Mapping flowering Paterson's Curse (*Echium plantagineum*) around Lake Hume, north eastern Victoria, using Landsat TM data.

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Summary

Dense and flowering infestations of Paterson's Curse (*Echium plantagineum*) near Lake Hume were accurately depicted using the microBRIAN image processing system to produce enhanced and classified images from two phenologically selected Landsat Thematic Mapper (TM) sub-scenes. The methods and calibration used have further application the most obvious being to weed (especially Paterson's Curse) infestation mapping over extensive areas.

Introduction

In 1985, the draft report on biological control of *Echium* spp. (Paterson's Curse/Salvation Jane, *Echium plantagineum* L. and Viper's Bugloss, *E vulgare* L.) was published by the Industries Assistance Commission (IAC, 1985) and the call for submission and comments yielded over 500 responses. Paterson's Curse is an annual plant which flowers each October/November. It is important in apiculture for brood build-up and honey production. It is also of value to the comparatively few dryland graziers who rely on it for a significant proportion of their fodder, but in general it is regarded as a serious weed problem by graziers (Parsons 1973). Control can be expensive. Direct costs, labour and chemical, for the Department of Conservation, Forests and Lands during 1983/84 were $425,442 and indirect costs were $490,400 giving a total of $915,842 for 1983/84. Total costs for 1982/83 were $422,720 (Field *et al.* 1985). Biological control offers potential for more effective long term management (Shepherd 1990) and is one of the priority research areas supported by the Australian Wool Corporation (Delfosse 1990).

The importance of monitoring the distribution of *Echium* spp. is well recognized and data used to calibrate the work reported here is available from grid-square mapping and related 'clip-board' field and questionnaire surveys (e.g. Lane *et al.* 1980) and related government files. Alternatively, comprehensive coverage can be achieved by analysis of earth resources satellite multispectral scanner data by a team able to integrate expertise in weed science, ground truth survey and image processing. In this case the data relates "instantaneously" to large areas at a time and field checking (ground truth validation) can be confirmed to sampling key areas. The resolution of the output map in analogue or digital form, is determined by the ground resolution of the imagery (e.g. Landsat TM 30 m x 30 m) instead of the coarser parish or grid square survey net, and synchronous distribution patterns over wide areas can be produced quickly once the image enhancement and classification scheme used has been validated.

This paper reports the results of an experiment designed to test the application of image processing techniques, available on microBRIAN (CSIRO/MPA 1988) to the mapping of *Echium* spp. from multispectral data obtained as sub-scenes for an area east of Albury-Wodonga (Figure 1) that is documented independently from Land Protection Division (LPD) ground surveys.

Analysis

The analysis of multispectral data acquired at the phenological stage of maximum spectral contrast offers a high potential for differentiating that pasture cover type from others. *Echium* spp. presents such potential in that, depending on seasonal factors, it flowers between the first weeks of October and the middle of December. The flowers are bright purple and reflectance from dense to moderately dense infestation are recorded in TM bands 1-4 (visible blue, green, red and near infra-red).

Because it is the distribution of only one cover class that is sought, an image analysis procedure was adopted that was specifically targeted at the spectral reflectance range of the *Echium* flowers.

Our analysis proceeded as follows:-

1. A contrast enhancement was applied to the two images. As a result, the areas known to be densest infestations were revealed but the pattern was confused with that of some forest cover types (e.g. Figure 2).
2. Band correlation (Table 1) shows that TM bands 1, 2 and 3 are highly correlated, therefore decorrelation stretch (Gillespie *et al.* 1986) was applied after careful selection of image gray scale (DN) values (see Ullah, *et al.* 1989).
3. The results of this step appear in Figures 3 and 4.
4. Results of step 3 were tested by field survey and the analysis of oblique air photographs and archival data, and found satisfactory.
5. After ground truth validation, image classification (theme overlay) was employed so that infested areas could be more readily distinguished for hard copy output and area estimates of infestations could be made (Figure 5).

Table 1. Correlation matrix of original TM data, bands 1-4 for the Bungil area (see figures 4 and 5).

TM Bands	1	2	3	4
1		0.893	0.926	0.3786
2		1	0.912	0.612
3			1	0.419
4				

Accuracy of Mapping

Figure 5 shows the Paterson's Curse distribution as bright red. Image pixel counting yields an estimated area of 437 hectares (2.15%) infestation dense enough to be mapped by the methods used here. At this stage of analysis, mapping accuracy was checked qualitatively in the field, from oblique air photographs and archival data of the type used in the earlier grid-square and parish mapping exercises, by random selection of field check location. More quantitative estimates using the confusion matrix or other approaches will require further funding for data acquisition, contemporaneous ground validation and analysis.

Discussion

Release of biological control agents was first made in the Wodonga-Tallangatta area in 1988. These releases were on a small scale and as yet the insects have not spread. The infestations of Paterson's Curse have not significantly altered since the scene was taken. Ground truthing of the area in 1989 showed that although insects persisted, the density of the plant had not decreased. The satellite imagery presented in figure 4 indicates a medium to dense infestation of Paterson's Curse as it was at the time of the release.

Infestations of the intensity identified here should be readily detectable across Australia, however, it is possible that less dense and more scattered infestations will be more difficult to identify. Further research using image analysis in conjunction with ground truthing should elucidate this problem. Satellite imagery probably offers a more accurate assessment of the distribution and intensity of infestations to be made than hitherto. At pres-

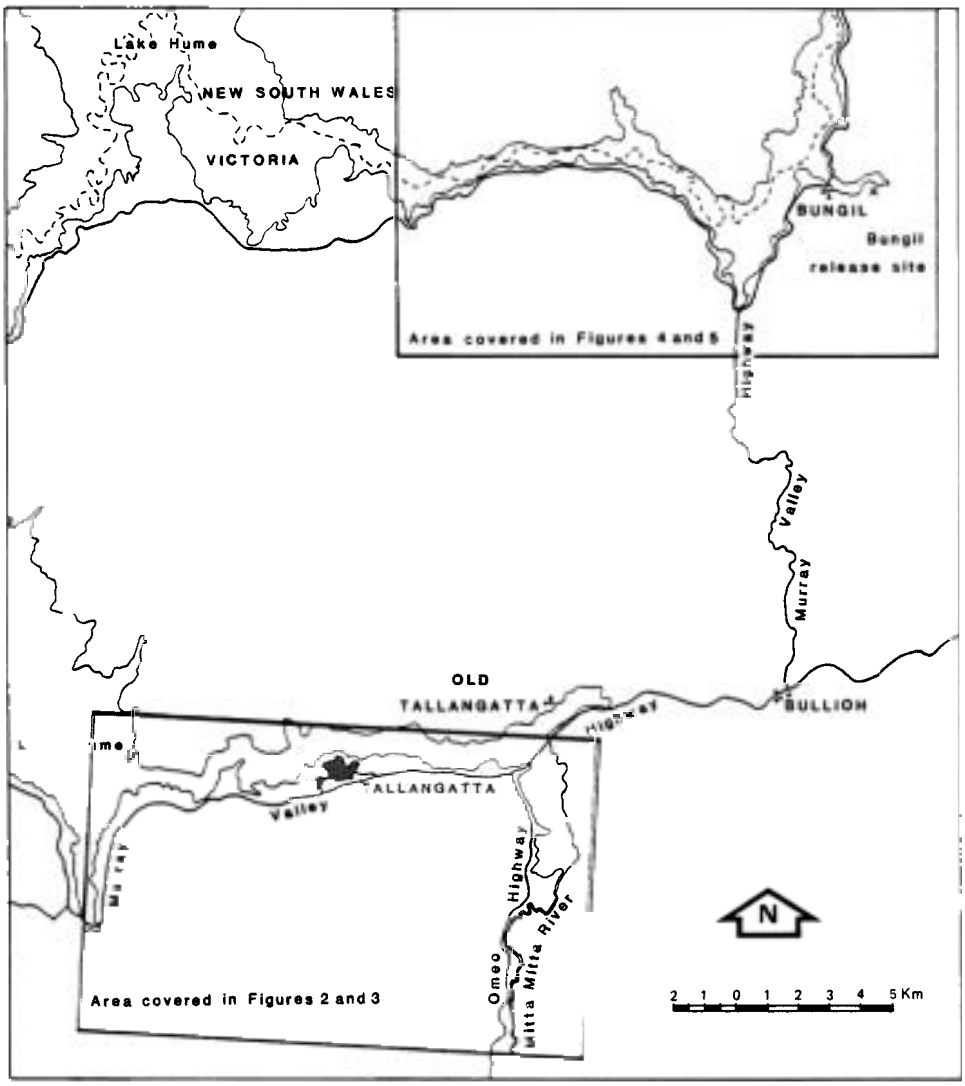

Figure 1. Location of sub-scenes in the Albury-Wodonga/Lake Hume area depicted in subsequent figures.

ent ecological surveys are time consuming and can only occur in a limited number of accessible areas. Satellite imagery will not totally replace vegetation surveys but used together they should give a good overview of any plant being studied which has detectable spectral characteristics which contrast with its immediately associated cover types.

The TM data used in this analysis is available in seven spectral bands, all of which need to be purchased unless it is already known that the data relevant to a particular analysis is contained in a specific range of bands. For studies based on flower colour as the dominating factor in the differentiation of cover type future image acquisition costs can be reduced by confining attention to TM bands within the visible spectrum. Not only the TM bands identified here are useful but also SPOT data which should yield comparable or better results, because higher spatial resolution (20 m x 20 m pixels) is offered, and in bands roughly corresponding to TM bands 1-4.

The project reported here comprises an experimental extension of the LPD/Wool Corporation research project headed by one of us (RS), on biological control of *Echium* spp. Further work would involve large area application of this method to areas for which ground truthing activities are carefully planned to coincide with satellite overpass.

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Figure 2. A linear contrast enhanced sub-scene of a TM image after geometric registration. The purple tones depict the distribution of (flowering) Paterson's Curse but only for areas more densely infested. The area documented on one of the archival ground photographs taken within a few days of the imagery is indicated by the broad arrows. Small arrows indicate the location of Tallangatta. The image is from the scene: Path 91, Row 85, 29/10/88.

Figure 3. The same data used to produce figure 2, but colour enhanced, and transformed to depict dense to moderately dense infestations of Paterson's Curse.

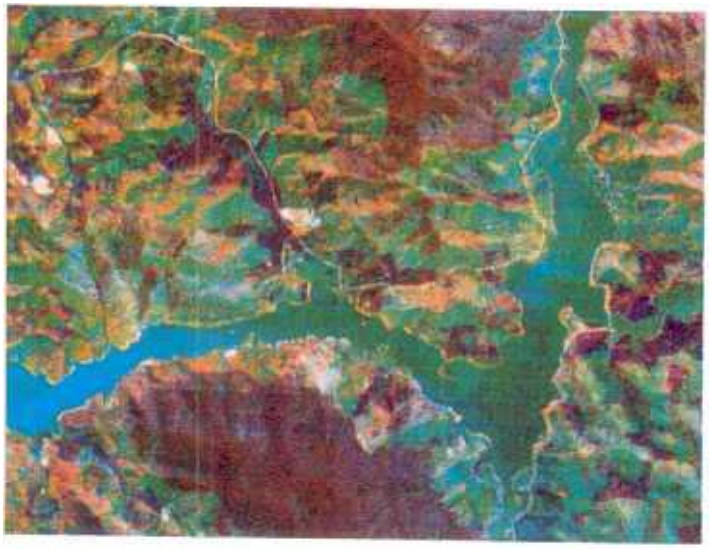

Figure 4. Unrectified but colour enhanced image representing Bungil and its adjacent areas. The deep dark purple patches indicate the distribution of areas infested with Paterson's Curse (e.g. see arrows). The image is from the scene: Path 92, Row 85, 5/11/88.

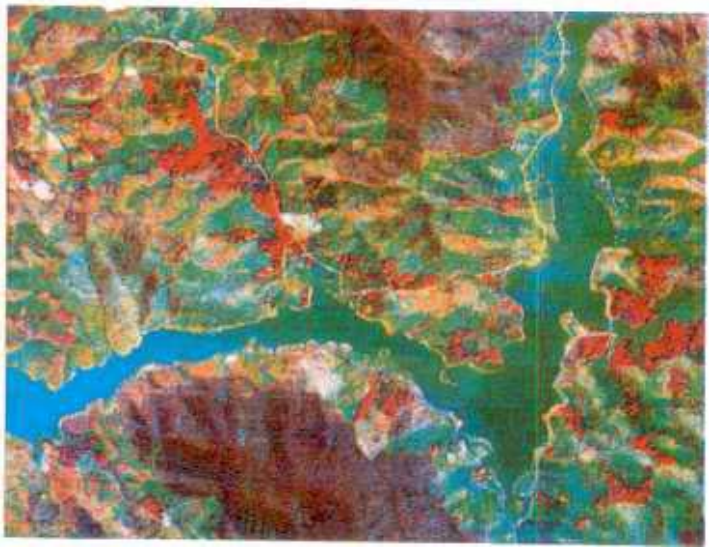

Figure 5. The same image, classified by a theme overlay technique shows the Paterson's curse distribution as bright red. Estimated area of Paterson's curse is 437 hectares (2.15%) out of total 20275 hectares covered by the image. The arrows indicate the location of the Bungil experimental biological release site.