Using multispectral satellite imagery and machine learning to automate agroforestry soil organic carbon and biodiversity prediction across Europe

Colin R. Tosh et al. *The Organic Research Centre. Trent Lodge, Stroud Road, Cirencester, Gloucestershire, GL7 6JN*

ORGANIC RESEARCH CENTRE

REFOREST

Machine learned models are allowing us to supply European agroforestry farmers with high-definition, farm-scale soil carbon and landscape biodiversity maps

1. Introduction

- A significant expense in nature-based carbon trading schemes comes from MRV activities[1].
- Machine learning models have the potential to learn soil carbon and other farm ecological characteristics from freely available field-derived data and satellite imagery[2].
- Farmers undergoing "ecological regeneration" also want easy-to-obtain ecological data to monitor how well they are doing.

2. Methods

- We have trained CNNs (convolutional neural networks) on around 40,000 Sentinel2 1C (10m) images across the EU and corresponding soil carbon and field biodiversity data from the LUCAS 2018 and GBIF databases.
- We are using these models to map living lab farms in the EU REFOREST project for soil carbon and plant biodiversity.

3. Results

- Models are not perfect but output useful ecological classification data (see Figures 1 and 2) and can certainly be improved further with the input of additional environmental variables.

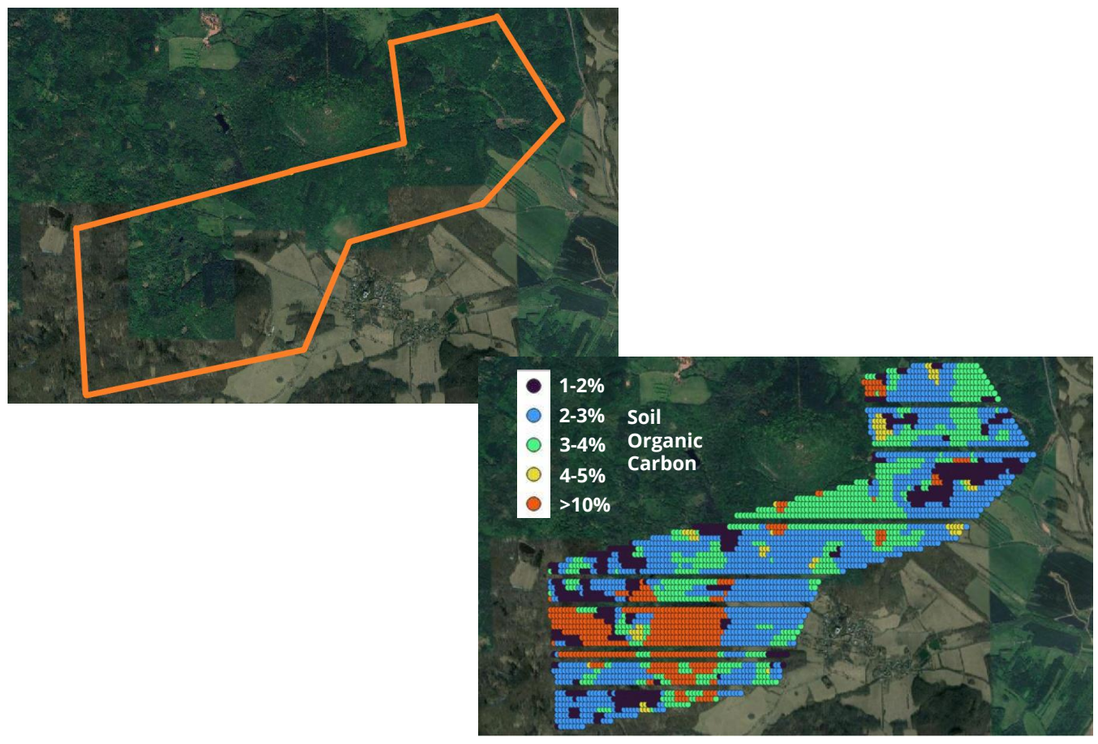


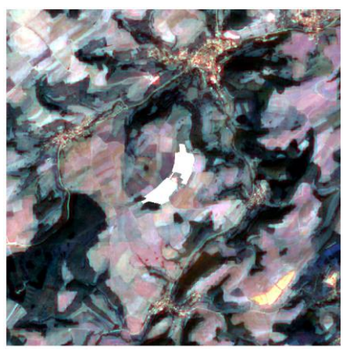
Figure 1. Predicted soil organic carbon across an agroforestry farm in the Czech Rep., farmed by Daniel Pitek. The map is generated from around 3000 Sentinel2 1C (10m) images sampled across the land at 50m spacing and fed though a pretrained CNN.

4. Discussion

- CNN models trained only with landscape imagery are already producing useful mappings of farm soil carbon and other ecological characteristics.
- With further input and resources these can certainly be made more accurate.
- We predict that reliable verification of agricultural activities will be possible in the near future using the combination of satellite imagery, additional numerical landscape data, and advanced multimodal neural network models.

(1) Unmanipulated satellite image of a German agroforestry farm and the wider landscape.

(2) Same image with the Saharan Desert pasted into the farm area.



CNN-predicted plant richness in (1) minus CNN-predicted plant richness in (2) = the predicted number of landscape-unique plant species found on the agroforestry farm.

Figure 2. We are using image manipulation with CNNs to quantify plant biodiversity on EU farms. Plant biodiversity is calculated on an umanipulated image then compared to an image with the farmed area replaced with a plantless landscape (here, an area of the Sahara Desert).

EUROPEAN CARBON FARMING SUMMIT

References

1. Elofsson, K., Karpavicius, L.M. and Yan, S., 2023. A meta-analysis of transaction costs... Aarhus University, DCE–Danish Centre for Environment and Energy.
2. Yuzugullu, O., Fajraoui, N., Don, A. and Liebisch, F., 2024. Satellite-based soil organic carbon mapping on European soils using available datasets and support sampling. Science of Remote Sensing, 9, p.100118.

Dr. Colin R. Tosh

colin.t@organicresearchcentre.com

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Scan the QR code to access developer links for the online version of the models