MOORS FOR THE FUTURE PARTNERSHIP

Monitoring the impact of blanket bog conservation using aerial imagery

Introduction

Moors for the Future Partnership (MFFP) is an organisation with a proven track record of instigating and delivering landscape-scale projects across the moorlands of the Peak District National Park (PDNP) and the South Pennine Moors (SPM) Special Area of Conservation (SAC).

In 2015, MFFP received funding from the EU LIFE fund, which supports environmental, nature conservation and climate action projects throughout Europe. The aim of this project, MoorLIFE 2020, is to conserve and protect the EU priority habitat active blanket bog within the SPM SAC and the ecosystem services it provides.

MoorLIFE 2020 monitoring

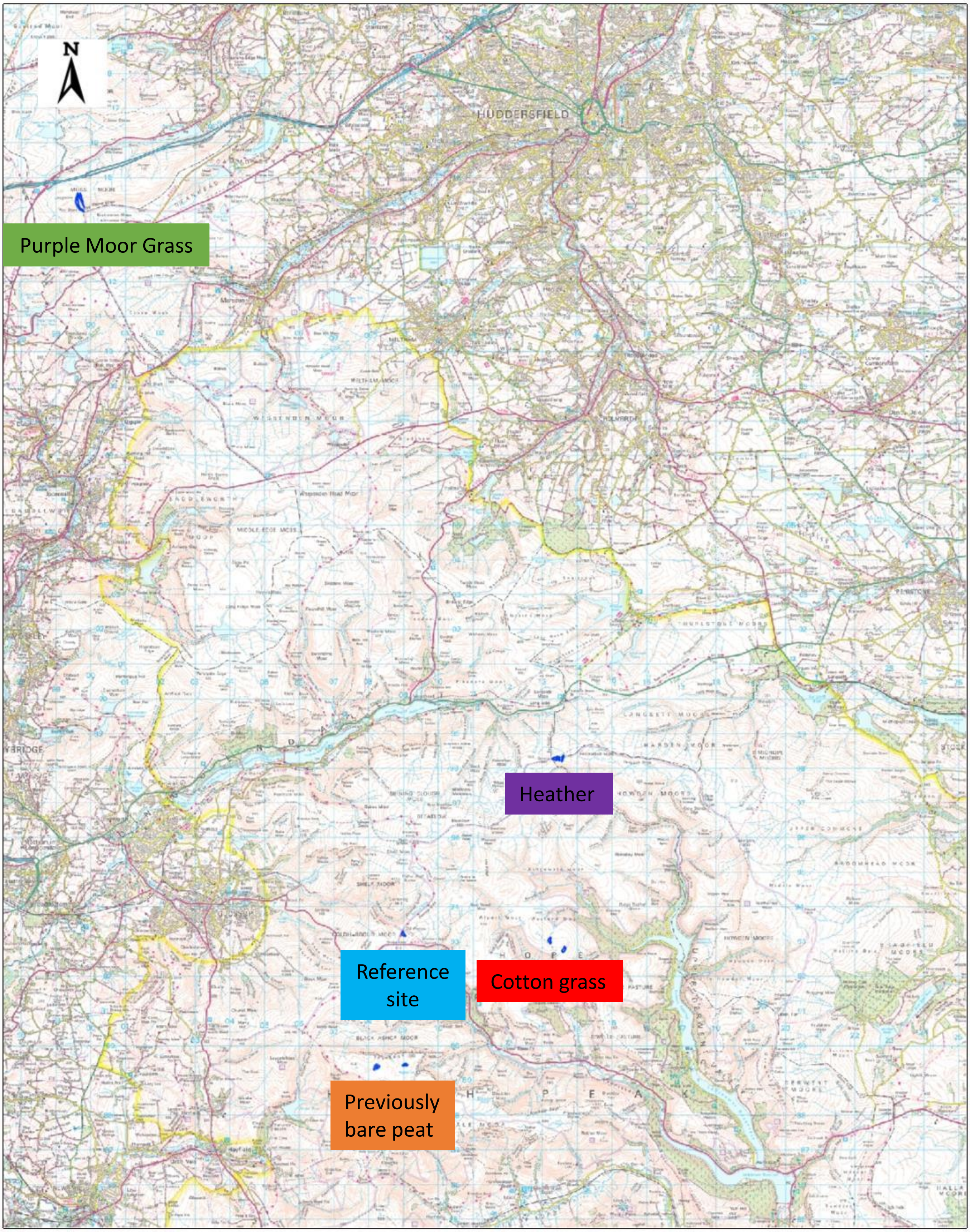
MFFP is particularly interested in monitoring the response of blanket bog communities that have become dominated by single species (cotton grass, purple moor grass and heather), as well as areas that were previously dominated by bare peat. Conservation actions aimed at the diversification of these communities will mainly involve the planting of *Sphagnum* propagules. Monitoring will be focussed in the first instance on a series of experimental catchments set up on these different blanket bog communities. Monitoring within these catchments will involve traditional survey methods including vegetation, water flow, water table and peat accumulation / erosion monitoring, as well as more contemporary survey methods including the use of the aerial imagery.

Aims and objectives

By using aerial imagery it is hoped to monitor the impact of blanket bog conservation actions at a landscape scale, rather than the traditional site scale. Specifically the aim is to:

1. Monitor land cover change across the project area, including:
    a) Increases in the extent of *Sphagnum* moss
    b) Reductions in the dominance of cotton grass, purple moor grass and heather
    c) Reductions in the extent of bare peat
2. Monitor changes in surface wetness
3. Monitor rates of peat accumulation and erosion

In August 2017, MFFP contracted Nottingham Trent University and CS Conservation Survey, to undertake a three-year project to map vegetation change using aerial imagery captured from an Unmanned Aerial Vehicle (UAV), also known as a drone.



0 1000 2000 3000 metres

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Title:

Location of experimental catchments.

Date:30 June 2020 Drawn by: Crouch Tia

Phase 1 image data capture

Originally, a Quest Q-200 fixed-wing UAV platform was going to be used. The Q-200 was supplied with a Sony A6000 DSLR camera for visible spectrum (RGB) images and a MicaSense RedEdge multispectral camera for multispectral images. The Sony A6000 has a ground resolution of 2.4 cm per pixel at 120 meters above ground level. The MicaSense RedEdge has 5 wavelength bands including Blue, Green, Red, Red Edge, and Near Infra-Red. Monochrome ground resolution is 8.2 cm per pixel at 120 meters above ground level. Both cameras can be carried by the Q-200 at the same time, allowing RGB and multispectral imagery to be captured simultaneously. However, due to issues with this platform, an alternate solution using sensors mounted on a senseFly eBee platform was adopted. The eBee can be flown independently with either a S.O.D.A. (Sensor Optimised for Drone Applications) or 'Parrot Sequoia' to collect RGB and 4-band (G, R, RE, NIR) imagery respectively. This approach requires two flights rather than one to capture both sets of imagery and must be flown lower (at approximately 60-70 m above the ground) to achieve comparable spatial resolution. This approach increases the number of flight lines required to capture the area and therefore increases image capture time.

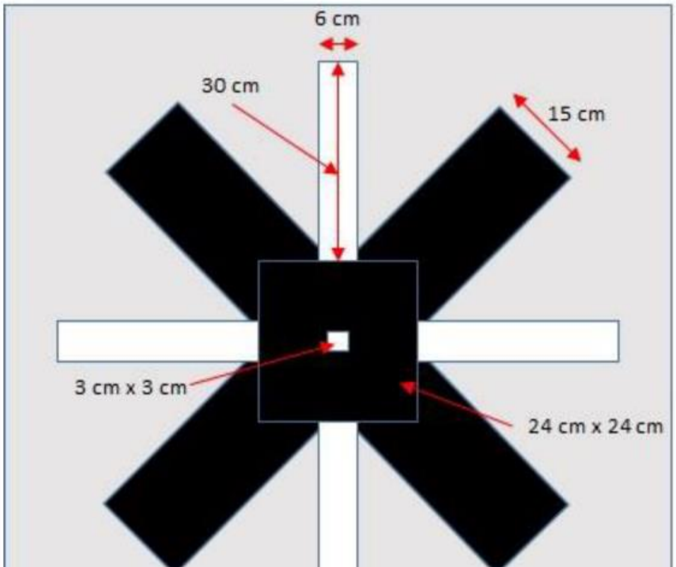
Phase 1 field data capture

In order to process UAV-derived imagery with the accuracy required, a number of ground control point (GCP) targets were positioned on the ground for each survey. The location of the GCPs was marked using a Trimble Geo 7X DGNSS, which besides being very user friendly, can achieve positional accuracy of *c.* 2-3 cm once the data has been post-processed. In order to classify aerial photographs into a land cover map using image classification software it is also necessary to have ground truth data for both image training and error determination. In 2018, the location of 'single species stands' of approximately 20 x 20 cm were recorded using the Trimble DGNSS. For each species, the survey team aimed to record a minimum of 20 samples per site. Usually, one day per site was spent conducting the ground survey. It was found that this method did not provide sufficient records, or spatial distribution. Despite the surveyors covering the whole site, the spatial distribution of records was clustered because single species stands occurred more frequently in gullies, while the vegetation on the tops was more mixed and therefore unsuitable for recording. As a result, image classification for phase 1 was undertaken using all available ground-truth data for image training, rather than adopting the standard procedure of retaining 50% for error determination. This prevented the comprehensive testing of protocols most suited for processing UAV imagery of these habitats.

senseFly eBee platform

Phase 1 results and lessons learned

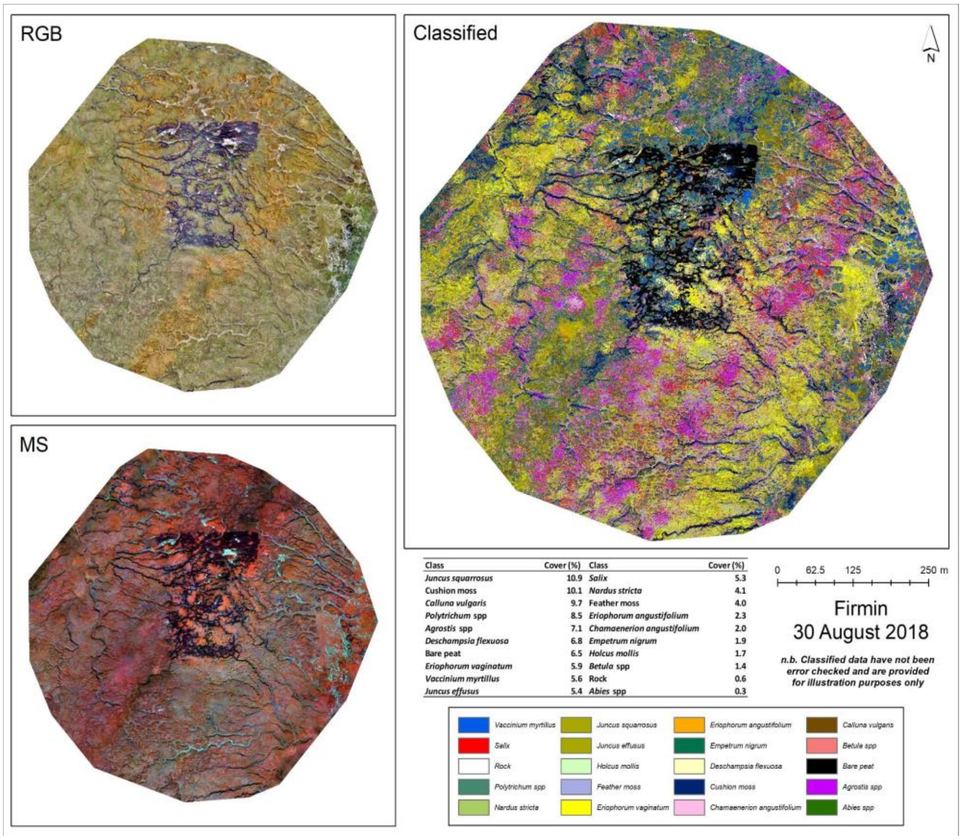
Phase 1 has delivered a first round of survey results and classified maps that contribute significantly to understanding the challenges, and possible benefits, associated with UAV image capture for large area monitoring. UAVs, at the altitudes to which they are restricted in the UK (120 m), produce high spatial resolutions but limited 'footprints' necessitating flying numerous flight-lines. As a result, the time required to cover even modest areas can be considerable. Over this period, light levels, colour balance and the angle of the sun are changing. During 2018, these issues were compounded by the need to fly each area twice using different sensors to provide the required RGB and multispectral imagery. However, appropriate GCP design, highly accurate GCP coordinates and well-distributed GCPs on each site enabled the imagery to be processed with a high spatial accuracy. The resultant RGB orthomosaics and DSMs therefore provide ultra-high resolution data covering the experimental plots and surrounding areas that can be used for visual assessment, hydrological modelling and potentially for identifying future morphological change (peat accumulation and erosion).



Multi-sensor ground control point target design

Trimble Geo 7X DGNSS

Phase 1 example of UAV imagery and classified map



Class	Cover (%)	Class	Cover (%)
Juncus squarrosus	10.9	*Salix*	5.3
Cushion moss	10.1	*Nardus stricta*	4.1
Calluna vulgaris	9.7	Feather moss	4.0
Polytrichum spp	8.5	*Eriophorum angustifolium*	2.3
Agrostis spp	7.1	*Chamaenerion angustifolium*	2.0
Deschampsia flexuosa	6.8	*Empetrum nigrum*	1.9
Bare peat	6.5	*Holcus mollis*	1.7
Eriophorum vaginatum	5.9	*Betula* spp	1.4
Vaccinium myrtillus	5.6	Rock	0.6
Juncus effusus	5.4	*Abies* spp	0.3

Phase 2 image data capture

Based on recommendations from phase 1, airborne photography was captured in phase 2 using manned aircraft via a contractor. Data from manned aircraft can be obtained at close to, and often better than, the resolution originally anticipated for the UAV capture so are essentially comparable from that aspect. Moreover, airborne photography can capture large areas 'in one go'. Images required to cover each MFFP experimental catchment and surrounding area are captured essentially instantaneously. This overcomes many of the potential concerns associated with the slow process required to 'build' coverage of large areas with UAVs. Airborne photography also removes risks to image capture associated with site access restrictions, for example during the bird breeding season. This increases the likelihood of finding 'windows' of good weather for flying. Equally importantly, use of airborne photography reduces surveyor time commitments, providing more time to conduct higher quality research and field work. The experimental catchments were flown by manned aircraft on 02/10/2019. Imagery was captured using an Ultracam Eagle 100 with a 100.5 mm lens at an altitude of 2400 m to yield an ultimate ground resolution of 10 cm in both axes. RGB and NIR bands were supplied fully ortho-corrected as 1 km^2 tiles (aligned with the Ordnance Survey National Grid) in TIFF format.

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Phase 2 field data capture

In 2019, every effort was made to increase the number and spatial distribution of vegetation survey samples. Each survey site was divided into approximately 100 grid squares. A circular area of approximately 30m radius in the centre of each survey grid square, the search locus, was searched for ‘single species stands’ of approximately 50 x 50 cm. One sample of each species was marked using the Trimble DGNSS at each search locus. A ‘running tally’ of each species was kept and additional samples recorded if species with a low number of records were observed in transit to each sample location. The overall aim of the sampling effort was to attempt to identify 100 examples of all species present at each study site. At the end of field survey the target of 100 samples at each site was only achieved for some species, either as a result of absolute scarcity or the lack of single stands of adequate size. Between 13 and 16 days per site was spent conducting the surveys.

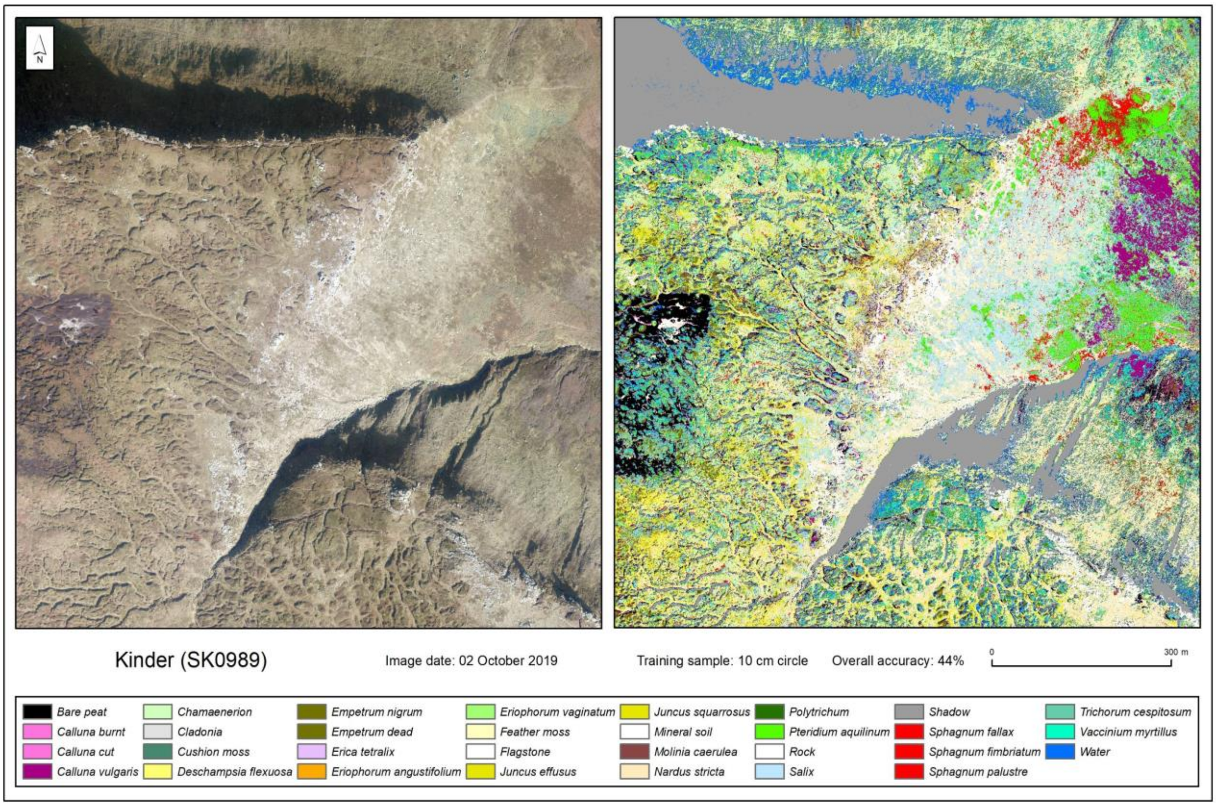
Phase 2 results and lessons learned

The extensive field survey effort to obtain ground truth for the survey provided 61 classes for image classification. A series of steps to systematically exclude samples and reduce class number were undertaken to assess the impact on classification accuracy. The overall classification accuracy achieved for all 61 classes was low (35%) and increased to only 46% in the most refined dataset comprising 23 classes.

The proximity of the survey sites to flight restriction zones for Manchester airport resulted in difficulties in flying the area within the specified period. As a result, imagery capture occurred much later in the year than specified, creating two issues with image quality. Firstly, very low sun angle led to a considerable impact from shadow within the images. Secondly, phenological development of many species was sub-optimal for classification i.e. some species were partly or fully senesced. Planning for future capture will explore ways to negate this issue.

However, using airborne imagery to address data acquisition requirements for mapping vegetation in the project appears to be an effective alternative to UAV derived imagery. We now have information on the ability to map the species present in the habitats and this can be used to inform the development of monitoring plans.

Phase 2 example of airborne imagery and classified map



What's next?

The experimental catchments were flown on 02/06/2020 by manned aircraft. The Covid-19 pandemic has resulted in a decline in air traffic; hence the difficulties in gaining permission from air traffic control experienced in 2019 were not an issue in 2020. Once these data have been analysed we will be able to see whether data captured at a more optimal time of year improves the accuracy of the classified maps. The MoorLIFE 2020 project has also been granted a 1-year extension. This means that we will have a further year of data capture in 2021.