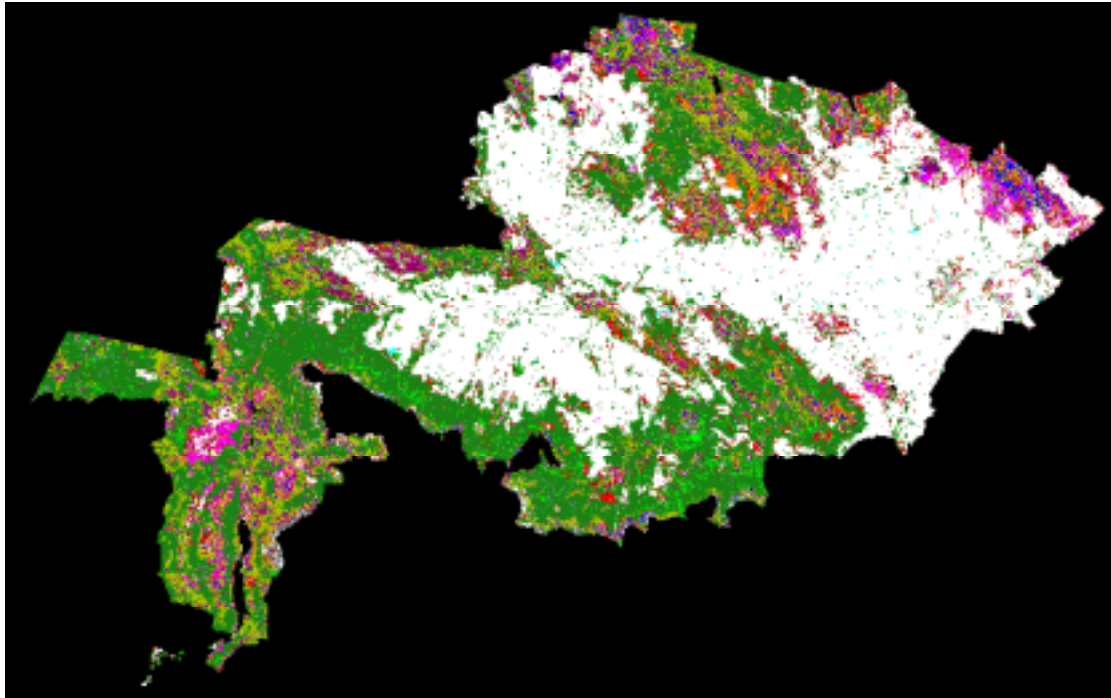


Appendix 4

Meander Valley Monitoring Study

Digital vegetation classification to determine if plantations can be detected using satellite data



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1. Introduction

In both natural resource management and the study of land cover change, it is vital to have reliable data relating to the locations of both pine and eucalypt plantations over extended time periods. Data from conventional sources are often inaccurate or incomplete and changes in the extent of plantations are so rapid that there are insufficient resources to track all changes in the field. Satellite remote sensing data can be an important asset as it has a high temporal resolution and can cover much larger areas than can be practically covered with on the ground surveys.

This project has involved the use of terrain corrected Landsat TM data to perform a digital vegetation classification of the Meander Valley Council region. Prior to this study it was unknown whether Landsat data could be successfully used to map plantations in the region. According to the specification for this consultancy there are two primary objectives of the project.

1. Perform a classification of the data which seeks to differentiate between areas of plantation (pine and eucalypt) and areas of native forest and young native forest regeneration.
2. Determine if the woody weed *Ulex* (gorse) can be discriminated in open paddock situations and under eucalypt forest canopies.

This report accompanies a CD containing the data products resulting from the image processing and analysis of the satellite data. Section 5 details the contents of the CD. The primary aim of this report is to describe the methodology behind the data analysis techniques in order to make replication by others simpler. A short discussion of the results is provided however, detailed analysis of the results and a discussion of the implications is not in the scope of this consultancy and will be undertaken by Bushcare.

2. The Satellite Data

The region considered is the Meander Valley Council (MVC) region, which is covered by Landsat scene 091/89. The data have a spatial resolution of 25 metres and the scene used in this study is from the 23rd of November 2000. Six of the Landsat TM spectral bands (see Table 1) were used in the classification procedure outlined in Section 3.

Table 1 Landsat TM bands used in the project

Band	Wavelength Range	Description
Band 1	0.45-0.52 μm	Blue
Band 2	0.52-0.60 μm	Green
Band 3	0.63-0.69 μm	Red
Band 4	0.76-0.90 μm	Near Infrared
Band 5	1.55-1.75 μm	Middle Infrared
Band 7	2.05-2.35 μm	Far Infrared

CSIRO Mathematical and Information Sciences in Western Australia provided the satellite data used in this project and performed some basic processing. The data were rectified (AMG Zone 55, Projection AGD66) and calibrated by CSIRO (Wallace and Wu, 2001). The data were also subjected to a terrain illumination correction using a high quality Digital Elevation Model in order to remove the effects of shadow in the analysis of the data. For a detailed description of the processing performed by CSIRO see Sections 2 and 3 of Wallace and Wu (2001).

3. Processing Methodology

Landsat images can be classified using a number of methods, the choice of which will depend on the purpose and the desired outcome. Unsupervised classification separates an image into classes based on statistical variance in reflectance values. While unsupervised classification is far less resource consuming than supervised classification, it can result in the creation of different classes from image to image. This means that detecting change in land cover over time is difficult. Supervised classification involves manually determining the classes used in the classification procedure and creating “training sites” to define each class. Subsequent images can be classified based on the same surface types used in the initial classification, allowing change detection over time.

After viewing the data and in consultation with Sean Cadman, Bushcare Extension Officer, it was decided that supervised classification of the data would be the technique most likely to best meet the stated objectives.

The supervised classification process is iterative. Signatures for each ground cover type are generated based on training sites (steps 4 and 5 below). The classification is performed using the signatures and the resultant classified image is examined for incorrectly classified areas (step 6). New signatures for the unrepresented classes are created and the image is reclassified based on these more comprehensive classes. This process can be repeated a number of times in order to refine the classification.

The southern region of the MVC area forms part of the Tasmanian Wilderness World Heritage Area (WHA). The WHA is largely high altitude terrain with complex alpine vegetation and several large water bodies. There are no plantations in the WHA and classification of the area is likely to result in a high level of error due to snow cover, which causes a high reflectance and thus misclassification. In consultation with Bushcare the WHA was removed from the study area prior to analysis.

All remote sensing analysis was performed using the software package ERMapper.

The steps used to produce the series of vegetation maps are listed below.

1. Bands 1, 2 and 3 and bands 2, 3 and 4 were respectively used to create a “true colour” and a “false colour” algorithm. These algorithms were used to visually identify features in the image and to provide a basis for creating the training sites described in step 4. Contrast stretching was applied in order to create images with the best levels of contrast and brightness.

2. A 6-band image was created using the raw bands 1-5 and 7. The bands were not transformed as it was decided that the raw data would provide the most accurate results and any transformations were likely to multiply errors. This data set was used in the classification procedures listed below.
3. An unsupervised classification was performed in order to determine which plantation types are spectrally distinct from native forest and to guide the choice of classes for the supervised classification detailed in steps 4 to 6.
4. In order to create training sites for the surface types or “classes” represented in the image a vector file is required. Polygons are annotated around known locations of each class (based on ground truth data), labelled with the appropriate class name and saved to the new vector file. Each class (eg water, rock, pine plantation) may have a number of polygons. The classes were determined by visually identifying distinguishable land cover types in the true colour and false colour images using known field data. A series of ground truth sites provided by Bushcare were used in conjunction with advice on vegetation communities from Sean Cadman who has a thorough knowledge of the vegetation in the region. Plantation ground truth data were also utilised.
5. The vector file containing the training polygons was used to perform a Standard Maximum Likelihood Classification of the 6-band image. ERMapper creates a “spectral signature” for each of the classes represented in the vector file. A spectral signature consists of the average and standard deviation of the reflectance values of all pixels within the polygon(s) representing a class. In the classification process, ERMapper assigns every pixel in the image to one of the classes defined by the training sites. The Maximum Likelihood Classification procedure derives a probability function for the spectral space, and then maps each pixel to the most likely class. The classification process results in the creation of a new data set with pixels having a value of 1 to n where n is the number of classes. Each class may be named and coloured manually.
6. The classified image was visually checked against ground truth data for incorrectly classified areas and classes were added or amalgamated.
7. Steps 4 to 6 were repeated until the classified image was satisfactory.
8. The classified image was reclassified into two final products. The reclassification procedure involves combining classes by assigning them to a single class number using a formula (eg “logged”, “irrigated” and “pasture” would all become one class called “cleared”). Sean Cadman determined the distinct classes to be used in each of the two final products. The classes chosen were those that would be most useful in the final analysis of results. The final classes were then named and coloured appropriately.
9. A 3 x 3 Median Ranking Filter was applied to the final classified image and the two reclass images in order to remove noise. This low pass filter operates on a neighbourhood of a pixel, with a smoothing effect. The pixel values for a

pixel and its eight neighbours are extracted and placed into ascending order. The fifth value is chosen and written into the filtered image in place of the original pixel value.

4. Results

The first objective of this consultancy was:

1. Perform a classification of the data which seeks to differentiate between areas of plantation (pine and eucalypt) and areas of native forest and young native forest regeneration.

The supervised classification methodology proved to be relatively successful in distinguishing areas of native regrowth and plantations. Figure 1 shows the spectral characteristics of each of the plantation classes and the native regrowth class. The chart compares the reflectance values (mean grey level on the y-axis is a measure of reflectance) of each class in each band. Softwood plantations are spectrally distinct from the other classes in bands 4 and 5, however there was some confusion between this class and the mature rainforest classes (not shown Figure 1). The native regrowth is relatively spectrally distinct from the hardwood plantation classes which was a somewhat unexpected, but positive, result.

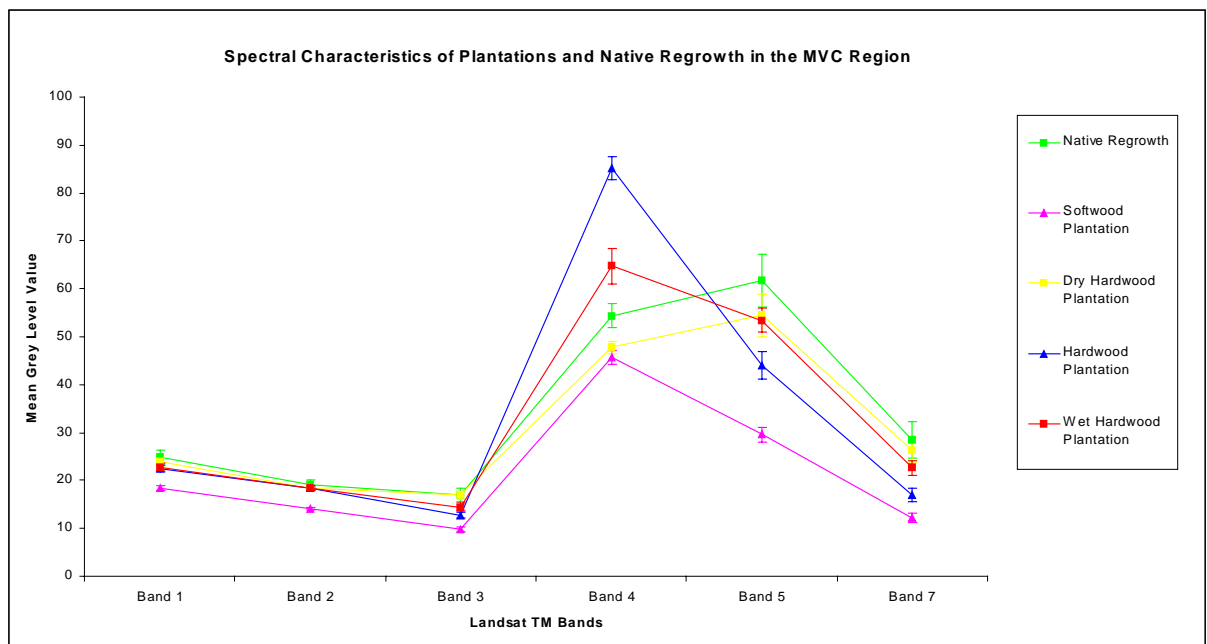


Figure 1 Spectral characteristics of the plantation and native regrowth classes. Error bars indicate $\pm \frac{1}{2}$ a standard deviation.

The second objective was:

2. Determine if the woody weed Ulex (gorse) can be discriminated in open paddock situations and under eucalypt forest canopies.

Although ground truth data were utilised to create training sites for gorse in both open paddocks and under eucalypt forest canopies, the size of the individual areas was insufficient to create reliable spectral signatures and classifications for the two classes. The Landsat TM pixels are 25 square metres in size and a number of pixels are required in a training site to produce an accurate signature and to survive the filtering process post classification. This means that areas of gorse would need to be at least 200 square metres in size which is rare.

The success of the vegetation classification can be attributed to a number of factors.

1. The satellite data were of high quality and were cloud free.
2. The data were corrected for atmospheric effects, reducing the “blue haze” that often accompanies Landsat TM data.
3. A high quality Digital Elevation Model was used in combination with a sophisticated illumination correction algorithm in order to remove the effects of shadow.
4. Expert local botanical knowledge of the region was combined with good ground truth data, allowing an accurate set of training sites to be developed for appropriate classes.

The results indicate that there is some over reporting of the plantation classes. However a visual examination of the results indicate that the application of simple environmental and size rule sets should further reduce these errors. Bushcare will conduct further analysis and interpretation of the results.

5. CD Contents Covered in this Report

6. References

Wallace, J.F. and Wu, X. (2001). Meander Valley Monitoring Study, Woody vegetation extent and change 1991-2000. CSIRO Mathematical and Information Sciences Report. Perth, Australia.

7. Acknowledgements

I would like to thank the Meander Valley Council for funding the work described in this report. I also thank Jeremy Wallace of CSIRO Mathematical and Information Sciences for providing the pre-processed data and for his expert advice. Thanks go to Sean Cadman, Bushcare Extension Officer, for his thorough knowledge of the region and assistance in the classification process. Finally, thanks to Mick Russell from the University of Tasmania for his assistance with the software.