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MAPPING BUSHFIRE HAZARD AND IMPACT

Developing spatial information on fire hazard for planners, land managers and emergency services

Marta Yebra, Albert Van Dijk and Geoff Cary

Fenner School of Environment and Society, Australian National University College of Medicine, Biology and Environment, ACT.

An Australian Government Initiative

CRC AUSTRALIA

Australian National University

PROJECT END-USERS

- John Bally, Bureau of Meteorology (Lead-end-user)
- Adam Leavesley and Neil Cooper, ACT Parks and Conservation.
- Robert Preston, Public Safety Business Agency (QLD).
- Andrew Sturgess and Bruno Greimel, QLD Fire and Emergency
- Laurance McCoy and Stuart Matthews, NSW Rural Fire Service
- Andrew Grace, Attorney-General's Dept, ACT
- Richard Wald, SA Country Fire Service
- Simeon Telfer, Department of Environment, Water and Natural Resources. SA
- Belinda Kenny, Office of Environment & Heritage, NSW
- David Taylor, Tasmania Parks and Wildlife Service.

New end-users: Bruce Murrell and Michael Konig (Boeing Defence Space & Security)

PROJECT EXTERNAL COLLABORATORS

- Darius Culvenor (Sensing Systems)
- Jim Gould (CSIRO)
- Tom Jovanovic (ANU)
- Alex Held, Arantxa Cabello and Michael Schaefer (CSIRO/ TERN-AUSCOVER)
- Emilio Chuvieco (University of Alcala, Spain)
- Philip Zylstra (UOW)
- Samsung Lim (UNSW)

PROJECT STUDENTS

PhD students on "Mapping forest fuel load and structure from LiDAR".

- **Narshima Garlapati** (ANU-APA+ BNHCRC top-up scholarship)
- **Yang Chen** (University of Monash-APA + BNHCRC top-up scholarship)

Undergraduate students

- **Lois Padgham** (ANU-Independent Research Project, ACT Parks). Topic: Cosmic ray soil moisture probe for fuel monitoring
- **Lauren de Waal** (Engineering Honours student at ANU) Topic: "Grassland curing and moisture content monitoring with automated sensing systems for bushfire prediction"

Academic study visitors

- **Susanne Marselis** (Graduated Msc Earth Sciences, University of Amsterdam)- (February-April 2015).

  Topic: Terrestrial LiDAR and fuel structure.
- **Xingwen Quan** (PhD student, University of Electronic Science and Technology of China, Chengdu) (October 2015-October 2016)

  Topic: Remote Sensing of Fuel Moisture Content

GOAL

- Produce reliable and operationally useful **spatial information on critical aspects of bushfire hazard** (fuel structure, load and flammability)

- Determine the **impact of unplanned and prescribed burning** on fuel accumulation as well as landscape values (habitat, water resources and carbon storage) over time, in support of fire management.

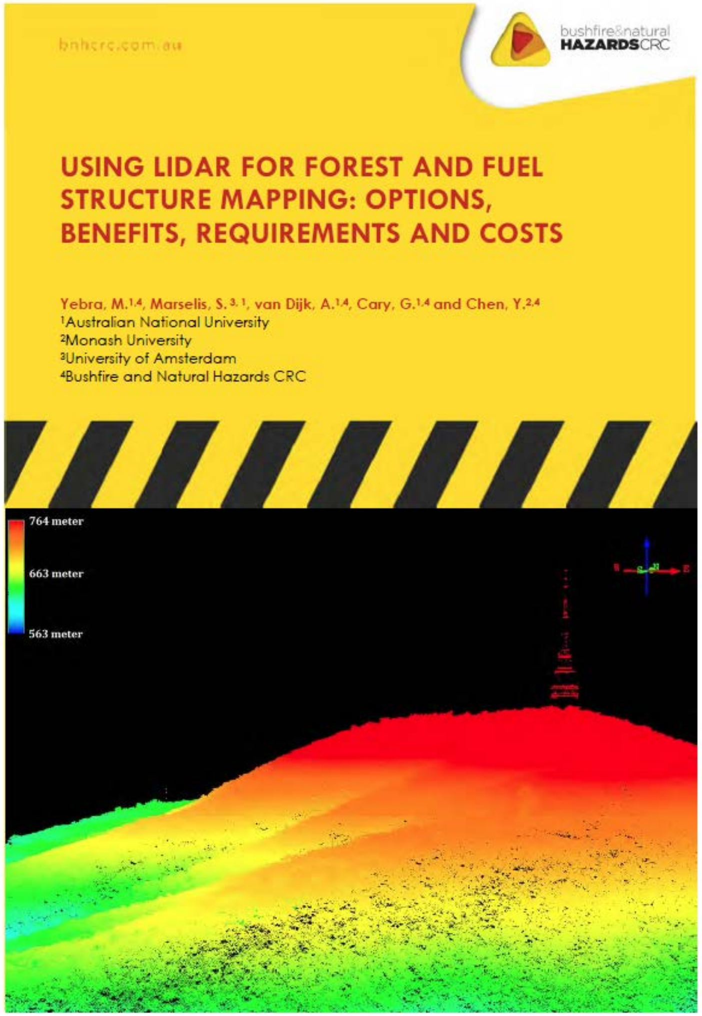
TWO DIFFERENT SET OF TRACKING METHODS

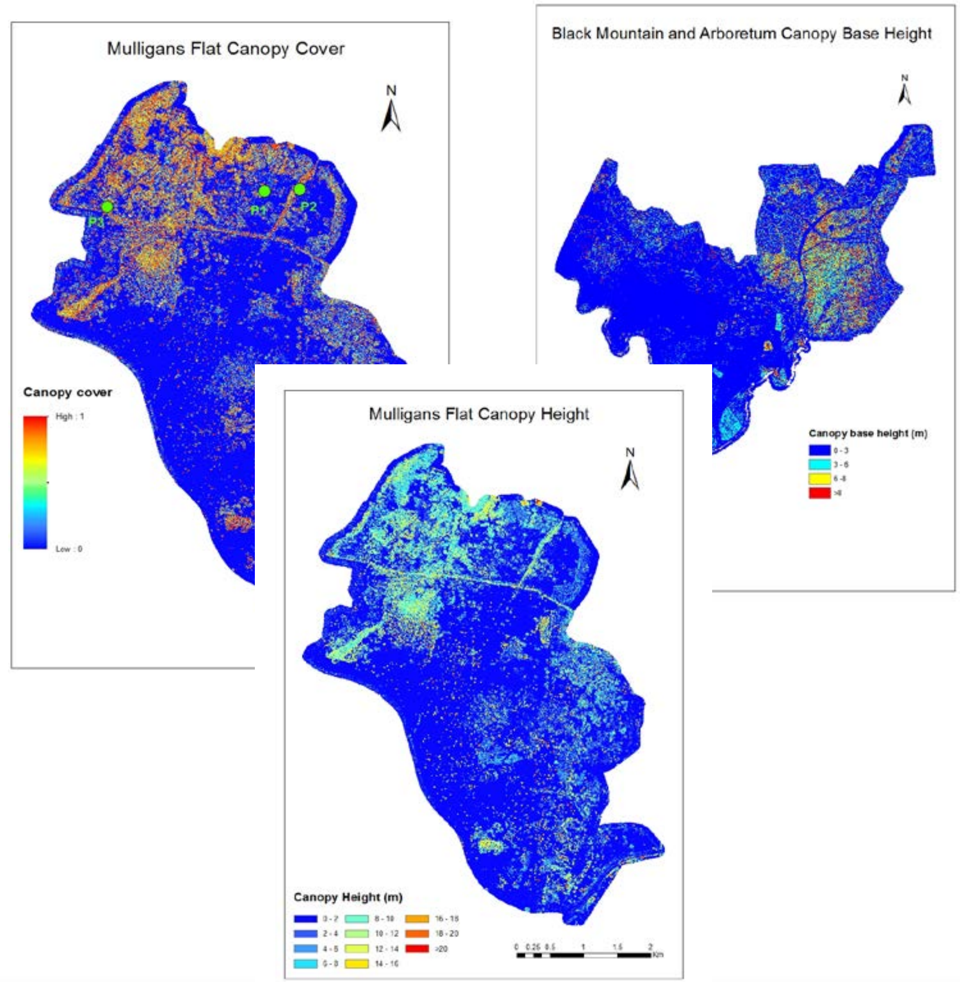
1) IN-FIELD methods
   a) Local scale
   b) End-user may need to collect and post-process the data using standardized protocols
   c) Provide objective, detailed and consistent observations at real time

2) Spatial information at national scale
   a) National scale
   b) Freely available and in most cases at near real-time

IN-FIELD METHODS

AUTOMATED AIRBORNE LIDAR FUEL STRUCTURE





AIRBORNE LIDAR FOR FUEL STRUCTURE MAPPING

Mapping forest fuel load and structure from airborne LiDAR data

bushfire&natural HAZARDSCRC

Narsimha Garlapati[1,2], Albert Van Dijk[1,2], Marta Yebra[1,2], Geoffrey Cary[1,2]

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Research Cluster: Monitoring and prediction, Project: Mapping bushfire hazard and impacts

AUSTRALIA IS A DRY CONTINENT, WITH HIGH CLIMATE VARIABILITY, AND IS CONTINUALLY VULNERABLE TO NATURAL HAZARDS LIKE BUSHFIRES. IN ORDER TO BETTER EVALUATE & REDUCE THE RISK OF BUSHFIRES, FIRE MANAGEMENT AGENCIES AND LAND MANAGERS NEED TIMELY, ACCURATE AND SPATIALLY EXPLICIT UNDERSTOREY FUEL METRICS ALONG WITH CLIMATIC AND OTHER SPATIAL TOPOGRAPHICAL INFORMATION. THE LIGHT DETECTION AND RANGING (LIDAR) DATA AND TECHNOLOGY IS A PROVEN ALTERNATIVE TO TRADITIONALLY TIME CONSUMING AND LABOUR INTENSIVE FUEL ASSESSMENT METHODS.

INTRODUCTION

- LiDAR technology and full-waveform form data has wide potential in forestry fuel mapping. This is because of increased capabilities in capturing the understorey and near surface fuel loads and other structural information with highest precision in a reasonable time.
- Now Bushfire research must overcome many challenges (time & spatial accuracies) with the utilisation of the advanced ALS-FWL technologies to develop more accurate fuel databases which are crucial for fire risk assessments.

Figure 1: Field survey plots (Photo credit: Phil Zylstra, UoW)

- **EARLIER fire management** was making reliable estimates about the fuels with the combination of extensive ground survey data along with other remote sensing data *(Figure 1)*.
- Even after the evolution of LiDAR, the remote identification and assessment of the elevated and near surface fuel (NSF) under denser canopies was challenging (Palace et al., 2015). This is because discrete pulses cannot detect the understorey fuel/other structures due to weakening of pulses which were unable to reflect back to the sensor from the ground *(Figure2)*.

Figure 2 : Black Mountain discrete LiDAR vegetation profile

Did you know?

Today airborne LiDAR systems (ALS) and technology with full-waveform LiDAR data (FWL) capability, has become a very accurate and affordable solution for forestry mapping covering larger areas in shorter timeframes ?(Wagner et al., 2008)

Figure 3: Full-waveform signal response on vegetation (Ma et al., 2015)

WHY FULL-WAVE LIDAR?
FW Laser pulses can penetrate through the dense canopies and are able to detect the understorey fuels over large areas with high spatial and volumetric accuracies. *(Figure 3)*

HOW MIGHT IT WORK?

ALS over ACT region → ACT FW LiDAR → Vegetation → Fuel Classification → Field Validation → Fuel Maps, Topographic Models → Fire Risk

Figure 4 : Proposed research methodology

THIS PhD RESEARCH

- Investigates and utilises cutting-edge active remote sensing technologies like LiDAR to advance Australian bushfire research and utilise the next generation spatial information.
- Assesses the competence of full-waveform LiDAR to map the understorey forest fuels and structures for the whole of the ACT.
- Identify and develop high resolution spatial products which are of particular interest to bushfire and emergency management.
- Will develop an accurate fire risk index and add value to existing spatial data, to make informed decisions in critical times.

RESEARCH QUESTIONS

- Is FW LiDAR any better than the discrete form?
- How and to what extent the can FW-LiDAR data can be used in mapping bushfire hazards and impacts?
- Is the available LiDAR data complying with the American Society of Photogrammetry and Remote Sensing (ASPRS) LiDAR data standards and project specifications?
- Can we establish an objective way to define the national fuel classification system and the fuel hazard assessments based on the LiDAR derived fuel metrics?

1. Ma,H., Song, J. and Wang,J., 2015. Forest Canopy LAI and Vertical FAVD Profile Inversion from Airborne Full-Waveform LiDAR Data Based on a Radiative Transfer Model, Remote Sensing, 7(2): 1897-1914.
2. Wagner, W., et al. (2008). "3D vegetation mapping using small-footprint full-waveform airborne laser scanners."
3. Palace,M. W., et al (2015). "Estimating forest structure in a tropical forest using field measurements, a synthetic model and discrete return lidar data.
4. Photos from mdpi, carbonmap, black mountain field work

Australian National University

ACKNOWLEDGEMENTS
1. ACT Government-Environment & Planning, Parks & Conservation for the FW LiDAR.
2. BNHCRC for top-up scholarship and project support.
3. CSIRO for the provision of discrete LiDAR and TERN for co-funding the FW acquisitions.

END-USER STATEMENT
This PhD research is well aligned with the BNHCRCs priorities and also with the stakeholders strategic objectives.
Andreia Siqueira, Geoscience Australia

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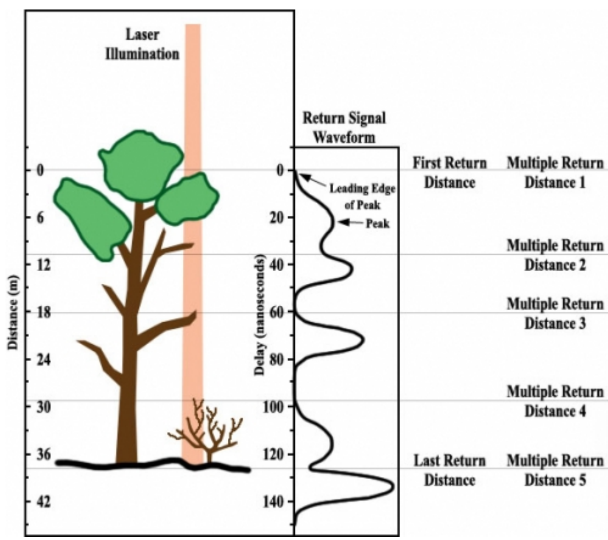
New Airborne **Full-wave** LiDAR collected across ACT July 2015 (funding from ACT Government and TERN)

Narsimha Garlapati PhD project

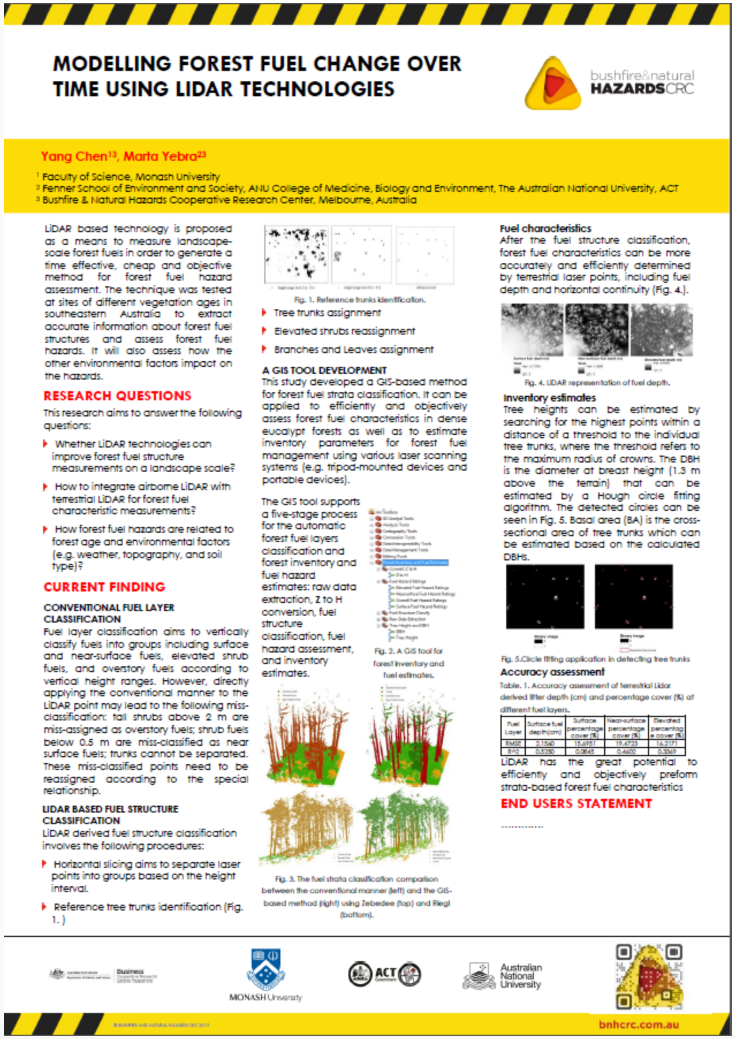


ACT Government

≈ AUD 100 per Km^2

TERN Terrestrial Ecosystem Research Network

AUTOMATED GROUND-BASED LIDAR FUEL STRUCTURE CLASSIFICATION



Marselis, S., Yebra, M., Jovanovic, T., van Dijk, A. Automated classification of mobile laser scanning observations to automatically derive information on forest structure and biomass. Submitted to *Environmental Modelling and Software* . Under review.

Chen, Y., Zhu, X., Yebra, M., Harris, S., Tapper, N. Strata-based forest fuel classification for wild fire hazard assessment using terrestrial LiDAR data. Submitted to *ISPRS Journal of Photogrammetry and Remote Sensing*. Under review.

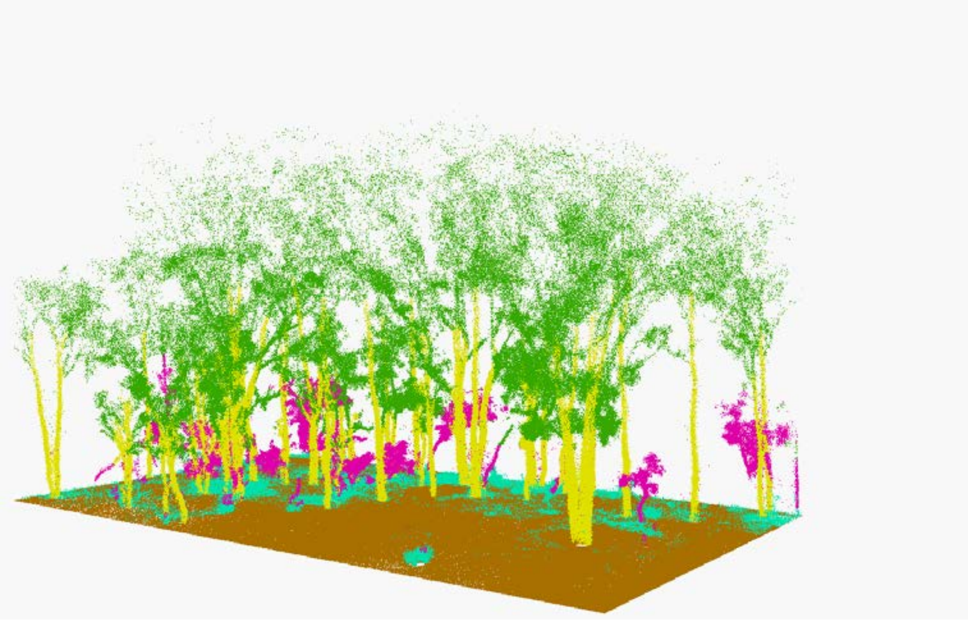
MOVING TOWARDS A MORE OBJECTIVE FUEL ASSESSMENT

Traditional visual assessment

Terrestrial LiDAR (Zebedee)

CLASSIFIED POINT CLOUD

The classification algorithm is able to **automatically recognise 98% of the trees** in the study site and **80% of the elevated vegetation** components with an **error of commission of 20%.**

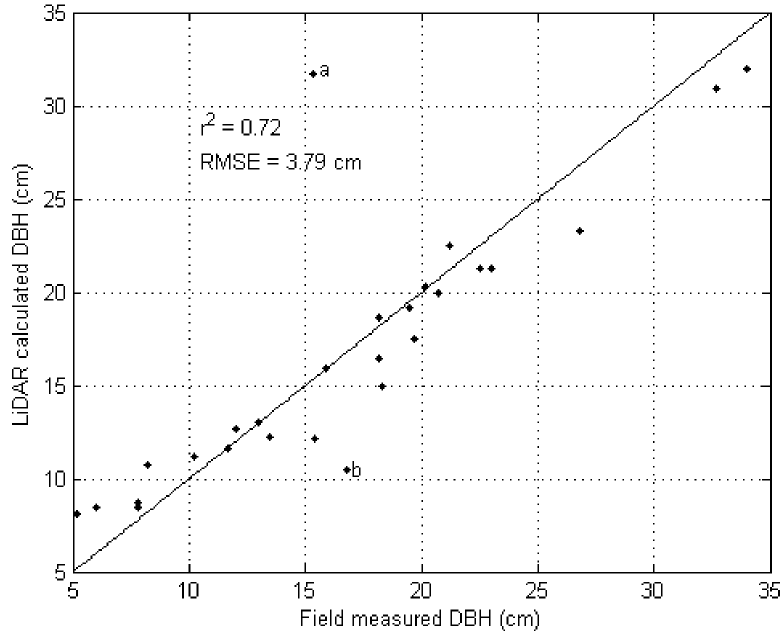


LiDAR classification	Field observed			
	Tree	Elevated	Not observed	Total
Tree	49	1	2	52
Elevated	0	12	1	13
Undetected	1	2	0	3
Total	50	15	3	68

Marselis, S *et al.* (2015, Submitted to *EMS)*

AUTOMATICALLY DERIVED INFORMATION ON FUEL STRUCTURE

1) Fractional cover and depth of near surface, elevated and canopy fuels
2) Diameter at breast height

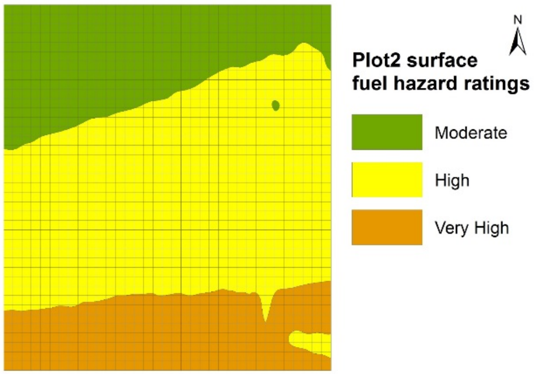


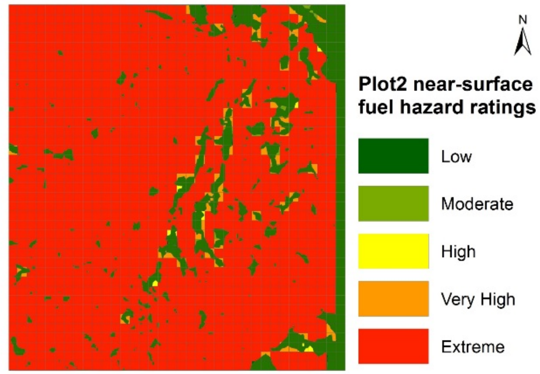
Marselis, S *et al.* (2015, Submitted to *EMS)*

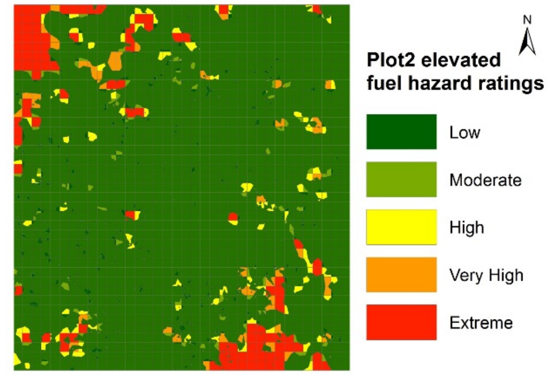
Fuel Property	R^2	RMSE
Litter-bed depth	0.87	10.97mm
Litter cover	0.8	5.38 %
NS cover	0.94	6.9%
Elevate cover	0.87	9.86%

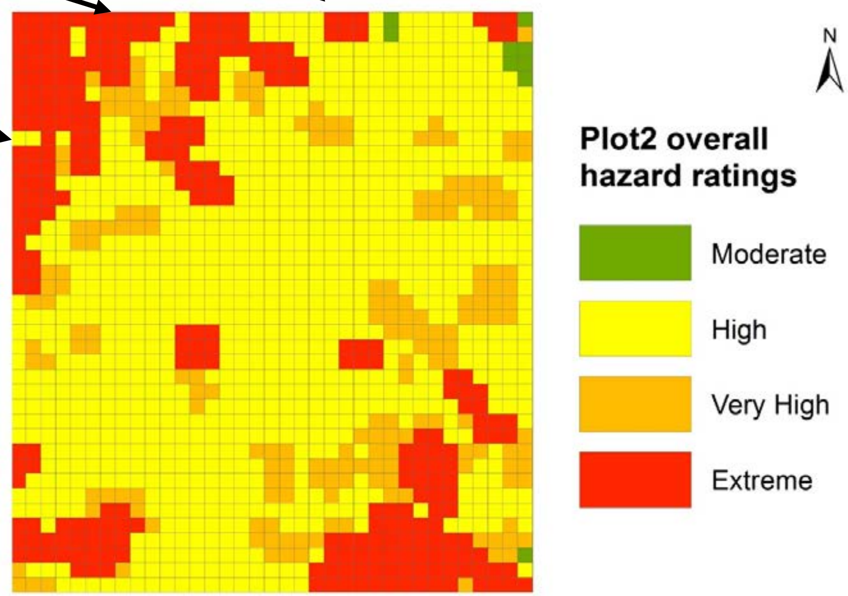
Chen, Y *et al.* (2015, Submitted to *ISPRS JPRS)*

LIDAR DERIVED OVERALL FUEL HAZARD RATINGS









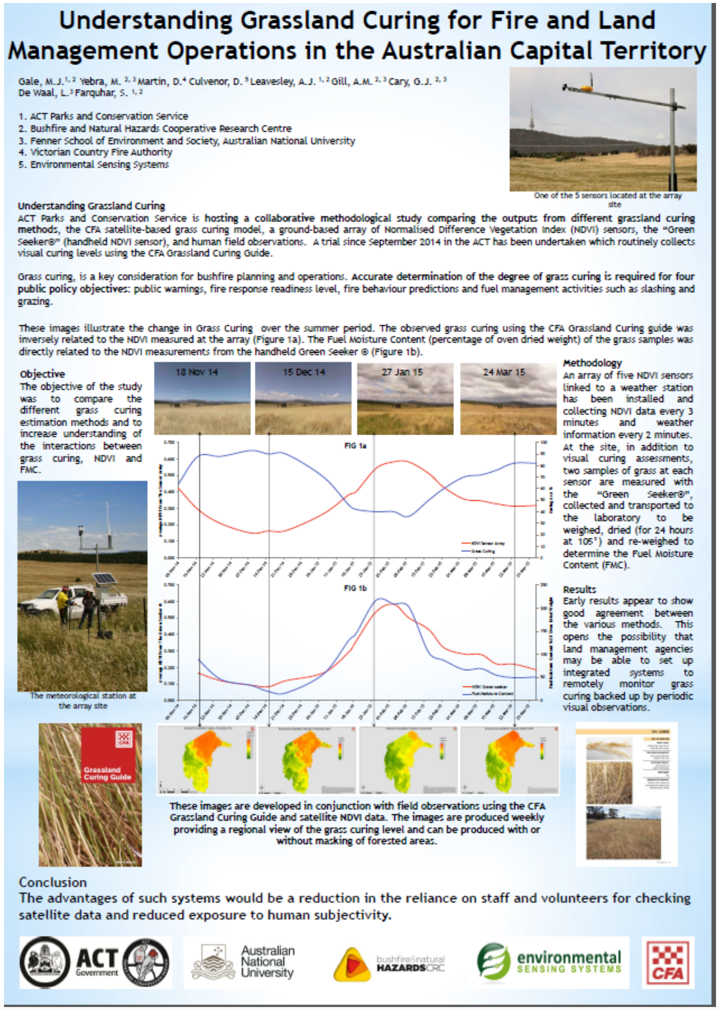
Chen, Y *et al.* (2015, Submitted to *ISPRS JPRS)*

SUMMARIZING

1) An algorithm has been developed to **automatically derived forest fuel structure and OFHA** from Zebedee LiDAR

2) This does not obviate field assessment but it will provide **more objective and consistent** way to assess the fuels in comparison to traditional visual assessments

INTEGRATED SENSOR SYSTEM FOR GRASSLAND CURING AND FMC



Understanding Grassland Curing for Fire and Land Management Operations in the Australian Capital Territory

Gale, M.J.[1,2] Yebra, M.[2,3] Martin, D.[4] Culvenor, D.[5] Leavesley, A.J.[1,2] Gill, A.M.[2,3] Cary, G.J.[2,3] De Waal, L.[3] Farquhar, S.[1,2]

1. ACT Parks and Conservation Service
2. Bushfire and Natural Hazards Cooperative Research Centre
3. Fenner School of Environment and Society, Australian National University
4. Victorian Country Fire Authority
5. Environmental Sensing Systems

One of the 5 sensors located at the array site

Understanding Grassland Curing

ACT Parks and Conservation Service is hosting a collaborative methodological study comparing the outputs from different grassland curing methods, the CFA satellite-based grass curing model, a ground-based array of Normalised Difference Vegetation Index (NDVI) sensors, the "Green Seeker®" (handheld NDVI sensor), and human field observations. A trial since September 2014 in the ACT has been undertaken which routinely collects visual curing levels using the CFA Grassland Curing Guide.

Grass curing, is a key consideration for bushfire planning and operations. Accurate determination of the degree of grass curing is required for four public policy objectives: public warnings, fire response readiness level, fire behaviour predictions and fuel management activities such as slashing and grazing.

These images illustrate the change in Grass Curing over the summer period. The observed grass curing using the CFA Grassland Curing guide was inversely related to the NDVI measured at the array (Figure 1a). The Fuel Moisture Content (percentage of oven dried weight) of the grass samples was directly related to the NDVI measurements from the handheld Green Seeker ® (Figure 1b).

Objective

The objective of the study was to compare the different grass curing estimation methods and to increase understanding of the interactions between grass curing, NDVI and FMC.

The meteorological station at the array site

18 Nov 14 | 15 Dec 14 | 27 Jan 15 | 24 Mar 15

FIG 1a

FIG 1b

Methodology

An array of five NDVI sensors linked to a weather station has been installed and collecting NDVI data every 3 minutes and weather information every 2 minutes. At the site, in addition to visual curing assessments, two samples of grass at each sensor are measured with the "Green Seeker®", collected and transported to the laboratory to be weighed, dried (for 24 hours at 105°) and re-weighed to determine the Fuel Moisture Content (FMC).

Results

Early results appear to show good agreement between the various methods. This opens the possibility that land management agencies may be able to set up integrated systems to remotely monitor grass curing backed up by periodic visual observations.

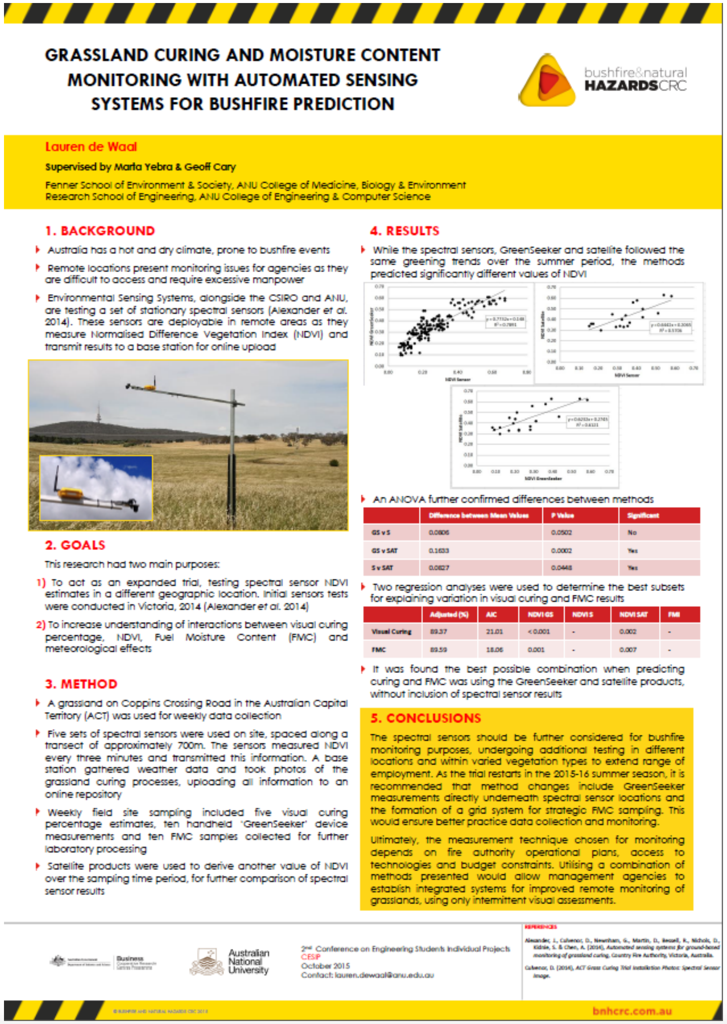
Grassland Curing Guide

These images are developed in conjunction with field observations using the CFA Grassland Curing Guide and satellite NDVI data. The images are produced weekly providing a regional view of the grass curing level and can be produced with or without masking of forested areas.

Conclusion

The advantages of such systems would be a reduction in the reliance on staff and volunteers for checking satellite data and reduced exposure to human subjectivity.

ACT Government | Australian National University | bushfire&natural HAZARDS CRC | environmental SENSING SYSTEMS | CFA



GRASSLAND CURING AND MOISTURE CONTENT MONITORING WITH AUTOMATED SENSING SYSTEMS FOR BUSHFIRE PREDICTION

bushfire&natural HAZARDSCRC

Lauren de Waal

Supervised by Marta Yebra & Geoff Cary

Fenner School of Environment & Society, ANU College of Medicine, Biology & Environment
Research School of Engineering, ANU College of Engineering & Computer Science

1. BACKGROUND

- Australia has a hot and dry climate, prone to bushfire events
- Remote locations present monitoring issues for agencies as they are difficult to access and require excessive manpower
- Environmental Sensing Systems, alongside the CSIRO and ANU, are testing a set of stationary spectral sensors (Alexander et al. 2014). These sensors are deployable in remote areas as they measure Normalised Difference Vegetation Index (NDVI) and transmit results to a base station for online upload

2. GOALS

This research had two main purposes:

1) To act as an expanded trial, testing spectral sensor NDVI estimates in a different geographic location. Initial sensors tests were conducted in Victoria, 2014 (Alexander et al. 2014)

2) To increase understanding of interactions between visual curing percentage, NDVI, Fuel Moisture Content (FMC) and meteorological effects

3. METHOD

- A grassland on Coppins Crossing Road in the Australian Capital Territory (ACT) was used for weekly data collection
- Five sets of spectral sensors were used on site, spaced along a transect of approximately 700m. The sensors measured NDVI every three minutes and transmitted this information. A base station gathered weather data and took photos of the grassland curing processes, uploading all information to an online repository
- Weekly field site sampling included five visual curing percentage estimates, ten handheld 'GreenSeeker' device measurements and ten FMC samples collected for further laboratory processing
- Satellite products were used to derive another value of NDVI over the sampling time period, for further comparison of spectral sensor results

4. RESULTS

- While the spectral sensors, GreenSeeker and satellite followed the same greening trends over the summer period, the methods predicted significantly different values of NDVI
- An ANOVA further confirmed differences between methods

	Difference between Mean Values	P Value	Significant
GS v S	0.0806	0.0502	No
GS v SAT	0.1633	0.0002	Yes
S v SAT	0.0827	0.0448	Yes

- Two regression analyses were used to determine the best subsets for explaining variation in visual curing and FMC results

	Adjusted (%)	AIC	NDVI GS	NDVI S	NDVI SAT	FMI
Visual Curing	89.37	21.01	< 0.001	-	0.002	-
FMC	89.59	18.06	0.001	-	0.007	-

- It was found the best possible combination when predicting curing and FMC was using the GreenSeeker and satellite products, without inclusion of spectral sensor results

5. CONCLUSIONS

The spectral sensors should be further considered for bushfire monitoring purposes, undergoing additional testing in different locations and within varied vegetation types to extend range of employment. As the trial restarts in the 2015-16 summer season, it is recommended that method changes include GreenSeeker measurements directly underneath spectral sensor locations and the formation of a grid system for strategic FMC sampling. This would ensure better practice data collection and monitoring.

Ultimately, the measurement technique chosen for monitoring depends on fire authority operational plans, access to technologies and budget constraints. Utilising a combination of methods presented would allow management agencies to establish integrated systems for improved remote monitoring of grasslands, using only intermittent visual assessments.

Business | Australian National University

2nd Conference on Engineering Students Individual Projects
CESIP
October 2015
Contact: lauren.dewaal@anu.edu.au

REFERENCES

Alexander, J., Culvenor, D., Newnham, G., Martin, D., Bessell, R., Nichols, D., Kidnie, S. & Chen, A. (2014), *Automated sensing systems for ground-based monitoring of grassland curing*, Country Fire Authority, Victoria, Australia.

Culvenor, D. (2014), *ACT Grass Curing Trial Installation Photos: Spectral Sensor Image*.

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INTEGRATED SENSOR SYSTEM FOR GRASSLAND CURING AND FMC

Trial with in-situ sensors for monitoring grass curing and FMC

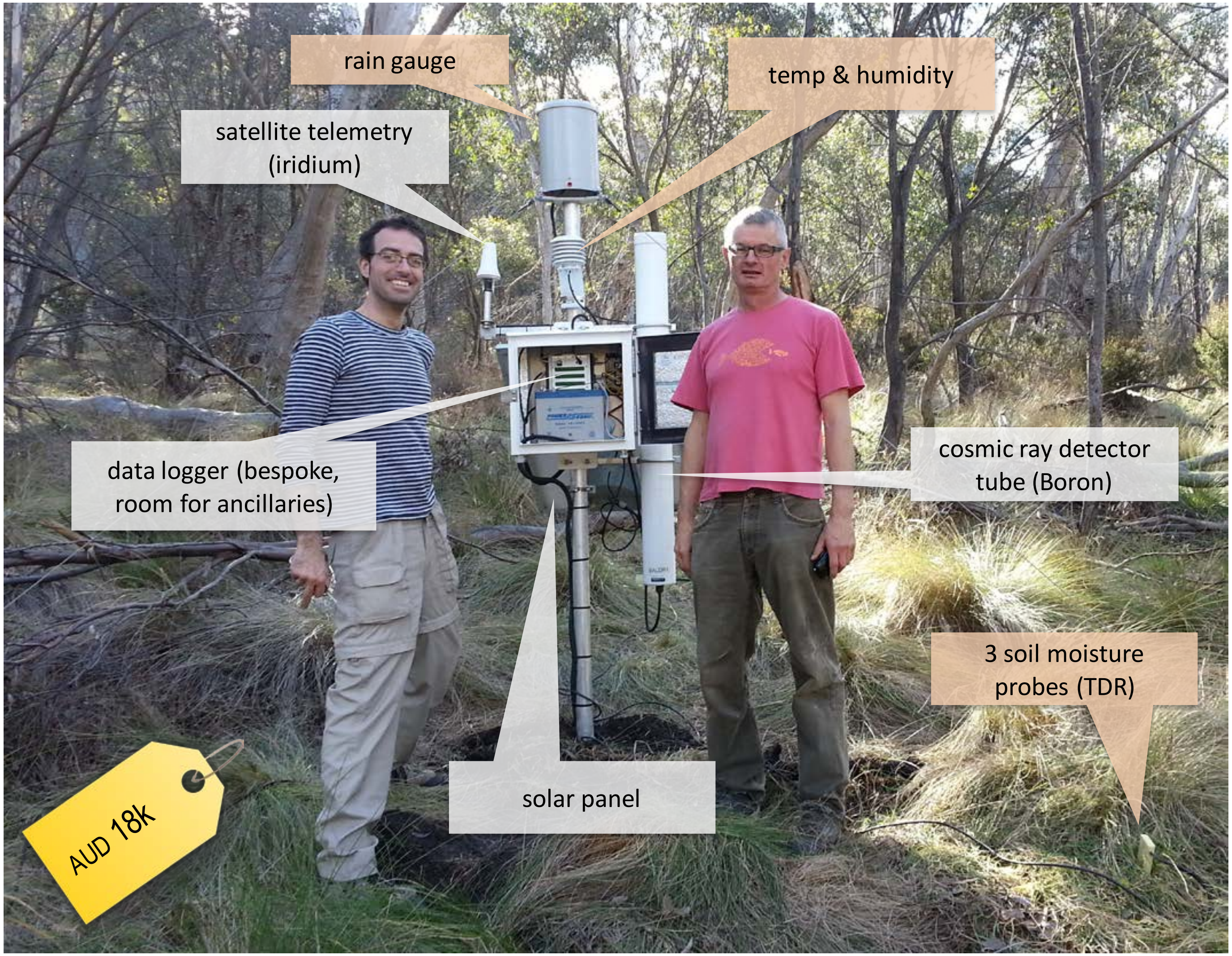
- Detailed and consistent observations
- Useful for models evaluation

TERN
Terrestrial Ecosystem Research Network

ACT PARKS CONSERVATION AND LANDS

environmental SENSING SYSTEMS

COSMIC RAYS FOR FIRE RISK WARNING

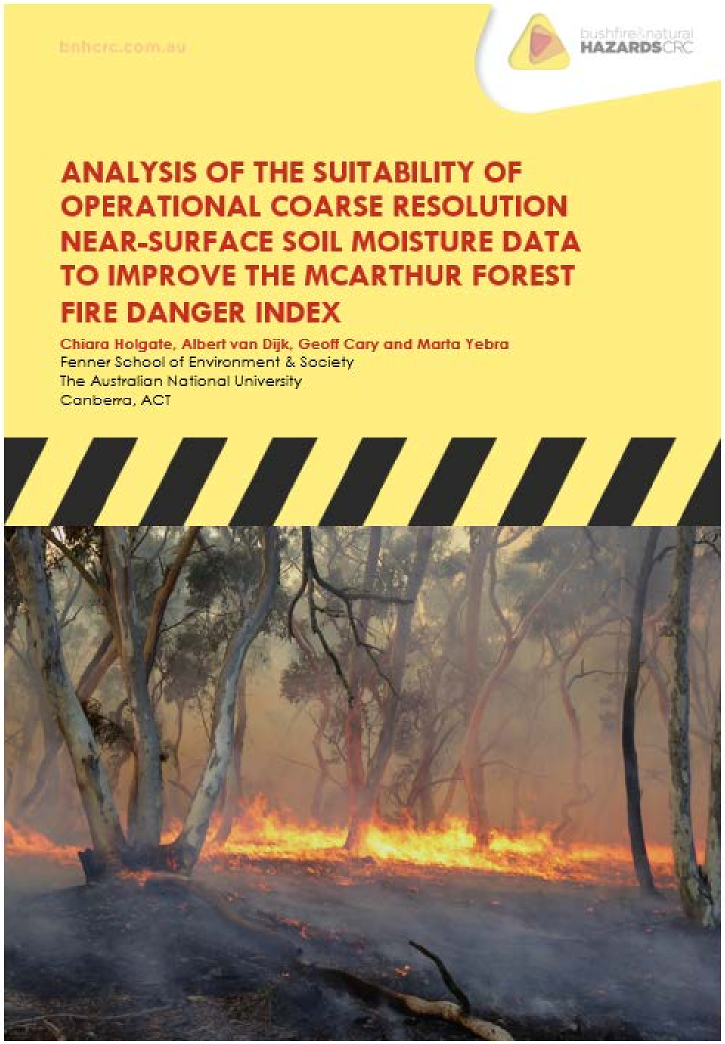


Funding: Actew/ActewAGL

FIELD WORK IN NAMADGI NATIONAL PARK

SPATIAL INFORMATION

SOIL MOISTURE DATA TO IMPROVE FFDI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ANALYSIS OF THE SUITABILITY OF OPERATIONAL COARSE RESOLUTION NEAR-SURFACE SOIL MOISTURE DATA TO IMPROVE THE MCARTHUR FOREST FIRE DANGER INDEX

Chiara Holgate, Albert van Dijk, Geoff Cary and Marta Yebra
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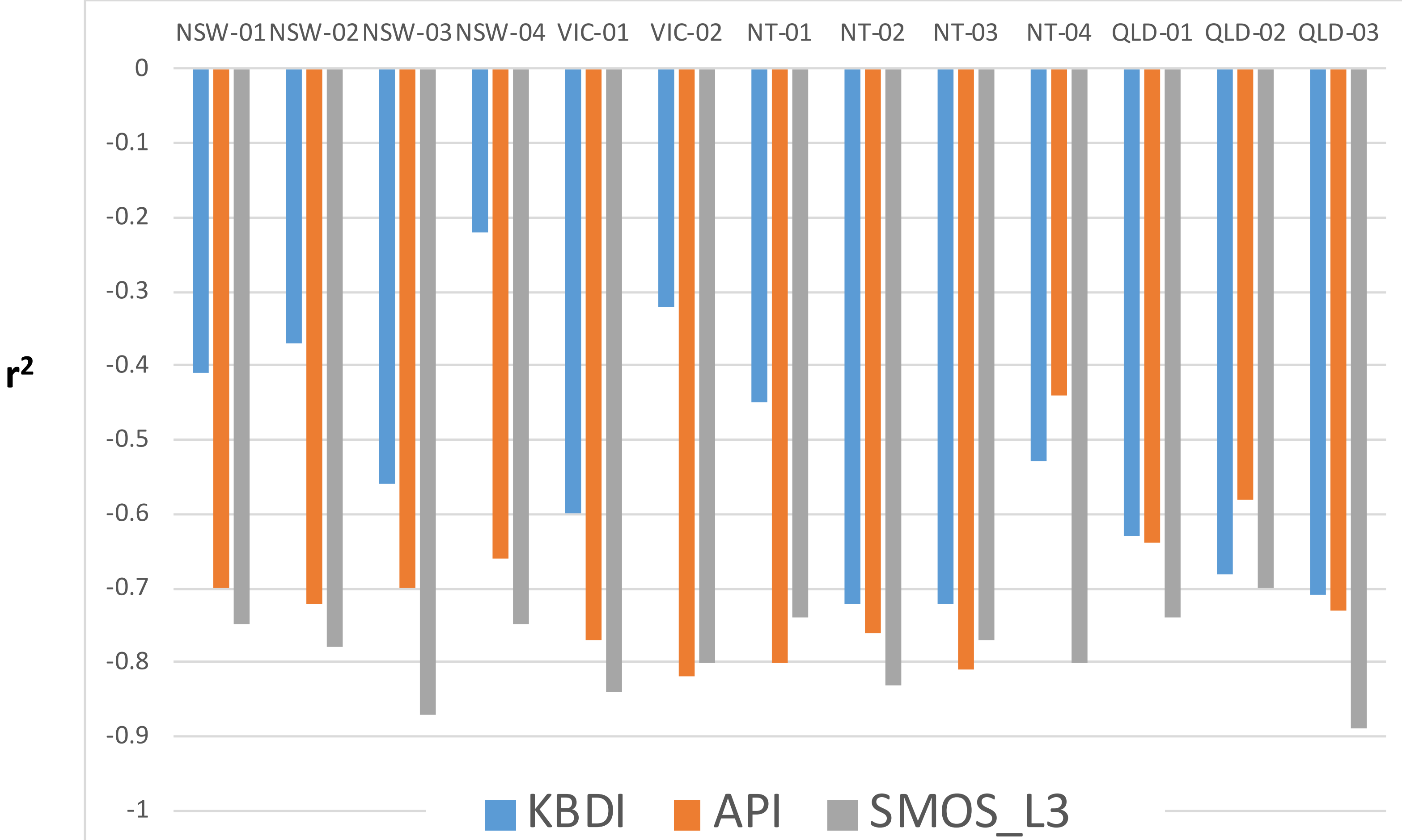
The Australian National University
Canberra, ACT

KBDI IS A RELATIVELY POOR PREDICTOR OF SOIL MOISTURE CONTENT



(2010-2013)

SUMMARIZING

1) **Better soil moisture estimates than KBDI** are freely and readily available, both from models and satellite products.

2) Replacing the KBDI with more accurate soil moisture estimates is not straightforward, as it requires **scaling of the soil moisture units**.

3) This highlights the **lack of physical basis** and interpretation for the McArthur FFDI

FUEL MOISTURE CONTENT DERIVED FROM MODIS

FUEL MOISTURE CONTENT DERIVED FROM MODIS

Model

Fuel Moisture Content based on the inversion of Radiative Transfer Models using MODIS data (Yebra et al 2008, 2009; Jurdao et al 2013a,b,c)

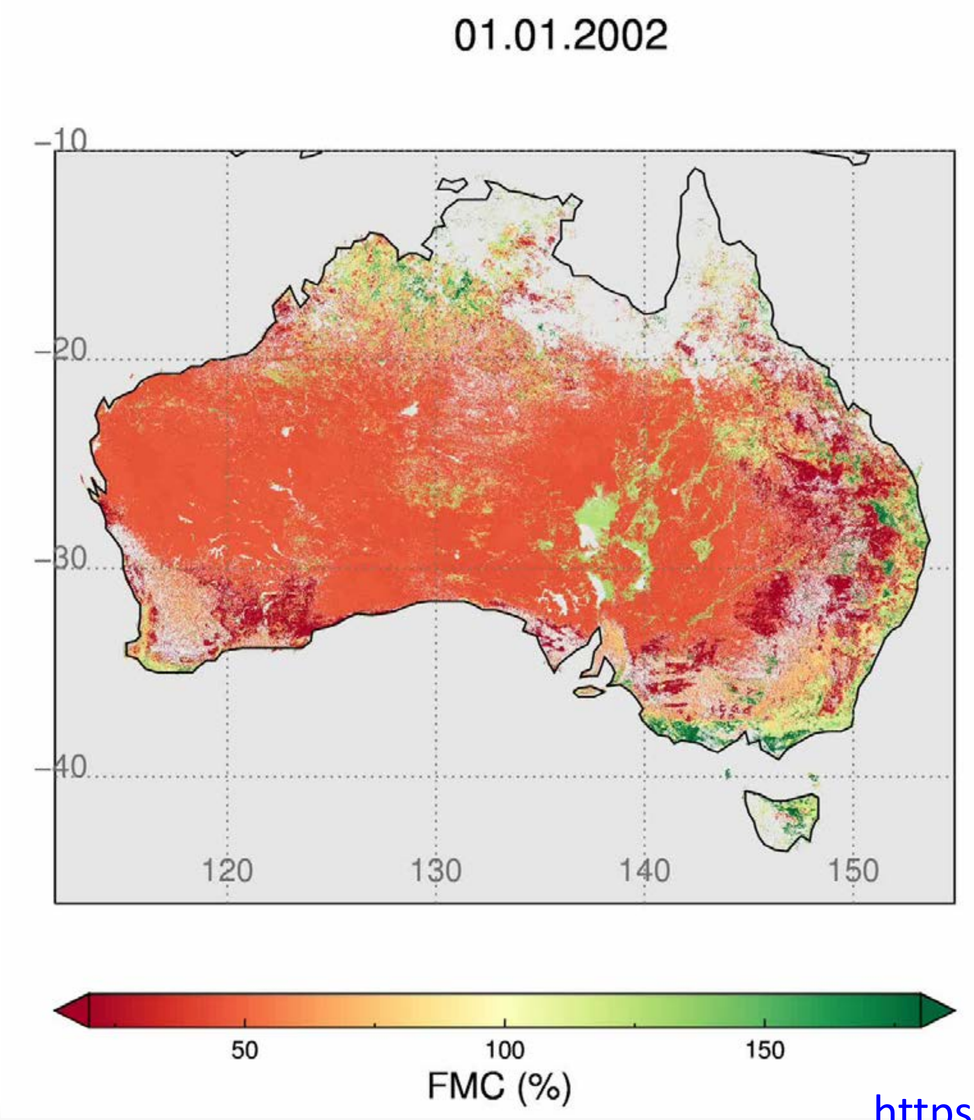
Basic data

- **500 m MODIS reflectance**, 8 days (daily)
- 250 m Dynamic Land Cover map (GA)
- Look up table

Data for **validation**:

- Grassland (Coppins Crossing+Braidwood) and woodlands (Namadgi) (2014-2015)- in collaboration with ACT Parks
- 79 sites located in NSW, ACT, VIC, QLD, WA, TAS (2006-2015) thanks to Glenn Newman, Gabrielle Caccamo, Brendan Pippen, Ross Bradstock.
- Data for the NT requested to Andrew Edwards.
- SA?

13 YEARS OF FUEL MOISTURE CONTENT



https://youtu.be/OacMUz048iI

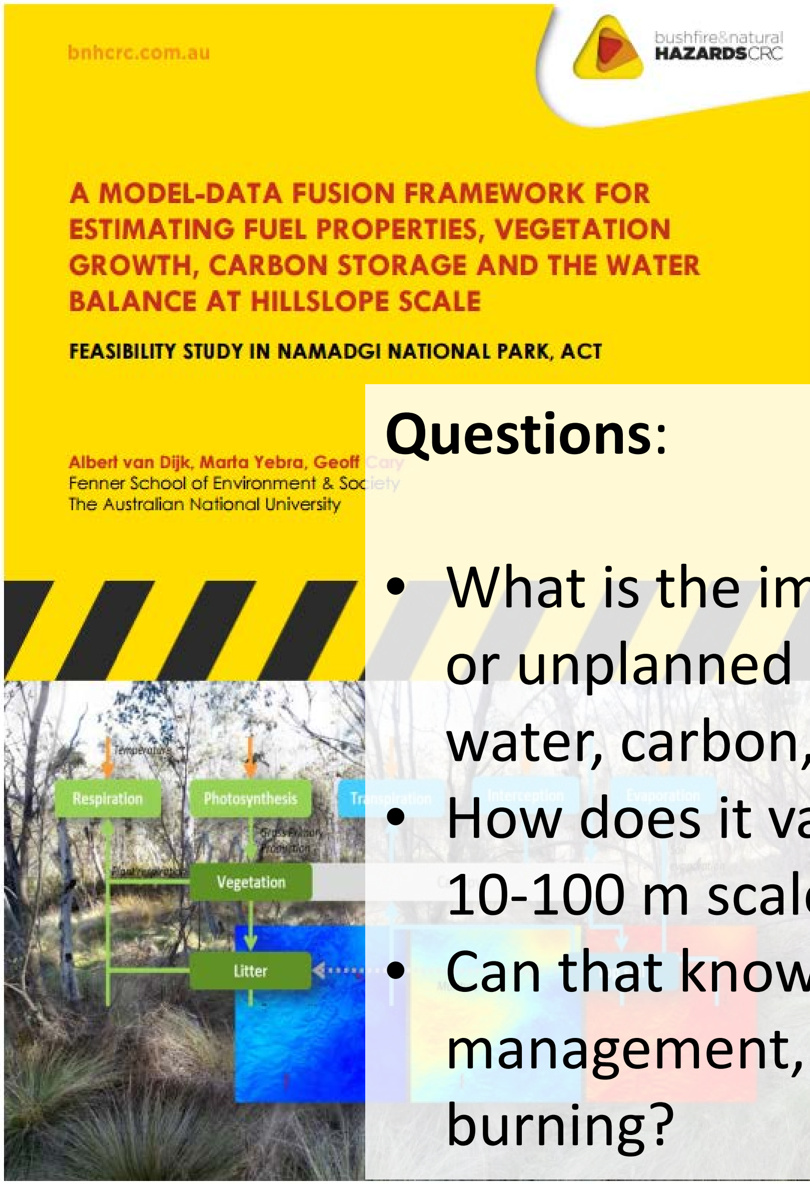
SUMARIZING

1) The first prototype of a **satellite-based Fuel Moisture Content** product for Australia at 500m resolution has been produced at 8-day intervals

2) Potential to apply it to Landsat (30m) but loosing temporal resolution (ca. 16 days at best)

3) What is more useful from an operational point of view?
   a) Absolute values
   b) Anomalies
   c) Probability of ignition (Moisture of Extinction (Chuvieco et al 2004) or logistic models (Jurdao et al 2012))
   d) Integrated in the new National FD RS based on physical parameters.

HIGH-RESOLUTION FIRE RISK AND IMPACT (HIFRI) FRAMEWORK



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journal homepage: www.elsevier.com/locate/rse

Global vegetation gross primary production estimation using satellite-derived light-use efficiency and canopy conductance

Marta Yebra [a,c,d,*], Albert I.J.M. Van Dijk [a,c,d], Ray Leuning [b], Juan Pablo Guerschman [d]

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In a previous study, Yebra, Van Dijk, Leuning, Huete, and Guerschman (2013) used eddy covariance measurements of water vapour fluxes at 16 sites distributed globally to establish relationships between G_{cw} and Moderate Resolution Imaging Spectroradiometer (MODIS) reflectance observations. When the derived estimates of G_{cw} were combined with net radiation, wind speed and humidity deficit data, the resulting estimates of evapotranspiration (ET) were compared favourably with those from alternative approaches. Moreover, the method allowed a single parameterisation for all land cover types, which avoids artefacts resulting from errors in vegetation classification. In principle, the same satellite-derived G_{cw} values can be used within a process-based model for Gross Primary Production (GPP) while providing a direct link to the coupled energy and water balance of plant canopies.

In many ecosystems, GPP is limited by the amount of absorbed photosynthetically-active radiation (APAR), rather than by canopy conductance. The simplest approach to estimating GPP for these conditions is to multiply APAR by a light-use efficiency term (LUE or ε, mol C mol^{-1} APAR) representing the plant's capacity to convert light into fixed carbon (Running, Nemani, Glassy, & Thornton, 1999; Sims et al., 2008; Sjöström et al., 2011). This approach requires maximum LUE to be

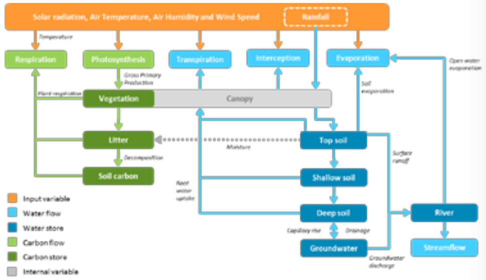
Questions:

- What is the impact of planned or unplanned burning on water, carbon, habitat?
- How does it vary in space over 10-100 m scale?
- Can that knowledge help management, e.g. prescribed burning?

HIGH-RESOLUTION FIRE RISK AND IMPACT (HIFRI) FRAMEWORK

Model

Spatial forest growth, water use and carbon uptake model based on the BoM AWRA model.



Basic data

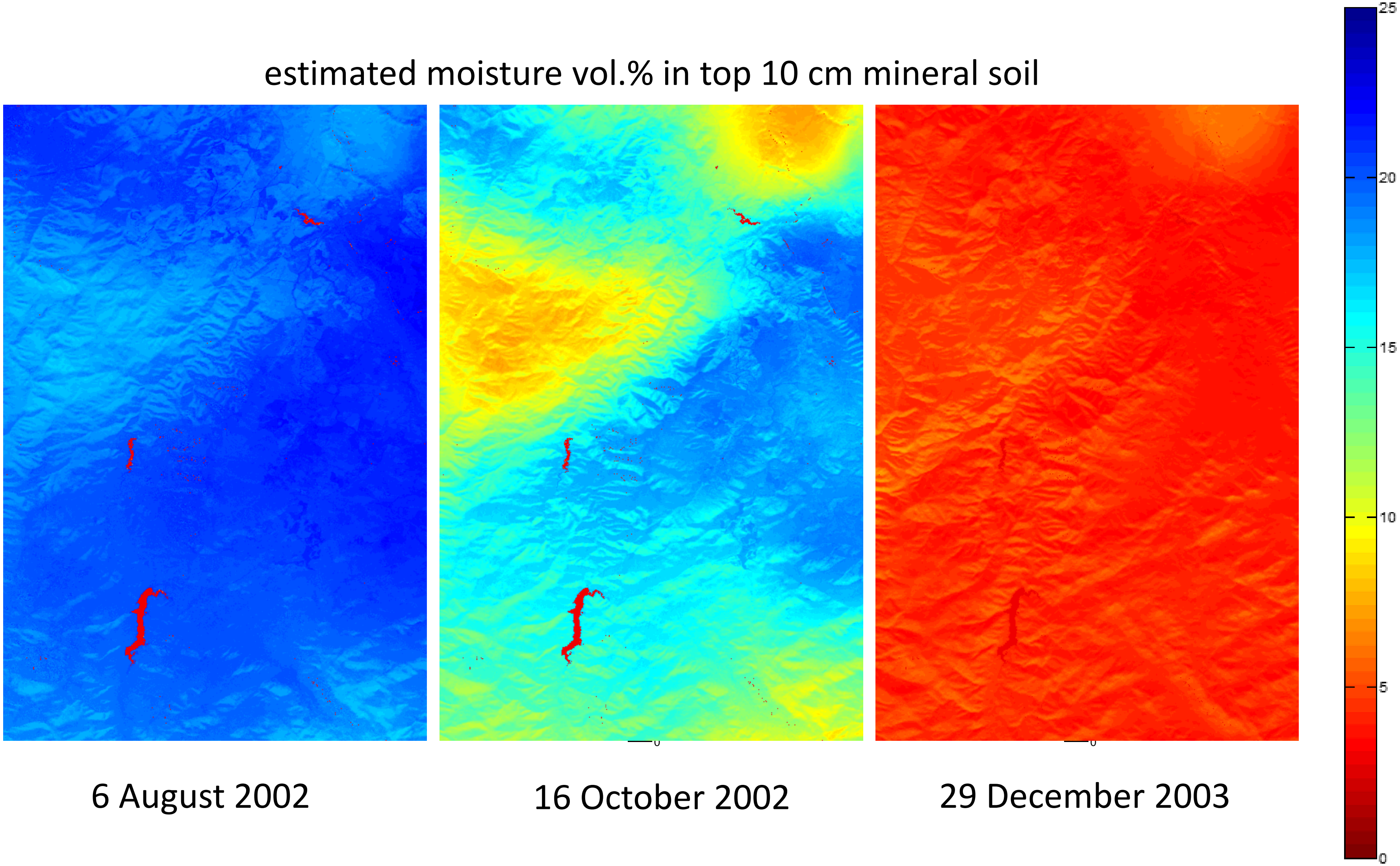
- 30m Data Cube Landsat data (vegetation)
- 1km TERN e-Mast daily precipitation and temperature
- 5km BAWAP/SILO daily short-wave radiation
- 30m relief and landscape morphology (TERN, GA)

Data for **validation** and investigation of **added value**:

- airborne LiDAR (forest structure)
- airborne hyperspectral data (canopy density, moisture)
- field measurements (vegetation and fuel attributes)
- TERN OzFlux site data @ Tumbarumba (water and carbon fluxes, vegetation structure)
- CosmOz cosmic ray sensor @ Corin Dam (large area soil moisture, micro-climate)

OUTPUT: SOIL MOISTURE PATTERNS

estimated moisture vol.% in top 10 cm mineral soil

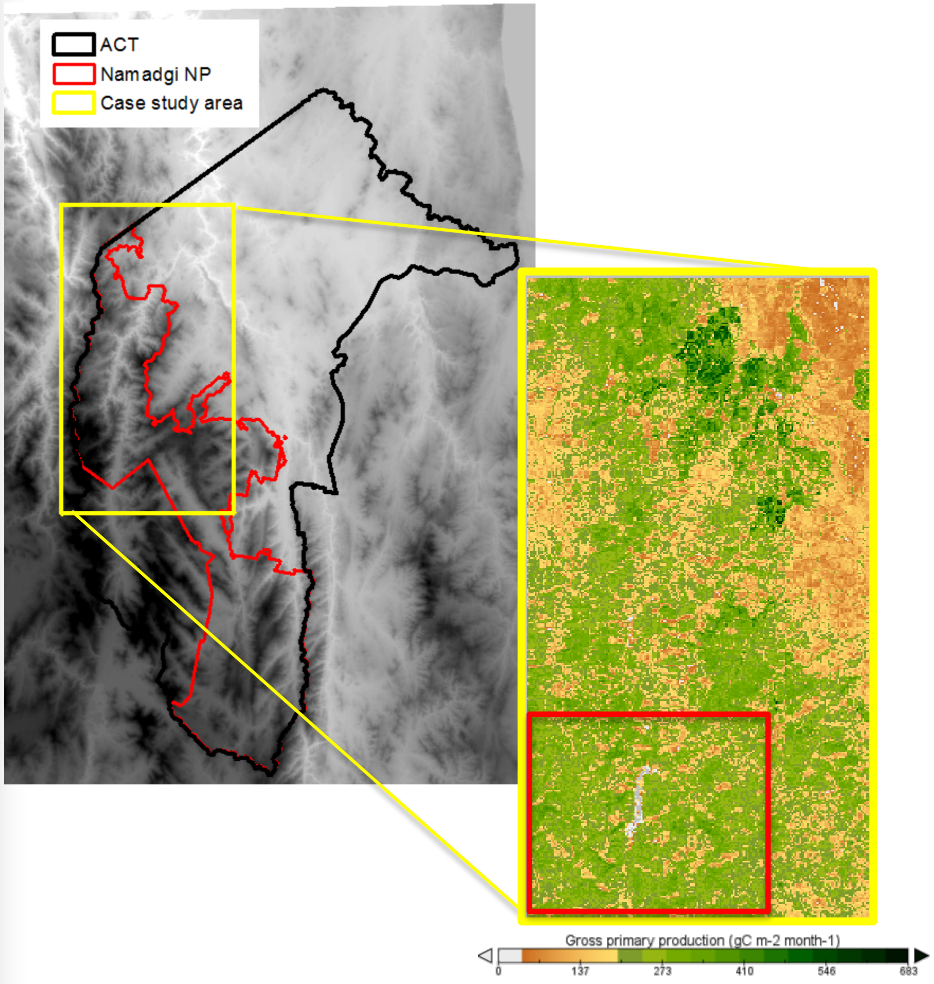


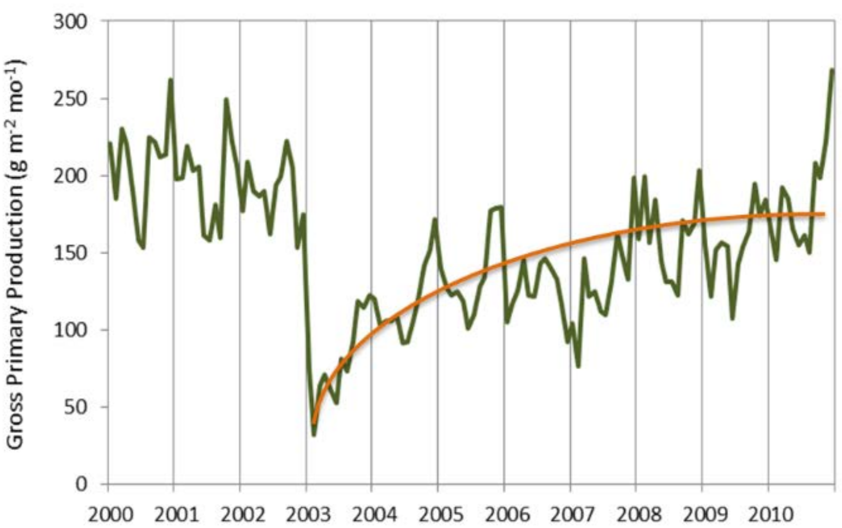
6 August 2002

16 October 2002

29 December 2003

CASE STUDY: CORIN DAM CATCHMENT





SUMMARISING

- Spatial estimates of various aspects of vegetation (fuel/carbon/biomass) and water can be generated
  - anywhere in Australia
  - at 30 m detail
  - daily time step

- What are the most useful applications? *What mapping products could you potentially see an application for?*

- Although driven by observations, it is still essentially a model, and so prediction **quality assessment** is paramount to gain confidence in the predictions.

- This can be achieved using a comprehensive range of observations :
  - vegetation, weather, water or soil
  - point-based or airborne

TAKE HOME MESSAGE

1) An algorithm has been developed to **automatically derived forest fuel structure and OFHA** from Zebedee LiDAR

2) We are testing two **integrated sensor systems** (curing sensors-COSMOS) for fire risk warning

3) Much **better soil moisture estimates than KBDI** are freely and readily available. However replacing the KBDI with more accurate soil moisture estimates is not straight forward.

4) A **satellite-based Fuel Moisture Content** product for Australia 500m resolution has been produced and can be converted into probability of ignition or integrated in the new National FD RS based on physical parameters.

5) HiFRI provides **estimates on forest fuel load and moisture content and fire impacts on landscape values** such as water resource generation and carbon storage by integrating satellite observations into an environmental model.

CURRENT PRIORITIES FOR FUTURE WORK

1) Complete documentation of outputs

2) Decide on next priorities based on end-user feedback

THANK YOU!

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