

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





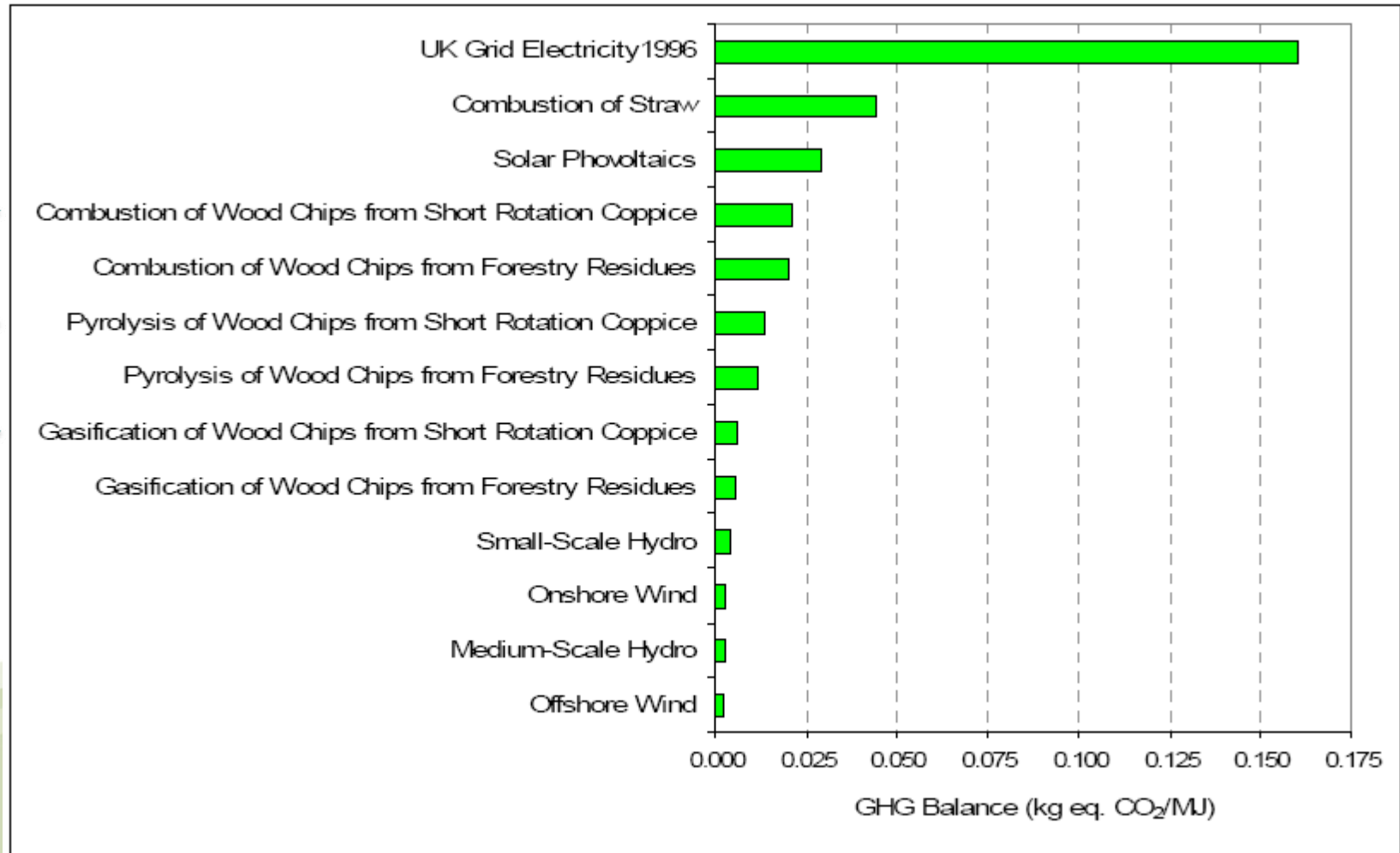
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Biomass energy crops

- '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



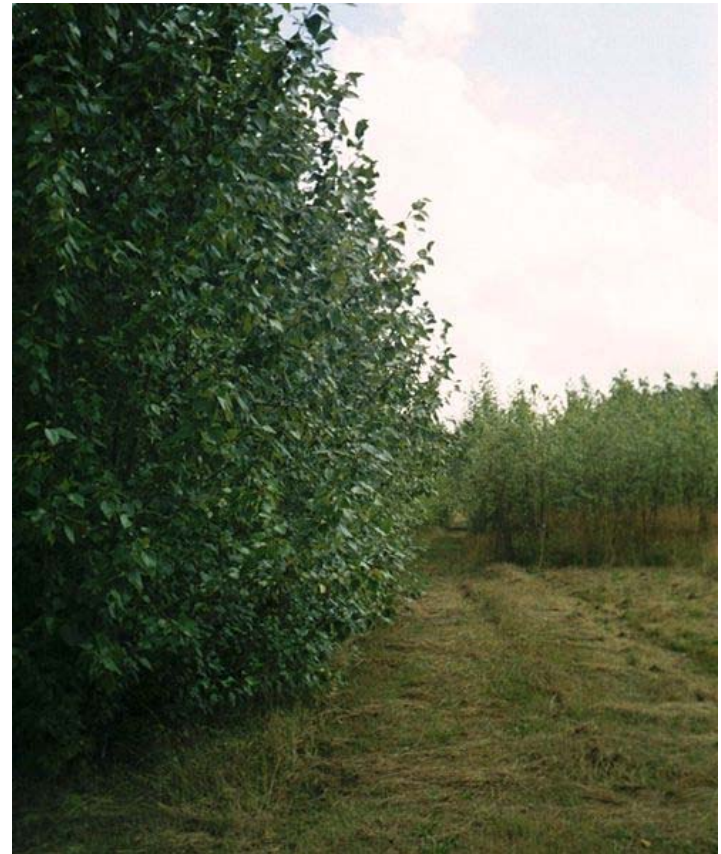
GHG abatement potential



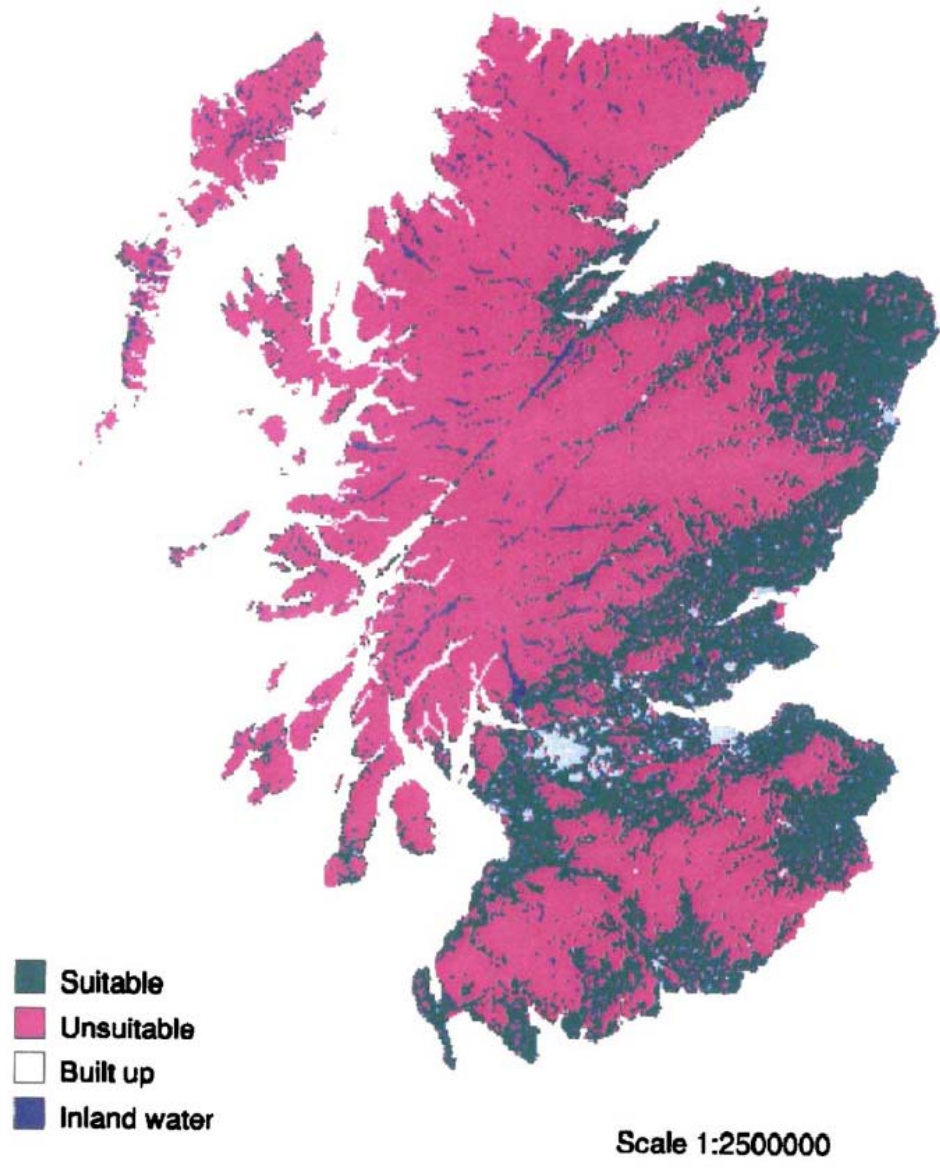
Scottish conditions

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



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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





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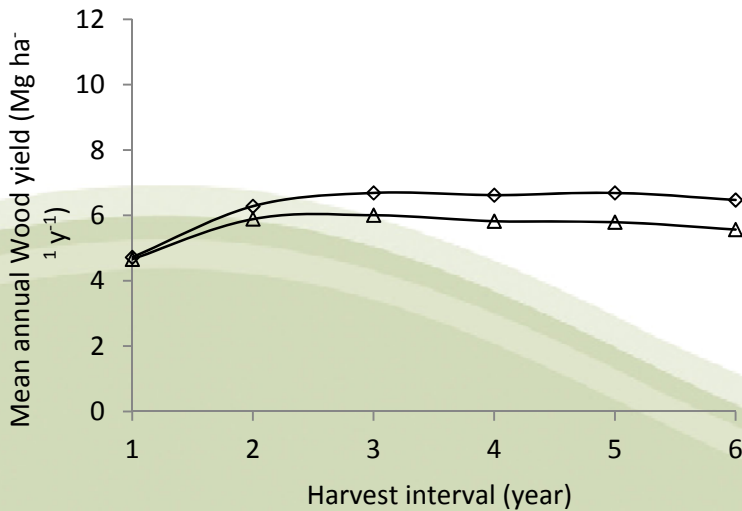
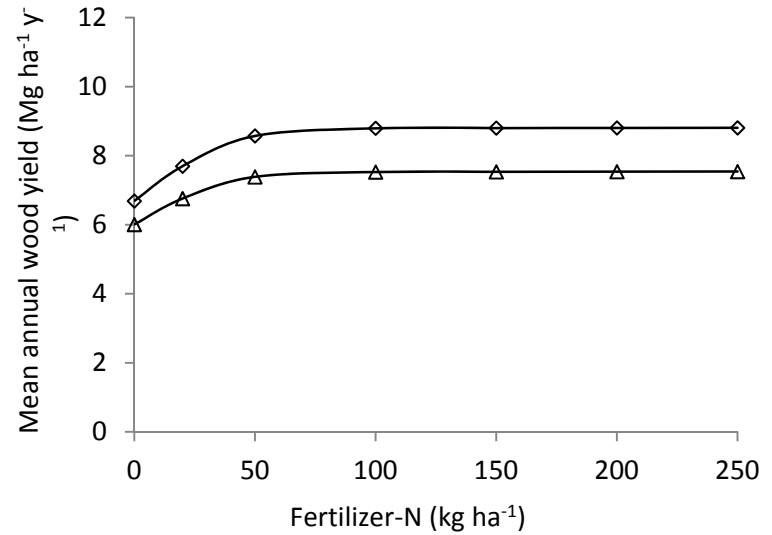
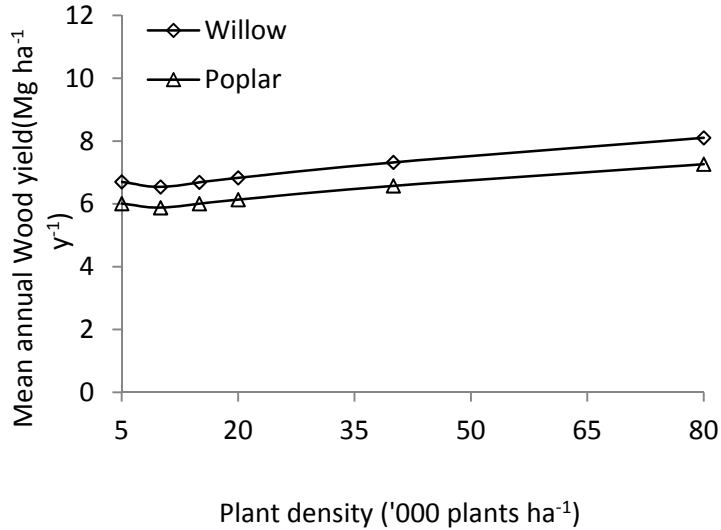
Details of the study

- 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
 - CO₂ : planting, herbicide applications, N fertilizer production & application, harvesting
 - N₂O: fertiliser application
- Economic analysis (gross margins)
 - Costs: establishment, fertiliser, harvesting
 - Returns from selling wood

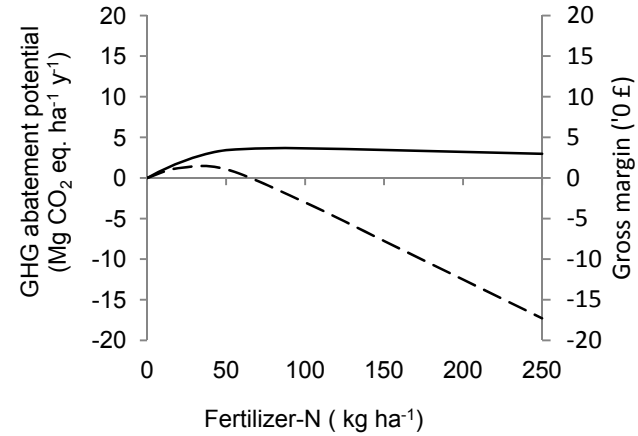
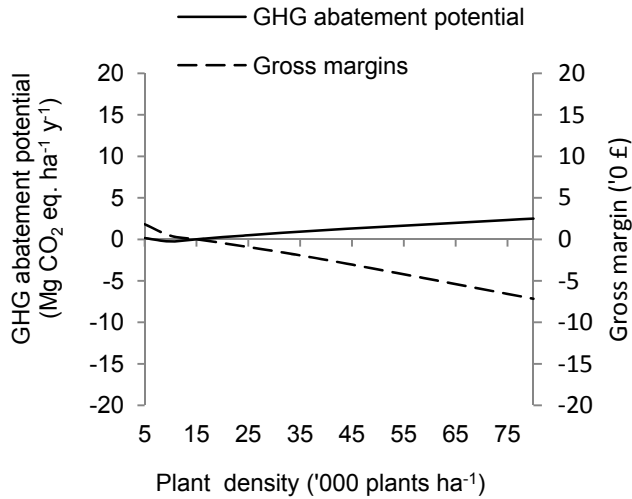


(Muhammed et al., submitted to Biomass & Bioenergy)

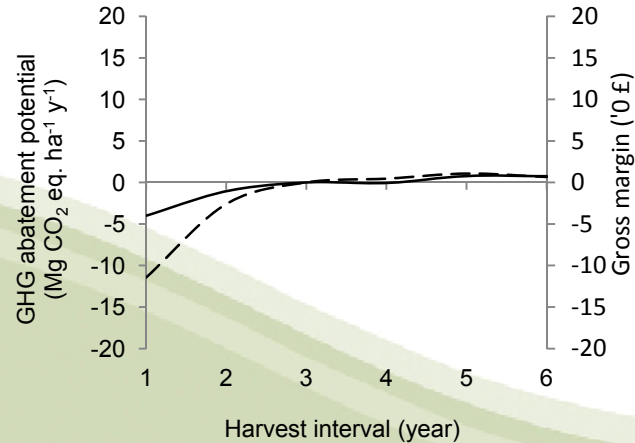
Response to management variables



Abatement potential, profitability

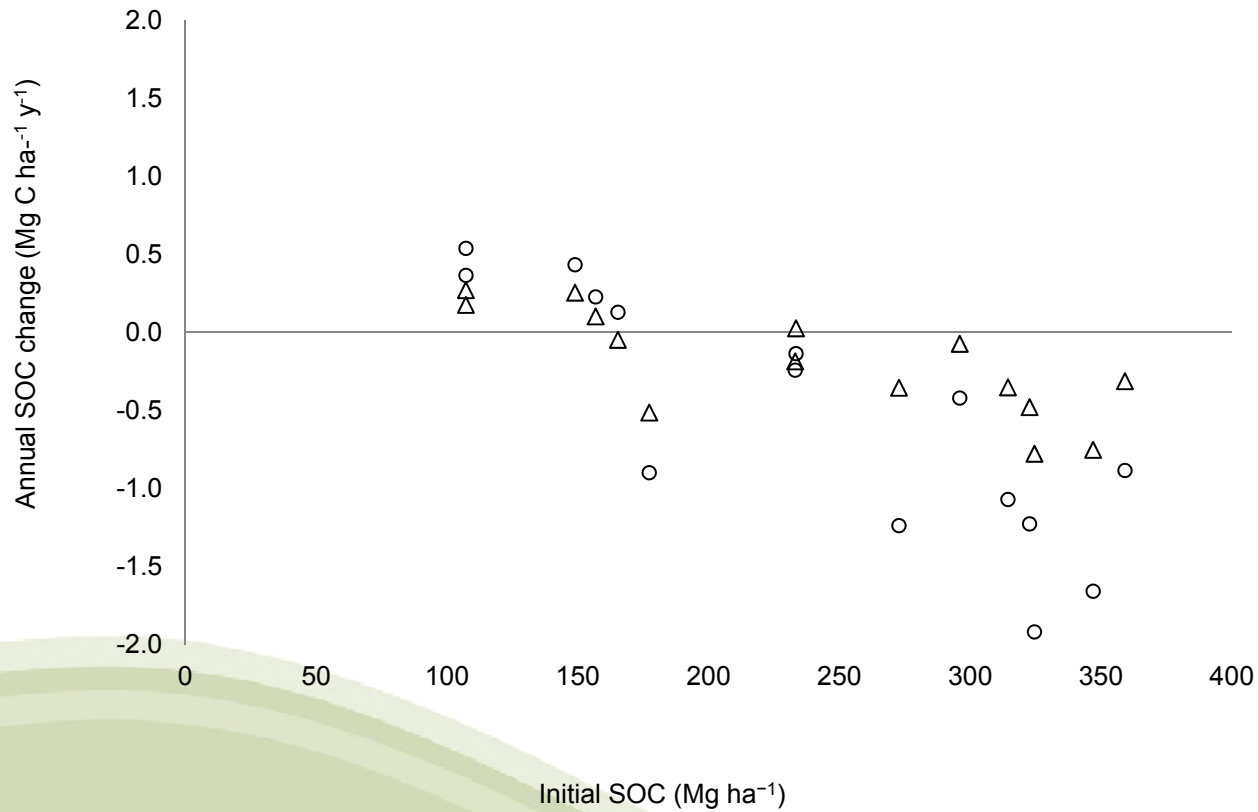


Willow



Changes in soil organic carbon

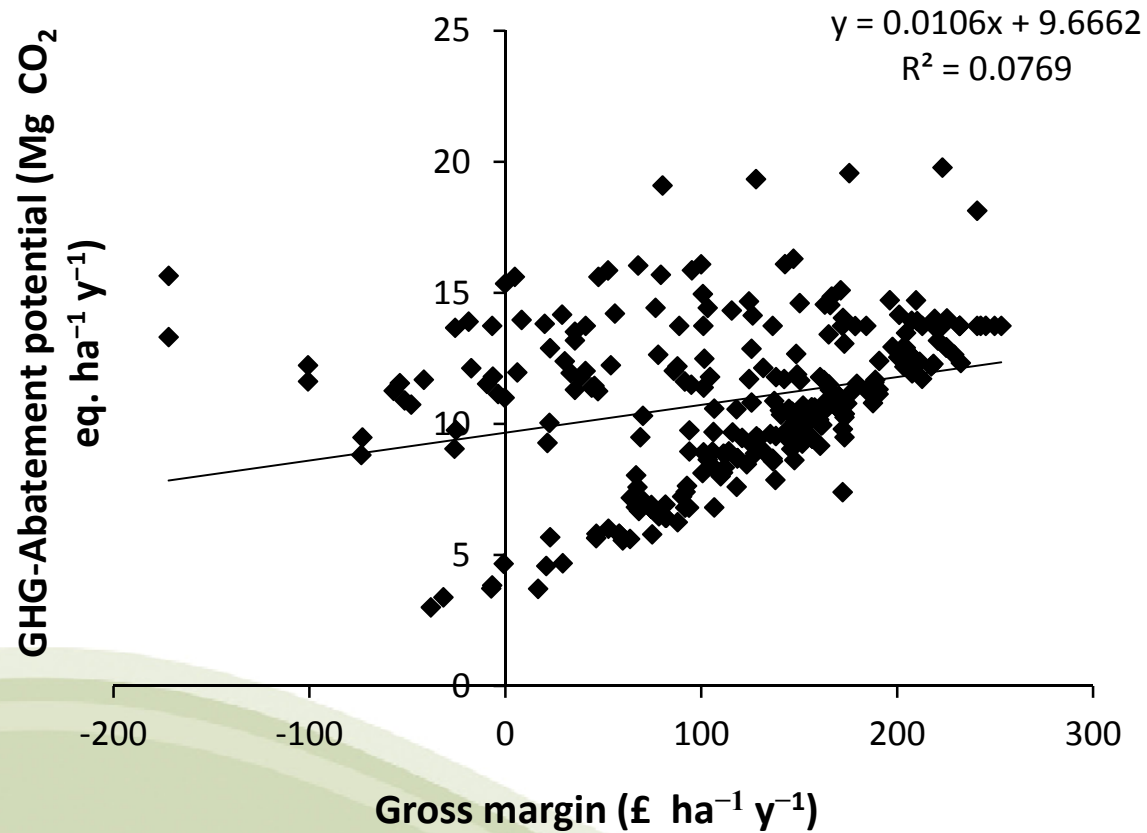
Poplar





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Gross margin vs. GHG-AP

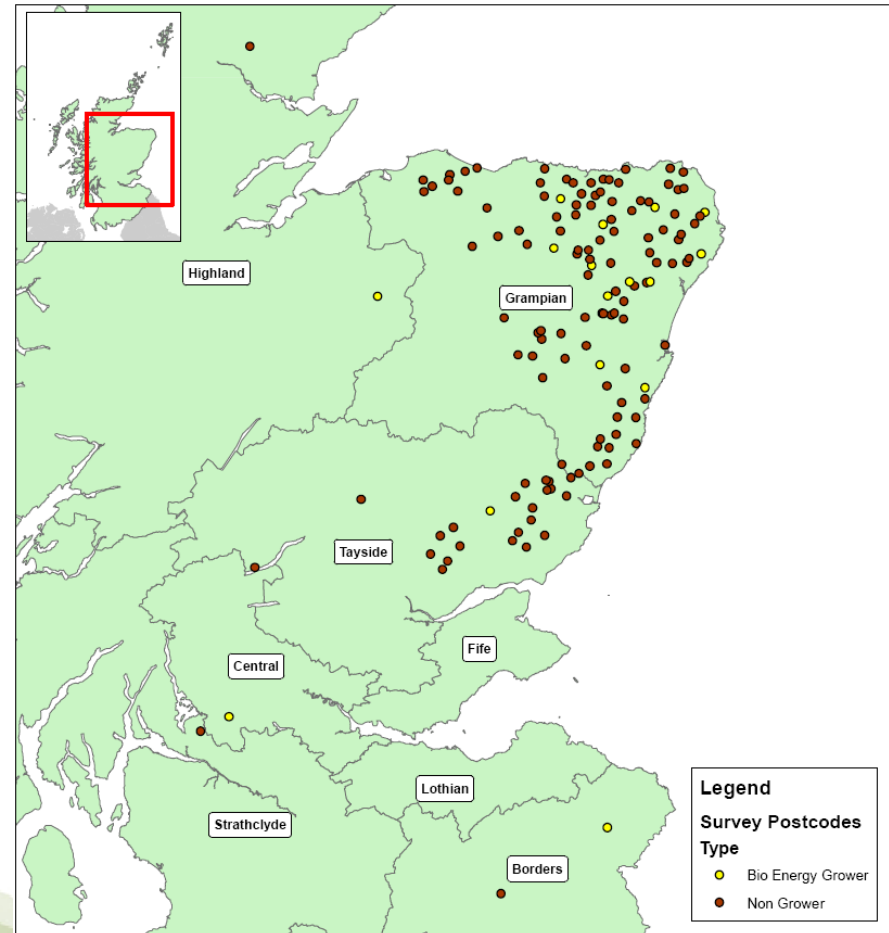




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Uptake of SRC

- 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: N₂O 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 CO₂e 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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- Chris Brown, University of Aberdeen, JHI
- Pete Smith, University of Aberdeen
- Innocent Bakam, JHI
- Andy Moffat, Forest Commission
- Nikki Baggaley, JHI

