Quantification of Birch and Bracken Encroachment on Heathland using Airborne Hyperspectral Imagery and Sentinel-2 Satellite Imagery

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Context

- British heathlands are valuable habitats for rare and vulnerable ground nesting birds .
- In Bedfordshire, forestry and agriculture led to the decline of heathland in the 1800s but the RSPB has been working on restoring dry heathlands at the Sandy Lodge Reserve since 2005.
- Extensive birch and bracken encroachment on heather makes restoration work difficult and fragments the landscape.
- Heather coverage and fragmentation degree are estimated in the field and heathland condition is reported to Natural England on an annual basis.

Objectives

- To classify heather, birch and bracken using spectral information.
- To quantify the respective coverage of each class.
- To carry out classification independently for both hyperspectral airborne data and multispectral satellite imagery and compare the outputs.

We believe that remote sensing could be successfully used to improve current estimates of heather coverage and fragmentation, while allowing for consistent and efficient monitoring.

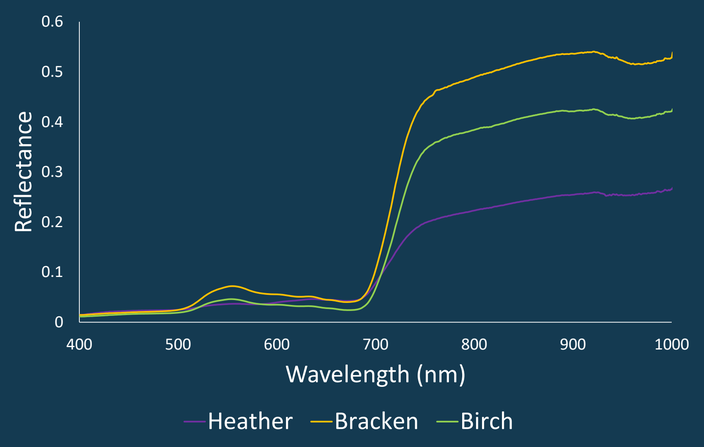

Figure 1. Average field spectra for heather (purple), birch (green) and bracken (yellow).

Figure 2. Overview of the RSPB Sandy Reserve with the two heathlands of interest.

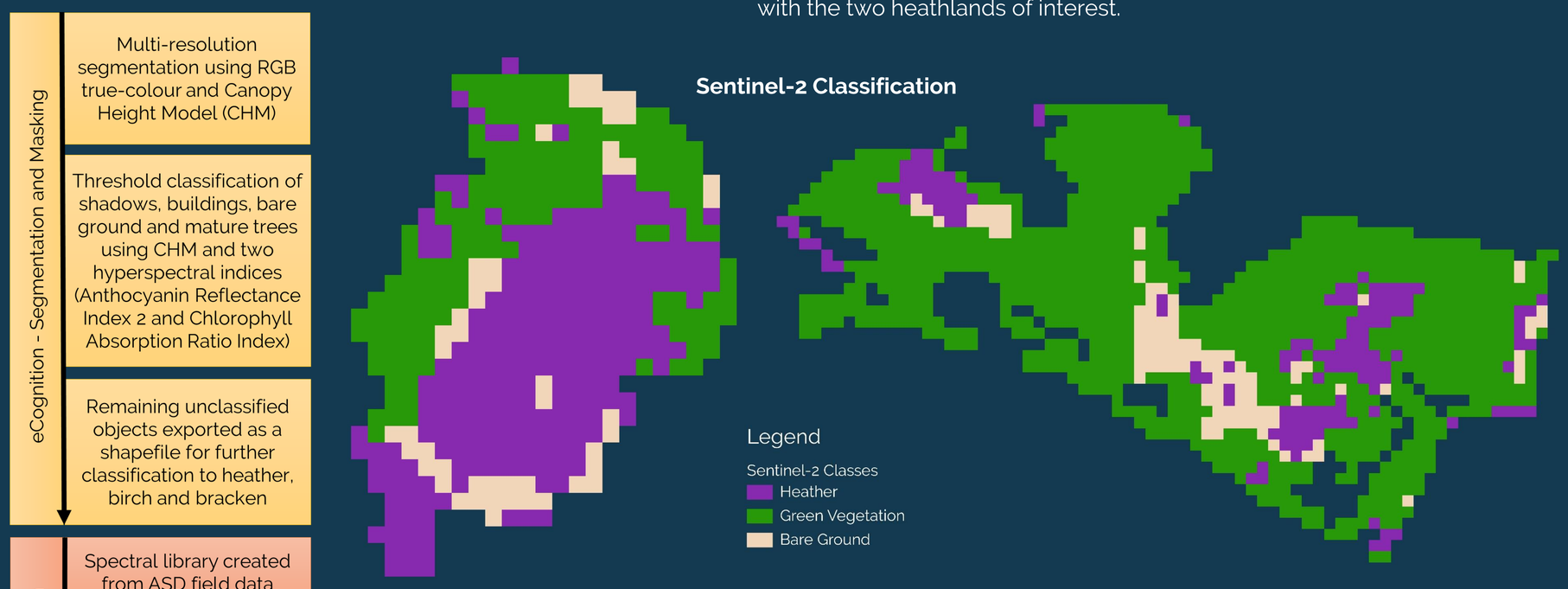

Figure 4. Methodology for classifying airborne hyperspectral data.

Figure 3. Sentinel-2 classified images for Heathland 1 (left) and Heathland 2 (right).

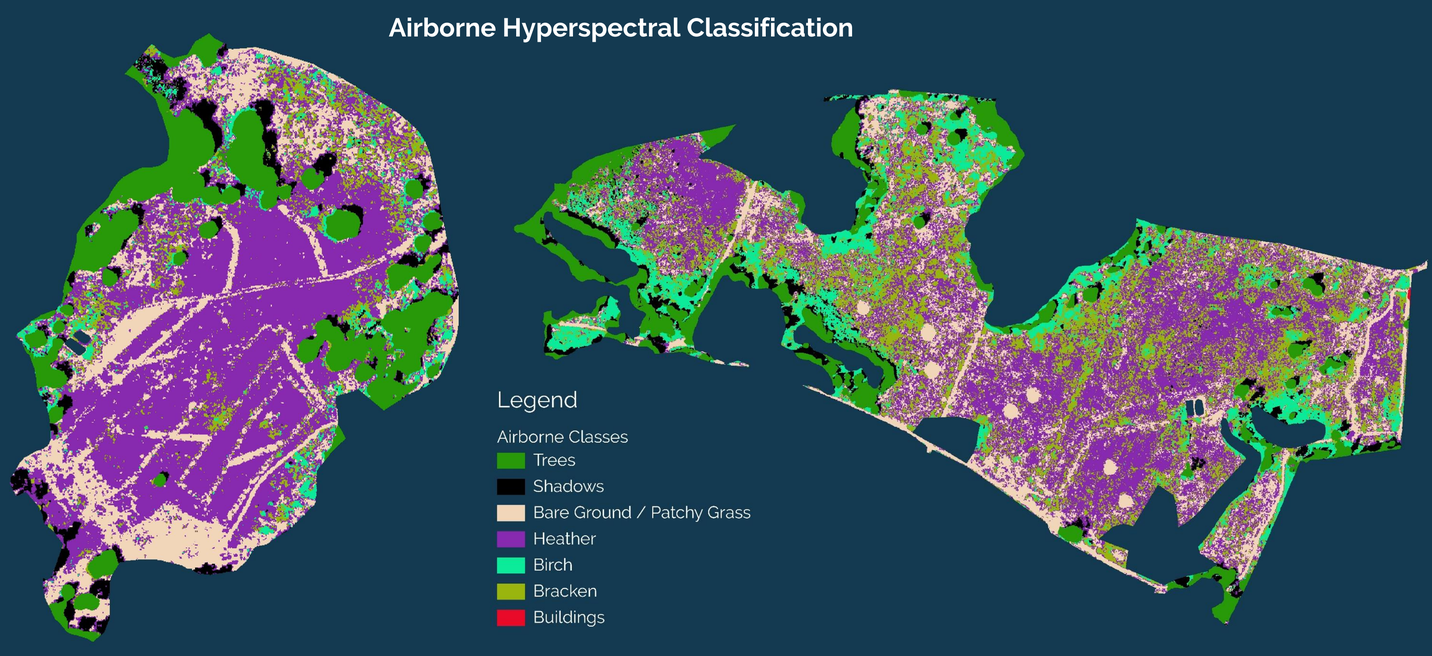

Figure 5. Airborne hyperspectral classified images using the SAM-scores for Heathland 1 (left) and Heathland 2 (right)

Data

- Processed Hyspex (VNIR 1800) and Phase One (iXA 180) airborne imagery from 26th June 2018 – RGB true-colour, DSM and hyperspectral (186 bands).
- Sentinel-2 L2A satellite imagery from 26th June 2018.
- Phase 1 Habitat Map manually updated from the RGB true-colour airborne Phase One imagery.
- Heather, birch and bracken canopy dual ASD field spectroscopy data collected from Sandy on 13th August 2019 (Fig. 1)

Methods and Results

- Heathlands were delineated using the Phase 1 map. Two areas were selected for analysis: heathland 1 was heather-dominated with little fragmentation, while heathland 2 was more complex to classify (Fig. 2).
- Sentinel-2 classification was carried out on a pixel-basis due to the low resolution. NDVI and NDI45 were calculated, and classification was achieved using thresholds for 3 classes only (Fig. 3).
- Hyperspectral airborne data was classified in 3 steps: 1) segmentation and masking, 2) pixel classification and 3) object classification (Fig. 4). This resulted in 7 classes (Fig. 5).
- Final classification maps were validated and class metrics were calculated (see the tables below).

Sentinel-2 Metrics

Heathland 1 Total Landscape Area: 44,297 m²

	Heather	Green Vegetation	Bare Ground
Area (m²)	23498	15899	4900
Total perimeter (m)	1900	1740	1080
Landscape %area	53	36	11
Perimeter-Area Ratio	0.08	0.11	0.22

Heathland 2 Total Landscape Area: 121,893 m²

	Heather	Green Vegetation	Bare Ground
Area (m²)	14499	96694	10699
Total perimeter (m)	2580	6940	1860
Landscape %area	12	79	9
Perimeter-Area Ratio	0.18	0.07	0.17

Airborne Hyperspectral Metrics

Heathland 1 Total Landscape Area: 33,722 m²

	Heather	Birch	Bracken	Bare Ground
Area (m²)	20418	1645	3231	8428
Total perimeter (m)	36010	9108	18719	17709
Landscape %area	61	5	10	25
Perimeter-Area Ratio	1.76	5.54	5.79	2.10

Heathland 2 Total Landscape Area : 96,717 m²

	Heather	Birch	Bracken	Bare Ground
Area (m²)	40291	13112	26783	16532
Total perimeter (m)	116066	34735	100946	49155
Landscape %area	42	14	28	17
Perimeter-Area Ratio	2.88	2.65	3.77	2.97

Conclusion

- The overall accuracy of heather classification for the airborne imagery was 95%, against 66% for Sentinel-2. For Heathland 1, both methods agreed well with the Phase One imagery, although Sentinel-2 could not detect the paths and smaller bracken/birch patches. Heathland 2 was more of a challenge because of its mosaic composition.
- The main difficulty using the airborne data was the distinction between young birch with sparse canopy and bracken (42% and 48% accuracy respectively). This was taken into account during the field collect and a wide variety of birch trees were sampled to mitigate for it. In contrast, Sentinel-2's resolution was too low and no CHM was available to distinguish between birch, bracken and other trees. It meant that results could not be directly compared to the airborne classification as only 3 classes were obtained.
- As expected, heather in Heathland 1 had a lower perimeter-area ratio than Heathland 2 for both airborne and satellite imagery, indicating less fragmentation. Comparison with the RSPB 2018 estimates is needed, as well as ground-truthing to validate the results.

References

- Greiwe, A. and Ehlers, M. (2012) Combined Analysis of Hyperspectral and High Resolution Image Data in an Object Classification Approach.
- Modified Copernicus Sentinel data 2019/Sentinel Hub.

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