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## GIS AND RESOURCES ANALYSIS

### SYSTEMES D'INFORMATION GEOGRAPHIQUE ET ETUDES DES RESSOURCES

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#### ABSTRACT

Resource management is becoming increasingly complex and difficult. Planners and managers require improved methods for obtaining data. Remote sensing, plus Geographic Information Systems (GIS) can provide these methods. This paper presents examples of some aspects of the process.

An assessment of GIS techniques for thematic mapping with SPOT XS data is given. Examples used are of two rural environments. One is an estuarine area with flanking broad pastoral and forestry land use. The second is an area of intensively managed primarily horticultural land use.

Techniques employed, problems encountered, results achieved and the relative merits of two processing systems employed, ERDAS and ARC/INFO, are given.

New Zealand SPOT data are used to demonstrate the utility of such procedures for general resources roles and also for general thematic mapping.

#### RESUME

Les problèmes de gestion de ressources sont devenus de plus en plus complexes et difficiles. Les planificateurs et aménageurs nécessitent des méthodes sans cesse améliorées pour l'obtention de données. La télédétection et les Systèmes d'Information Géographique sont désormais à l'origine de ces

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méthodes. Le présent papier offre des exemples dans ce domaine.

On présente une revue des techniques d'information géographique pour la cartographie thématique à partir de données SPOT. Deux exemples sont présentés sur un environnement rural complexe. Le premier concerne une zone estuarienne dont chaque rive est caractérisée par des activités forestières et pastorales. Le second est relatif à une zone d'intenses activités horticoles.

Les techniques utilisées, les problèmes rencontrés, les résultats obtenus et les avantages respectifs de deux systèmes : ERDAS et ARC Info sont présentés. Des données SPOT de Nouvelle-Zélande sont utilisées pour démontrer l'utilité de telles procédures dans l'étude globale des ressources.

## INTRODUCTION

The job of natural resource management has become increasingly more challenging. National, regional and local planning all involve the wise management of resources. A range of methods, techniques and principles are implemented to provide maximum knowledge of land from local, regional to national scales, to facilitate current management and to optimise future planning decision.

Usually a first stage towards good planning and management is the acquisition of detailed, comprehensive and accurate land use maps. Satellite imagery such as LANDSAT TM and SPOT goes a long way to providing useful spatial data as a first step towards land use maps. However, regional planners usually require categories of thematic information not immediately achieved from satellite data. Integration of SPOT P + XS products partly meets this demand (Lasselin & Cochrane, 1990) but optimal use of SPOT data to provide these additional thematic requirements of managers and planners needs new dimensions in analysis.

GIS can offer resource managers complex analysis of land and resource information that previously could not be undertaken to produce new solutions to problems. Thus the merging of spatial patterns and radiometric values (DN values, pixel brightness, colour tones) of digital satellite imagery in raster format with a range of land attribute values (land indices) and change indices in vector format can more readily provide the thematic maps desired by planners.

Cadastral patterns, valuation, topographic land cover, soils, vegetation and urban functional classes etc., can all be merged with the basic spatial data.

SPOT derived landuse maps can be augmented with the additional quantitative landscape indices to provide an enormously expanded range of information of importance to

regional planners and resource managers. Multitemporal SPOT imagery and multitime comparisons of landscape indices provide sets of change data vital in many facets of inventory management and planning. The assessment of change requires that a comparative analysis be conducted using before and after event imagery, and geographic information system technology provides the ability to store and retrieve baseline data as well as providing the comparative tools necessary. Some of the first stages of these digital image processes are addressed in this paper.

## METHODS

Processing was carried out using SPOT XS data of a New Zealand scene (443/426) on a SUN SPARC STATION 1+, courtesy of Eagle Enterprises Limited of Auckland.

Two subscene subsets (500 lines x 500 pixels) were selected of two areas, A1 - Matakana Island, and B1 - Te Puke, of the Bay of Plenty area in North Island, New Zealand. These were colour combined using SPOT XS bands 1,2,3, blue, green, red, respectively. Data were rectified, enhanced and a range of processing techniques evaluated using ERDAS Version 7.4 and ARC/INFO version 5.0.1 software.

For the unsupervised classification, three main commands were used :

Classification:

Unsupervised :

CLUSTR to perform sequential clustering  
STATCL to perform statistical clustering  
ISODATA to perform isodata clustering

Supervised classification was used for subscene AI - Matakana to define land cover categories:

old/young pine trees  
forest and scrub  
1st/2nd quality grass  
bare/swampy ground, and sea

B1 - Te Puke subscene categories of land cover analysed were :

citrus  
kiwifruit  
1st/2nd quality grass  
bare ground (fallow)  
forest

For the supervised classification, using ARC/INFO the following procedures were employed :

DIGSCRN	To digitize training samples (polygons) to use for the classification with SIGEXT.
SIGEXT	to create signatures from training polygons digitized with DIGSCRN.
SEED	to identify training cells with a seed pixel and perform alarm evaluations using parallelepiped decision rule with $\sigma = 3$ .

A range of other commands used to create intermediate classifications and the final map products (colour figs. P19A to P19H), are analysed in the results section.

## RESULTS AND DISCUSSION

GIS procedures have been used because versatility of commands in these kinds of programmes are user-friendly and allow an operator to manipulate data easily. Many operations that are difficult to perform with an image processing system that works with raster data are relatively easy to do with a GIS operating with vector data, like topologic operation.

Among the advantages is the capability to display simultaneously on a screen a raster image and vectorial data such as cartographic elements, (points, lines, polygons) of a cadastral map on the graphics plane. This provides a rapid synoptic view and the easy checking of data. Furthermore it is possible to update an old cadastral map by highlighting the areas of change or interest with different values. Additional merits are (1) the availability of an extensive number of tools and commands facilitating these operations and 2) the creation of a printed map as a final result.

One of the most successful areas of integration of data exchange formats between image processing systems and GIS is seen in the construction of a digital elevation model (DEM). It is possible to obtain a realistic perspective view of the ground useful in geologic/geomorphologic evaluations. Such products are also useful in agricultural landuse, soil, transport and planning applications. Forestry applications with DEM include the identifying of suitable sites for new plantations, evaluation of the real extension of plantations, monitoring logging operations, and planning of transportation routes.

Matakana and Te Puke areas have been chosen to recognise the different stages of growth of the pine forests (Matakana) and for identification and extension of citrus and kiwifruit orchards (Te Puke). Some cover classes are easily differentiated from inspection of the colour composite images. On the Matakana subscene (colour fig. P19G) the distinction between young and old pine trees is recognised from their light and dark brown tones respectively. The forest/scrub category shows as a yellowish-tan tone. Distinction between very shallow sea water, sand and mud flats, and bare ground, all recorded as cyan tones, is difficult. The dark green-black

areas represent the swampy ground. An example of swampy ground shows at the left upper (northwest) corner of the image. The area is utilized as high value grazing ground in summer when pastures become dry.

On the basis of distinctive tonal values spectral irradiance of cover classes in the Te Puke subscene (colour fig. P19A), it is possible to recognise the citrus orchards (dark red) the kiwifruit orchards (grey blue), the bare ground (light cyan) and the forest (dark brown-black). The pasture has been defined in two categories : 1st quality pasture and 2nd quality pasture. Nevertheless three classes have been recognized. These are 1st quality pasture (GG1) with higher values in the IR in comparison with the second group of the 1st quality pasture category (GG2), and 2nd quality pasture. The latter has higher values in the visible red and green wavelength bands.

### **SUPERVISED CLASSIFICATION - TRAINING CELLS**

To define the signatures for each class sometimes one training cell has been enough, as for the kiwifruit orchards. These are characterised by a high degree of spectral uniformity throughout the area (Edwards and Cochrane, 1990). Sometimes more training cells have been used because of a substantial range among the pixel values in the three bands for different objects belonging to the same class.

When more than one training sample has been chosen, the resulting signatures have been merged to create an unique signature for the class. This process has been the most delicate because of merging some signatures that did not represent well the mean value of the class could lead to a wrong interpretation and classification with the inclusion of pixels belonging to different classes.

The two enlargements of the citrus orchard and adjacent area have been obtained using ERDAS colour composite image (colour fig. P19E) and ARC/INFO fully classified map (colour fig. P19F). Both subscenes have been magnified 5 times. Nevertheless with ERDAS it is possible to magnify an object only by a whole number of times (Ex: 1, 2, 3, ...) because of the nature of the pixel. On the contrary with ARC/INFO the magnification is continuous (ex: 1.3, 2.7, 1.5) using the command MAPEXTENT, knowing the size of an object and computing simple calculations. With both the enlargements (colour figs. P19E and P19F) it easy to see the extent of the citrus orchards. The dark brown-black stripes among the orchards are shelterbelts (colour figs. P19A and P19E) used to protect the citrus orchards from the cool southerly winds.

The same kind of shelterbelts are used to protect the kiwifruit orchards (Edwards and Cochrane 1990) occupying most of the right (eastern) half of the subscene (colour fig. P19E).

## ERDAS PROCESSING

With the unsupervised classification or with SIGEXT we achieved medium results. It has not be possible to differentiate in B1 (Te Puke) GG1 and GG2 (1st quality pasture). The best results have been achieved with the SEED classification. We have had the possibility to differentiate both subscenes in well distinguished classes.

A1 - Problems to merge shallow water and deep water : inclusion in the signature of swampy ground. Therefore two different signatures.

B1 - Problems to merge GG1 and GG2 : inclusion in the resulting signature of part of 2nd quality pasture. Therefore two different signatures.

Using SEED the training polygons and a DIG file containing the polygons information is created automatically.

SIGMAN has allowed processing to perform a quick alarm using the parallelepiped decision rule with sigma = 3 and to merge and delete uncorrect signatures. We have had some problems with the subcommands MERGE, DELETE and RENAME.

### Enhancement

Automatic stretching has been used with sigma = 2 (95% pixels classified). With manual stretching (WFM has been used also to overlay the graph for the images and to perform linear and nonlinear spectral enhancement) we have not obtained a visible enhancement in comparison with automatic stretching.

BSTATS has been used to generate a statistic file used automatically by the software for the automatic stretching.

### Classification:

Unsupervised : CLUSTR to perform sequential clustering  
STATCL to perform statistical clustering  
ISODATA to perform isodata clustering.

Supervised : DIGSCRN to digitize training samples (polygons) to use for the classification with SIGEXT.  
SIGEXT to create signatures from polygons digitized with DIGSCRN.  
SEED to identify training cells with a seed pixel and perform alarm evaluations using parallelepiped decision rule with sigma = 3.

Check : ELLIPSE used to view sample scatterplots of signatures data. Two different kinds

of bare ground have been identified as belonging to the same class with ELLIPSE command.

CMATRIX used to perform the contingency matrix evaluation using Mahalanobis method.

SIGDIST used to calculate distance between signatures.

DIVERGE used to compute signature divergence using Jeffrie-Matusita distance.

All four commands have been used to check the signatures and to decide to merge or delete them before classifying the image using the command MAXCLAS.

MAXCLAS has been used to classify the resulting signatures using the training polygons in the DIG file and all the three bands, using the maximum likelihood decision rule. MAXCLAS creates automatically a GIS file. The resulting GIS file has been converted with CVT73 from the new format of ERDAS version 7.4 to the previous format of ERDAS version 7.3 because the version 5.0.1 of ARC/INFO does not support the ERDAS 7.4 format.

### ARC/INFO PROCESSING

Using ARC/INFO complex modifications of the topology and database are easy to perform. It is easy to alter the codification of attributes, to modify the features of a coverage, to merge polygons, to mosaic coverages, to overlay different layers containing different kinds of information. These forms of readily acquired data are the improved techniques desired by planners and managers. One of the best performance of a GIS is however the final product : the map. It is possible to fill polygons with different shades, usually user-defined, to use one's own formats, symbols, colours, lines, etc. Thus the increasingly complex and difficult role of resources management is greatly facilitated by the speed, versatility and utility of these processing procedures.

GIS can provide a range of thematic maps addressing a specific problem, diverse maps for comprehensive coverage, for updating patterns, for mapping of change, maps of economic or environmental facets, or fully classified complex maps.

The ARC/INFO command ERDASSVF has been used to convert ERDAS GIS file in a SVF file. To convert data from a raster format to a vector format GRIDPOLY command has been used. The Matakana and Te Puke ARC/INFO coverages have been submitted to a process of elimination of the clumps with an area smaller or equal to  $800\text{m}^2 = 2$  pixels with the command ELIMINATE. After the classification and smoothing functions have eliminated the clumps, the area previously occupied by them is assigned to the widest adjacent polygon (see fig. 1).

A higher value in the elimination process would have carried an abnormal increase in the area of the forest and therefore an area of 800m<sup>2</sup> has been believed suitable.

	Initial	Eliminated	Final
A1	11111	7656	3455
B1	19759	14014	5745

For both the subscenes the command DISSOLVE has allowed removal of boundaries of adjacent polygons with the same class code but with different value of signatures as for shallow/deep sea class in the Matakana subscene and similarly for GG1/GG2 in the Te Puke area.

Minor modifications have been performed using the ARC/INFO module ARCEDIT.

The resulting landuse map has been created using the module ARCPLOT and the map composition commands.

Future steps:

Digital elevation model (DEM) of the images and overlaying of cadastral and landuse maps.

Hardware and Software characteristics :

Computer : SUN SparcStation 1+  
12 Mb memory  
1400 Mb disk (mostly ARC/INFO data)  
1/4 inch 150 Mb tape drive  
Running SunOS (UNIX) version 4.1.

Monitor : 19 inches colour monitor, 256 colours display.

Network : The SparcStation was connected to another SparcStation 1+, 2 PCs, a SUN 3/160 and a PRIME 750/

ERDAS version 7.4 (SUN 4)  
ARC/INFO version 5.0.1 (SUN4)

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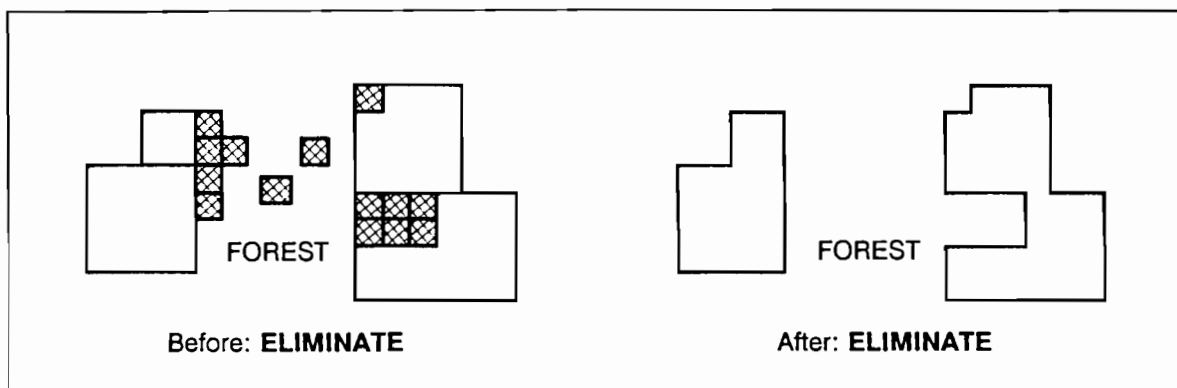
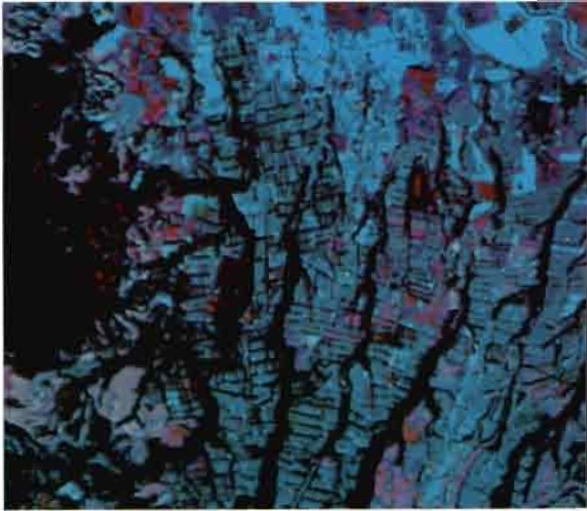


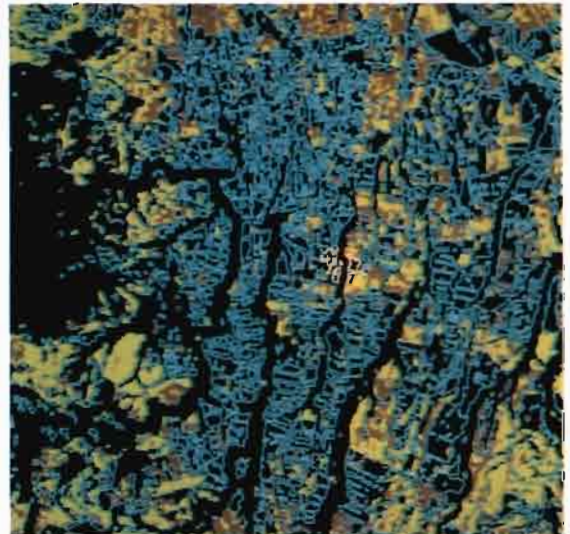
Figure 1 : Clumps elimination process with ELIMINATE function.

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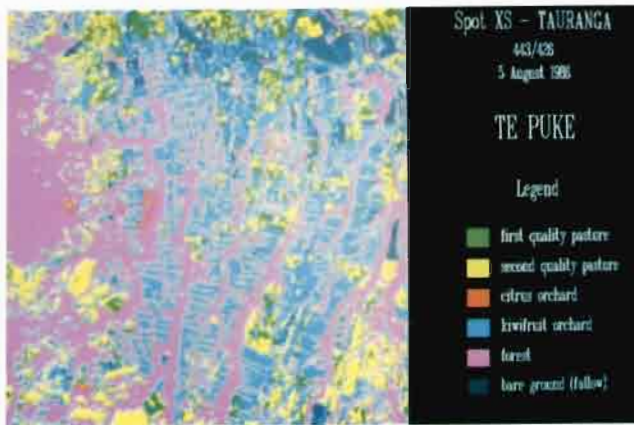
P19A : ERDAS colour composite image of B1 Te Puke subscene of SPOT image (443/426). Scale 1:110,000. C CNES/dist SPOT IMAGE.

P19B : Te Puke subscene showing theming process and polygons by ARC/INFO Red = 1st quality pasture - Yellow = 2nd quality pasture Polygon pattern readily visible.



P19C : Te Puke subscene fully classified showing polygon overlay.

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P19D : Te Puke subscene fully classified by ARC/INFO.

P19E : Part of Te Puke subscene enlarged X 5 - ERDAS process.

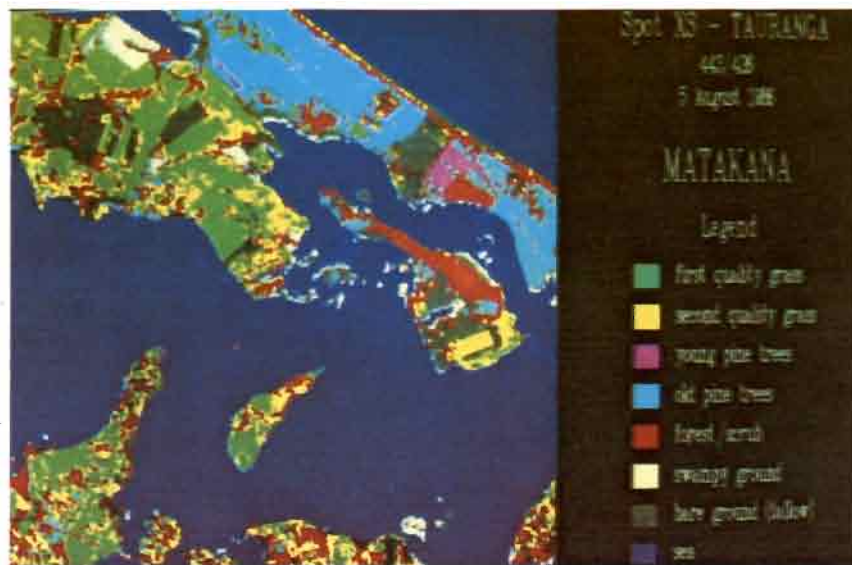


P19 F : Part of Te Puke subscene enlarged X 5 - ARC/INFO process fully classified. See colour fig. P19D for key and colour codes

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P19G : ERDAS colour composite of Matakana subscene of SPOT image (443/426). Scale 1:50,000



P19 H : Matakana subscene fully classified by ARC/INFO process



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