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Project Title: Removing impediments to environmental monitoring from remotely sensed images and field data sets.

PART 1: Review of the Status of Remote Sensing for Environmental Monitoring and Management Applications in Australia.

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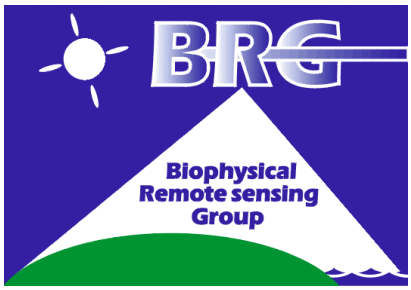

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(i) Executive Summary

The findings presented in this report are part of a larger study being conducted by the Biophysical Remote Sensing Group at the University of Queensland. The five main stages of this larger project encompass:

(1) Identifying current and expected impediments to the widespread utilisation of remotely sensed data in coastal environments;

(2) Selecting representative sites in key environments that are the subject of local, state, national and international research and monitoring programs;

(3) Coordinating the acquisition of relevant image and field data sets from the representative sites and acquiring existing data sets;

(4) Integrating field and image data sets at specific scales using spatial statistical analyses and hierarchical models; and

(5) Identifying the type of information able to be extracted at specific spatial and temporal scales from each representative environment and upgrading the framework accordingly.

The goal of this project was to build on a previous survey and an evaluation of remote sensing for monitoring environmental indicators in the wet tropics of North Queensland and apply a similar approach to resource monitoring and management in Australia as a whole. This approach will build on national scale assessments from Wallace and Campbell (1998) and Price-Waterhouse Coopers PWC (2000), to identify the current level of use of remotely sensed data, it's perceived limitations, and the information requirements it can be used to meet. By completing a similar survey, the information provided will demonstrate the type(s) of remotely sensed data and processing techniques required by natural resource monitoring and management agencies in Australia. The results provide guidelines for future activities of professional, industry, research and educational bodies to improve the use of remotely sensed data by identifying the current levels of use, types of data, processing capabilities and perceived limitations.

The format followed by this report will be to explain the design of the survey, then summarise the results of each question at national and state levels, allowing conclusions to be made on the status, perceived limitations and future directions for remote sensing applications for environmental monitoring and management in Australia. In addition, the findings can also be seen as a more detailed assessment of impediments to and solutions for use of remote sensing as part of the Australian Spatial Information Industry, through its Industry Action Agenda.

Two key considerations in establishing the survey were its content and format. The design of the content was based on the main types of information that needed to be obtained: type of monitoring and management responsibilities; current level and type of remotely sensed data use and processing; expenditure on remote sensing; and perceived limitations of remote sensing. A web-based survey developed by Institute for Applied Science (IAF), Fachhochschule Nurtingen, Germany, was used as the basis for some of the questions and format.

The web-based format enabled an explanatory email (Appendix 8.1) to be sent out to the sample population with a link to the web-site containing the survey form (www.geosp.uq.edu.au\BRG\surveys\GENERAL_survey.html). An initial mail-out to 1577 people and organisations was completed. In February 2001, this was followed by reminder emails and personal email, fax and phone calls in some cases. A total response of 160 questionnaires was received. The target sample population for the survey consisted of those agencies concerned with monitoring and managing terrestrial and aquatic environments in Australia from local to state and national scales. Every effort was made to include all of the relevant agencies in government, non-government and private sectors, and to address all application areas. As a result of the source of contacts for the surveys, a bias resulted with a predominance of government agencies responsible for monitoring

and managing terrestrial environments. Under-represented agencies and areas of application included the private sector and agencies concerned with atmospheric, climatic, meteorological, and oceanographic areas. In some ways this also reflected a criticism raised in the PWC (2000) review, that applied remote sensing work (esp. environmental monitoring) was being performed predominantly by government agencies and not outsourced.

The results of the survey and analyses at national, state and local scales presented in this report provide significant extension to the findings of Wallace and Campbell (1998) and PWC (2000), in terms of how remotely sensed data are used and the capabilities of management agencies to continue using these data. Recommendations to improve access and "use-ability" of remotely sensed data support several of the key recommendations in the recently released 2001 Spatial Information Industry Action Agenda for Australia (www.dist.gov.au/agendas/Sectors/siiaa).
Based on the information collected in this survey, the current **status** of remote sensing for environmental monitoring and management applications in Australia, from local to national scales can be described as:

- Focussed on programs for monitoring (regular mapping + change detection) in terrestrial environments at regional scales (> 10,000km^2) on annual or as-required time- scales.
- Employing "traditional" sources of remotely data, such as stereo-colour aerial photography and satellite multispectral (Landsat Enhanced Thematic Mapper, SPOT XS) image data to complete mapping and monitoring programs.
- Consisting of organisations with small (two – four person) staff groups with specialized backgrounds in remote sensing, spatial analysis and geographic information systems.
- Most frequently applying image processing and analysis operations for visual interpretation, geometric pre-processing, classification for mapping land-cover types and change detection.
- Being dominated by organisations using software from ESRI/Erdas and Map-Info/ER-Mapper to complete image processing operations.
- Spending between $1000 - $10000/year on acquisition of remotely sensed data, but unable to accurately identify the total costs (or cost per unit area) of their specific mapping and monitoring programs.
- Concerned with the cost of image data as a critical impediment to the widespread use of remotely sensed data in the future.
- Cognisant of developments in available image data sets through professional journals and conferences.

In terms of the **limitations** of current and expected remote sensing technologies for environmental monitoring and management at local to national scales, a number of consistent points were evident relating to:

- Costs of image data sets (at all scales) were perceived as too high and a major impediment to more widespread adoption of remote sensing technologies for environmental monitoring and management.
- Specific groups of respondents indicating the need for improvements in several image resolution attributes to make remotely sensed data more suited to their applications, i.e., most local governments requested higher spatial resolution digital multispectral data, whilst groups concerned with agricultural and oceanographic applications requested higher temporal frequency for data collection.

- The increased variety of image data types now available commercially is impacting data users as a common request was for additional training to understand what these data were (and weren't) useful for and an approach to enable the most relevant data set(s) to be selected for a specific application.

As a means to identify directions for developing the remote sensing industry it is useful to compare the key impediments of the remote sensing data users to those identified by PWC (2000) for the remote sensing industry. Major impediments of the remote sensing industry included: (i) the failure of potential users to use remotely sensed data; (ii) slow and limited private sector growth in this industry area; (iii) a large number of small private companies (60 in Australia, with 13 in NSW, 11 in QLD, and 13 in ACT, 12 in WA, 3 in VIC and 8 in SA); (iv) a lack of government outsourcing of projects, resulting in competition of the private sector with government funded groups in universities and government agencies; (v) relatively high data costs; (vi) lack of skilled personnel; and a (vii) lack of funds for research and development.

Results from the survey completed in this project identified specific activities that remotely sensed data were being used for, along with the capabilities and future development requirements of groups using remotely sensed data. These results indicate some of the elements responsible for impediments identified by PWC (2000), i.e., the failure of potential users to use remotely sensed data and limiting the use of remotely sensed data (i.e., costs, resolution, confusion over appropriate data type and how to process). By considering these issues together, several recommendations for **future developments** can be made to increase usage of remotely sensed data in Australian agencies and companies responsible for environmental monitoring and management.

- The issue of perceived higher costs of image data sources could be addressed in two ways. One approach would be to provide government subsidised base data sets (which is already done with Landsat data). This would still enable companies to value-add processing and sell corrected data and information. A second approach would be an educational campaign on the true costs of image data sets, to move away from the historical inertia introduced by aerial photography and moderate spatial resolution satellite data sets.

- Increasing the spatial and temporal resolution of imaging satellites is occurring as new satellite systems continue to be launched, providing a greater variety of data types, especially for higher spatial resolutions and specific applications (e.g. ocean colour and agricultural monitoring).

- A focus for the Industry and Professional Bodies operating as the Australian Spatial Information Business Association and the Spatial Sciences Coalition in cooperation with relevant universities, should be on educational and training programs to be provided for potential remote sensing data users. These programs would cover three key issues: (1) fundamentals of remote sensing applications (what can I see in optical, thermal and microwave images and why?); (2) types of remotely sensed data and information products and how to select the data for my application; and (3) procedures for transforming image data to information.

- There is also a significant need to develop a systematic program for linking education, applied research and industry applications. This presents an opportunity for the Spatial Sciences Coalition to act as an organising point for establishing collaborative links between universities and private companies to address industry questions. The Australian Research Council's Industry Linkage Grants (http://www.arc.gov.au/ncgp/linkage/projects/default.htm) facilitate this approach, while smaller projects could apply NASA's Commercial Remote Sensing Program (http://www.esad.ssc.nasa.gov/eocap/eocapmain.asp). Adopting either of these approaches would provide industry training and experience for students and an effective transfer of research into application.

1. Introduction & Background

This project was initiated to address three issues:

i. To extend the findings of recent studies on the operational applications of remote sensing in Australia (Wallace and Campbell 1998, Price-Waterhouse Coopers & Technical Field Surveys 2000);

ii. Provide a basis for extending the framework developed in Phinn (1997, 1998) and Phinn *et al.* (2000) to guide remote sensing applications in Australian environments; and

iii. Combine the results from these works into a model for making optimum use of historic, current and next generation of satellite and airborne imaging systems for resource monitoring and management.

The survey design and analysis presented in this report addresses issue (1) above and stage (1) below of a larger study being conducted by the Biophysical Remote Sensing Group at the University of Queensland.

The five main stages of the larger project will encompass:

(1) Identifying current and expected impediments to the widespread utilisation of remotely sensed data in coastal environments;

(2) Selecting representative sites in key environments that are the subject of local, state, national and international research and monitoring programs;

(3) Coordinating the acquisition of relevant image and field data sets from the representative sites and acquiring existing data sets;

(4) Integrating field and image data sets at specific scales using spatial statistical analyses and hierarchical models; and

(5) Identifying the type of information able to be extracted at specific spatial and temporal scales from each representative environment and upgrading the framework accordingly.

One of the key premises that the Phinn (1997, 1998) framework for evaluating the suitability of remotely sensed data for monitoring problems outlined, was the presumed need for information on the condition of an environment and how it changes over time. Subsequent applications of the framework in South-East Queensland, the wet-tropics of North Queensland and the Alligator and Mary River (Northern Territory) catchments were limited in their effectiveness as certain institutional and economic factors prevented the output information from being utilised effectively and adopted as a useful resource monitoring approach (Phinn Held and Stanford 2000; Phinn *et al.* 2000, 2001). Reviewers of the framework for international journals have also suggested that although the framework can be used to select optimal data sets, if it is to fit into operational resource management it must establish and mitigate impediments for use of remotely sensed data. A questionnaire was developed and sent to the main “resource managers” in local, state and federal government agencies in Australia to identify their perceived impediments and solutions (Phinn, Held and Stanford 2000). This will be supplemented by a literature review and focus on papers such as Wallace and Campbell (1998) and Price-Waterhouse-Coopers (2000).

The format and content of this survey evolved from two previous activities at the University of Queensland and a number of similar studies in Australia and overseas. To provide a basis for linking research to government agency needs in the wet tropics of northern Australia, Phinn *et al.* (2000) modified a web-based survey developed by Institute for Applied Science (IAF),

Fachhochschule Nurtingen, Germany to assess the demand for airborne digital cameras for environmental monitoring (www.iaf.fh-nuertingen.de/iaf). The Phinn *et al.* (2000) survey was sent to 111 management agencies to identify their remote sensing requirements and capabilities for forest and water quality monitoring in the wet-tropics of North Queensland. Based on responses to this survey another project was undertaken (Phinn *et al.* 2001), similar to that of Wallace and Campbell (1998), to evaluate the feasibility of remote sensing techniques for monitoring regional scale State of the Wet Tropics (SoWT) indicators as defined by the Wet Tropics Management Authority (Scientific Advisory Committee and Board). Each indicator was reviewed in detail in terms of surrogate remotely sensed measures, suitable platforms, repeat monitoring capability and costs. Critical points raised in the SoWT project included examples for a number of monitoring projects and example costs associated with: project planning, image rectification and normalisation, integration of ancillary data, mapping /change-detection, interpretation of mapping and change results, validation, refinement and correction, and production of reports and summary products. By establishing the needs of the management organisation, current levels of remotely sensed data use and perceived limitations, detailed specifications were able to be provided on how remotely sensed data could be matched to their needs and provide the organisation with sufficient information to determine if the remotely sensed approach would be useful.

The goal of this project was to build on a previous survey and an evaluation of remote sensing for monitoring environmental indicators in the wet tropics of North Queensland and apply a similar approach to resource monitoring and management in Australia as a whole. This approach will build on national scale assessments from Wallace and Campbell (1998) and Price-Waterhouse Coopers (2000), to identify the current level of use of remotely sensed data, it's perceived limitations, and the information requirements it can be used to meet. By completing a similar survey, the information provided will demonstrate the type(s) of remotely sensed data and processing techniques required by natural resource monitoring and management agencies in Australia. The results obtained from this study provide guidelines for future activities of professional, industry, research and educational bodies to improve the use of remotely sensed data by identifying the current levels of use, types of data, processing capabilities and perceived limitations.

Wallace and Campbell's (1998) report was based on workshop involving key remote sensing practitioners and experts in Australia to evaluate the feasibility of remote sensing for monitoring National State of the Environment Indicators. The focus of the survey was on identifying the operational status (operational, feasible, possible or impossible) of remote sensing to deliver information on specific indicators, not to address the general level of remote sensing use in these agencies. The Price-Waterhouse Coopers (2000) was commissioned by Department of Industry, Science and Resources (DISR) in 2000 as a survey on the status of the space and remote sensing industries in Australia. This project sent out a survey to 519 people in private companies, government agencies and academic institutions in Australia, with a response rate of 27%. The focus of the questions was on establishing the present size, distribution and operations of the remote sensing (RS) industry as well as identify the principal users of remote sensing technologies. Key findings of this report are listed briefly below.

- The main activities of the remote sensing industry in Australia, consisting of 120 organisations and valued at $45.2 million in annual revenue were: (i) Satellite, airborne and ground sensors development and operation; (ii) development and operation of ground reception stations; (iii) development and marketing of image processing software; and (iv) data acquisition, catalogue, supply and value adding operations.

- Opportunities identified for market development included: (i) high spatial resolution image acquisition and processing; (ii) national and state scale environmental assessment programs (e.g. State of Environment, Greenhouse Accounting), (iii) integration of remote sensing and GIS; (iv) data and information provision by the internet; and (v) airborne hyperspectral applications.

- Major impediments to development of the remote sensing industry were grouped into several categories, including: (i) the failure of potential users to use remotely sensed data; (ii) slow and limited private sector growth in this industry area; (iii) a large number of small private companies (60 in Australia, with 13 in NSW, 11 in QLD, and 13 in ACT, 12 in WA, 3 in VIC and 8 in SA); (iv) a
- lack of government outsourcing of projects, resulting in competition of the private sector with government funded groups in universities and government agencies; (v) relatively high data costs; (vi) lack of skilled personnel; and (vii) a lack of funds for research and development. This survey did not identify what remotely sensed data were being for, nor did it cover the capabilities and future development requirements of groups using remotely sensed data.

Based on the impediments identified in the survey and other responses two key roles were identified for the government to take in developing the industry, (i) developing an appropriate industry development framework and representative body; and (ii) providing policy to enable reasonable costs and access to data. The former requirement has been addressed through the development of the Australian Spatial Information Business Association (representatives of private companies), the Australian Spatial Sciences Coalition (a grouping of professional societies from remote sensing, GIS, surveying and mapping sciences) and the Australian Spatial Information Industry Action Agenda (SIAA). The SIAA was released in September 2001 (www.dist.gov.au/agendas/Sectors/siiaa) and contains five main actions for furthering the spatial information industry in Australia, including remote sensing. The main action points are summarized as:

(1) Development of a joint policy framework;
(2) Improved data access and pricing;
(3) Increase effective research and development;
(4) Evaluate and reform education and skills formation; and
(5) Develop domestic and global markets.

The release of this action agenda was quite timely as the strategies developed to address the five main actions will address several of the limitations and impediments identified in this project, especially in terms of action items (1) and (2).

Aside from market surveys, NASA's 10 year plan White Paper on Remote Sensing, and a recent national study initiated by the American Society for Photogrammetry and Remote Sensing (Appendix 8.4, asprs.survey.ssc.nasa.gov/welcome.asp), there are no other comprehensive national scale surveys on the status of remote sensing for resource management. There are application specific surveys for development of specific environmental monitoring programs, e.g. water quality (Vos *et al.* 1998).

The format followed by this report will be to explain the design of the survey, then summarise the results of each question at national and state levels, allowing conclusions to be made on the status, perceived limitations and future directions of remote sensing applications for environmental monitoring and management in Australia.

2. Survey Design

2.1 Survey Source

Two key considerations in establishing the survey were its content and format. The design of the content was based on the main types of information that needed to be obtained, such as: type of monitoring and management responsibilities; current level and type of remotely sensed data use and processing; expenditure on remote sensing; and perceived limitations of remote sensing. A web-based survey developed by The Institute for Applied Science (IAF), Fachhochschule Nurtingen, Germany, was used as the basis for some of the questions and format. Due to the size of the sample population, time requirements and costs involved in conducting a mail-out questionnaire, a web-based format was adopted. This approach was developed by one of the research team (M. Stanford) originally for a Rainforest Cooperative Research Centre project (Phinn *et al.* 2000). The web-based format enables an explanatory email (Appendix 8.1) to be sent out to the sample population with a link to the web-site containing the survey form (www.geosp.uq.edu.au\BRG\surveys\GENERAL_survey.html). Responses entered into the survey form are automatically entered into a Microsoft® Access database. The database can then be queried to determine response rate and conduct analyses of the responses. An initial mail-out to 1577 people and organisations was completed In February 2001, this was followed by reminder emails and personal email, fax and phone calls in some cases. The contact details for the sample population were obtained from a number of Internet sources and stored in Microsoft® Excel databases:

National survey:

http://www.environment.gov.au
Library → Networks (INFOTERRA Australia) → Themes (Atmosphere, Biodiversity, Coasts and Oceans, Environment Protection, Heritage, Inland Waters, Land) → Commonwealth Government and State and Territory Government Homepages.

http://www.algin.net.au/cnclist.htm
Councils on the web → contact lookup for each council within each state and territory of Australia.

http://www.env.qld.gov.au/environment/
Environmental Protection Agency

http://www.earthlink.com.au/index.html
Earthlink → Australia's Environmental Directory (formerly green-pages)

http://www.lgsa.org.au/
Local Government and Shires Associations

http://www.landcaresa.org.au/
Landcare in South Australia

http://www.tassie.net.au/TasLandcare/pages/who.html
Landcare in Tasmania

http://www.pirsa.gov.au
Primary Industries and Resources SA

http://www.wa.gov.au/westfish/
Fisheries WA

http://www.wrc.wa.gov.au/
WA Water and Rivers Commission

http://www.environs.org.au/
Environs Australia → Local government environment network

http://www.affa.gov.au/
Agriculture, Fisheries and Forestry Australia

Coastal Zone Survey

Coastal zone monitoring and management contacts were derived through a contact list provided by the Cooperative Research Centre for Coastal Zone, Estuary and Waterway Management in Moreton Bay, Port Curtis and the Fitzroy River Estuary. The main listing used was derived from the South-East Queensland Regional Water Quality Monitoring Strategy email distribution list (local and state government agencies, universities and non-government organisations operating in South-East Queensland.

Limitations of Survey:

The target sample population for the survey consisted of those agencies concerned with monitoring and managing terrestrial and aquatic environments and in Australia from local to state and national scales (Appendix 8.3). Every effort was made to include all of the relevant agencies in government, non-government and private sectors, and to address all application areas. As a result of the source of contacts for the surveys, a bias resulted with a predominance of government agencies responsible for monitoring and managing terrestrial environments. Under-represented agencies/application areas were private agencies and atmospheric, climatic, meteorological, and oceanographic areas. In some ways this also reflected a criticism raised in the PWC (2000) review, that applied remote sensing work (esp. environmental monitoring) was being performed predominantly by government agencies and not outsourced.

2.2 General Survey

The contents of this section illustrate the format used in the survey. The example given here is for the sample population that was concerned with coastal zone management in Moreton bay, South-East Queensland.

Remote Sensing Information Requirements Survey

Monitoring & Management Agencies Responsible for Moreton Bay

As part of a project being conducted for the Cooperative Research Centre for Coastal Zones, Estuaries and Waterways Management in Australia we are investigating the application of remote sensing for monitoring and managing coastal and estuarine environments, in particular Moreton Bay. The outputs from our project are:

(1) Remote sensing products (data and processing techniques) addressing identified specific monitoring and management agency information requirements. This includes an inventory and assessment of availability and accessibility of RS data for Moreton Bay.
(2) Documented techniques for acquiring and processing remotely sensed data in Moreton Bay to produce reliable output information. This coastal ecosystem health information consists of relevant aquatic, inter-tidal and terrestrial parameters.
(3) Development of remote sensing algorithms for the environmental zones/parameters required by monitoring and management agencies.

The goal of this survey is to determine the type of monitoring information currently collected for Moreton Bay and the extent to which remotely sensed data are used in this process.

We would greatly appreciate your input so that we may identify monitoring information requirements, levels of current use, expectations from remotely sensed data, impediments to current and future use and ideal data for applications.

The survey will only take about 10 minutes to complete.

If you choose to participate your contribution will remain anonymous and we will provide you with our summary report when it is completed.

Participant:

Title:

Surname:

First name:

Organisation:

Position:

Address:
City:
State:
Postcode:

Phone:

Fax:

*Email:

* The sender or email address is a required field for this survey to be submitted over the WW

Question 1:

As a monitoring or management agency:

- What (environment, structure, flora, fauna or process) are you required to monitor in Moreton Bay?
- What information are you required to collect for the purposes of monitoring Moreton Bay?
- How often are you required to report on this information?
- What size of an area to you typically monitor?

Question 2:

Do you use remotely sensed data?	Yes		No	

If yes which type(s) of data do you use,

Airborne photography	Area covered (km2)
Type ;	
Panchromatic	
Colour	
IR	
Colour IR	
Optical airborne	
Type;	
Digital multispectral (DMSV, ADAR)	
Multispectral scanners(daedalus)	
Hyperspectral (CASI, HYMAP, GER)	
Optical satellite	
Type;	
IKONOS	
Landsat TM	
SPOT PAN/XS	
IRS	
NOAA-AVHRR	
GMS	
Active airborne and satellite	
Type;	
SAR - airborne	
Laser profiling/scanning	
SAR (ERS,JERS,Radarsat)	

Question 3:

What is your current capacity in terms of technical staff and level of computing infrastructure?

eg 1 staff member, 1 workstation with LAN to 3 machines

Question 4:

What are the standard or most commonly applied processing routines that you apply to remotely sensed data sets used in your organisation (answer more than one if necessary):

Processing Routine	
none - only for cartography purposes	
Geometric correction	
Radiometric correction	
Image enhancement	
Data fusion	
Visual interpretation	
Image classification	
Image based modelling	
Change detection	
Terrain modelling	

Question 5:

What GIS/Image processing software do you use?

GIS		**Image processing**	
Arcview		Imagine	
Arcinfo		ER Mapper	
Microstation		ENVI	
Genamap		TNTMips	
MapInfo		Microbrian	
Idrisi		other:	
Other inc CAD etc:			

Question 6: please check one.

Do you and your organisation keep up with software upgrades etc?

Yes		No	

Question 7:

What types of activities and projects are remotely sensed data used for in your organisation?

Activity	
Landuse mapping/planning	
Geological mapping	
Watershed mapping	
Urban planning	
Coastal zone management	
Benthic habitat mapping	
Mangrove mapping	
Wetlands mapping	
Water quality mapping	
Vegetation mapping	
Disturbance mapping	
Rehabilitation monitoring	
Other - please specify:	

Question 8:

How frequently do you acquire remotely sensed data for your organisation's applications?

Image acquisition	
Daily	
Weekly	
Monthly	
6 months	
Yearly	
3-5 years	
Very infrequently	
Opportunistically	

Question 9:

What is your approximate annual expenditure on remotely sensed datasets?

Expenditure	
<$100	
$100-$1000	
$1000-$10000	
>$10000	

Question 10:

What do you consider to be the main limitations of current remotely sensed data and processing routines for extracting the information required by your organisation?

Limitations	
Cost (too expensive)	
Spatial scale (not detailed enough)	
Spatial extent (limited coverage)	
Spectral (inappropriate spectral bands available)	
Radiometric (insufficient resolution to detect required changes)	
Temporal (infrequent coverage or not available at key times, eg cloud cover	
No commercially available approach for image processing to meet requirements	
Other or feel free to elaborate on question 9:	

Question 11:

If you were to increase utilisation of remotely sensed data in the future within your organisation, what improvements should be made to current data and/or availability?

Increase utilisation by;	**Increase**	**Decrease**
Cost (decrease)		
Spatial scale (change scale)		
Spatial extent (change coverage)		
Spectral (inappropriate spectral bands available)		
Radiometric (insufficient resolution to detect required changes)		
Temporal (infrequent coverage or not available at key times, eg cloud cover)		
Available approaches for image processing to meet requirements		
Other or elaborate on question 10:		

Question 12:

List any local state or national reporting responsibilities that your organisation has that remotely sensed data are/or used for:

Question 13:

What is the cost of implementing your existing methodologies per hectare or square kilometre for your sites of interest, ie for forest timber volume/habitat &/or species assessments etc. For example, if using air photo interpretation, costs of the hardcopy and digitised product per hectare or per frame?

Question 14:

Do you and your organisation keep up with new developments in remote sensing technology via discussion groups, user group meetings etc? If so how?

Question 15 (a):

In terms of expected developments in commercially available remote sensing technology will these new datasets be useful to your organizations requirements?

Yes		No	

Question 15 (b):

Do you have the technical and financial capabilities to fully utilise these data?

Yes		No	

Question 16:

Will your organisation be training people specifically to utilise these new datasets?

Yes		No		Undecided	

Question 17:

Do you have access to local university graduates especially trained in using spatial information technologies?

Yes		No		Undecided	

Thankyou for participating

Please note: Personal details are optional

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This survey may also be completed and submitted by fax or mail simply by printing the form from your web browser.

3. Survey Response Statistics

SPREADSHEET	TOTAL CONTACTS	TOTAL EMAIL ADDRESSES	TOTAL FAX NUMBERS	TOTAL ADDRESSES	RECEIVED BACK
NATIONAL GOVERNMENT	185	161	120	105	**148** see below
NATIONAL NON-GOVERNMENT	68	65	62	60	**12** see below
ACT GOVERNMENT	13	12	4	12	**4**
ACT NON-GOVERNMENT	2	0	2	1	**0**
NSW GOVERNMENT	329	133	275	269	**22**
NSW NON-GOVERNMENT	4	1	4	4	**0**
NT GOVERNMENT	47	34	13	15	**8**
QLD GOVERNMENT	210	143	171	186	**30**
QLD NON-GOVERNMENT	31	3	27	31	**2**
SA GOVERNMENT	169	137	110	115	**19**
SA NON-GOVERNMENT	5	5	2	2	**2**
VIC GOVERNMENT	161	125	129	136	**19**
VIC NON-GOVERNMENT	4	3	3	4	**1**
WA GOVERNMENT	187	120	131	144	**18**
WA NON-GOVERNMENT	1	1	0	0	**0**
TAS GOVERNMENT	161	42	108	92	**11**
TOTALS	**1577**	**985**	**1161**	**1176**	**160**

160 TOTAL RESPONSES

National government contains responses from government agencies at a national and state scale

Each state only contains responses for the state level (both government and non-government organisations)

4. Analysis of Survey Responses

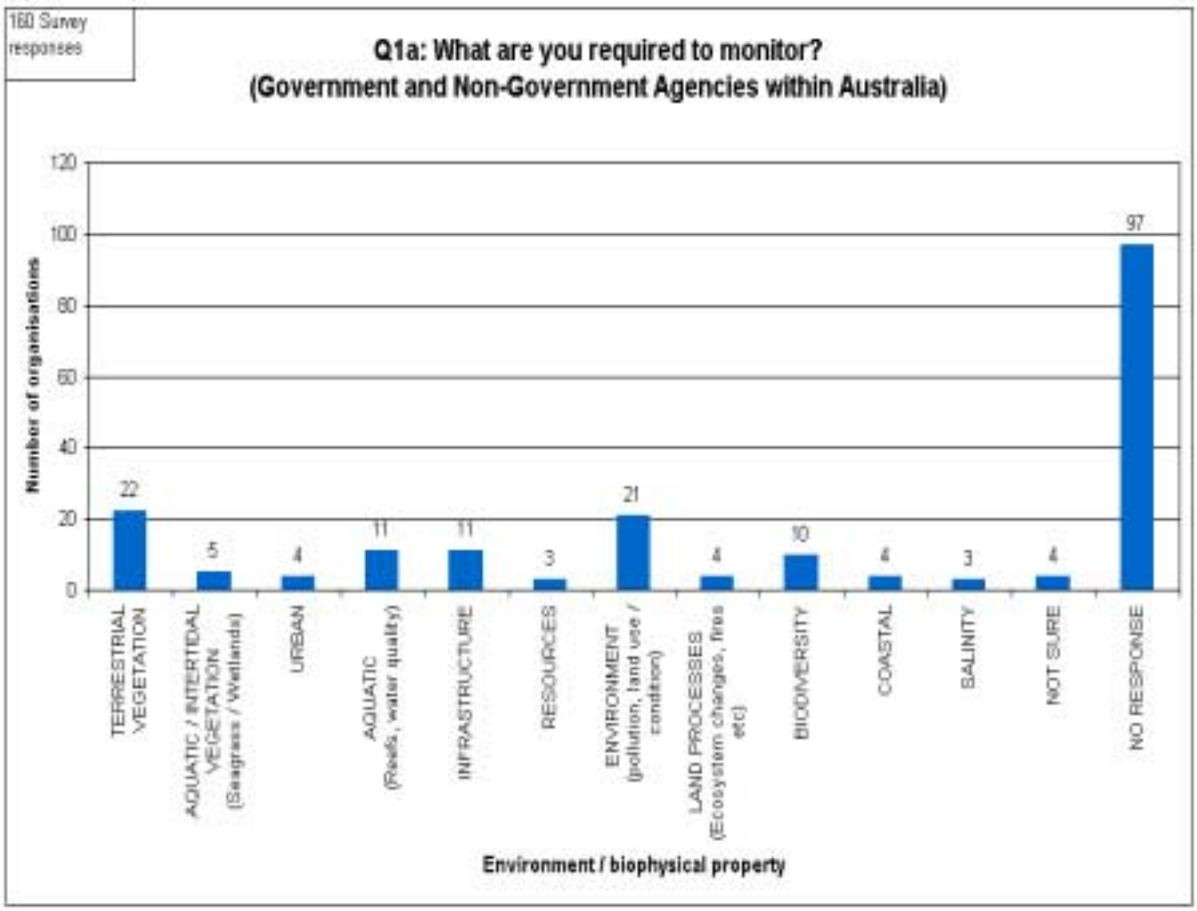
4.1 All Surveys – National Scale

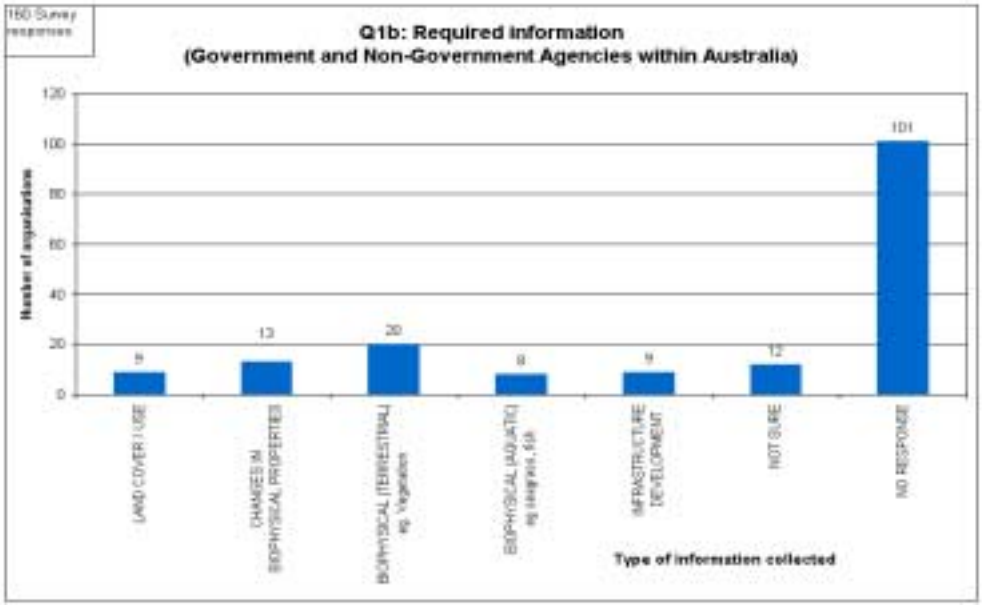
Question 1:

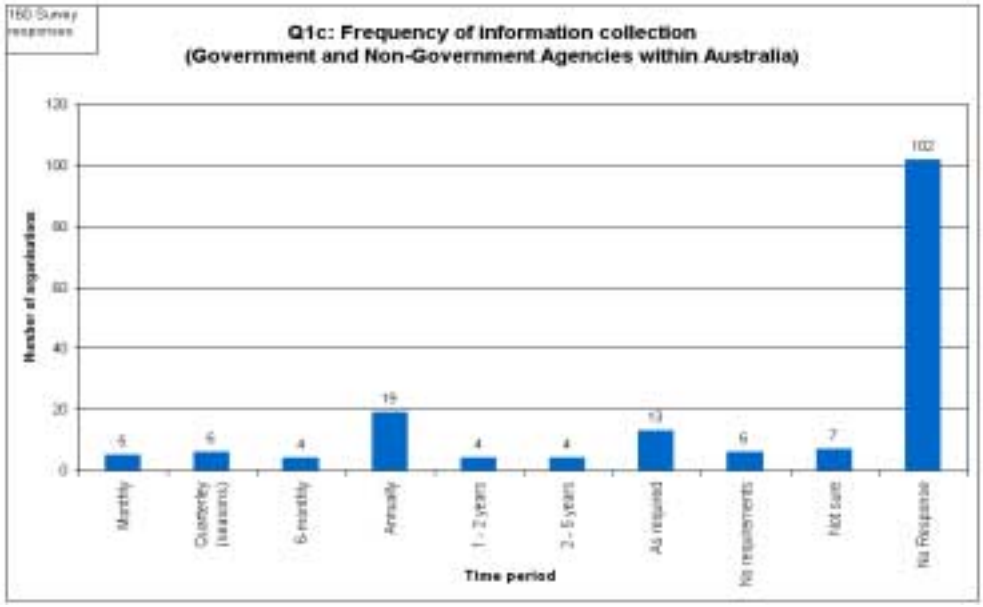
As a monitoring or management agency:

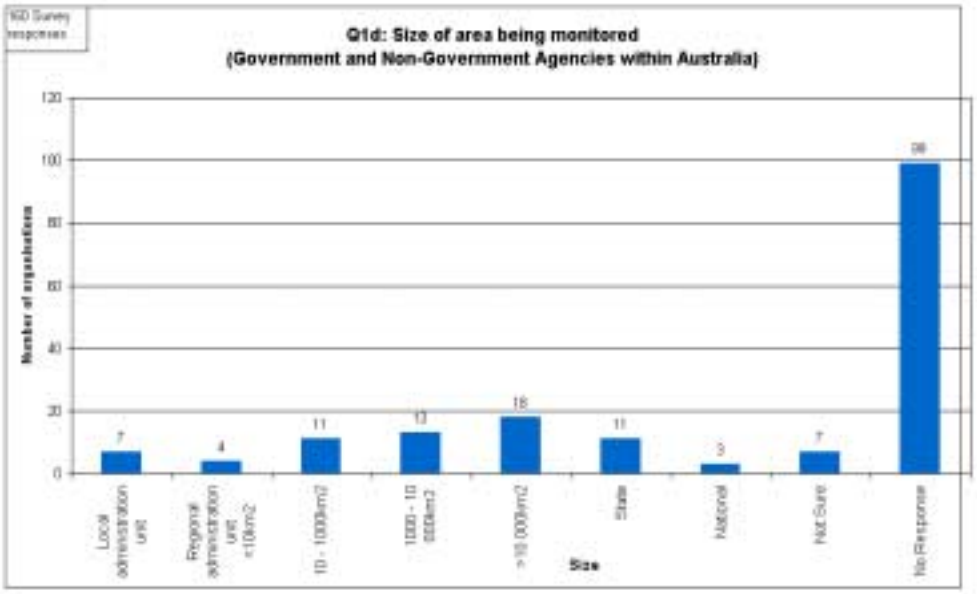
- What (environment, structure, flora, fauna or process) are you required to monitor?
- What information are you required to collect for the purposes of monitoring \?
- How often are you required to report on this information?
- What size of an area to you typically monitor?

The majority response for this question seems to be a focus of remote sensing application of state and national government agencies on monitoring general environmental conditions (mainly terrestrial vegetation and land-cover), from biophysical information (including land-cover and land-cover change), over regional to state-wide scales (1000 to > 10,000km^2) at annual or as-needed time scales. The more local scale (< 1000km^2), higher temporal frequency applications are concerned with monitoring infrastructure and aquatic environments.




160 Survey responses
Q1b: Required information
(Government and Non-Government Agencies within Australia)
Number of organisations
120
100
80
60
40
20
0
9
13
20
9
9
12
101
LAND COVER / USE
CHANGES IN BIOPHYSICAL PROPERTIES
BIOPHYSICAL (TERRESTRIAL) eg. Vegetation
BIOPHYSICAL (AQUATIC) eg seagrass, sst
INFRASTRUCTURE DEVELOPMENT
NOT SURE
NO RESPONSE
Type of information collected

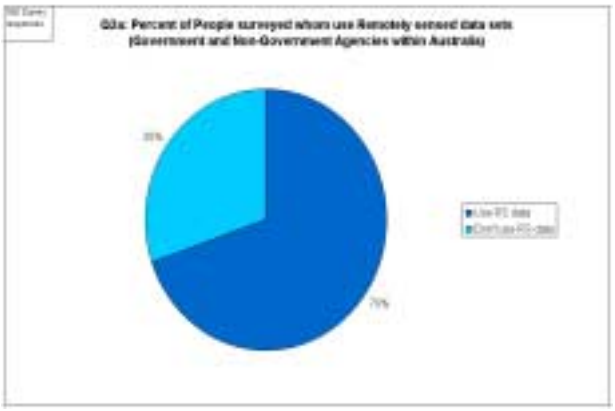

160 Survey responses
Q1c: Frequency of information collection
(Government and Non-Government Agencies within Australia)
Number of organisations
120
100
80
60
40
20
0
5
6
4
19
4
4
13
6
7
102
Monthly
Quarterly (seasons)
6-monthly
Annually
1 - 2 years
2 - 5 years
As required
No requirements
Not sure
No Response
Time period

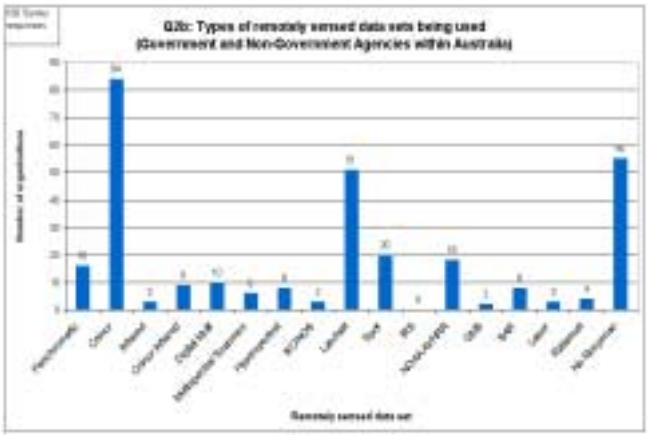

160 Survey responses
Q1d: Size of area being monitored
(Government and Non-Government Agencies within Australia)
Number of organisations
120
100
80
60
40
20
0
7
4
11
13
18
11
3
7
98
Local administration unit
Regional administration unit <10k/m2
10 - 1000km2
1000 - 10 000km2
>10 000km2
State
National
Not Sure
No Response
Size

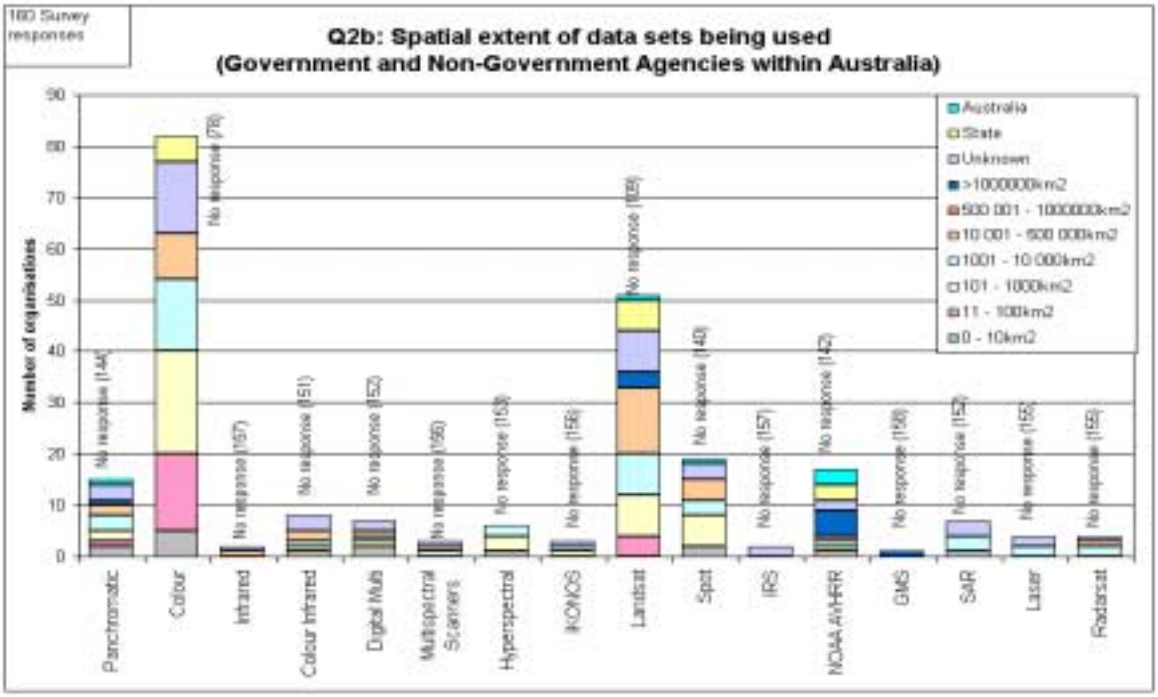
Question 2:

Do you use remotely sensed data? please check one.
If yes which type(s) of data do you use,

Of the 71% of respondents using remotely sensed data for environmental monitoring, the majority of those used colour aerial photography (>50%) and then Landsat Thematic Mapper image data, with the next most commonly used data sets being SPOT products, panchromatic and aerial photography. Synthetic aperture radar and airborne multispectral and hyperspectral image data were the next most frequently used with very limited use reported for Ikonos, Indian Resource Satellite, colour infrared photography, geostationary meteorological satellite and airborne laser data. The scales at which each data set was applied corresponded to the findings in Question 1 that there was a local-regional scale focus, with the next most frequent scales of application being state and nationwide. Aerial photography data sets were most frequently applied to local-regional scale projects (11- 10000 km^2). Moderate resolution image data (Landsat, SPOT, IRS) were applied mainly over 10,000 – 500,000km^2 projects, while AVHRR data are used at continental scales. Airborne multispectral, hyperspectral and laser data sets were used for focussed local to site scale specific projects (< 1000 km^2).



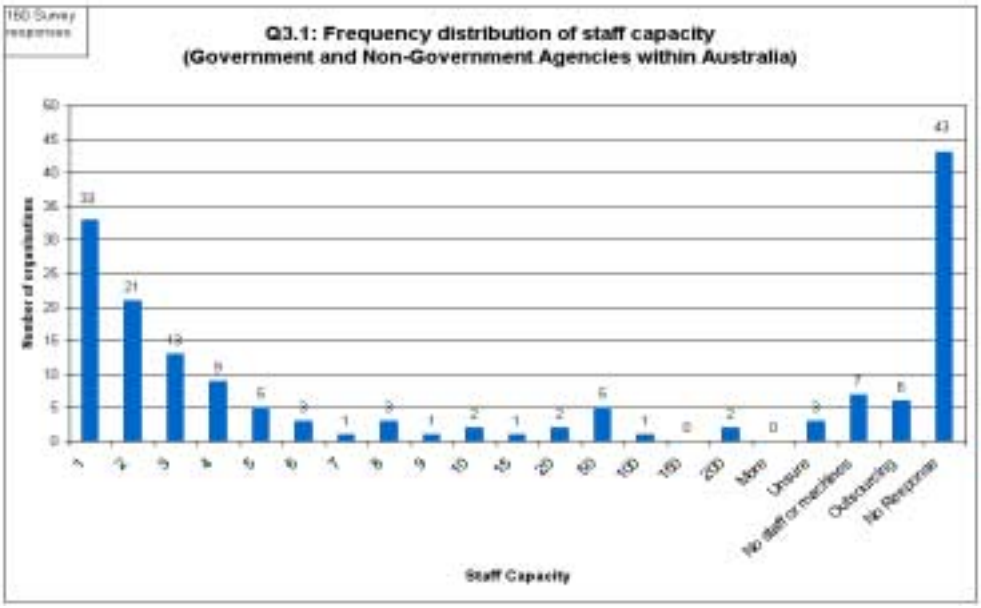


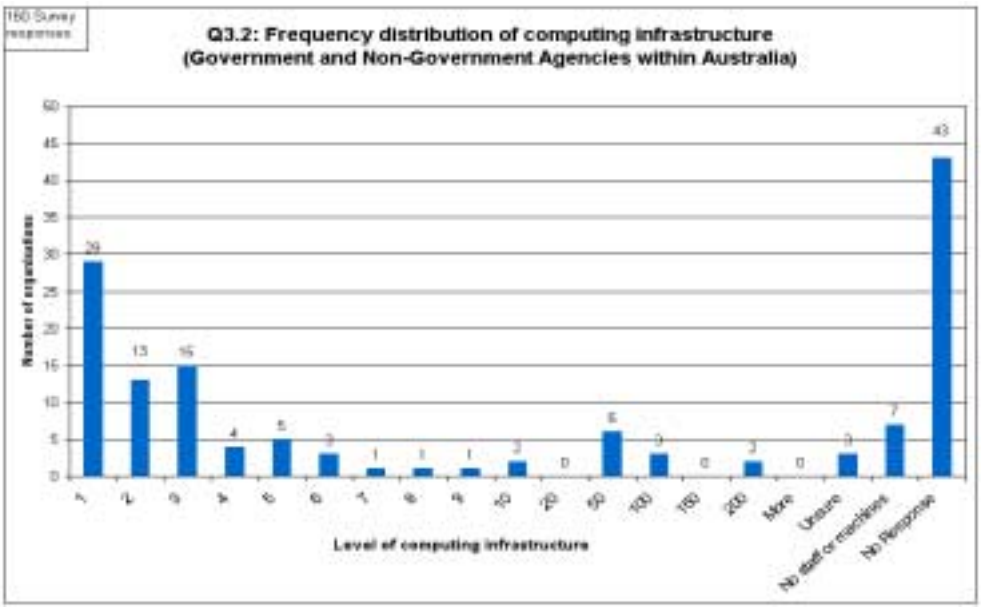


Question 3:

What is your current capacity in terms of technical staff and level of computing infrastructure?

The majority of organisations working on remotely sensed data most commonly had one or two specialised staff devoted to collection and processing of remotely sensed data each of whom had access to between one and three dedicated computers. The nature of this question did not allow determination of whether the sole responsibility of these employees was related to collecting and processing remotely sensed data. This may be the case for those groups with 3- 8 employees.

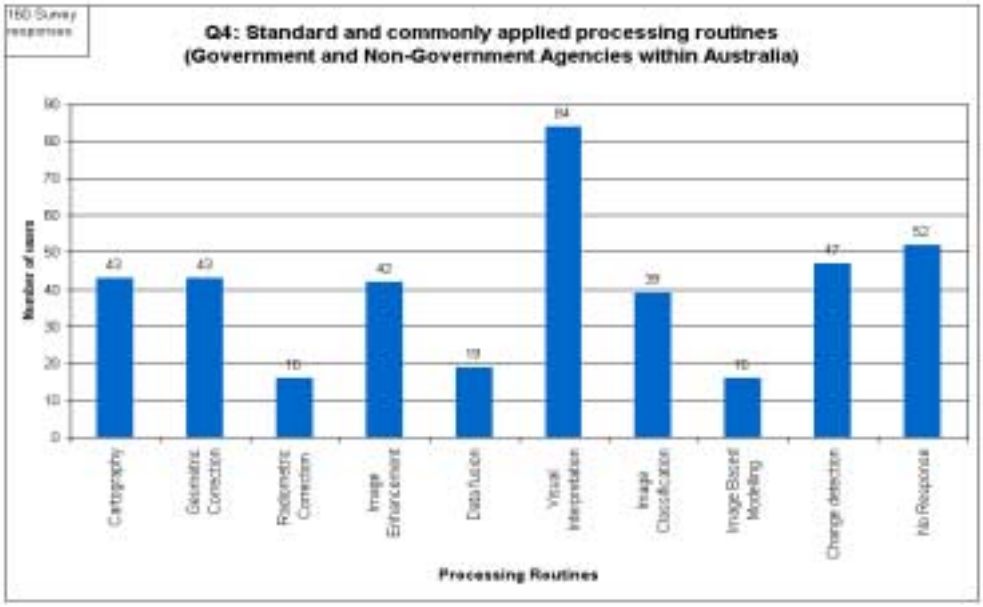




Question 4:

What are the standard or most commonly applied processing routines that you apply to remotely sensed data sets used in your organisation (answer more than one if necessary):

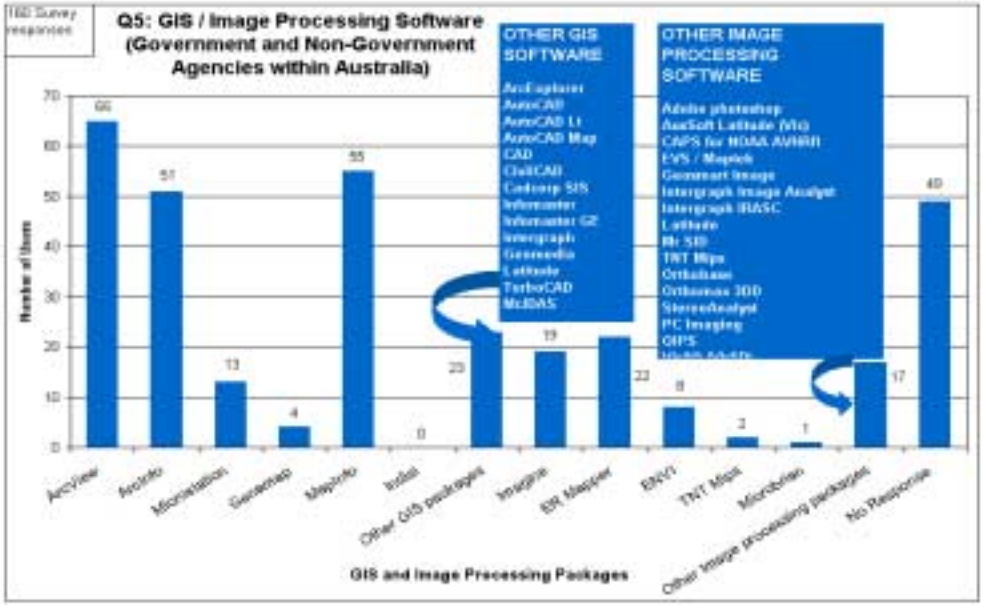
Processing routines applied to remotely sensed data were dominated by visual interpretation, as a direct result of the dominance of aerial photography as the primary data source. Subsequent image processing operations were dominated equally by pre-processing (geometric correction, image enhancement), information extraction (image classification, change detection) and information presentation/communication (cartography). To a lesser extent, other processing operations included radiometric correction (critical for change detection), data fusion and image based modelling. These results indicate that most agencies are purchasing low-level image data and performing in-house pre-processing prior to conducting image classification operations to produce maps of vegetation or land-cover at regional scales, which are then used in change detection operations for monitoring. There appears to be limited use of remotely sensed data for mapping and monitoring changes in biophysical variables.



Question 5:

What GIS/Image processing software do you use?

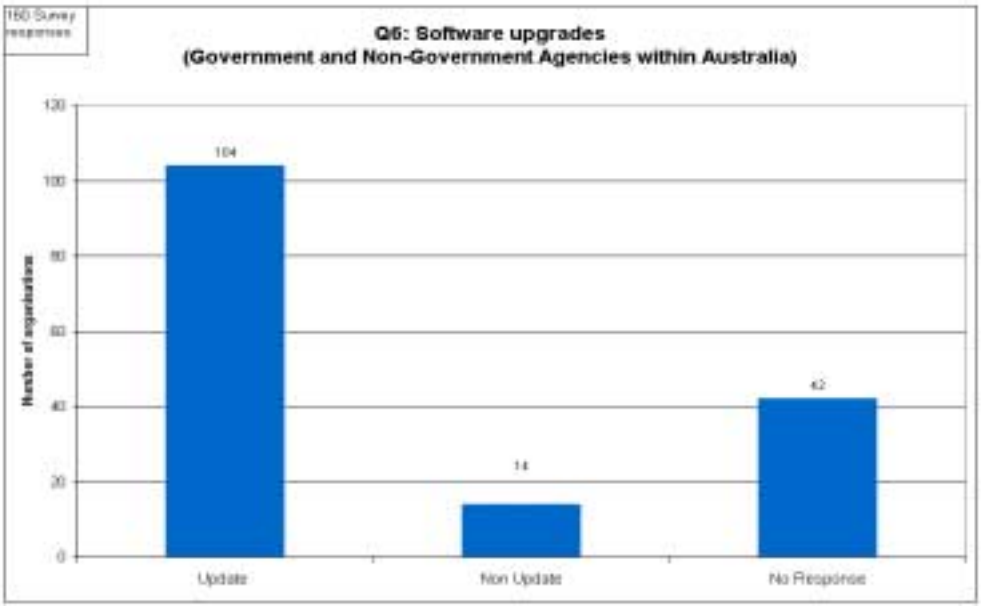
The majority of organisations surveyed used GIS as their primary spatial data processing software, including image processing applications, with ESRI (Arcview and ArcInfo) dominating MapInfo and a range of other graphics and drafting packages. Image processing software packages were used less frequently, but were dominated by ER-Mapper and Erdas Imagine, followed by ENVI and then a long list of specialised image processing systems (McIDAS), graphics packages, and less commonly used image processing packages.



Question 6: please check one.

Do you and your organisation keep up with software upgrades etc?

The majority of respondents kept up with software upgrades.



Question 7:

What types of activities and projects are remotely sensed data used for in your organisation?
Note: there could be more than one response for this question.

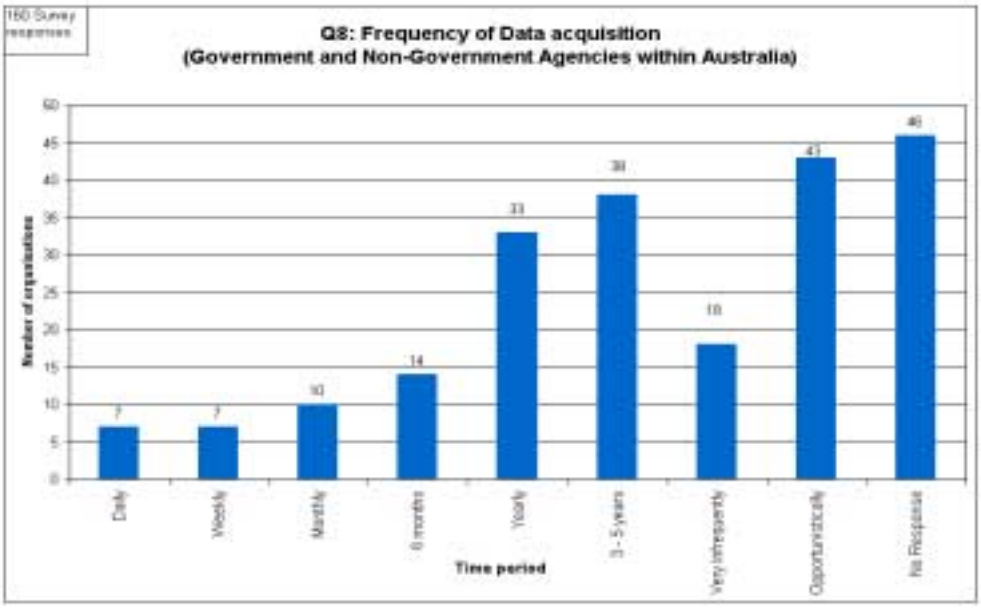
Three distinct groupings of remotely sensed data applications were evident from the responses to this question. Land-cover/land-use and vegetation mapping were by far the most dominant (at all application scales), followed by a group of environment specific applications (urban, watershed, disturbances, coastal zone, rehabilitation monitoring, fire/fuel load mapping and geological mapping). A number of other distinct applications were provided and are listed in the table below.

Q7: OTHER ACTIVITIES AND PROJECTS
Forest Resource Assessment and Carbon monitoring
Salinity hazard and hydrogeological mapping
Wetland mapping and inundation mapping / salt water intrusion
Marine protected area planning and habitat mapping as well as fish distribution mapping
Land degradation eg. soil erosion, water quality and quantity from remote stations, groundwater hydrogeology etc
Seepage / leakage detection
Meteorological processes, hazard monitoring, and pollutant impacts
Environmental flows
Land clearance (change in green vegetation)
Algal bloom monitoring, ocean current dynamics
Development assessment to determine impacts and ways to minimise them
Weed mapping
Cartographic interpretation & change analysis
Orthorectification
Infrastructure such as swimming pools and fencing
Strategic planning for location of parks and reserves
Flood mapping for floodplain & drainage planning
Park infrastructure maintenance
Estimating water licence compliance by estimating water usage requirement of crops grown. Crops were mapped using visual interpretation of aerial photographs
Risk assessment
Land condition assessment
Stream morphology
Inventory stratification

Question 8:

How frequently do you acquire remotely sensed data for your organisation's applications?

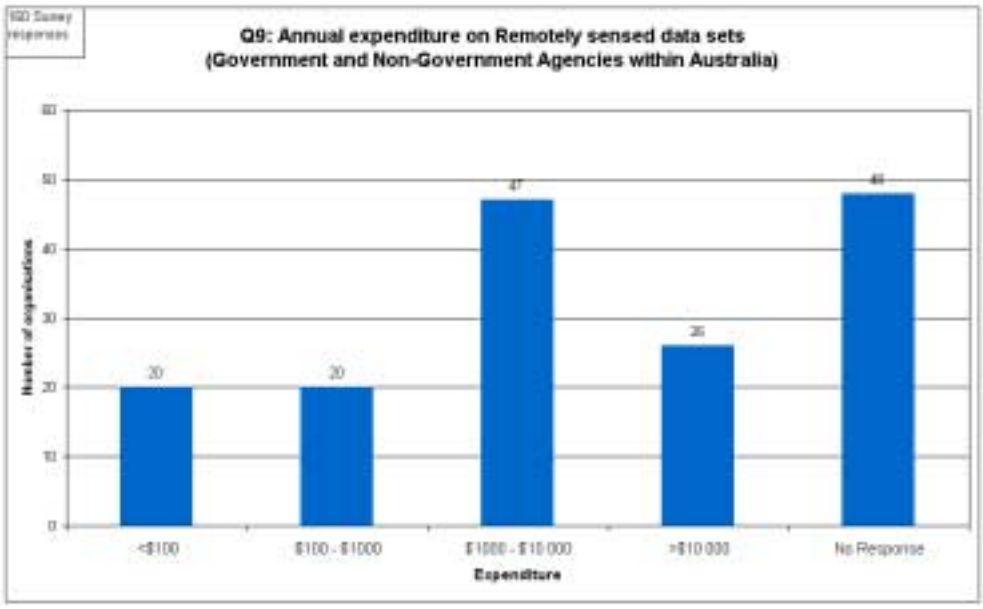
The majority of respondents collected remotely sensed data either opportunistically (as determined by data costs and available finances) or on an annual to 3-5 year repeat cycle, with decreasing number of organisations collecting data at higher (monthly – daily) frequencies. The majority of the data collections at annual- opportunistic scales were for land-use/land-cover and vegetation mapping applications, as well as large scale projects, hence the limited need and resources for repeated coverage to update the initial maps. Higher frequency monitoring requirements were usually for specialised activities (fire monitoring, crop monitoring, sea-surface temperature).



Question 9:

What is your approximate annual expenditure on remotely sensed datasets?

There was a split- majority of respondents to this question, with one majority unable to defined their annual expenditure (due to number of operations involved in processing the data). The other majority (29%) spent between $1000 - $10000 annually on purchasing remotely sensed data sets, with smaller proportions (13 – 16%) spending in the < $100, $100 - $1000 and > $10,000 range. Organisations spending in the $1000 - $10,000 category were purchasing local scale coverage of aerial photographs (with photogrammetric processing) or regional scale Landsat or SPOT coverages.



Question 10:

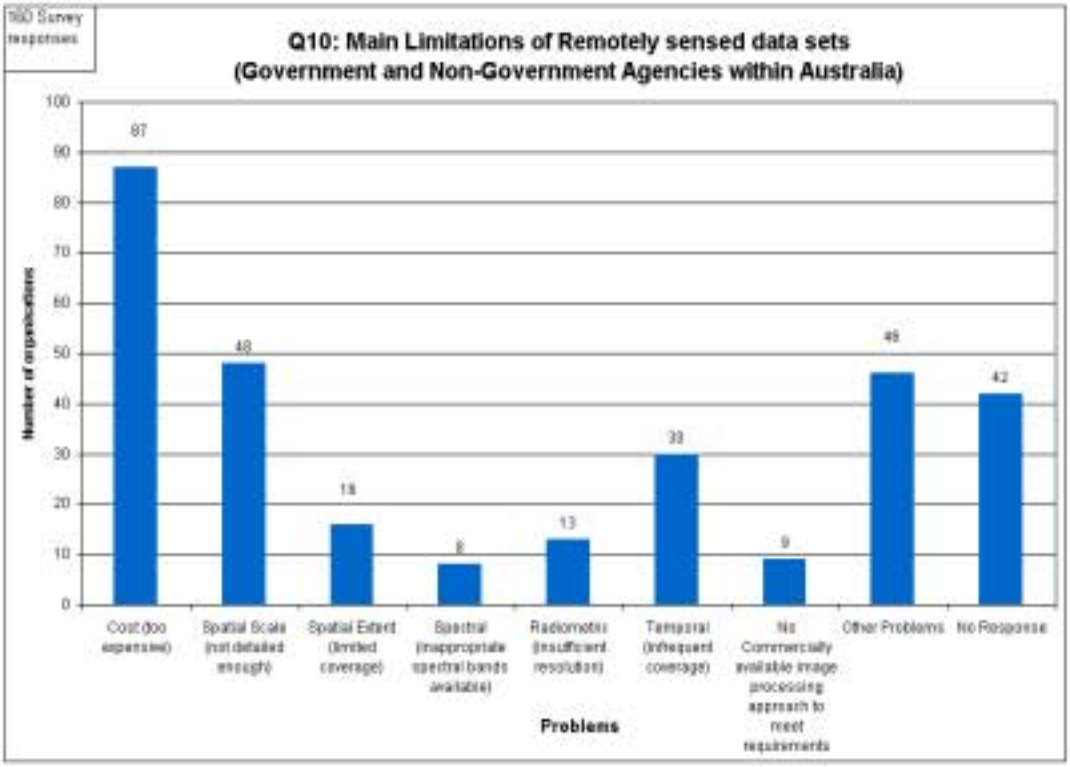
What do you consider to be the main limitations of current remotely sensed data and processing routines for extracting the information required by your organisation?

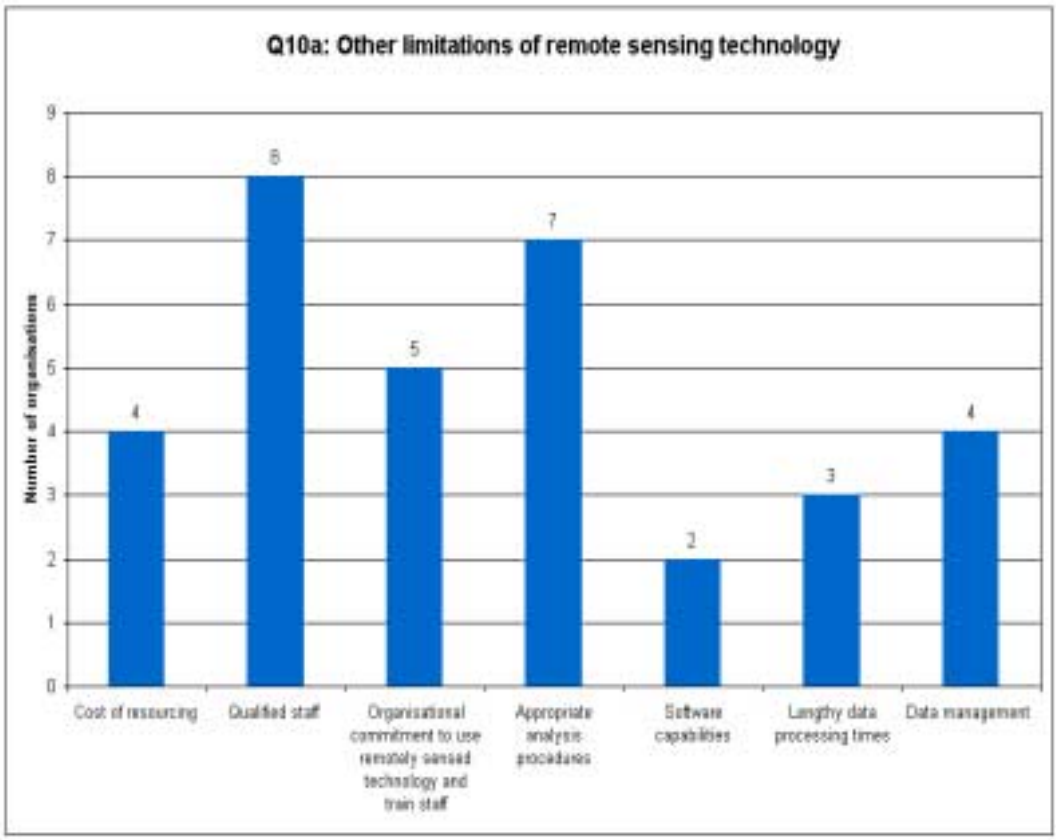
Costs of purchasing and processing remotely sensed data were identified as the major limitation by respondents of currently available remotely sensed data and processing routines. This was supported by the response in Question 11 as the most frequently cited improvement required to increase the use of remotely sensed data in their organisations was to reduce data costs. In terms of organisations and applications, those respondents identifying high data costs and requesting reductions were local, state and federal government agencies using aerial photography and moderate resolution optical image data (Landsat). Those organisations satisfied with costs were using free or low cost data sets such as NOAA-AVHRR or SeaWifs. The second most specific set of limitations were for spatial resolution not being detailed enough and temporal resolution not being frequent enough. Of the 50 organisations requiring more detailed spatial scales of information over 80% of these groups were local councils or organisations responsible for local scale environments, such as catchment monitoring groups, environmental consulting agencies and mine management groups. There were no distinct common requirements of those groups requiring increased temporal resolution, except in areas of crop and oceanographic monitoring. No consistent groupings of organisational scale or application commonalities were evident in the organisations identifying limitations with spatial extent, spectral resolution, radiometric resolution and lack of suitable commercial software. The list of limitations unable to be included in our classification is included below. Several common themes from this were: (1) lack of suitably trained staff for image and spatial data processing; (2) excessive amounts of available data and lack of

"operational and reliable" techniques for processing it; and (3) limited rigor applied to validation of information derived from remotely sensed data.

Q10: OTHER MAIN LIMITATIONS OF REMOTELY SENSED DATA SETS (taken directly from survey respondents)
The greatest limitation in the creation of "information" from "data" is the rigor and validation of the imagery. This aspect is always underestimated and the value of remotely sensed data has suffered.
The problem is no longer technology. The intelligent data integration can overcome all the above aspects. Lack of appropriate application is now due to organisational culture and lack of education in resource assessment and monitoring theory.
Hyperspectral to discriminate clays, salt and veg composition & structure
The cost of imagery is high and also the cost of researching & developing robust applications is high. Adequate spectral resolution data is available but as the cost generally increases with resolution the optimal dataset may not be practically accessible.
ETM and SPOT have proved acceptable for most projects when processed digitally. Clients however do not like the poor visual appearance of raw imagery.
Many methods simply do not have proven and well articulated applications - implies limited cost benefit
The main limitation with the TM data that we use is that some of the vegetation that has previously been mapped from Aerial photography is too sparse to significantly add to the brightness of the a pixel, this can make it very hard to determine if there has actually been change or not
Electronic image size is not portable data should be purchased and supplied by national or state government and provided for all community to use (including Local Council)
Lack of coordination of Council's varying needs. Lack of knowledge (myself included) of what would be the best data to access. I use aerial photography (1:15000) because its easy to handle is clear to view (eg by Councillors) and can be taken on site.
Lack of effective delivery mechanisms (IKONOS IRS). Rectification problem with airborne sensors (except LADI)
Large files requiring large processing capabilities
You choose the data to meet your needs with appropriate tradeoffs - there's never going to be one system that does everything.
Regional offices without appropriate technology
Interpretation of grassland habitat not available eg can not distinguish between weeds and native grassland
Takes too long
Insufficient organisational commitment to exploring innovative information sourcing techniques
Our main limitation was the inability of our current software to handle the display of aerial photos.
Cost too expensive to cover large areas yearly

Q10: OTHER MAIN LIMITATIONS OF REMOTELY SENSED DATA SETS (taken directly from survey respondents)
We would include this cost in the cost to our clients for planning projects. Where data has to be purchased it might represent 1/10 of the project cost. However increasingly clients (particularly municipalities) have well-developed GIS systems with air photos and cadastral layers (the two which are most useful to us) in the systems and coordinated / corrected. This situation has improved vastly in the last two years following the municipal amalgamations in Victoria and the push towards implementing GIS as a principal municipal management tool.
Qualified staff, software and where to find data
No qualified staff
Cost of resourcing too expensive
The biggest limitation is the knowledge of what can be achieved from remotely sensed data by the 'geographers' (in broad terms). We are asking for LADS to be used over the ocean. Its cost is very high and so is a serious limitation.
Lack of understanding of available new more appropriate technologies by scientific staff responsible for project management (as opposed to technical and GIS staff)
Lack of fine scale digital topographic data. Hence limits spatial accuracy of imagery.
We use AVHRR data to provide a broad regional perspective and use Landsat TM to provide more detailed view of smaller areas. Ideally we would like full NT coverage at Landsat resolution with AVHRR frequency but would struggle with the data size and processing time
Need processes that work over a range of environments
Lack of expertise to manipulate data. Inappropriate hardware for running necessary software to analyse or interpret data.
Limited correlation between remotely sensed parameters and forest structure.
1. High cost of working with data, eg creating classification. 2. Problems with change detection both in terms of seasonality. 3. Data management issues (file size - RAM hard drive space)
Restrictions on the use of data. Difficult to access stereo imagery. Clouds. Frequent monitoring in more wavelengths with better spatial and thermal resolution.

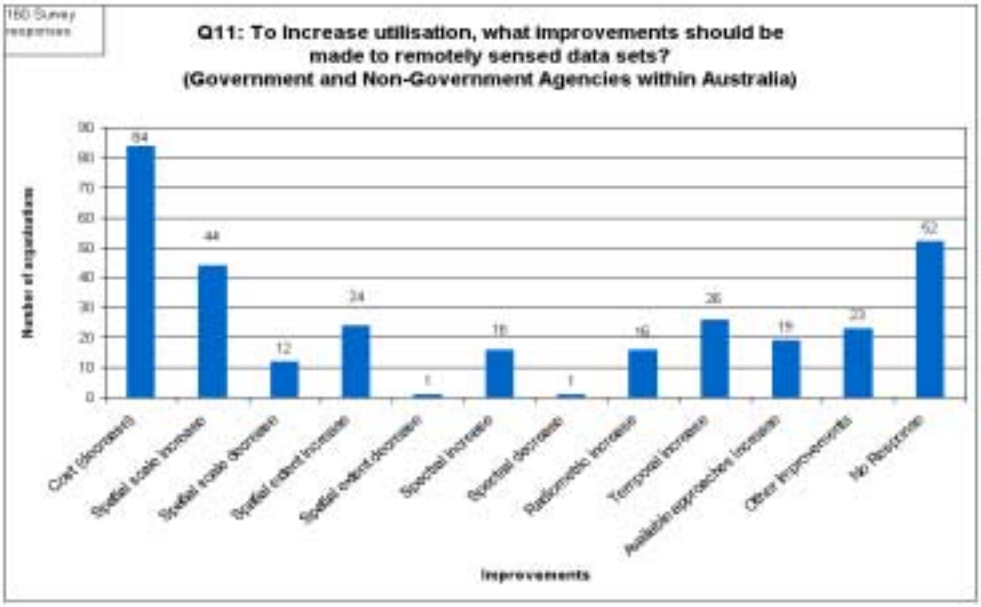

160 Survey responses
Q10: Main Limitations of Remotely sensed data sets
(Government and Non-Government Agencies within Australia)
Number of organisations
100
90
80
70
60
50
40
30
20
10
0
87
48
16
8
13
30
9
46
42
Cost (too expensive)
Spatial Scale (not detailed enough)
Spatial Extent (limited coverage)
Spectral (inappropriate spectral bands available)
Radiometric (insufficient resolution)
Temporal (infrequent coverage)
No Commercially available image processing approach to meet requirements
Other Problems
No Response
Problems

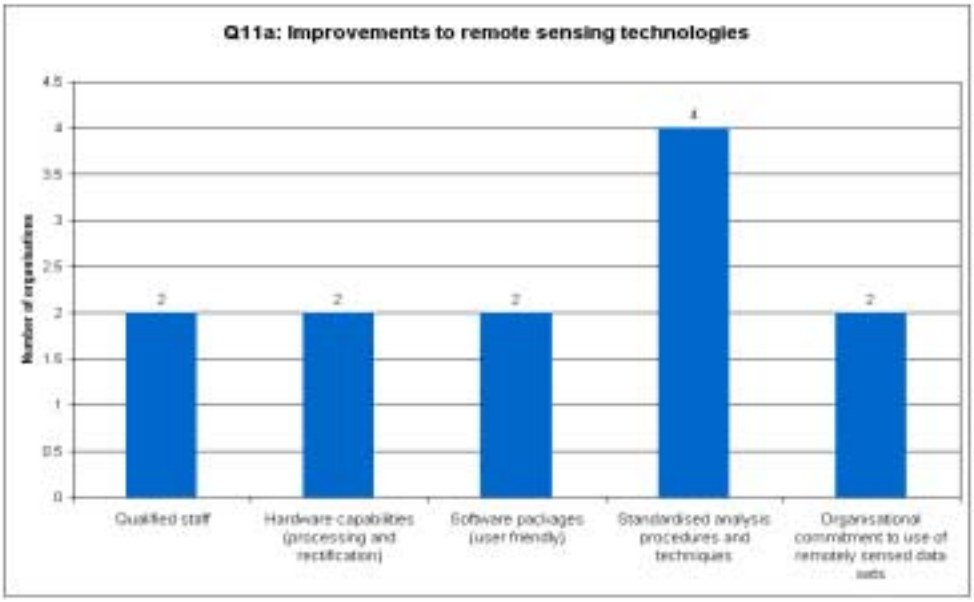

Q10a: Other limitations of remote sensing technology
Number of organisations
9
8
7
6
5
4
3
2
1
0
4
8
5
7
2
3
4
Cost of resourcing
Qualified staff
Organisational commitment to use remotely sensed technology and train staff
Appropriate analysis procedures
Software capabilities
Lengthy data processing times
Data management

Question 11:

If you were to increase utilisation of remotely sensed data in the future within your organisation, what improvements should be made to current data and/or availability?

Responses to this question provided a follow on to Question 10. in defining limitations with remotely sensed data sets and processing applications. The most common response from all organisations was the need for a decrease in both the costs of remotely sensed data sets and the time/resources required for the processing operations. Increase in image spatial resolution was identified by organisations responsible for local scale areas as common requirement, and was directed specifically at digital image data sets rather than aerial photography. Increase in temporal resolution was requested by a different set to those identifying it as an issue in Question10., in this case local and state governments and research groups concerned with mapping invasive weeds, rehabilitation and disturbances (e.g. fire) dominated this group. There were no consistent organisations or applications requesting alterations to spatial extent, spectral resolution and radiometric resolution. A significant number of organisations (at all government and application scales) did identify the need to improve available image processing routines to reliably and accurately extract information from remotely sensed data. This was also reflected in the summary table of other suggested improvements below.



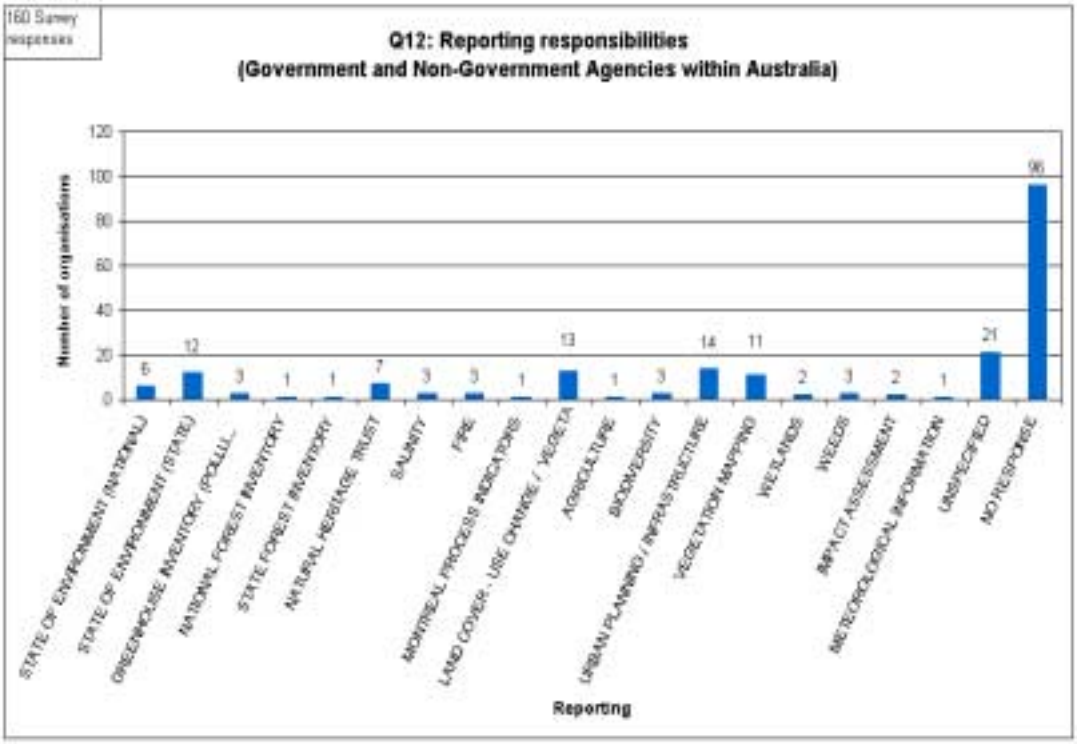


IMPROVEMENTS	FREQUENCY
Qualified staff	2
Hardware capabilities (processing and rectification)	2
Software packages (user friendly)	2
Standardised analysis procedures and techniques	4
Organisational commitment to use of remotely sensed data sets	2
Other	11

Question 12:

List any local state or national reporting responsibilities that your organisation has that remotely sensed data are/or used for:

Responses to this question illustrated the diverse range of activities that remotely sensed data are currently being used for on a trial or operational basis in Australia. At the national and states scales state of environment reporting and inventory programs (greenhouse accounting, Montreal Process - forest, vegetation, land-cover) dominate, with specific focus projects such as salinity, fire, wetlands, weeds, biodiversity and agricultural monitoring at state to local scales. Local scale activities included urban/infrastructure mapping and projects associated with National Heritage Trust funding.



Question 13:

What is the cost of implementing your existing methodologies per hectare or square kilometre for your sites of interest, ie for forest timber volume/habitat &/or species assessments etc. For example, if using air photo interpretation, costs of the hardcopy and digitised product per hectare or per frame?

Responses to this question were extremely varied and a significant number (> 50%) of respondents chose not to, or were unable to answer it. Despite the question clearly stating that the costs were to include data, processing, validation and output a number of responses were only provided for data purchase costs. This indicates a limited understanding of the true costs involved in most remote sensing applications in Australia, as previously indicated in a smaller scale study by Phinn *et al.* (2000).

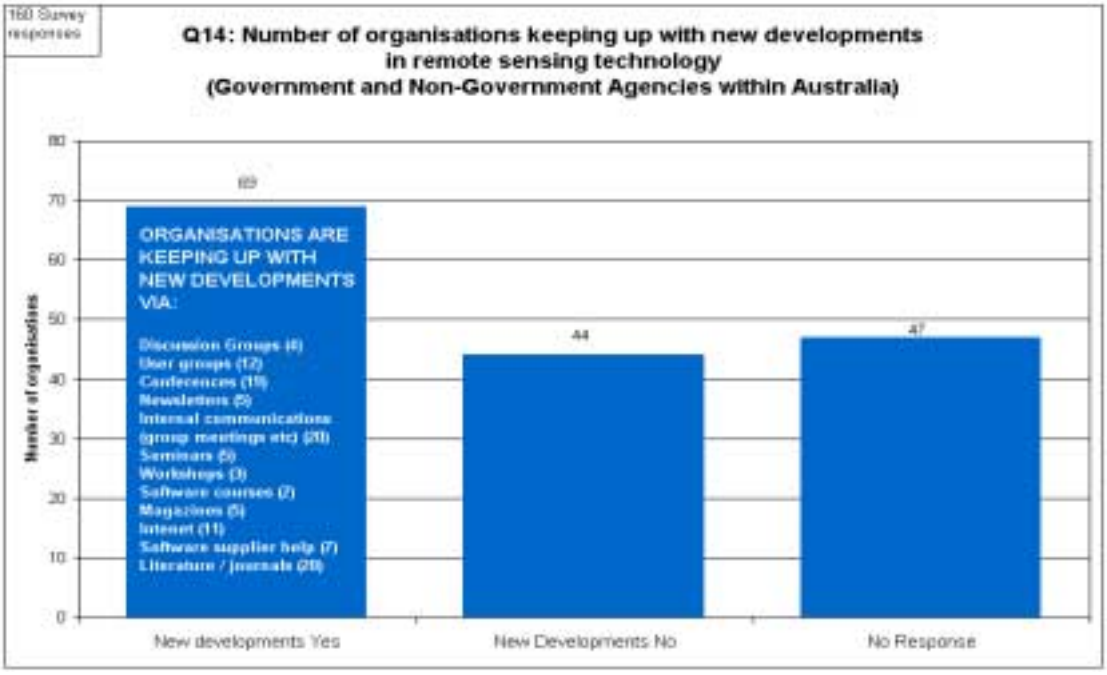
From the valid responses there were three groups in terms of expenditure. Those spending less than $\$5/km^2$ were for acquisition of hardcopy aerial photography and digital moderate resolution satellite images, those spending $\$5 - \$50/km^2$ were for processed/validated maps from moderate resolution satellite imaging systems, digital orthophotographs, airborne multispectral data and interpreted maps from aerial photographs, and those spending $\$50 - \$500/km^2$ were for products derived from digital orthophotographs, processes airborne multispectral data, airborne hyperspectral image data and high spatial resolution satellite image data.

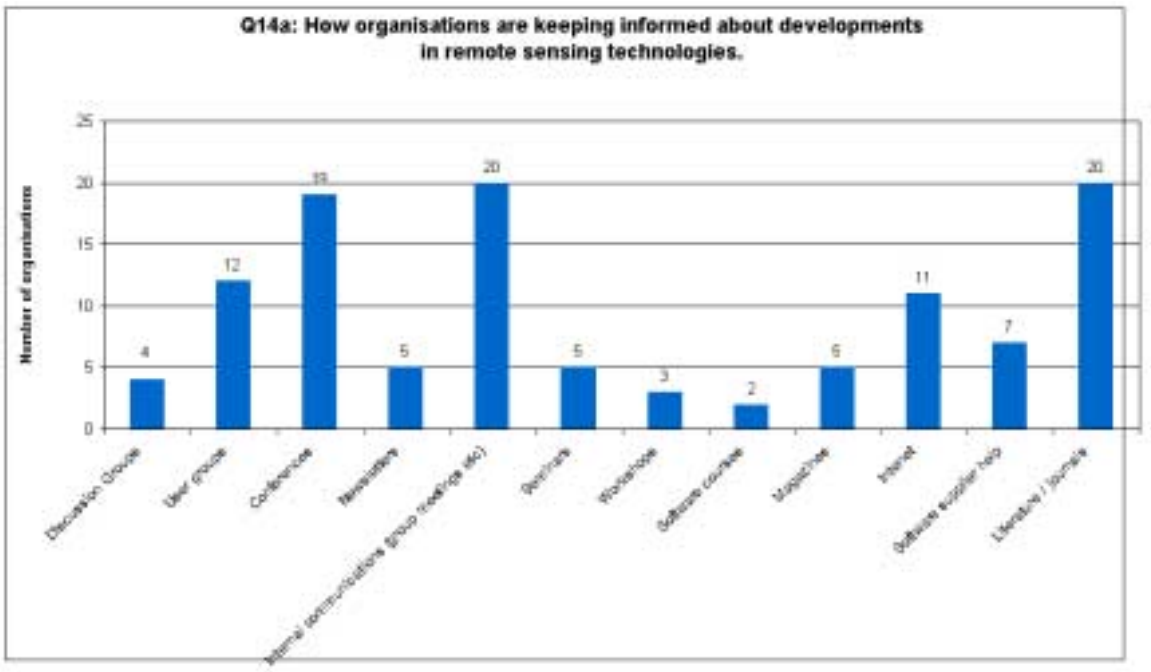
Data Type / Activity	**COST**
Aerial Photographs / km2	$0.5, $1 - $5, $2
Aerial Photographs / frame	$30, $50, $100, $150, $200, $350, $430, $500
Aerial Photographs / set of frames	$1000, $10 000
Aerial Photographs with contours (frame)	$400
Digital Aerial Photographs (frame)	$300
Orthophotography (/km2)	$0.5 - $1.5
Landsat Full Scene	$1,400
SeaWIFFS (/km2)	$80
Lidar (/km2)	5 - 25c
Magnetic, electromagnetic and radiometrics (/km2)	$3.50
Landcover Mapping	1 - 10c
TM Land use mapping	0.91c
Habitat mapping (/property) using AP	$300
Digitising vegetation using AP	$8,000
Coral Reef Mapping (/km2)	$10

Question 14:

Do you and your organisation keep up with new developments in remote sensing technology via discussion groups, user group meetings etc? if so how?

The majority of organisations responding to the survey kept up with new developments in remote sensing through three main forms of communication: (1) trade and scientific journals and literature; (2) communication with colleagues in internal meetings; and (3) conferences. Less frequently used means of communication were User group meetings, the Internet, Seminars, Workshops and Newsletters.

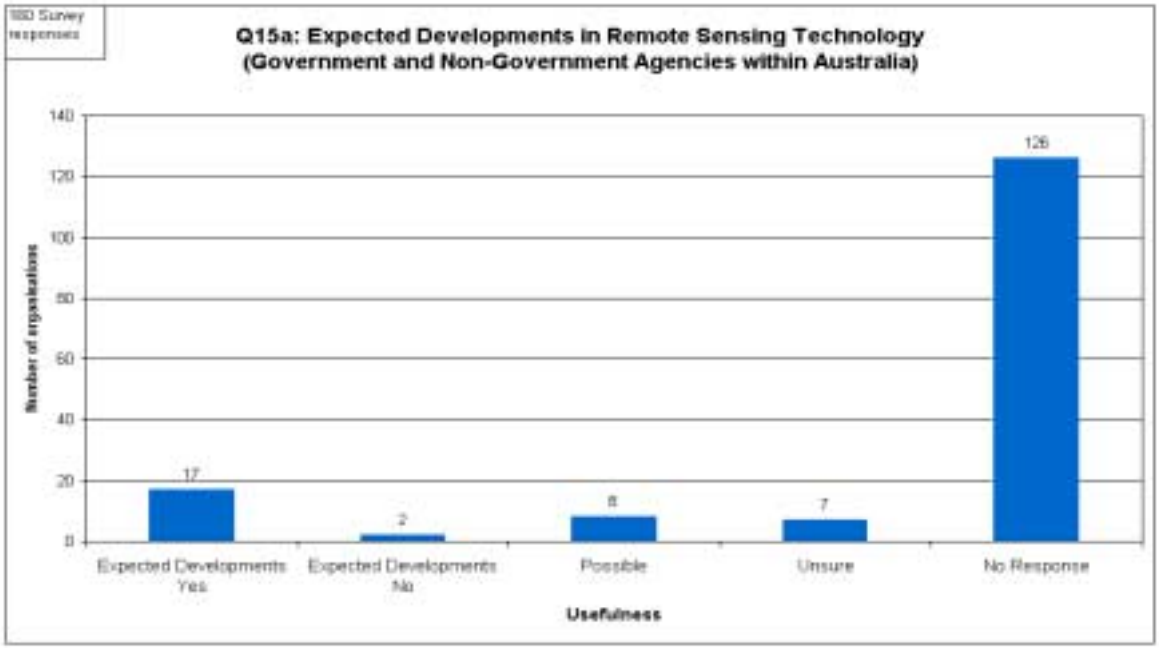


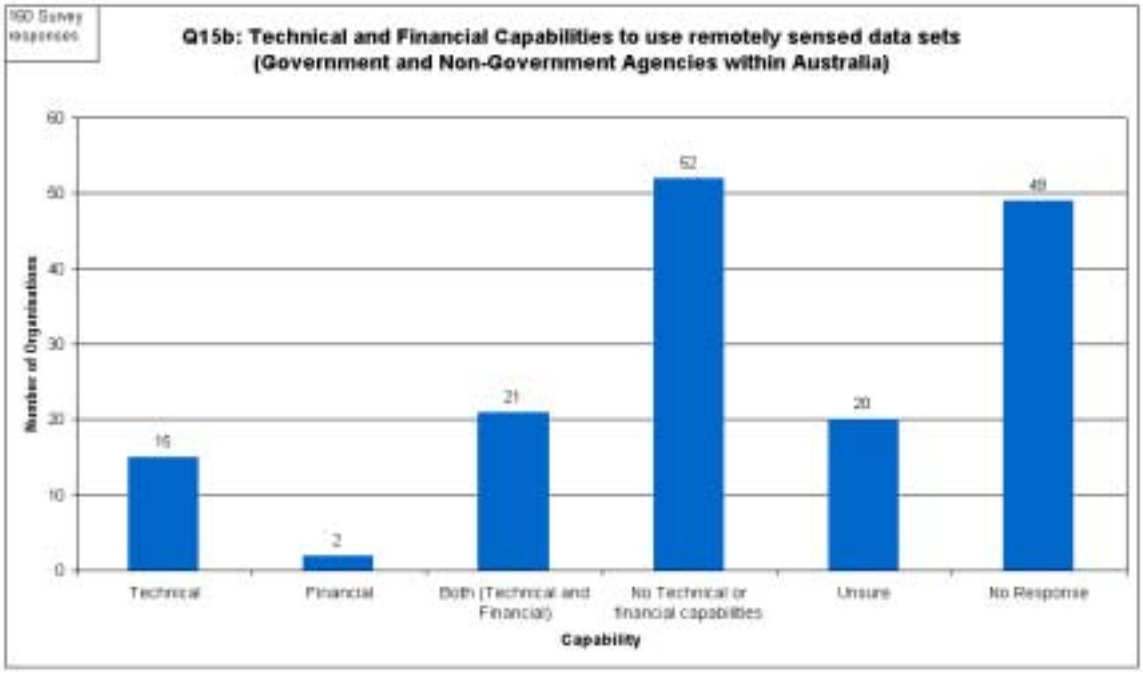


Question 15 (a):

In terms of expected developments in commercially available remote sensing technology will these new datasets be useful to your organisation's requirements? (b) Do you have the technical and financial capabilities to fully utilise these data?

Of the 32 organisations (from 157) responding to this question, approximately 50% of them considered expected developments in commercial remote sensing would be useful to their activities. This low response may be attributed to the lack of knowledge about these developments, or as indicated in the graph for Question 15.b, the lack of both technical and financial capabilities to acquire and process these data. Those organisations indicating both technical and financial capability for using the new data sets were confined to state and federal environmental management agencies, while those without the capabilities were local councils, some select state agencies and non-government/non-profit agencies.

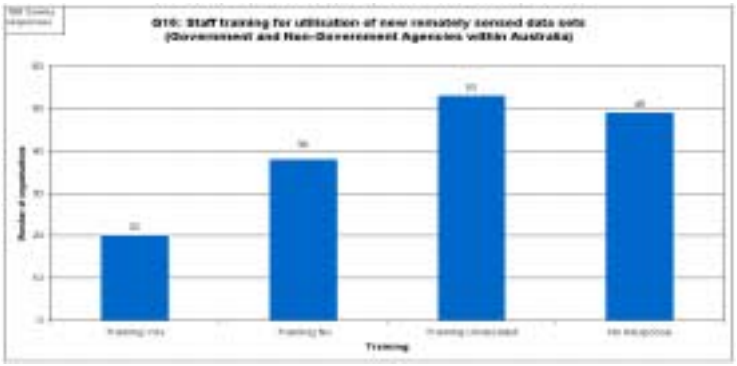




Question 16:

Will your organisation be training people specifically to utilise these new datasets?

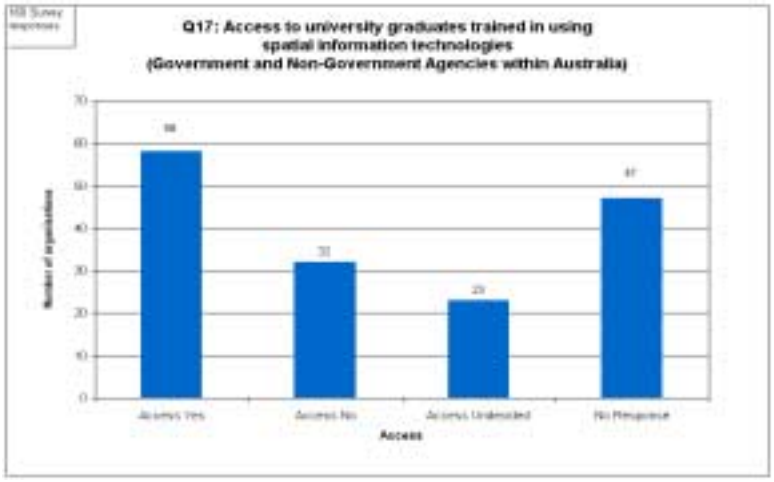
The majority of organisations were undecided on the issue of staff training, and there was no grouping of organisations indicating that they would or would not train staff. All levels of government, private agencies and non-profit groups were represented in each category of response to this question. This response reinforces the findings from the previous question that agencies are not fully aware of current or future remotely sensed data sets and available processing options.



Question 17:

Do you have access to local university graduates especially trained in using spatial information technologies?

The majority of federal and state government agencies in all states considered they had access to suitably trained graduate students. Those agencies that did not have access to students were dominated (52%) by local councils throughout Australia in regional areas, and most commonly in Queensland.



4.2 State Scale

Question 1:

As a monitoring or management agency:
- **What (environment, structure, flora, fauna or process) are you required to monitor?**
- **What information are you required to collect for the purposes of monitoring?**
- **How often are you required to report on this information?**
- **What size of an area to you typically monitor?**

The general monitoring focus for each state / territory was on the environment (pollution, condition, land use) and terrestrial and aquatic vegetation. Salinity, biodiversity and infrastructure were also considered important monitoring responsibilities within each state / territory. Environmental conditions were evaluated by the collection of biophysical information (including land-cover and land-cover change) and infrastructure / resource development. Biophysical information was typically collected for local administration units, on regional (<10km^2) scales and areas >10 000km^2 as well as for the entire state. Surveys for information were generally conducted quarterly, annually or on an "as needs basis".

Question 2:

Do you use remotely sensed data? please check one.
If yes which type(s) of data do you use,

Remotely sensed data was used by government and non-government agencies for environmental monitoring purposes within each state and territory. However, considerably less (of the population surveyed) use these data sets in Queensland, South Australia and the ACT. Of those agencies using remotely sensed data, aerial photography (colour, panchromatic, colour infrared and infrared), Landsat, Spot and NOAA products were the most widely utilised. The next most commonly used data sets included Synthetic aperture radar, Digital multispectral video, Laser and Radarsat. Although Queensland, South Australia and the ACT had fewer agencies using remotely sensed data, they employed a more diverse array of sensors and data types for environmental monitoring purposes. The scales at which each data set were applied corresponded to the findings in Question 1 being that there was a local-regional scale focus, with the next most frequent scales of application being statewide. Aerial photography data sets were most frequently applied to local-regional scale projects. Moderate resolution image data (Landsat, SPOT) were applied mainly over 10,000 – statewide projects, while AVHRR data are used at state and continental scales.

Question 3:

What is your current capacity in terms of technical staff and level of computing infrastructure?

Generally, organisations within each state comprise of small staff numbers dedicated to remotely sensed data handling and application. Computing infrastructure in most agencies corresponds directly to the number of operational staff. However, in some organisations, computing infrastructure was less than the staff assigned due to part-time work contracts and the option of outsourcing work to other agencies / contractors specialised in using remotely sensed data.

Question 4:

What are the standard or most commonly applied processing routines that you apply to remotely sensed data sets used in your organisation (answer more than one if necessary):

Visual interpretation dominated the selected processing routines applied to remotely sensed data for organisations surveyed in each state and territory. This was a direct result of the dominance of aerial photography as the primary data source. However, it was noted (question 2) that organisations within Queensland and South Australia utilised more remotely sensed data types compared to the other states. Consequently these states along with Western Australia, Victoria, New South Wales and the Northern Territory, employed more data analysis and processing techniques (geometric and radiometric correction, image enhancement, data fusion and image based modelling) for environmental monitoring purposes.

Question 5:

What GIS/Image processing software do you use?

The majority of organisations surveyed in each state / territory used GIS as their primary spatial data and image processing software, with ESRI (Arcview and ArcInfo) and MapInfo dominating responses. Image processing software packages were used less frequently, but commonly utilised software included ER-Mapper and Erdas Imagine, followed by ENVI. Image processing packages were not used by any of the organisations surveyed in the ACT.

Question 6: please check one.

Do you and your organisation keep up with software upgrades etc?

The majority of respondents kept up with software upgrades. Organisations not upgrading software (on a regular basis) tended to be small shire or city councils as well as private monitoring agencies.

Question 7:

What types of activities and projects are remotely sensed data used for in your organisation?
(Note: there could be more than one response for this question).

Land-cover / land-use and vegetation mapping (for disturbance, fire fuel load mapping and rehabilitation monitoring) were by far the most dominant application of remotely sensed data in each state / territory. The majority of activities listed were conducted by organisations surveyed in each state / territory. Watershed and coastal zone mapping activities were prominent in South Australia, New South Wales, Tasmania, Victoria, Western Australia and Queensland. Urban planning projects were commonly conducted in Queensland, Victoria, New South Wales and South Australia.

Question 8:

How frequently do you acquire remotely sensed data for your organisation's applications?

The majority of organisations collected remotely sensed data either opportunistically (as determined by data costs and available finances) or on an annual to 3-5 year repeat cycle. Monitoring agencies within the Northern Territory, South Australia, New South Wales, Western Australia and Victoria collected data at higher (monthly – daily) frequencies. The majority of the data collections at annual- opportunistic scales were for 'State of Environment' reporting responsibilities which require collection of land-use / land-cover and vegetation data. Whilst data collected at finer temporal resolutions were used for projects such as weed and algal bloom mapping (Northern Territory and New South Wales).

Question 9:

What is your approximate annual expenditure on remotely sensed datasets?

Agencies surveyed within each state and territory spent varying amounts annually on remotely sensed data sets (expenditure being a function of project requirements). Of those respondents who were able to provide an estimate of their expenditure, most spent $1000 - $10 000 per year on data sets. Organisations paying less than this on an annual basis were typically shire or city councils and private monitoring agencies.

Question 10:

What do you consider to be the main limitations of current remotely sensed data and processing routines for extracting the information required by your organisation?

The main limitations of remotely sensed data sets perceived by the majority of organisations within each state and territory included, data cost followed by spatial scale temporal collection frequency and radiometric resolution. Other limitations mentioned included data sizes, the cost of software to process data sets and training staff to utilise the data.

Question 11:

If you were to increase utilisation of remotely sensed data in the future within your organisation, what improvements should be made to current data and/or availability?

Within each state / territory, data cost decrease, followed by an increase in spatial scale, spectral resolution and temporal data collection were selected as the necessary improvements to remotely sensed data sets. Additional improvements noted included increasing processing times and making software cheaper and more 'user-friendly'.

Question 12:

List any local state or national reporting responsibilities that your organisation has that remotely sensed data are/or used for:

The majority of organisations were responsible for reporting on land-cover and land use within their state / territory. State of Environment reporting (at the state scale) was the focus for organisation within New South Wales, Tasmania, Queensland and Victoria.

Organisations within Victoria were also responsible for urban planning and infrastructure reporting.

Question 13:

What is the cost of implementing your existing methodologies per hectare or square kilometre for your sites of interest, ie for forest timber volume/habitat &/or species assessments etc. For example, if using air photo interpretation, costs of the hardcopy and digitised product per hectare or per frame?

The majority of organisations surveyed within each state / territory were unable to determine costs. Costs varied depending on the project being conducted and the data required.

Question 14:

Do you and your organisation keep up with new developments in remote sensing technology via discussion groups, user group meetings etc? if so how?

Most organisations surveyed kept up with new developments in remote sensing technology through various means outlined in section 4.1.

Question 15 (a):

In terms of expected developments in commercially available remote sensing technology will these new datasets be useful to your organisation's requirements?

Question 15 (b):

(b) Do you have the technical and financial capabilities to fully utilise these data?

The majority of organisations in Queensland, Tasmania, Western Australia, South Australia, New South Wales, the ACT and Victoria did not have the technical or financial capabilities to utilise new remote sensing technology. Agencies within the Northern Territory, New South Wales, South Australia, Western Australia and Queensland noted having the technical capabilities necessary but not the financial resources. Whilst a few organisations within each state / territory, except the ACT, did have both the technical and financial capabilities required to utilise new remote sensing technology.

Question 16:

Will your organisation be training people specifically to utilise these new datasets?

The majority of organisations within Victoria, Tasmania and Western Australia declared that they would not be training staff in the future to use remotely sensed data sets. However, most organisations within Queensland, South Australia, New South Wales, the Northern Territory and the ACT were undecided whether they would be training staff to utilise new data sets.

Question 17:

Do you have access to local university graduates especially trained in using spatial information technologies?

The majority of organisations in Western Australia, Victoria and New South Wales did have access to university graduates, whilst those in Queensland and Tasmania did not. Most organisations in the Northern Territory were unsure whether they had access to graduates or not. It was an equal split between agencies in South Australia and the ACT that had and did not have access to university graduates trained in remote sensing applications.

4.3 Regional Scale (Coastal Zone CRC) for Moreton Bay

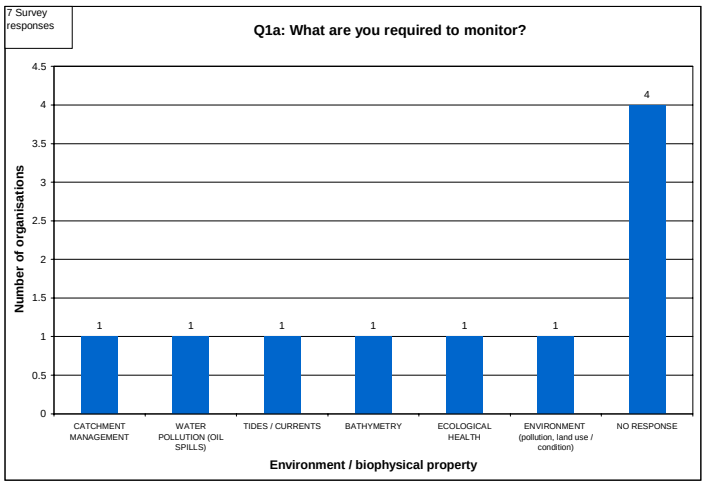
The response rate to this section of the survey was particularly disappointing given that the survey was sent to 163 people in all of the organisations (local and state government agencies, and community groups) that are part of the South East Queensland Water Quality Management strategy. The low response rate may be due to the broad nature of the group sent the questionnaires, although an initial examination of the mailing list did confirm that the survey was being sent to appropriate agencies. Recipients of the survey were asked to forward it to a more relevant person in their organisation if they could not answer it, or if it was not relevant to their division.

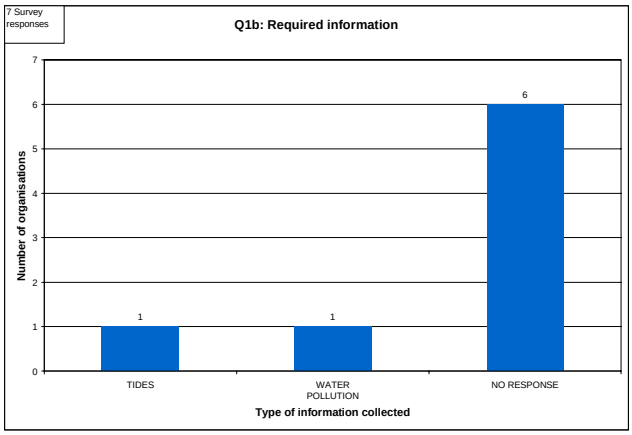
Question 1:

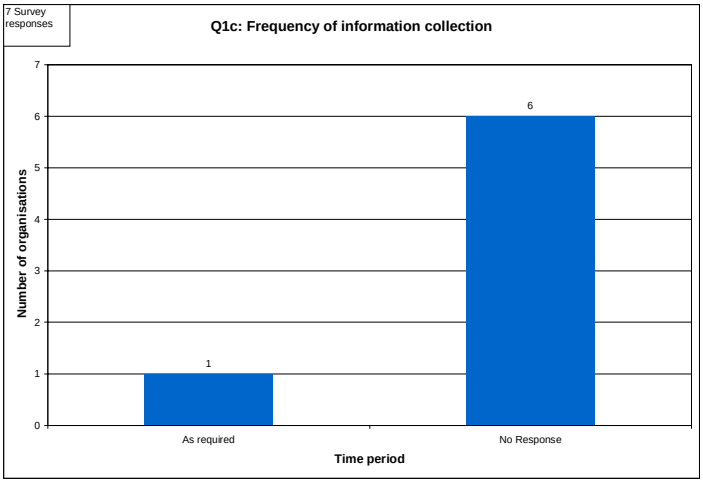
As a monitoring or management agency:

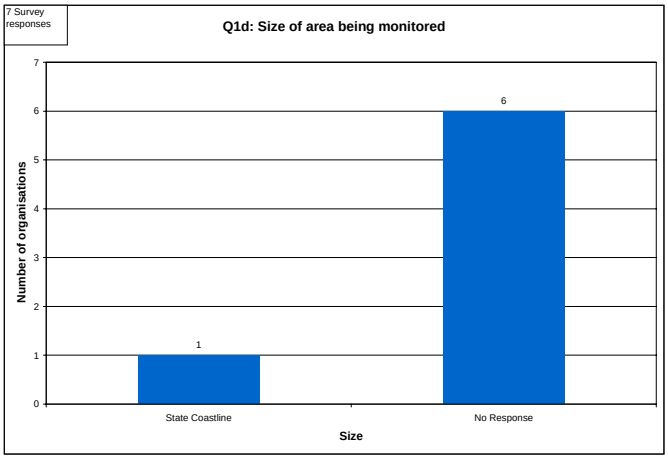
- **What (environment, structure, flora, fauna or process) are you required to monitor?**
- **What information are you required to collect for the purposes of monitoring?**
- **How often are you required to report on this information?**
- **What size of an area to you typically monitor?**

In terms of useful information collected on the type of monitoring program conducted by groups in the South-East Queensland region the environmental properties requiring monitoring included: catchment hydrology; water pollution; tides and currents; bathymetry; and general ecosystem health and environment condition indicators. No useful response was provided on the required frequency of monitoring.





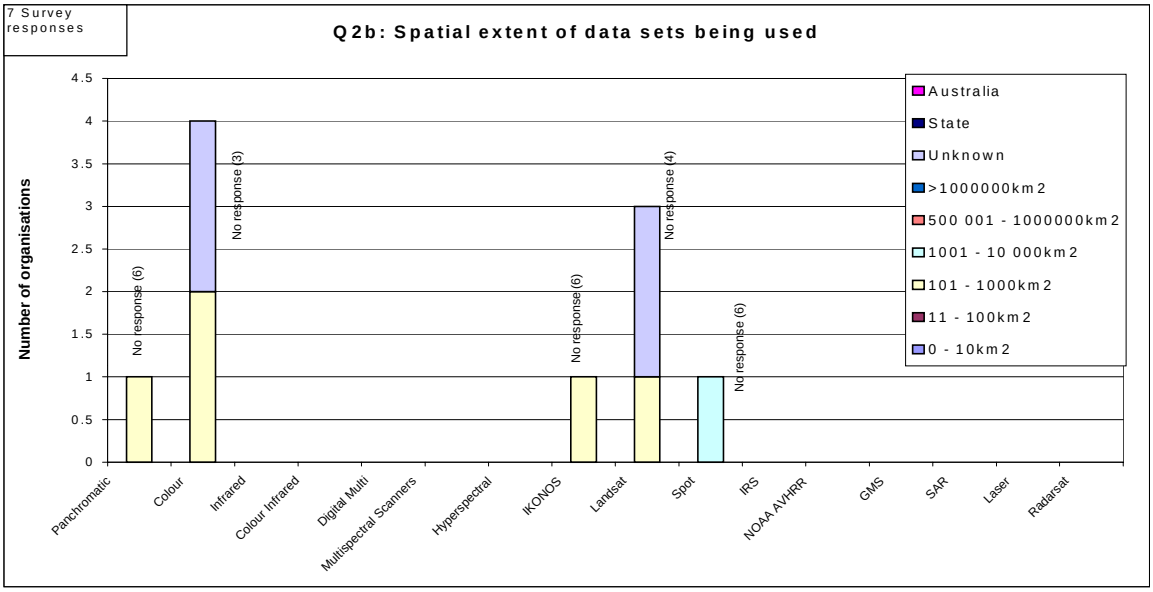


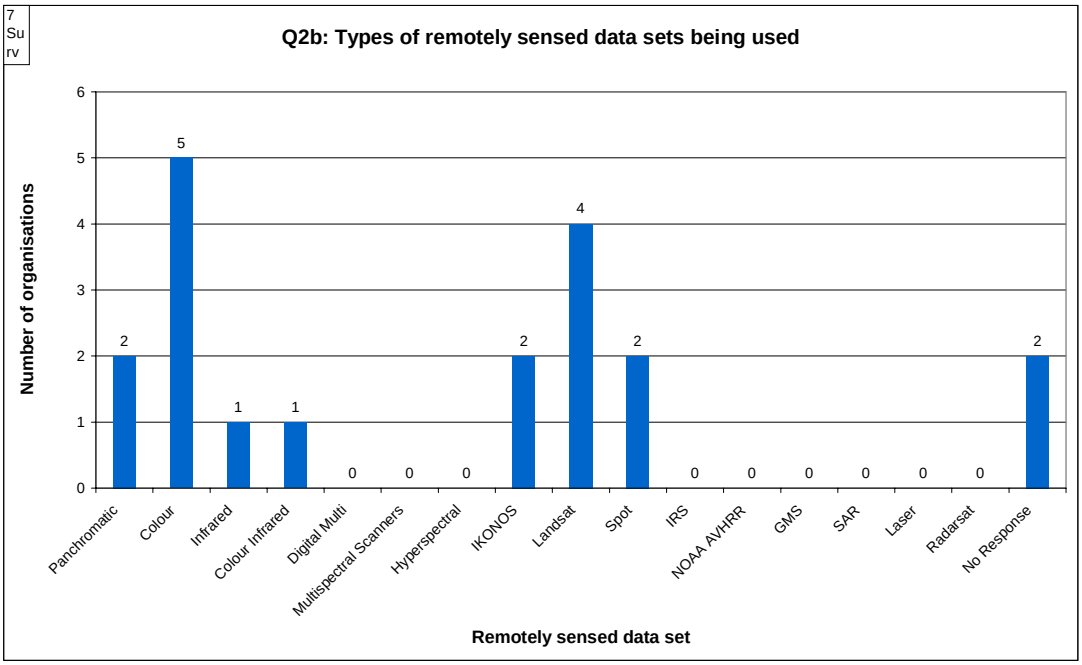


Question 2:

Do you use remotely sensed data? please check one.
If yes which type(s) of data do you use,

As would be expected given the management jurisdiction of the groups contacted for this section of the survey, the majority were using aerial photography and multi-spectral Landsat, Ikonos and SPOT image data local scales (101 – 1000km^2).

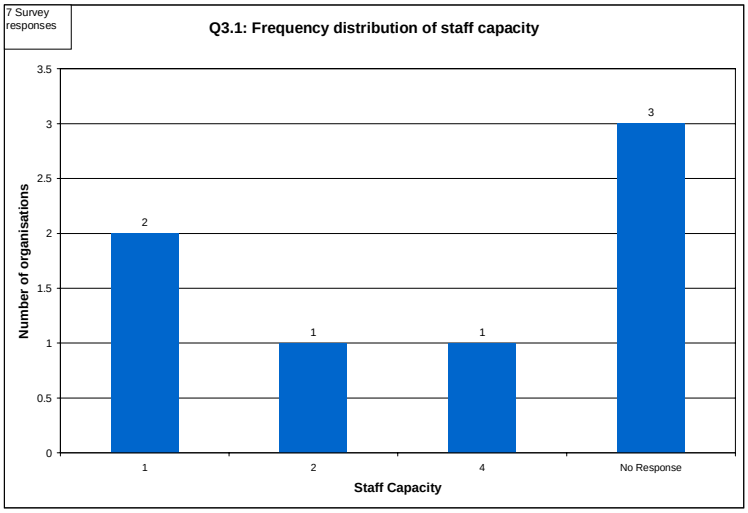


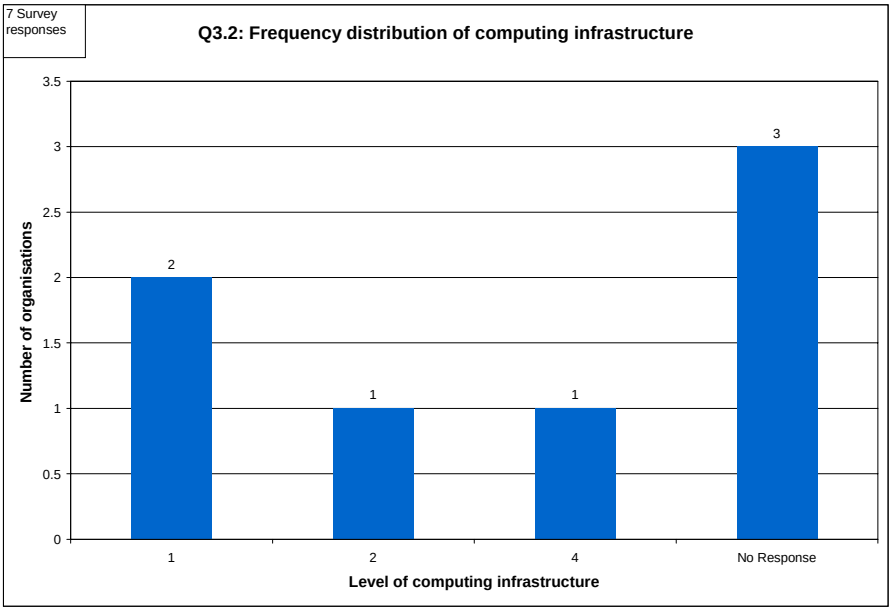


Question 3:

What is your current capacity in terms of technical staff and level of computing infrastructure?

Similar personnel and computing infrastructure levels were observed to the state and national surveys, with agencies having one to two staff and two to four computers dedicated to image processing and GIS activities.

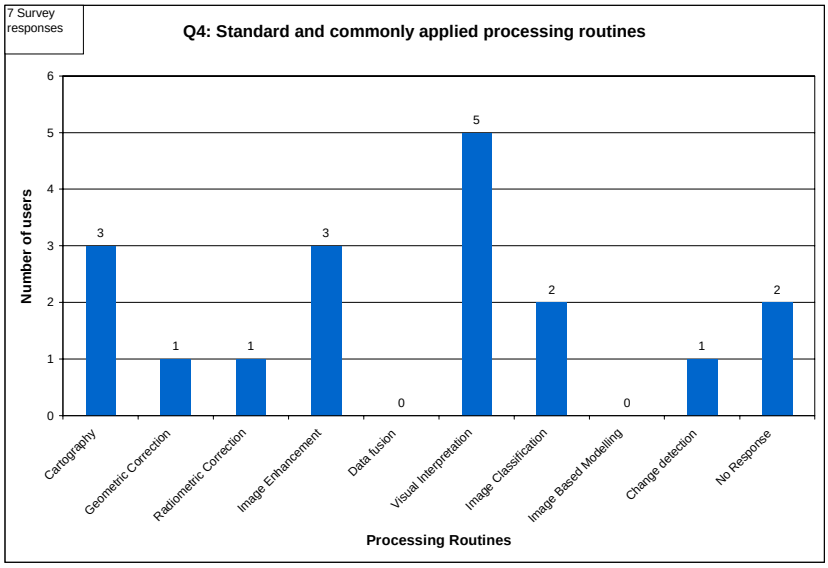




Question 4:

What are the standard or most commonly applied processing routines that you apply to remotely sensed data sets used in your organisation (answer more than one if necessary):

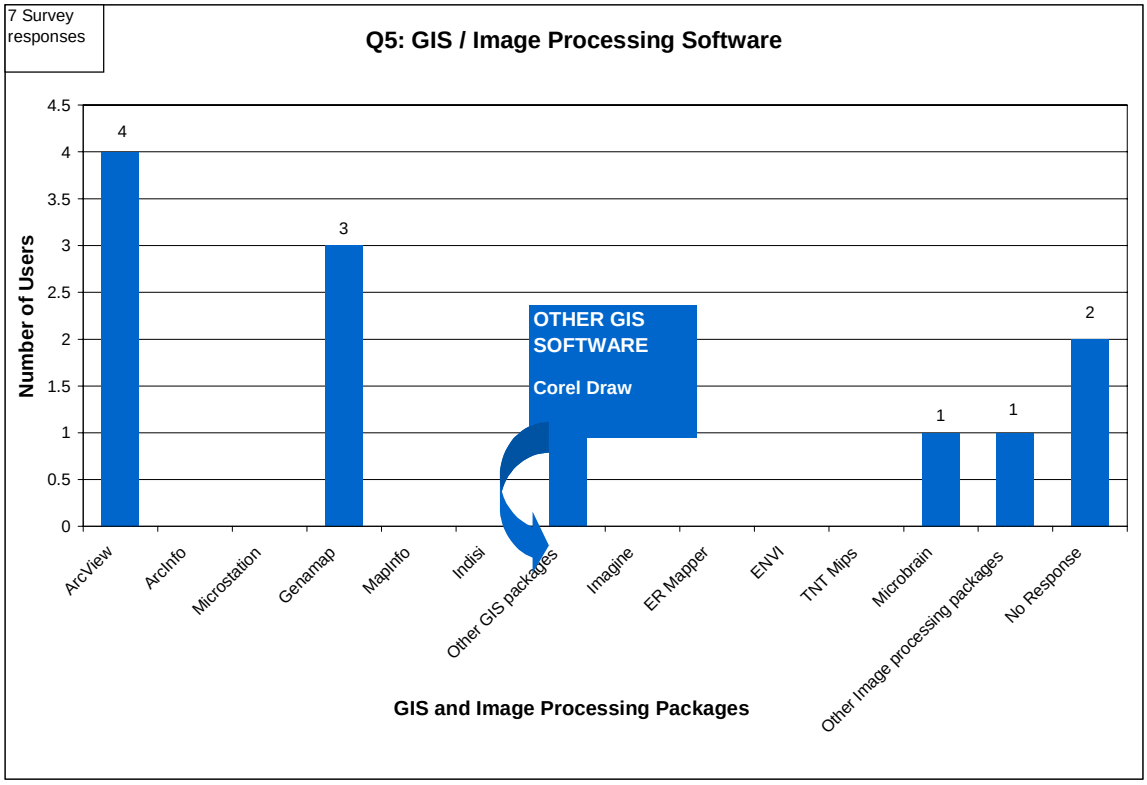
Visual interpretation of colour aerial photographic dominated the processing routines used, with digital image processing (pre-processing and classification) for mapping coastal, inter-tidal and sub-tidal features or updating current maps (cartography) being the main focus of digital image processing.



Question 5:

What GIS/Image processing software do you use?

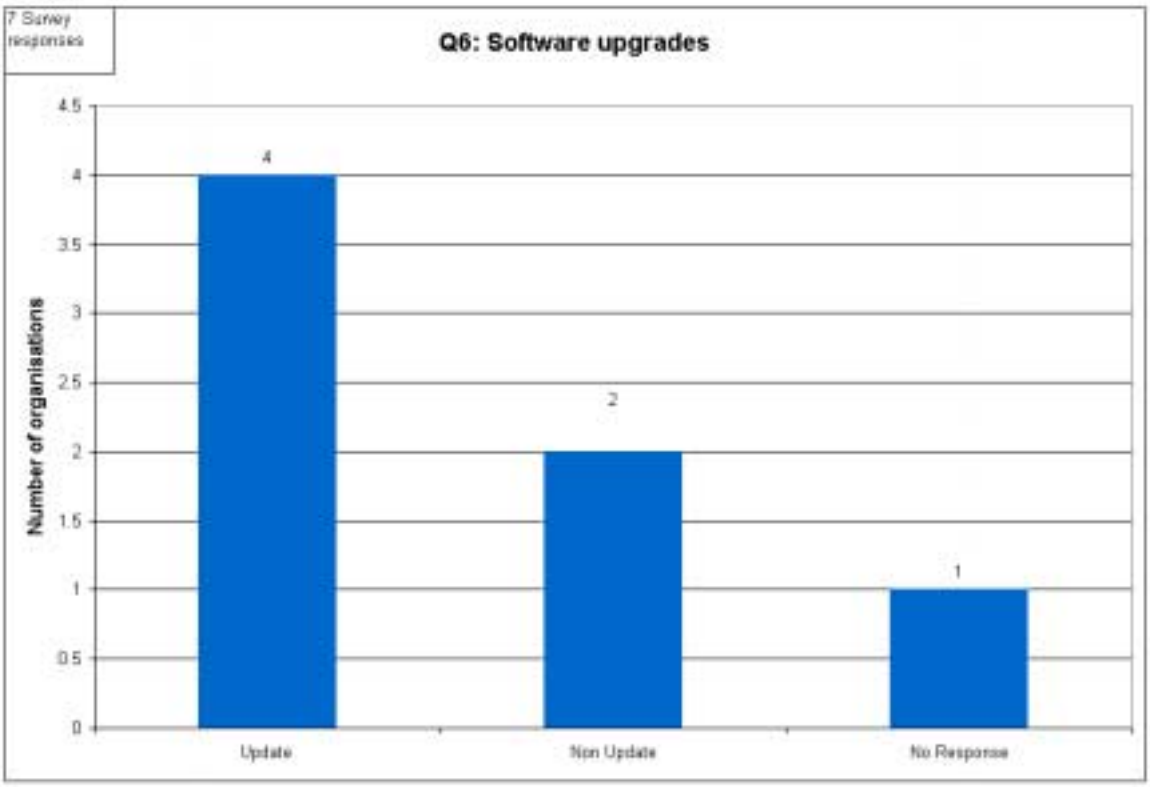
Image processing is not the core activity of the majority of organisations involved in monitoring and managing the catchment and water quality in Moreton Bay and its tributaries, hence the reliance on GIS systems for simple image processing operations.



Question 6: please check one.

Do you and your organisation keep up with software upgrades etc?

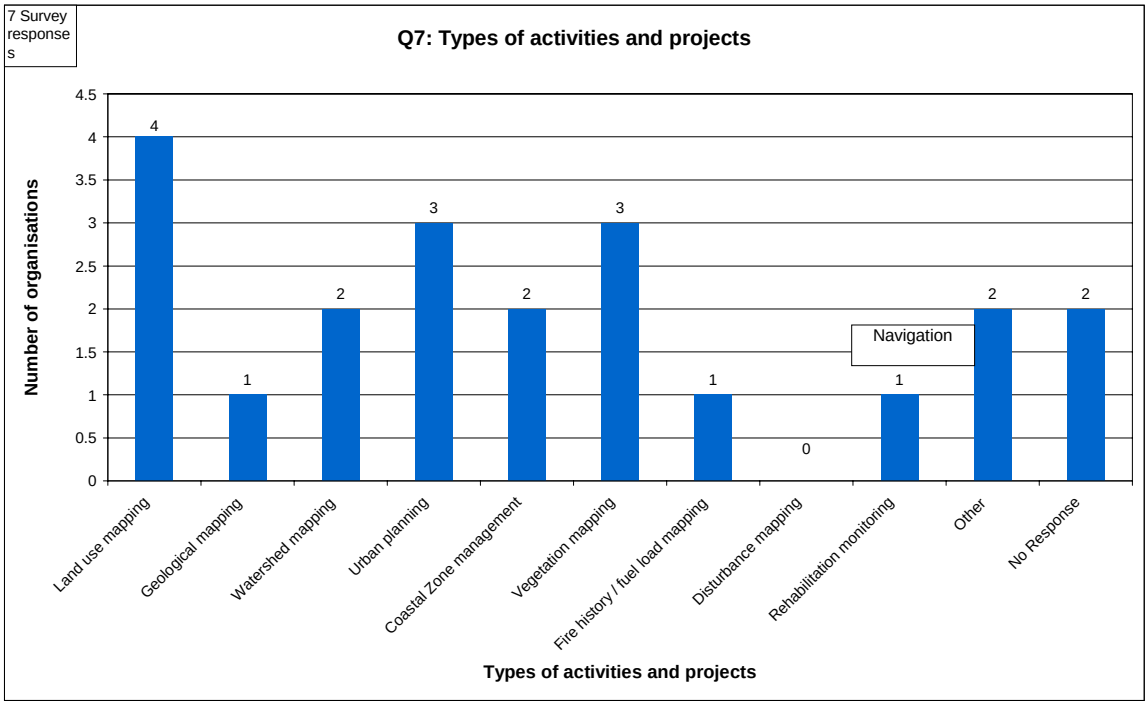
The majority of organisations surveyed kept up with software upgrades.



Question 7:

What types of activities and projects are remotely sensed data used for in your organisation?
(Note: there could be more than one response for this question).

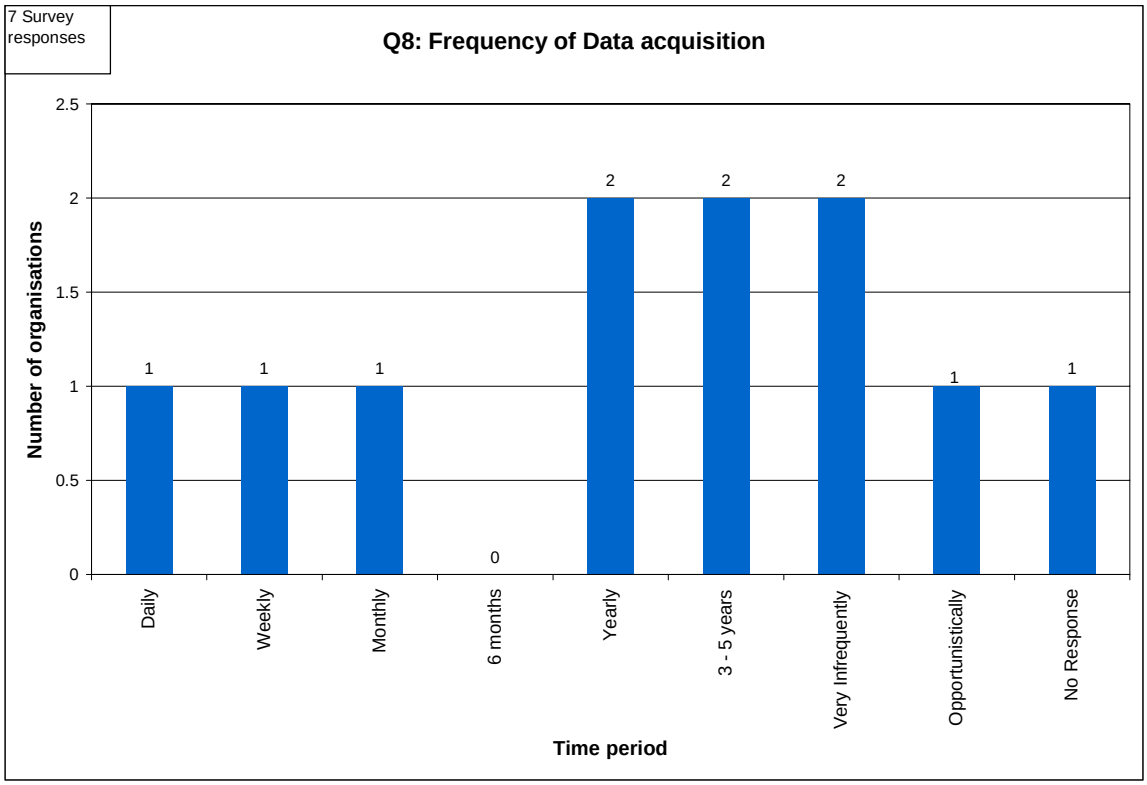
An interesting variety of responses were recorded for this question. This was to be expected given the number of agencies participating in SEQRWRMS, covering terrestrial environments affecting riverine, estuarine and nearshore water quality, stream hydrology, waste water treatment and protected area management. Remotely sensed data were most frequently used for land-use and vegetation (terrestrial, intertidal and aquatic) mapping, and urban planning at local scales.



Question 8:

How frequently do you acquire remotely sensed data for your organisation's applications?

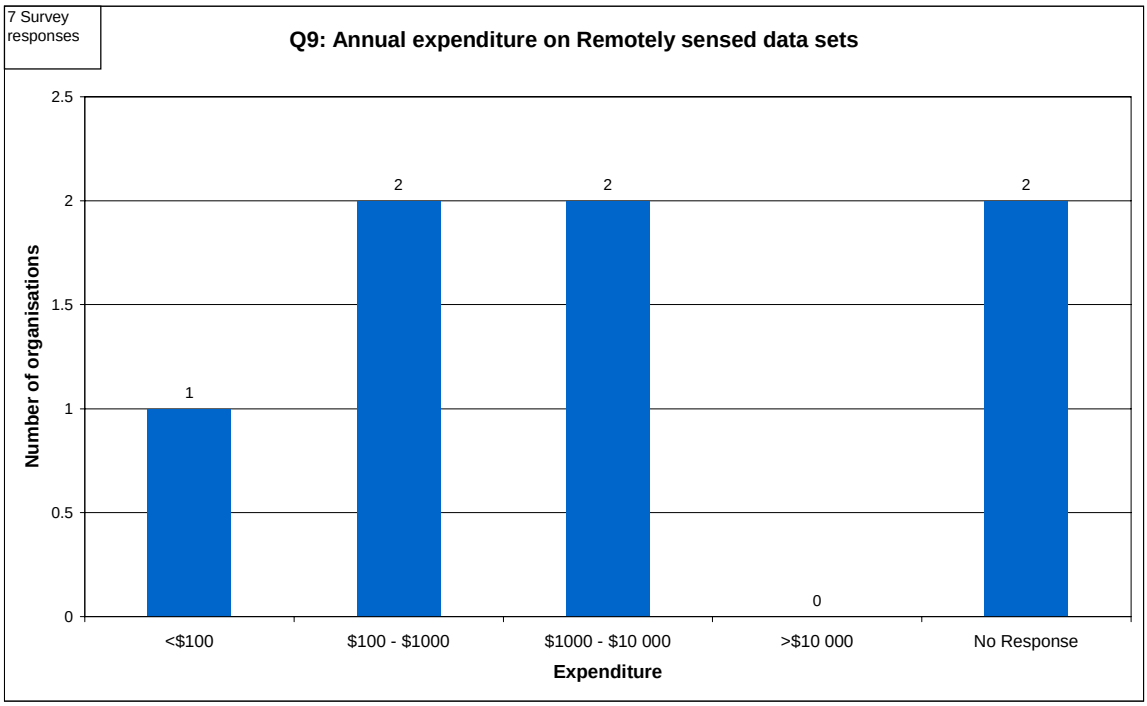
Acquisition frequencies for remotely sensed data sets were linked to the type of data obtained, with aerial photography and Landsat images being collected either yearly or every three to five years, both as part of ongoing state and local agency data collection plans.



Question 9:

What is your approximate annual expenditure on remotely sensed datasets?

Similar response to the national survey, those using data infrequently or opportunistically were spending $100-$1000, whilst those with regular aerial photograph or satellite image coverage were spending between $1000 and $10000 annually.



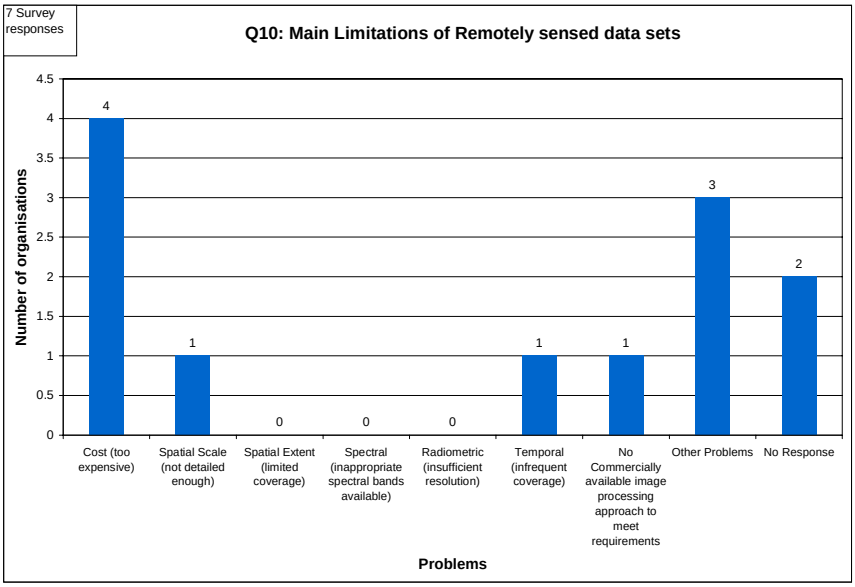
Question 10:

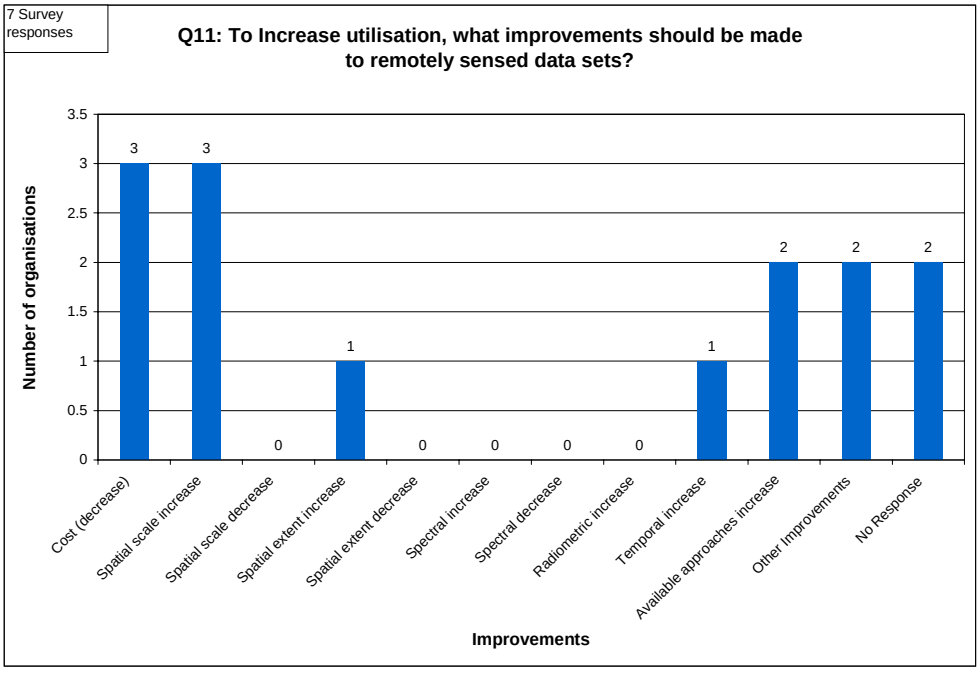
What do you consider to be the main limitations of current remotely sensed data and processing routines for extracting the information required by your organisation?

Question 11:

If you were to increase utilisation of remotely sensed data in the future within your organisation, what improvements should be made to current data and/or availability?

Similar response to national and state scale surveys, with cost being identified as one of the major limitations to using remotely sensed data. Insufficient detail (lack of suitable spatial resolution) was again identified by an organisation with local scale urban planning interests as a need. This response was also indicated for Q.11, with a large number of respondents identifying decrease in costs and increase in spatial resolution as improvements that would increase their capacity to be able to use remotely sensed data more effectively.

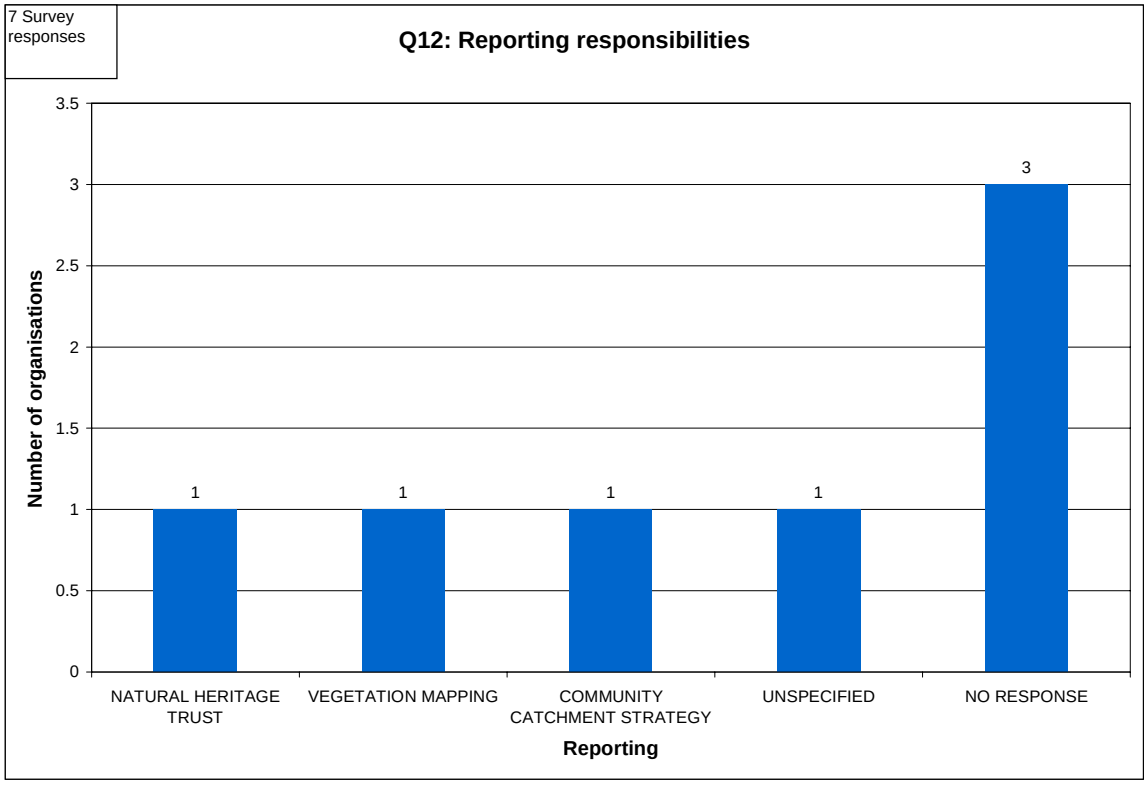




Question 12:

List any local state or national reporting responsibilities that your organisation has that remotely sensed data are/or used for:

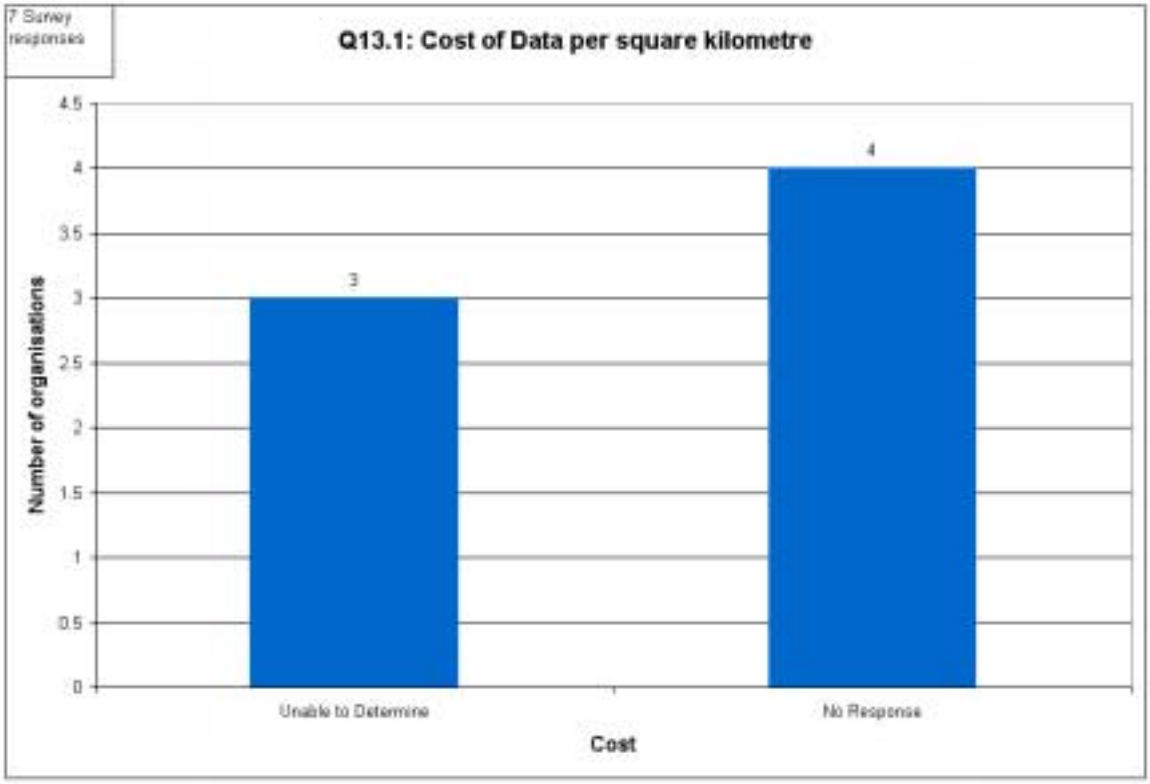
Three main responsibilities were identified: Natural Heritage Trust related projects; Vegetation Mapping; and Community Monitoring Programs.



Question 13:

What is the cost of implementing your existing methodologies per hectare or square kilometre for your sites of interest, ie for forest timber volume/habitat &/or species assessments etc. For example, if using air photo interpretation, costs of the hardcopy and digitised product per hectare or per frame?

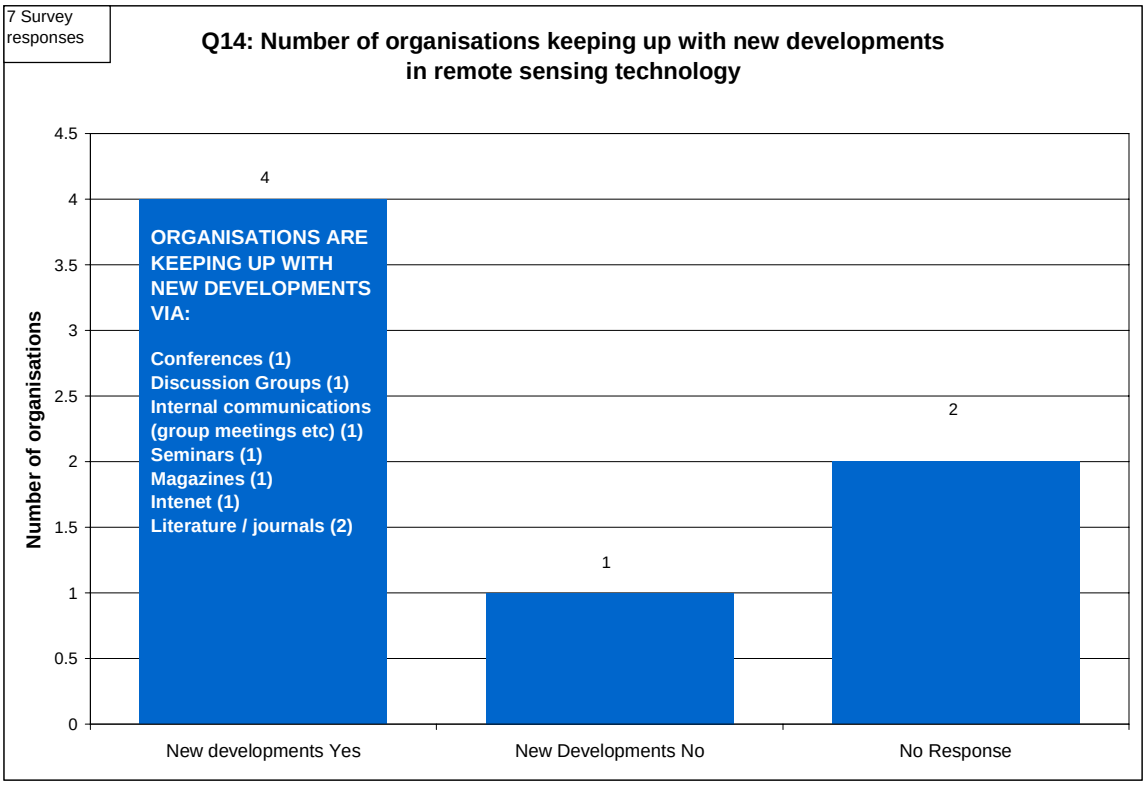
The majority of organisations were unable to answer this question.



Question 14:

Do you and your organisation keep up with new developments in remote sensing technology via discussion groups, user group meetings etc? if so how?

No predominant method for keeping track of developments in the field, with an equal use of all methods.



Question 15 (a):

In terms of expected developments in commercially available remote sensing technology will these new datasets be useful to your organisation's requirements?

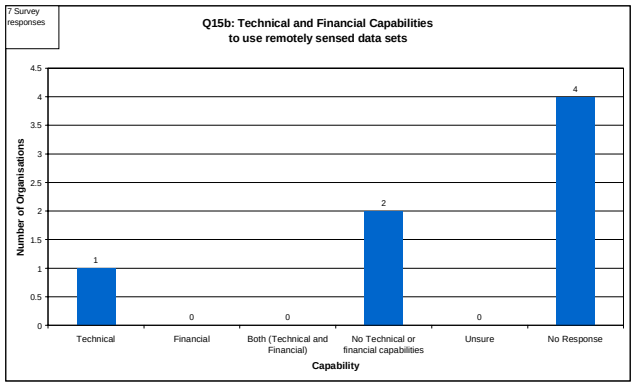
Question 15 (b):

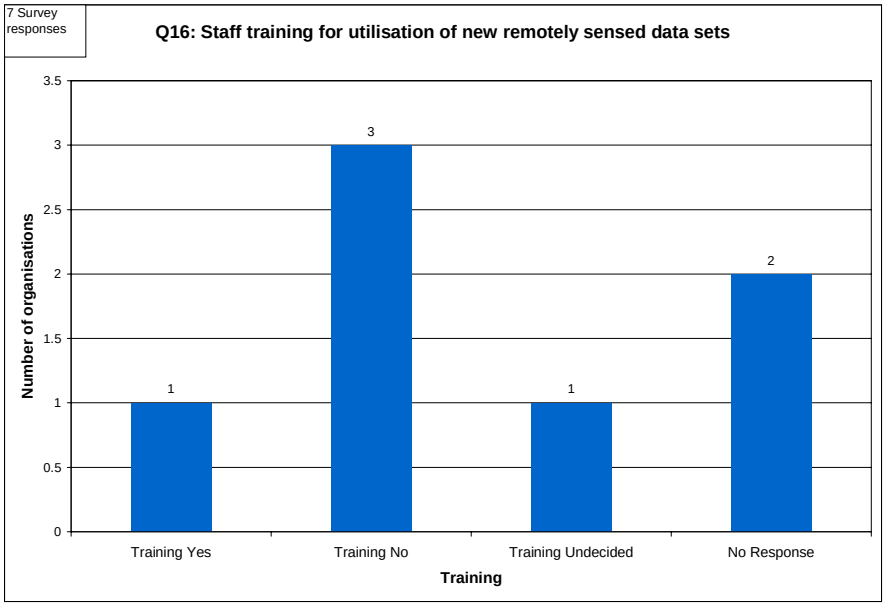
(b) Do you have the technical and financial capabilities to fully utilise these data?

Question 16:

Will your organisation be training people specifically to utilise these new datasets?

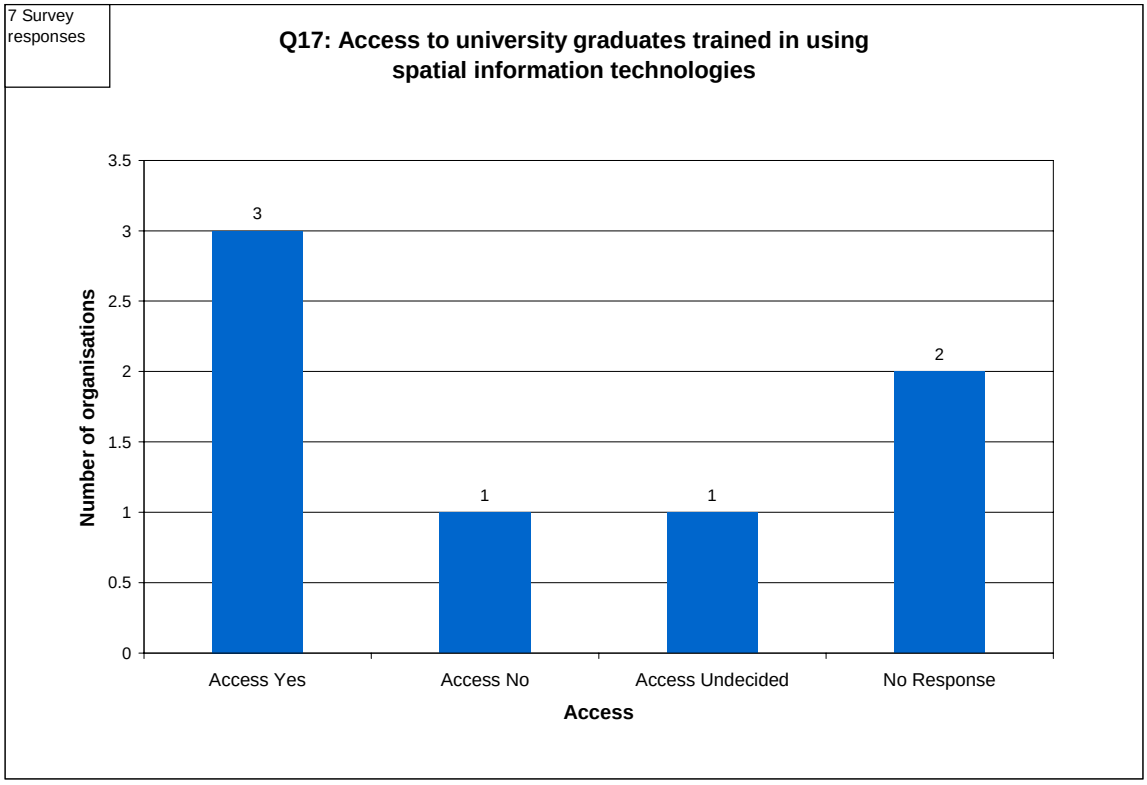
The responses to questions 15-16 indicated that the organisations surveyed were not aware of future developments in the types of remotely sensed data and information available, nor are they willing to invest money in developing staff with skills to use these data effectively.





Question 17:

Do you have access to local university graduates especially trained in using spatial information technologies?



5. Conclusions:
Status, Limitations and Future Directions for Remote Sensing Applications for Environmental Monitoring and Management in Australia

The results of the survey and analyses at national, state and local scales presented in this report provide significant extension to the findings of Wallace and Campbell (1998) and PWC (2000), in terms of how remotely sensed data are used and the capabilities of management agencies to continue using these data. Recommendations to improve access and "use-ability" of remotely sensed data support several of the key recommendations in the recently released 2001 Spatial Information Industry Action Agenda for Australia (www.dist.gov.au/agendas/Sectors/siiaa). Moving beyond the results from previous report (components of the remote sensing industry and its suitability for selective monitoring of environmental indicators at national scale), it is clear that a significant amount of current and future environmental monitoring and management can be undertaken on a regular basis using remotely sensed data sets.

Based on the information collected in this survey, the current **status** of remote sensing for environmental monitoring and management applications in Australia, from local to national scales can be described as:

- Focussed on programs for monitoring (regular mapping and change detection) in terrestrial environments at regional scales (> 10,000km^2) on annual or as-required time-scales.
- Employing "traditional" sources of remotely data, such as stereo-colour aerial photography and satellite multispectral (Landsat Enhanced Thematic Mapper, SPOT XS) image data to complete mapping and monitoring programs.
- Consisting of organisations with small (two – four person) staff groups with specialized backgrounds in remote sensing, spatial analysis and geographic information systems.
- Most frequently applying image processing and analysis operations for visual interpretation, geometric pre-processing, classification for mapping land-cover types and change detection.
- Being dominated by organisations using software from ESRI/Erdas and Map-Info/ER-Mapper to complete image processing operations.
- Spending between $1000 - $10000/year on acquisition of remotely sensed data, but Unable (or unwilling) to accurately identify the total costs (or cost per unit area) of their specific mapping and monitoring programs.
- Concerned with the cost of image data as a critical impediment to the widespread use of remotely sensed data in the future.
- Cognisant of developments in available image data sets through professional journals and conferences.

In terms of the **limitations** of current and expected remote sensing technologies for environmental monitoring and management at local to national scales, a number of consistent points were evident relating to:

- Costs of image data sets (at all scales) were perceived as too high and a major

impediment to more widespread adoption of remote sensing technologies for environmental monitoring and management.

- Specific groups of respondents also indicated the need for improvements in several image resolution attributes to make remotely sensed data more suited to their applications, i.e., most local governments requested higher spatial resolution digital multispectral data, whilst groups concerned with agricultural and oceanographic applications requested higher temporal frequency for data collection.

- Users are now aware of the increased variety of image data types available commercially, as a common request was for additional training to understand what these data were (and weren't) useful for and an approach to enable the most relevant data set(s) to be selected for a specific application.

As a means to identify directions for developing the remote sensing industry, it is useful to compare the key impediments identified in this survey for data users, to those identified by PWC (2000) for the remote sensing industry. Major impediments of the remote sensing industry identified by PWC (2000) included: (i) the failure of potential users to use remotely sensed data; (ii) slow and limited private sector growth in this industry area; (iii) a large number of small private companies (60 in Australia, with 13 in NSW, 11 in QLD, and 13 in ACT, 12 in WA, 3 in VIC and 8 in SA); (iv) a lack of government outsourcing of projects, resulting in competition of the private sector with government funded groups in universities and government agencies; (v) relatively high data costs; (vi) lack of skilled personnel; and a (vii) lack of funds for research and development. Results from the survey completed in this project identified specific activities that remotely sensed data were being used for, along with the capabilities and future development requirements of groups using remotely sensed data. These results indicate some of the elements responsible for impediments identified by PWC (2000), i.e., the failure of potential users to use remotely sensed data and limiting the use of remotely sensed data (i.e., costs, resolution, confusion over appropriate data type and how to process). By considering these issues together, several recommendations for **future developments** can be made to increase usage of remotely sensed data in Australian agencies and companies responsible for environmental monitoring and management. The following suggested directions provide additional details on how to achieve several of the key tasks identified in the Spatial Information Industry Action Agenda for Australia (www.dist.gov.au/agendas/Sectors/siiaa) :

- The issue of perceived higher costs of image data sources could be addressed in two ways. One approach would be to provide government subsidised base data sets (which is already done with Landsat data). This would still enable companies to value-add processing and sell corrected data and information. A second approach would be an educational campaign on the true costs of image data sets, to move away from the historical inertia introduced by aerial photography and moderate spatial resolution satellite data sets.

- Increasing the spatial and temporal resolution of imaging satellites is occurring as new satellite systems continue to be launched, providing a greater variety of data types, especially for higher spatial resolutions and specific applications (e.g. ocean colour and agricultural monitoring).

- A focus for the Professional Bodies operating as the Spatial Sciences Coalition and Australian Spatial Information Business Association in cooperation with relevant universities, should be on educational and training programs to be provided for potential remote sensing data users. These programs would cover three key issues: (1) fundamentals of remote sensing applications (what can I see in optical, thermal and microwave images and why?); (2) types of remotely sensed data and information products and how to select the data for my application; and (3) procedures for transforming image data to information.

• There is also a significant need to develop a systematic program for linking education, applied research and industry applications. This presents an opportunity for the Spatial Sciences Coalition and Australian Spatial Information Business Association to act as an organising point for establishing collaborative links between universities and private companies to address industry-wide questions, for example as the basis of a Cooperative Research Centre. The Australian Research Council's Industry Linkage Grants (http://www.arc.gov.au/ncgp/linkage/projects/default.htm) facilitate this approach, while smaller projects could apply NASA's Commercial Remote Sensing Program (http://www.esad.ssc.nasa.gov/eocap/eocapmain.asp) to a series of problem identified by the professional and industry bodies. Adopting either of these approaches would provide industry training and experience for students and an effective transfer of research into application.

In conclusion, although the response rate to this survey was relatively low (10%), the respondents were from a wide cross section of government agencies and provided a detailed overview of the status of remote sensing for environmental monitoring and management in Australia. In combination with the findings of previous reviews (e.g., Wallace and Campbell 1998 and PWC 2000) the survey results demonstrate the current applications and capabilities of remote sensing for environmental monitoring and management and requirements to ensure remotely sensed data will be of use for these activities in the future.

6.Acknowledgments

University of Queensland Foundation, Research Excellence Award 2000/2001 for providing primary funding for this project.

The Rainforest and Coastal Zone, Estuaries and Waterway Management Cooperative Research Centres for funding preliminary surveys and the current project work in South-East Queensland.

All of the Survey Respondents for providing their time and thoughts for completing the survey.

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8. Appendices

8.1 Survey Cover Letters

Moreton Bay

As part of a project being conducted for the Cooperative Research Centre for Coastal Zones, Estuaries and Waterways Management in Australia we are investigating the application of remote sensing for monitoring and managing coastal and estuarine environments in Moreton Bay.

The objective of our project is:

To develop operational methods in collaboration with managers for monitoring the condition of Moreton Bay through a combination of field sampling, remote sensing and spatial modelling.

A major part of this project is to establish the remote sensing requirements for management agencies responsible for Moreton Bay. We would greatly appreciate your input so that we may identify monitoring information requirements, levels of current use, expectations from remotely sensed data, impediments to current and future use and ideal data for applications.

If you choose to participate your contribution will remain anonymous and we will provide you with our summary report when it is completed.

The survey is available on-line at:

www.geosp.uq.edu.au\BRG\ surveys\GENERAL_survey.html

Please feel free to send the details on to anyone that may be interested.

Thanks for your time,

CRC for Coastal Zones, Estuaries and Waterways Management – Remote Sensing Group
Dr Stuart Phinn
Dr Arnold Dekker
Dr Alex Held

Port Curtis

As part of a project being conducted for the Cooperative Research Centre for Coastal Zones, Estuaries and Waterways Management in Australia we are investigating the application of remote sensing for monitoring and managing coastal and estuarine environments in Port Curtis.

The objective of our project is:

To develop operational methods in collaboration with managers for monitoring the condition of Port Curtis through a combination of field sampling, remote sensing and spatial modelling.

A major part of this project is to establish the remote sensing requirements for management agencies responsible for Port Curtis. We would greatly appreciate your input so that we may identify monitoring information requirements, levels of current use, expectations from remotely sensed data, impediments to current and future use and ideal data for applications.

If you choose to participate your contribution will remain anonymous and we will provide you with our summary report when it is completed.

The survey is available on-line at:

www.geosp.uq.edu.au\BRG\ surveys\GENERAL_survey.html

Please feel free to send the details on to anyone that may be interested.

Thanks for your time,

CRC for Coastal Zones, Estuaries and Waterways Management – Remote Sensing Group
Dr Stuart Phinn
Dr Arnold Dekker
Dr Alex Held

Fitzroy Estuary

As part of a project being conducted for the Cooperative Research Centre for Coastal Zones, Estuaries and Waterways Management in Australia we are investigating the application of remote sensing for monitoring and managing coastal and estuarine environments in Fitzroy Estuary.

The objective of our project is:

To develop operational methods in collaboration with managers for monitoring the condition of Fitzroy Estuary through a combination of field sampling, remote sensing and spatial modelling.

A major part of this project is to establish the remote sensing requirements for management agencies responsible for Fitzroy Estuary. We would greatly appreciate your input so that we may identify monitoring information requirements, levels of current use, expectations from remotely sensed data, impediments to current and future use and ideal data for applications.

If you choose to participate your contribution will remain anonymous and we will provide you with our summary report when it is completed.

The survey is available on-line at:

www.geosp.uq.edu.au\BRG\ surveys\GENERAL_survey.html

Please feel free to send the details on to anyone that may be interested.

Thanks for your time,

CRC for Coastal Zones, Estuaries and Waterways Management – Remote Sensing Group
Dr Stuart Phinn
Dr Arnold Dekker
Dr Alex Held

General Survey

As part of a project being conducted for the University of Queensland we are investigating the extent of remote sensing (aerial photography, airborne images, satellite images) applications in environmental monitoring and management in Australia.

The objective of our project is to establish how and why remote sensing data are, or are not being used for environmental monitoring and management activities in Australia at local, state and national levels.
The results from the project will be used to define the strengths of remote sensing applications in Australia and define directions for future applications oriented research to meet the needs of monitoring and management agencies.

If you choose to participate your contribution will remain anonymous and we will provide you with our summary report when it is completed.

The survey is available on-line at:

www.geosp.uq.edu.au\BRG\ surveys\GENERAL_survey.html

Please feel free to send the details on to anyone that may be interested.

Thanks for your time,

Dr Stuart Phinn
Biophysical Remote Sensing Group
Department of Geographical Sciences & Planning
University of Queensland
Brisbane, Queensland, AUSTRALIA, 4072
Ph: 61-7-3365-6526 Mobile: 0417-629765
Fax: 61-7-3365-6899
email:s.phinn@mailbox.uq.edu.au
Website: http://www.geosp.uq.edu.au/staff/sphinn/

8.2 Price-Waterhouse Coopers Industry Survey Form- 2000

Commonwealth Government Statistical Clearing House Approval Number 00532--01

SURVEY OF THE

STATUS OF THE AUSTRALIAN REMOTE SENSING INDUSTRY AND DATA USAGE

PLEASE COMPLETE THE ENCLOSED QUESTIONNAIRE AND RETURN BY EMAIL OR POST IN THE REPLY PAID ENVELOPE BY 16 JUNE 2000. YOUR RESPONSE IS MOST IMPORTANT FOR PROMOTING THE NEEDS OF THE INDUSTRY TO GOVERNMENT!
ALL INFORMATION WILL BE TREATED AS CONFIDENTIAL.

IF YOU HAVE ANY QUESTIONS RELATING TO THIS SURVEY, COULD YOU PLEASE CONTACT MIKE AUBREY BY EITHER
PHONE: (02) 6337 6660 - FAX: (02) 6337 6667 or EMAIL: tfs@lisp.com.au

This survey is being managed by:

Technical & Field Surveys Pty Ltd
1562 Limekilns Rd BATHURST NSW 2795

This survey is part of a review of the Australian Space and Remote Sensing Industries. PricewaterhouseCoopers, assisted by Technical & Field Surveys Pty Ltd, has been commissioned by the Department of Industry, Science and Resources (DISR) to prepare the review.

DISR wishes to identify policy initiatives that will foster the growth of the industries. To do this, we need to establish the present size, distribution and operations of the remote sensing (RS) industry as well as identify the principal users of remote sensing technologies. It is recognised that the remote sensing industry has private, government and educational components and that it has hardware manufacturing, software development and application and training activities as well as products and services segments.

There are significant changes and business opportunities in the remote sensing industry at present with new satellites, new participants and substantial new project applications. Your assistance in completing this questionnaire is needed to ensure that the significance of the industry to Australia and the information that it provides is recognised and its growth is facilitated.

Although the questionnaire is lengthy, many questions can be answered with a tick in the appropriate column or a yes/no entry but any amplification you may care to make will be welcomed. There is a section for general comments.

While as much information as possible is desired we recognise that some sections may be inappropriate. Please note such questions as "not applicable" but still return the questionnaire. Even a very general response will be useful. The questions relating to dollar values are important since they provide quantitative evidence of activities. If you wish to answer this section but the actual figures are difficult to obtain, an order of magnitude estimate will suffice.

The information you provide through this survey will not be used by PwC or the Department to identify individual respondents. Only aggregated information will be presented and comments made by respondents will not be attributed. Completed questionnaires will be treated by PwC as commercial-in-confidence and not provided to the Department. All questionnaires will be destroyed following acceptance by the Department of the final report.

1. CONTACT DETAILS

Please nominate a person who we can contact with any further queries about your responses to this questionnaire

ORGANISATION:	University of Queensland		
DEPARTMENT:	Geographical Sciences & Planning		
NAME:	Dr Stuart Phinn		
POSITION:	Lecturer/Director Biophysical Remote Sensing Group		
ADDRESS:	Dept. Geographical Sciences & Planning University of Queensland, Brisbane, QLD, 4072		
TEL:	07-33656526	Email:	s.phinn@mailbox.uq.edu.au
FAX:	07-33656899	Web Address:	http://www.geosp.uq.edu.au/brg/

2. GENERAL BACKGROUND

(a) Many organisations incorporate remote sensing within a wider range of spatial information activities. What are the principal activities of your organisation?

Remote Sensing education and training, pure and applied research in remote sensing

(b) Please indicate what proportion of your operations remote sensing represents (for example, in terms of employee hours spent dealing with remotely sensed data relative to other data, sales of remote sensing products or services as a percentage of total sales):

Main activity	100%
Major activity	
Substantial but minor activity	
Occasional activity	
Minimal activity	
Nil Remote Sensing activity	

(c) In what activity is the remote sensing component of your organisation primarily involved (please tick as many as necessary)?

Hardware manufacture/supply		Software services	
Data acquisition/capture	✓	Data distribution/supply	
Value-added products or services		Consulting	✓
R&D	✓	User of products or services	
Project planning & management	✓	Policy development	
Training	✓	Other (please specify)	

(d) What is the status of your organisation?

Private Industry - Sole proprietor		Private Industry - partnership	
Private Industry - trust		Incorporated Company	
Private Industry - other		Association/Society	
Federal Government		State Government	
Local Government		R&D organisation	
Educational institution	✓		
Other (please specify			

Do you or your organisation belong to a spatial industry association? Please nominate the association(s):

(e) What are your application areas (tick as many as necessary)?

General Geology		Mapping & cartography	✓
Mineral exploration		Physical environment	✓
Hydrocarbon exploration		Biological environment	✓
Agriculture	✓	Environment clearance	
Forestry	✓	Emergency Services	
Water resources		Finance/Insurance	
Regional planning		Defence	
Engineering/Utilities		Business information	
Meteorology/climate		Remote sensing technology	✓
Urban planning			
Other (please specify)			

(f) Is your organisation:

Wholly Australian-owned?	Y	
Partly Australian owned?	%	
Wholly overseas owned?		N

3. REMOTE SENSING DATA

(a) Do you supply, or have you used, any of the following data?

Please enter the appropriate letter in the box (U=user; S=supplier; D=distributor; V=value-adder)

	Never	**Rarely**	**Occasionally**	**Often**
Satellite:				
Landsat				U
SPOT				
NOAA or similar data				U
Radar				U
High resolution data (<10m)				U
Thermal data				
Other (please specify)				
Airborne:				
photography				U
Multispectral/hyperspectral				U,S
Laser				
Radar				U

(b) Please identify which recent or proposed data, products or services are likely to increase your usage of remote sensing? (Please ✓ as appropriate)

Data/Activity	**Not at all**	**Somewhat**	**Substantially**
5-6 metre resolution			
1 metre resolution		✓	
Additional spectral bands (hyperspectral)		✓	
Better revisit frequency			✓
More accurately located/rectified data		✓	
On-line data supply		✓	
On line data access with processing software	✓		
Integrated information products (e.g. imagery + digital map overlays)	✓		
Interpreted information products (e.g. land-cover; crops; etc)	✓		

(c) What is the geographic range of your services or usage? (Please ✓ as appropriate)

International	✓	Regional e.g. Asia-Pacific	
National	✓	State	✓
Regional	✓	Local	✓

(d) In what locations do you have offices with remote sensing capabilities:

(e) Please describe the principal types of study in which you apply remotely sensed data (e.g. crop forecasting, signal propagation for cellular networks, carbon accounting etc.)?

Forest structure/condition assessment, mangrove community mapping
Water/seagrass/coral condition assessment, wildlife habitat monitoring
Crop yield estimation, catchment landcover mapping, urban landcover mapping

(f) Which are your main customer groups (please rank 1,2,3 etc in order of value of sales in last 12 months).

	International Government/Agency	International Business	Australian Government/Agency	Australian Business
Aid Work				
Environment				
Mining				
Agriculture				
Forestry				
Defence				
Rural				
Marine				
Urban/Utilities				
Other (specify)				

4. GOVERNMENT INVOLVEMENT

Do you agree or disagree (use "S" for strongly) that the role of government in remote sensing in Australia should be to:

Possible role	**Agree**	**Disagree**
(a) acquire and provide access to a long term archive of basic data?	S	
(b) carry out basic R&D?	✓	
(c) fund external R&D?	✓	
(d) design and plan major resource and environmental applications?	✓	
(e) operate major resource and environmental projects in-house?	✓	
(f) offer services and support to external users on a fee for service basis?		S
(g) provide policy settings which stimulate private industry development?	✓	
(h) provide direct industry support by outsourcing government projects	✓	
(i) consider remote sensing only as a component of the GIS industry		S
(j) actively promote and support industry growth and development?	✓	
(k) transfer commercially-viable technology from government to private industry?	✓	
(l) support remote sensing industry innovation?	✓	

5. REMOTE SENSING OPERATIONS

NOTE: Where values of budgets, revenue, exports etc. are requested please enter a letter from the list below representing, if possible, an annual average of the past two years or otherwise the most recent annual amount.

A =	***Below $50k***	***B =***	***$50-100k***	***C =***	***$100-250k***
D =	***$250-500k***	***E =***	***$500-1000k***	***F =***	***$1000-2500k***
G =	***$2500-5000k***	***H =***	***over $5000k***		

(a) ACTIVITIES

When were your remote sensing operations established?	1997
Do you use in-house remote sensing equipment/software?	Y
Do you engage in, or support, remote sensing R&D?	Y
Do you provide remote sensing education or training?	Y
Do you perform remote sensing studies in-house?	Y
Do you use external remote sensing consultants?	N
Do you engage in remote sensing innovation?	Y

If you are a current supplier or user of remote sensing data or facilities, would you give estimates for the following questions:

(b) BUDGETS

What was the annual average value (see note above) of your production of remote sensing products and services, and/or expenditure on remote sensing products:

	Supplier	**Buyer**
Products		D
Services		
Exports		

(c) GROWTH

Have your remote sensing activities increased or reduced over the past 5 years (in terms of actual revenues or budget allocation)? Do you expect that they will increase or reduce over the next five years?

Estimated annual movement	Growth %	Reduction %
1995-1999	%	%
2000-2004	%	%

(d) IMPORTS

If you have imported remote sensing products or services in the last 2 years can you please briefly describe the nature and source of products/services involved?

2 x Analytical Spectral Devices (Boulder, Colorado, U.S.A) field spectrometers: UV-VNIR+U/W optics (US$38k) and NIR (US$52k).
1 x ADAR 1000 digital multispectral imaging system, Positive Systems, Montana USA (US$100k)

What was their annual value (see note above)?

	Products	Services
Value	D	

(e) EXPORTS

What was the annual value of export revenue or expenditure on projects (undertaken either in Australia or overseas) that were funded by non-Australian sources, eg, World Bank (see note.)

	Products	Services
Export Revenue		
Project expenditure		

(f) STAFF (Including casual staff)

How many people are employed in your organisation	5
Number of staff engaged in RS full time?	5
Number occasionally involved in or using RS (equivalent number of full time positions)?	4

(g) R&D

If you undertake or contract out R&D relating to remote sensing can you please indicate:

What are the main objectives of R&D undertaken (eg software, sensor or applications development)	Applications development for monitoring the health and condition of mangroves, seagrass, coral reefs, tropical and sub-tropical forests and wet/dry tropical wetlands.	
Your annual expenditure on R&D (see note above)	A$ D	
What percentage of your total R&D for Remote sensing is undertaken in-house?	100%	
What percentage of your R&D for remote sensing is payed for by other Australian organisations?	100%	
What percentage of your R&D for remote sensing is payed for by overseas organisations?	0%	
Are Australian government grants used to support your R&D?	Y	
Are Australian government tax concessions used to support your R&D?	Y	
Estimated annual value of support received	A$250,000	

6. HARDWARE & SOFTWARE

Do you develop or supply specialised RS hardware?	Y
Do you use specialised RS hardware?	Y
Do you develop or supply specialised RS software?	Y
Do you use specialised RS software?	Y

If you answered yes to any of these questions, please list the main types of hardware and software and identify those developed by your organisation.

Hardware	Airborne imaging system (external mounts) and field spectrometer systems for use in forest and aquatic environments
Software	Code developed in IDL, matlab and C++ for processing airborne image and field spectrometer data sets

7. REMOTE SENSING USAGE

If you are an end-user of remotely sensed data, could you give an indication of annual usage and expenditure in any or all of the following categories?

Number of images used per year	> 100 (i.e. lots of airborne images)
Average time spent on interpreting each image (days)	0.5 - 3
Cost of performing remote sensing studies	A$ 240,000
Value of commissioned interpretations or studies	A$
Value of physical surveys e.g. scanner surveys	A$ 60,000
Expenditure on follow-up of the results of RS studies	A$

8. COMMENTS

(a) Have you any evidence to indicate past or expected **cost-benefits** of remotely sensed data within your organisation, such as identifying potential new resources, achieving better management capability, gaining cost savings, operating more efficiently or enhancing the accuracy of information? Please comment on any such benefits.

(b) Have you any evidence to indicate past or expected benefits of remotely sensed data to improving the national economy? Please comment on any such benefits.

Use of sugar cane crop yield information to re-schedule and optimise harvesting resources.

(c) Can you identify any spin off benefits from your use of remote sensing, such as potential new applications or capabilities or the development of new, related activities or industries?

(d) Please provide comment on any **impediments** to your remote sensing operations or activities under the following headings:

(i) Impediments due to government policies or actions, such as lack of effective policy, industry development support, project outsourcing, R&D funding, etc.

ISSUE	**COMMENT**
Insistence on certification for quality assurance	Not an impediment and should be applied more widely.
Lack of competitive neutrality	N/A
Inappropriate specification of industry standards, e.g. algorithms, methods and software	N/A
Lack of separation between purchaser and provider in government	N/A
Government acting as wholesaler and retailer in data and product distribution	N/A
Government provision of services where industry is capable	Should be addressed with more outsourcing of basic processing to private industry
Lack of access to government markets	N/A
Lack of project outsourcing from governments	N/A
Lack of access to public data	Yes, i.e., with SLATS data and inability to pass on results from research to private industry groups, whereas government groups have

ISSUE	COMMENT
	full access.
High cost of public data	N/A
Unfair price setting and discounting	N/A
Subsidised services within government	N/A
Lack of effective industry development policies	N/A
Inappropriate positioning of remote sensing in government planning (space not spatial data sector)	
OTHER:	

(ii) Impediments within the industry, such as access to markets, skilled personnel, data, facilities, R&D support, industry representation, etc.

(iii) Financial or economic impediments, such as lack of access to equity capital, limited operating funds, high price of data, interest rates on borrowings, etc.

(iv) Competitive impediments, such as subsidised competition from government, educational or research establishments or foreign organisations.

9. WORKLOAD ON SMALL BUSINESS

To assist the Commonwealth to manage the workload on business in responding to surveys could you please indicate the total number of hours/minutes spent by you and others in answering this questionnaire? ……..0 hrs……25 …minutes.

Thank you for taking the time to complete this questionnaire. The results will be put to good use in informing government of the level of activity in the remote sensing industry and the extent of commitment within the industry and the user community. It is expected that the results will assist in the development of policies that will foster the growth of the remote sensing industry and enhance the availability of data.

8.3 List of people/organisations the survey was sent to (National Scale).

8.4 American Society for Photogrammetry and Remote Sensing: Remote Sensing Industry Analysis and Forecast 2000-2010 - User Requirements Survey.

8.5 Power-point Presentation of the Report