Mapping, Modelling and Remote Sensing Buffel grass *(Cenchrus ciliaris)* Infestations in Arid Australia

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ABSTRACT

Invasive plants pose a serious threat to ecological, environmental and cultural values of infested regions and can be costly to control. Grass invasions are particularly concerning because they can alter wildfire regimes and change ecosystem function and structure at a global scale. Mapping, monitoring, and understanding invasive species ecology sufficiently to identify habitats prone to invasion are important for containment of the invasive plant. To this effect, remote sensing and spatial information science can be useful.

In arid and semi-arid rangelands worldwide African perennial Buffel grass *(Cenchrus ciliaris L.)* has been introduced to improve pasture. However, it has become contentious because it can rapidly invade and transform non-target landscapes. Most research into Buffel grass relates to its agricultural uses, and little is known about the invasive ecology of the species. There is a need to consolidate existing knowledge, as well as map the current distribution, model potential distribution and improve efficiency in the detection of new infestations in remote landscapes. This research addresses these needs by developing and applying techniques from the spatial sciences to map and model Buffel grass distribution in remote, arid Australia.

For controversial invasive species like Buffel grass, awareness about the ecological dangers of allowing spread to continue unchecked is important. Here, a new, comprehensive review is presented of the ecology, distribution and biodiversity impacts of Buffel grass when behaving as an invasive species. Importantly, this review also lays foundations for research into localised habitat requirements, setting the scene for all subsequent components of this research. The review reveals that temperature is a primary limitation to distribution at a global scale, soil texture may be a significant habitat parameter at localised scales and disturbance is required for seedling emergence. It is strongly suspected that Buffel grass fuelled fires are responsible for declining numbers of characteristic arid plants, the Saguaro Cactus (Arizona, USA) and the River Red Gum (Australia), and worldwide, arid landscapes stand out as requiring urgent control.

The distribution of Buffel grass in invaded landscapes in arid southern Australia is not explicitly known. Over 3100 km of South Australian roads were surveyed to document current Buffel grass distribution in collaborative work with government. The

grass was found to be wide ranging along major highways, but was mostly only sparsely distributed.

Empirical modelling of species' distribution helps identify local environments that may be prone to invasion, and is becoming an increasingly important step in effective management planning. Buffel grass roadside survey data were used in an exploratory regression analysis to identify environmental parameters of the species' distribution across regional South Australia. Roadside populations were recorded separately from populations away from the road on adjacent land and considered as separate dependant variables for predictive modelling. The models return strong results and on the basis of these we make management recommendations that containment of propagules along roadsides will be the most important factor in preventing spread and that where roads intersect drainage lines should be focal points for monitoring.

Remote sensing presents as an ideal mode for mapping and monitoring invasion as it affords a landscape scale view and can be cost effective compared with laborious field work. However, it is challenging to implement because of the overall similarity of the spectra of different grasses and variability of Buffel grass stands, and photosynthetic status within stands over space and time. In this thesis, Buffel grass discrimination is trialled using high spatial resolution satellite imagery and aerial photography. Multispectral (eight-band) satellite imagery (2 m GSD) namely, Worldview-2 was found to effectively map dense infestations, but for early detection of emerging infestations, it is shown that aerial imagery spatial resolution no coarser than 5-6 cm GSD is required.

Presented in this thesis are tools needed to assess, monitor, predict and ultimately mitigate Buffel grass spread in arid Australia, including maps of present distribution, techniques for mapping and monitoring invasion over time, and an understanding of the species ecology as an invader to predict regions vulnerable to infestation. The methodology for roadside survey which makes the data more applicable to landscape-wide predictive habitat modelling could be adopted for any species where roads are considered a vector for spread. The research has important implications for Buffel grass management in regional arid Australia, and also for understanding the exotic distribution of Buffel grass worldwide. For detection of emerging Buffel grass infestations at a regional scale, aerial survey is recommended. Use of satellite imagery for monitoring of larger infestations is one area for future research.

PUBLICATIONS ARISING FROM THIS THESIS

Refereed

Marshall, V.M, Lewis, M., Ostendorf, B. (2012) *"*Buffel grass *(Cenchrus ciliaris)* as an invader and threat to biodiversity in arid environments: A review" Journal of Arid Environments, 78, 1-12

Marshall, V.M, Lewis, M., Ostendorf, B., Tuke, J. (2013) "Buffel grass roadside survey and invasive species distribution modelling" Environmental Monitoring and Assessment, (undergoing revision)

Marshall, V.M, Lewis, M., Ostendorf, B. (2013) "Detecting new Buffel grass infestations in Australian arid lands: evaluation of methods using high-resolution multispectral imagery and aerial photography" Environmental Monitoring and Assessment (Accepted: 30 September 2013, *In press*)

Non-refereed

Shepherd, B., **Marshall, V.M** (2010) "Buffel grass roadside survey 2010" Dept. Of Water Land and Biodiversity, Rural Solutions SA, Adelaide

Marshall, V.M., Lewis, M.M., Ostendorf, B. (2012) "Remote sensing for the surveillance of Buffel grass in central Australia" SA Weeds Conference, Waite Institute, Adelaide (http://www.wmssa.org.au/documents/marshall_saweeds12.pdf)

Marshall, V. M., Lewis, M. & Ostendorf, B. (2012) "Do additional bands (Coastal, NIR-2, Red-edge, and Yellow) in Worldview-2 multispectral imagery improve discrimination of an invasive tussock, Buffel grass *(Cenchrus ciliaris)*?" In: XXII International Society of Photogrammetry and Remote Sensing Conference, August 25–September 1 Melbourne, Australia

STATEMENTS OF AUTHORSHIP

CHAPTER 2

Statement of Authorship

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Author Contributions

By signing the Statement of Authorship, each author certifies that their stated contribution to the publication is accurate and that permission is granted for the publication to be included in the candidate's thesis.

Name of Principal Author (Candidate)	Victoria Marshall		
Contribution to the Paper	Development, conceptualisation and realisation of the research, wrote manuscript, corresponding author		
Overall percentage (%)	85		
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Contribution to the Paper	Supervised development, conceptualisation and realisation of the research and evaluated manuscript		
Overall percentage (%)	10		
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Name of Co-Author	Bertram Ostendorf		
Contribution to the Paper	Supervised development, conceptualisation and realisation of the research and evaluated manuscript		
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Name of Co-Author	Megan Lewis		
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APPENDIX ONE

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For Mum

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