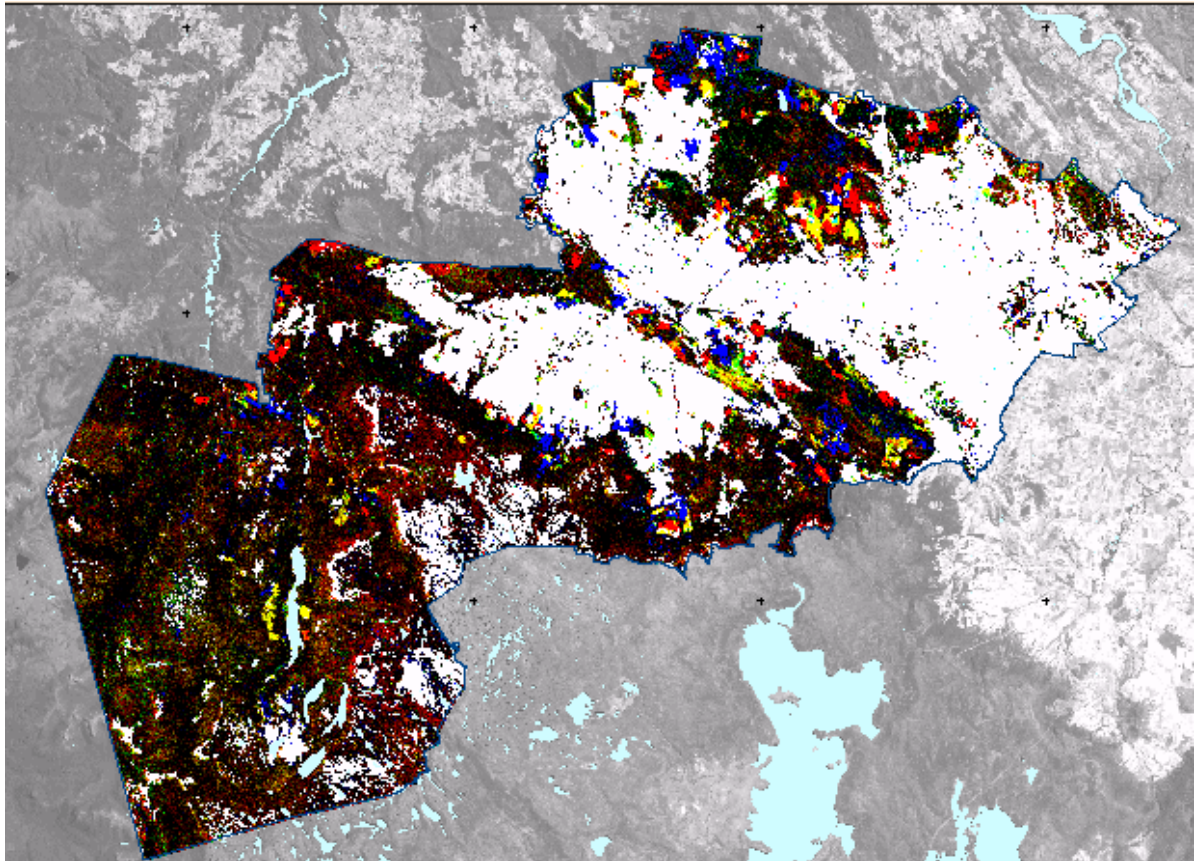


Appendix 3

Meander Valley Monitoring Study
Vegetation Trends & Index History 1991-2000
Meander Valley NRM Region Landsat scene (091/89)

(** UPDATE of previous report covering 1991-1999 **)



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July 2001

Meander Valley Monitoring Study

Vegetation Trends & Index History 1991-2000

This report is an update of the previous report (May 2001) covering 5 dates from Feb1991 to Nov1999. A sixth image (23 November 2000) has been added to the processing stream. Only minor changes have been made to the report to describe the updated processing. New CDs of the data have been produced.

This report describes the 'Vegetation Trend' products for the Meander Valley study. The digital data files are supplied on CD, accompanied with an A0 hard copy map of one view of the data. The data can be used to produce a variety of displays, and also for numerical comparison of changes in areas of interest. Suggested displays and uses of the data are described in Section 4 of this report, and the CD contents are listed in Section 7.

The 'Vegetation Trend' product is multi-channel image file which contains summaries of change in reflectance of vegetation over time. It is produced from the six dates of calibrated and terrain-corrected TM data, over the interval February 1991 to November 2000. The index used is the corrected TM band 7, based on the analysis described in an accompanying report to the study. The summaries of change which are produced for each pixel are recorded as 6 bands, scaled to fit the 1-byte range of 0-255.

- Band 1 : Mean index brightness over all dates
- Band 2 : linear trend (slope) in brightness over time (scaled)
- Band 3 : Quadratic trend (scaled)
- Band 4 : standard deviation (sd) about mean (scaled)
- Band 5 : residual sd after fitting linear trend (scaled)
- Band 6 : residual sd after fitting linear and quadratic trends (scaled)

Details of the processing and scaling are given in section 3 below. Areas which were never classified as having perennial vegetation cover over the period have been masked out and given a zero value in all bands; these will include some areas of very thin native vegetation. The data have been processed within the MVC boundary only, as this was the only area for which an accurate DEM was available.

The bands can be displayed separately or together to summarise trends and stability of vegetation over time as measured by the index, and in particular to highlight areas with different patterns of change. One recommended display shows positive and negative linear trends in different colours; while other bands can be used to examine deviations from these trends (see section 4 below).

The Index History file is simply the Band7 value for the five dates recorded as five bands; these data are used for extracting and plotting graphical time trends for sites or areas of interest. The data can also be used for interpretation of change in visual displays where cloud is not present in any date.

Examples of the use and interpretation of these data are given in the appendix, which is unchanged from the previous report.

The Area

The region considered is the Meander Valley Council (MVC) area illustrated in Figure 1. The region is covered by Landsat scene 091/89. The results are provided for the MVC region and are calibrated and corrected for terrain effects using the good-quality DEM for the area.

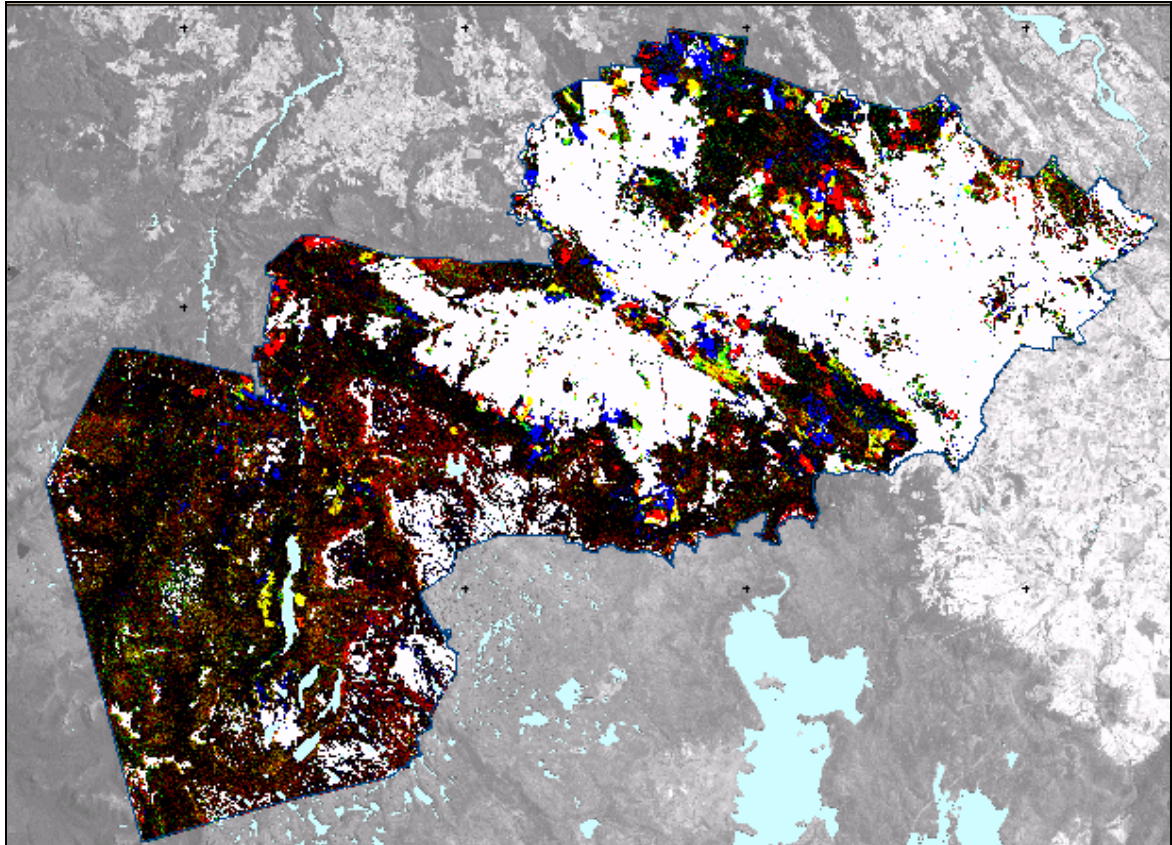


Figure 1. The MVC region: display of the woody vegetation trend data from 1991 to 1999 (not the updated image – see CD or A0 poster). White areas are masked as never-woody; dark areas are stable; colours indicate timing and direction of changes in woody vegetation.

1. The Satellite Image Data and Basic Processing

Landsat Thematic Mapper (TM) data from the following dates were used to derive the maps.

<i>Landsat Scene 091/89</i>
24 February 1991
4 December 1995
23 November 1997
26 January 1998
29 November 1999
23 November 2000

All data were rectified (AMG Zone 55, Projection AGD66) and calibrated prior to processing. Four of these images contained some cloud over the MVC area. The effects of cloud on the results are discussed in sections 3 and 4 below.

The data were also subjected to a terrain illumination correction (McDonald et al 2000) prior to the analysis and processing described below. The effect is to produce an apparent 'flattened' image in which the numerical values for consistent land cover are approximately the same, independent of the terrain. This correction was applied to the MVC area only, as this was the area of interest, and also the only area for which a digital elevation model (DEM) of sufficient quality was available. The high-quality DEM for the MVC was gridded and provided by Mark Brown of Tasmania's DPIWE.

2. Outline of data processing methodology

The processing steps to produce the vegetation trend and index history files are listed below. The methodology is similar to that being used in Western Australia's Land Monitor Project (Caccetta et al 2000) with the additional terrain illumination step.

1. Co-register the sequence of images to a common map base. Orthorectification was used.
2. Calibrate the images to a common radiometric base. This step incorporates a physically based correction for solar position and a bi-directional reflectance distribution function (BRDF) correction as adopted in the AGO methodology (Wu et al 2001, Furby 2001).
3. Apply terrain correction based on DEM derivatives; parameters were estimated from cloud-free vegetated areas in the MVC region, using the method described in McDonald et al 2000.
4. Select an index sensitive to woody vegetation density and produce a composite 6-date file of the index. TM band 7 was chosen based on the woody-nonwoody analysis (Wallace and Wu 2001, report to MVC). This five-band file is the 'index history' file on the CD.
5. Mask out cloud and cloud shadow at each date based on manual interpretation and digitising. Masked areas are replaced with NULL values and are ignored in the trend summary calculations. NOTE: any cloud or cloud shadows which have not been detected and are not masked out will produce artefacts in the final file as cloud at any date drastically affects the image signal.
6. Mask out all areas which were 'never-woody' over the period; i.e. those areas which were mapped as 'non-woody' on ALL five dates based on the TM sequence (Wallace & Wu 2001, report to MVC).
7. Calculate scaled temporal summaries of the index over time. The linear and quadratic components of the response are estimated independently using orthogonal polynomials (Draper & Smith, ch 5). The calculated trends (e.g. slope over time) and deviations are real numbers. These are rescaled linearly to fit in the 1-byte range of 0-255. Inversion of the scaling will recover the real values if required for quantitative analysis. The six scaled bands are written to

a file. Note that the input values are the index values [band7] at different dates, so the units for (e.g.) the slope are index counts per year.

Table 2 : Scaling of bands in the VEGTRENDS file

Band	Scaling and translation applied
1 Mean Band 7 over 6 dates	No scaling; mean of five values
2 Slope (linear trend over time)	Lin coeff * (255/10) + 127.5 <i>[scales slopes from -5 to +5 into the 0-255 range]</i>
3 Quadratic curvature	Quad coeff * (255/8) + 127.5 <i>[scales coefficients from -4 to +4 into the 0-255 range]</i>
4 Standard deviation (SD)	SD * 4
5 SD of residuals from linear model	SDlin * 4
6 SD of residuals : quadratic	SDquad * 4

4. Data display and guide to interpretation

The vegetation trend data can be displayed in a number of ways to highlight different trends over time. The temporal response of the index values for a patch of vegetation may be smooth over time, or more complex depending on the timing of disturbance and rates of change. For example, clearing will result in a sudden increase in brightness within a single time interval, while selective logging, fire, grazing or understorey changes may result in more gradual and subtle change. If the response is stable or smooth, then the trend bands (mean, linear and quadratic) will provide an adequate summary over time. The residuals (bands 4,5,6) can be used to identify areas where the response deviates from simple trends.

Simple summaries map of trends over the period can be made by displaying positive and/or negative linear trends in different colours, with or without display of the quadratic trend. One display commonly used by the authors is to display the positive slopes (decline in vegetation) in red, and the negative slopes (increase in density) in green with suitable thresholds. With suitable enhancement, this results in a simple 'traffic light' display with unchanged vegetation in black.

A standard display of more complex changes through time is made by assigning those positive and negative linear trends (band2) to red and blue respectively, and assigning the negative quadratic trends to green; a negative quadratic indicates disturbance followed by recovery of vegetation density in the period (e.g. from logging and regrowth or replanting), and mixed colours in this display indicate different degrees and shapes of overall change and recovery. See the appendix for examples of interpretations and trend plots based on this display.

One version of this display is provided as an A0 map to accompany this report. An ERMapper algorithm to produce this display is provided on the data CD; it can be easily modified by ERMapper users to alter the display colours. A 3-band RGB file ready for display is also provided.

5. Limitations

It is important to note that understanding and ecological interpretation of the physical changes shown in these data require other data and knowledge. The trends and interpretations are based on the spectral contrast between perennial vegetation and other cover types. The changes in the index over time at a location indicate physical changes on the ground at that location, and these changes can be associated with changes in vegetation. It is important to note that there are many causes and interpretations of changes in vegetation reflectance, and that the physical changes which result in a similar numerical reflectance response will vary with vegetation type and background. The numerical values, while consistent and comparable through time, have not been calibrated to vegetation density on the ground, and inferences drawn about change at a location should be validated by other means, and may not transfer across vegetation types.

For example, while these data may indicate recovery after logging or clearing in terms of reflectance values, no inference can be drawn from these data alone concerning the type or condition of the vegetation in comparison with the pre-disturbance vegetation.

The cloud mask and the replacement with null values is described above. Where cloud has been masked, the null values are ignored, but data for those areas are missing in the years concerned. Where cloud or cloud shadow have not been detected and masked, erroneous changes will result. If such effects are suspected, the original images can be checked.

The mask of non-woody vegetation cover types is based also on TM spectral data. A report to the MVC Project (Wallace and Wu 2001) describes the derivation and limitations of the mask. It may have excluded from the data areas of woody vegetation which remained very thin or highly reflective over the period of the image sequence.

6. Disclaimer

The information contained in these vegetation maps and the interpretation guide are necessarily based in part upon various assumptions and predictions. The Commonwealth agency CSIRO Mathematical and Information Sciences accepts no responsibility for any inaccuracies in these vegetation products and persons relying on these maps do so at their own risk.

7. CD Contents : MVC Trends

All georeferenced files are in map projection AMG Zone 55, Datum AGD66. TM-derived products are at 25m pixel size.

File 1 : Vegetation trends and residuals file

MVC_6date_VegTrend.bil (.ers .hdr)

This is a 6-band ERMapper and ARCview file with bands and values described above.

Areas outside the MVC and areas not covered by perennial vegetation throughout the period have been masked and set to value zero in all bands. For display, it is suggested that these values be set to white, or the 'never-bush' mask file (below) should be used as an overlay.

Associated files :

display_vegtrends.alg - ERmapper algorithm to produce the display shown on the hard-copy. The 'positive linear', 'negative quadratic' and 'negative linear' trends are displayed in red, green, blue as described above.

MVCtrends_lql_RGB.tif - a 3 band 'pre-enhanced' version for direct RGB display of the data in GEOTIFF format which can be readily imported to many display programs. For varying the display, the user should access the original file.

Raster File 2 : Index history file

MVC_b7_6date.bil (.ers .hdr)

A five-band file, comprising TM band 7 for the five dates. Cloud-masked areas at each data have been set to a value zero in the appropriate band.

Raster file 3 : Woody Mask File

mvc_6date_everwoody.bil (.ers .hdr)

A single band classified raster file with codes as follows: 0-outside MVC; 1-classified woody on one or more dates; 2-never classified as woody over the period. Derived from the neighbourhood-smoothed 6-date woody extents file (separate report Wallace & Wu, updated July 2000).

Other files:

ER Mapper Vectors showing areas masked out for cloud on each of four dates.

mvc_cloud91.erv etc

A print file of the A0 poster suitable for HP Designjet 300DPI A0 printer.

mvc_vegtrends.hp

Report on data product (this report), and appendix in Word & PDF formats:

MVC_VegTrend_6date.doc (.pdf)

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Acknowledgements

We thank the Meander Valley Council for funding the work described in this report.