SELF FUNDED PHD OPPORTUNITIES

This document contains two abstracts:

1. **Ultra-high resolution image data analysis for grassland species mapping**
2. **Mapping plant stress in submerged aquatic vegetation using very-high and ultra-high resolution multi-spectral imagery and structure from motion photogrammetry**

1) Ultra-high resolution image data analysis for grassland species mapping

Director of Studies: Dr Fleur Visser

Other supervisors: Prof Carsten Skjoth

Due to the small size of grass plants, it has so far not been possible to map the presence of grass species in detail from remote sensing image data. However, with the continuing improvements in spatial and spectral resolution of satellite and airborne image sensors, species level assessment of grassland habitat is becoming increasingly possible. Such assessments are of importance for a range of applications.

For example, some 40% of the UK's land surface is grassland, however, only a very small portion of this consists of unimproved, species-rich grassland. More of this important habitat is still being lost or degraded, with an associated decline in numbers of butterflies and breeding birds. To assist in the protection and restoration of these precious grassland habitats, there is a great need for tools that can accurately map and monitor grassland composition.

Human health is another field that would welcome detailed information of grassland species composition. As grasses produce pollen, they are the cause of respiratory allergic responses in the population. Geographical distribution of grass species may affect the health outcomes such as hospital admissions for asthma. Therefore, tools to accurately map and monitor grassland composition can contribute to our understanding of how the environment affects human health.

In this PhD research project, the student will collect ultra-high resolution multi-spectral image data (e.g. using a UAS/drone). Based on this, they will develop an appropriate image data analysis workflow to identify grass species, which could include Object Based Image Analysis (OBIA) techniques, as well as Statistical Machine Learning methods and where useful be combined with other approaches, such as Structure from Motion (SfM) to obtain additional data dimensions. Results at this level can subsequently be used to assess the possibility of grassland community assessments from coarser resolution UAS/drone data and Sentinel or WorldView satellite imagery.

- Fieldwork costs – transport to / from field sites and field equipment (e.g. site markers) = £1100

Please, note that our previous PhD students have been able to secure funding for fieldwork activities, so we hope some of the costs can be met this way. Organizations from which students have successfully obtained funds are The British Society for Remote Sensing and Photogrammetry

(RSPSoc), The British Hydrological Society (BHS), The British Society for Geomorphology (BSG) and the Earth and Space Foundation.

2) Mapping plant stress in submerged aquatic vegetation using very-high and ultra-high resolution multi-spectral imagery and structure from motion photogrammetry

DoS: Dr Fleur Visser

Other supervisors: Dr Jonas Schoelynck, Prof Ian Maddock

Submerged Aquatic Vegetation (SAV) is an important component of ecologically healthy river systems. The plants are however under increasing pressure from different kinds of environmental changes. Such changes range from introduction of invasive, non-native species grazing the plants to changes in river flow conditions, which can cause structural damage. Plants will respond to this in various ways. It may affect the vegetation canopy structure, the vegetation community composition and it may even show in the physical appearance of individual plants, as they are under stress. Continued stress will lead to the deterioration of SAV cover in streams and reduce the ecosystems services it provides.

For terrestrial vegetation, the use of spectral remote sensing is an established method for detecting and mapping plant response to stress factors, such as diseases or drought. For SAV little is known about its response to stress factors and even less work is done to map this, using remote sensing techniques. Several studies have shown variation in vegetation canopy due to changes in flow conditions, but they are not as numerous as for land vegetation. Also, the techniques used to measure reflectance from terrestrial vegetation, which is needed for the calculation of spectral indices, are not easily transferable to a submerged environment. Light is strongly absorbed in water, in particular those wavelengths suitable for detection of plant health or stress. Correction of reflectance measurements for depth of the overlying water column requires a highly detailed model of the vegetation canopy. Until very recently, such models were not available and spectral detection of submerged plant stress therefore impossible. Recent developments in remote sensing data collection and analysis techniques have created new opportunities for observing shallow and clear submerged river environments.

In this PhD research project, the student will use very-high resolution (VHR: ~ 1 cm -1 m) and ultra-high resolution (UHR: < 1 cm) multi-spectral remote sensing imagery in combination with Structure from Motion photogrammetry (SfM) and spectral image classification to map vegetation cover extent and topography, as well as vegetation structure and composition. In addition, the student will attempt to identify spectral stress signals within the SAV canopies, similar to those found for terrestrial vegetation, using the canopy structure information obtained with SfM photogrammetry. Part of the work will take place in a flume, set up with vegetation cover, where relevant stress factors will be applied (e.g. hydrodynamic stress, light limitation stress, nutrient stress, salt stress or stress by herbivory). As part of ongoing collaborative work between University of Worcester staff and staff at the University of Antwerp, Belgium, the student will have the option to undertake controlled experiments at the flume facilities available at the new state-of-the-art mesocosm facility 'MESODROME' at the University of Antwerp Drie Eiken campus in Belgium

(www.uantwerpen.be/mesodrome). Assessments of specific stress factors can also be undertaken on selected field sites depending on available conditions.

Expected project costs:

- Fieldwork costs – transport to / from field sites and field equipment (e.g. site markers) = £1100*
- Plant hormone sampling costs (10 replicates x 6 locations x 2 different stress levels x £15 cost per sample) = £1800
- Visit University of Antwerp = £1500**

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**Dr Jonas Schoelynck will help securing funding for travel and accommodation costs for the student to undertake labwork at the 'MESODROME' at the University of Antwerp Drie Eiken campus in Belgium. Opportunities to fund such activities are available through the Flemish Council for Scientific Research (FWO).