

**Evaluating Hyperspectral Imagery
for Mapping the Surface Symptoms of Dryland Salinity**

by

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TABLE OF CONTENTS

TABLE OF CONTENTS	iii
LIST OF FIGURES	vii
LIST OF TABLES	xiii
ABSTRACT	xv
ABSTRACT	xv
DECLARATION	xvii
DEDICATION	xviii
ACKNOWLEDGEMENTS	xix
PUBLICATIONS	xxi
1 INTRODUCTION	1
1.1 The problem of dryland salinity	2
1.2 The surface symptoms of dryland salinity	2
1.3 Conventional mapping and monitoring dryland salinity	5
<i>1.3.1 Aerial photography</i>	<i>6</i>
<i>1.3.2 Geophysical mapping of subsurface salinity</i>	<i>7</i>
<i>1.3.3 Multispectral remote sensing of surface expressions of salinity</i>	<i>7</i>
1.4 The advantage of high spectral resolution imagery	10
<i>1.4.1 Spectral response of plants</i>	<i>11</i>
<i>1.4.2 Effects of stress and senescence on plant spectral response</i>	<i>12</i>
<i>1.4.3 Spectral variation between plant groups and species</i>	<i>12</i>
<i>1.4.4 Spectral characteristics of soils</i>	<i>14</i>
1.5 The potential of hyperspectral imagery to map dryland salinity	15
1.6 Conclusion	16
1.7 Research aims	17
1.8 Significance	18
1.9 Thesis outline	19
2 CHARACTERISING SALINITY AT POINT STURT	21
2.1 Introduction and aims	21
2.2 Study Site	21
<i>2.2.1 Climate</i>	<i>22</i>

2.2.2	<i>Landscape and hydrogeology</i>	22
2.2.3	<i>History</i>	23
2.2.4	<i>Present landuse and vegetation</i>	24
2.2.5	<i>PIRSA soil maps</i>	25
2.2.6	<i>National Land and Water Resources salinity map</i>	27
2.2.7	<i>Landsat ETM dryland salinity maps</i>	28
2.3	Field methods	29
2.3.1	<i>Identifying surface expressions of salinity</i>	29
2.3.2	<i>Soil sampling</i>	30
2.3.3	<i>Salinity and soil water content</i>	32
2.3.4	<i>Soil mineralogy</i>	32
2.4	Results	33
2.4.1	<i>Saline soils</i>	33
2.4.2	<i>Vegetation symptoms of salinity</i>	38
2.5	Conclusion	41
3	SPECTRAL CHARACTERISATION OF SALINITY	43
3.1	Introduction and aims	43
3.2	Methods	44
3.2.1	<i>Spectral collection sites</i>	45
3.2.2	<i>Time of year</i>	45
3.2.3	<i>Collection of soil and vegetation spectra</i>	45
3.2.4	<i>Statistical analysis</i>	48
3.3	Results and discussion	48
3.3.1	<i>Spectral characteristics of saline soils</i>	48
3.3.2	<i>Spectral characteristics of perennial species</i>	50
3.3.3	<i>Statistical comparisons of grass species</i>	51
3.4	Conclusion	55
4	MAPPING SALINITY SYMPTOMS WITH HYMAP HYPERSPECTRAL IMAGERY	57
4.1	Introduction and aims	57
4.2	HyMap imagery	59
4.3	Hyperspectral processing and mapping	61
4.3.1	<i>Preprocessing: atmospheric and cross track illumination correction</i>	62
4.3.2	<i>Hyperspectral image analysis</i>	63
4.4	Accuracy Assessment	66
4.5	Results and Discussion	67
4.6	Conclusion	77

5	MAPPING SALINITY SYMPTOMS WITH HYPERION SATELLITE IMAGERY	79
5.1	Introduction and aims	79
5.2	Analysis of Hyperion imagery	81
	5.2.1 <i>Hyperion data</i>	81
	5.2.2 <i>Specialised image pre-processing for Hyperion imagery</i>	83
	5.2.3 <i>Standard hyperspectral processing methods</i>	86
5.3	Results	87
5.4	Conclusions	92
6	MAPPING SALINITY SYMPTOMS WITH CASI AIRBORNE IMAGERY	95
6.1	Introduction and aims	95
6.2	CASI survey and data specifications	97
6.3	CASI data pre-processing methods	98
6.4	Salinity symptom mapping with CASI imagery	100
	6.4.1 <i>Endmember extraction</i>	102
	6.4.2 <i>Partial unmixing mapping of sea barley grass and samphire</i>	102
	6.4.3 <i>Saltpan partial unmixing mapping methods</i>	102
6.5	Accuracy Assessment	104
	6.5.1 <i>Samphire and saltpan maps</i>	104
	6.5.2 <i>Sea barley grass maps</i>	104
6.6	Results of partial unmixing mapping	105
6.7	Discussion and Conclusions	110
7	COMPARISON OF HYPERSPECTRAL AND CONVENTIONAL SALINITY MAPS	113
7.1	Introduction and aims	113
7.2	Methods	113
7.3	Results	114
	7.3.1 <i>Comparison to PIRSA salinity maps</i>	114
	7.3.2 <i>Comparison to NLWRA dryland salinity map</i>	119
	7.3.3 <i>Comparison to Landsat based salinity maps</i>	120
7.4	Conclusion	121
8	DISCUSSION AND CONCLUSION	125
8.1	Review of results	125
	8.1.1 <i>Surface symptoms of dryland salinity selected for mapping with hyperspectral imagery</i>	125
	8.1.2 <i>Optimum time of year for mapping</i>	126
	8.1.3 <i>Comparison of different hyperspectral imagery</i>	127

8.1.4	<i>Analysis of multiple image swaths</i>	128
8.1.5	<i>Mapping salinity with Hyperion satellite imagery</i>	130
8.1.6	<i>Mapping accuracies</i>	130
8.1.7	<i>Optimum processing procedure for vegetation and soil symptoms of salinity</i>	133
8.2	Limitations	134
8.3	Significance of findings	135
8.3.1	<i>Optimal time of year for mapping salinity</i>	135
8.3.2	<i>Image analysis and multiple swath mapping</i>	136
8.3.3	<i>Comparison of different sensors</i>	136
8.3.4	<i>Mapping saline areas with vegetation cover</i>	137
8.3.5	<i>Improvements on conventional salinity mapping</i>	137
8.4	Implications of hyperspectral salinity mapping	138
9	REFERENCES	141
	APPENDIX 1	157
	APPENDIX 2	158
	APPENDIX 3	169

LIST OF FIGURES

Figure 2-1 Point Sturt Peninsula is located at the mouth of the Murray River in South Australia.....	21
Figure 2-2 Monthly mean rainfall (top) and temperature (bottom) from 1989 to 2003 (from Hindmarsh Island immediately south of Point Sturt). Data from the Bureau of Meteorology [http://www.bom.gov.au/].....	22
Figure 2-3 Hydrogeological map of Point Sturt Peninsula showing the boundary between the clay and limestone aquifers (dashed line), major recharge areas (after Henschke (2000)) and elevation contours.	23
Figure 2-4 Mosaic of three aerial photographs taken in 1956 of Point Sturt (courtesy of Department of Environment and Heritage, Mapland, South Australia). The land had been extensively cleared by this time. At the time there were significant areas of remnant vegetation in the west and little vegetation on the bare dune ridges just north of the site where the township of Clayton later developed. White exposed soils are visible throughout the peninsula.....	24
Figure 2-5 PIRSA salinity induced by watertable map showing salinity classes associated with each soil landscape unit. Note that Class E (moderately high to high salinity) was is not represented on the Point Sturt Peninsula.	27
Figure 2-6 The National Land and Water Resources Audit extent of land affected by salinity in 2000 (Salinity 2000) was obtained from the Australian Natural Resources Atlas [http://audit.ea.gov.au/anra/atlas_home.cfm].	28
Figure 2-7 Map of <i>severely saline areas</i> (red) based on Landsat ETM imagery and spatial modelling (Thomas, 2001).	29
Figure 2-8 Map of showing 4 main saline sites. The clay aquifer discharges at Sites A, AA and F whereas the limestone aquifer discharges at Site B.	30
Figure 2-9 Detail of Site A showing GPS locations where surface and depth soil samples (red) were collected. The soil transect (black) extended north from the samphire, across the sea barley grass and terminating on a rise covered with non-halophytic grass.	31
Figure 2-10 Symptoms of high to extreme salinity at Point Sturt during the dry season: a) plant dieback; b) dead trees; c) samphire (<i>Halosarcia pergranulata</i>), and marine	

couch grass (<i>Sporobolus virginicus</i>); d) red phase samphire; e) saltpan at Site A and f) pigface (<i>Carpobrotus glaucescens</i>).....	34
Figure 2-11 a) Saltpan soil pit (Site A1) showing the leached upper horizon grading to iron oxide dominated lower horizon at 30 cm and b) the downward view illustrates the shallow groundwater seeping into the pit at a depth of 60 cm, shortly after digging was completed.	35
Figure 2-12 Soil analysis along transect extending out from saltpan at Site A. EC values, soil moisture and pH decreased away from the samphire-sea barley grass interface (0 m) indicating the change from high salinity to non-saline soils.	38
Figure 2-13 Dense large zones (left) of sea barley grass (<i>Critesion marinum</i>) with well developed seed heads (right) were evident during spring (September 2004)	39
Figure 2-14 Moderately saline area at Site AA (November 2003). Green sea barley grass (a) and curly rye grass (b) have colonised the lowlying saline soil. Silver grass and brome grass (c and d) surround the pan. Close-up images of the 4 major grass species are inset.	40
Figure 3-1 Collecting spectra in the field with the portable spectrometer	46
Figure 3-2 Schematic diagram of the field of view (~5cm) of the spectrometer	46
Figure 3-3 Method for collecting spectra from soil and plant samples in the laboratory	47
Figure 3-4 Comparison of salt crust spectra from Site A and Site B	49
Figure 3-5 Continuum removed salt crust spectra from Site A, Site B and USGS gypsum spectra.	49
Figure 3-6 Field spectra of green samphire.....	50
Figure 3-7 Field spectra of red samphire	50
Figure 3-8 Detail showing green and red samphire reflectance peaks.....	50
Figure 3-9 Comparison of dryland lucerne and samphire spectra	50
Figure 3-10 Mean spectra of sea barley grass and brome grass at the time of maximum growth or “spring flush” (September)	51

Figure 3-11 “Spring flush” t values by wavelength for pairs of comparisons between mean spectra of sea barley grass and brome grass. There is no significant difference at any wavelengths.....	52
Figure 3-12 Mean spectra acquired at the time of senescence (November) of four grass species: a) field spectra; b) laboratory spectra.....	52
Figure 3-13 T-values by wavelength comparing the mean spectra of sea barley grass to non-halophytic grass species. The spectra differ significantly where $t > t_{critical}$, equivalent to a probability=0.05. There are consistently significant differences at most wavelengths except at the red edge around 700 nm.	54
Figure 4-1 Mosaic of six parallel hyperspectral image strips displayed in true colour, covering approximately 140 km ² . The locations of study Sites A & B are also displayed.	60
Figure 4-2 Daily rainfall prior to the acquisition of HyMap imagery on 14 March 2001. There was only one major rainfall event one month before.	61
Figure 4-3 Selection of endmembers extracted from one image strip. Similar endmembers from the same landcover types (for example more irrigated and dry vegetation) were not displayed.	68
Figure 4-4 Comparison of samphire endmember (dashed) and samphire mean spectrum (solid). The ROI spectrum was generated from a region that encompassed a known samphire patch.	69
Figure 4-5 Detail of soil image-derived endmember spectra. The absorption features correspond to USGS minerals spectra of a) gypsum b) calcite 3) montmorillonite or kaosmectite	70
Figure 4-6 MF gypsum map where bright areas, indicating areas of high gypsum abundance, coincide with the location of known saltpans.....	72
Figure 4-7 Samphire map comprising georeferenced MTMF results of 4 image strips. Bright pixels indicated areas of high abundance.	73
Figure 4-8 Saltpans were mapped at Site A and B with HyMap imagery. Matched filtering discriminated the highly saline soils of the saltpan from the non-saline dunes and quarries.....	74

Figure 4-9 Samphire was mainly mapped along the coast and surrounding the major saltpan at Site A and in the central discharge area.	74
Figure 4-10 Optimum processing flow for mapping multiple HyMap image swaths	75
Figure 5-1 Daily rainfall prior to the acquisition of Hyperion imagery on 18 February 2002. There is only one major rainfall event one month before.	82
Figure 5-2 Hyperion raw image swath.....	83
Figure 5-3 Hyperion strip spatially subset to the Point Sturt area (georegistered true colour)	84
Figure 5-4 A representative selection of endmembers extracted from the Hyperion image. Noisy endmembers are not displayed.....	87
Figure 5-5 Processing flow for Hyperion data.	88
Figure 5-6 MTMF result using mean samphire reference spectrum. The samphire around the central salt pans (red square) and along the coast was successfully mapped.	90
Figure 5-7 MTMF result using mean saltpan reference spectrum. Bright salt pans are dispersed throughout the central and coastal discharge areas. The main Site A pan is not clearly mapped.	90
Figure 5-8 Saltpan (top) and samphire (bottom) maps are displayed in GIS layout. Several salt pans throughout the discharge regions are also successfully mapped. The central and coastal samphire areas are well defined.	91
Figure 6-1 Mosaic of seven CASI image swaths	98
Figure 6-2 Daily rainfall six months prior to the acquisition of CASI imagery on 25 November 2003. There are fewer rainfall events in November.	98
Figure 6-3 CASI image spectra before (left) and after (right) ACORN atmospheric correction. The spectrum on the right clearly shows the prominent overcorrection around 940 nm.....	99
Figure 6-4 Example of CASI spectra after atmospheric correction with FLAASH. In the saline soil spectra note the small 740 nm peak and the smaller overcorrection rise around 940 nm.....	100

Figure 6-5 Two irrigated vegetation spectra 1) inverse-MNF spectra with MNF bands 2&5 excluded showing the increase in red reflectance (dotted) and 2) inverse-MNF spectra with no across track illumination bands removed (solid line).....	101
Figure 6-6 Endmember spectra from swath 710.....	103
Figure 6-7 Salinity symptom mapping flow	106
Figure 6-8 CASI salinity symptoms map at Point Sturt. Many mapped saltpans (blue) and samphire (cyan) were confined to the central and coastal saline areas. Sea barley grass (yellow) mapped areas were more sparsely distributed adjacent saline areas.....	107
Figure 6-9 Detail of salinity symptom maps overlain with the PIRSA SLU polygons. The black dotted line shows a discontinuity in mapping saltpans across 2 image swaths	109
Figure 6-10 Zonal statistics showing the % area of sea barley grass, samphire and saltpans mapped in nonsaline and saline areas defined in the PIRSA SLU maps.....	109
Figure 7-1 PIRSA salt affected areas overlaid with the salinity maps produced from a) HyMap, b) Hyperion and c) CASI hyperspectral data (with image extent outlined in red).	117
Figure 7-2 HyMap: Samphire and saltpans were mapped in 21.5% of the high salinity SLUs (class F) and 13.7% of the very high to extreme salinity SLUs (class G).....	118
Figure 7-3 Hyperion: samphire and saltpans were mapped in 26% of the high saline areas (SLUs class F) and 24.8% of the very high to extremely saline (SLUs class G). More saltpans and samphire were mapped in low saline SLUs compared to HyMap .	118
Figure 7-4 CASI: samphire and saltpans were mapped in 20.6% of the highly saline areas and 15.9% of the very high to extremely saline areas. The highest proportion of sea barley grass was mapped in moderately saline areas. A high proportion of sea barley grass was also mapped in non-saline areas.	118
Figure 7-5 Detail of HyMap salinity symptom (Site A) overlaid with PIRSA Soils Landscape Units attribute of salinity induced by watertable	119
Figure 7-6 NLWRA dryland salinity 2000 map overlain with the HyMap samphire and saltpans maps.	120

Figure 7-7 Detail of the NLWRA dryland salinity 2000 map and the HyMap salinity maps overlying the true colour HyMap image. The HyMap image analysis was better able to map saline land with a good cover of samphire vegetation along the central and southern coasts. 120

Figure 7-8 a) Map of *severely saline areas* (red) based on Landsat ETM imagery (source (Thomas, 2001) previously presented in Chapter 2) b) compared to the HyMap saltpan and samphire maps (bottom)..... 122

Figure 8-1 Comparing the optimum processing flow for mapping vegetation (a) and soil (b) symptoms of dryland salinity. 134

LIST OF TABLES

Table 2.1 PIRSA soil landscape unit description of salinity levels. Sea barley grass would be mainly expected to occur in the moderate to moderately high salinity level areas and samphire and salt pans in the very high to extreme areas (after Maschmedt, 2000).	26
Table 2.2 PIRSA soil landscape unit attribute that refers to <i>salinity induced by watertable</i> levels. This attribute is designated 7 salinity classes A-G, where A is assigned to soil polygons with negligible salinity and G is assigned to extremely saline polygons (After PIRSA, 2001). Descriptions of salinity levels, from negligible to extreme, are shown in Table 1.	26
Table 2.3 Analysis of three surface soil samples from the main salt pans at Site A and B. The surface layer of crystals at Site B is halite.	35
Table 2.4 Soil analysis of samples collected at 10 cm depths from salt pan at Site A. The pH and EC measurements indicate extremely saline, alkaline soil. The higher values at the surface indicated the surface evaporative concentration of the groundwater salts. The XRD results confirm the presence of the evaporite minerals halite and gypsum....	36
Table 2.5 Soil analyses at 10 cm depths from 2 other sample sites on the main Site A salt pan. These soils also show the increased salinity at the surface due to evaporation. No XRD analysis was performed.	37
Table 2.6 Soil analysis from three soil transect samples. Soil water EC and pH all decrease at increasing distance from the samphire-sea barley grass interface. The XRD analysis shows the change from clay to sandy soils along the transect. Soil analysis results for all transect soil samples are shown in Figure 2.12.	37
Table 2.7 Summary of salinity symptoms at Point Sturt and their suitability for mapping with hyperspectral imagery.....	42
Table 3.1 Species and number of samples of spectra collected in September (spring flush). Some samples were not analysed because of excessive noise *	47
Table 3.2 Species and number of samples of spectra collected in November. The field spectra of wheat were not used because insufficient good quality spectra were collected*	47

Table 4.1 Partial unmixing mapping tests on image swath 03. Matched filtering produced the most accurate maps (KHAT=0.67) when using the gypsum 1750 nm feature.....	71
Table 4.2 a) Error Matrix for the samphire map (129 sample sites over 4 image strips)	76
Table 5.1 Comparison of Hyperion and HyMap salinity mapping accuracies. Salt pans maps from both sensors showed a moderate agreement with field data however, Hyperion samphire maps showed poor agreement compared to HyMap	93
Table 6.1 PIRSA SLU attribute “salinity induced by watertable” is assigned 8 classes A-G (after (PIRSA, 2001A)).	105
Table 6.2) Error Matrix for the samphire map (133 sample sites over 6 image swaths)	108
Table 6.3) Error Matrix for the saltpan map (138 sampling sites over 7 image swaths)	108
Table 7.1 Expected salinity symptoms associated with each PIRSA SLU “salinity induced by watertable” class (after (PIRSA, 2001A) and Maschmedt, 2001). Sea barley grass would be mainly expected to occur in the moderate to high levels of salinity and samphire in the high to extreme areas (Classes F and G). *Class E was not represented at Point Sturt.....	114
Table 8.1 Hyperspectral imagery was acquired from 3 different sensors: 2 airborne and one satellite instrument. The HyMap and Hyperion data was captured during the dry season and the CASI imagery was captured during spring senescence.	128
Table 8.2 Summary of salinity symptoms mapped with HyMap, CASI and Hyperion imagery. Salinity levels are based on PIRSA classifications.....	132

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

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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