Evaluating Hyperspectral Imagery for Mapping the Surface Symptoms of Dryland Salinity

by

Anna Dutkiewicz

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ABSTRACT

Airborne hyperspectral imagery has the potential to overcome the spectral and spatial resolution limitations of multispectral satellite imagery for monitoring salinity at both regional and farm scales. In particular, saline areas that have good cover of salt tolerant plants are difficult to map with multispectral satellite imagery. Hyperspectral imagery may provide a more reliable salinity mapping method because of its potential to discriminate halophytic plant cover from non-halophytes.

HyMap and CASI airborne imagery (at 3m ground resolution) and Hyperion satellite imagery (at 30 resolution) were acquired over a 140 sq km dryland agricultural area in South Australia, which exhibits severe symptoms of salinity, including extensive patches of the perennial halophytic shrub samphire *(Halosarcia pergranulata)*, sea barley grass *(Hordeum marinum)* and salt encrusted pans. The HyMap and Hyperion imagery were acquired in the dry season (March and February respectively) to maximise soil and perennial vegetation mapping. The optimum time of year to map sea barley grass, an annual species, was investigated through spectral discrimination analysis.

Multiple reflectance spectra were collected of sea barley grass and other annual grasses with an ASD Fieldspec Pro spectrometer during the September spring flush and in November during late senescence. Comparing spectra of different species in November attempted to capture the spectral differences between the late senescing sea barley grass and other annual grasses. Broad NIR and SWIR regions were identified where sea barley grass differs significantly from other species in November during late senescence. The sea barley grass was therefore shown to have the potential to be discriminated and mapped with hyperspectral imagery at this time and as a result the CASI survey was commission for November. Other salinity symptoms were characterised by collecting single field and laboratory spectra for comparison to image derived spectra in order to provide certainty about the landscape components that were to be mapped.

Endmembers spectra associated with saltpans and samphire patches were extracted from the imagery using automated endmember generation procedures or selected regions of interest and used in subsequent partial unmixing. Spectral subsets were evaluated for their ability to optimise salinity maps. The saltpan spectra contained absorption features consistent with montmorillonite and gypsum. A single gypsum endmember from one

image strip successfully mapped saltpans across multiple images strips using the 1750 nm absorption feature as the input to matched filter unmixing. The individual spectra of green and red samphire are dominated by photosynthetic vegetation characteristics. The spectra of green samphire, often seen with red tips, exhibit peaks in both green and red wavebands whereas the red samphire spectra only contain a significant reflectance peak in the visible red wavelength region.

For samphire, Mixture Tuned Matched Filtering using image spectra, containing all wavelength regions, from known samphire patches produced the most satisfactory mapping. Output salinity maps were validated at over 100 random sites. The HyMap salinity maps produced the most accurate results compared to CASI and Hyperion.

HyMap successfully mapped highly saline areas with a good cover of samphire vegetation at Point Sturt without the use of multitemporal imagery or ancillary data such as topography or PIRSA soil attribute maps. CASI and Hyperion successfully mapped saltpan, however, their samphire maps showed a poor agreement with field data. These results suggest that perennial vegetation mapping requires all three visible, NIR and SWIR wavelength regions because the SWIR region contains important spectral properties related to halophytic adaptations. Furthermore, the unconvincing results of the CASI sea barley grass maps suggests that the optimal sensor for mapping both soil and vegetation salinity symptoms are airborne sensors with high spatial and spectral resolution, that incorporate the 450 to 1450 nm wavelength range, such as HyMap.

This study has demonstrated that readily available software and image analysis techniques are capable of mapping indicators of varying levels of salinity. With the ability to map symptoms across multiple image strips, airborne hyperspectral imagery has the potential for mapping larger areas covering sizeable dryland agriculture catchments, closer in extent to single satellite images. This study has illustrated the advantage of the hyperspectral imagery over traditional soil mapping based on aerial photography interpretation such as the NLWRA Salinity 2000 and the PIRSA soil landscape unit maps. The HyMap salinity maps not only improved mapping of saline areas covered with samphire but also provided salinity maps that varied spatially within saline polygons.

DECLARATION

This work contains no material which has been accepted for the award of any other degree or diploma in any university or other tertiary institution and, to the best of my knowledge and belief, contains no material previously published or written by another person, except where due reference has been made in the text.

I give consent to this copy of my thesis being available for loan and photocopying.

Signed:……. Date:……..

Anna Dutkiewicz

DEDICATION

This thesis is dedicated to my entire family: to my mother Joan, for her infinite humanity, my father Wladyslaw who taught me that life is about the passionate pursuit of what you believe in, to my brother Michal for his love of the natural world and creative enthusiasm, my brother Adam for not settling on mediocrity in life, my sisters Ursula for her inspiration to believe in yourself and Cecilia, who taught me patience, forgiveness and personal strength. Thanks to Aislinn for giving me so much joy and being so understanding, and to Brian for his generosity, support and encouragement.

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PUBLICATIONS

Refereed Publications

A. Dutkiewicz and M. Lewis, 2004, Can sea barley grass be mapped with remote sensing imagery? In *Proceedings of Salinity Solutions: Working with Science and Society Conference*, Bendigo, Victoria, August 2004.

A. Dutkiewicz, M. Lewis, B. Ostendorf, 2003, Evaluation of hyperspectral imagery for mapping the symptoms of dryland salinity, In *Proceedings of Spatial Sciences Coalition Conference*, Canberra, ACT, Sept 2003.

Other Publications

A. Dutkiewicz and M. Lewis, 2004, Spectral discrimination of sea barley grass and the implications for mapping salinity with hyperspectral imagery, In *Proceedings of Australian Remote Sensing and Photogrammetry Conference* (ARSPC), Fremantle, WA, October, 2004