REMOTE SENSING for
Vegetation Community Mapping

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An Evaluation of Image and Field Data for Vegetation Community Mapping in Tropical Savannas

May 2014

OUTLINE

- Vegetation community mapping - defined
- Background and current status
- Overview of common remote sensing methods
- CASE STUDY - Objectives
- Study area
- Datasets
- Aerial Photography Interpretation
- Pixel-based image analysis
- Object-based image analysis
- Accuracy assessment & cost effectiveness
- The future of Remote Sensing

VEGETATION COMMUNITY MAPPING

definition, background, current status & common methods

VEGETATION COMMUNITY MAPPING: defined

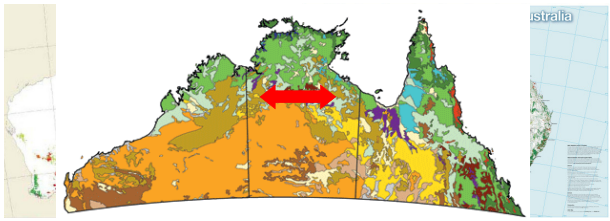
an assemblage of plant species typically occurring together and forming repeating units across a landscape

- An applied science that depicts the spatial extent of vegetation communities at a fixed point in time
- An iterative process that broadly involves:
  - Field sampling, analysis & classification
  - Image acquisition pre-processing & interpretation/classification
  - Map attribution
  - Accuracy assessment
- It provides baseline information for a variety of policy, regulation and management purposes
- Maps can be produced at various spatial scales, attribute detail and accuracy
- An increasing requirement for finer spatial scale maps and degree of accuracy

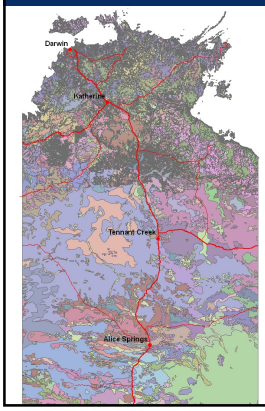
VEGETATION COMMUNITY MAPPING: Australia

Attempts to map Australia's native vegetation

- Native & non native vegetation cover 1:5,000,000 - Carnahan 1976 (modified AUSLIG 1990)
- Forest types 1:250,000 - National Forest Inventory (NFI) 1990s
- National Vegetation Information System (NVIS) – 1999 ongoing
- NVIS & NFI integration – early 2000s
- Australian Tropical Savannas – Queensland Environment Protection Agency & Cooperative Research Centre 2001



VEGETATION COMMUNITY MAPPING: Northern Territory

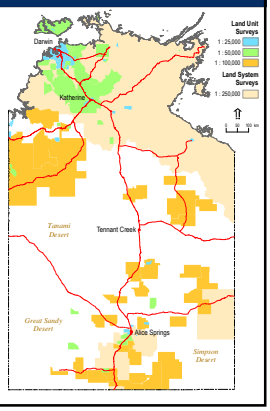


Integrated surveys

NT vegetation map

Finer spatial scales

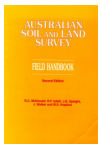
NT NVIS product

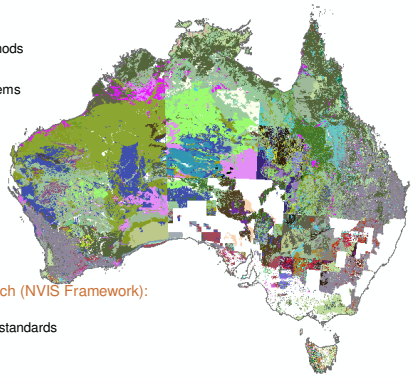


NATIONAL VEGETATION INFORMATION SYSTEM

Patch work quilt a result of:

- Inconsistent data collection methods
- Different spatial scales
- Incomparable classification systems





The need for a national approach (NVIS Framework):

- National guidelines & survey standards
- Data collection
- Vegetation attributes

VEGETATION COMMUNITY MAPPING: common methods

Each method requires field sampling to classify the vegetation communities

Aerial Photography Interpretation (API):

- Traditional technique - labour intensive
- Manual stereoscopic interpretation of aerial photograph pairs
- Delineation of reoccurring patterns on-screen (GIS)
- Rapid field checking
- Continues to be a universally accepted method

Pixel-based Image Analysis (PBIA):

- Image classification using supervised or unsupervised algorithms
- Relies on spectral signatures of pixels
- Fails to capture the structural & floristic composition of vegetation communities
- Low accuracies

Object-based Image Analysis (OBIA)

- Uses spectral and spatial information
- Segmentation
- Groups pixels based on homogeneity criterion
- Contextual information to classify objects (rulesets, information hierarchy)
- Potential to map vegetation communities

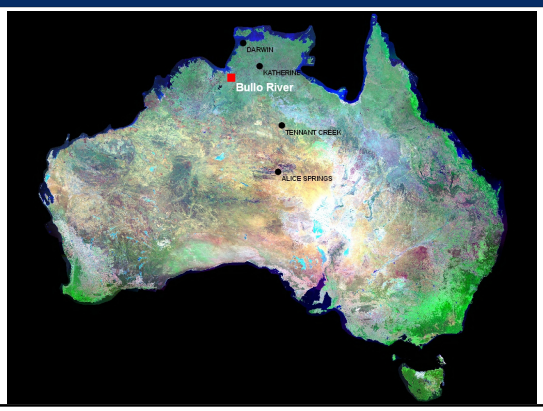
CASE STUDY:

An Evaluation of Image and Field Data for Vegetation Community Mapping in Tropical Savannas

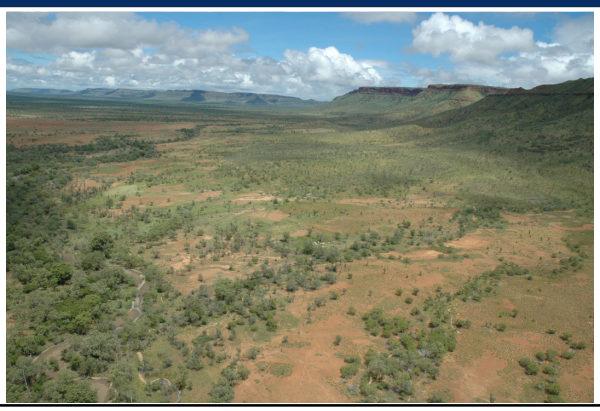
OBJECTIVES

- Evaluate 3 common methods to map vegetation communities & the influence of incorporating ancillary data into image classification:
  1. Aerial photography interpretation
  2. Pixel-based image classification
     - *Unsupervised image classification (image only & integrated approaches)*
     - *Supervised image classification (image only & integrated approaches)*
  3. Object-based image classification
     - *Nearest Neighbour classification (image only & integrated approaches)*
     - *Step-wise classification (image only & integrated approaches)*
- Compare low- and moderate-resolution image datasets including Landsat5 TM and SPOT5 to the above methods
- Assess the effect spatial scale has on attribute and spatial detail by generating thematic maps at 1:25 000 and 1:100 000 for each method
- Assess the cost-effectiveness of each approach and dataset including accuracy assessment and costs and time associated with each approach

STUDY AREA



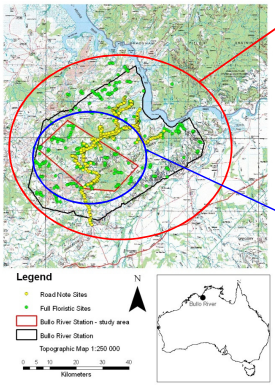
STUDY AREA – variety of vegetation communities



FIELD, IMAGE

AND ANCILLARY DATA

FIELD DATA



Bullo River Station

411 full floristic & structural sites

412 road notes

Collected 2006 – 2009

Three helicopter-based trips

Three vehicle-based trips

The Subset

137 full floristic & structural sites

104 road notes

Training Areas

50% used for supervised image classification

50% reserved for validation (accuracy assessment)

FIELD DATA ATTRIBUTES

- Pre-selection of sites (aerial photography, SPOT5, Landsat5 TM)
- 20 x 20 m quadrats
- Full floristic inventory
- Structural attributes (cover, height, growth form)
- Strata (upper, mid, ground)
- Environmental information (landform, basic soils)

ANALYSIS & CLASSIFICATION

Plant Identification

Databasing

Multi-variate analysis of field data to determine floristic groupings:

- Cluster analysis
- Intuitive classification
- 31 vegetation communities for Bullo River and 22 for the subset

Vegetation Classification

- National Vegetation Information System (NVIS)
- Floristics
- Structure (height & cover)
- Growth Form
- Strata

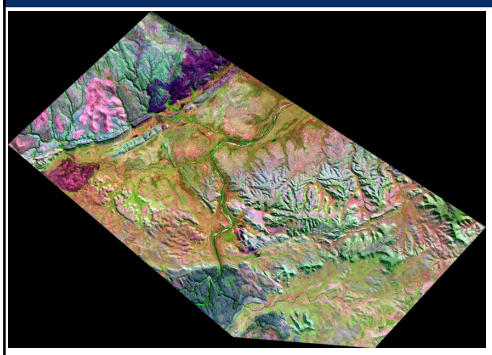
- Information Hierarchy Level V (highest level of detail floristically)
- Vegetation community describes up to 3 dominant strata including mean height & cover, modal growth form and up to 5 dominant species

Eucalyptus tectifica +/- Corymbia foelscheana, Erythrophleum chlorostachys, Corymbia grandifolia Low Woodland over *Cochlospermum fraseri, Terminalia canescens, Brachychiton tuberculatus* Tall Sparse Shrubland over *Eriachne obtusa, Heteropogon contortus, Sehima nervosum, Ampelocissus frutescens, Waltheria indica* Mid Tussock Grassland

IMAGE DATA – Aerial Photography

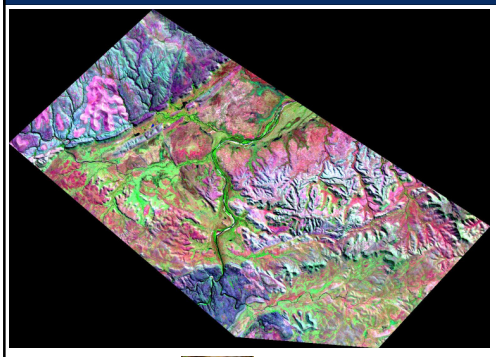
Aerial Photography Mosaic

IMAGE DATA – SPOT 5



- SPOT5 10m Multi-spectral, 4 Band)
- Captured May 2006
- 24 ground control points – DGPS
- Ortho-rectification
- Level 1A processing
- 10 km margin SRTM 30 sec data
- min error 4.98 m X & 4.30 m Y
- RMSE was 2.68 m X, 2.11 m Y & 3.41 m XY

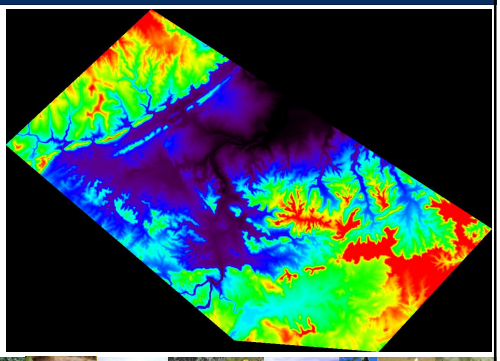
IMAGE DATA – Landsat 5 TM



- Landsat5 TM 25 m Multi-spectral, 7 band
- Captured May 2006
- 24 ground control points – DGPS
- Geometrically corrected using SPOT5 ortho-rectified scene
- Standard technique developed by Qld Dept. Natural Resources and Water

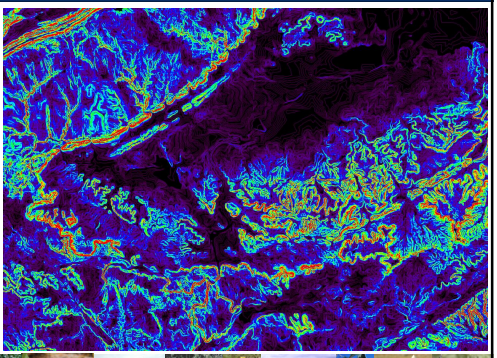
ANCILLARY DATA – Digital Elevation Model

- Digital elevation model
- Currency 1990-1994
- Australian Defence Force
- Dted2 30 x 30 m post spacing & 10 m contours
- Extent of Auvergne 1:250,000 topographic map sheet



ANCILLARY DATA – Slope Model

- Slope model
- Generated from digital elevation model

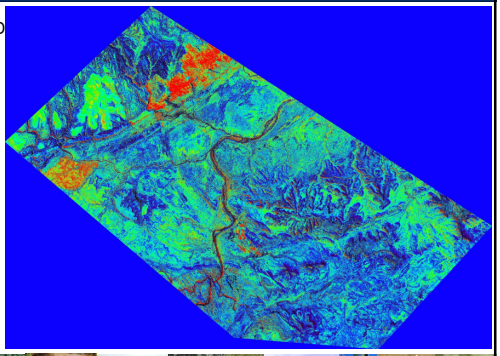


ANCILLARY DATA – NDVI

NIR-RED/NIR+RED

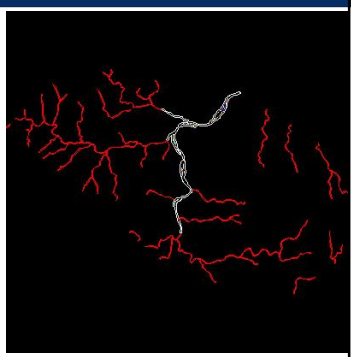
NDVI Landsat5 TM

NDVI SPOT5



ANCILLARY DATA – Hydrology

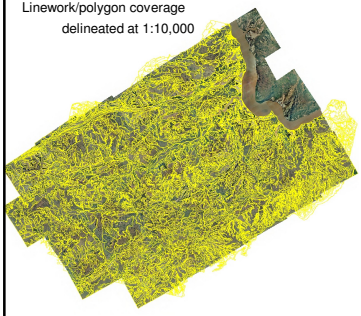
- Hydrology 1:250,000 (Bullo River Station Water Resources Survey)
- Riparian Communities



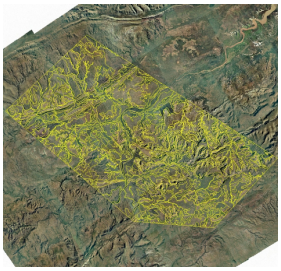
AERIAL PHOTOGRAPHY INTERPRETATION

LINEWORK DELINEATION

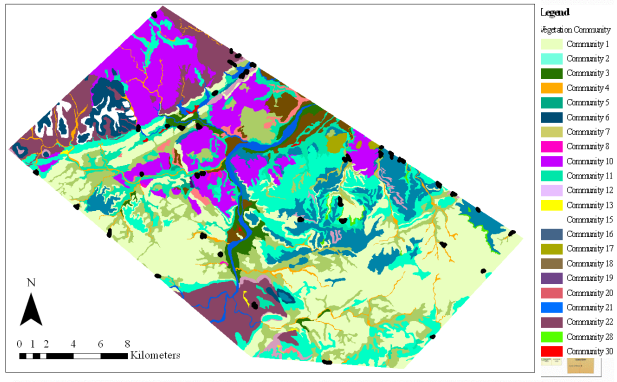
Linework/polygon coverage delineated at 1:10,000



Subset 1:25K & 1:100K

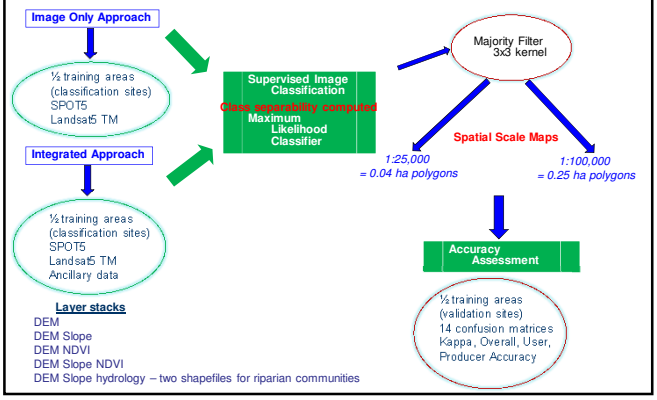


THEMATIC MAPS



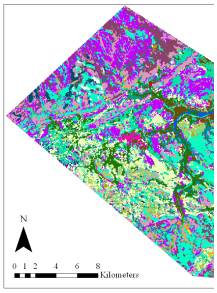
PIXEL-BASED IMAGE ANALYSIS

METHODS

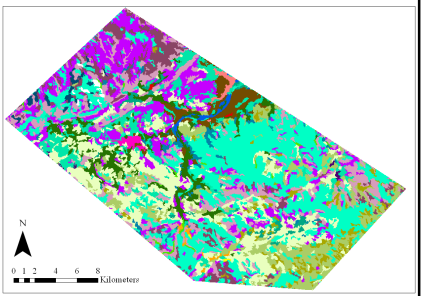


THEMATIC MAPS – spatial scale comparison

Example of the highest overall accuracy resultant map – Landsat5 TM with DEM and slope model layer stacked



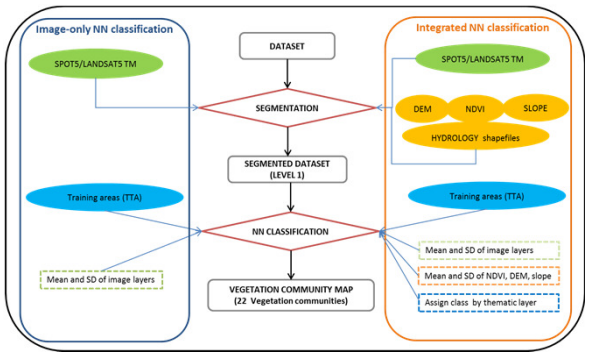
Landsat5 TM 1:25,000



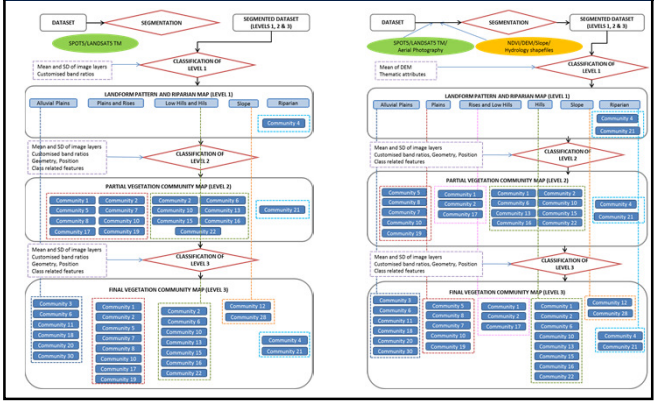
Landsat5 TM 1:100,000

OBJECT-BASED IMAGE ANALYSIS

NEAREST NEIGHBOUR CLASSIFICATION

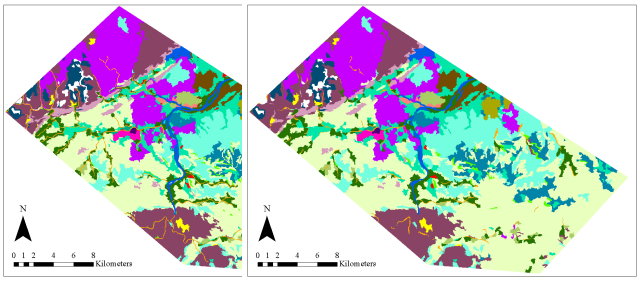


STEP-WISE CLASSIFICATION



THEMATIC MAPS – spatial scale comparison

Example of the highest overall accuracy resultant map – SPOT5 step-wise integrated classification

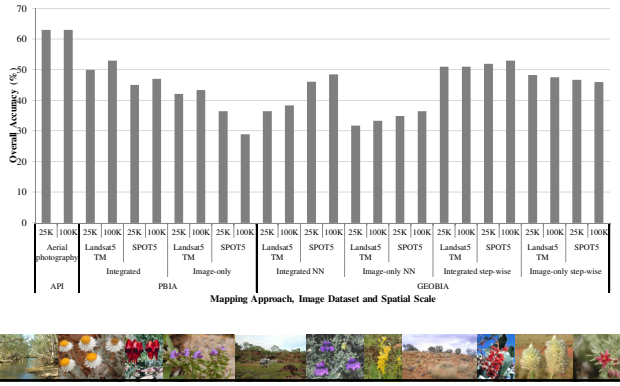


SPOT5 1:25,000

SPOT5 1:100,000

ACCURACY ASSESSMENT AND COST EFFECTIVENESS

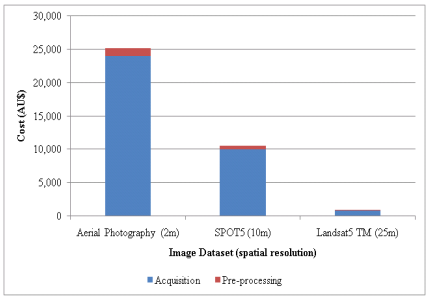
ACCURACY ASSESSMENT



COST COMPONENTS & SUBCOMPONENTS

Component	Subcomponent	Detailed Costs and Time Invested
(1) Field data acquisition and preparation*	Field sampling*	Working hours, staff salaries, staff travel allowance, helicopter hire cost (wet rate), vehicle lease cost, fuel cost
	Plant identification and databasing*	Working hours, staff salaries
	Multi-variate analysis and vegetation classification*	
(2) Image data acquisition and preparation	Image acquisition	Working hours, staff salaries, image cost
	Image pre-processing	Working hours, staff salaries
(3) Image Classification	API linework	Working hours, staff salaries
	API attribution	
	PBIA training	
	PBIA classification	
	GEOBIA segmentation	
	GEOBIA training	
	GEOBIA classification	
(4) Accuracy Assessment*	Accuracy assessment*	Working hours, staff, salaries

DATASET COSTS

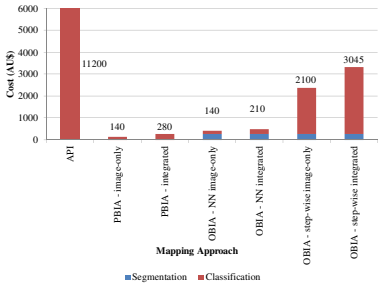


Aerial photography: $24,000

SPOT5: $10,000

Landsat5 TM: $760

METHOD COSTS



Highest costs for each approach:

API: $11,200

OBIA: $3,045

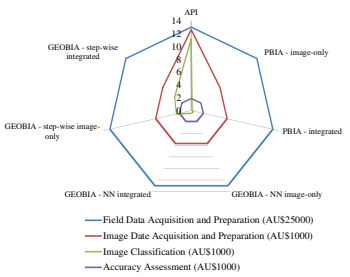
PBIA: $280

Trends:

Cost increased when ancillary data was incorporated

Accuracy also increased

METHOD & COMPONENT COSTS



- Field data acquisition and preparation was the highest cost = $325,000
- Accuracy assessment was the lowest cost = $1,900
- API overall was most expensive method = $388,000
- PBIA overall was least expensive method = $338,000
- Correlation with cost and accuracy

CONCLUSIONS

- API presented the highest overall accuracy (67%) for the 1:25,000 spatial scale map
- Image-only pixel-based approach applied to Landsat5 TM at 1:25,000 demonstrated the lowest (28%)
- Most labour-intensive component was the field data acquisition and preparation
- Accuracy assessment component was the least expensive
- Overall, API was the most labour-intensive & expensive approach
- Pixel-based image analysis was the least expensive overall
- Object-based image analysis has the potential to capture the floristic component and associated structural elements of vegetation communities using a stepwise approach (segmentation, contextual information, extrapolation)
- The incorporation of ancillary data considerably improved overall accuracies applied to both the image datasets for all approaches by up to 10%
- Definite correlation with overall accuracy and associated costs for the seven mapping approaches - an increase in overall accuracy reflected an increase in total costs
- Further research is required to determine the sampling intensity and what impact this has on the final map and overall accuracy

FUTURE OF REMOTE SENSING

Vegetation Community Mapping

Future of Remote Sensing

- Improved image processing software
- Commercially available high resolution satellite imagery
- Ancillary data
- Segmentation algorithms
- Classification algorithms
- Integration of techniques (i.e. pixel & object-based image classification - segmentation)

Remote sensing technologies used to map/classify vegetation communities rely greatly on field data to inform classifications. The collection of field data is integral to accurately map vegetation communities, irrespective of the approach applied.

Questions?

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An Evaluation of Image and Field Data for Vegetation Community Mapping in Tropical Savannas

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