Working for sustainable development

# Prospects for C trading

**IAI Conference, Terrigal, New South Wales, Australia.**


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# A scientific consensus is emerging

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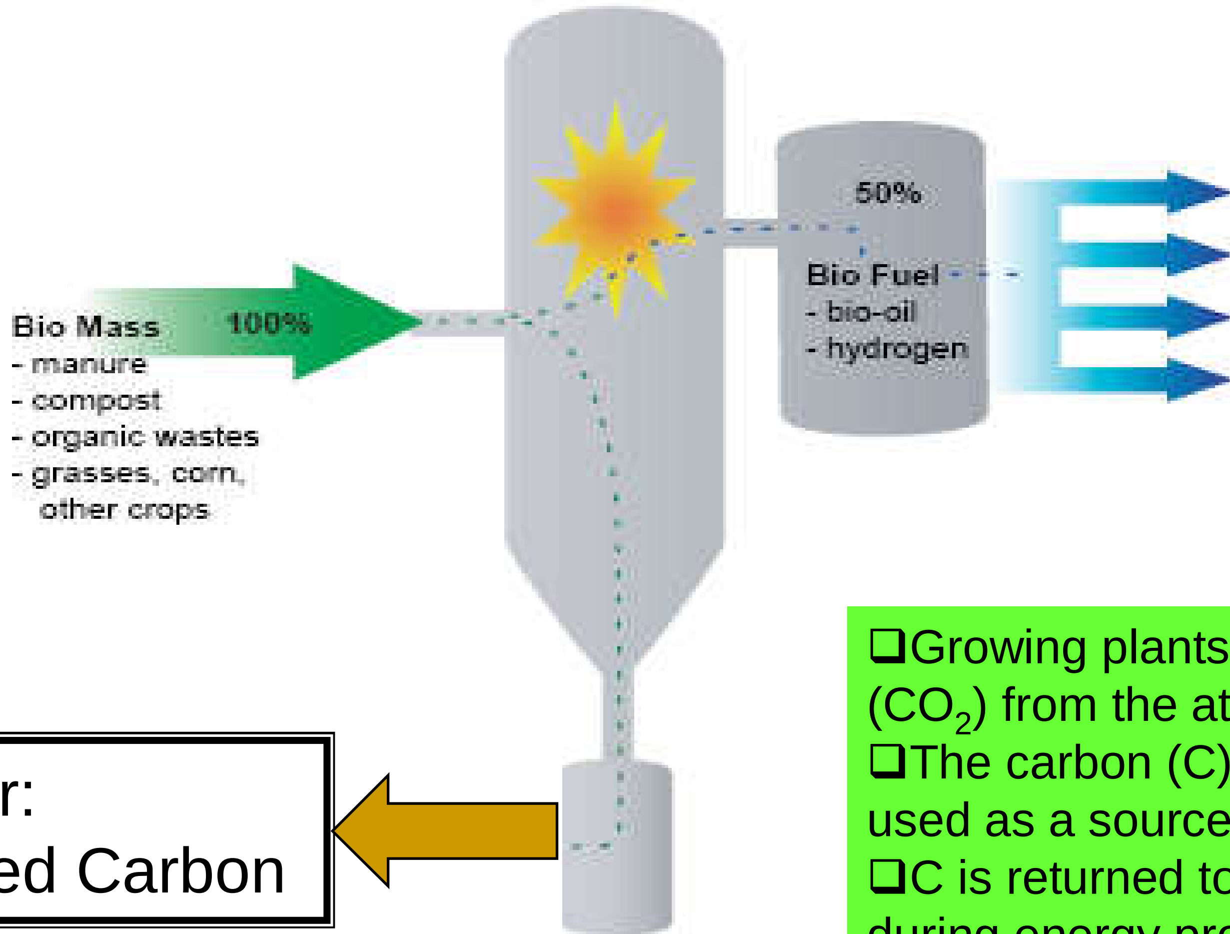
**Drop of the black stuff:** *terra preta* **contrasts strongly with normal soil in colour (left) and produces much more vigorous crops (below).**

# Black is the new green

middens of settlements and are cluttered with crescents of broken pottery. The larger patches were once agricultural areas that the farmers enriched with charred trash of all sorts. Some soils are thought to be 7,000 years old. Compared with the surrounding soil, *terra preta* can contain three times as much phosphorus and nitrogen. And as its colour indicates, it contains far more carbon. In samples taken in Brazil by William Woods, an expert in abandoned settlements at the University of Kansas in Lawrence, the *terra preta* was up to 9% carbon, compared with 0.5% for plain soil from places nearby[1].

From Smith's time onwards, the sparse scholarly discussion of *terra preta* was focused mainly on the question of whether 'savages' could have been so clever as to enhance their land's fertility. But Woods' comprehensive bibliography on the subject now doubles in size every decade. About 40% of the papers it contains were published in the past six years.

# Trade off between energy & environment




Energy or bio-product

Bio-char: Stabilized Carbon

- ❑Growing plants remove carbon dioxide ($CO_2$) from the atmosphere.
- ❑The carbon (C) contained in biomass used as a source of energy.
- ❑C is returned to atmosphere as $CO_2$ during energy production.

# Energy inputs, outputs and yield

| | Bio-energy crop | | | Crop-waste | |
|---|---|---|---|---|---|
| | Switchgrass | Miscanthus | Forage Corn | Wheat straw | Corn stover |
| | | | **Inputs (Mj ha$^{-1}$)** | | |
| Field production | 5,521 | 6,505 | 20,789 | 2,024 | 2,352 |
| Transportation and processing | 3,671 | 4,430 | 11,990 | 2,410 | 2,440 |
| **sub-total inputs** | **9,192** | **10,935** | **32,779** | **4,434** | **4,792** |
| | | | **Output (Mj ha$^{-1}$)** | | |
| Pyrolysis optimised for energy | 64,225 | 80,050 | 99,425 | 40,056 | 43,456 |
| Pyrolysis optimised for bio-char | 48,811 | 60,838 | 75,563 | 30,442 | 33,027 |
| | | | **Energy yield Mj/Mj** | | |
| Pyrolysis optimised for energy | 7.0 | 7.3 | 3.0 | 9.0 | 9.1 |
| Pyrolysis optimised for bio-char | 5.3 | 5.6 | 2.3 | 6.9 | 6.9 |

Gaunt and Lehmann, unpublished data

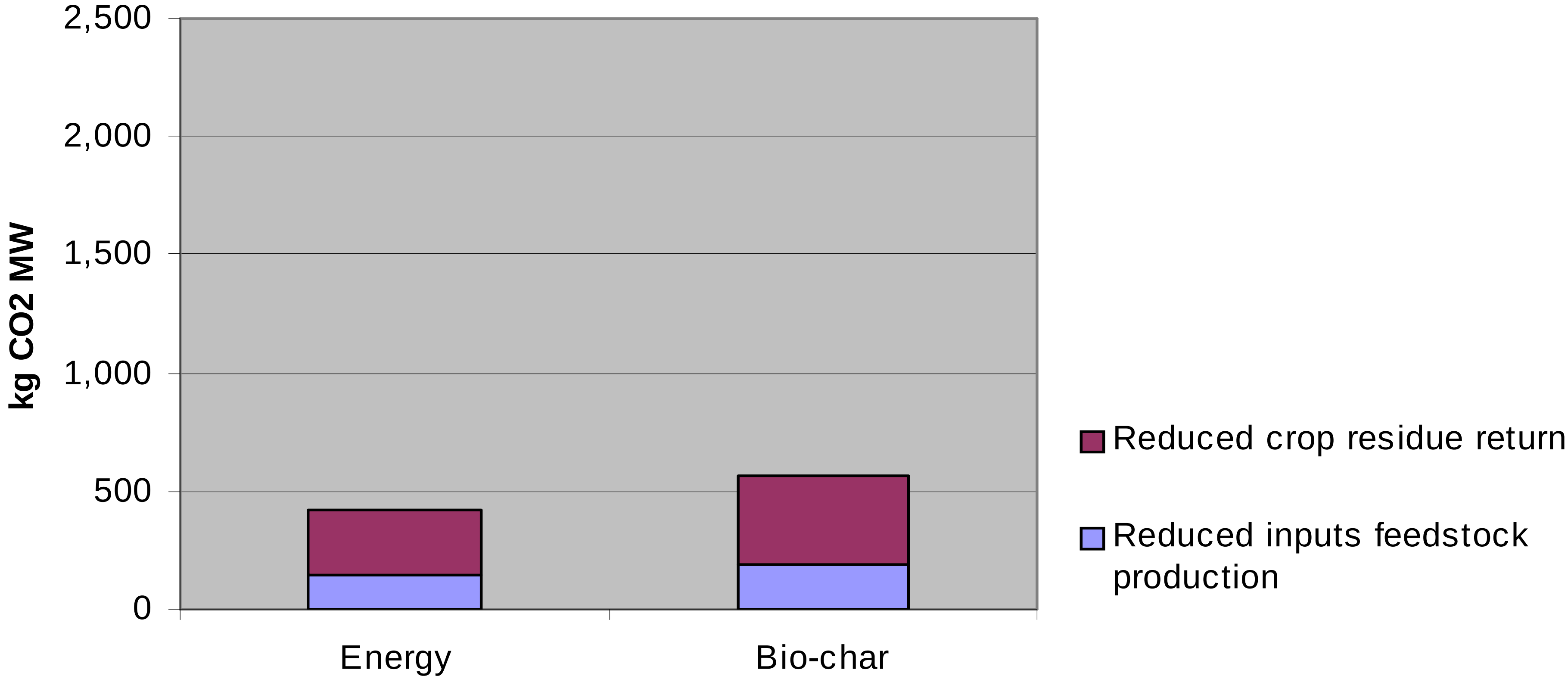
# Carbon trading

- Formal and informal markets exist – driven by the Kyoto process
  - Avoided greenhouse gas emissions and C sequestration associated with a change in practice can be used to offset emissions produced elsewhere
  - Trading mechanisms (CDM & JI) were established to realize benefits
- C sequestered by soil in agricultural cropland is excluded under Kyoto & EU Emission Trading Scheme but allowed on Chicago Climate Exchange (min till)

# Carbon trading: Key issues

- Kyoto: establish baseline and demonstrate additionality
  - What would the emissions have been without the change in practice proposed over life of project?
  - Justify that change wouldn't have happened anyway
- Kyoto and Chicago: defining boundaries, monitoring protocol and verification (project & point source)
  - e.g. under Kyoto planting new areas of trees OK, improved management or preservation of existing trees excluded

# Avoided emissions (kg $CO_2$ / MW) Change: Cereal cultivation to Bio-energy crop




Gaunt and Lehmann, preliminary unpublished data

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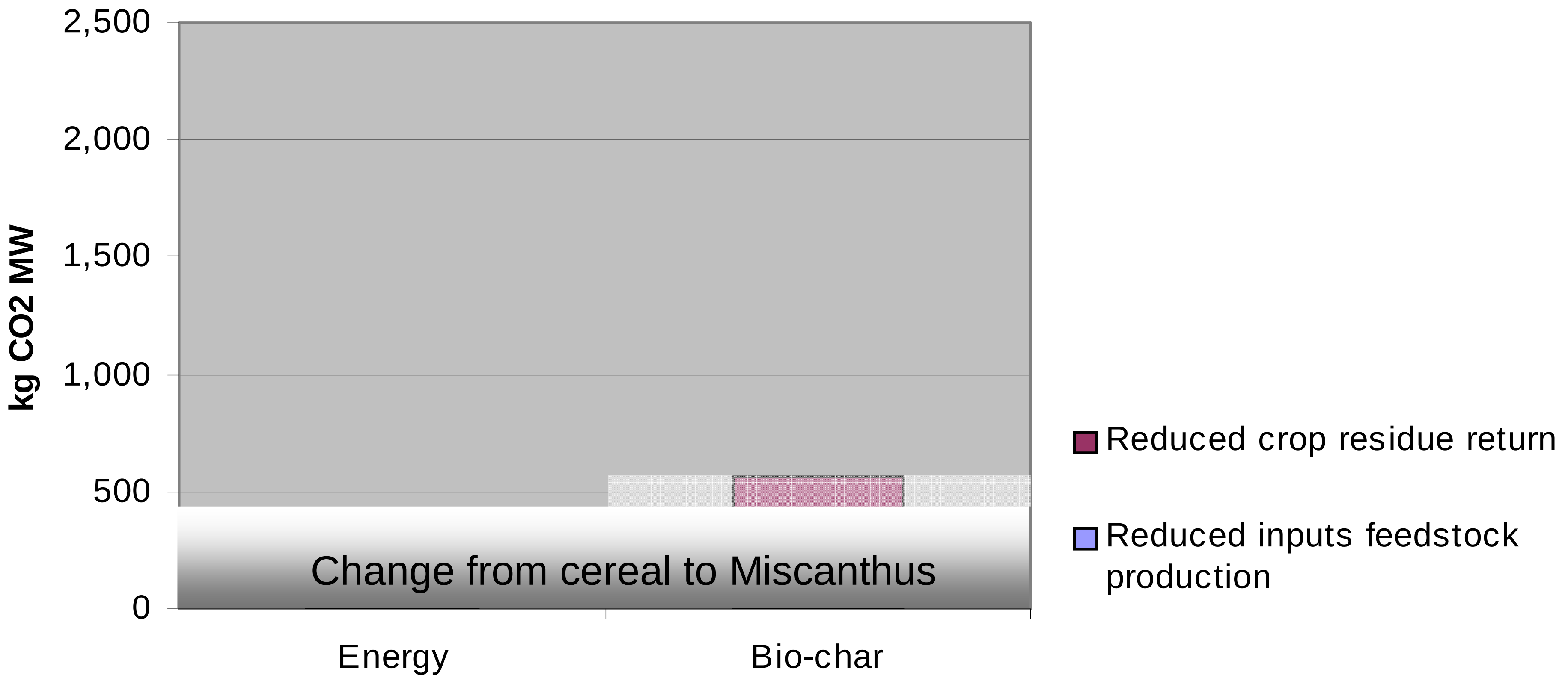
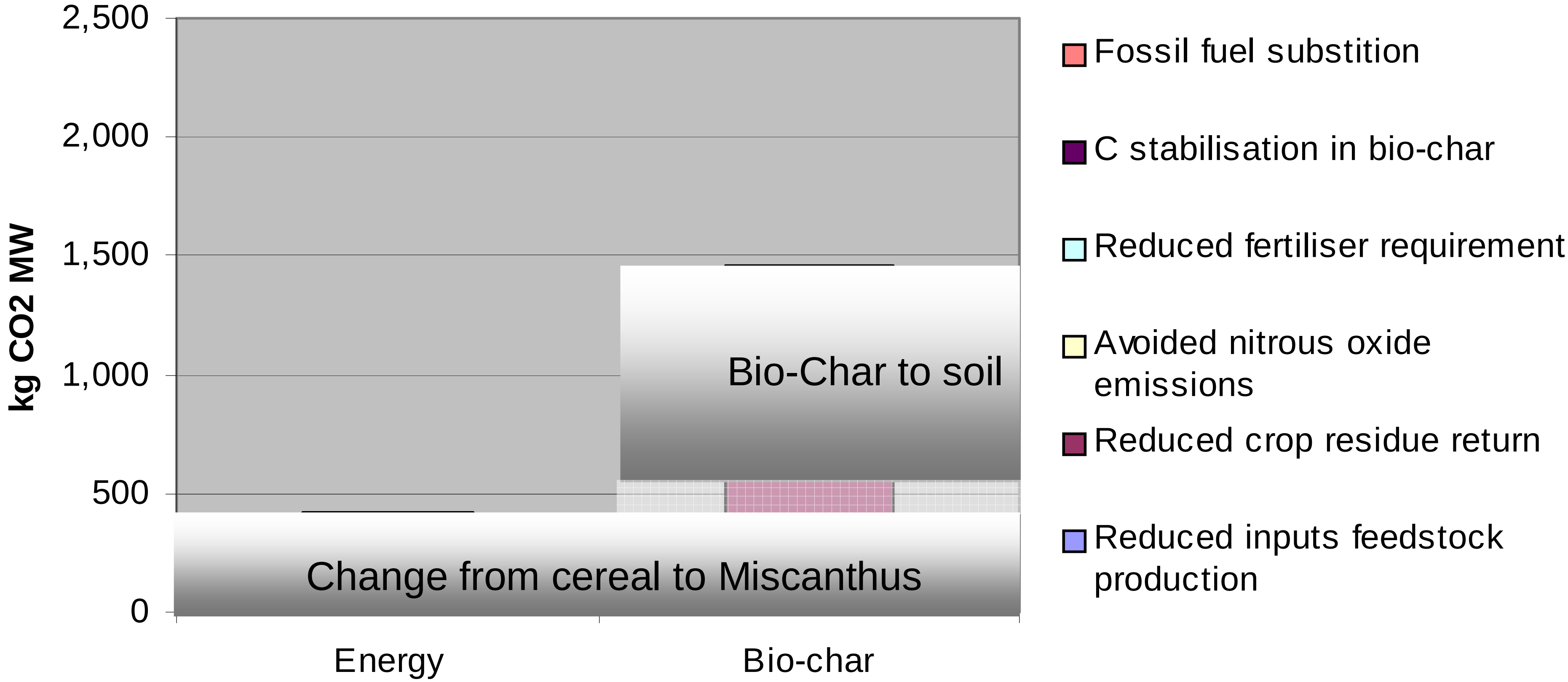
# Avoided emissions (kg $CO_2$ / MW)
# Change: Cereal cultivation to Bio-energy crop



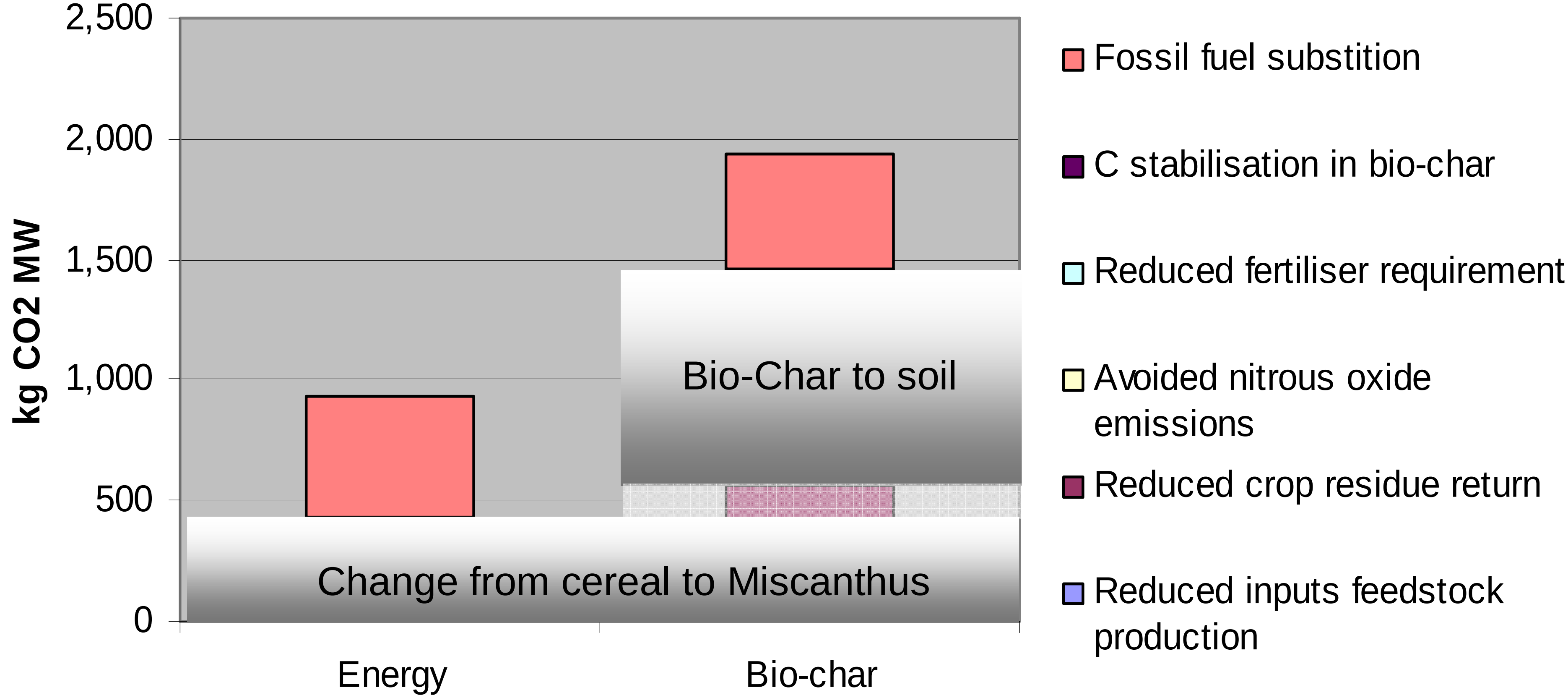

Gaunt and Lehmann, preliminary unpublished data

# Avoided emissions (kg $CO_2$ / MW)
# Change: Adopt pyrolysis: bio-char to soil



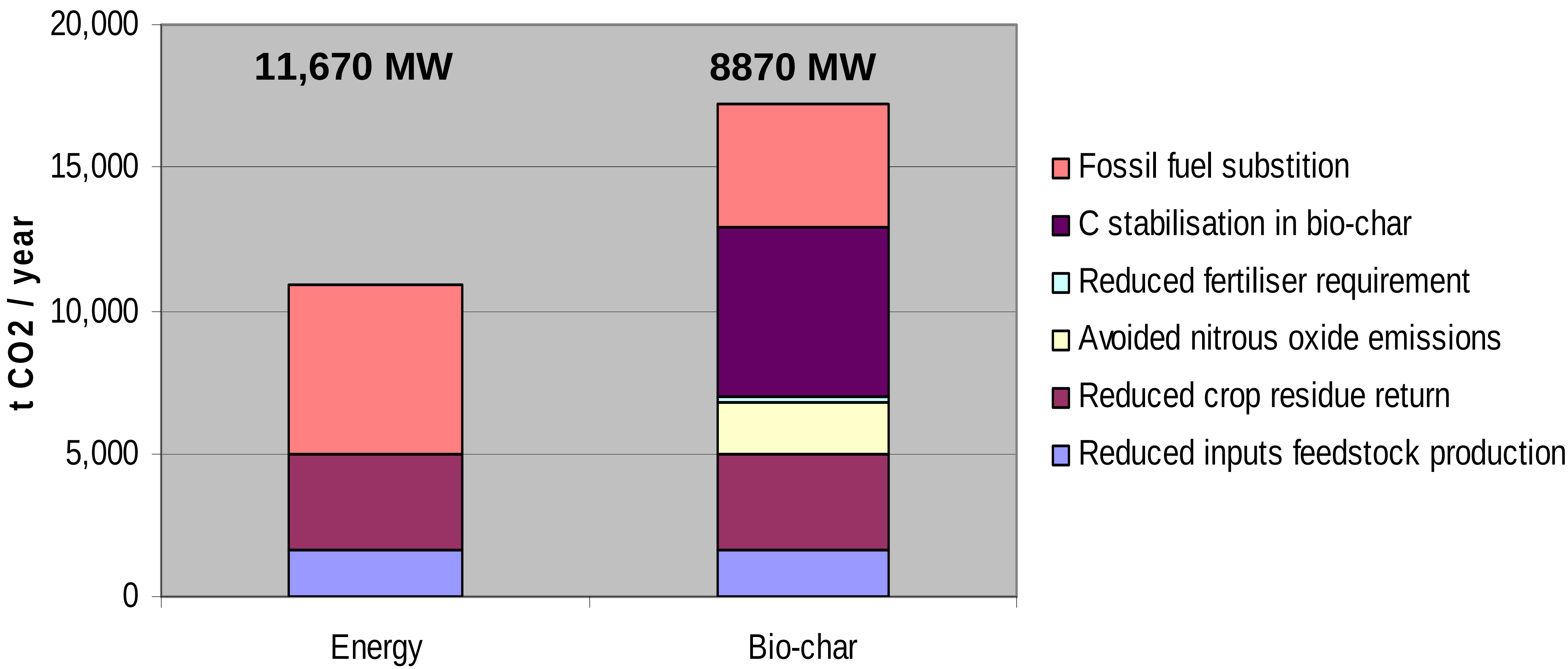

Gaunt and Lehmann, preliminary unpublished data

# Avoided emissions (kg $CO_2$ / MW)
# Change: Cereal cultivation to Bio-energy crop



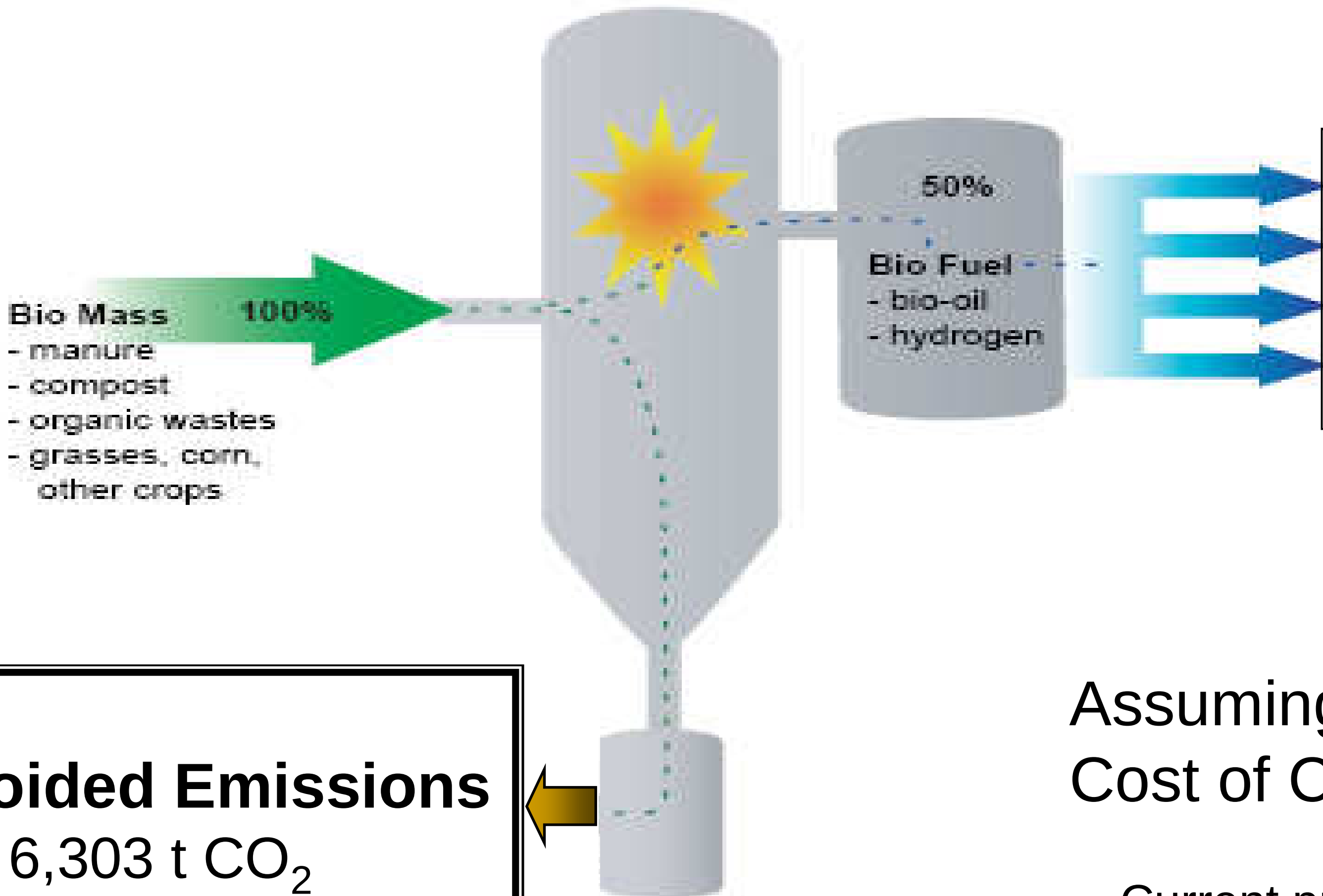

Gaunt and Lehmann, preliminary unpublished data

# Avoided emissions per year of operation




Gaunt and Lehmann, preliminary unpublished data

# Trade off during a year of typical operation




**Electricity**

Trade off 2,801 MW

**Avoided Emissions**

6,303 t $CO_2$

Assuming $80 MW
Cost of $CO_2$ $36 t $CO_2$

Current price ~ $5-10 t $CO_2$
Future price ~ $100 t $CO_2$

# Bio-energy already receives subsidy:
# Renewable Obligation Certificates (ROC) UK
# Production credits in US

| ROC $/MWh | Energy $/t CO2 | Bio-char $/t CO2 |
|---|---|---|
| 50 | 54 | 26 |
| 60 | 64 | 31 |
| 80 | 86 | 41 |

# Summary

- Slow, low-temp pyrolysis energy solutions optimized for bio-char offer the prospect of “net-negative” emissions
- Cost of $CO_2$ offset is high relative to current market but in the “ball park” when compared to projected market prices
- $CO_2$ values do not capture the environmental and agronomic value of bio-char beyond emissions offset

# Some thoughts……..

- Are we monetizing the "Avoided emission associated with adoption of pyrolysis – a new efficient bio-energy technology" or "Soil C sequestration"?
- Key issue is to provide confidence that the end use of bio-char does not return C to atmosphere?
- Monitoring, verification and auditing may determine end use of bio-char
  - Land restoration
  - Landfill
  - Soil conditioner product

GYA Working for sustainable development

# Thank you

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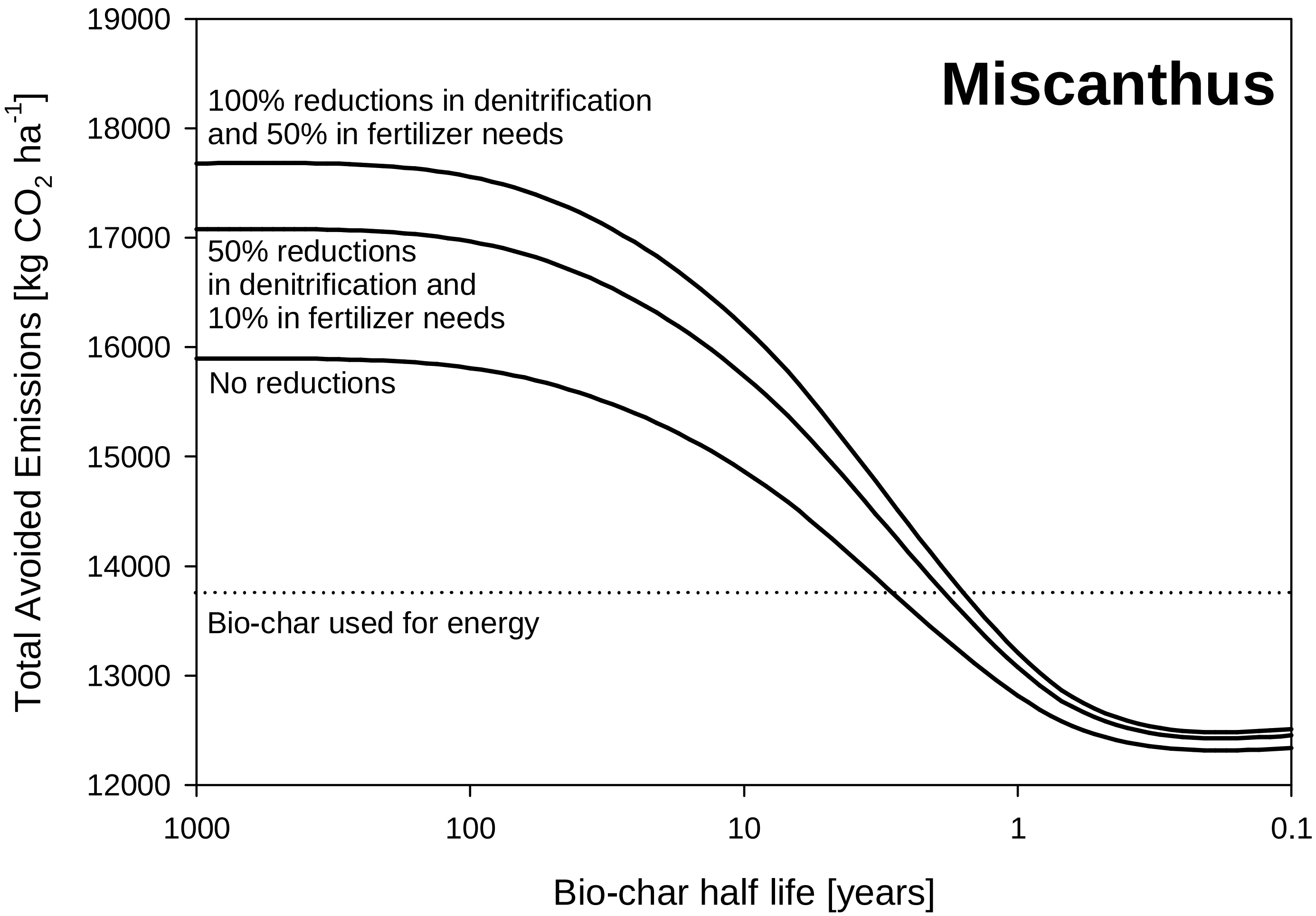
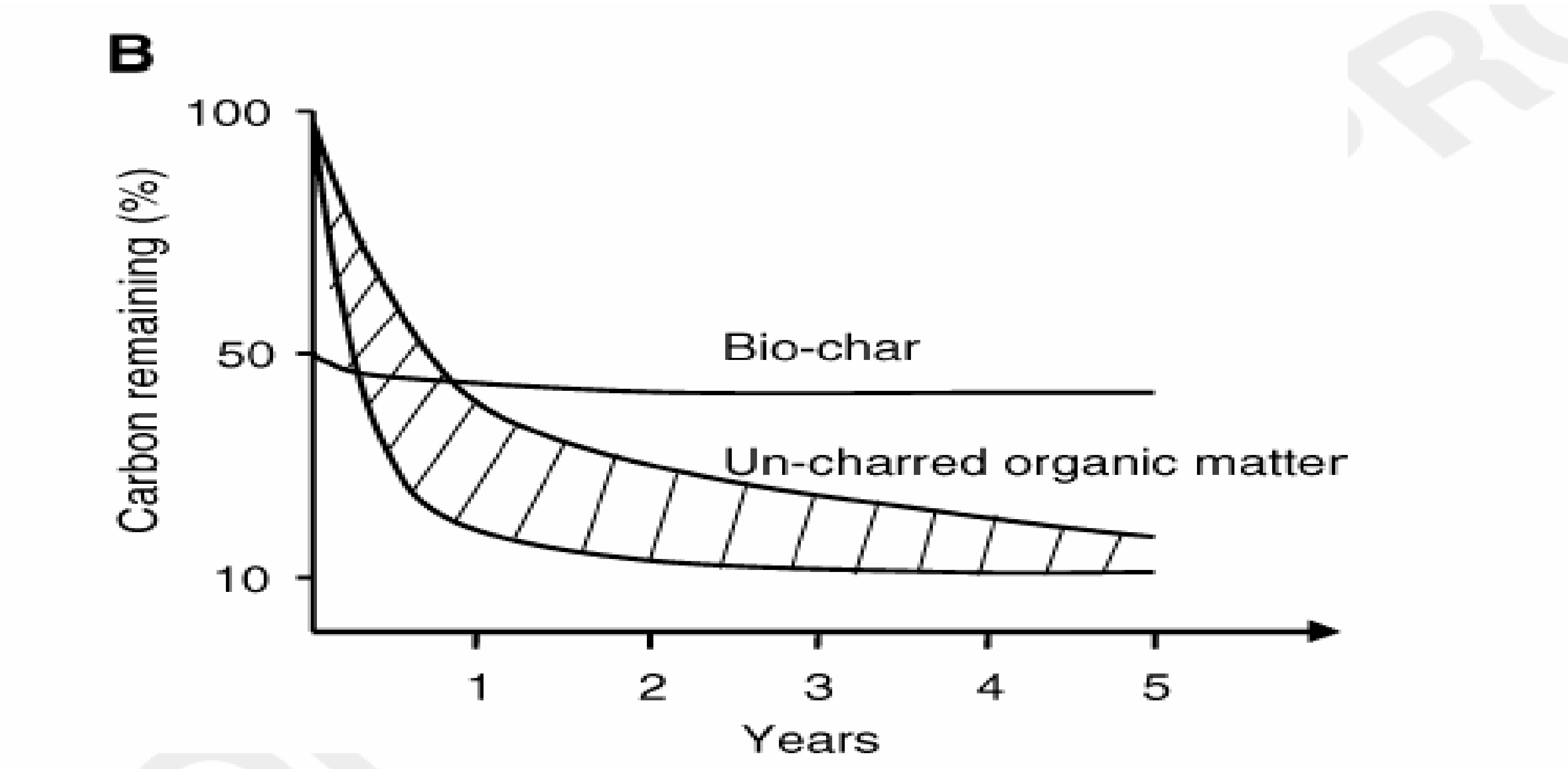
Cornell University

# Sensitivity to assumptions



# Just in case!


B
100
50
10
Carbon remaining (%)
Bio-char
Un-charred organic matter
1
2
3
4
5
Years

# Carbon dioxide emissions (kg CO2 / MWh) of electricity generation

| | Bio-energy crop | | | Crop-waste | |
|---|---|---|---|---|---|
| | Switchgrass | Miscanthus | Forage Corn | Wheat straw | Corn stover |
| Pyrolysis optimised for energy | 119 | 113 | 274 | 92 | 91 |
| Pyrolysis optimised for bio-char | 156 | 149 | 360 | 121 | 120 |

Gaunt and Lehmann, preliminary unpublished data

# The benefits of bio-char application

**Photos: Julie Major, Cornell University**

# Benefits of bio-char application to soil

- Affects soil biology, chemistry and physical properties
  - Enhances crop growth
  - Suppresses methane emissions
  - Reduces Nitrous oxide (estimate 50%)
  - Reduces fertiliser requirement (estimate 10%)
  - Reduces leaching of nutrients