Greenhouse gas abatement potential of biomass crops in Scotland under various management options

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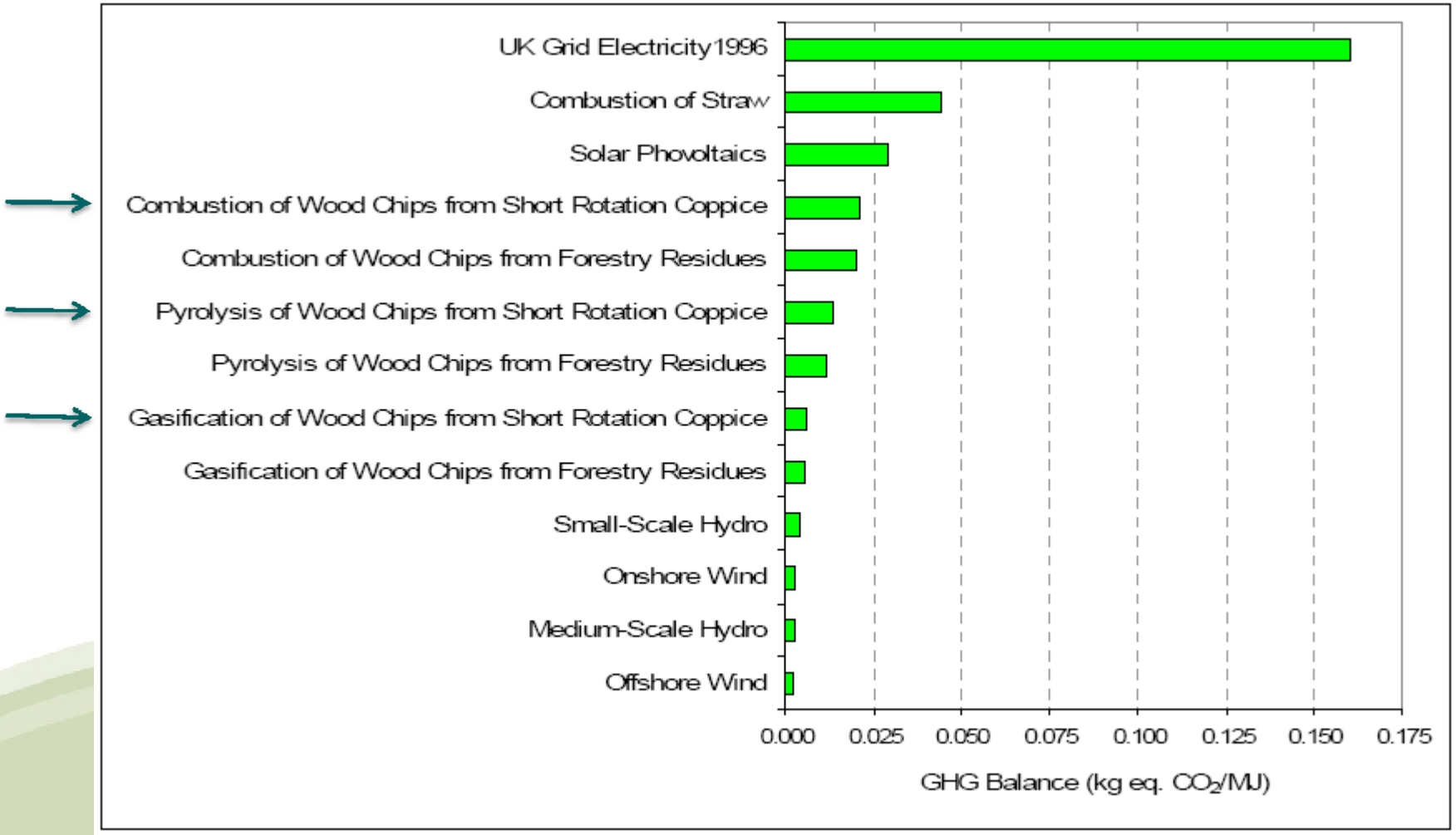
Emission reduction targets

- By 2050, Scotland plans to decarbonise the energy (heat and electricity) sector with 100% renewables
- Renewables Obligation (Scotland): 10.4% electricity generation from renewable sources by 2010
- Scottish Biomass Support Scheme providing a total of £7.5M over 2006-08
- Scottish Biomass Heat Scheme (£3.3M) introduced from 2009

Biomass energy crops

- ‘Carbon-neutral’ fossil fuel substitute, but may also help sequester C in the soil
- Defra study: modelling showed that there was higher potential for C sequestration than natural woodland, particularly by Miscanthus
- Short rotation coppice: willow and poplar – rapid establishment, fast growing
- Average yield 6-12 odt ha^{-1} yr^{-1}, potential up to 30 odt ha^{-1} yr^{-1}

GHG abatement potential



Galbraith et al., 2006. "Review of Greenhouse Gas Life Cycle Emissions, Air Pollution Impacts and Economics of Biomass Production and Consumption in Scotland". SEERAD Environmental Research Report 2006/02, Project FF/05/08.

Scottish conditions

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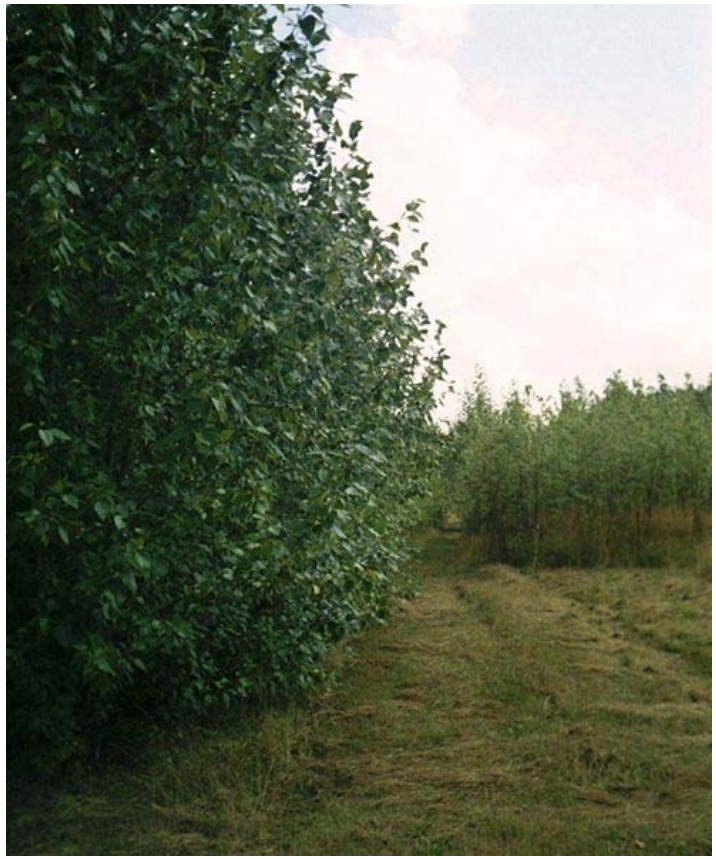
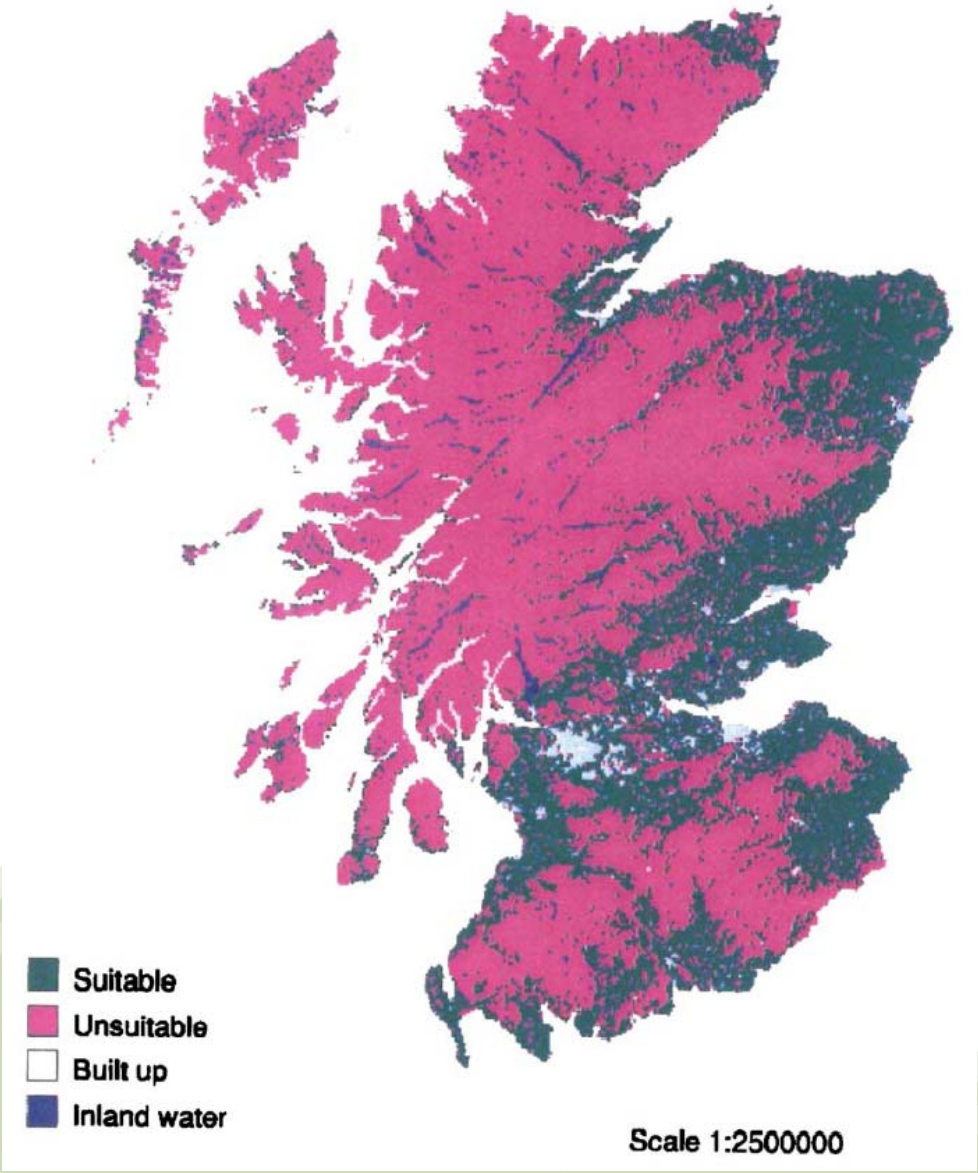
Galbraith *et al.*, 2006

- Existing studies need to be modified for Scottish conditions
- Data on key parameters, e.g.:
  - fertiliser application rates
  - crop yields
  - transport distances, etc.
- Emission factors – e.g. N_2O:
  - IPCC: 1.25% of total N applied
  - Range: 0.3-2.0% of applied N



Land suitability for SRC



- Scotland domestic electricity requirement: ~10.5 GW
- Potential from biomass
  - 3.3 GW (electricity) (31%)
  - 5.7 GW (CHP) (54%)
- 5% uptake
  - 0.16 GW (electricity) (1.5%)
  - 0.29 GW (CHP) (2.3%)
- 75-80% of the land suitable for SRC is on existing arable and grassland soils

Anderson, Towers & Smith (2005)

Land suitability for SRC

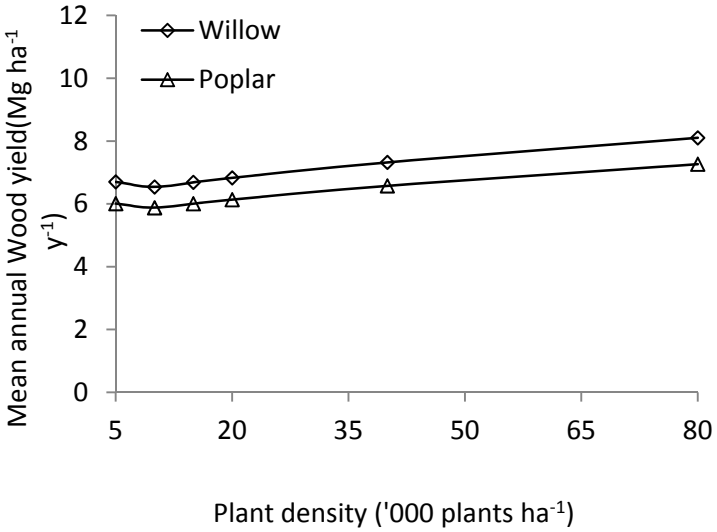
- In practice, land potentially available for bioenergy crops is likely to be marginally productive agriculture or grassland
- Nutrient removal by high yielding varieties of SRC:
  - 135 kg N ha^{-1} yr^{-1}
  - 18 kg P ha^{-1} yr^{-1}
  - 85 kg K ha^{-1} yr^{-1}
- May need application of organic or inorganic fertilizers to maintain yield levels

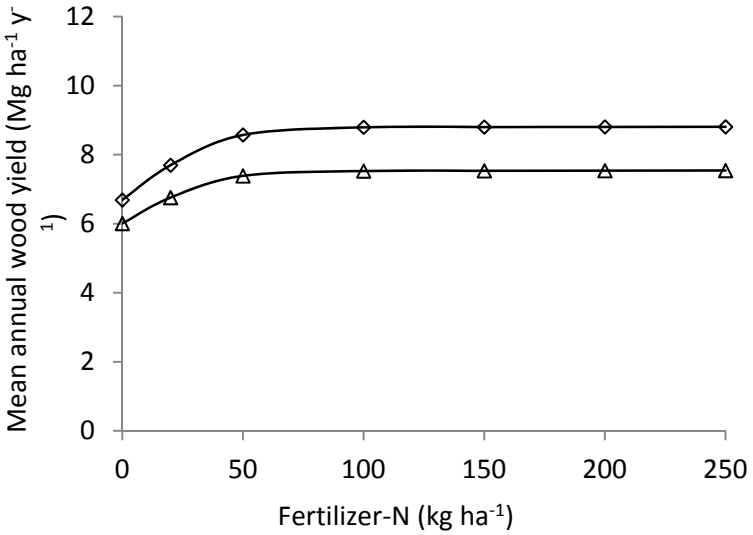
Details of the study

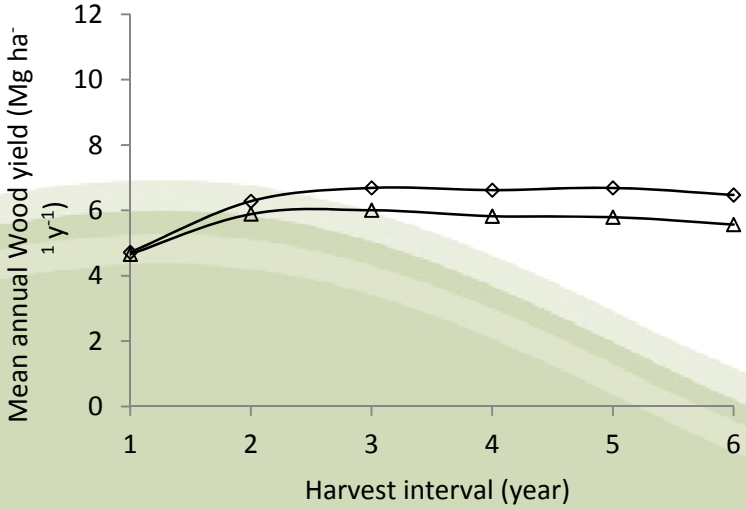
- Tested using data from Forest Research, Phase II: 1996-2002
- Willow (Jorunn, Q83), poplar (Beaupré, Trichobel)
- Crop management options
  - Plant density (5,000- 80,000 plants ha^{-1})
  - Harvest cycle (1- 6 years)
  - Rates of N fertilizer application (0-250 kg N ha^{-1})
  - Reference: 15,000 plants ha^{-1}, no fertilizer, 3-year harvest interval
- GHG emissions
  - CO_2 : planting, herbicide applications, N fertilizer production & application, harvesting
  - N_2O: fertiliser application
- Economic analysis (gross margins)
  - Costs: establishment, fertiliser, harvesting
  - Returns from selling wood

(Muhammed et al., submitted to Biomass & Bioenergy)

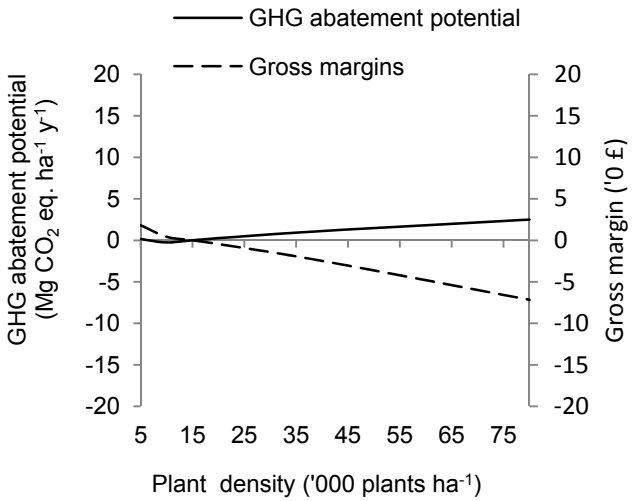
Response to management variables

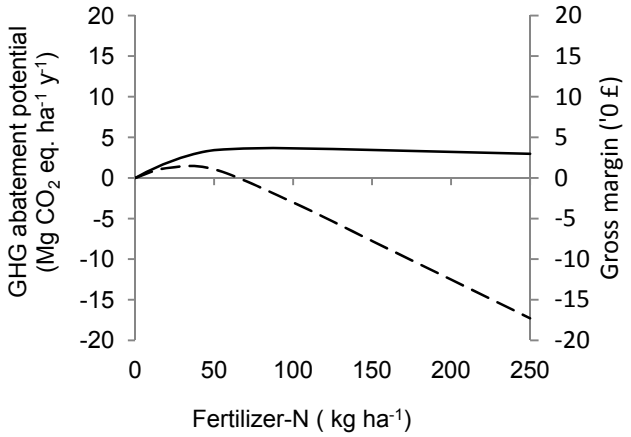




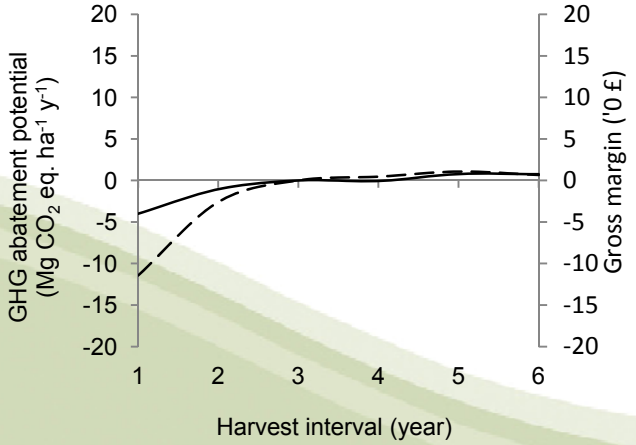


Abatement potential, profitability





Willow



Changes in soil organic carbon

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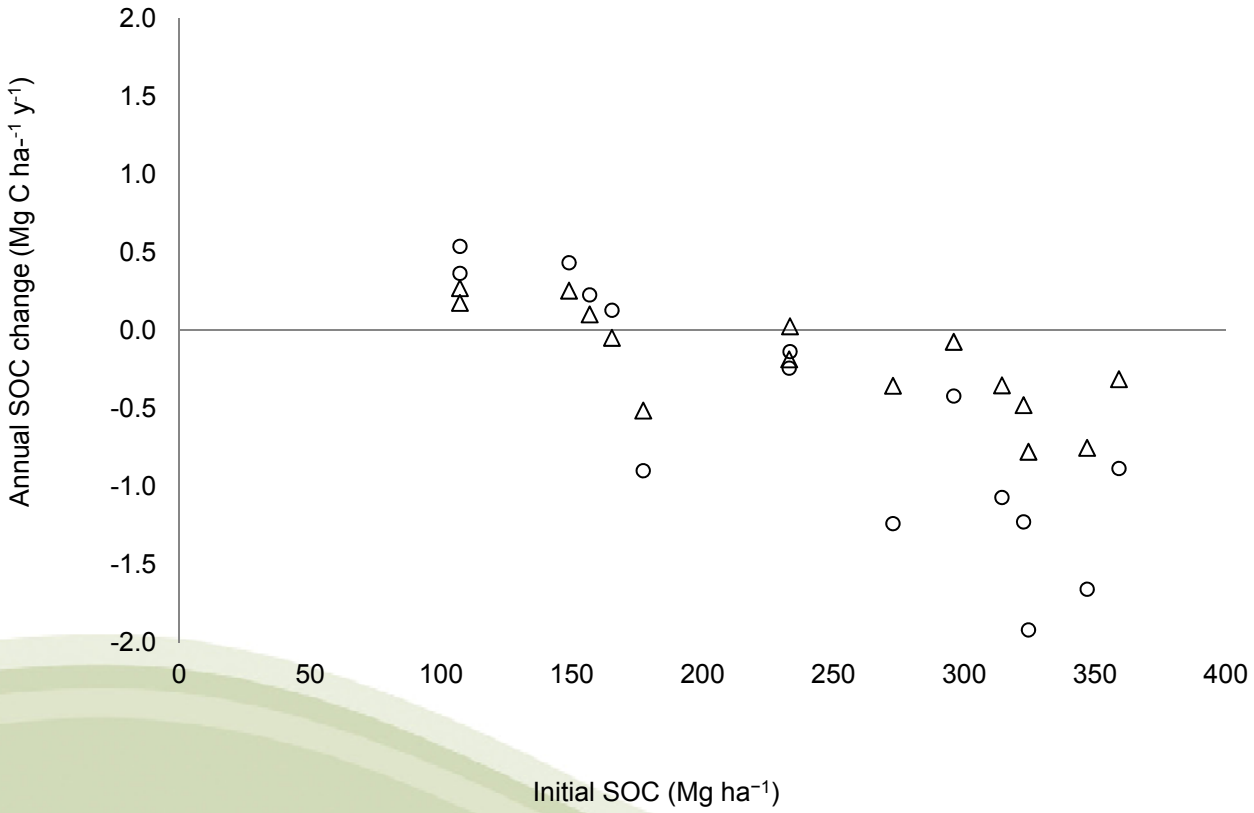
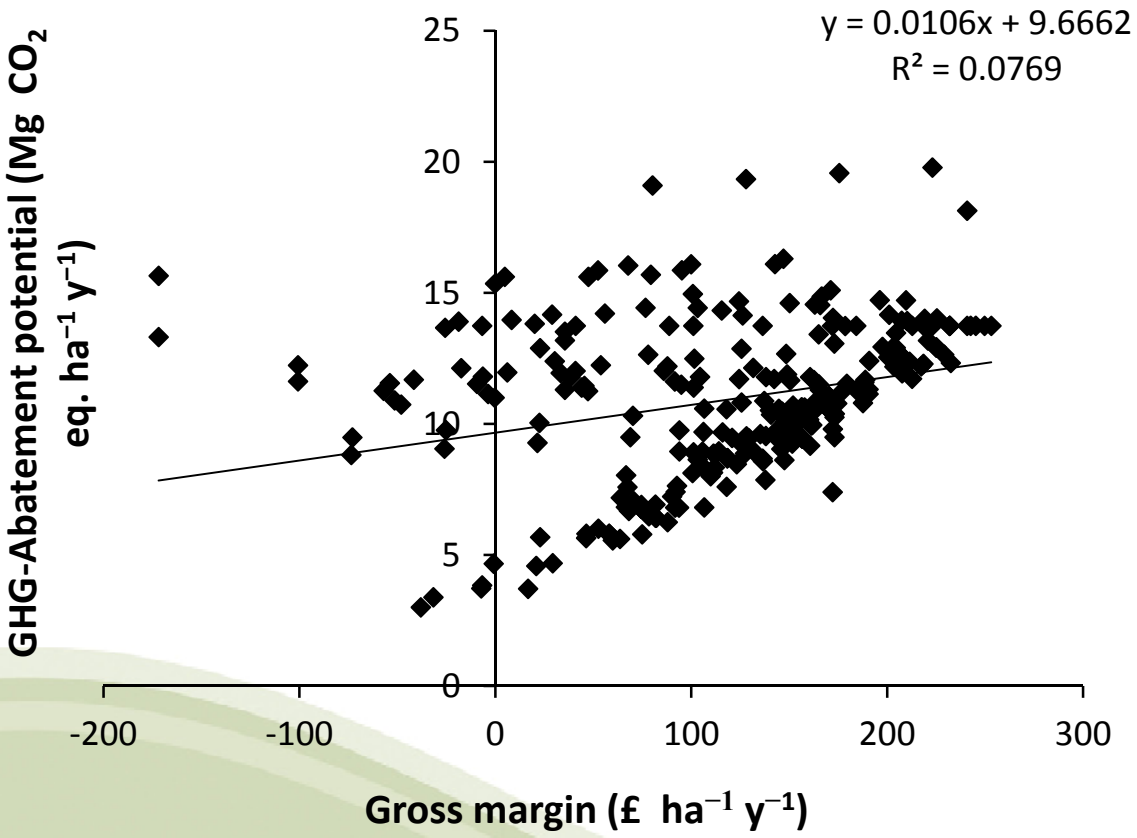
Poplar

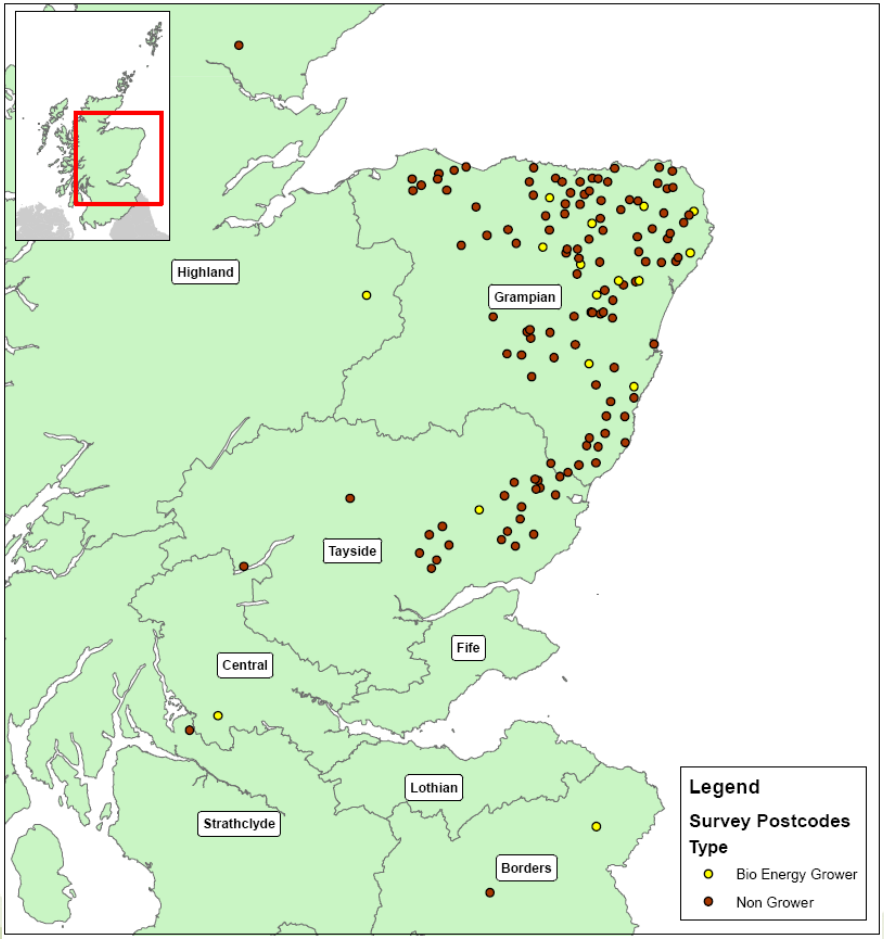


Gross margin vs. GHG-AP



Uptake of SRC

- 30,000 ha needed to meet demand
- 225 ha in Scotland, applications for further 809 ha in pipeline
- Factors influencing choice of SRC
  - Strong market for bioenergy crops
  - Power companies taking the lead
  - Improved income security
  - Availability of capital investment
  - Clearer government policies
  - Improved government support
  - Increase in available information
  - Moral reasons to reduce GHG emissions
  - Neighbouring farmer(s) growing a bioenergy crop
  - Public pressure



(C Brown, PhD thesis, University of Aberdeen)

Conclusions

- Increasing plant density and decreasing harvest frequency increased GHG-AP
- N-fertilizer application (50-100 kg N ha^{-1}):
  - Low organic soils (<180 t C ha^{-1}): resulted in the buildup of carbon
  - High organic soils: N_2O emissions higher than the C saving through marginal increases in wood yield and C input to the soil
- Under the best economic scenarios (5,000 plants ha^{-1}, 20 kg N ha^{-1}, and 5 year harvest interval), SRC willow and poplar have a GHG-AP ranging from 9.9-11.6 and 8.8-10.0 t CO_2e ha^{-1} y^{-1}, respectively
- Opportunity cost of alternative land uses – high grain prices make it commercially unattractive without incentives

Contributors

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