WS004

Sugar Research and Development Corporation

Workshop on New Technologies In Sugar Cane Crop Forecasting

Report to SRDC: Project Number WS004

Submitted: August 2001

Written by:

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- Raymond De Lai (HRIC)

"Partnership in Sustainable Catchment Management"

HERBERT Resource Information Centre

CRC SUGAR

CSR™

Introduction

Background to the workshop

Work over the last 3 years in the Herbert Resource Information Centre has demonstrated that it is possible to use remotely sensed satellite imagery to produce a reasonably accurate crop forecast provided there is limited ground truthing to validate spectral signatures. In both the 1999 and 2000 harvest seasons, the estimates derived from the Landsat TM images were closer to the actual yield for the Herbert than the crop estimates derived from conventional methods.

SRDC agreed to fund a project in the Herbert involving the HRIC and the University of Queensland to develop the technology further (project UQ037 Development of an all-weather sugarcane crop yield model using satellite image data). The project was led by Mr Mark Noonan who was employed by the HRIC and was doing this work as part of a Masters degree at UQ. CRC Sugar also agreed to provide funding to assist Mr Noonan with his Masters project. Mr Noonan left the HRIC in November 2000 and arrangements have been made to complete the project through the university. The project is due for completion in June 2001.

In the last year there has been a large amount of interest in this methodology from other mill areas such as Mossman, Mulgrave and Mackay and all sugar mills are searching for ways of producing accurate crop estimates without having to send out large numbers of people to inspect every block of cane on every farm. QSL have also expressed interest in this technology given the importance of accurate and timely estimates of sugar production for their operation. Initially the HRIC agreed to assist some of the mills in using the model, but with the departure of Mr Noonan this is no longer possible. Some mills (and QSL) are now approaching a variety of commercial companies to see whether they are able to perfect this methodology and customize it for their specific requirements.

With the HRIC being placed under increasing pressure from different users to provide advice and expertise, and with the HRIC Board having decided that they should not get involved in research and development, CRC Sugar was requested to coordinate an industry workshop which focused on new technologies in sugarcane crop forecasting. SRDC was approached regarding possible funding and this was eventually secured.

Workshop objectives

- To review the benefits in the Herbert of using a sugarcane crop yield forecasting model, developed by the Herbert Resource Information Centre, which utilises multispectral satellite imagery and GIS.
- To determine the current and future needs of the sugar industry in the area of automated crop forecasting using satellite imagery and GIS.
- To identify impediments to the successful application of automated crop forecasting using satellite imagery and GIS
- To create an R&D structure that will allow the further development of a robust, accurate and automated system for crop forecasting using satellite imagery
- To develop an action plan which deals with the location, resourcing and funding of current and future research
- To develop, if appropriate, a proposal to go to SRDC for future funding of this work

- To produce a report on the workshop for SRDC.

Outcomes/Benefits

- More accurate, cost effective crop forecasts which can be updated as the harvest season progresses
- Improved coordination of research efforts in this area to avoid unnecessary duplication
- A plan outlining the vision for the industry in crop forecasting and possible links or integration with other areas such as climate forecasting and mathematical analysis of block productivity records.

Crop Forecasting Industry Workshop Program

8.00am **Welcome by SRDC (R Muchow)**

8.05am **Workshop Overview (A Wood / W Andrew)**
-scope of workshop
-separation of R&D from operational aspects

8.15am **Scene setting**
-background to remote sensing **(S Phinn)**
-crop forecasting in the Herbert **(HRIC / CSR / CSIRO)**
-research progress in SRDC project UQ037 **(S Phinn)**
-crop forecasting in Mackay **(Mackay Sugar/ A Higgins)**
-mathematical modeling & Mossman work **(A Higgins / A Stafford)**
-QSL work & links with climate forecasting **(O Crees / Y Everingham)**
-Aerosonde work with unmanned aerial vehicles **(D Fowler / G Brett)**

9.55am **Morning Tea**

10.25am **Presentations from representatives**
-what do you want to get out of crop forecasting using satellite imagery?
-what role do you see yourself or your organisation playing?
-what issues and difficulties can you foresee?

11.10am **Small group workshops**
-what does the sugar industry want to see in the future?
-what impediments are likely to influence adoption of technology
-what organisation(s) would best fulfill the role of conducting R&D?
-opportunities for alliances or cooperative ventures
-future funding

12.15pm **Lunch**

1.00pm **Report back session**
-reports from each working group
-discussion and identification of key themes

2.00pm **Action planning**
-broad recommendations for a plan to go forward
-appointment of a Steering Committee/Working Group

3.00pm **Review and Evaluation of Workshop**
Closing Remarks

3.30pm **Close and afternoon tea**

Crop forecasting workshop participants

Russell Muchow	SRDC	rmuchow@srdc.gov.au
John Baird	SRDC	jbaird@csr.com.au
Bill Andrew	AEC Consulting	consult@orion-group.com.au
Raymond DeLai	HRIC	hric@ozemail.com.au
Andrew Wood	CSR TFD	awood@csr.com.au
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Lou Mastrippolito	Canegrowers Hbt	
Bernie Milford	Canegrowers Bris	bernard_milford@canegrowers.com.au

Welcome (Russell Muchow, SRDC)

The following points were mentioned:

- SRDC's investment approach to R&D
- The attractiveness/feasibility framework for assessing projects
- How will the R&D will be managed
- How will the delivery of benefits be maximised.

Workshop Overview (Andrew Wood and Bill Andrew)

The following points were covered:

- The background to the workshop
- The role of CRC Sugar in organising the workshop
- The role of SRDC in funding the workshop
- Aims and objectives of the workshop
- Separation of R&D from operational and commercial aspects of crop forecasting
- Deliberate exclusion of commercial operators from the workshop. Attendance restricted to Industry people and research practitioners
- Importance of accurate and timely crop forecasts at a number of scales including the whole of industry scale for sugar marketing, at the mill area scale for season length and season start/finish decision making, at the farm scale for equity considerations, and at the cane block scale for farm management.

The workshop aims to develop a plan outlining the vision for the industry in crop forecasting and to define the research and development needs to achieve that vision. The workshop will attempt to identify research projects addressing strategic Industry needs that are not operational or commercial and that can be justified as being valuable to the Sugar Industry.

Setting the Scene

Remote Sensing Basics and Agricultural Applications

AND

SRDC Project 37: Development of an All-Weather Sugarcane Crop Estimation Model

Presenter:

Stuart Phinn

Cooperative Research Centre for Sustainable Sugar Production

The University of Queensland

BRG Biophysical Remote sensing Group

Remote Sensing Basics
& Agricultural Applications

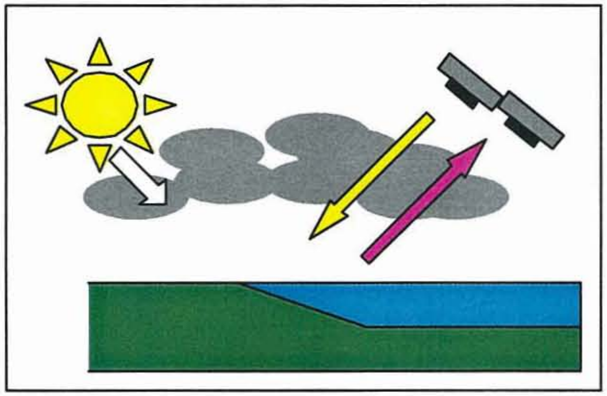
- **What is Remote Sensing?**

  - Measurements made without direct physical contact
  - Images collected from the ground, aircraft or satellites

  - Measurement of how different types of light are:
    - *Absorbed*
    - *Transmitted*
    - *Reflected*

Types of Remotely Sensed Data

- Passive (optical or thermal) Imaging Systems
  - Relies on reflected sunlight or emitted thermal energy
  - Unable to use through clouds, smoke or at night
  - Vegetation response controlled by pigments, canopy structure & biomass

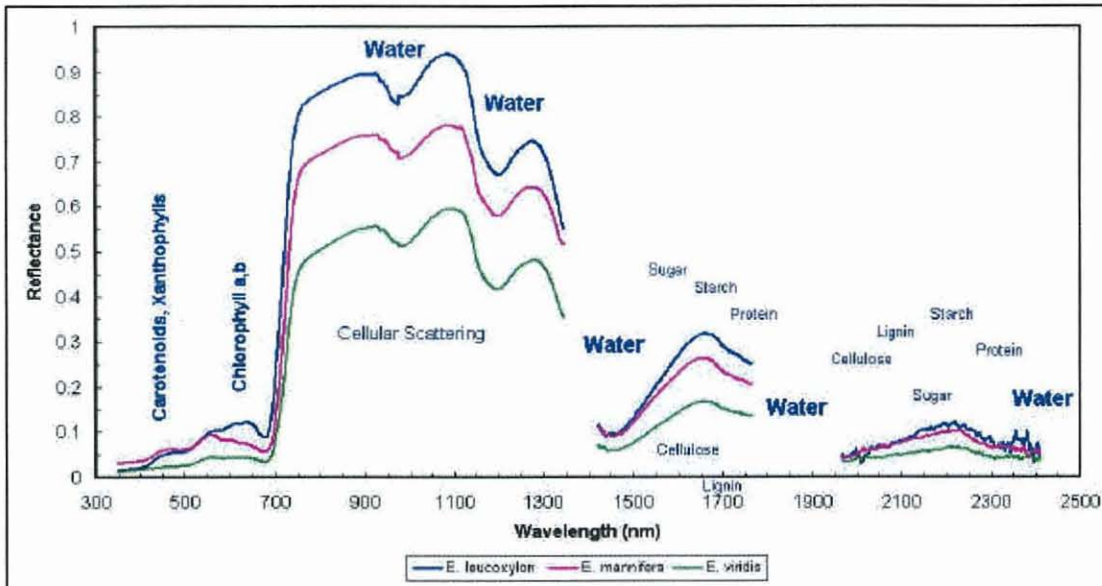


Radarsat1
Herbert River
Image subset
© ACRES 2001

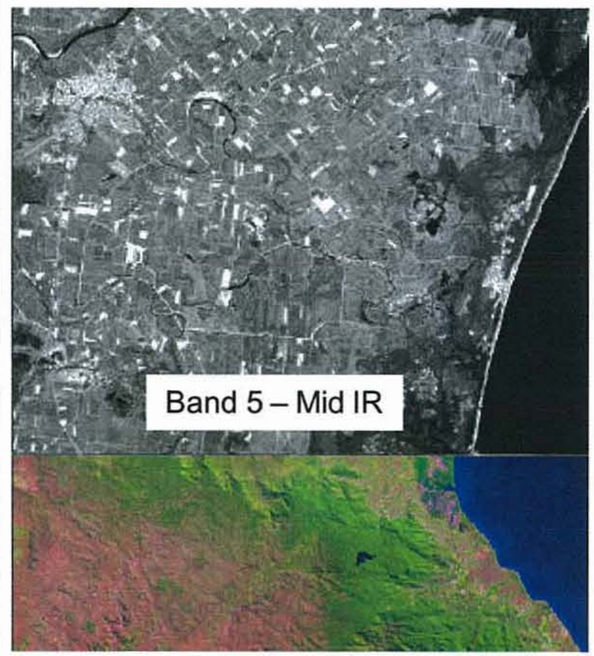
- Active (microwave or radar) Imaging Systems
  - Relies on a transmitter/sensor configuration
  - Able to see through, clouds, smoke and at night
  - Vegetation response controlled by water content, canopy structure & biomass

Passive Remotely Sensed Data - Sugarcane

- **Passive (optical or thermal) Imaging Systems**
  - Information derived from MULTI-SPECTRAL passive data sets:
    - Pigment content (photosynthetic, non-photosynthetic)
    - Water content
    - Canopy structure
    - Biomass

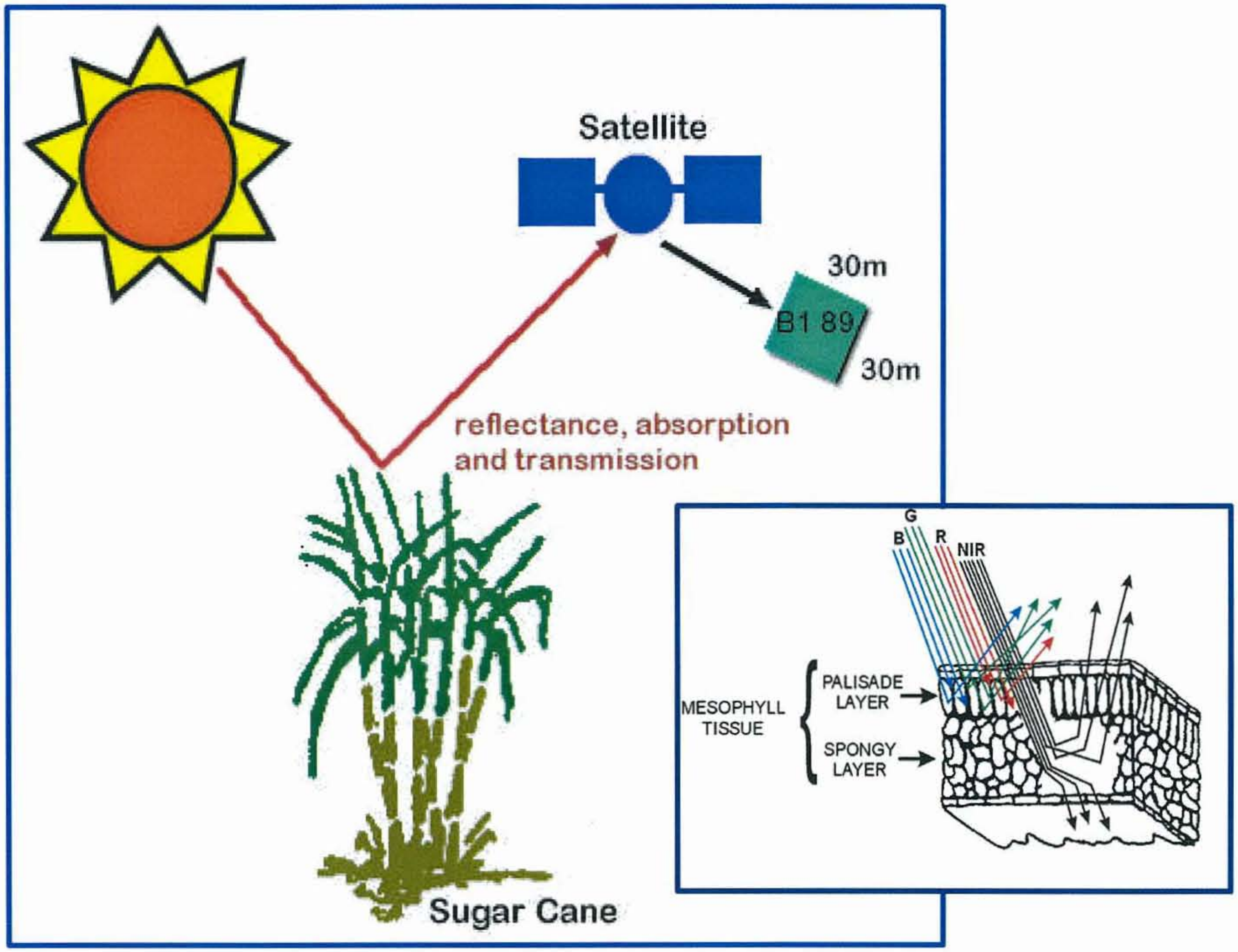


Source: A.Held, CSIRO



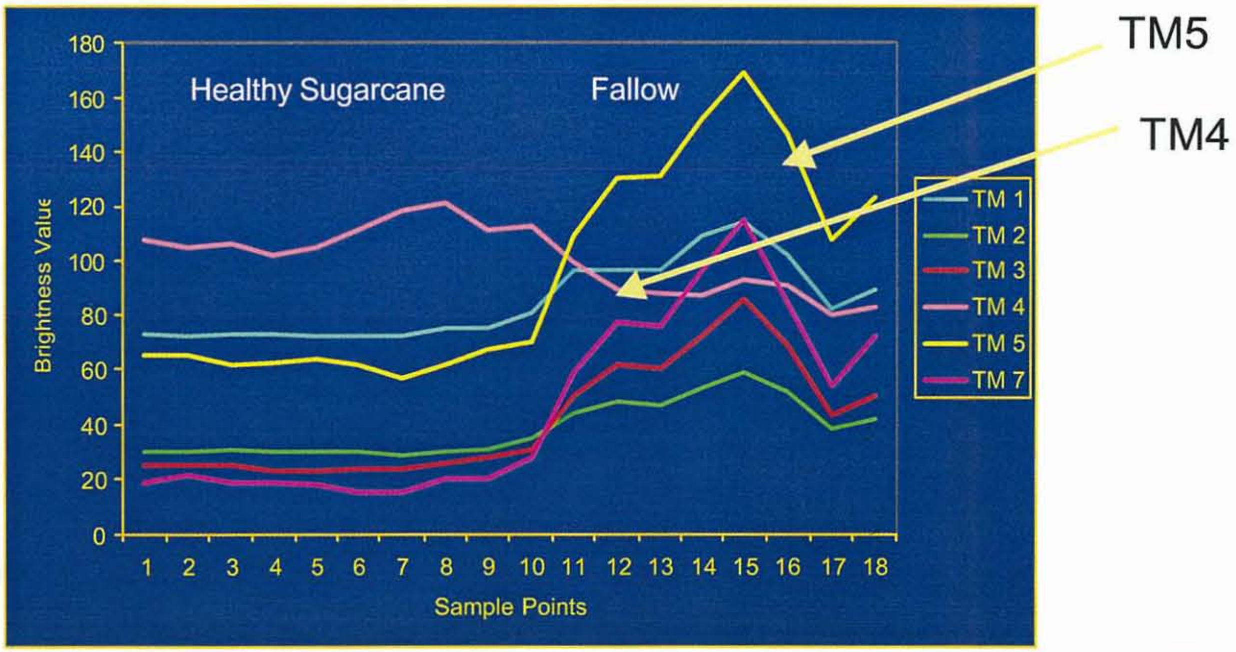
Landsat ETM Scene, Herbert Mill District
April, 2000

Crop Canopy Reflectance Model



Healthy Sugarcane v's Fallow Blocks

- Fallow blocks reflect high amounts of visible red and MIR radiation.
- NIR (TM4) reflection decreases when moving along a transect from healthy sugarcane to fallow.
- Visible blue and green show little change along the transect, compared to the other types of radiation.



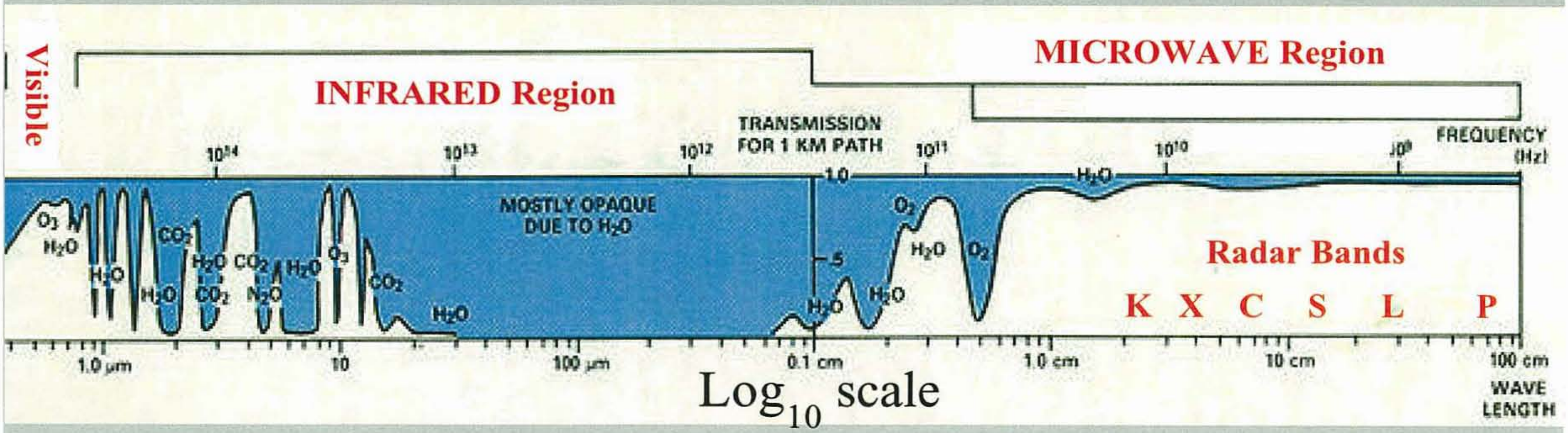
Active Remotely Sensed Data - Sugarcane

- **Active (microwave) Imaging Systems**
  - Information derived from Radar data sets:
    - Surface roughness
    - Water content
    - Canopy structure
    - Biomass

Radarsat Scene, Herbert Mill District
April, 20 2001
C-band (6cm wavelength, HH polarisation)

  - Radar BANDS + POLARISATION

EMR Spectrum



Band Name	Wavelength λ (cm)	Frequency *f* (GHz)	Some interactions
K_a	0.75 – 1.1	40 – 26.5	rain
K	1.1 –1.67	26.5 – 18	ë < 4cm
K_u	1.67 – 2.4	18 – 12.5	ice, snow
X	2.4 – 3.8	12.5 – 8	
C	3.8 – 7.5	8 – 4	Leaves, grasses
S	7.5 – 15	4 – 2	
L	15 – 30	2 – 1	branches
P	30 – 100	1 – 0.3	Stems/trunks

- Radar image data: Multi-Spectral Dimension

  C = 5cm ⇒ Radarsat1 data

  L = 25cm

  P = 60cm

- Radar image data: Multi-Spectral Dimension

  C = 5cm ⇒ Radarsat1 data

  L = 25cm

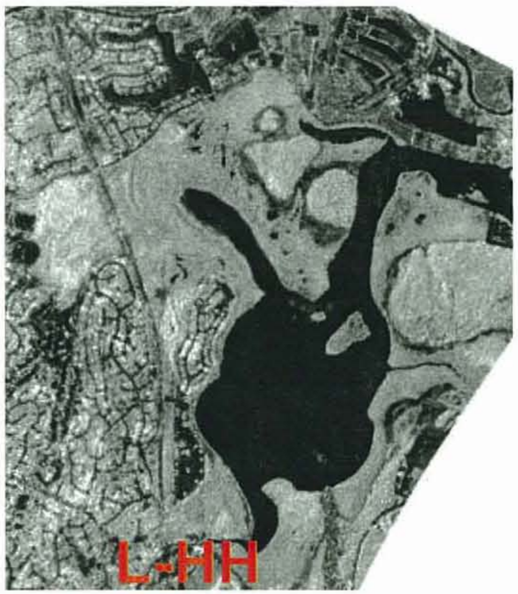
  P = 60cm

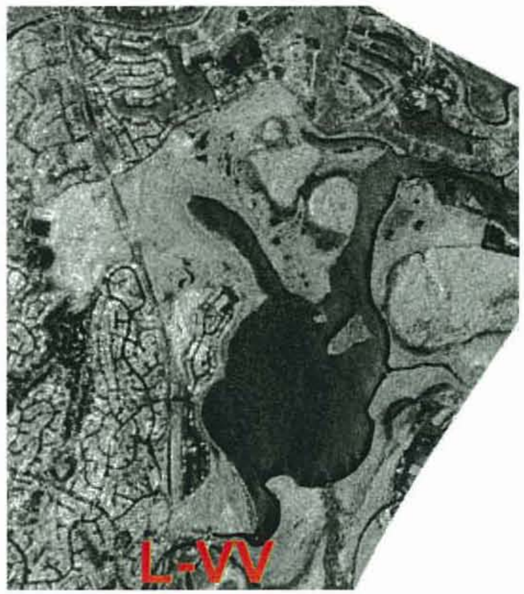
- Radar image data: Polarisation Dimension

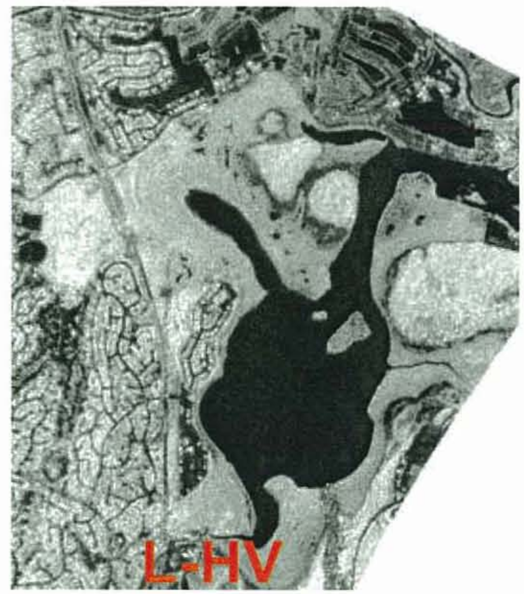
  HH = horizontal ⇒ Radarsat1 data

  VV = vertical

  HV/VH = horizontal/vertical

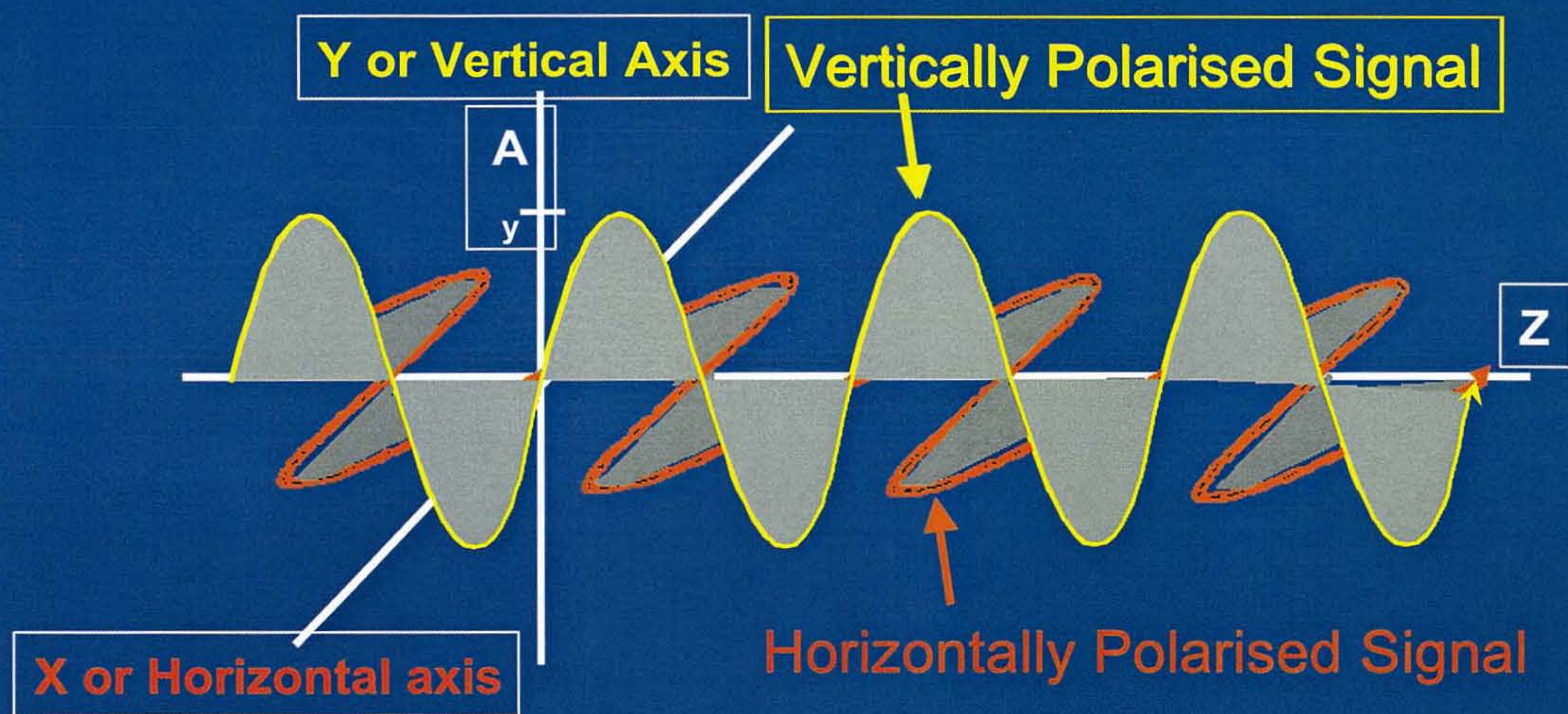






Imaging Radar – Polarisation Types

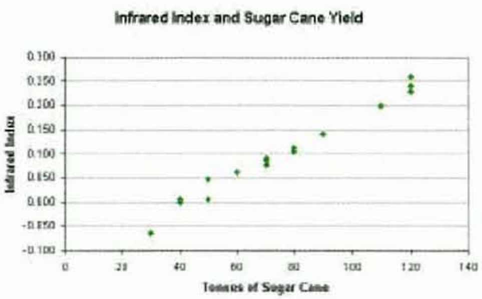
Polarisation describes the signal orientation or signal plane



Remote Sensing Applications - Sugarcane

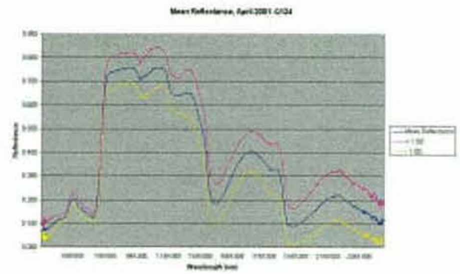
- **Passive (optical or thermal) Imaging Systems**

Yield estimation



Harvest area mapping

Cover type mapping



- **Active (microwave) Imaging Systems**

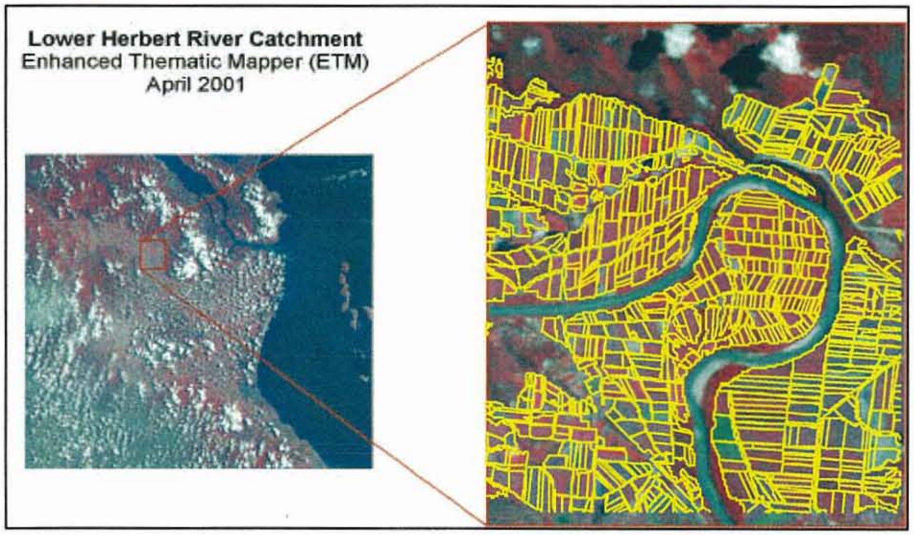
Yield estimation ?

Harvest area mapping ?

Cover type mapping ?

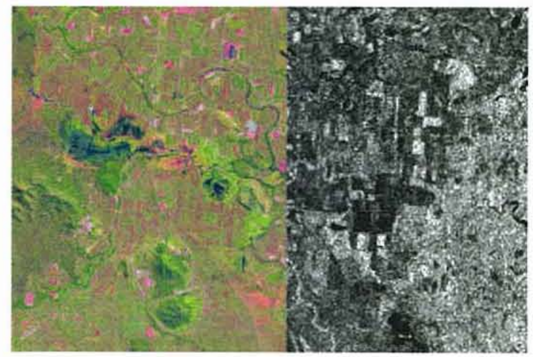
Remote Sensing - Limitations

- **Passive (optical or thermal) Imaging Systems**
  - Cloud cover
  - Smoke/haze
  - Variable illumination conditions
  - Time between repeat overpasses
  - Limited range of biomass indices



- **Active (microwave/radar) Imaging Systems**
  - Limited commercial availability of suitable image bands
  - Limited commercial availability of suitable image polarisation
  - Terrain distortions

SRDC Project 0037- Progress Report Development of an All-Weather Sugarcane Crop Yield Estimation Model



- Project Objectives
- Supporting Theory
- Radarsat Image Data Characteristics
- Sequence of Processing Operations
- Mapping Harvested v's Non-Harvested Areas
- Estimating Yield from Radarsat Image Data: - April 2001
  - September 2000
- Explanation of Results
- Conclusions & Directions for Future Work

• Project Objectives and Outputs:

To test whether commercially available synthetic aperture radar (SAR) image data has the potential to be used to sequentially monitor sugarcane crops accurately and reliably for:

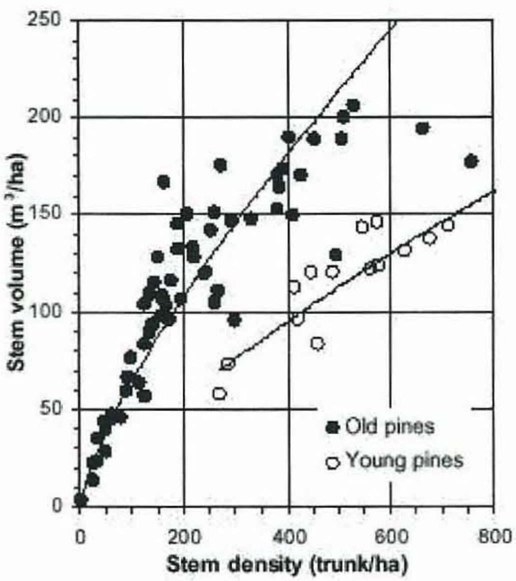
(1) Crop yield estimation
(2) Mapping the extent of harvested areas

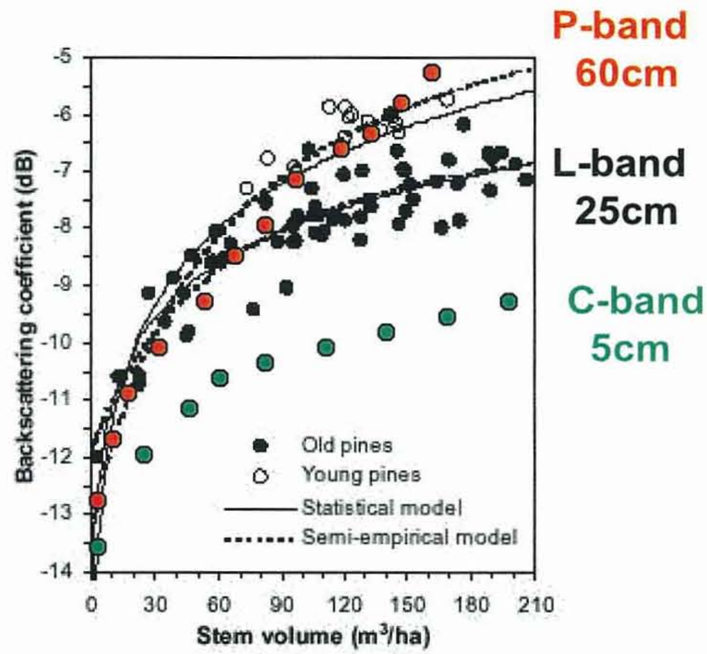
Outputs:

- Empirical relationships between radar response and crop yield
- GIS and image processing-based sugarcane crop yield estimation model and harvested area mapping methdology
- Maps showing the distribution of crop yields in the Herbert District

• Supporting Theory

- Research has shown imaging radar return signals are controlled by vegetation density and biomass:

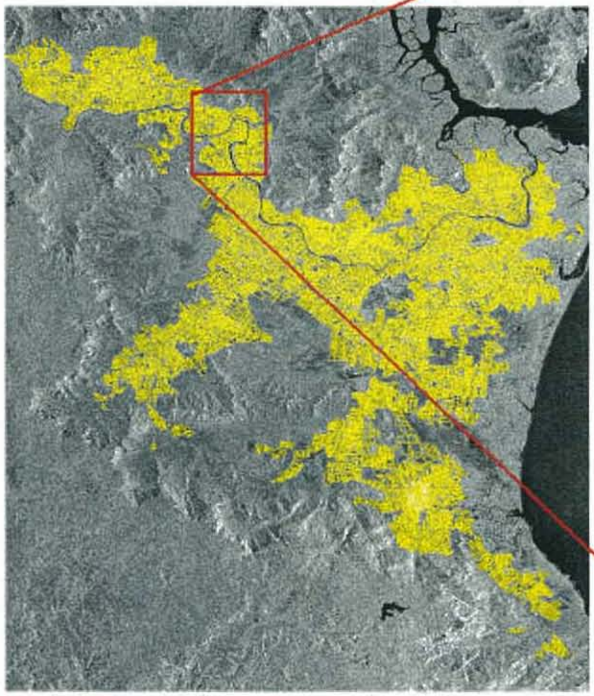




Source: Castel, T., Guerram F., Ruiz, A., Albarran, A., Caraglio, Y., Houllier, F. (2000) Retrieval of biomass of a large Venezuelan pine plantation using JERS-1 SAR data. In Proceedings of the International Geosciences and Remote Sensing Symposium, Honolulu, HI, July 24-28, 2000.

• Radarsat1 Image Data Characteristics:

Lower Herbert River Catchment
RADARSAT-1 Standard Beam 5,
C-Band HH, September 2000



Pixel size = 25m (from 12.5m)
Single spectral band = C (5cm)
Polarisation = HH

• Sequence of Processing Operations:

Radarsat1 images

Pre-processing:
- Register to cane-block layer/ETM image
- Resample to 25m pixel
- Filter to remove speckle (5x5, Lee or Kaun)
- Image DN values retained

Cane-block & Yield Estimates

Pre-processing:
- Join yield estimates to cane-block polygons
- Extract polygons with yield estimate
- Identify polygons unharvested at the time of image acquisition

Yield Estimates

- April, September 2000
- April 2001
- Extract mean radar response for fields with yield estimates
- Assess relationship between estimated yield and radar response

Mapping Harvested Areas

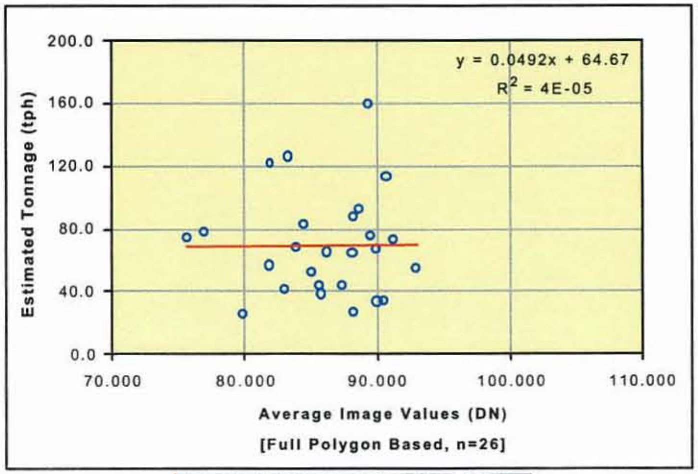
- Select representative harvested and unharvested areas
- Assess separability of harvested and unharvested areas
- Apply classification routine

Output:

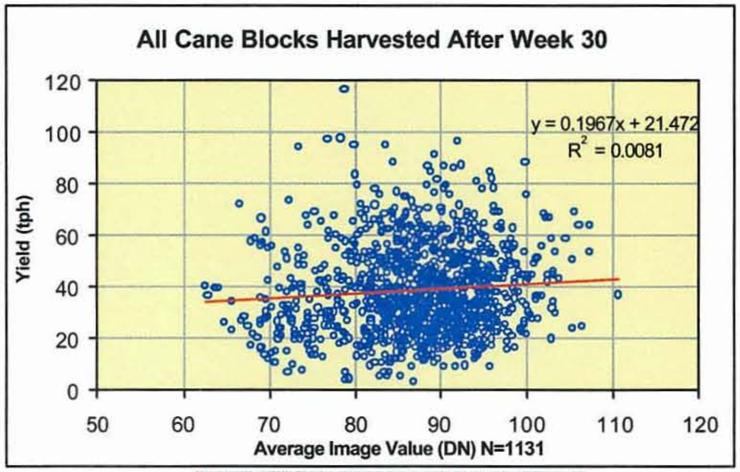
- Model for estimation of yield from Radarsat data
- Method for mapping harvested areas from Radarsat data

- **Estimating Yield from Radarsat Image Data:**

- April 2001

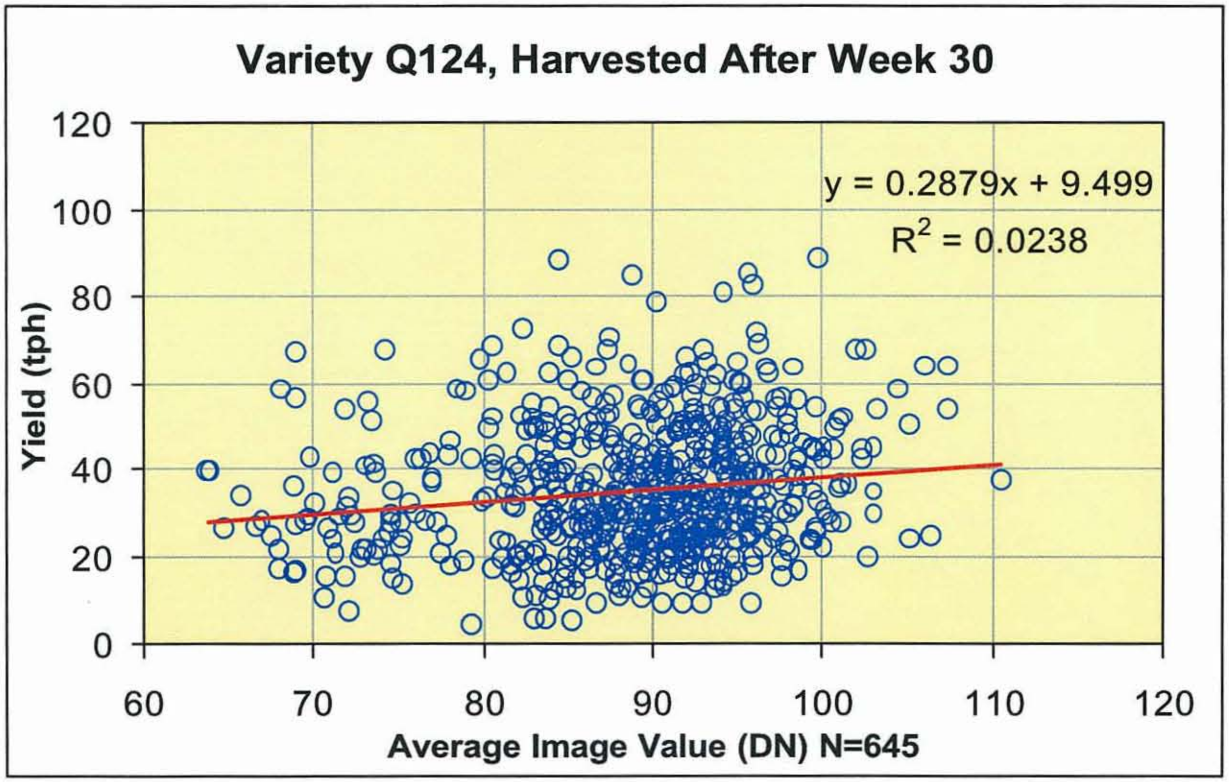


- September 2000



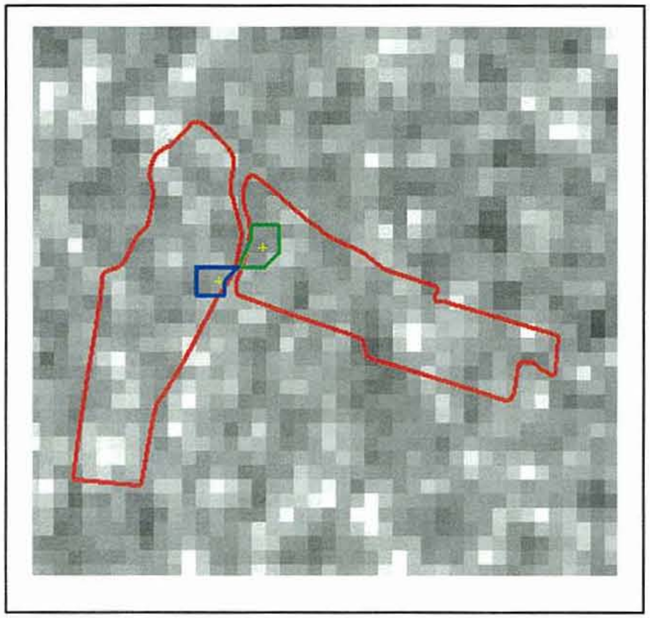
- **Explanation of Results**

Stratification by sugar-cane variety?



• Explanation of Results

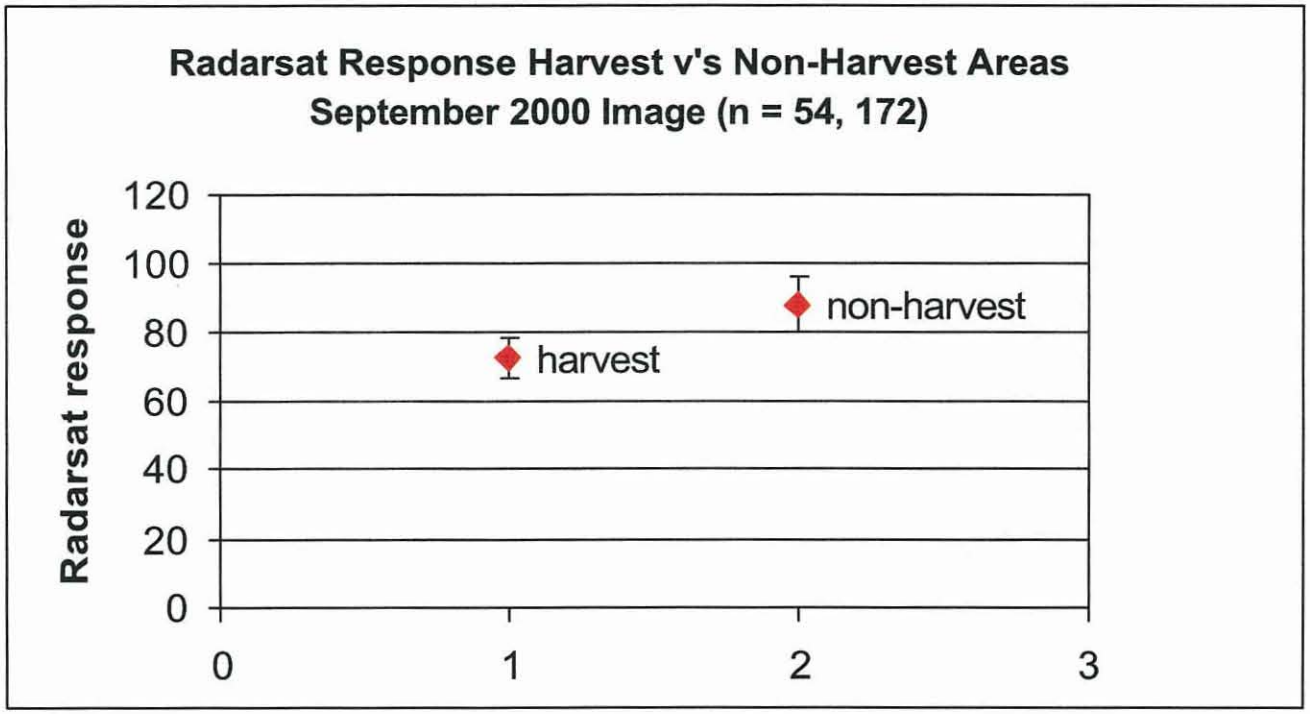
- Limited variation in C-band response:
  - Short radar wavelength interacts with surface roughness
  - HH polarisation responds to surface roughness, not plant structure



Polygon		No. of Pixels	Area (ha)	Mean	Standard Deviation	Range	Yield Estimate (tph)
5180-3-1	Full	140	8.48	89.2	7.06	45	84.7
	Subset (green)	7	0.44	84.6	5.44	18	
5180-4-1	Full	165	9.79	90.02	6.9	29	33.2
	Subset (blue)	5	0.31	84.6	3.05	8	

- **Mapping Harvested v's Unharvested Areas**

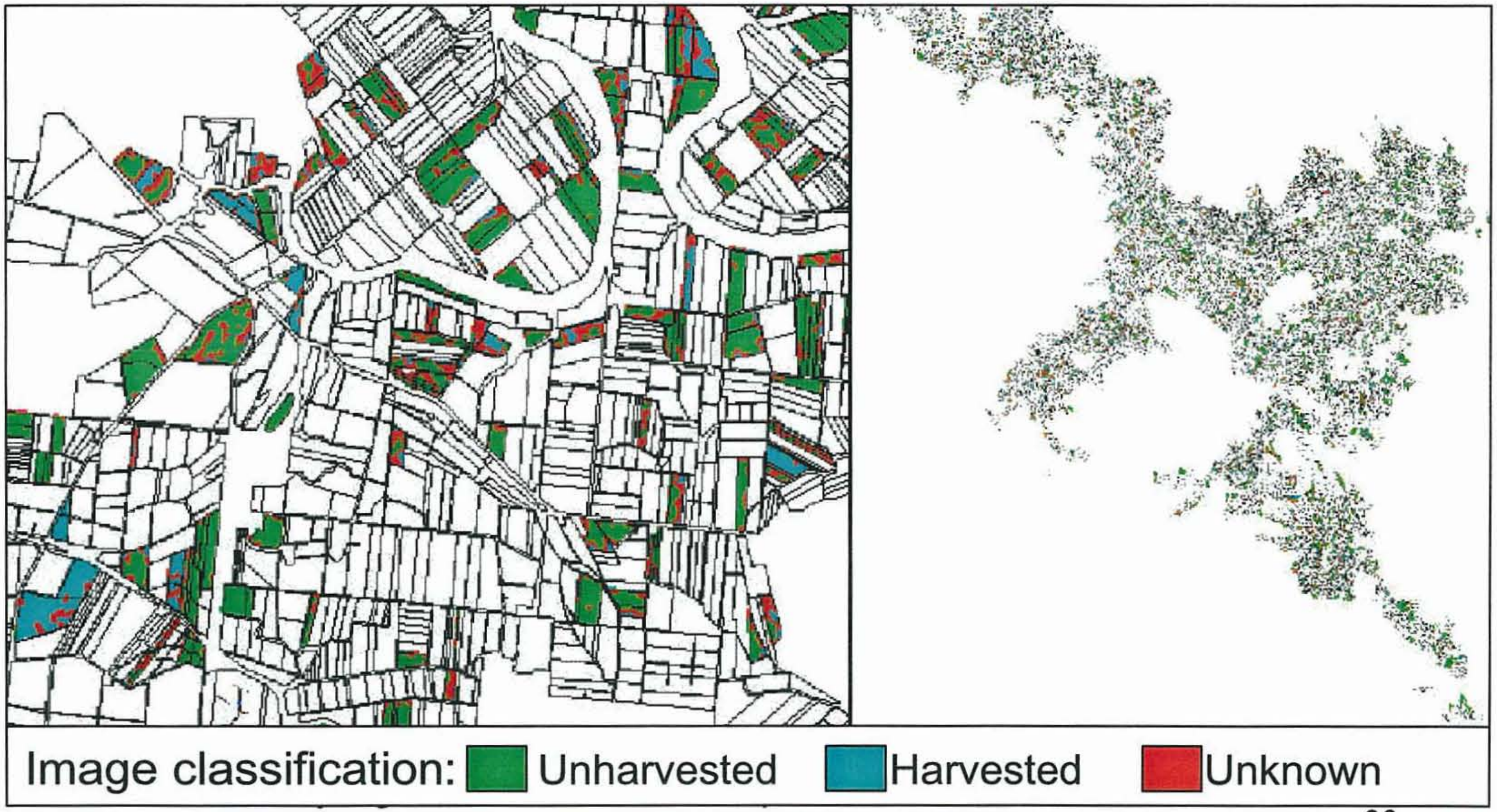
- Statistically significant difference in Radarsat C-band between harvested and unharvested areas



ANOVA results:
Statistically significant difference for $p < 0.01$

• Mapping Harvested v's Unharvested Areas

- Statistically significant difference in Radarsat C-band between harvested and unharvested areas



Conclusions & Directions for Future Work

- Estimated sugar-cane yield does not explain observed variation in Radarsat image data

- C-band HH polarised image data cannot be used to estimate yield

- Harvested and unharvested sugarcane field have statistically significant differences and can be mapped from Radarsat image data

- Estimated yield could be mapped from:
  - Longer wavelength imaging radar systems to be launched in 2002
  - Multi-polarised C-band imaging radar systems

- A trial evaluation can be conducted with:
  - Multi-wavelength, fully polarimtric radar images
  - Rocky Point and Mossman/Daintree (8/2000) for UQ/CSIRO

- Future satellite SAR:

Future satellite SAR:	ENVISAT C-band all polarisations	(10/2001)
	ALOS/PALSAR L-band all polarisations	(06/2002)
	Radarsat 2 C-band all polarisations	(06/2003)

Cooperative Research Centre for Sustainable Sugar Production

Remote Sensing Basics & Agricultural Applications

SRDC Project 0037- Development of an All-Weather Sugarcane Crop Yield Estimation Model

Stuart Phinn
Jon Knight & Michael Stanford
Biophysical Remote Sensing Group
School of Geography, Planning and Architecture
The University of Queensland

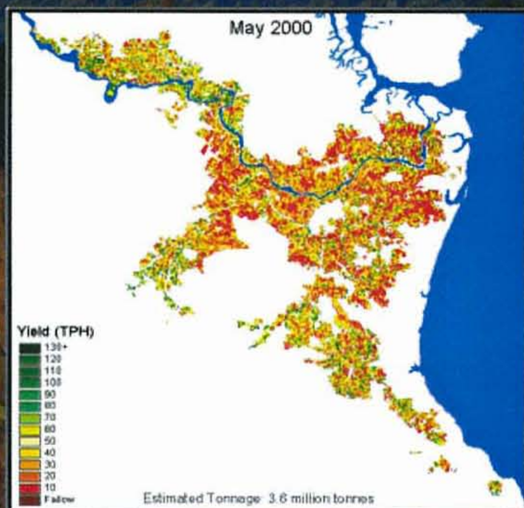
The University of Queensland

BRG Biophysical Remote sensing Group

Sugar Cane Yield Estimates Using LandSat Satellite Imagery in the Herbert

Presenters:
Raymond De Lai
Mike Sefton
Stuart Kininmonth

Sugar Cane Yield Estimates Using LandSat Satellite Imagery in the Herbert



Presented by:

Raymond De Lai
Mike Sefton &
Stuart Kininmonth

Herbert Resource Information Centre

Joint Venture Partners

CSR Herbert River Mills

Herbert Cane Protection and Productivity Board

Canegrowers Herbert River District

Hinchinbrook Shire Council

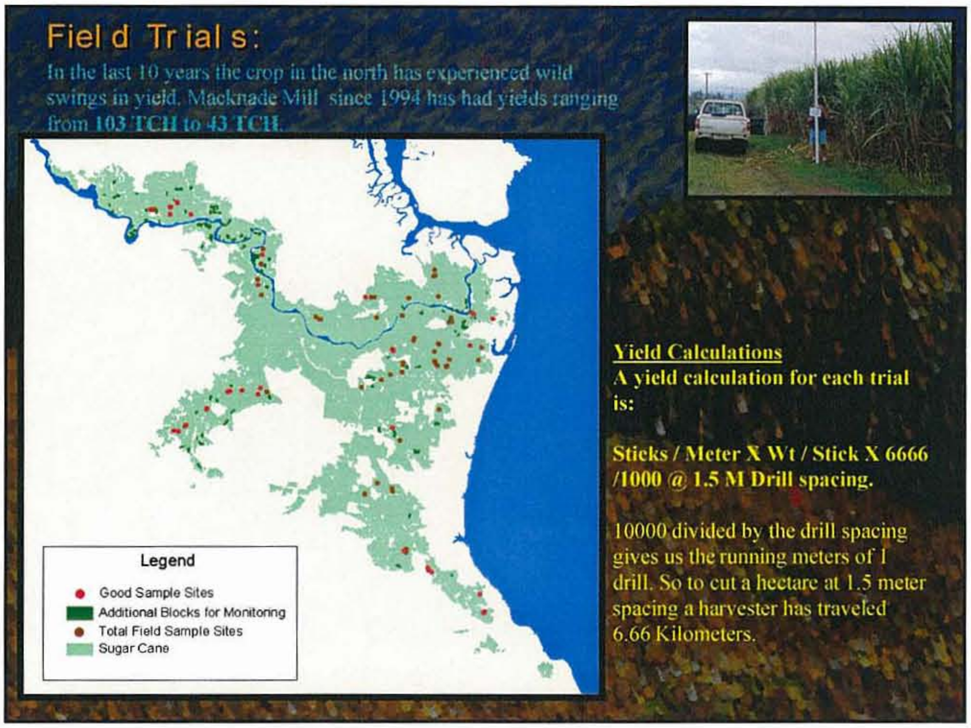
Queensland Department of Natural Resources and Mines

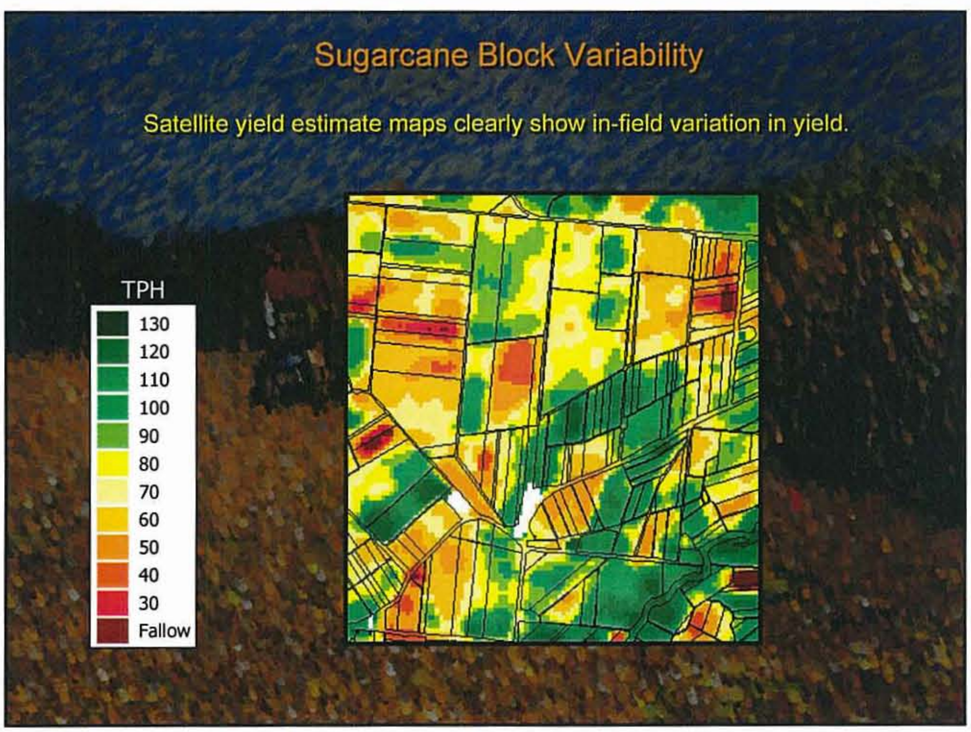
CSIRO Sustainable Ecosystems

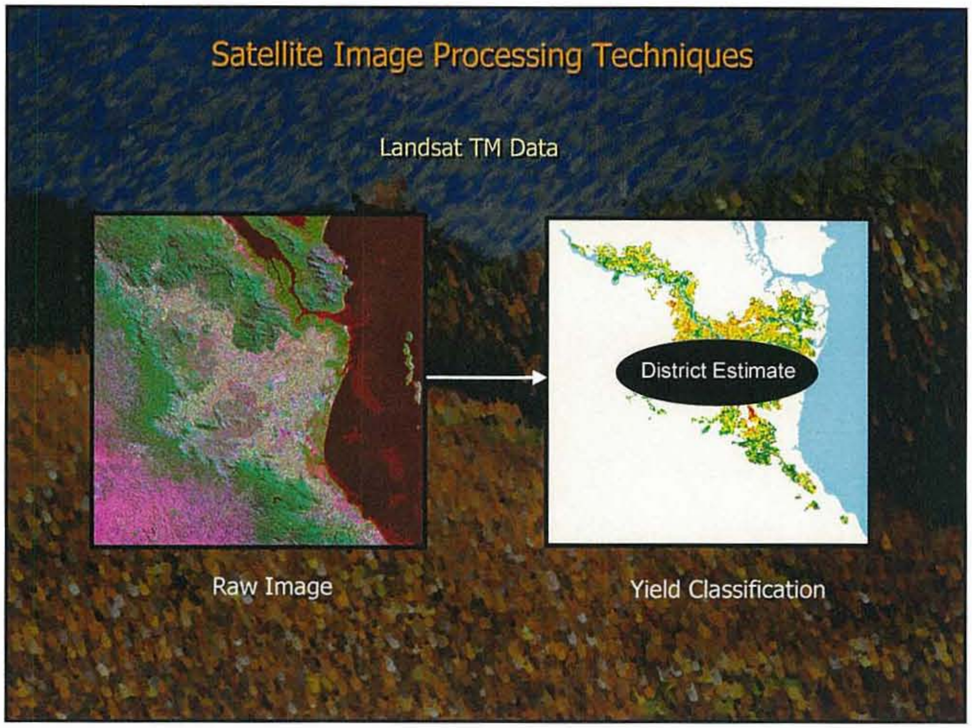
Introduction
The Herbert Resource Information Centre (HRIC) is a best practice Joint Venture GIS facility providing improved access to a range of information to organisations and individuals to assist better resource planning and management in the Herbert River Catchment.

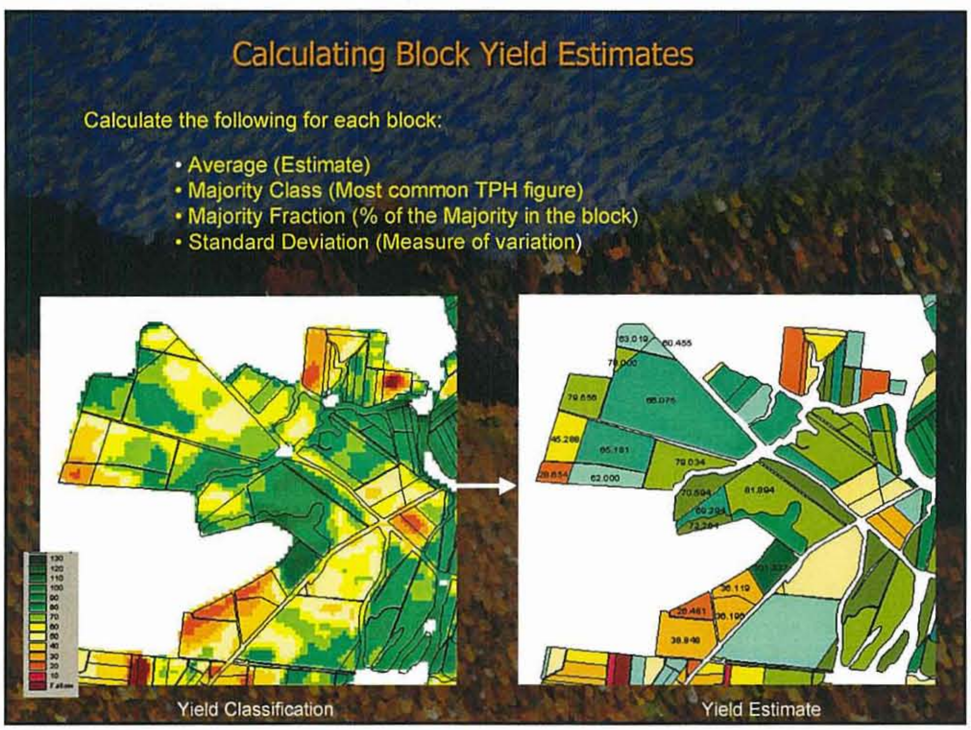
Our Vision
The HRIC will be used by its partners and the wider community to ensure the ecologically sustainable development of the Herbert River Catchment.

Mission
To manage the acquisition and dissemination of geographic information within a collaborative framework, to the advantage of all interests in the Herbert River Catchment.


Fiel d Tr ial s:
In the last 10 years the crop in the north has experienced wild swings in yield. Macknade Mill since 1994 has had yields ranging from 103 TCH to 43 TCH.
Legend
Good Sample Sites
Additional Blocks for Monitoring
Total Field Sample Sites
Sugar Cane
Yield Calculations
A yield calculation for each trial is:
Sticks / Meter X Wt / Stick X 6666 /1000 @ 1.5 M Drill spacing.
10000 divided by the drill spacing gives us the running meters of 1 drill. So to cut a hectare at 1.5 meter spacing a harvester has traveled 6.66 Kilometers.


Sugarcane Block Variability
Satellite yield estimate maps clearly show in-field variation in yield.
TPH
130
120
110
100
90
80
70
60
50
40
30
Fallow

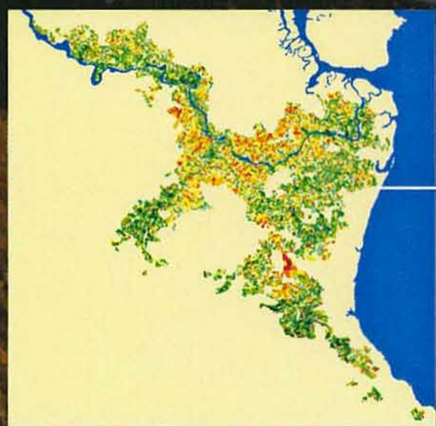

Satellite Image Processing Techniques
Landsat TM Data
District Estimate
Raw Image
Yield Classification


Calculating Block Yield Estimates
Calculate the following for each block:
• Average (Estimate)
• Majority Class (Most common TPH figure)
• Majority Fraction (% of the Majority in the block)
• Standard Deviation (Measure of variation)
Yield Classification
Yield Estimate

Calculating District Estimates

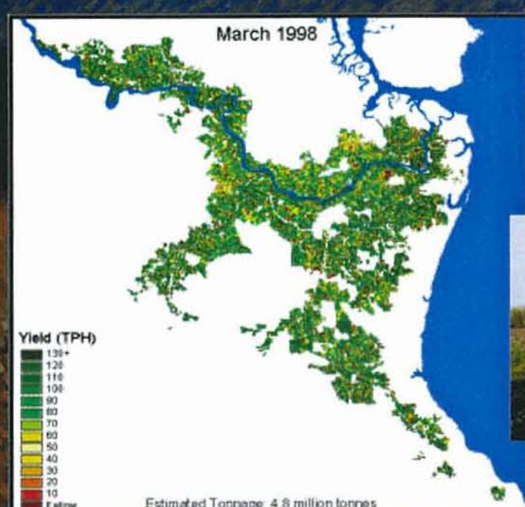
Block Estimate x Area (ha) = Total Tonnes for Block (TTB)

Addition of all TTB = District Estimate



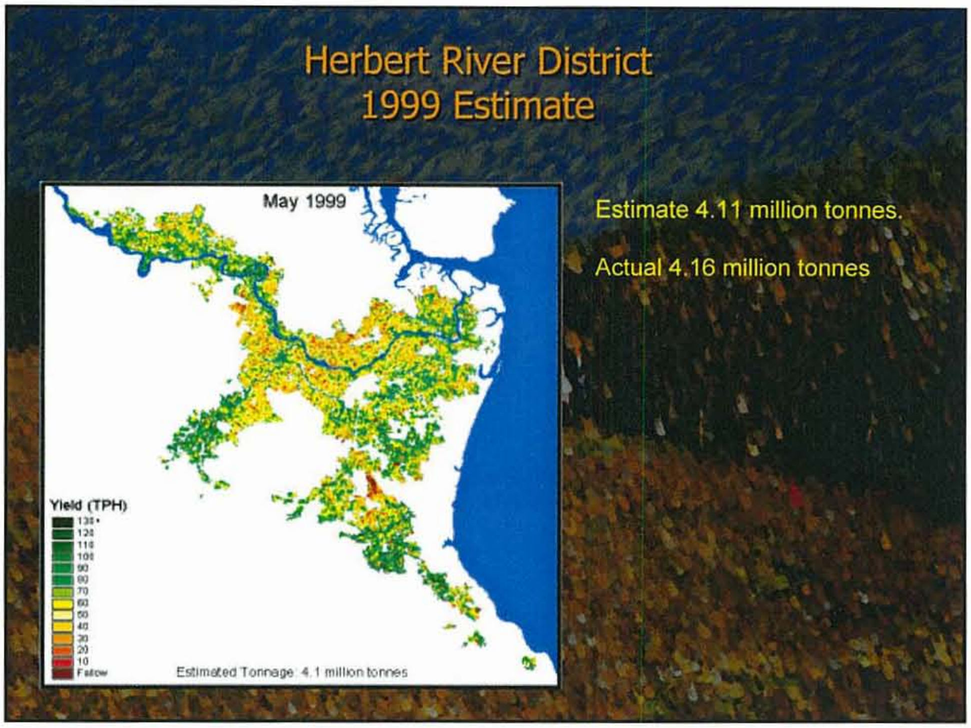
Farm_no	Block_no	Subblock_n	Area_ha	Estimate	May99_tt
V452A	14	4	0.41	64.000	26.240
V452A	14	3	8.88	94.720	841.114
V452A	14	1	3.97	75.238	298.695
V452A	14	2	10.94	74.829	818.629
V345	1	1	3.10	81.429	252.430
V345	2	1	6.02	49.231	296.371
V347	7	1	2.17	45.000	97.650
V347	6	5	1.03	61.905	63.762
V345	2	2	4.62	62.360	288.103
V345	2	3	0.57	76.875	43.819
V390	12	2	5.62	57.190	321.408
V347	6	3	2.54	48.684	123.657
V347	6	4	1.01	63.077	63.708
V347	6	2	3.60	50.313	181.127
V347	7	2	4.92	49.255	242.335
V345	2	4	1.94	68.529	132.946
V347	6	1	1.77	42.381	75.014
V390	12	1	9.23	77.514	715.454
V345	2	5	0.78	73.478	57.313
V445	5	1	3.64	63.803	232.243
V345	3	3	1.40	64.800	90.720
V345	3	1	6.79	51.949	352.734
V390	13	1	2.85	72.414	206.380
V445	8	1	0.49	57.000	27.930
V345	4	1	1.32	71.667	94.600
V345	5	3	7.75	34.472	267.158
V390	5	1	8.13	61.757	502.084
V390	13	2	3.94	81.169	319.806

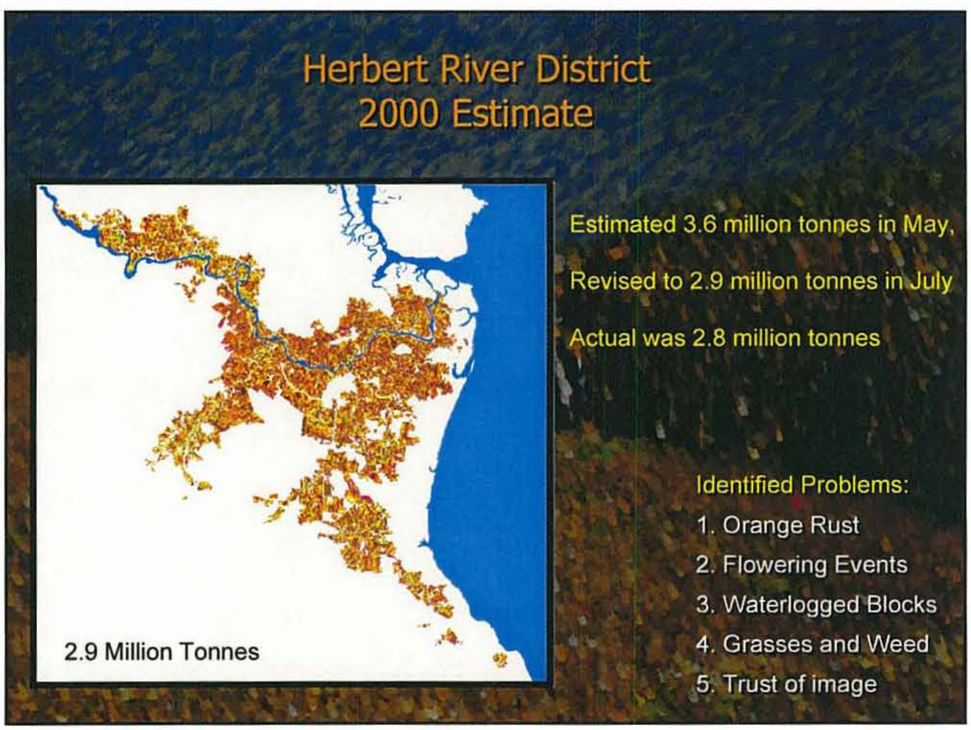
Herbert River District 1998 Estimate



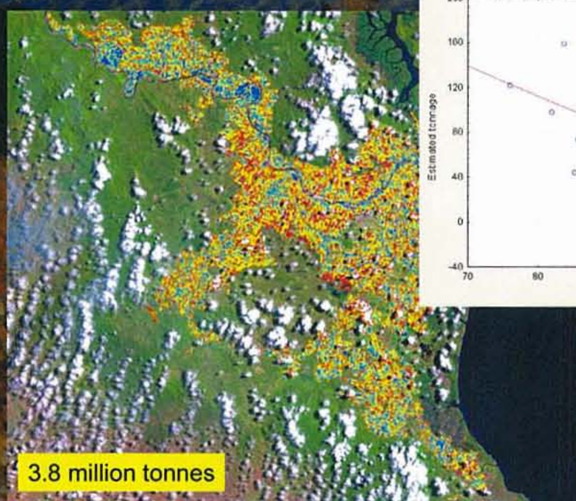
Estimate 4.8 million tonnes.

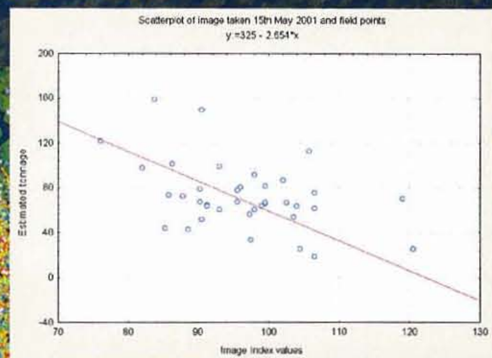
Unable to verify due to early finish to harvesting.


Herbert River District
1999 Estimate
May 1999
Yield (TPH)
Estimated Tonnage: 4.1 million tonnes
Estimate 4.11 million tonnes.
Actual 4.16 million tonnes


Herbert River District
2000 Estimate
2.9 Million Tonnes
Estimated 3.6 million tonnes in May,
Revised to 2.9 million tonnes in July
Actual was 2.8 million tonnes
Identified Problems:
1. Orange Rust
2. Flowering Events
3. Waterlogged Blocks
4. Grasses and Weed
5. Trust of image

Herbert River District
2001 Estimate





CSR did it's own estimate - and has made some improvements to the model.

3.8 million tonnes

Herbert River District
2001 Assessment of Grub Damage

2752 ha affected

District	Total Area (ha)	Grub Area (ha)	Not effected Area (ha)
BAMBAROO	2577	128	2449
ESTATE	5183	116	5067
FAIRFORD	2817	107	2710
FORESTHOME	1841	74	1767
FOUR MILE	2477	126	2351
GARRAWALT	3415	189	3226
HALIFAX	1011	63	948
HAWKINS CREEK	4261	287	3973
HELENS HILL	6126	363	5763
INGHAM LINE	4827	180	4647
LANNERCOST	3717	220	3497
LEACH	4044	306	3737
LONG POCKET	1248	76	1172
LOWER STONE RIVER	1513	28	1484
MACKNADE	2306	71	2235
RIPPLE CREEK	5	0	4
SEYMOUR/RIPPLE CREEK	2396	94	2303
TREBONNE	1794	77	1717
UPPER STONE RIVER	4311	143	4168
YURUGA	2677	99	2578
(blank)	22	3	19
Grand Total	58567	2752	55815

Recommendations from Yield Estimation

Several recommendations to the process are noted.

1. Additional modeling of the impact of grass and exposed water to the infrared index are required. Grass growth in poor cane plantations provide additional yield value in the present model. Examination of the temporal changes between images will provide additional growth modeling opportunities.

2. The collection of field estimations requires refinement. The estimation points need to be located in such a way that there is minimum influence from off-paddock land uses. Roads and fallow areas will distort the zonal buffering process. In particular the collection field data needs to include disturbance factors such as grass presence, irrigation history and exposed water.

3. The relationship between field data and image reflectance requires refinement. A linear relationship was utilized but a higher order polynomial function may be required.

4. The use of additional reflectance bands to permit a broader range of cane conditions is recommended. This analysis only used Near and Middle Infra Red bands and possibly this is limiting the field calibration.

5. That attribute data, such as soil type, date of planting, variety, be included in the analysis to reflect the heterogeneity of the cane plantations. Variability of the yields are likely to be reduced in homogenous plantations and therefore confidence in predictions can be increased.

Flood Affects on Crop Production

May 1999 Classification

Flood of March 1997

Soil Types and Crop Production

- Crop productivity information from the satellite classifications can be attached to information sources, such as soil types.
- After a heavy wet season, the sandy well drained soils faired much better than the clays and loams.

Estimate Accuracy

Role of estimating is to predict what the total harvest will be at the end of the year.

Assessing the accuracy of the estimates is difficult without TRIAL PLOTS being harvested and WEIGHED at the time of classification

When a comparison between the harvest block average and estimate is performed, several factors must be taken into consideration:

1. Time of harvest
2. Weather events since the estimate was done
3. Mill district
4. Cane variety
5. Plant class

In-field assessments conducted with cane inspectors the estimate was shown to be close to the visual estimates.

There is no block productivity recording in the Herbert

Be careful when comparing results at the block level to figures captured for block recording pruposes due to 'noise' in block productivity results (eg. cocktailing, entry errors, technical deficiencies)

Upsides

Over past 4 years, the technology has given relatively accurate estimates, particularly above Farm Level:

> in the Year 2000, the revised estimate in the Herbert was the ONLY estimate that was close to the actual.

Even if satellite yield estimation is out, it is out by the same amount across the district

Relatively objective - removes individual biases; yet includes cane inspectors knowledge

Provides qualitative indication of crop health/yield as well as quantitative

Relatively inexpensive - a Quarter Landsat scene only costs $920, and only requires 2 days to process it to get a result (field work takes about 2days)

Provides information at various scales that can be used for various purposes (eg. Sugar Rescue Package funding support through to farm and block scale crop management

Can link this technology very easily with other yield forecasting technologies

Downsides

With optical sensors, such as Landsat, getting a cloud free image can be problematic (although can process an image with some cloud, or can process a number of images with partial cloud to get a final result)

Frequency of satellite passes - Landsat is every 2 weeks

Time to get an image from the time a satellite passes over to getting it onto the desktop (used to be 10 working days, but by paying an extra $200, we got our last image in 3 working days)

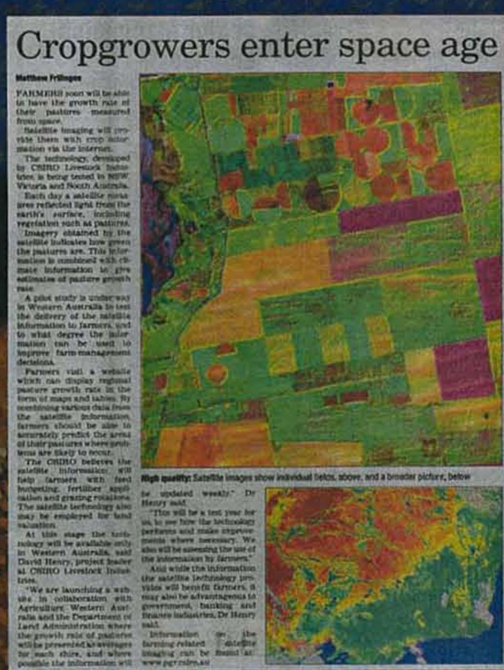
More accurate results at the farm/block/district level, than the block/sub-block level

Requires somebody with remote sensing experience to process the image - can't use a 'black box' approach

Process technology is still in 'infancy' phase - needs further development

Potential Outcomes and Benefits

- Increased crop productivity from low-yielding cane "sinks" due to increased awareness of block variability and the promotion of differential management practices.
- An accurate and repeatable tool for quantifying yield estimates that may offer industry wide solutions.
- Increased regional productivity and CCS levels through the development of regression models that identify optimal harvest times for crops on regional and localised scales.
- Optimisation of the harvest and transport systems by improved scheduling and better utilization of capital.



Cropgrowers enter space age

Matthew Frilingos

FARMERS soon will be able to have the growth rate of their pastures measured from space.

Satellite imaging will provide them with crop information via the internet.

The technology, developed by CSIRO Livestock Industries, is being tested in NSW, Victoria and South Australia.

Each day a satellite measures reflected light from the earth's surface, including vegetation such as pastures.

Imagery obtained by the satellite indicates how green the pastures are. This information is combined with climate information to give estimates of pasture growth rate.

A pilot study is under way in Western Australia to test the delivery of the satellite information to farmers, and to what degree the information can be used to improve farm management decisions.

Farmers visit a website which can display regional pasture growth rate in the form of maps and tables. By combining various data from the satellite information, farmers should be able to accurately predict the areas of their pastures where problems are likely to occur.

The CSIRO believes the satellite information will help farmers with feed budgeting, fertiliser application and grazing rotations. The satellite technology also may be employed for land valuation.

At this stage the technology will be available only in Western Australia, said David Henry, project leader at CSIRO Livestock Industries.

"We are launching a website in collaboration with Agriculture Western Australia and the Department of Land Administration where the growth rate of pastures will be presented as averages for each shire, and where possible the information will be updated weekly," Dr Henry said.

"This will be a test year for us, to see how the technology performs and make improvements where necessary. We also will be assessing the use of the information by farmers."

And while the information the satellite technology provides will benefit farmers, it may also be advantageous to government, banking and finance industries, Dr Henry said.

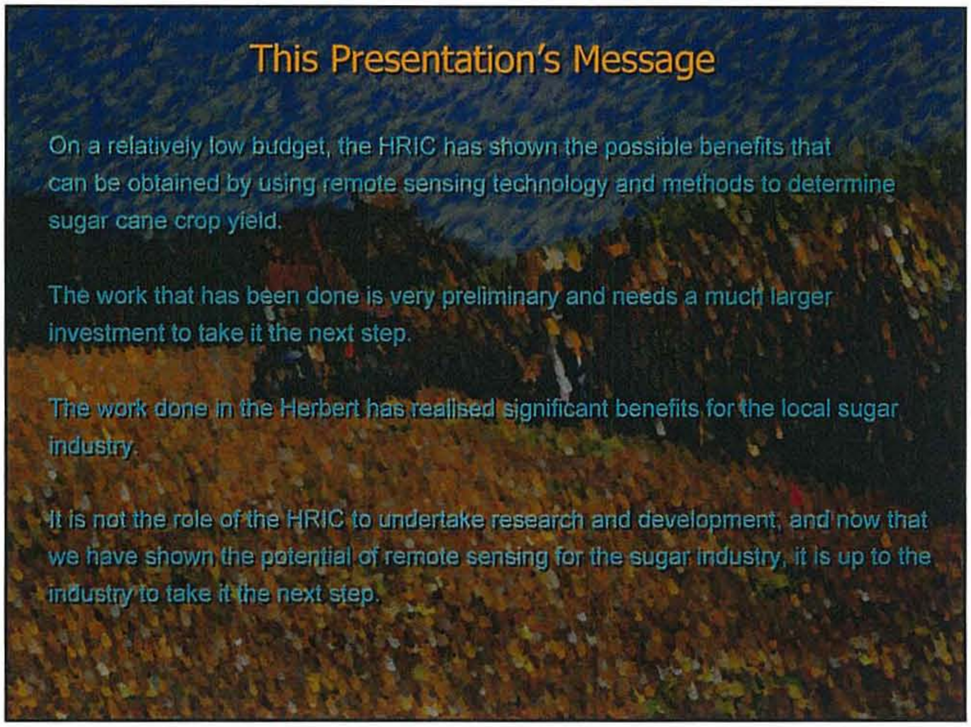
Information on the farming related satellite imaging can be found at: www.pgr.csiro.au

High quality: Satellite images show individual fields, above, and a broader picture, below

An item of interest….

Visit:

www.pgr.csiro.au


This Presentation's Message
On a relatively low budget, the HRIC has shown the possible benefits that can be obtained by using remote sensing technology and methods to determine sugar cane crop yield.
The work that has been done is very preliminary and needs a much larger investment to take it the next step.
The work done in the Herbert has realised significant benefits for the local sugar industry.
It is not the role of the HRIC to undertake research and development, and now that we have shown the potential of remote sensing for the sugar industry, it is up to the industry to take it the next step.


Thank-you for your attention & participation....

Mackay Sugar
Remote Sensing - 2001

Presenter:
John Markley

Mackay Sugar
Remote Sensing - 2001

- Overview – 2000 season
- 2001 Developments
- Results to date
- Issues Arising
- Harvest management

Overview – 2000 season

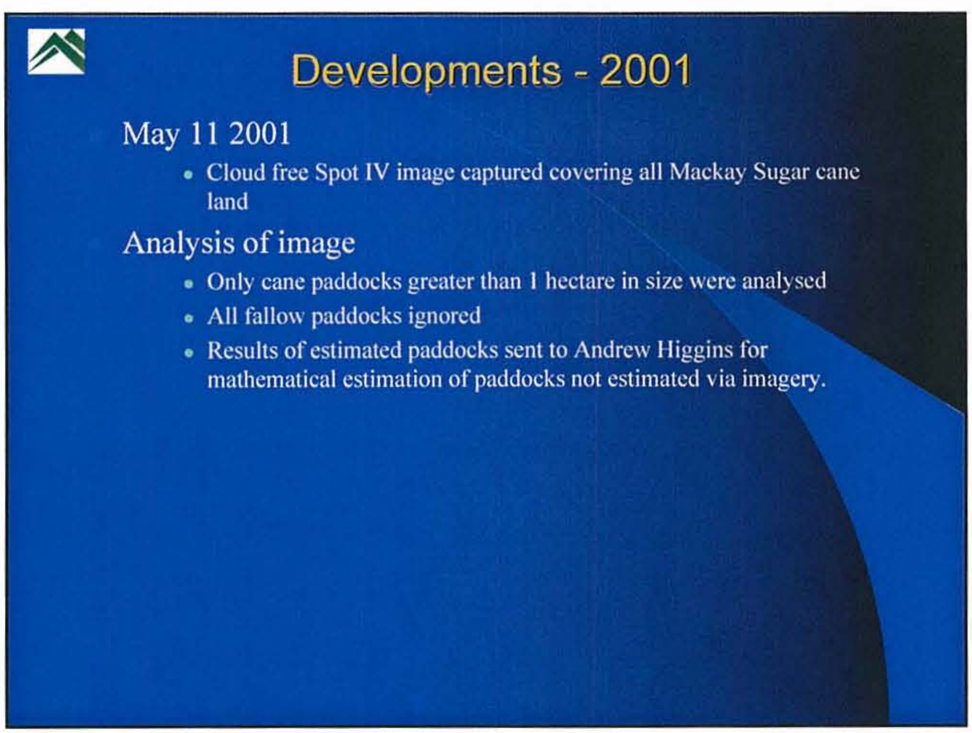
2000 season trial – 70% of district analysed

July 1 2000 image

- Estimated crop 60.6 tph
- Actual crop 57 tph

Subsequent images proved reliable in estimating area harvested


Developments - 2001
January 2001
Capture of ortho-rectified aerial photographs of the Mackay Sugar cane land.
Mapping of cane block layer from ortho photos commenced.
March 2001
Engagement of GeoImage to develop yield estimate calibration and methodology.
Purchase of ER Mapper image analysis software
April 2001
Purchase of partial Spot IV image (25% of area) captured March 20
Analysed image using calibration from 2000 season Landsat TM data
May 2001
Transfer of satellite estimated paddocks to Andrew Higgins for mathematical calculation of un-estimated paddocks.


Developments - 2001
May 11 2001
Cloud free Spot IV image captured covering all Mackay Sugar cane land
Analysis of image
Only cane paddocks greater than 1 hectare in size were analysed
All fallow paddocks ignored
Results of estimated paddocks sent to Andrew Higgins for mathematical estimation of paddocks not estimated via imagery.

Results - 2001

Number of paddocks	32,723
Cane paddocks	27,633
Cane paddocks GT 1 hectare	22,500

March 20 Analysis

- 7028 of 27633 (25.4%) of cane paddocks
- Av. estimated yield 75.6 tph
- Average estimated yield (all paddocks) 75.2 tph

May 11 Analysis

- Average yield estimate 76.8 tph

Issues Arising

Use of 2000 Landsat (and partial 1997 image) calibration for 2001 analysis.

Use of Landsat TM calibration for Spot IV image analysis

Differences in the Spot IV satellite sensors

Apparent under estimation of lodged crop

Over estimation of weed/grass infested paddocks

Use of different calibrations for different varieties.

Harvest Management

- Capture 3 or 4 images during harvest season
- Analysis of images to determine area harvested at image capture
- Re-estimation of farms using proportional estimation of Tonnes harvested/area harvested versus estimated yield
- Incorporation of paddocks harvested into GIS (FarmMap)

What does Mackay Sugar Co-op Assn.want to get out of crop forecasting using satellite imagery?

- Accurate pre-season crop tonnage and CCS forecasts at block-paddock level
- Regular area harvested information which can be aligned with cane crushed tonnages.
- Grower information which facilitates improved farm management.

What role does Mackay Sugar Co-op Assn. see itself playing?

Mackay Sugar seeks to achieve self sufficiency in crop forecasting and harvest management systems.

Mackay Sugar is prepared to collaborate with commercial service providers and R D & E organisations to deliver agronomic services to our grower shareholders where benefits to the co-operative can be demonstrated.

What issues and difficulties does Mackay Sugar Co-op Assn. foresee ?

Cost and accuracy of calibrations.

- Map layer maintenance
- Cane consignment accuracy
- Calibrations for new applications
- Cost of higher resolution imagery
- Coping with non-cane vegetation arrowed cane and lodged cane.

Options for imagery

- All weather imagery
- Timing of passovers versus hours of harvest
- Applications for high resolution hyperspectral satellite images.

What issues and difficulties does Mackay Sugar Co-op Assn. foresee ?

Achieving the benefits.

- Connecting to the WEB
- Providing complete solutions for millers, growers and harvesters.
- Enhancing sugar marketing effort and price.

Enhancing Cane Yield Estimates Made by Satellite Imagery

Presenter:

Andrew Higgins

Enhancing Cane Yield Estimates Made by Satellite Imagery

[1,2]Andrew Higgins
[3]John Markley

1 Cooperative Research Centre for Sustainable Sugar Production
2 CSIRO
3 Mackay Sugar

Improving Satellite Image Estimates

Issues

1. Accuracy of satellite image estimate declines at farm and paddock level

2. There is a need to produce estimates where the satellite was ineffective due to cloud cover

How has this been addressed?

A mathematical model that uses a combination of historical productivity data and the satellite (or partial satellite) estimate at zone and mill level

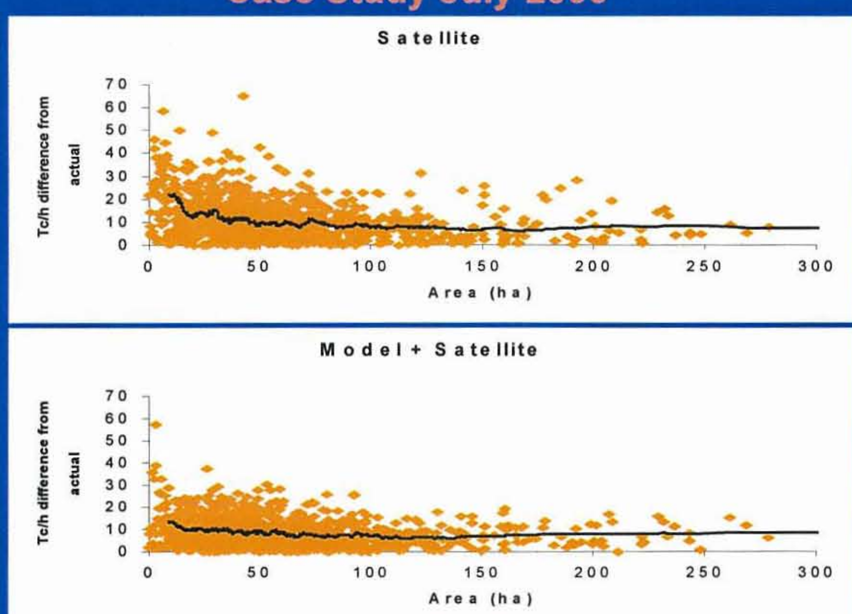
Improving Satellite Image Estimates

New estimates are calculated using a mathematical equation based on:

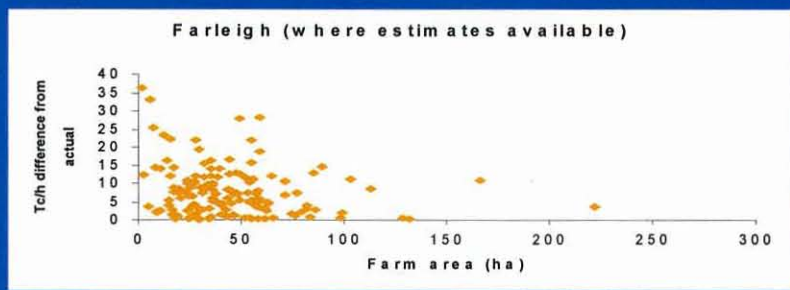
- the average TC/h at zone and mill level from the satellite image
- which is fine tuned at paddock and farm level via the relative performance farms, varieties, crop classes and harvest dates in the previous year using historical block productivity data

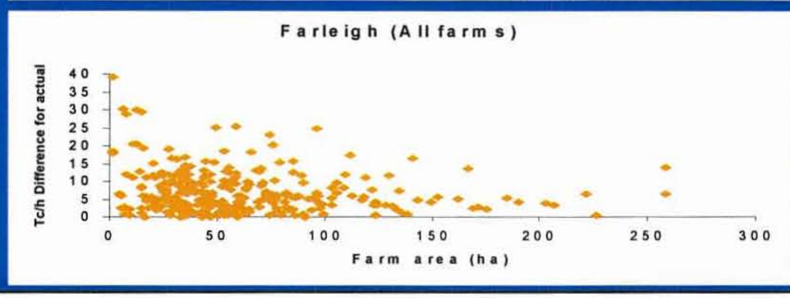
Accuracy of Satellite Estimate

Case Study July 2000



Extrapolating to Farms with no Satellite Estimate





Comparison of Mill Level Estimates

2000 Harvest Season

Mill	Tc/h (actual)	Tc/h(Satellite)	Tc/h (Satellite + model)
Farleigh	54.8	57.5	54.1
Marian	53.3	62.5	61.2
Pleystowe	58.8	61.1	60.7
Racecourse	57.4	57.9	57.2

Improving Cane Yield Estimates For Farm Paddocks

[1,2]Andrew Higgins
[1,3]Alan Stafford
[1,2]Samantha Peel

1 Cooperative Research Centre for Sustainable Sugar Production
2 CSIRO
3 Sugar North Limited

Improving Cane Yield Estimates

Issues

1. Cane yield estimates from farm paddock to mill level are very expensive to produce

2. Improvement in accuracy is needed to reduce operational and capital costs and enhance profitability

How has this been addressed?

A combined mathematical predictive and optimisation model was developed which uses historical productivity/estimate data to significantly improve upon the accuracy of existing estimation techniques

Improving Cane Yield Estimates

New Methodology

Re-estimates calculated using mathematical equations that are a function of:

1. expected cane yield using historical block productivity data
2. performance of paddock in previous year
3. performance of farm and mill in current year relative to previous
4. the pre-season estimate

The best weighting of these components depends on the crop class, district and mill region.

Improving Cane Yield Estimates

Application to Mossman

- **Case study years are 1995 to 1997**
  - pre-season estimates supplied by farmers
  - electronic historical block productivity and pre-season estimate data available
- **Re-estimates are generated at the 6 and 12 week mark of the harvest season**
- **Re-estimates generated using mathematical model are compared to the technique used by a Mossman cane inspector**

Improving Cane Yield Estimates
Results for Mossman

Average difference between actual and estimate cane yield for paddocks (t/ha)

	Year		
	1997	1996	1995
Original pre-season estimate	18.09	17.15	14.97
Model re-estimate after 6 weeks of the season	14.72	14.63	14.37
Model re-estimate after 12 weeks of the season	14.16	14.13	13.43
Cane inspector re-estimate after 6 weeks	18.44	17.90	19.27
Cane inspector re-estimate after 12 weeks	16.42	15.81	13.96

Improving Cane Yield Estimates
Implementation for Mossman

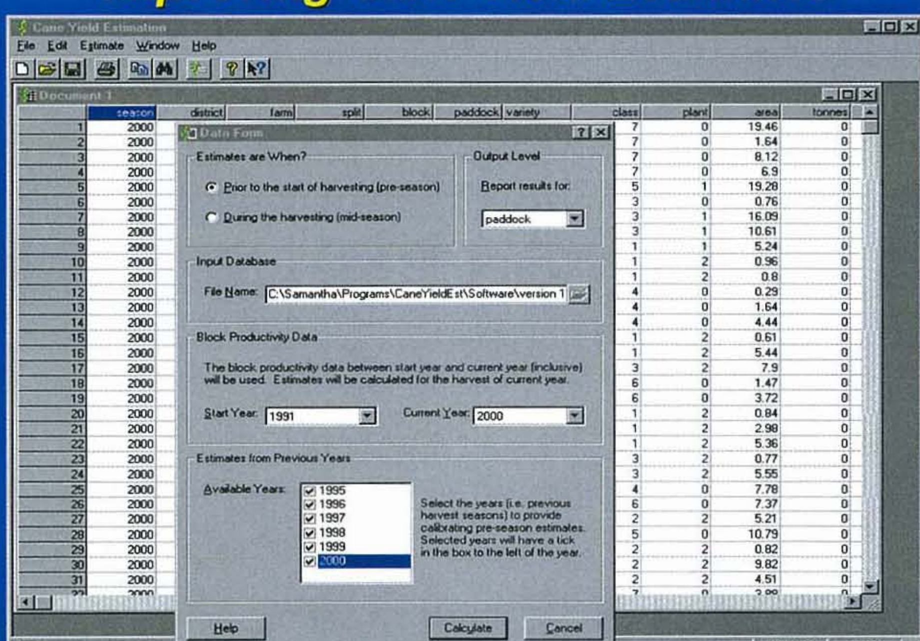
- **Applied in 1998 to 2000 by Mossman cane inspector**
  - Re-estimates derived at 4, 6, 12 and 15 weeks.
  - Highlighted well consigned harvest cane.
  - Indicated inaccurate estimates by farmers and poor consignment by some contractors.
- **User-friendly version in 2001**
  - User friendly version developed under SRDC CTA044
  - Installed at the Mossman grower advisory centre
  - Applied successfully after 3 weeks of the 2001 season

Improving Cane Yield Estimates

Robust

- Applicable to all mill regions that maintain block productivity information.
- Easy adaptation to mills of varying block recording schemes.
- Able to be run on any modern PC configuration with almost instant CPU time.

Improving Cane Yield Estimates



Mathematical Model, the Mossman Perspective (Notes and Presentation)

Presenter:

Alan Stafford

Alan Stafford
Mossman Agricultural Services
Technical Field Officer
GIS & Harvest Management.
20th. July 2001.

Mathematical Model, the Mossman perspective.

As Andrew has already given you the technical overview of the Yield Estimate Model, it falls on me to give you some details from the end user perspective.

I field trialled the model during the 1998 season,. It was a difficult year as we had sustained cyclone damage to the better quality cane, the early cut was almost a perfect pattern match with 0.02% difference between model prediction and actual cut. The individual block prediction was, in correctly consigned cane, within 5 tph of actual cut.

We made extensive use of the model during 1999 and 2000. I would send the latest block data information to Andrew in Brisbane, he processed it and E-mailed the forecast data back. I found the data to be of immense benefit as I was, still am, the only field officer for the entire mill area. This methodology was the only way I could regularly assess all farms.

Early this year we generated the first pre-season estimate forecast. Mossman Agriculture supplied Andrew with a district prediction and the CSIRO team generated a block by block forecast for us. It was somewhat optimistic but reflected the data we supplied. Development of the model had also reached the stage where I could perform all functions from my own desk, saving time and enabling me to try combinations of previous years to fine tune for individual districts.

We, in the interim had come on board with the Herbert Landsat cane estimation project. An Image was acquired, 29th. March and we ran the model utilizing 30 ground truthing sites. I have to confess that I am less than thrilled with the detailed results; however, the overall mill area statement is seriously compatible with the results from my next step.

After 5 weeks of crushing data was accumulated, I ran the forecast model. It positively reflected both the Landsat Mill area statement and my own long-standing 'percentage cut to estimate' generator. The most important aspect is that:-
On an individual block situation; the Cane Yield Estimation Model reflected a close relationship to the actual cut figures.

I think the data indicated in the graph shows to you the close correlationship between cut and forecast data.

Certainly we can no longer rely on the old fashioned Cane Inspector block evaluation.
I have some reservations concerning Landsat data evaluating Crop vigour.
We, in the northern region of Queensland have a major problem with cloud cover in the first half of every year.
Is satellite imagery the universal panacea? Should we all concentrate on having the best possible block data consigned?

Remember the Cane Yield Estimation Model can only produce with good block data.
Remember that the BSES and Productivity Board staff must have good block level data to aid in the continuation of a viable sugar industry.

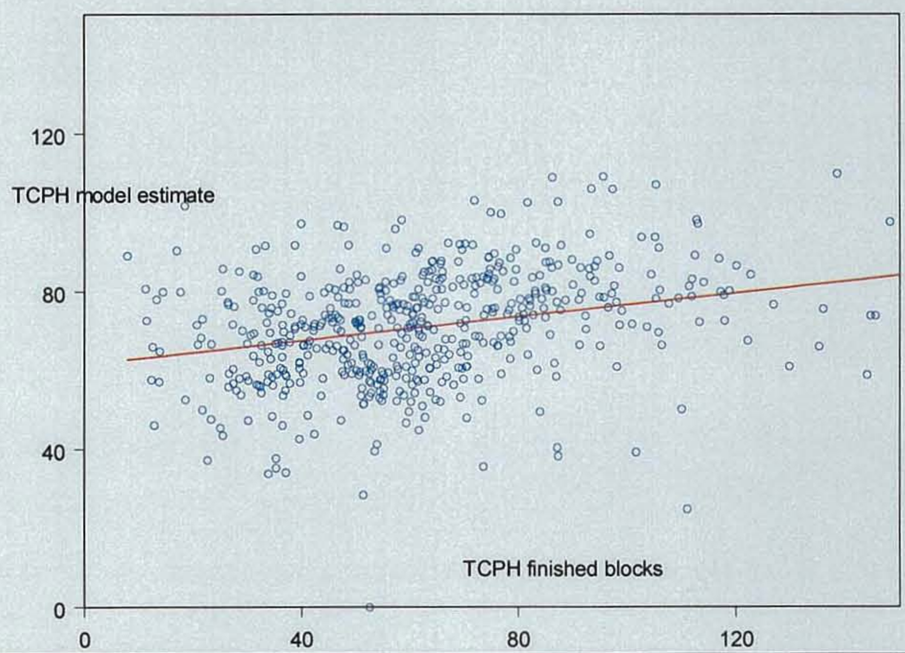
CANE YIELD ESTIMATION MODEL

COMMENCED DEVELOPMENT IN 1998

IN 2001 GENERATED A PRE-SEASON FORECAST

AFTER 5 WEEKS CRUSHING RE-RAN MODEL

Raw Data from weeks 1 to 5



WHAT IS THE FUTURE?

Crop Forecasting
QSL Activities

Presenters:

Owen Crees

Yvette Everingham

Crop Forecasting
QSL activities

QUEENSLAND SUGAR

What does QSL need?

- **More accurate crop estimates**
- **Monthly estimates Nov – Jun**
- **Regional or industry estimates**
  - NOT grower or mill area estimates
- **Needed to**:
  - plan marketing strategies for small and large crops
  - plan pricing strategy
  - ensure delivery to key customers
  - avoid contract defaults

QUEENSLAND SUGAR

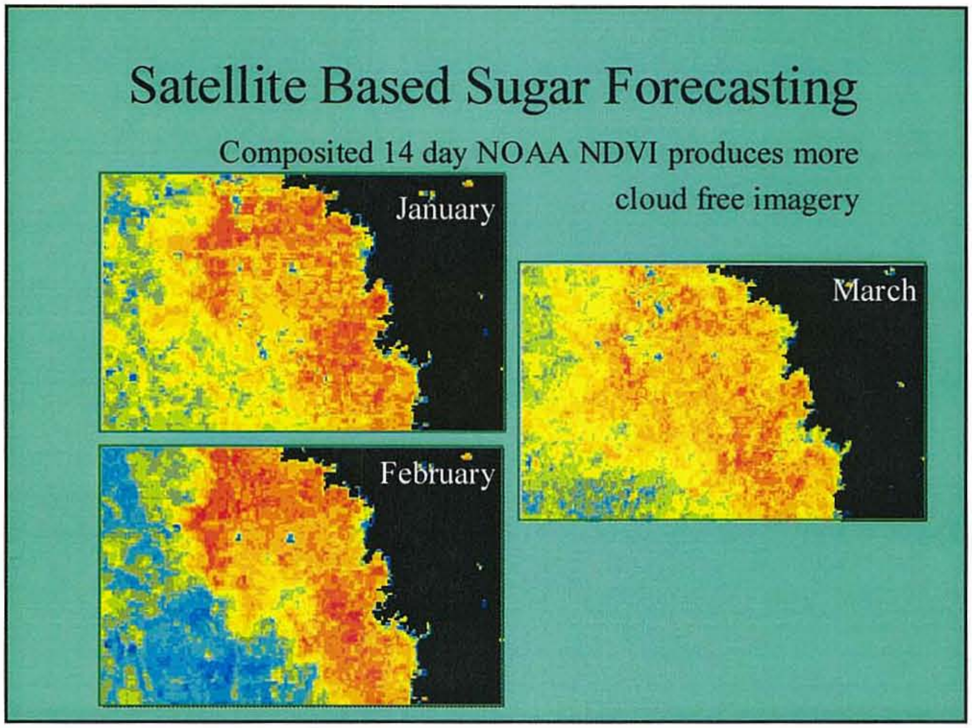
Historical crop estimates 1980 - 2000

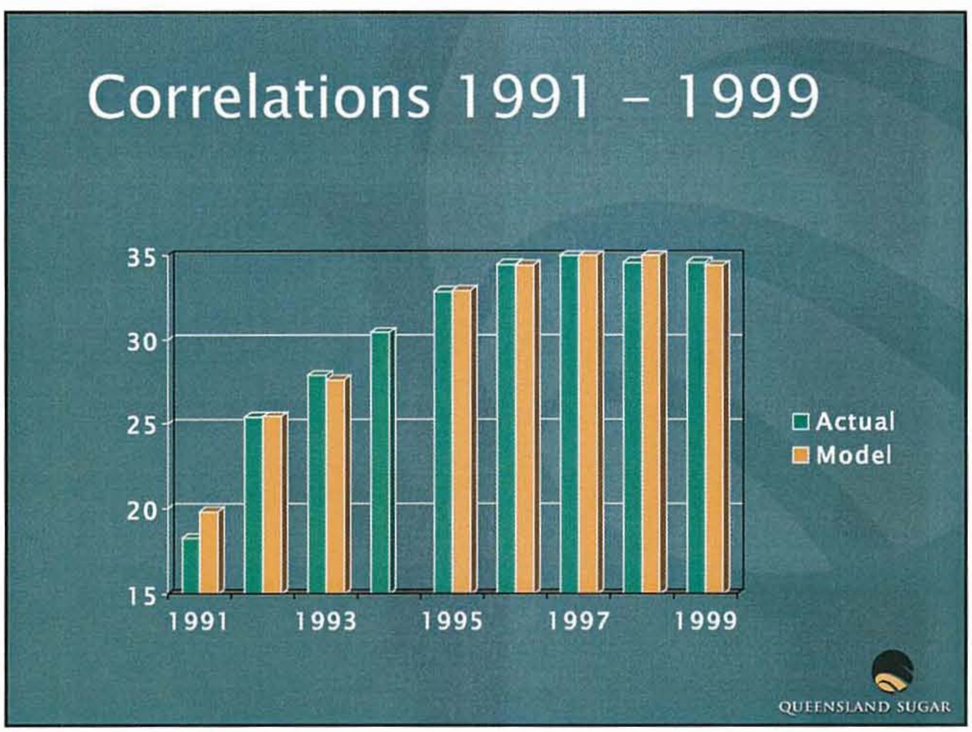
QUEENSLAND SUGAR

Agrecon System

- Originally developed for grains
- Access to all satellite systems
- Resolution 1m to 1 km
- Uses historical yield and image databases
- Composite images cloud free
- No field sampling
- Empirical correlations only

QUEENSLAND SUGAR


Satellite Based Sugar Forecasting
Composited 14 day NOAA NDVI produces more cloud free imagery
January
February
March


Correlations 1991 - 1999
35
30
25
20
15
1991
1993
1995
1997
1999
Actual
Model
QUEENSLAND SUGAR

2000 Season

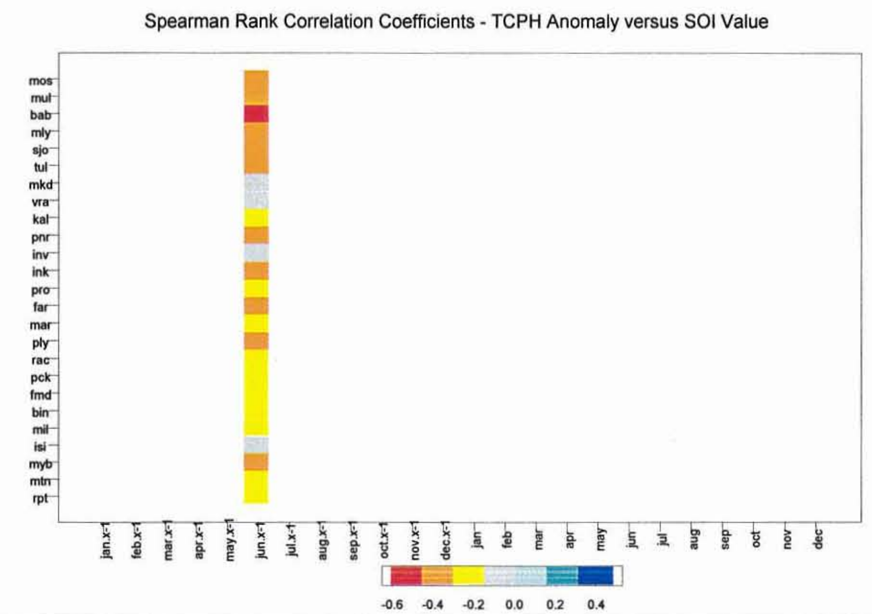
QUEENSLAND SUGAR

Costs

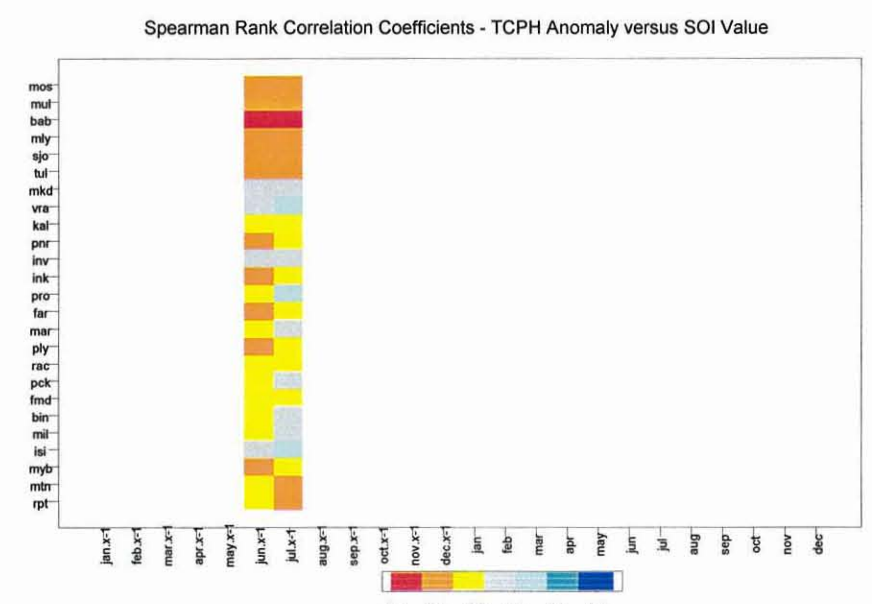
- **Agrecon low resolution images**
  - 1 km resolution every 2 weeks
  - Internet access for mill area estimates
  - $450/year per mill area (estimated)

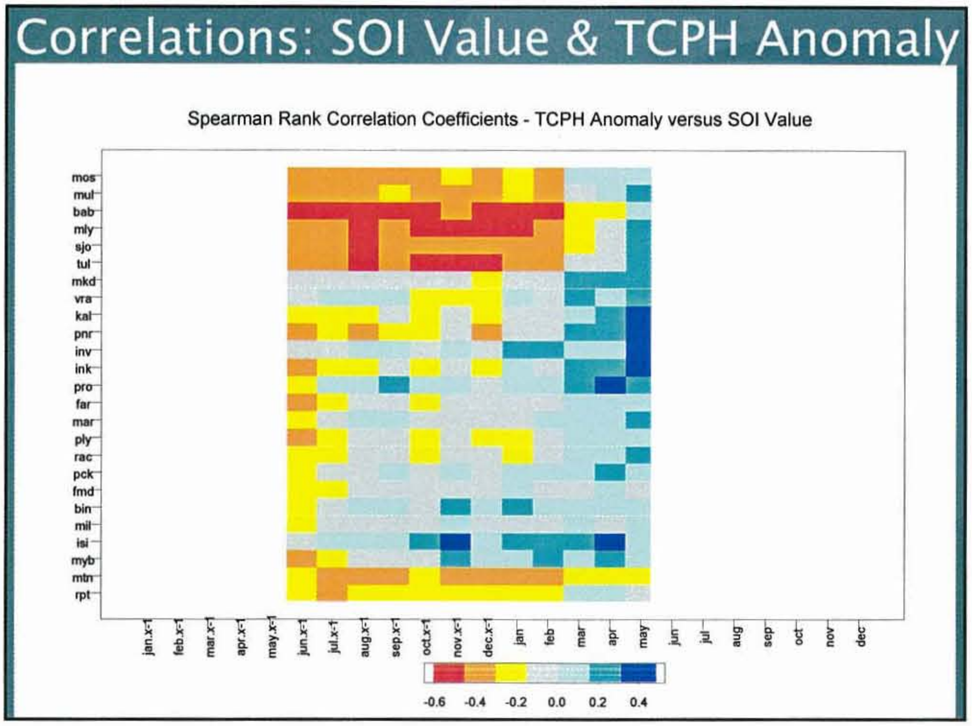
QUEENSLAND SUGAR

Correlations: SOI Value & TCPH Anomaly

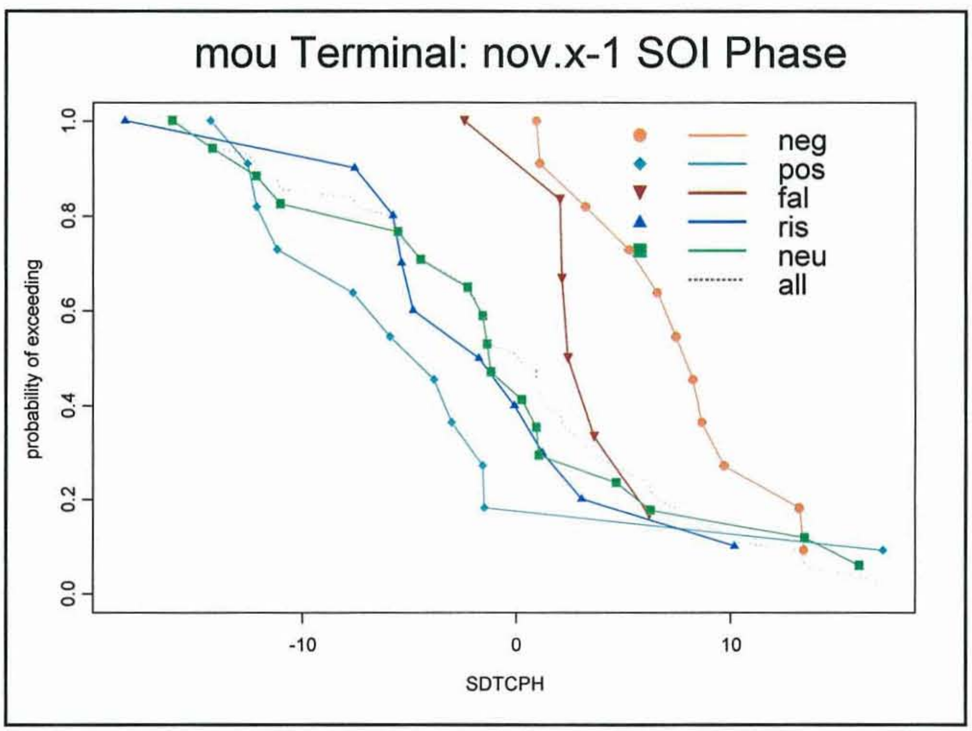


Correlations: SOI Value & TCPH Anomaly

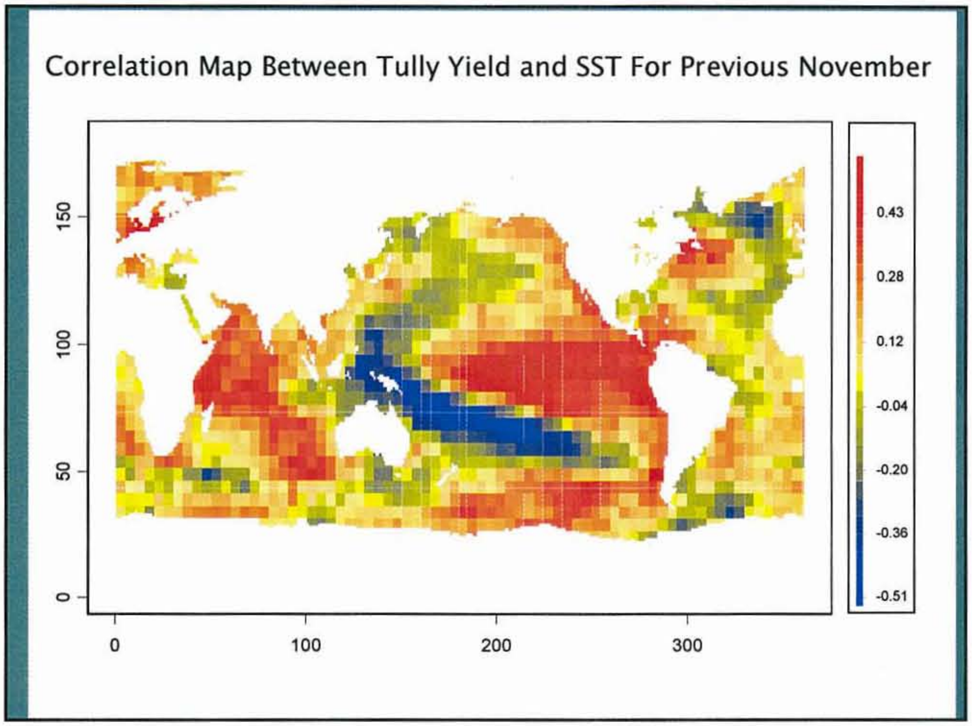




Correlations: SOI Value & TCPH Anomaly
Spearman Rank Correlation Coefficients - TCPH Anomaly versus SOI Value
mos
mul
bab
mly
sjo
tul
mkd
vra
kal
pnr
inv
ink
pro
far
mar
ply
rac
pck
fmd
bin
mil
isi
myb
mtn
rpt
jan.x-1
feb.x-1
mar.x-1
apr.x-1
may.x-1
jun.x-1
jul.x-1
aug.x-1
sep.x-1
oct.x-1
nov.x-1
dec.x-1
jan
feb
mar
apr
may
jun
jul
aug
sep
oct
nov
dec
-0.6 -0.4 -0.2 0.0 0.2 0.4



mou Terminal: nov.x-1 SOI Phase
probability of exceeding
0.0
0.2
0.4
0.6
0.8
1.0
-10
0
10
SDTCPH
neg
pos
fal
ris
neu
all


Correlation Map Between Tully Yield and SST For Previous November
150
100
50
0
0
100
200
300
0.43
0.28
0.12
-0.04
-0.20
-0.36
-0.51

The Application of Mini UAVs in Sugarcane Crop Forecasting

Presenter:

Daniel Fowler

The Application of Mini UAVs in Sugarcane Crop Forecasting

Daniel Fowler (Aeronautical Engineer)
Gavin Brett (R&D Chief Engineer)

What is a UAV?

- UAV - Unmanned Aerial Vehicle
- An aircraft designed to operate without onboard human presence
- Generally capable of autonomous (robotic) operation
- Raison d'être
  - Dull
  - Dirty
  - Dangerous

Mini UAVs

- Relatively low per unit cost
- Require limited ground support
- Can operate with minimal human oversight
- Capable of operating "low and slow"
- Long endurance
- Highly mobile

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A technology whose time has come

- Materials
- Information technology
  - GPS (navigation)
  - Miniaturisation (electronics & payloads)
  - Processing power
- Communications
- Regulatory environment

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The Sugarcane Crop Forecasting Application

To deliver geo-referenced, mosaiced and radiometrically corrected data in an industry standard format.

aerosonde

Platform Comparison

Satellites	Mini UAVs
Very Stable	Adequately Stable
Limited availability due to cloud cover (visible/IR sensors)	Can fly under cloud
Payloads not customisable	Customisable and tuneable payloads
Long revisit cycles (less of a problem with off-nadir capable sensors)	Timely operations with flexible mission planning.
Captures large areas of congruous data in a single image	Post processing required to produce congruous data over large areas

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Modus Operandi

- Multi-spectral imaging payload
  - 3/4 band digital imaging system
  - Sensitivity from blue to NIR/MIR
  - Tuneable bands
- Largely automated GIS-driven flight planning
- Autonomous data collection
- Post processing
  - Radiometric corrections
  - Geo-referencing and mosaicing

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Technical Tasks

- Developing procedures to apply radiometric corrections and, ortho-corrections to large volumes of data in a time efficient manner
- Optimising the use of the available spectra

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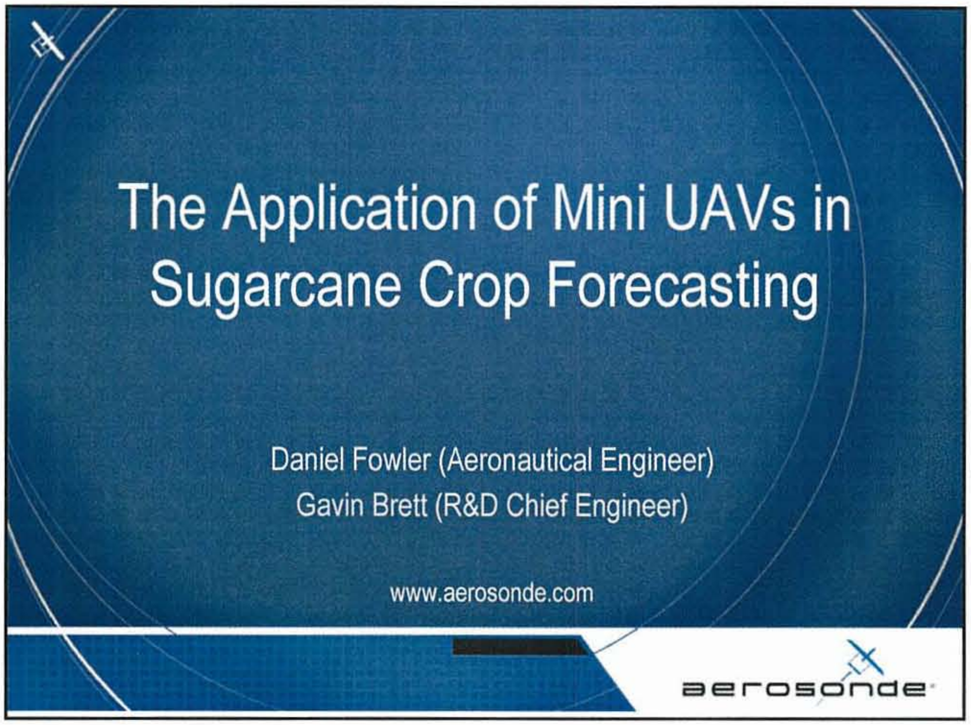
The Application of Mini UAVs in Sugarcane Crop Forecasting
Daniel Fowler (Aeronautical Engineer)
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www.aerosonde.com
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Presentations from Industry Representatives

Presentations from Industry Representatives

Industry representatives were asked to give short presentations which addressed three questions:

1. What does your organisation want to get out of crop forecasting using satellite imagery?
2. What role do you see yourself or your organisation playing?
3. What issues and difficulties can you foresee?

The following people gave presentations:

- Doug Neville for Mackay Sugar
- Robin Juffs for CSR
- Owen Crees for QSL
- Bernie Milford for Canegrowers
- Trevor Crook for Mulgrave Mill

Handouts addressing these questions, which appear on the next four pages, were provided by Mackay Sugar, CSR Technical Group, CSR Cane Supply and Transport Group and Queensland Sugar.

Other issues which were raised either in presentations or discussion were:

- Forecasting crop size for our main international competitors
- Need a cost/benefit analysis of improved crop forecasting across the whole of the sugar industry
- Really want to measure sugar yields and not cane yields
- Can this technology be used for mapping crop maturity to facilitate optimising CCS by matching crop harvest to patterns of maturity
- Very costly to maintain block attribute layers. Possible use of satellite imagery for updating attributes.
- Accuracy of block data is a real issue – implications for farm management.

What does Mackay Sugar Co-op Assn. want to get out of crop forecasting using satellite imagery?

- Accurate pre-season crop tonnage and CCS forecasts at block-paddock level
- Regular area harvested information which can be aligned with cane crushed tonnages.
- Grower information which facilitates improved farm management.

What role does Mackay Sugar Co-op Assn. see itself playing?

- Mackay Sugar seeks to achieve self sufficiency in crop forecasting and harvest management systems.
- Mackay Sugar is prepared to collaborate with commercial service providers and R D & E organisations to deliver agronomic services to our grower shareholders where benefits to the co-operative can be demonstrated.

What issues and difficulties does Mackay Sugar Co-op Assn. foresee?

- *Cost and accuracy of calibrations.*
    - Map layer maintenance
    - Cane consignment accuracy
    - Calibrations for new applications
    - Cost of higher resolution imagery
    - Coping with non-cane vegetation arrowed cane and lodged cane.
- *Options for imagery*
    - All weather imagery
    - Timing of passovers versus hours of harvest
    - Applications for high resolution hyperspectral satellite images.
- *Achieving the benefits*
    - Connecting to the WEB
    - Providing complete solutions for millers, growers and harvesters.
    - Enhancing sugar marketing effort and price.

CSR Sugar

Crop Forecasting Industry Workshop
20 July 2001

CSR Technical Operations

What do you want to get out of crop forecasting using satellite imagery?

- A consistent and improved approach to Crop Forecasting across CSR Mills for use in
  - Financial Reporting.
  - Sugar Marketing.
  - Cane Supply Contracts.
  - Harvest / Transport Management.

- A consistent and efficient use of limited Industry Resources for Crop Improvement and Crop Optimisation.

- Early detection of disease or abnormal growth patterns.

What role do you see yourself or your organisation playing?

- CSR will be active in both developing and applying new technologies in Image Analysis and Ground Truthing.

- Dedicated Resources are functional in Cane Supply Operations and the Technical Field Department as part of the general GIS strategic development for the Group.

- Continued support of the HRIC and industry funded satellite imaging R&D.

What issues and difficulties can you foresee?

- Controlling industries expectations of the capability of the technology.
- Establishing and accepting Confidence Limits associated with image analysis techniques and ground truthing.
- Lead time sought for marketing decisions relative to crop stage of growth (eg Nov).
- Reliability and Timeliness of images and co-incidental information.
- Linking with reliable crop growth models.
- Ground truthing costs.
- Image costs.

JCB

CSR Ltd - Sugar Mills Group. Level 4, Stanley Place, 188 Wills Street, Townsville, Queensland, 4810, Australia.
PO Box 642, Townsville Qld. 4810, Australia.
CSR Limited. A.C.N. 000 001 276. Telephone (07) 4720 8800. Facsimile (07) 4720 8899

CROP FORECASTING WORKSHOP – 20 JULY 2001

THE VIEW OF THE COMBINED CSR CANE SUPPLY & TRANSPORT REGIONS – Herbert, Burdekin & Plane Creek

Q1. What do you want to get out of crop forecasting using satellite imagery?

- an improved all-weather tool for forecast of total crop, and assessment of progress of harvest
- a tool to generate estimates at farm level for grower equity
- the ability to refocus our field operations while maintaining credibility of information transfer.

Q2. What role do you see yourself or your oragnsiation playing?

- pass all previous work & IP onto a researcher for enhancement & improvement.
- prepared to trial and assess future changes that are developed
- continue to improve processes internally eg data handling, link to harvesters with GPS to improve calibration

Q3. What issues and difficulties can you foresee?

- ensure pure research outcomes able to be delivered onto the ground
- development will continue into longer term; access to funding
- use by BSES to track PBR varieties

Crop forecasting – QSL perspective

1. **What does QSL want from crop forecasting systems?**

    - More accurate crop forecasts
    - Monthly estimates Nov – Jun
    - Monthly updates of crop estimates through the season
    - Regional or industry estimates only
    - Similar forecasts of key competitors eg Brazil, China, EU, India
    - QSL does not need estimates at individual block, grower or mill level.

2. **What role would QSL play?**

    - If all mills have good forecasting systems, and provide QSL with regular updates of crop forecasts, then QSL's only role is in using the information to manage its marketing activities.
    - QSL prefers to work in collaboration with mills and growers to obtain a series of forecasts each year that provide the information needed by all parties in the most cost effective manner.
    - QSL is unlikely to take a lead role unless it is clear that our needs are not compatible with the needs of any other group.

3. **What are the issues and potential difficulties?**

    - QSL has different needs to those of individual mills and growers. QSL needs industry wide crop forecasts well before the season starts, not detailed local crop estimates.
    - Pre-season forecasts require more than satellite images – climate outlook information is also essential in forecasting production.
    - Climate prediction is an emerging science and is not well enough developed at this stage for the Queensland sugar industry environment.
    - Confidentiality of crop forecasts, within the Queensland industry, and within the world sugar market.
    - Locally based systems may not be applicable to the remainder of the industry or competitor industries.

Reports from Small Group Workshops

Crop Forecasting Workshop
Small Group Work and Reporting

The participants in the Workshop were broken up into four groups, and asked to consider the following questions:

Category One: *What Research Needs To Be Done?*
1. what does the sugar industry want to see in the future?
2. what impediments are likely to influence adoption of technology

Category Two: *How Should This Research Be Done?*
1. what organisation(s) would best fulfill the role of conducting R&D?
2. opportunities for alliances or cooperative ventures
3. future funding

Each group recorded information with their answers to these questions onto butchers paper.

The report back session involved a representative from each group presenting their answers to the above questions. The information presented was collated into four mind-maps (attached). The four themes for these mind-maps were:

1. Technology

The groups raised a number of points relating to the technology research needs. The main element identified was further development of the existing technologies such as remote sensing; mathematical modelling; and climate modelling.

2. Limitations/Impediments

Information was collated on the limitations and impediments of research for Crop Forecasting and Estimation. The main themes identified were risk management; diversity of clients; disparate efforts; resources and skills. A large number of limitations and impediments were listed, with trust and coordination being required to address them.

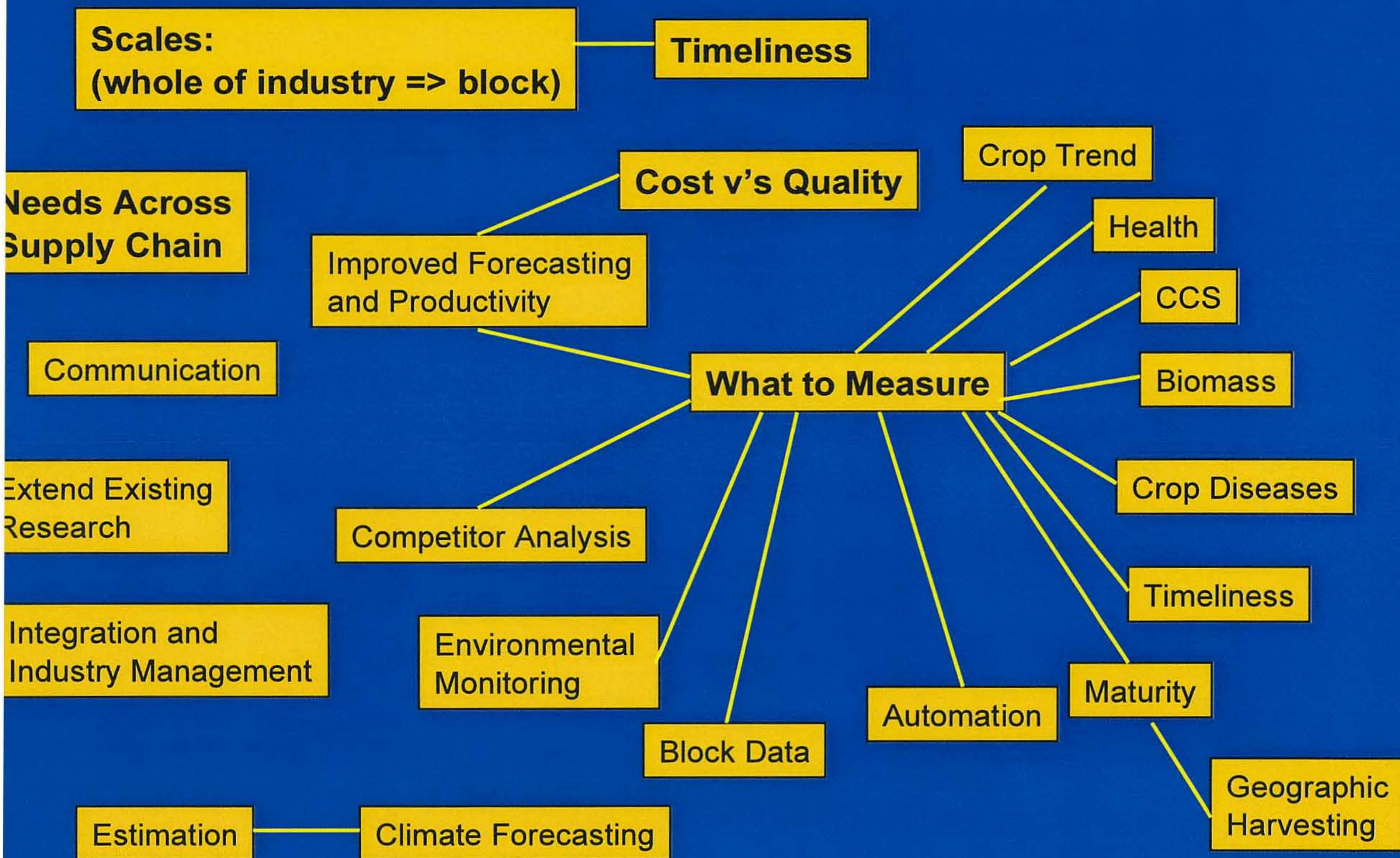
3. Needs

Industry research needs were identified. The main need elements were identified as scale; timeliness; cost versus quality; what to measure; and needs across supply chain.

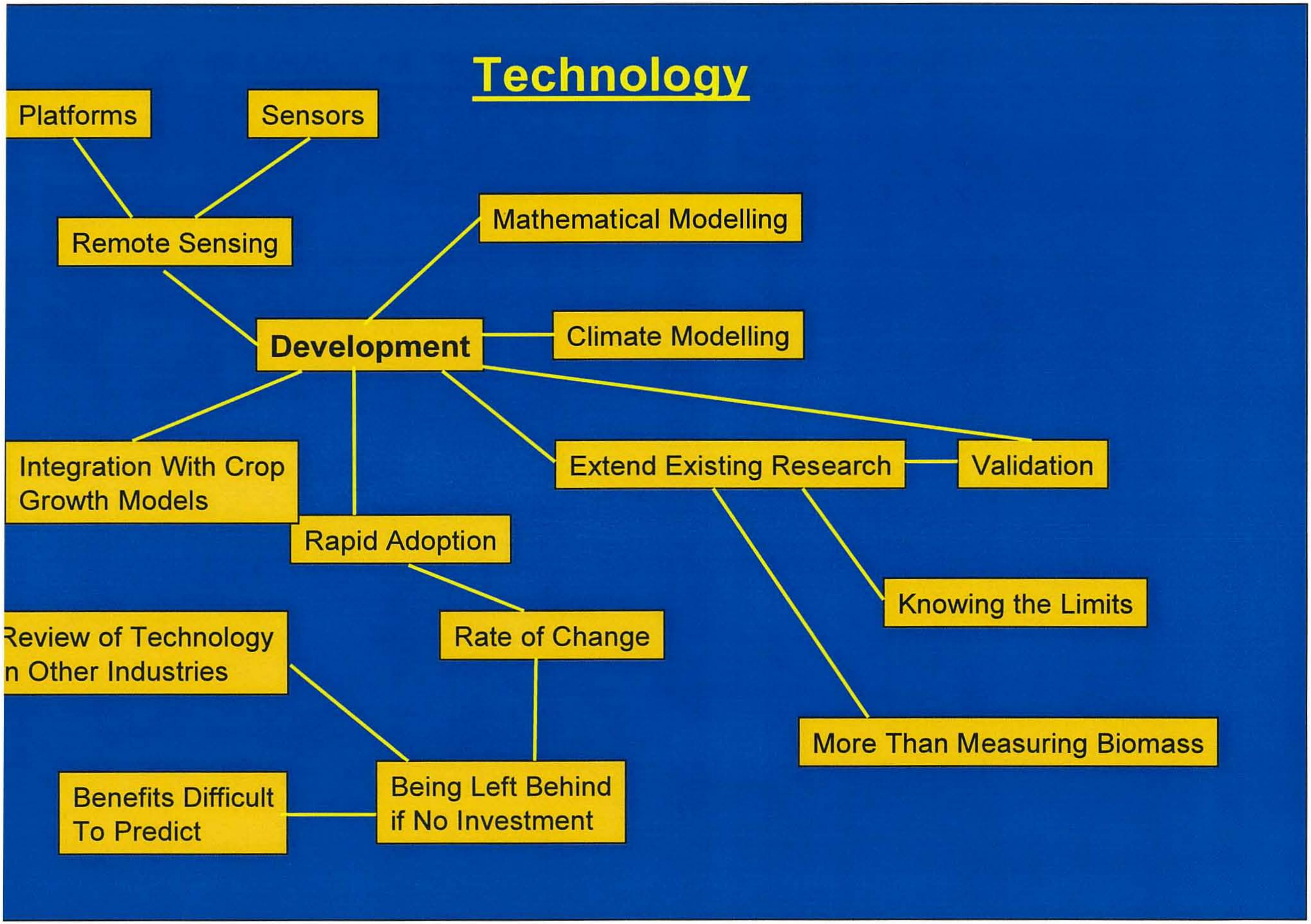
4. Making It Happen

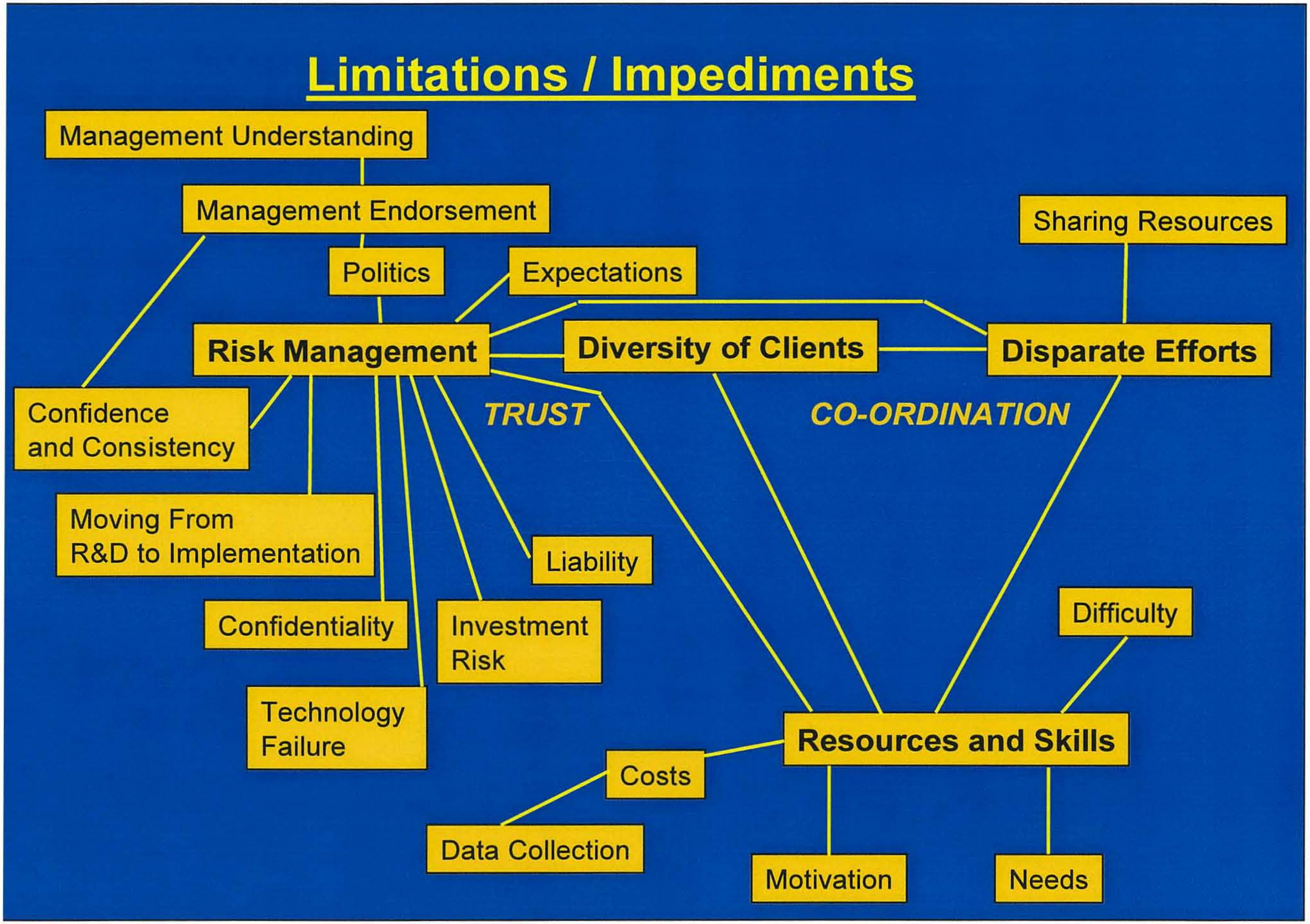
Good information was presented on the issues related to having research in Crop Forecasting and Estimation. The main elements listed related to investment; leadership; networking; partnerships; and/or going it alone. Two critical aspects of making the research happen are sharing information and speed of development.

Needs



Scales:
(whole of industry => block)
Timeliness
Cost v's Quality
Crop Trend
eeds Across
upply Chain
Improved Forecasting
and Productivity
Health
CCS
Communication
What to Measure
Biomass
xtend Existing
esearch
Competitor Analysis
Crop Diseases
Timeliness
Integration and
Industry Management
Environmental
Monitoring
Maturity
Automation
Block Data
Geographic
Harvesting
Estimation
Climate Forecasting


Technology
Platforms
Sensors
Remote Sensing
Mathematical Modelling
Development
Climate Modelling
Integration With Crop Growth Models
Extend Existing Research
Validation
Rapid Adoption
Knowing the Limits
Review of Technology
n Other Industries
Rate of Change
More Than Measuring Biomass
Benefits Difficult To Predict
Being Left Behind if No Investment


Limitations / Impediments
Management Understanding
Management Endorsement
Politics
Expectations
Sharing Resources
Risk Management
Diversity of Clients
Disparate Efforts
Confidence and Consistency
TRUST
CO-ORDINATION
Moving From R&D to Implementation
Liability
Confidentiality
Investment Risk
Difficulty
Technology Failure
Resources and Skills
Costs
Data Collection
Motivation
Needs


Making It Happen
CSIRO
BSES
Industry
Networking
Other Industries
Commercial Companies
Risk
Sharing Information
Investment
Partnerships
Going It Alone
Universities
Speed of Development
R&D
Industry
Government
Leadership
Skills
Industry
Postgraduates
CRC
SRDC
Roles
Structures
Alliances
Processes
Investigate Technologies
Integrate Technologies
Roles
Integrate Improved Estimates Into Business Processes

Action Planning

Action planning

In the discussions following the report back session from the small group workshops, the Industry representatives at the workshop were unable to agree on a co-ordinated approach to future R&D in crop forecasting. The focus tended to be very much on the operational aspects of crop forecasting and the main type of research considered was "reactive" research in response to problems as they developed.

It was felt that the main issue at the present time is to maintain momentum in the drive to improve the crop forecasting methodology. At present this involves small groups working independently with commercial operators external to the sugar industry. Representatives felt that this did not matter as long the job gets done. They felt that more would be lost in trying to get everyone to work together as this would slow down the momentum. However, they felt that there was a need to have a steering group or users group to facilitate networking and the sharing of experiences and ideas. By networking the separate efforts of CSR, Mackay Sugar, Bundaberg Sugar and QSL and involving different research groups such as CRC Sugar and CSIRO, together they should be able to work out where R&D is needed to improve the crop forecasting efforts.

The Industry needs were expressed in terms of different parts of the supply chain as a scale matrix, as shown overleaf. This requires a lot of further work for it to be completed and is a research project in its own right.

Research needs

In terms of research needs for the sugar industry, the following R&D areas were identified in the workshop:

1. There is a need to refine crop forecasting and harvest monitoring techniques at different spatial scales (macro scale for sugar logistics; mill area scale for harvest). Need to ensure that the sum of the mill area estimates produced by one method is approximately equal to the macro scale estimate produced by another method.
2. Need to look at ways of remotely sensing crop maturity (CCS) to optimise harvest scheduling and maximise industry profitability.
3. There are opportunities to use crop forecasting technologies for assessing the size of the sugarcane crop for our major competitors such as Brazil, Thailand and South Africa.
4. Need to find out the needs and levels of accuracy required for crop forecasts for different groups in the industry (growers, millers, sugar marketing). Is frequent monitoring of the crop cost efficient?
5. Need to review the literature on crop forecasting using satellite imagery around the world to find out what other models are used internationally. Find out what imagery will produce useful data (different wavelengths, pixel size and resolution).
6. Need to look at methodology that is appropriate for each type of imagery (Landsat, Spot, Radarsat, Noah etc). Interpretation of different imagery will most likely require different methodologies.
7. Need to look at integration with precision agriculture technology and block recording systems for improved validation of model output and ground truthing. Yield

mapping for parts of a block; block recording for a whole block; crop forecasting using satellite imagery for a whole farm.

8. The sugar industry needs to look at ways of pulling together remote sensing, mathematical modelling, crop growth simulation modelling and climate forecasting into an integrated forecasting system. The integrated whole should be better than the sum of the separate parts and if one technology fails, say because of cloud cover, then the others should allow a reasonably accurate forecast still to be produced. Issues for this include scale, risk management and timeliness.

Further developments / observations

1. It was agreed that there needs to be a crop forecasting users group established. Michael Hartcher (CSR Townsville) agreed to be the coordinator. Other workshop participants who expressed an interest in being involved were: Michael Sefton, peter Allen, Andrew Higgins, Alan Stafford, Peter Twine, Eddie Rowe, Raymond DeLai, Stuart Phinn, John Markley, Yvette Everingham, Bernie Milford and Clinton Scott.
2. This workshop was the first time the Industry had met to talk about crop forecasting. Further meetings should be held from time to time to review where the industry is heading with this technology.
3. It was evident from the discussions that the industry is currently preoccupied with its business needs rather than its research needs.
4. Whilst the HRIC provided leadership in this area for the first 3 years and now wishes to relinquish this role, no other group came forward to provide the leadership required. The Industry needs some high level leadership in order to promote a co-ordinated approach. Unfortunately this was not forthcoming. CRC Sugar would have been the ideal industry organisation to do this but no longer has the expertise in this area. BSES also has no expertise in this area.

Industry Needs Matrix

Supply Chain

Scale

	Whole of Industry	Marketing	Milling	Harvesting	Growing
Block			Quality Management	Crop Maturity Bin Placement	Crop Maturity Plan Harvest Plan for next year Crop Management
Farm			Equity Transport Schedules Group Allotments	Harvesting Contracts	Business Management
Group			Equity Transport Planning & Coordination	Business Management Equity	Equity
Mill			Business Management Season length & timing Budgeting	Season length & timing	Season length & timing Expansion Options
Terminal	[1]Storage	[1]Forward Selling Shipping Storage			
Industry		[1]Quantity to forward sell			
Global	[1]Competitor Analysis				

Notes:

[1] Longer lead time required, therefore, start at higher level

Fundamentally, block scale can be aggregated up to provide requirements at each other scale, BUT, keep in mind lead-time and feasibility. Therefore, may need to work at each level?

Closing Remarks

Closing Remarks

Owen Crees from Queensland Sugar Ltd made the following closing remarks:

- First time a large group from the Sugar Industry has got together to discuss crop forecasting.
- It was apparent that there is a lot of enthusiasm and energy within the Industry for remote sensing and other new technologies.
- There is an important difference between crop forecasting and crop estimation
- At present, arrangements between individual sugar milling or marketing groups and commercial partners are taking us forward.
- Whilst there is some duplication of effort, this is not necessarily a bad thing. Any attempt to coordinate activities and pull them together would inevitably slow down progress. He was in favour of a continuation of current arrangements.
- Milling groups and grower groups have different needs which again supports separate individual effort.
- However there is a need to share data and ideas through an Industry users group.
- The big and relatively easily achievable gains have already been obtained form the technology. Further gains will become progressively more difficult to achieve in the future.