A high spatial resolution woody cover map for Great Britain: preliminary results.

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Summary

Small-scale woody features such as hedgerows and small patches of trees provide valuable ecosystem services and are important for biodiversity conservation. However, there is currently no dataset available for mapping these features at a national scale. A product has been developed for mapping these features which combines airborne radar data (NEXTMap®) and optical imagery from satellites. The NEXTMap® DIFF product provides canopy height information at 5 x 5 m spatial resolution and this dataset was used to identify 'tall' features in the landscape. NDVI imagery was then used to separate tall vegetation from other tall features such as buildings and rocky outcrops. This method was successful in identifying small-scale woody features but worked less well for large areas of woodland. Therefore, these larger areas were filled in using the Land Cover Map 2007 dataset to produce the final woody features product with a binary (woody/non-woody) classification at a 5 x 5 m spatial resolution. The product was verified against aerial photography and initial results are promising. Work is ongoing to refine the classification and to produce a woody features map for the whole of Great Britain. This product has numerous potential applications, including investigations of habitat connectivity, catchment run-off processes and quantification of carbon stocks.

1 Introduction

At present there is no national dataset for mapping small-scale woody features, such as hedgerows and small patches of trees. These features are important as they provide numerous ecosystems services and support biodiversity (Baudry *et al.*, 2000). The Centre for Ecology and Hydrology's Countryside Survey records information on woody linear and point features (Norton, 2012), however the data is only collected for a subset of 1 km squares across Great Britain (GB). Land Cover Map 2007 provides national scale forest cover information but it does not provide data at sufficient resolution to map sample small-scale woody features (Morton, 2011). Hence, the aim of this study was to determine whether a high resolution woody cover product could be produced using airborne radar data (NEXTMap®) and NDVI imagery from satellites. The resulting dataset has numerous potential applications including modelling catchment run-off and assessing habitat connectivity.

2 Methods

The NEXTMap® dataset is a product of Intermap Technologies®, which was produced using airborne interferometric synthetic aperture radar. The dataset comprises an orthorectified radar image (ORI); a digital surface model (DSM) and a digital terrain model (DTM), each with a 5 m spatial resolution and a vertical RMS error of 1 m (Intermap, 2010). In this study, the difference between the DSM and the DTM (NEXTMap DIFF) was used to give a canopy height estimate. NDVI imagery was derived from optical satellite imagery. A summer NDVI image was produced using an image collected on 18th July 2006 from the Linear Imaging Self

Scanning Sensor (LISS-III), a four band pushbroom sensor onboard the Indian Remote sensing Satellite (IRS) with a spatial resolution of 23.5 m. A winter NDVI image was produced using a Landsat 5 TM image, collected on 1st November 2006.

Ground-truth data was produced by manually digitising woody features for 6 randomly selected 1 km squares using aerial imagery. These digitised polygons were then converted to a woody/non-woody raster. These data were used to investigate the most effective thresholds and to validate the resulting woody cover product.

The NEXTMap DIFF and summer NDVI imagery were combined to identify 'tall' and 'green' features in the landscape. All pixels which met the following condition were classed as woody pixels:

NEXTMap DIFF > 1.5 m AND summer NDVI > 0.8

The resulting image was successful at identifying small-scale woody features, but it did less well for larger areas of trees. Therefore, data from Land Cover Map 2007 (LCM2007) was used to identify larger woodland areas to produce the final woody cover product.

3 Results

When larger woody areas were first excluded by using LCM2007, the NEXTMap dataset and, to a lesser extent, the summer NDVI image were found to be suitable for separating woody and non-woody pixels (Fig 1). The winter NDVI image was not suitable for this purpose since woody and non-woody pixels had similar distributions.

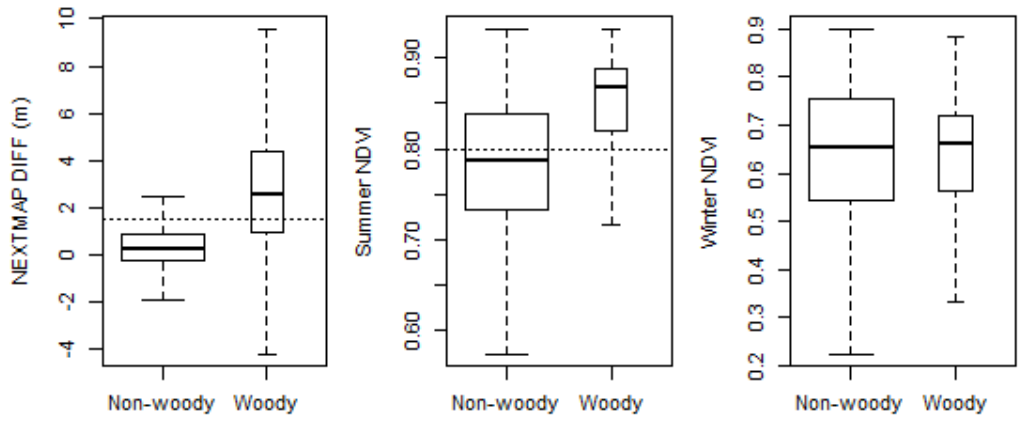

Figure 1. Boxplots showing NEXTMap DIFF, summer NDVI and winter NDVI data split into woody and non-woody pixels based on 'ground-truth' data. Larger woody areas were first excluded using the LCM2007 dataset. Whiskers give the maximum 1.5 IQR, outliers not plotted, widths proportional to sample size. Horizontal dashed lines show the thresholds used in the woody cover product.

When validated against ground truth data the woody cover product performed well with an overall classification accuracy of 85.6 % (Table 1). However, there were a large number of non-woody pixels that were wrongly classed as woody, largely due to overestimation of forest area by LCM2007. When used to predict the total woody area in each of the 1 km squares the woody cover product had an RMSE of 0.053 km^2 and a positive bias of 0.042 km^2 (Fig. 2).

Table 1. Confusion matrix for the woody cover product.

Reference/ Predicted	Non-woody	Woody	Total	Recall (%)
Non-woody	**174152**	12334	186486	93.4
Woody	22331	**31183**	53514	58.3
Total	196483	43517	240000	
Precision (%)	88.6	71.7		

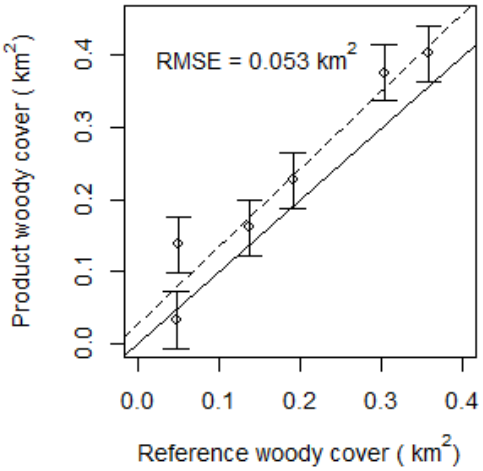

Figure 2. Scatter plot of woody cover area within a 1 km^2 predicted by the woody cover product versus the reference area from the 'ground-truth' data. Solid line shows the 1:1 relationship and the dashed line shows the best fit line estimate using least squares linear regression, with error bars showing the residual standard error.

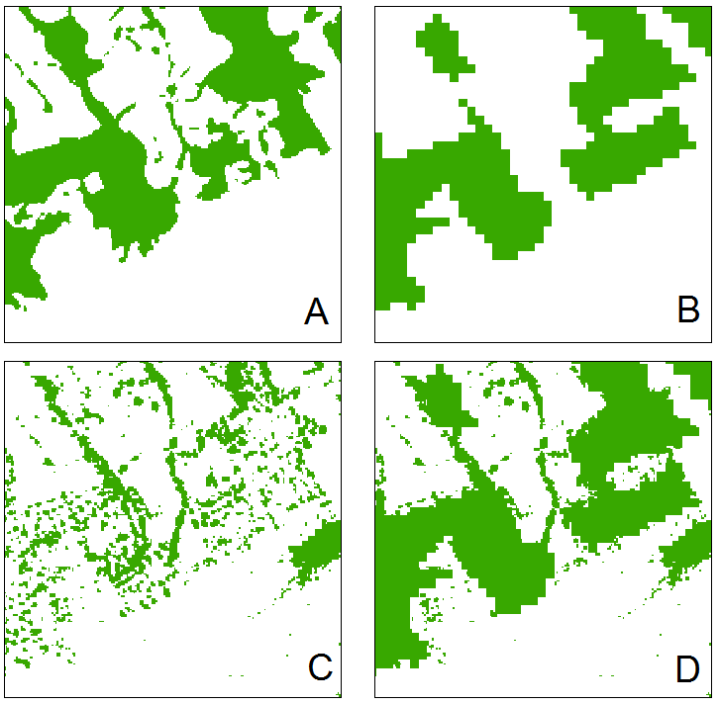

Figure 3. Example data for a 1km square. (A) ground-truth data; (B) LCM2007; (C) small woody features from NEXTMap and NDVI; (D) woody cover product (D=B+C).

Fig 3 shows how the small woody features, estimated from NEXTMap and NDVI data (Fig

3.C) are combined with the LCM2007 data (Fig 3.B) to produce a final woody cover product (Fig 3.D).

4 Conclusions

NEXTMap airborne radar data and summer NDVI imagery were able to identify small-scale woody features in the landscape. These datasets were combined with LCM2007 to produce a woody cover product which was able to distinguish woody and non-woody areas with an overall accuracy of 85.6 %. LCM2007 had a tendency to overestimation woody cover areas; hence, alternative datasets such as the National Forest Inventory or OS woodland layer will be considered in forthcoming work. Results have demonstrated that there is potential for a national scale woody cover product to be developed. Work is ongoing to improve the classification accuracy and to produce a woody cover map for the whole of Great Britain. Pan-sharpened NDVI imagery will be considered; for example, the Landsat 8 OLI sensor has a panchromatic band with a spatial resolution of 15 m, which would allow finer scale features to be picked out. The dependence of the optimal NDVI threshold on the date of the image and the sensor will also be investigated further.

5 Acknowledgements

NEXTMap® data was obtained from Intermap Technologies Inc 2003. Landsat-TM5 satellite imagery © <Satellite/Ground station operator> 2007, Distributed by Eurimage. IRS-LISS3 satellite imagery supplied by European Space Agency © Euromap, Space Imaging and Antrix Corporation Limited.

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