SCAR fellowship report 2013/2014

Mapping lichens on the Antarctic Peninsula using remote sensing and photographic documentation by citizen scientists.

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Host: Prof. Peter Convey, British Antarctic Survey

Duration: June-July 2014

Introduction:

Most studies of Antarctic Peninsula (AP) flora have focused on a limited number of locations. The relative paucity of botanists working in Antarctica, combined with logistic limitations, makes traditional methods for studying biodiversity at a large-scale impractical. With new habitat exposed due to deglaciation and the increase in tourism in the area, cost-effective and pragmatic but reliable survey methods are needed to accelerate assessments of biodiversity.

Previous work using satellite remote sensing has shown that traditional approaches such as the Normalised Difference Vegetation Index (NDVI; Rouse *et al*., 1974) are difficult to apply in the Antarctic (Fretwell *et al*., 2011). It has already been recognized that any work using NDVI for the detection of vegetation might overlook the presence of lichens even if their land cover is extensive (Petzold and Goward, 1988). The reflectance spectra of lichens and vascular plants are different in both the visible near infrared (VNIR; 0.4 - 1 μm) and shortwave infrared (SWIR; 1 - 2.5μm) portions of the solar spectrum; in particular the depth of the visible – near-infrared step is characteristically smaller in lichens (Petzold and Goward, 1988; Haselwimmer and Fretwell, 2009). In the AP, where lichen contribution to vegetation diversity and extent increases in importance, NDVI would show decreasing spectral vegetation values, and areas completely covered with lichens could be erroneously classified as having sparse cover of vascular plants (Petzold and Goward, 1988). Because of the good development of

lichen-dominated communities in the Antarctic Peninsula, the potential of mapping their distribution directly by matching image pixel spectra with the reference spectra of lichens using a matched filtering algorithm (Harsanyi and Chang 1994) was used in this study. Such techniques have been widely used in lithological studies (e.g. Harris et al. 2005, Grebby et al. 2011), but have not before been applied for the mapping of lichens. This approach gives much improved information on sub-pixel vegetation cover, community extent and composition.

The monitoring of changes in the flora in the AP, where the areas available for new colonization are increasing, is crucial to understanding how the terrestrial ecosystem in this area will change over time.

Work undertaken and results:

Two different approaches were taken for mapping lichen distribution, at two different spacial and spectral resolutions, and with two different kinds of ground truthing. A large scale study, using 30 m resolution imagery and 8 bands imaging from 0.43 to 2.28 μm, and citizen collected data for 22 sites along the Antarctic Peninsula, allowed us to test a new remote sensing technique for the detection of lichens. Then, a small scale study, using 0.5 m resolution airborne imagery, with a total of 172 bands imaging from 0.4 to 2.5 μm and a land-based survey of vegetation presence, was used to test the same techniques at a very small scale.

The first approach used Landsat 7 and 8 imagery to estimate lichen distribution using a matched filter with lichen spectral data collected in the Antarctic. For ground truthing of this method, citizen collected data were used. We compared the performance of NDVI versus the matched filter analysis, and showed that the use of a matched filtering technique for lichens allowed for the detection of lichen flora in the Antarctic Peninsula, showing a significant improvement over NDVI for the mapping of flora in this area when using an NDVI threshold of 0.2 (conventionally taken to indicate the almost certain presence of vegetation, Fretwell et al. 2010). We also compared the performance of spectra from different species of lichens in the matched filtering technique. The results of this comparison suggest that studies based on the spectrum of only one species of lichen will be sufficient for mapping of lichen habitats in this environment, consistent with the conclusion of Zhang et al. (2008). Maps of lichen distribution

using the matched filtering technique for the entire Antarctic Peninsula were developed. The approach for mapping lichen cover in the Antarctic Peninsula proposed for this approach is an important step forward in the understanding of lichen distribution and can assist in the identification of areas for conservation. A manuscript with the results and conclusions of this part of the project is in review in the journal “Polar Research” (attached to this report is a copy of the manuscript).

The second approach used airborne hyperspectral data that were collected using ITRES Research Ltd. CASI-1500 and SASI-600 imaging spectrometers from Lagoon and Kirsty Islands (67^{o} 35' S, 68^{o} 16' W), in the Ryder Bay area off Adelide Island, in February 2011. As ground truthing, we used 17 of the 19 sites (10 x 10 m each) for which the presence of lichens was confirmed in the field (Figure 2). We compared the areas where the lichen filter showed presence of lichens and areas where NDVI values were greater than 0.2. These data confirm the results from the previous approach, that the use of a matched filtering technique allows for the detection of lichen flora, showing a considerable improvement over NDVI for the mapping of flora in this area. These results were presented at the Remote Sensing and Photogrammetry Society Conference in September 2014, and were awarded the first place for the paper/poster prize (attached to this report is a copy of the conference proceedings paper, and the poster presented). Following the success of this study, a manuscript is in preparation for the journal “Remote sensing of Environment”. This manuscript further explores the possibility of estimating vegetation diversity from the remote sensed imagery.

Manuscripts and presentation at professional meeting:

Paula Casanovas, Martin Black, Peter Fretwell, Peter Convey. Mapping lichen distribution on the Antarctic Peninsula using remote sensing, lichen spectra and photographic documentation by citizen scientists. In review at Polar Research.

Martin Black, Paula Casanovas, Andrew Fleming, Peter Fretwell and Peter Convey. Mapping of Antarctic lichen communities using high resolution hyperspectral data. Manuscript in preparation for Remote Sensing of Environment.

Martin Black, Paula Casanovas, Peter Convey, and Peter Fretwell. 2014. High resolution mapping of Antarctic vegetation communities using airborne hyperspectral data. RSPSoc 2014, 2-5th September 2014, Aberystwyth, UK. Granted **First Place** for the Poster Paper Prize by the Remote Sensing and Photogrammetry Society.

Financial statement:

All funds granted for this fellowship (US$12000, approximately £7000 at the time of the fellowship) were used for travel to the British Antarctic Survey in Cambridge, UK, from the fellow's place of residence (Falkland Islands), accommodation, transportation and living expenses during her stay in Cambridge.

Acknowledgements:

I would like to thank Martin Black and Peter Fretwell especially for all their help during this project, and Pete Convey, as he was excellent mentor for this project. Hyperspectral data used were collected during an airborne survey funded by the UK Foreign and Commonwealth Office and conducted by the British Antarctic Survey, ITRES Research Ltd. (http://www.itres.com) and Defence Research & Development Suffield, Canada (http://www.drdc-rddc.gc.ca) in February 2011. Martin Black is funded by a Natural Environment Research Council (NERC) PhD studentship in conjunction with the British Antarctic Survey and the University of Hull (NERC Grant: NE/K50094X/1). Fieldwork was supported by an Antarctic Funding Initiative CGS grant (CGS-086) and a spectrometer loan from the NERC Field Spectroscopy Facility (FSF Loan No.: 675.0613). Paula Casanovas was supported by the SCAR fellowship scheme 2013-14.

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