CSIRO Vegetation Assessment and Monitoring Initiative

Earth Observation Centre
Canberra

- The purpose of this document is to inform the interested reader about a new CSIRO *Initiative in Vegetation Assessment and Monitoring*

- It does this by outlining
  - Situation and Needs analyses
  - CSIRO research response
  - Time lines of products and applications

- Though principally designed to share information, this document also solicits and directs feedback from readers seeking active engagement with the Initiative

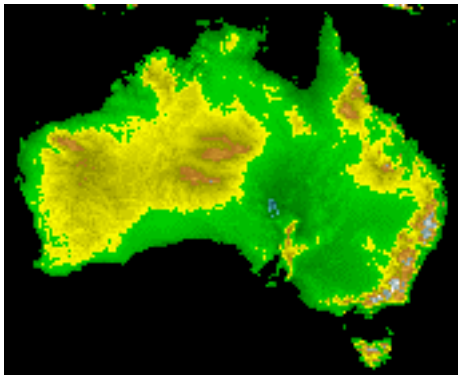
- A *Situation Analysis* of the very broad and expanding area of Environmental Management reveals two clear signals
  - Within Australian society, Landscape Rehabilitation, Agricultural and Ecological Sustainability, Greenhouse and Biodiversity are issues which enjoy a high and persistent level of political interest
  - This interest translates to a high level of expectation by Australian society that environmental management agencies, Public and Private, will 'get it right'

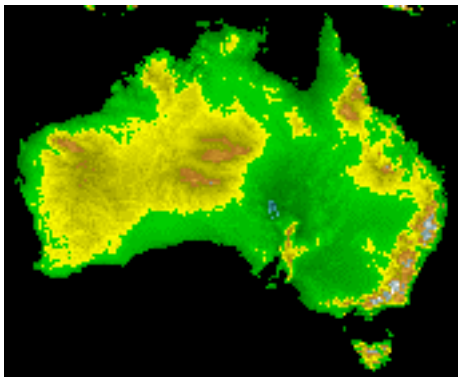
- That is, Australian society expects Public and Private sector Environmental Management to be *responsive* and *comprehensive*

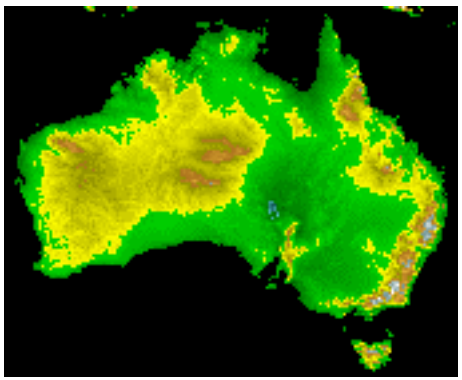
- However, it is now clear that the rate limiting step in improving management is the supply of *relevant*, *revealing* and *timely* data

- This escalating data demand has three sources:
  - Informing *Policy & Strategic* development
  - Providing *Feedback* to management
  - Demonstrating *Compliance*

- To meet these data demands, there is a present and growing future need for *enhanced capacity* in *assessing and monitoring* environmental variables which are *relevant* to management







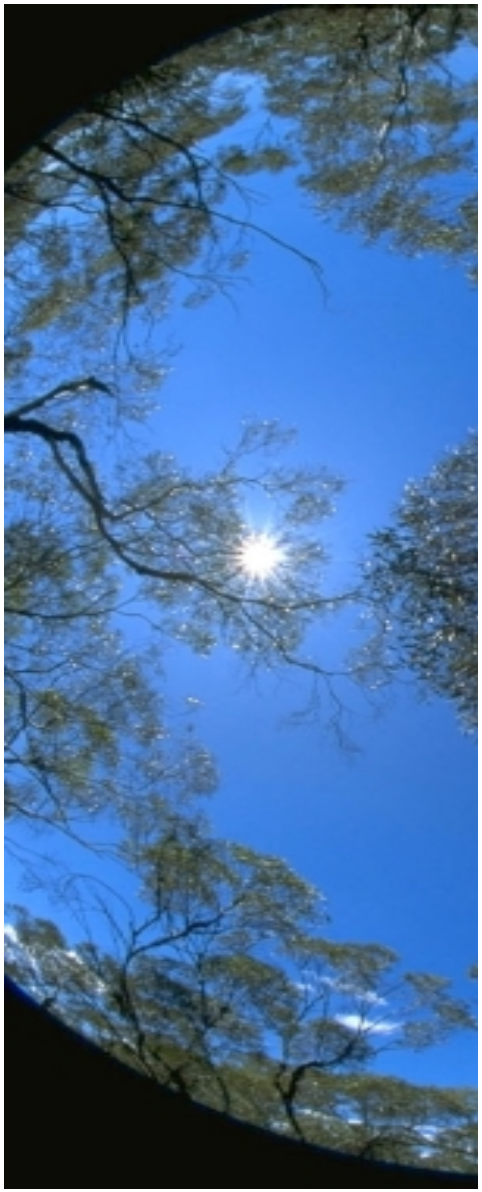
- Within the issues of Sustainability, Greenhouse and Biodiversity - grouped as 'Condition of the Environment' - many of the required environmental measures (or indices) relate to vegetation *structure* and its *dynamics* on landscape scales

- This interrelation is fundamental because
  - Vegetation is the primary trophic level.
  - Structure represents the cumulative response of vegetation to climate, competition, use and / or disturbance.
  - Change in structure is accompanied by change in landscape functioning.

- Measurements of vegetation type (growth form) and canopy structure (height, density, vertical & horizontal biomass, gappiness, etc.) form the basis of assessing landscape condition under all landuse regimes, incl.
  - Forestry
  - Conservation

- Similarly, measurements (and interpretation) of structural *change* provide critical feedback for management of aggrading or degrading trends
  - Distribution and intensity of use
  - Remediation
  - Rehabilitation

- We conclude that a *current and foreseeable need* in many areas of Environmental Management is an *enhanced capacity* for assessing and monitoring (vegetation) canopy structural variables (eg):
  - *Tree heights, sizes and shapes*
  - *Vertical and horizontal foliage density*
  - *Cover & Gap by layer and Type*
- Deciding on what would be the most *effective* and *pervasive* enhancement of measurement capacity, as well as undertaking the required research and development to achieve and demonstrate it, comprises the *CSIRO Initiative in Vegetation Assessment and Monitoring*



- First: five *prerequisites* for enhanced canopy measurement capacity

  - 1) Objective measurement

    Machine acquisition of the primary data

  - 2) High signal to noise ratio

    Minimise the uncertainty associated with the primary data and all derived (secondary) outputs

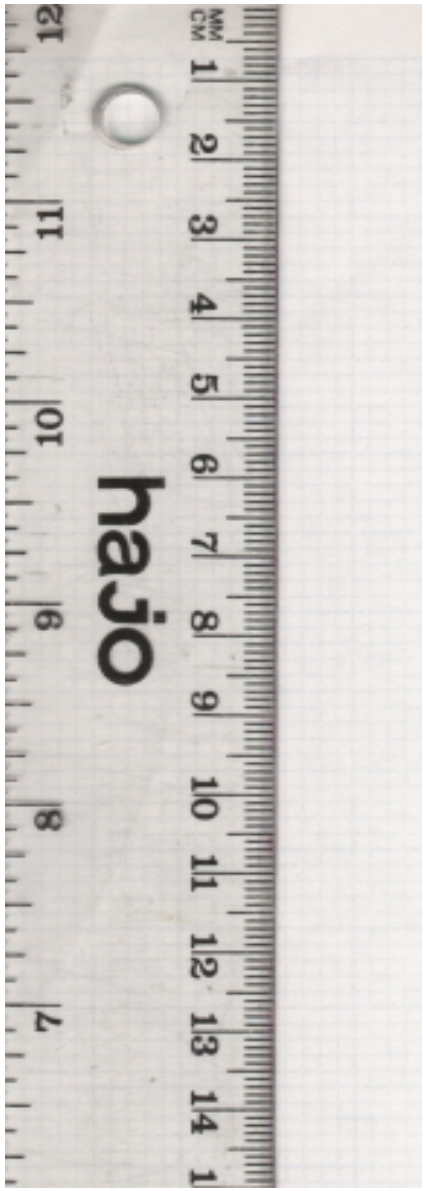
  - 3) Flexible sampling in space and time

    Operation at local to global scales

    Integration with other data types to multiply utility

    Task-specific sampling options to minimise costs

    Multi-stage sampling capability to maximise certainty



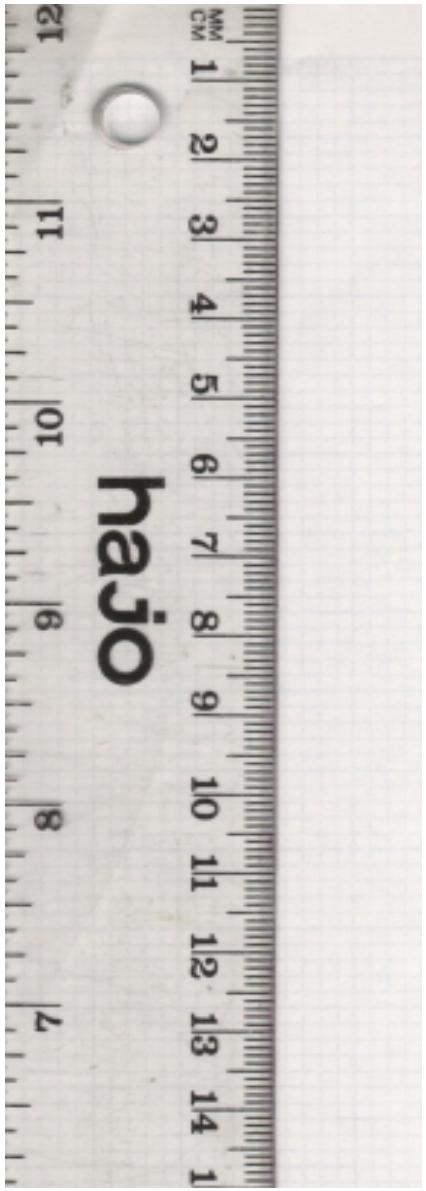
- 4) High inherent accuracy (assessment) and precision (monitoring)

  For maximum credibility, the same data type should be used for assessment and for monitoring (change detection)

- 5) Robust and Transparent modelling between measured variables (primary data) and required (derived) attributes

  Scaffolding: By designing the measurement system to closely match existing methodologies, the (considerable) volume of current understanding, eg. forest mensuration, can be assimilated into the analysis techniques

  Compliance: Verification and accreditation requires transparency in derivation of outputs



- Prerequisites 1-4 dictate *remote sensing*, while 5 narrows the choice of *technology* to *LIDAR*

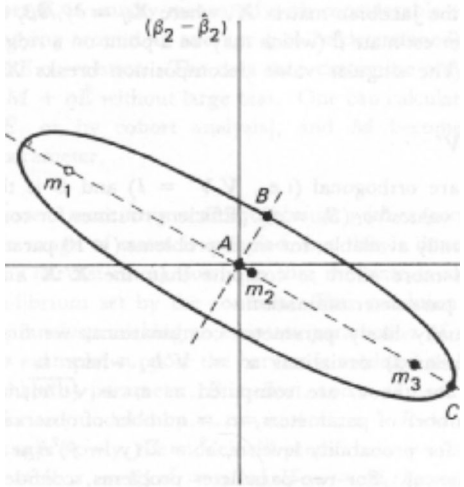
- Other technologies, such as Hyperspectral and Synthetic Aperture Radar (SAR), have disqualifying limitations
  - Complex relationships between structure and data
  - High expense in instrumentation, acquisition and processing
  - Links to standard structural measurements not established

- The CSIRO Earth Observation Centre (EOC) is coordinating CSIRO's Canopy LIDAR R&D strategy

- Over the next 3 years (2000 - 2003) there will be a concerted effort involving scientists from a number of CSIRO Divisions and Research and Commercial Partners

- This R&D effort will be directed into
  - Designing enhanced *instrumentation*
  - Refining (CSIRO) *analysis methodology*

- The R&D strategy follows *three* concurrent paths



Confidence regions for uncertain parameters ca
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Using symbols as defined in the text, the length of
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mbinations m_1, m_2, and m_3 define a reduced mod
es.

) and values $\hat{\beta}^{(j+1)} = \hat{\beta}^{(j)} + z_i V_i$ would represe

ider the following simple example. Suppose
possible about β_1, β_2, β_3 in the "experimental
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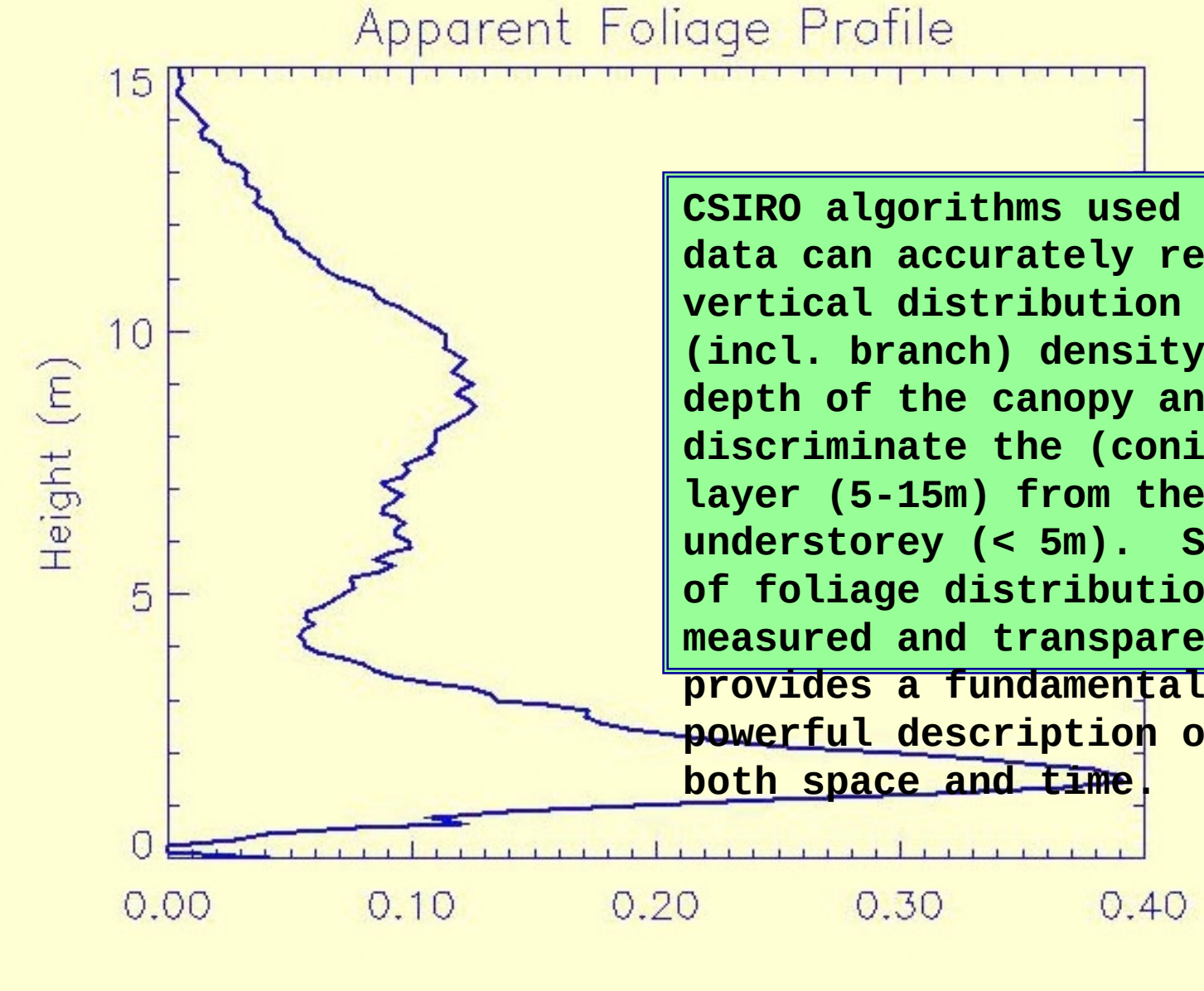
or absent. Suppose no "control" observatio
ents absent, and that there are two observati
Letting the first two observations be for tr
hat $\partial \hat{y}_i / \partial \beta_1 = 1$ for all observations, we get

$$X = \begin{bmatrix} 1 & 1 & 0 \\ 1 & 1 & 0 \\ 1 & 0 & 1 \\ 1 & 0 & 1 \end{bmatrix}$$

- **Path 1:** *Refine* (CSIRO) methodology for extracting relevant canopy variables using existing LIDAR datasets
  - This initial research has used data from a NASA research LIDAR instrument (SLICER)
  - These data, acquired in 1996, are available for largely coniferous forest canopies
  - Nonetheless, this first test of CSIRO research has yielded clearly applicable results (eg over the page & at our Web Site)
  - Research within NASA continues to confirm the utility of canopy LIDAR



CSIRO algorithms used on NASA SLICER data can accurately retrieve the vertical distribution of foliage (incl. branch) density throughout the depth of the canopy and thereby discriminate the (coniferous) tree layer (5-15m) from the shrubby understorey (< 5m). Such a profile of foliage distribution, objectively measured and transparently derived, provides a fundamental and thus powerful description of vegetation in both space and time.

- **Path 2:** *Apply and Validate* CSIRO methodology using data from the (space-borne) NASA Vegetation Canopy Lidar (VCL) instrument

  - The VCL instrument is scheduled for launch in September 2000

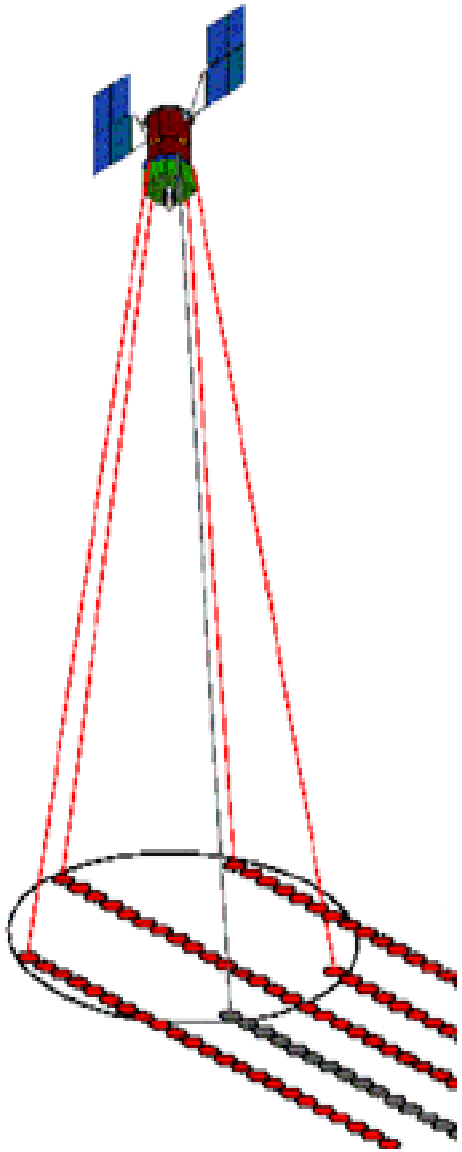
    See http://essp.gsfc.nasa.gov/vcl/

  - CSIRO is currently negotiating details of data access and a continental network of effective validation sites and supporting measurements
  - Product will be a contemporary, continent-wide description of vegetation structure

    Canopy life form, cover, LAI, biomass, etc.

    Integrated with existing satellite data (AVHRR, MODIS, SPOT, SPOT VEGETATION & LANDSAT)

    Anticipate completion mid-2003



- **Path 3:** With a commercial partner, *design and build* an airborne Vegetation LIDAR for commercial operation within Australia and elsewhere
  - In progress, first steps
    - Current anticipated completion date is mid 2002
  - Device will include both LIDAR and imaging components and be known as the *Vegetation Structural Imaging System* (VSIS)
  - Targeted applications include
    - Commercial forestry (inventory, monitoring)
    - Carbon trading (verification of 'Kyoto Forests')
    - Conservation land use (habitat mapping, monitoring) & Land rehabilitation
    - Agri-pastoral land use (assessment, monitoring)

- **Path 3 (continued):** With a commercial partner, *design and build* a portable ground based LIDAR for scientific and commercial purposes within Australia and elsewhere
  - In progress, first steps

    Current anticipated completion date is 2001
  - Device will be a portable LIDAR and is known as the ECHIDNA project
  - The ECHIDNA instrument will provide unique stand alone descriptions of canopy structure as well as serving to help interpret airborne or spaceborne LIDAR data.

- **Path 3 (continued):** To facilitate the interpretation and use of canopy descriptions provided by both VSIS and ECHIDNA lidars, advanced software for interpretations of forest structures and 3D Visualisation techniques will be developed.

$$\tilde{S}(r) = -\tilde{C}\rho_v \frac{dP_{gap}(r)}{dr}$$

$$\tilde{H}(r) = \int_0^r \tilde{S}(r')\,dr'$$

$$= \tilde{C}\rho_v (1 - P_{gap}(r))$$

$$\tilde{S}(h) = \tilde{C}\rho_g P_{gap}(h)$$

$$= \tilde{C}\rho_g - \frac{\rho_g}{\rho_v}\tilde{H}(h)$$

- The forest description provided by ECHIDNA and VSIS will match but *advance* those that foresters and ecologists have been struggling to map and scale from field sites for many years.

- **Summary:** CSIRO has analysed current and foreseeable *data needs* in renewable resource management
  - The capacity to assess and monitor vegetation canopy *structure* is a requirement common to current and foreseeable environmental management issues

- CSIRO has looked hard at the *future* and resolved that the *best option* is *Vegetation* LIDAR

- CSIRO is now working to realise this future with Research and Commercial Partners

- **Feedback & Contact:**

- Comments and expressions of interest are welcome

- Please direct them to:

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