Monitoring and Mapping for biodiversity using remote sensing: a case study from Norfolk

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1. Introduction

Due to legislative obligations included in the EC Habitats Directive, as well as domestic commitments to provide audits of ecosystem function and service provision, information on location and condition of semi-natural habitats in the UK is required. Earth observation (EO) has been identified as an important monitoring tool for conservation bodies and DEFRA, helping to meet surveillance standards under resource constraints.
"Making Earth Observation Work for UK Biodiversity Conservation" is a three part project, designed to establish the practical role of EO in surveying UK priority habitats designated under the UK Biodiversity Action Plan (BAP) and Annex I habitats.

1.1 Phase I – Review and Scope Potential (Completed)

Reviewing recent activity, Phase I (Medcalf et al. 2012) demonstrated the potential contribution of EO techniques combined with geoinformatics to the surveillance of habitat extent, composition and condition on an operational level. A user guide, the "Crick Framework", was developed, wherein habitats were grouped into five tiers representing the current likelihood of the habitat being identified using EO techniques.

1.2 Phase II – Pathfinder Projects (Completed)

By carrying out projects in a pilot area of Norfolk, Phase II tested the application of EO techniques in operational surveillance for biodiversity in the UK and assessed effectiveness, practicality and cost-performance-ratio. During this phase, the Crick Framework was updated.

1.3 Phase III – Influencing (Current Phase)

Phase III is intended to develop a common research agenda between the UK and other European Member States utilizing EO. Herein research needs, identified both during Phase I and during EO application for biodiversity surveillance in Europe, should be addressed utilising data supplied through EU and MS programmes (particularly GMES/Copernicus).

2. Findings

2.1 Implementation and Evaluation of a Pilot Project

During the pilot study in Phase II further development of an "object based image analysis" (OBIA) habitat mapping approach was required. In this approach, the knowledge of

landscape context is applied to image classification, allowing for spectrally similar vegetation to be distinguished on the basis of the different settings it occurs in. For the successful application of OBIA, Ordnance Survey MasterMAP (OS MM) and digital terrain models proved to be essential, both at landscape (wider countryside, including agriculturally managed and semi-natural habitats) and site scale (localised, e.g., nature reserves). In order to identify small objects (e.g., scattered scrub) and linear features, ultra-high resolution imagery obtained through an Unmanned Aerial System (UAS) was incorporated, which aided in the delineation of habitat extent and in the identification of features relevant to Annex I SAC sites.

2.2 Implications of Phase II for Senior Policy Makers

It was demonstrated that EO techniques provide a good cost-performance ratio for the mapping of Annex I and priority habitats: 1/3rd of these habitats can be mapped directly, while key data sets for the identification of the remaining ones are provided. The efficacy of EO techniques is added to by their applicability to large or difficult to reach areas and the capacity to improve mapping accuracy at individual sites. A further advantage of EO techniques is that the rule bases and processed imagery and data, once developed, can be built upon and adapted to provide additional outputs, meeting the needs of other policies utilising habitat mapping. Consequently, follow-on work can be carried out at very low costs, compared to techniques requiring re-surveying or manual re-interpretation of imagery.

Supporting and augmenting current techniques, the main fields of application identified for EO techniques include, on the countryside-scale, filling of knowledge gaps regarding habitats and the generation of maps for approaches to biodiversity delivery, as well as, on smaller scales, the development of management plans, particularly for discrete areas, the identification of threats to habitats and the monitoring of mitigation measures put in place.

2.3 Implications of Phase II for Habitat Practitioners

Based on cover forming species present, the EO techniques can distinguish a range of high priority habitats at accuracies greater than 78%. Habitats distinguished on the basis of small or understorey species cannot be separated; however, the identification of broader habitats can be used to target field survey work to identify specific habitats. Additionally, measures difficult to obtain from the ground, such as "the extent of stands of negative indicator species", can be obtained as part of the EO process.

The resolution and temporal frequency of imagery required for EO techniques to be applied successfully depends on the habitat: Patchier habitats require higher spatial resolution imagery while habitats undergoing frequent changes associated with their biogeographical, agricultural and habitat system context require higher temporal frequency imagery. The EO process itself requires a combination of EO and ecological expertise, as well as GIS and geoinformatical knowledge. Particularly relating knowledge of the ecology of the site to the imagery is integral to creating the rule base for map creation.

The end product is a high-quality, site-based habitat map that can be used in monitoring, surveying and site maintenance and an adaptable dataset; continuous improvement upon the rule base is possible, the data can be used to apply a different classification system or to provide a more detailed assessment of one particular area.

3. Conclusions

Overall, Phase II of the research has established the practical role EO can play in addressing habitat monitoring and surveillance needs in the UK for priority habitats designated under UK Biodiversity Action Plan (BAP) and Annex I habitats.

Accuracy assessment, feedback from local habitat practitioners and assessment by the research team of how well the techniques worked suggest that the EO techniques developed can support the mapping and surveillance of high priority habitats. Work in Norfolk and Wales demonstrates that the techniques are capable of consistent implementation and evidence suggests that the technique is transferable for application in the UK, and abroad. The approaches can support and augment current surveillance techniques in a practical way, sometimes improving upon the accuracy of habitat mapping or providing a better performance-cost-ratio.

3.1 Future Research

Future research needs identified during the project include assessment of the suitability and potential role for satellite radar in an OBIA approach and further vegetation structural features that can be described by LiDAR. Measures (indices) to assist with the site-based assessment of the condition of Annex I habitats need to be researched and formulated.

Further widening the applicability of EO techniques will require knowledge transfer with conservation agencies to create image analysis classification systems suited for particular habitat mapping needs.

Acknowledgements

The project team would like to thank Paul Robinson (JNCC) and Helen Pontier (Defra) as well as the steering group members from country agencies and associated organisations for their input during all phases of this project.
We would like to particularly acknowledge the input of the late Mark Crick into this project. His knowledge and enthusiasm made him a pleasure to work with.

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