The use of remote sensing technologies to investigate severe woodland decline in Western Australia

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Introduction

Eucalyptus gomphocephala (tuart) is a magnificent woodland tree dominating the coastal dune system in the south-west of Australia, extending from near Cervantes in the north to near Busselton in the south, approximately 400km in length and frequently only 1km wide (Boland et al. 2006). Only approximately 30,000 ha of once extensive *E. gomphocephala* woodland remains (Government of Western Australia 2002), and there is increasing concern over its health as a severe decline of unknown cause(s) is having a major impact (Archibald et al. 2004; Edwards 2004). The present study aims to determine whether remote sensing technologies and other spatially explicit datasets can be used with ground-based studies to establish long-term monitoring sites, map spatial and temporal patterns of the decline. It will also compare and monitor quantitative changes in individual tree crown health with the key objective of finding significant correlations with abiotic and/or biotic factors. Preliminary results from this study are presented.

Materials and Methods

Site establishment for the second phase of research into the cause(s) of *E. gomphocephala* decline targeted the Yalgorup region based on previous findings by the Tuart Health Research Group (http://www.tuarthealth.murdoch.edu.au/). A digitized dataset of the Tuart Atlas (Government of Western Australia 2003) which maps the distribution of *E. gomphocephala* throughout Western Australia, was used with vegetation trend image datasets, a product of the Land Monitor Project (Caccetta et al. 2000). These datasets are derived from Landsat Thematic Mapper images collected between 1990 and 2006. The trend files were derived using a 'vegetation cover-index' established from spectral bands three and five of the Landsat imagery time sequence and from which a variety of displays can be generated in 25m pixel images (Wallace et al. 2006). In the present study digital datasets of the Tuart Atlas and the vegetation trend maps showing five classes (major loss, loss, stable, gain, major gain in vegetation cover) were displayed in a handheld computer running ESRI Arcpad 6.0 and linked to a Haicom GPS for location of suitable field locations. Sites showing gain in vegetation trend outside the extent of the Tuart Atlas were also investigated due to a lack of this trend class within the Tuart Atlas. Twelve 50m x 50m plots were established in March 2006 based on the location of four x 25m pixels in either loss or major loss (four sites), stable (four sites) and gain or major gain (four sites). All *E. gomphocephala* within each site were mapped to sub-metre accuracy with a Trimble differential GPS system. Stem diameter, height and crown health parameters were recorded according to the USDA FS (2002). Airborne Digital Multi-Spectral Imagery (DMSI) was acquired in 2006 and 2007 and supplied by SpecTerra Services for approximately 10,000 ha of Yalgorup National Park encompassing the twelve sites. The imagery was acquired at 0.5m pixel resolution to provide a number of pixel samples across individual tree crowns. The sensor used for acquiring the imagery was fitted with four standard 20nm wide spectral band-pass filters centred at wavelengths sensitive to changes in plant pigments (450nm, 550nm, 675nm and 780nm). Individual data frames were corrected using geometric and radiometric techniques.

Results

Ground-truthing of the Tuart Atlas dataset found areas within the Yalgorup region with *E. gomphocephala* present that were not reported within the Atlas. A survey of sites showing gain in vegetation cover over time were surveyed outside the Tuart Atlas and some of these sites were vegetation types other than *E. gomphocephala* (e.g. *Agonis flexuosa* or *Dryandra sessilis* increasing in cover post-fire). However, some of the healthiest stands of *E. gomphocephala* were located using this method. The 12 sites established according to their vegetation trend were 'ground-truthed' and crown health of *E. gomphocephala* corresponded well with the trends. A subset of the 12 plots shows the vegetation trend maps, time trend plots displaying the specific information on the temporal change in canopy cover, and field images of *E. gomphocephala* displaying typical crown health attributes at each site (Figure 1). All 12 sites showed strong correlations between ground data and vegetation trends. Between four and fourteen *E. gomphocephala* trees have been assessed for crown health at each site with foliar nutrition, soil physical, chemical and microbial properties including mycorrhizal abundance and diversity also assessed beneath each tree. All individual tree crowns have been manually delineated and overlayed on the high resolution DMSI imagery to determine which spectral indices best correlate with the crown health indices recorded in the field.

Discussion

This study has shown the trend maps derived from the Landmonitor Project to be an extremely useful tool for targeting ground surveys and establishing field sites for research into tree decline. The establishment of long-term monitoring sites will enable further assessment of the accuracy of the temporal changes within these sites. In the case of *E. gomphocephala* woodlands in the Yalgorup region, *E. gomphocephala* is suffering the most severe decline. However, more recently other declining overstorey and mid-storey species including *A. flexuosa*, *Eucalyptus marginata* and *Banksia grandis* have been observed. The mid-resolution (25 m pixel) imagery will not distinguish between these species. It is therefore important if focusing on the health of individual tree species that high-resolution imagery (e.g. 0.5 m pixels) such as DMSI be acquired for the accurate monitoring of crown health of individual trees over time. We are now developing a model that will be tested in the field to enable accurate spatial and temporal mapping of the decline. Extensive data acquired in the field (Barber et al. 2007) will be combined to help us determine the cause(s) of the decline.

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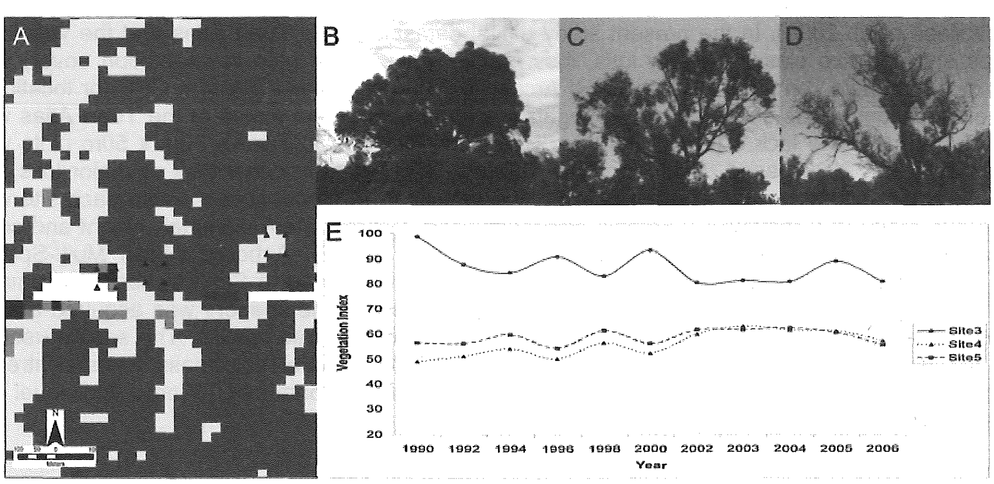

Figure 1. Vegetation health data of thee sites in Yalgorup National Park as acquired through remote sensing and ground-based assessments. (A) Vegetation trend map derived from Landsat Thematic Mapper satellite imagery showing the markers (▲) on each corner of individual sites with site 3 gaining in vegetation cover ( ), site 4 showing a loss in vegetation cover( ) and site 5 showing a stable trend in canopy cover ( ) between 1990 and 2006. (B) Crown health of a typical tuart at site 3. (C) Crown health of a typical tuart at site 5. (D) Crown health of a typical tuart at site 4. (E) Temporal change in vegetation cover between 1990 and 2006 according to a vegetation index derived from Landsat Thematic Mapper imagery. An increase in slope indicated a decrease in vegetation cover.