
The issue

- Agriculture contributes to greenhouse gas emissions through (e.g.) direct emissions from live-stock, fuel or fertiliser use

- But also loss in soil organic carbon through (e.g.):
  - ❖ Deforestation, or
  - ❖ Changing cultivation

The issue

- Soil is the largest reservoir of carbon in the terrestrial biosphere
- Agricultural soils have a potential to store carbon and offset CO_2 emissions
- Certain management practices can effect re-sequestration of carbon into soils



The issue

Farmers can offset their greenhouse gas emissions through (e.g.):

- Tree planting;
- Conservation tillage;
- Grazing and livestock management;
- Improved fertiliser management;
- Bio-fuel production;
- Conversion from annual to perennial crops or pasture;

Policy background

- Australian Government recently announced development of a Carbon Farming Initiative
- Gives farmers access to voluntary carbon markets
- Carbon sequestration will be credited as abatement under the National Carbon Offset Standard

Policy background

“ The single largest opportunity for CO_2 emissions reduction in Australia is through bio-sequestration in general, and in particular, the replenishment of our soil carbons. It is also the lowest cost CO_2 emissions reduction available in Australia on a large scale”

“Carbon can be captured in soils with a payment to farmers of approximately $10 per tonne.”

Questions

How realistic is it to expect Australian farmers
to be able to store carbon in soils?

1. What sequestration rates can be achieved?

2. What impact would there be on farm productivity (and profit) if a farmers chooses to change practices?

Questions

1. Much research into the biophysical potential of agricultural soils to store additional carbon

2. BUT limited information about the costs and benefits of changing farm practices to increase carbon sequestration

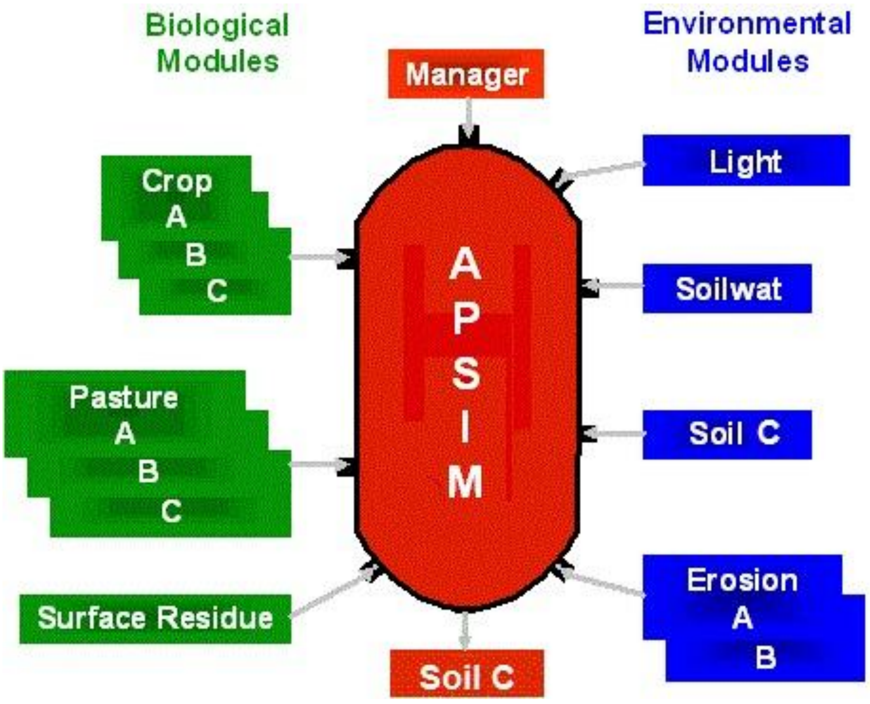
Method

- Bio-economic modelling of carbon sequestration potential and farm profit under different scenarios

- Case study of Central Wheat-belt (WA)

- Focus on three conservation practices:
  - ❖ Shifts in enterprise mix (pasture-crop rotations)
  - ❖ Increased stubble retention
  - ❖ Increased crop productivity

Method



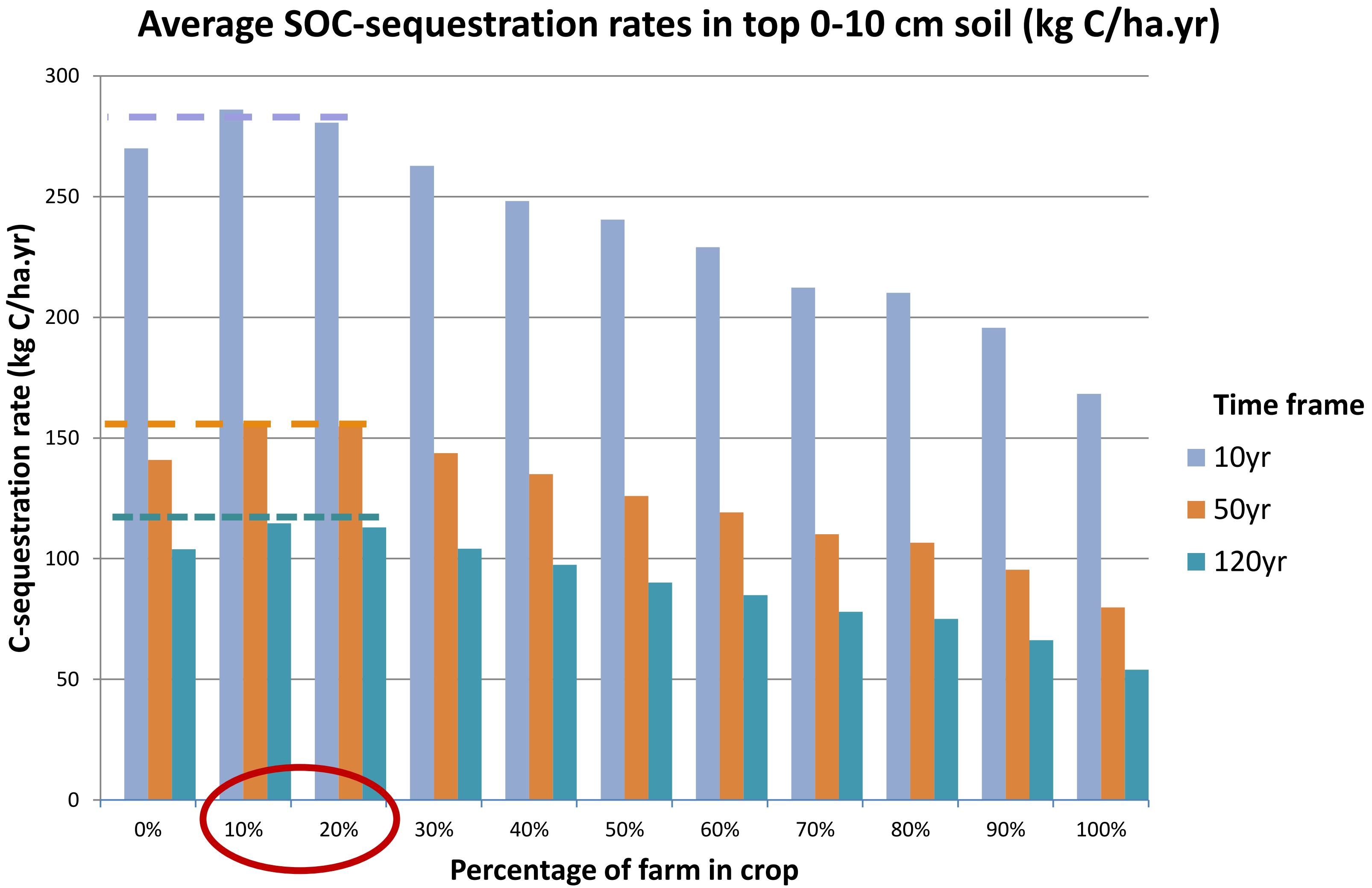
- Biophysical modelling ⇨ Agricultural Production Systems Simulator (APSIM):
  - ❖ Central Wheatbelt climate and soils
  - ❖ 82 crop rotations
  - ❖ Stubble management (0, 50, 100% retention)
  - ❖ Lucerne productivity (base, high)
  - ❖ Thee time frames (10, 50, 120yr)
- Output:
  - ❖ Maximum attainable soil organic carbon content
(top-soil, whole profile)

Method

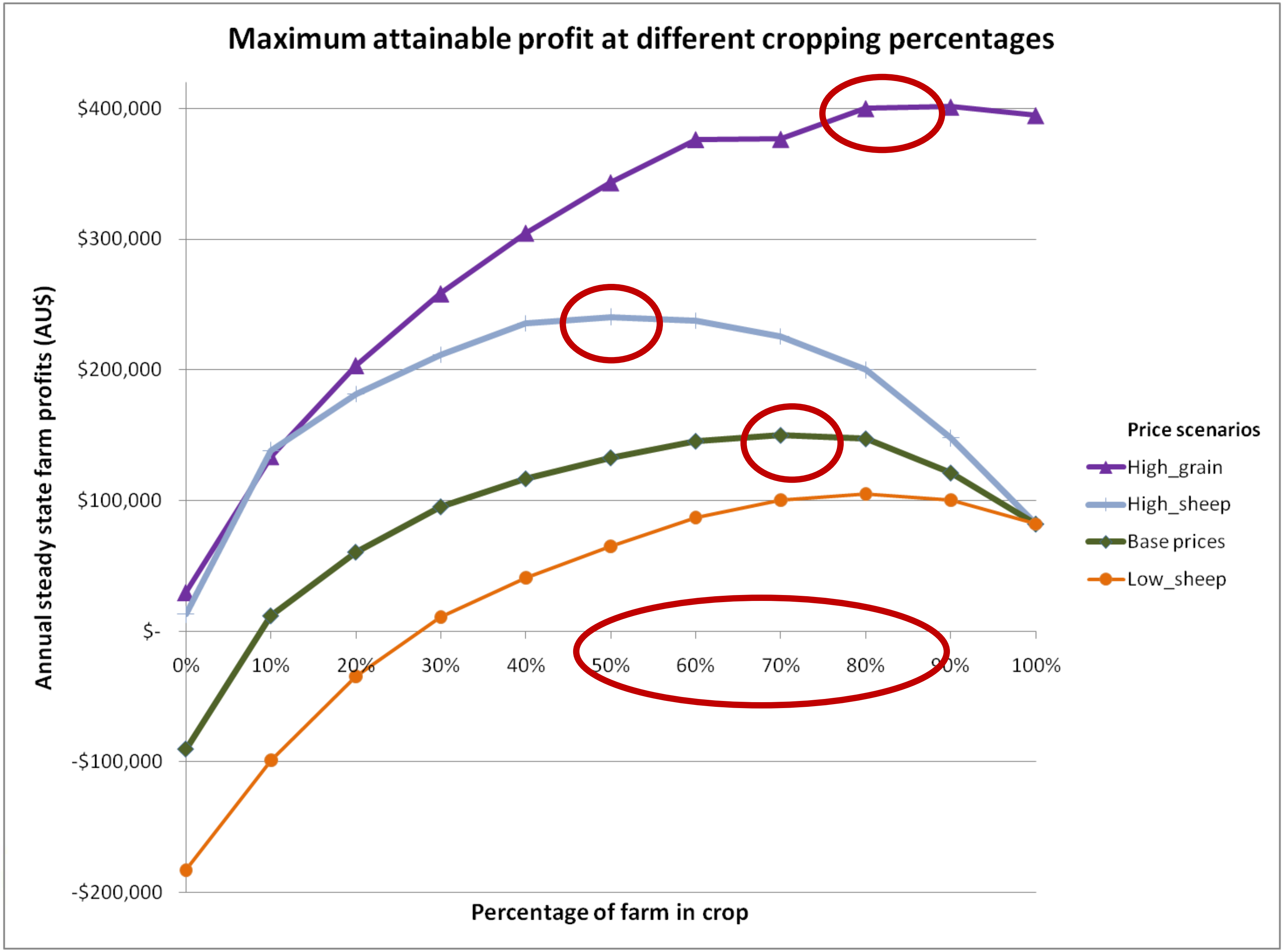
- Farm-economic modelling ⇨ Model of Integrated Dryland Agricultural System (MIDAS):
  - ❖ Commodity prices
  - ❖ Enterprise mix (cropping rotations and livestock)
  - ❖ Fertiliser and stubble management
  - ❖ Different soil types
  - ❖ Land, labour and managerial constraints

- Output:
  - ❖ Optimal combination of rotations on each soil type
  - ❖ Maximum attainable profit

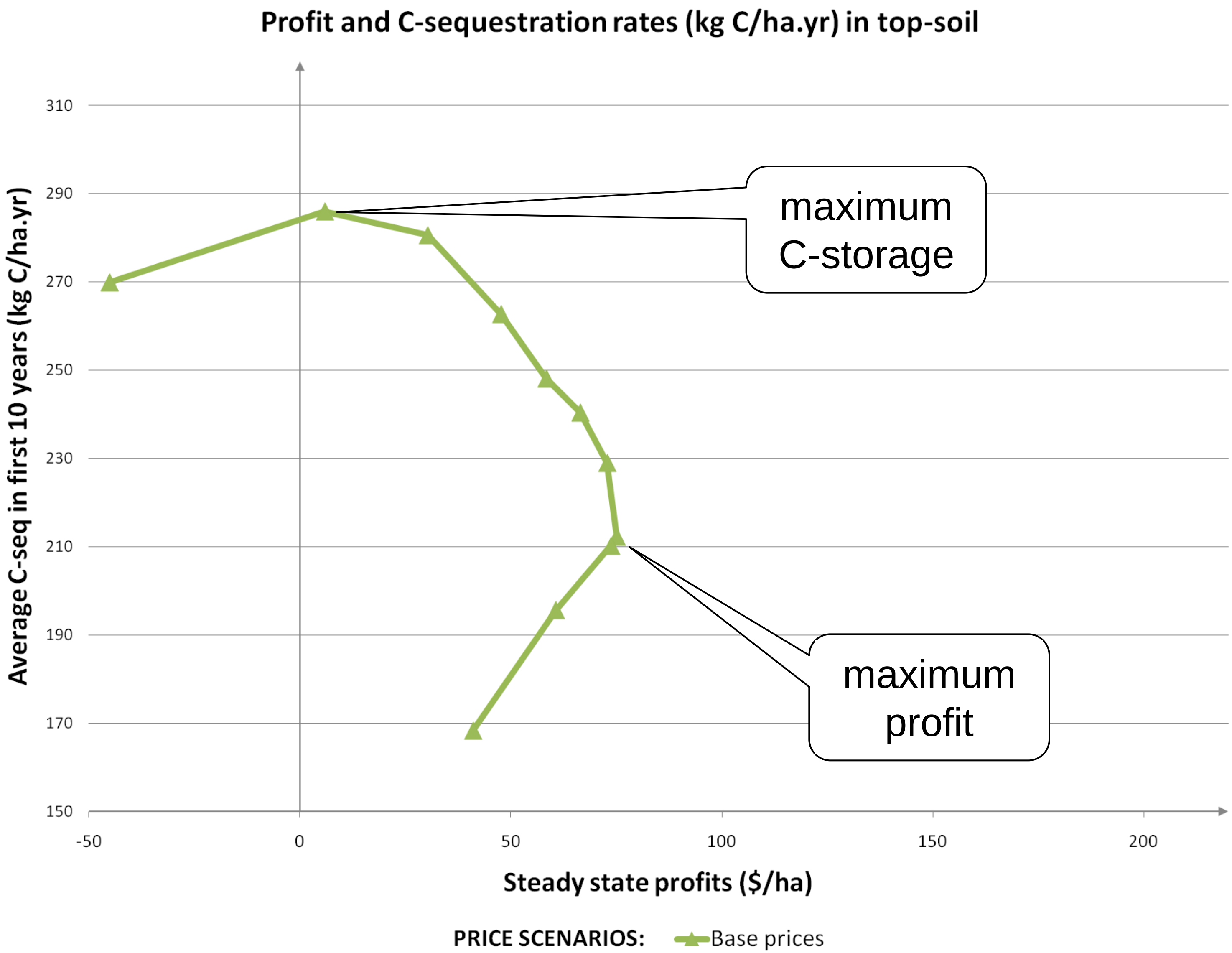
Results – APSIM



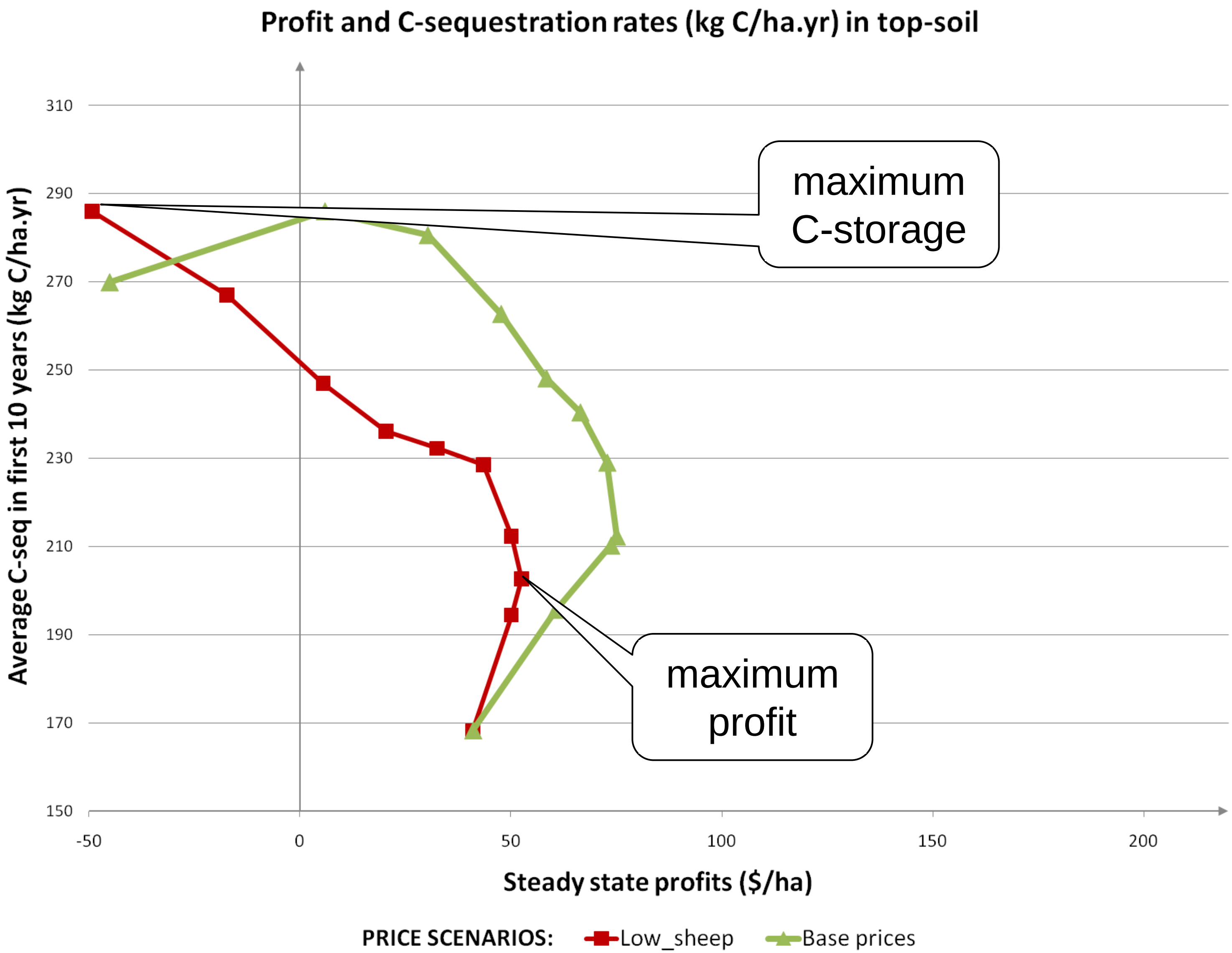
Results – MIDAS



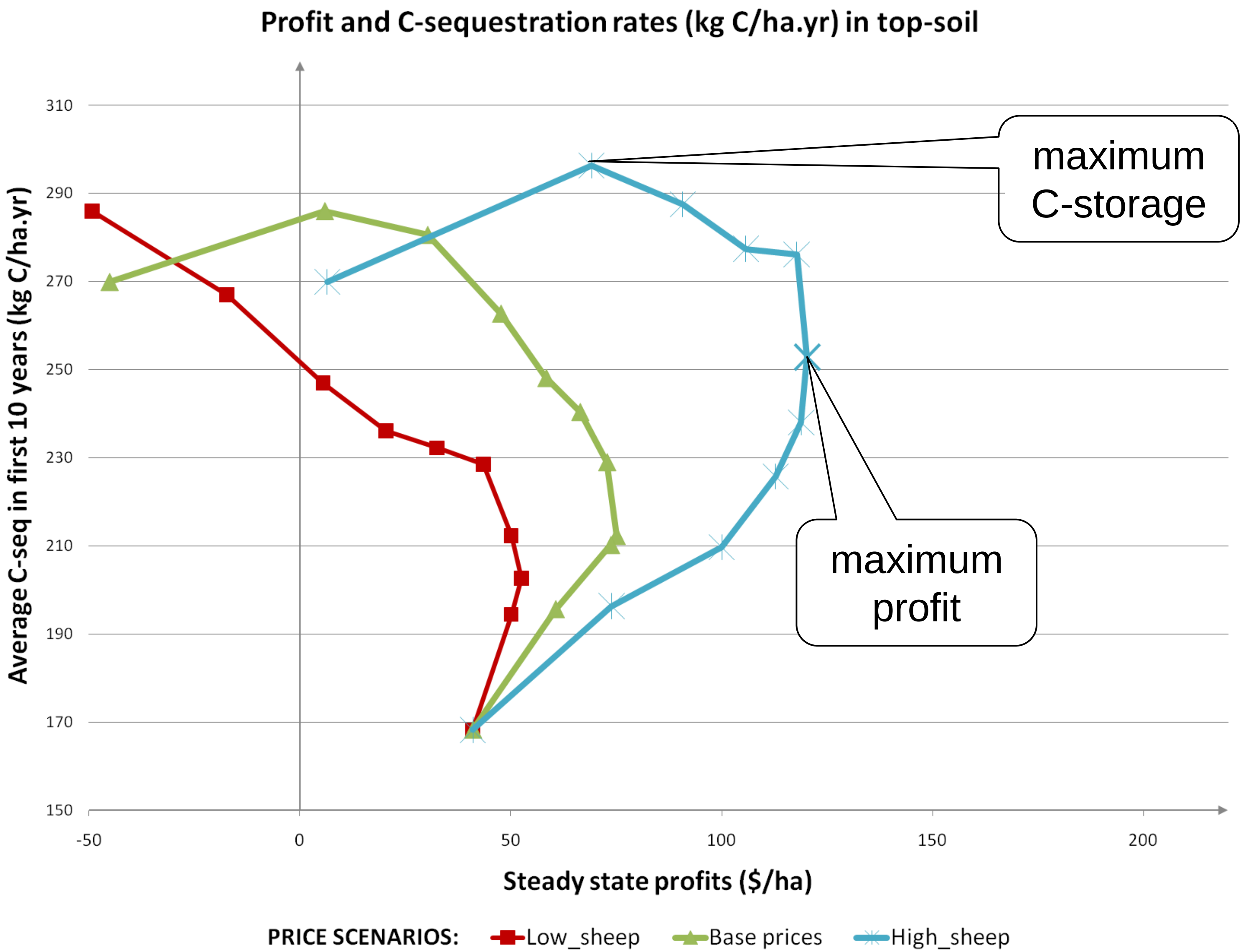
Results – Bioeconomics



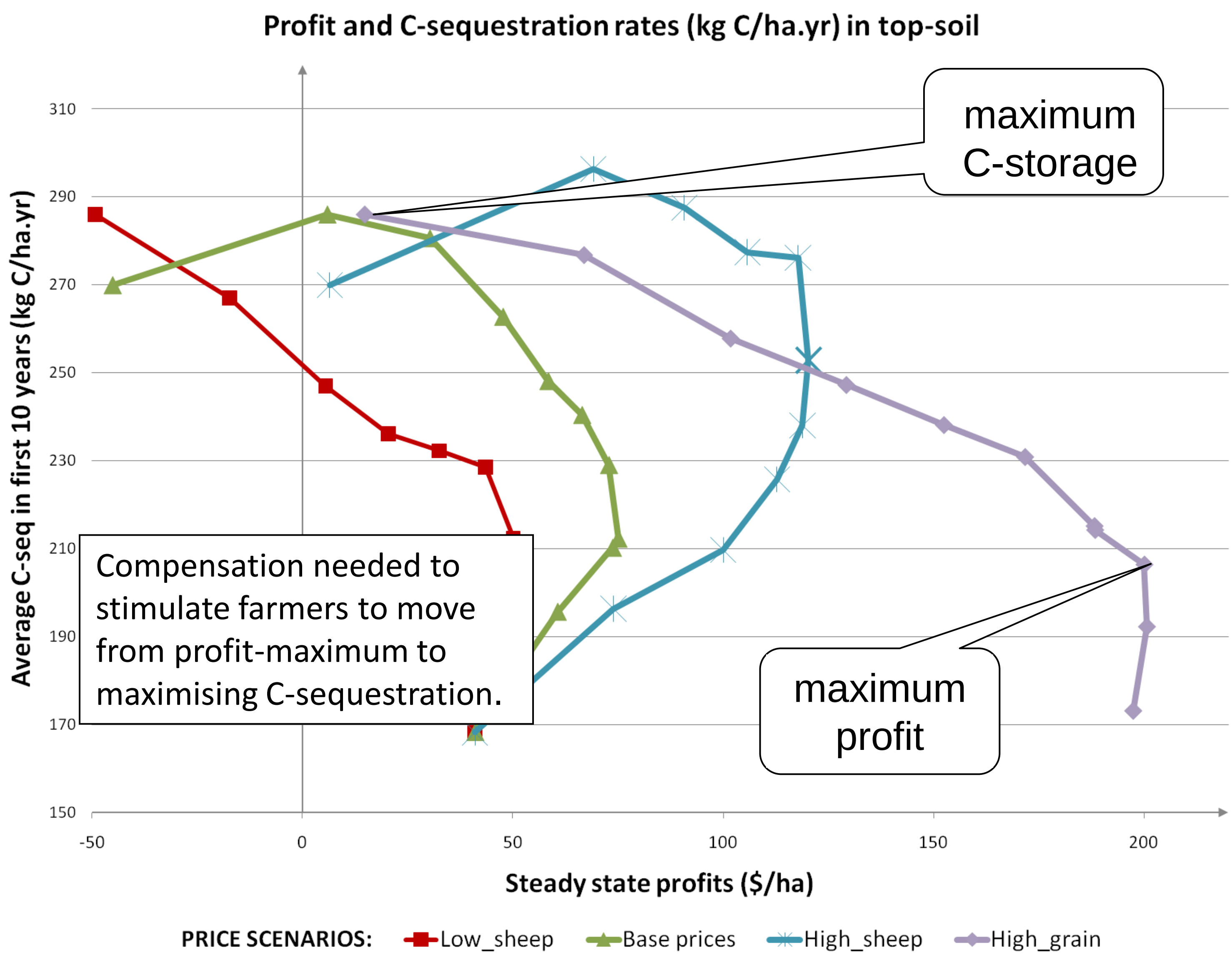
Results – Bioeconomics



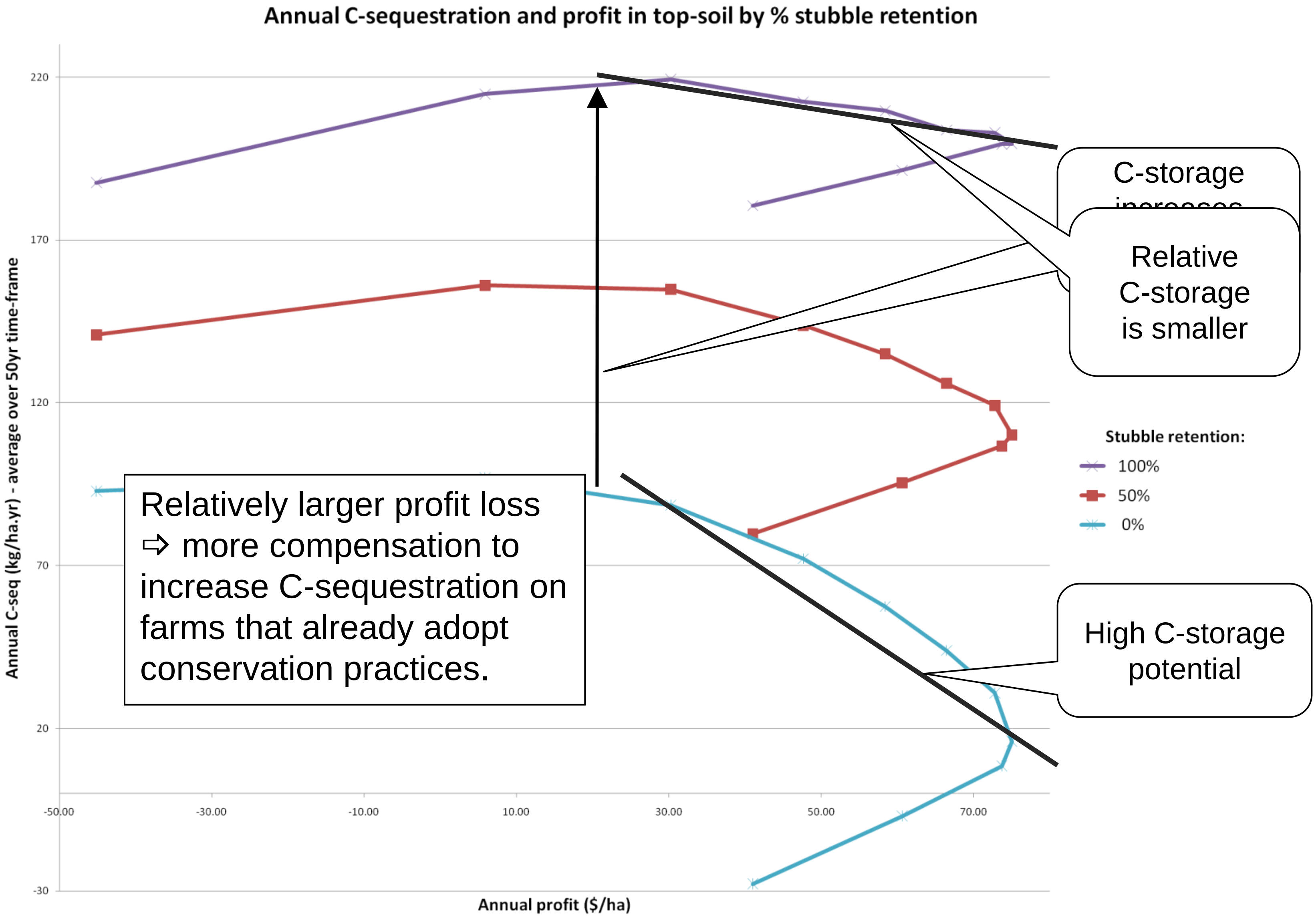
Results – Bioeconomics



Results – Bioeconomics



Results - Bioeconomics



Discussion

- Increasing residue retention will increase soil organic carbon;
- But how ‘additional’ is that type of management?
- Under the Carbon Farming Initiative, practices that are commonly used and cost-effective without offsets are not eligible to sell for credits;
- Hence our analysis of crop rotations;

More results

- We showed that changing crop rotations to increase soil carbon will come at a profit loss to farmers;

- How much compensation would a farmer need per tonne of CO_2?

More results

Carbon payments under different scenarios

Scenario	Time horizon	Annual payment ($ / tCO_2)	
1) Base case	10yr	$ 256	~2.7 tCO_2/ha
	50yr	$ 410	~8.4 tCO_2/ha
2) Low grain price	10yr	$ 99	~0.5 tCO_2/ha
	50yr	$ 158	~1.7 tCO_2/ha
3) Full retention	10yr	$ 192	~0.5 tCO_2/ha
	50yr	$ 615	~3.6 tCO_2/ha
4) Lucerne increased	10yr	$ 112	~2.9 tCO_2/ha
productivity	50yr	$ 175	~9.2 tCO_2/ha

Notes: Storage calculated for 0-10cm topsoil; 1 tonne C = 3.667 tonnes CO_2;

Base case = 50% stubble retention; Full = 100% retention;

Discussion

- Results are highly sensitive to:

1. Commodity prices =
   if prices ↑, carbon farming becomes less attractive;
2. Residue management =
   if stubble retention ↑, carbon farming becomes relatively more expensive;
3. Lucerne productivity =
   if Lucerne ↑, carbon farming becomes more attractive;
4. Time frame for analysis =
   higher compensation if farmers has to commit longer;

Discussion

- Getting farmers to change their enterprise mix to increase soil carbon sequestration will come at significant costs;

- Permanence obligations ⇨ risks for farmers and loss in option values?
- Additionality ⇨ farmers who already follow conservation practices ‘missing out’?

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Further steps

- Joint analysis of CO_2-emissions and soil C-seq;
- Incorporate C-seq potential in MIDAS to enable an optimisation subject to carbon prices;
- Comparison with other C-seq options (e.g. biofuel production or tree planting);
- Risk of long-term obligation;