Comparison of Carbon Storage by Agroforestry and Agriculture

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- Are there differences in the amount of carbon stored, and in which pools are these differences found?
- Is it possible to model carbon accumulation in tree and crop biomass?
- Longevity and implications for agroforestry?

Field Site

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- Hybrid poplar silvoarable experiment at Silsoe, Bedfordshire.
- Established in 1992, as part of a network of UK sites.
- 2.5 ha plot surrounded by 1 ha arable control.

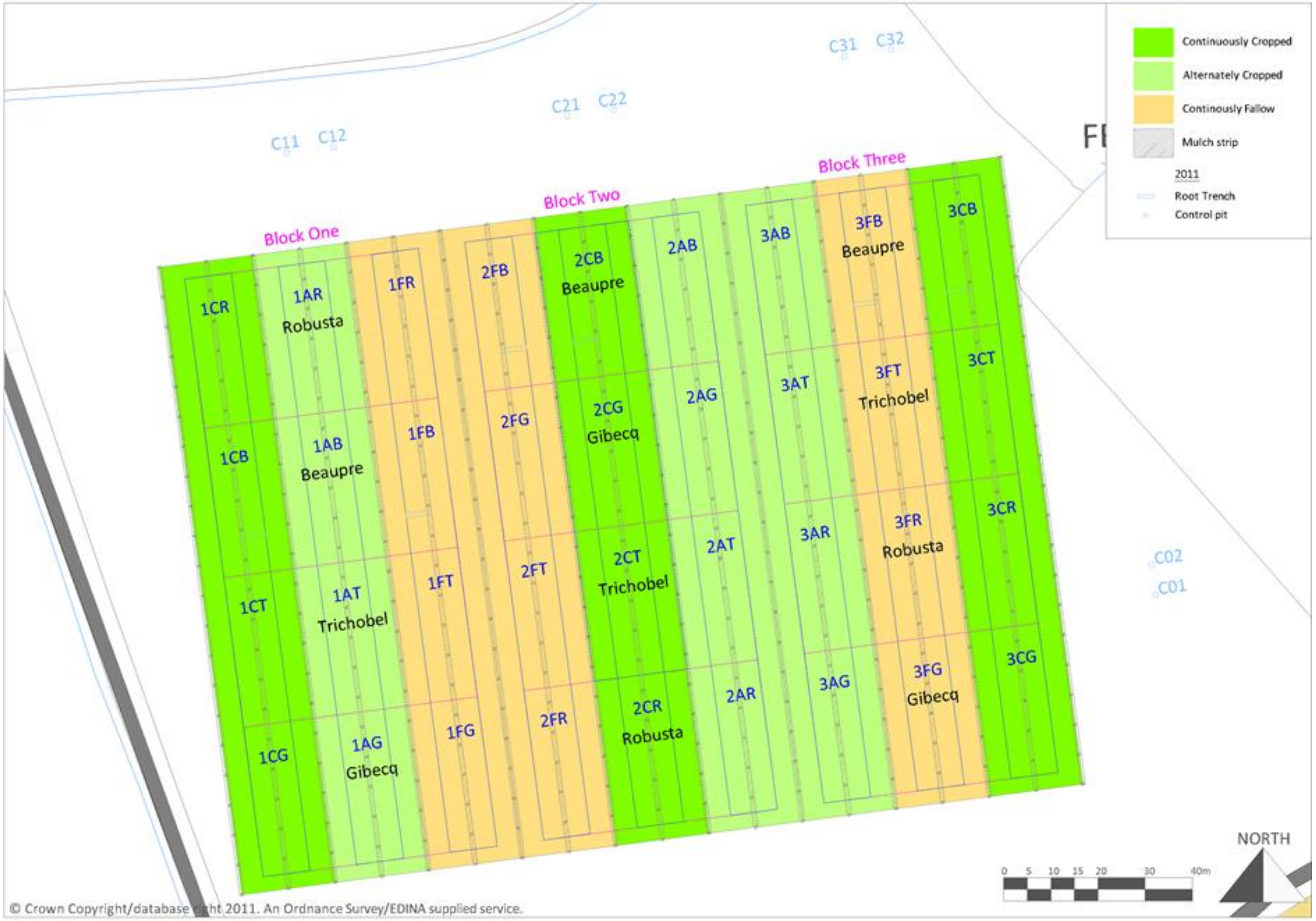
- 8 m wide intercropped alleys plus 2 m tree rows (156 trees ha^{-1}).

Treatments

- Three treatments:
  - Cropped
  - Fallow
  - Arable Control

- Cropped between 1992 and 2004.

- Continuous fallow from 2005 onwards.



Methodology

- Measurements of biomass taken by destructive harvest.

- Moisture and carbon content determined in the laboratory from samples.

Methodology

- Root balls excavated, cleaned of soil and weighed.

- Remaining coarse roots sampled, and mass estimated.

Methodology

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- Soil carbon measurements to a depth of 150 cm.
- Distribution of coarse and fine roots recorded along trenches.

Results: Total C storage

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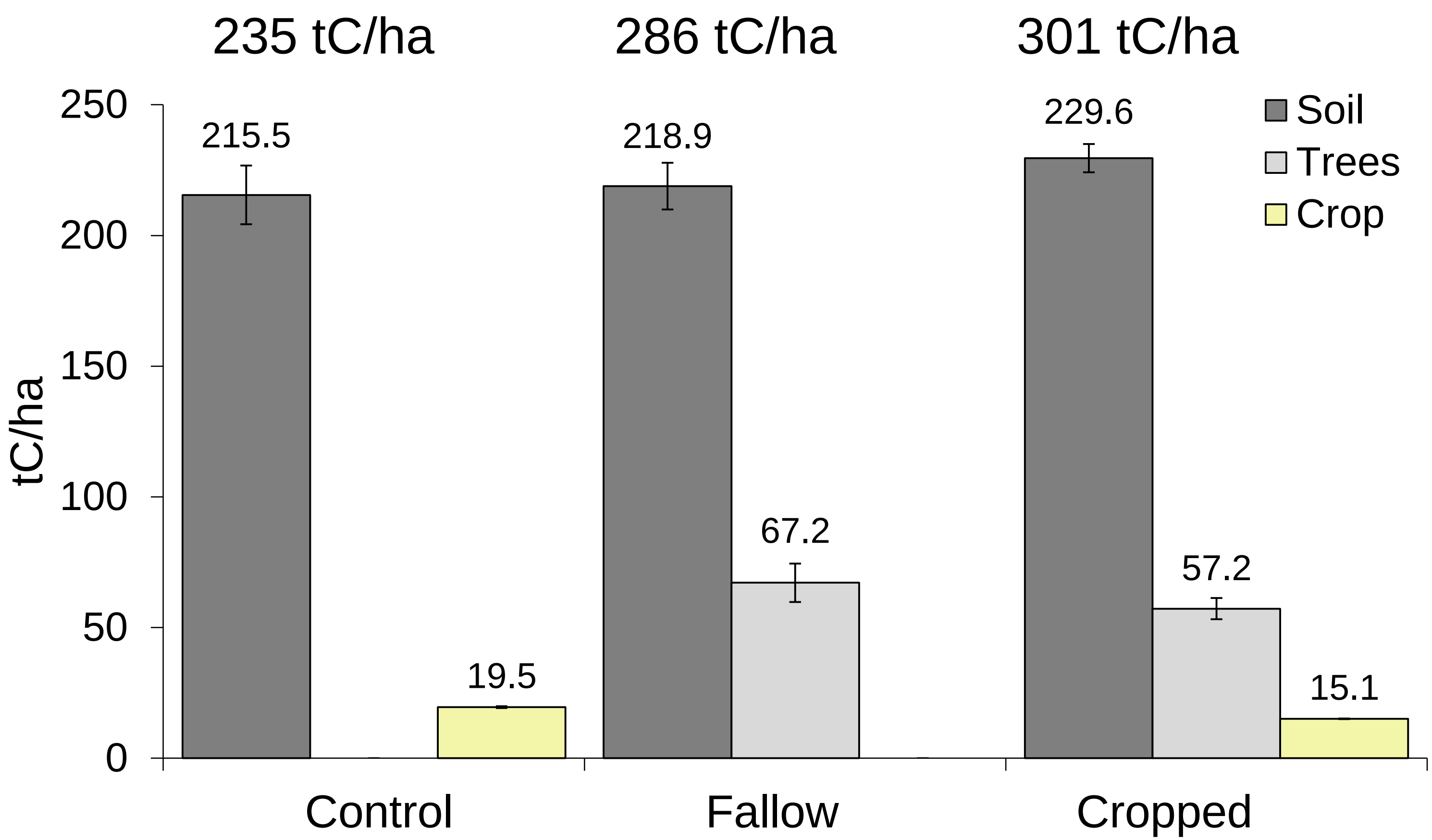
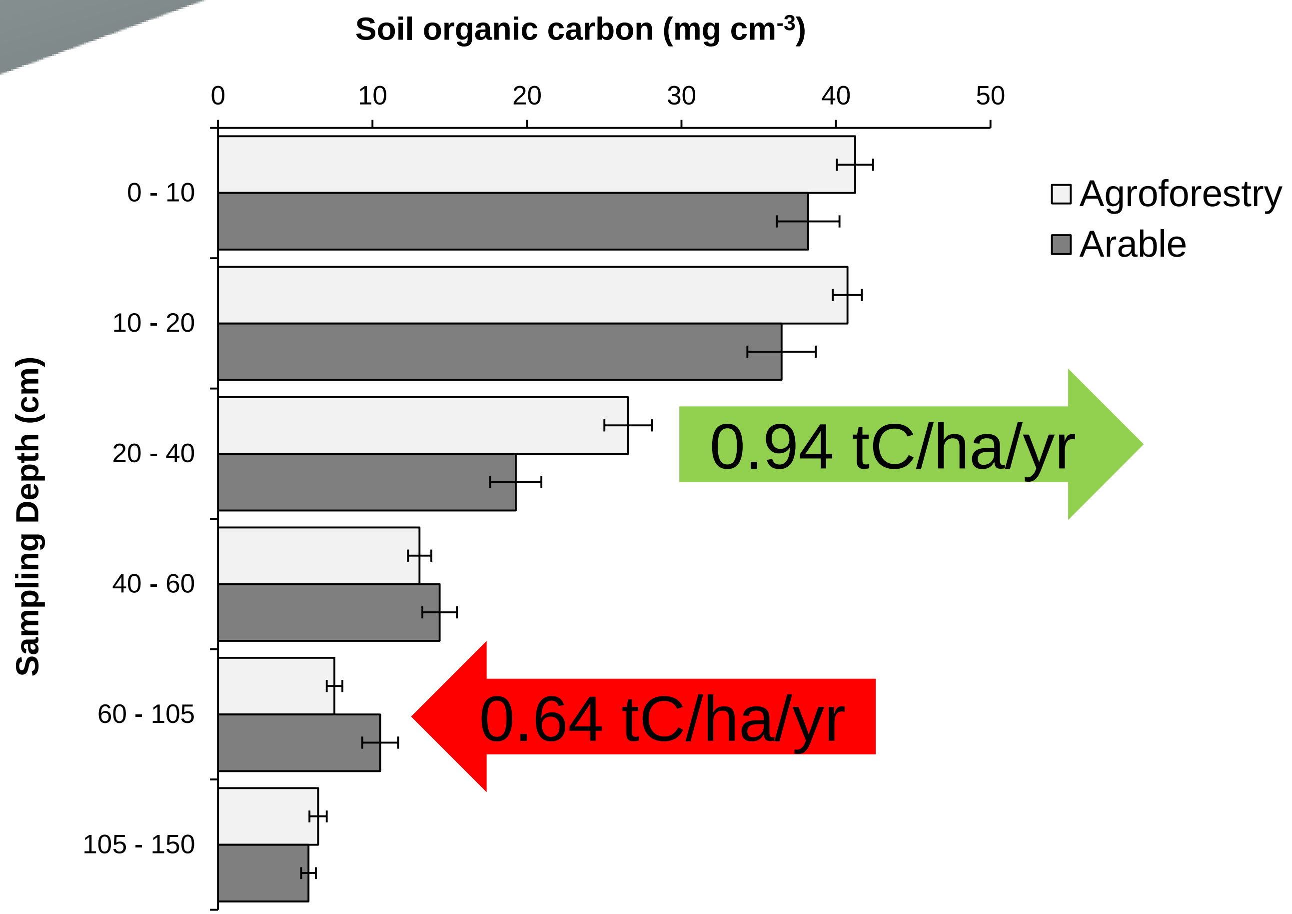


Carbon stored in the soil, tree and harvested crop components of the control, cropped and fallow treatments, 19 years after establishment. Error bars represent standard errors. Crop: n=10, Trees: n=3, Soil: cropped and fallow n= 15, control n=6.

Results: Soil Carbon



Soil organic carbon in the Silsoe agroforestry experiment (n = 30) and arable control (n = 6). Error bars indicated standard errors. Arrows indicate soil organic carbon change in the agroforestry compared to the arable for respective increments, when multiplied up by the depth of that increment.

Results: Soil Carbon

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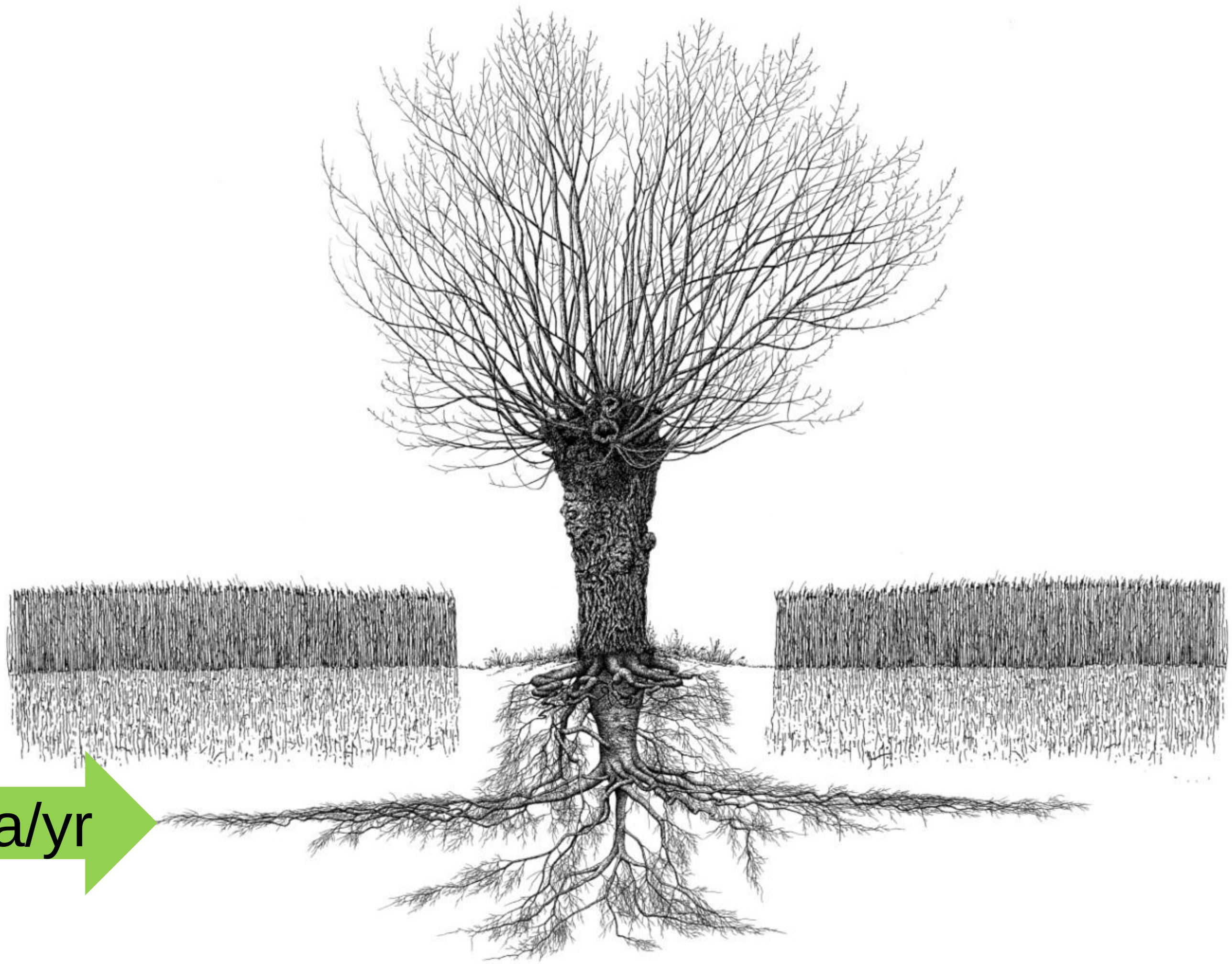

0.94 tC/ha/yr

Soil carbon changes at the 20 – 40 cm increment corresponded with the depth at which most coarse and fine roots were found in the agroforestry plot. Reproduced with kind permission of David Dellas - Arbre-et-Paysage 32 ©.

Results: Soil Carbon

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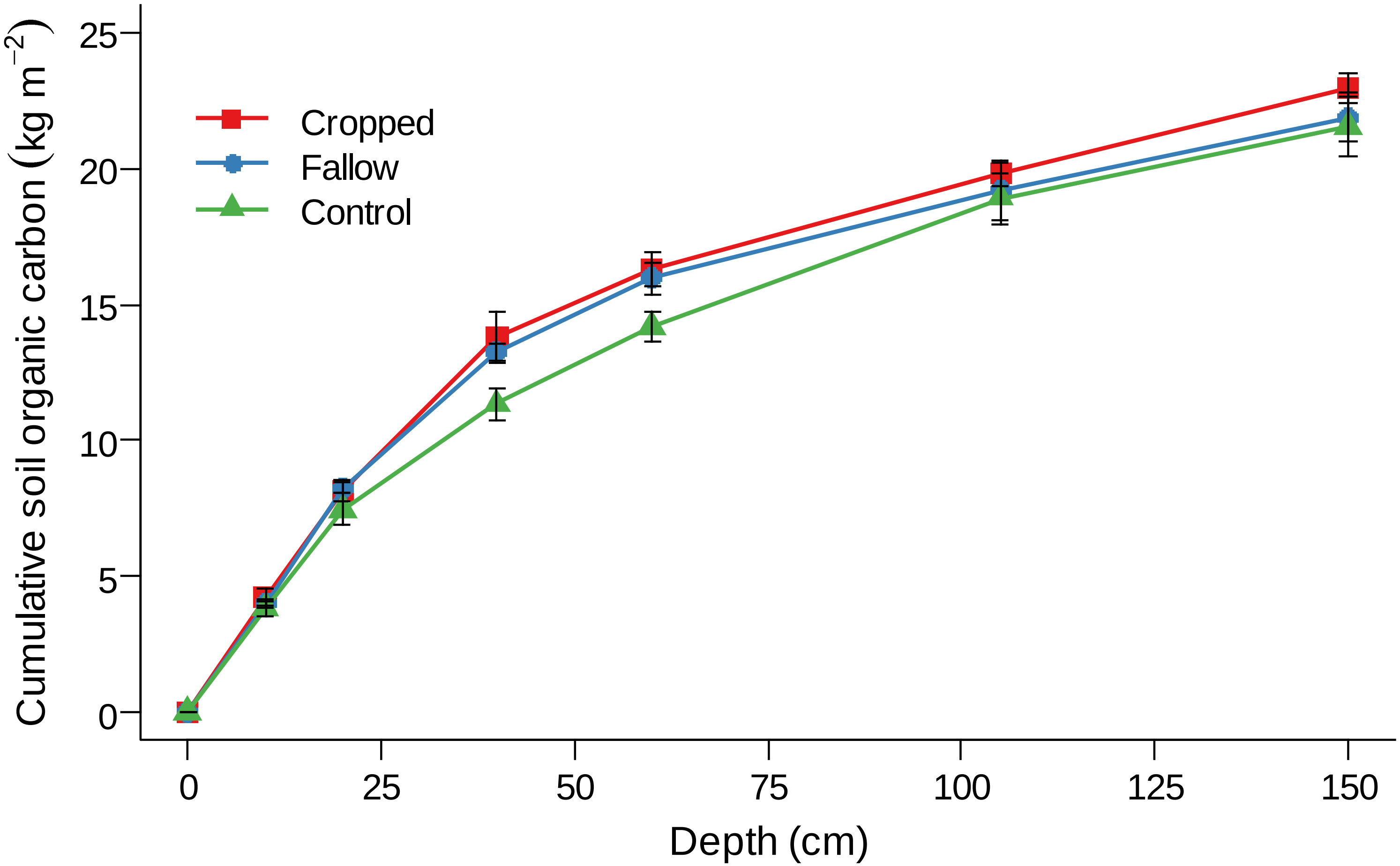

Cumulative soil organic carbon for each treatment at the Silsoe agroforestry experiment. Error bars indicate standard error of the mean (fallow: n=15, cropped: n=15, control: n=6). Considering the whole depth of 150 cm, no differences were found between treatments. Had sampling stopped at 60 cm, a difference between the agroforestry treatments and the control would have been implied.

Yield-SAFE

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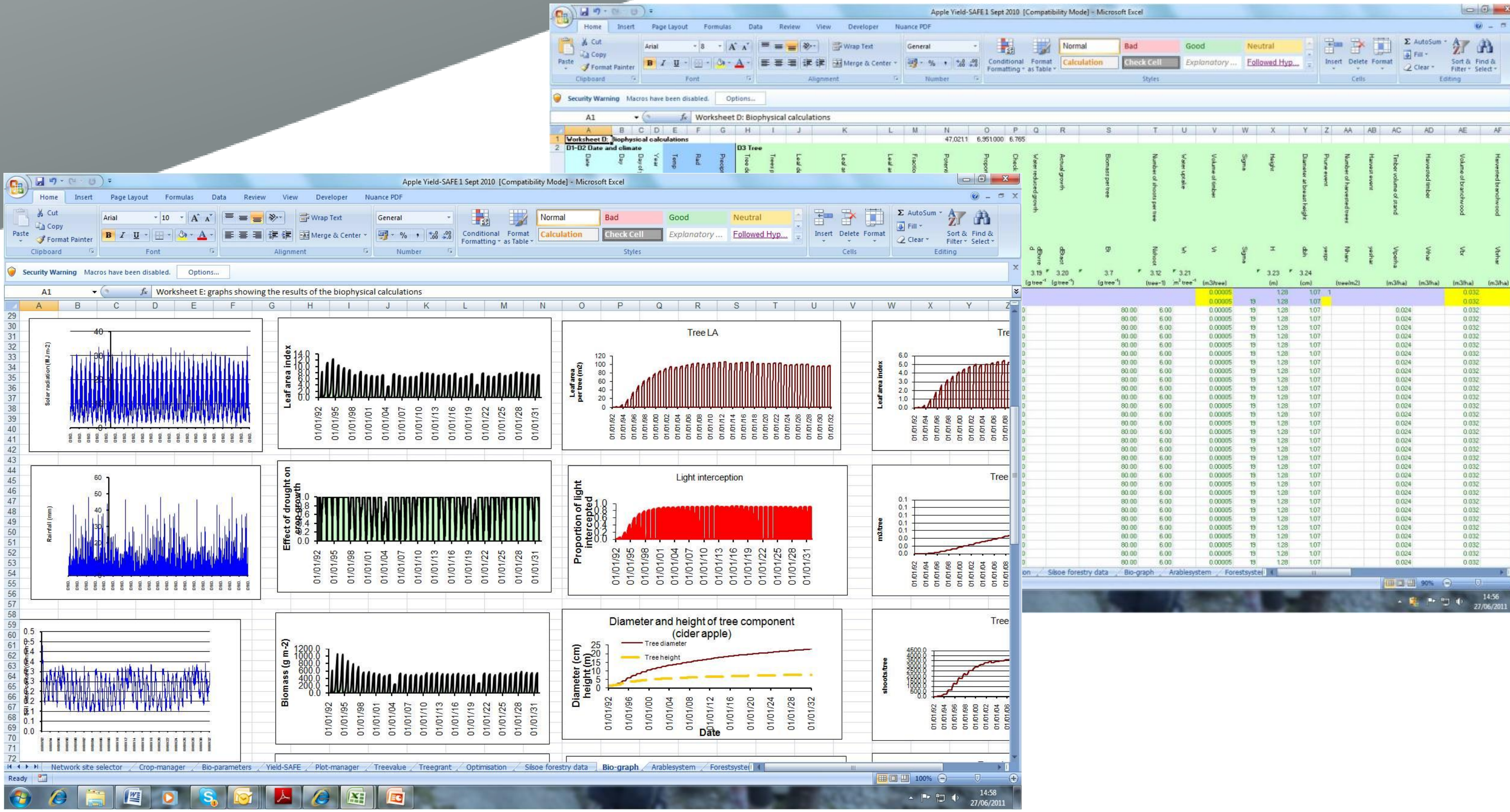
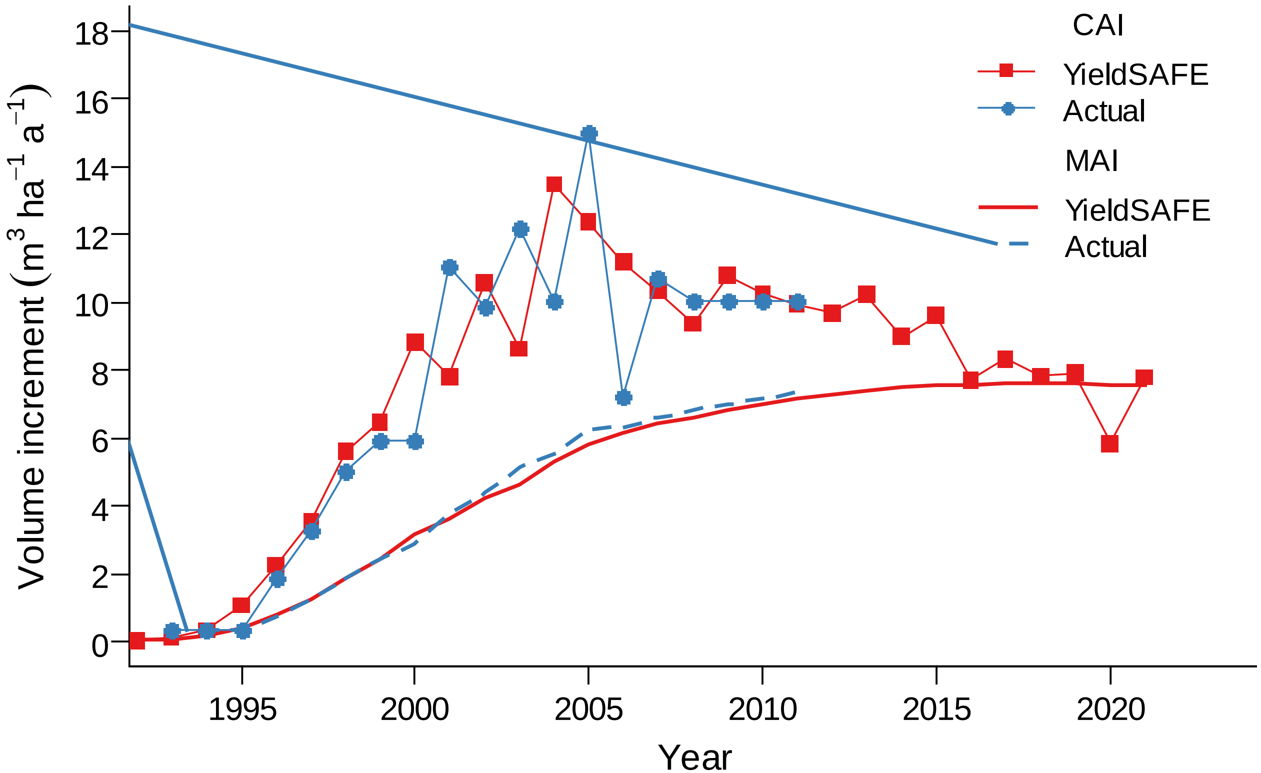


Yield-SAFE: a spreadsheet parameter sparse model of tree-crop interactions previously used for poplar, cherry and walnut trees (van der Werf et al., 2007).

Yield-SAFE

- Parameters updated using field measurements.

- Model calibrated to match observed growth patterns.



Current and mean annual volume increment for the cropped treatment based on the actual data collected in 2011, and outputs produced by the Yield-SAFE model.

Yield-SAFE

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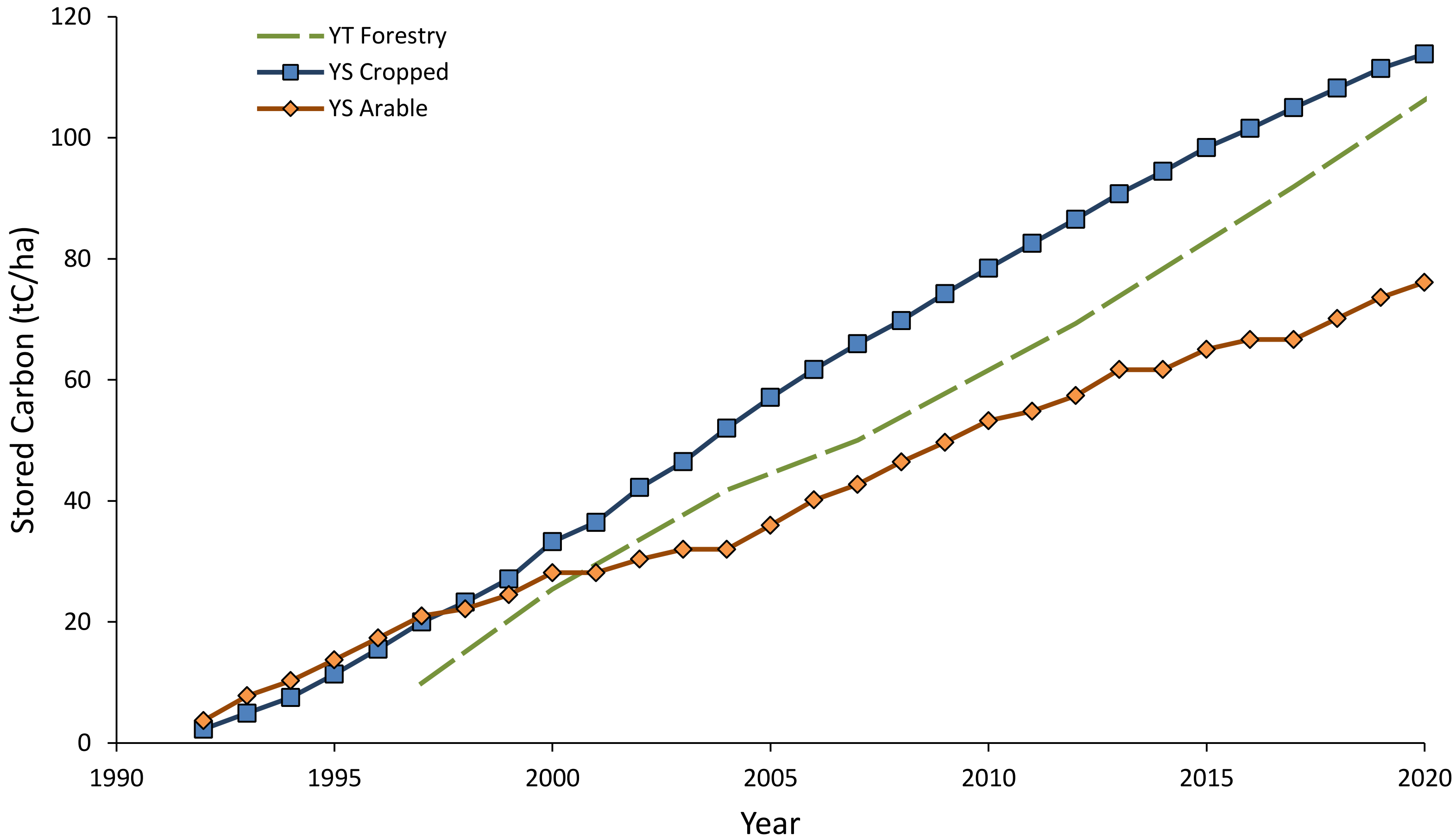

Predicted total carbon stored in a cropped agroforestry system, a conventional forestry system (yield class 10: 1089 trees ha^{-1}, thinned twice down to 133 trees ha^{-1}), and an arable system according to Yield-SAFE predictions, excluding soil carbon. YT Forestry is derived from yield table data presented by Christie (1994); root biomass was derived from allometry.

Longevity of storage

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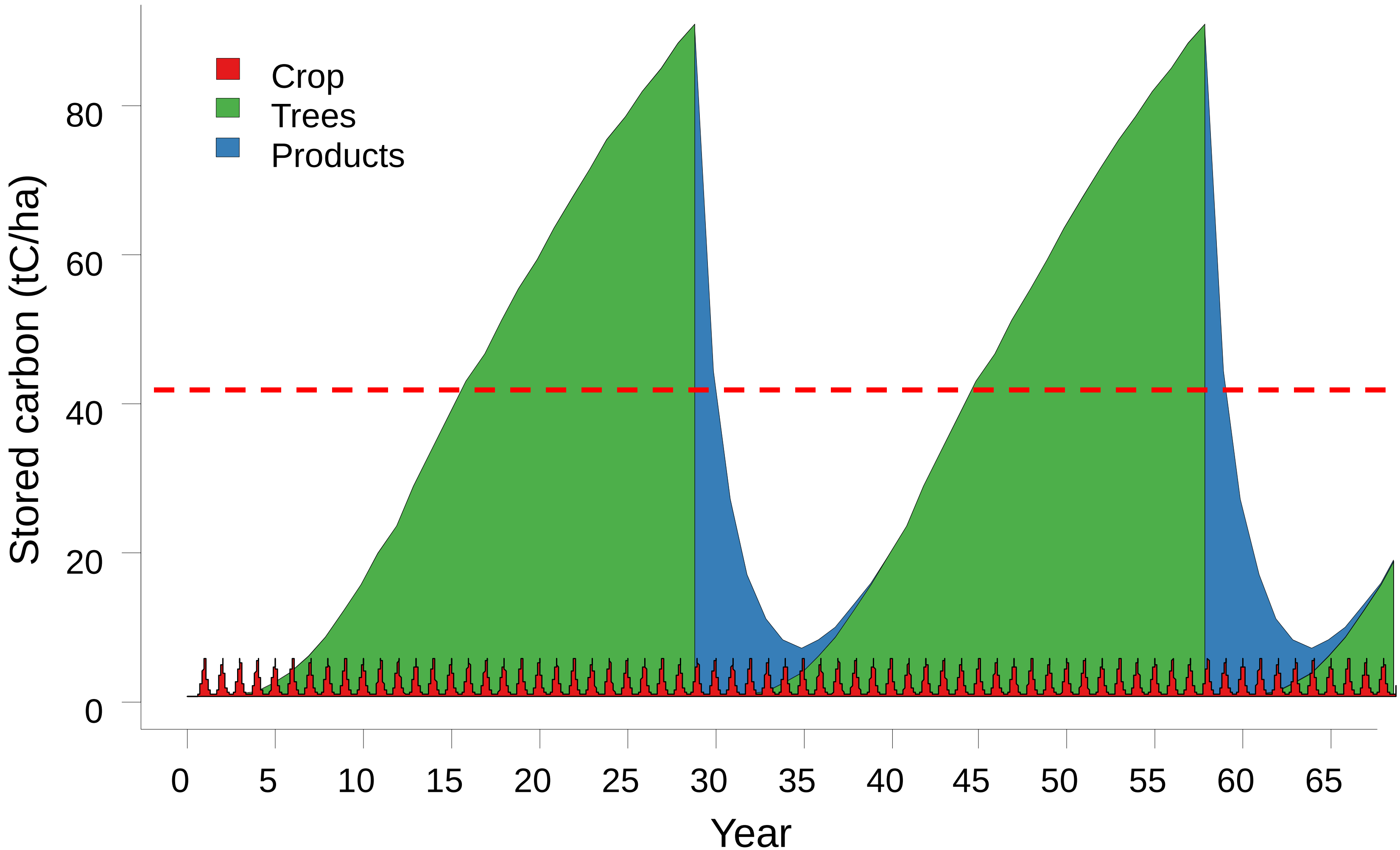
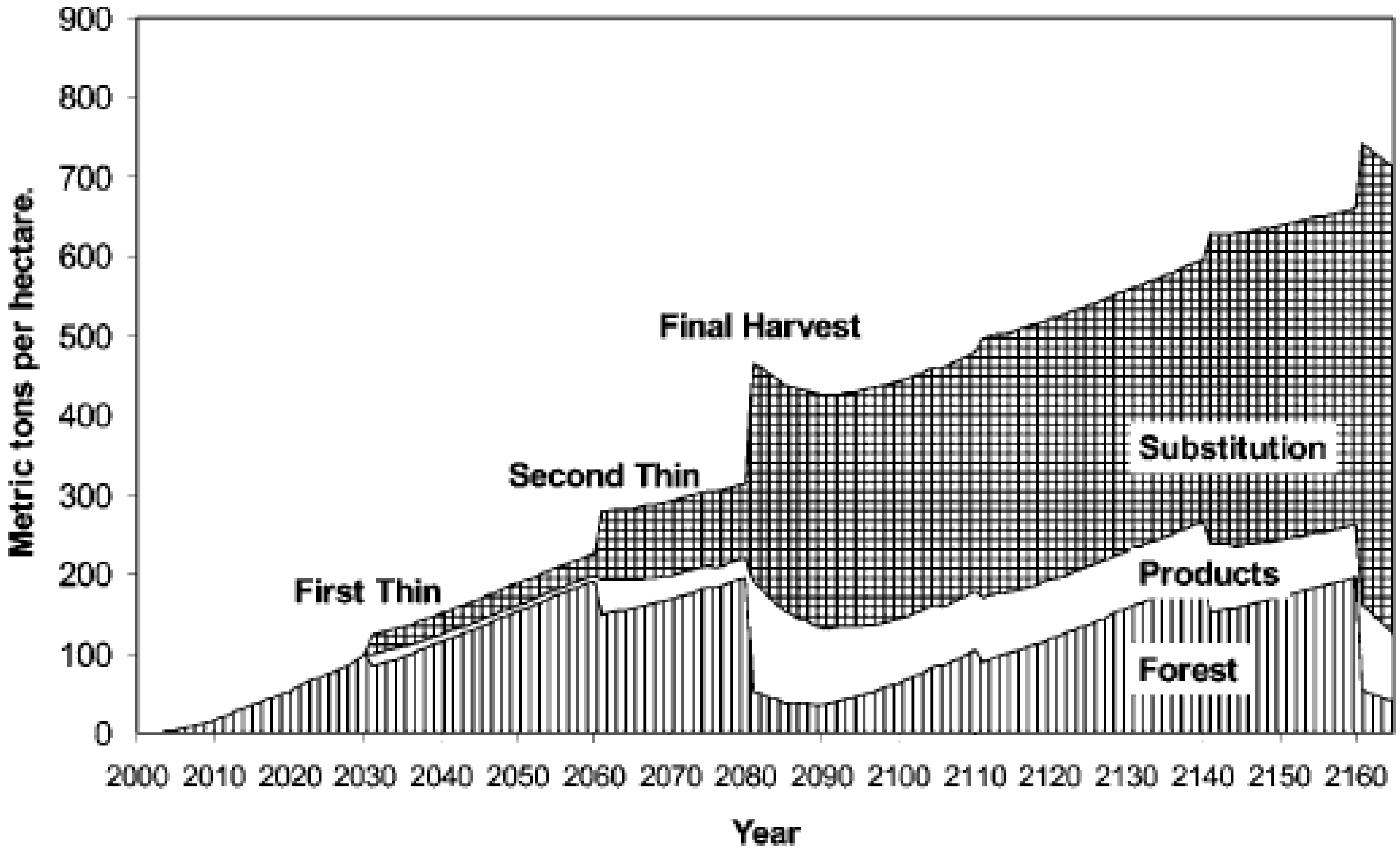


Cumulative carbon storage based on Yield-SAFE outputs. Product longevity is derived from Thompson & Matthews (1989), assuming that trees are used for packing or pulp. Mean carbon storage in trees (42 tC/ha) is indicated by the dashed red line.

Longevity of storage



Carbon in the forest and product pools with concrete substitution for an 80-year rotation. Reproduced from Perez-Garcia (2005).

Summary

- Agroforestry systems can store more carbon than forestry and agricultural systems.

- Sampling depth.

- Longevity.

- Possible to model carbon storage.

- Further work on ash in farm woodlands planned.

References

Christie, J.M. (1994). Provisional yield tables for poplar in Britain. Edinburgh: Forestry Commission.

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Van der Werf, W., Keesman, K., Burgess, P., Graves, A., Pilbeam, D., Incoll, L.D., Metselaar, K., Mayus, M., Stappers, R., van Keulen, H., Palma, J., & Dupraz, C. (2007) Yield-SAFE: A parameter-sparse, process-based dynamic model for predicting resource capture, growth, and production in agroforestry systems. Ecological Engineering, 29(4), pp. 419-433