UK-SCAPE

UK Centre for
Ecology & Hydrology

Case study: UKCEH Land Cover Maps

Leadership and transformation

The UKCEH Land Cover Maps are a prime example of how science can be made more efficient using state-of-the-art computation.

Our new approach to map generation uses freely available Sentinel-2 satellite images and, through an automated process to create training data combined with machine learning, produces UK-wide annual land cover maps. The land cover maps for 1990, 2000, 2007 and 2015 each took several years to complete. With the new process, we can produce a new map in just a few weeks, giving rise to a time-series dataset of land cover at yearly intervals since 2017.

UKCEH is also providing international leadership in this area, working with organisations in South America to produce their own land cover maps, with their own classifications. This work led to an exciting new web-based application called YourMapsYourWay that enables users anywhere in the world to access satellite imagery and produce their own bespoke land cover maps.

www.ceh.ac.uk/data/ukceh-land-cover-maps

Did you know?

- UKCEH Land Cover Map data is used to map crops in over 1.5m fields over the whole of GB every year, including 1,655,942 fields in 2022.

- The maps support the reduction of water pollution from agriculture. These data are provided in the dataset called UKCEH Land Cover Maps Plus: Crops.

Integration

UKCEH is the only organisation in the world producing annually updated, detailed national land cover maps and this has been enabled by two fundamental developments: satellite image processing tools via Google Earth Engine, and automatic classifier training based on UKCEH land cover time series.

In 2010, Google released the Google Earth Engine (GEE), a cloud-based satellite image processing system. GEE provides easy access to multiple analysis-ready, satellite image collections, a sophisticated and continuously improving set of analytical tools and millions of free CPU hours. GEE has fundamentally changed the productivity of earth observation science.

Copernicus Sentinel-2 optical analysis-ready images became available within GEE in 2016, and this was the catalyst for UKCEH annual land cover maps. Using GEE analytics, UKCEH compress an entire Sentinel-2 annual image collection – roughly 70 images per location per year – into four UK-wide composite images that encapsulate seasonal changes in plant growth (seasonal information essential for accurate mapping of vegetation). These images are then exported into UKCEH's bespoke classification software, which has produced annual land cover maps since 2017.

Prior to Google Earth Engine and Sentinel-2, UKCEH scientists had to compile national image mosaics manually, requiring images from multiple vendors. With GEE and the arrival of Copernicus Sentinel-2 images this step is reduced into a few lines of code and image processing is completed in minutes.

Each year UKCEH automatically select several hundred thousand stable land parcels from their most recent three maps to generate training labels for the new Random Forest classifier. There is a small risk that some land parcels will have changed class in the intervening year, but most will be correct, thus preserving the majority signal and therefore suitable to classify the annual update.

Network Rail has been working with UKCEH since 2020 to develop and implement its Biodiversity Action Plan. As a result of this collaboration Network Rail won the Best Green Corridor award from the International Union of Railways (UIC) International Sustainable Railway Awards 2022. Neil Strong, Network Rail's biodiversity strategy manager, says:

" *Network Rail are committed to protecting and maintaining biodiversity on its 52,000 hectare estate. The partnership with UKCEH has enabled detailed, satellite-derived habitat maps of all GB lineside habitats for 2019, 2020 and 2021. These maps will be updated each year and are essential to monitor the habitat dynamics and biodiversity of Network Rail's land as its biodiversity action plan unfolds.* "

Did you know?

- The UK land surface is approximately 244,000,000,000 square metres.

- Sentinel-2 satellites capture images over the entire land surface every 5 days, about 70 times per year.

- This results in nearly 4 terra bytes of Sentinel-2 satellite data captured for the UK each year.

- The UKCEH land cover process uses every single image and compresses this into 8Gb of information to give a UK 10m land cover map.

Co-development, dialogue and engagement

UKCEH Land Cover Maps are generated with 21 land cover types at 10m pixel resolution – meaning 10,000 data points per square kilometre. The UKCEH team are currently exploring the potential to produce enhanced maps of UK habitats at 3m resolution, which will have significant benefits for a wide range of conservation objectives, in particular helping the UK realise biodiversity targets.

Pioneering work towards this goal has been completed with Network Rail to help it meet its statutory obligations to manage its biological assets sensitively. The Network provided boundary outlines of its extensive land holdings, and UKCEH produced 3m resolution maps for part of the network. These were used within Network Rail's biodiversity monitoring programme, leading to an international award. UKCEH have also produced 3m maps for the Nuclear Decommissioning Authority to support habitat restoration.

We have also developed an innovative web-enabled tool called YourMapsYourWay (YMYW) using Google-Earth Engine. Users draw their own land cover training labels on-screen to rapidly classify satellite images. Results are reviewed, the training labels are revised and the classification is re-run. Through this iterative approach users can produce bespoke land cover maps in just a few hours. YMYW has been used by UKCEH to produce experimental bracken maps for UK national parks and was used by Latin American partners to produce habitat maps for pollinators. These examples demonstrate the flexibility of the YMYW approach in that it can enable non-specialists to rapidly produce detailed habitat maps ideally suited to their needs.

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Impacts

The UKCEH Land Cover Maps are used by environmental charities such as the WWF, RSPB, and the Woodland Trust, and by consultancies and government departments.

DEFRA and the Department for Business, Energy and Industrial Strategy (BEIS), as was, used them extensively. UKCEH has produced a suite of time-series land cover maps for BEIS to assist with tracking greenhouse gas emissions over time to identify sources and sinks of carbon. This involved filling in the back catalogue by producing yearly maps from 1990 to 2007. Archive satellite imagery coupled with the new speed of production made this possible.

The WWF and Tesco commissioned UKCEH to use a derivation of the maps to monitor the cultivation of vegetables on peatland soils. This agricultural practice can be damaging for biodiversity and can switch the land from being a carbon sink to a carbon source. By overlaying carbon flux data on the UKCEH maps, we can quantify the effects of agricultural practice on carbon emissions.

One of the major drivers to detect land use change is to meet environmental goals. For example, large scale biodiversity offsetting will need to be monitored and informed.
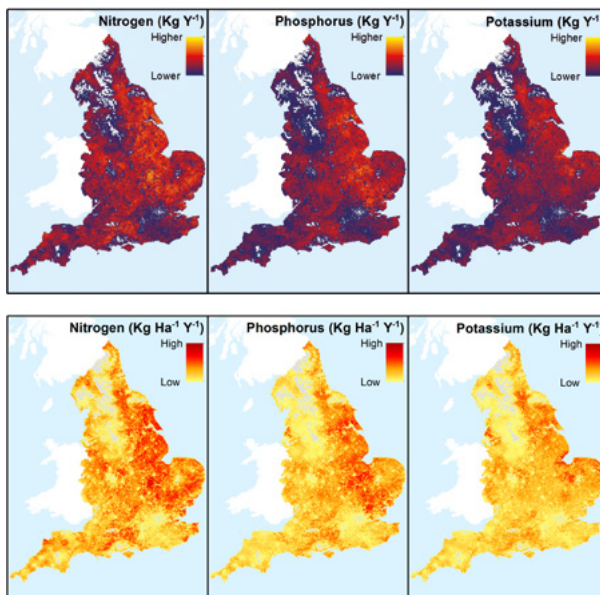
UKCEH Land Cover plus: Fertilisers and Pesticides

UKCEH maps can contribute to other projects helping to answer the question, 'What is the net effect on carbon or biodiversity if we plant this crop here?' The maps could also guide decision making in the future, defining optimal configurations of the landscape according to a range of constraints to improve the environmental condition of the UK.

Impacts in numbers 2018-2023

- £277,000 funding leveraged by external organisations drawing on land cover maps

- 74 article citations

Behind the science: meet the experts

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To access the Land Cover Map data please contact spatialdata@ceh.ac.uk