Validation of satellite derived grass curing for Western Australia

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Past Methodology (Bushfire CRC Project A1.4)

The **remote sensing component** of the Bushfire CRC Project A1.4 aimed to **develop satellite-based methods for the timely assessment of grassland curing across Australia and New Zealand**. This research makes the use of emerging satellite data products, which will ensure the relevance of the work into the future. In particular the research addresses the question of how multispectral measurements from satellite instruments such as AVHRR and MODIS may be best processed to quantitatively estimate the degree of grassland curing, and the accuracy of these curing estimates.

The steps in the approach taken were:

1. The compilation of an extensive dataset of field curing measurements collected across Australia and New Zealand over several seasons;
2. Field-based spectrometry at a limited number of sites in order to better understand changes in the reflectance spectrum of grasslands due to curing;
3. Comparison of spectral approaches such as vegetation indices to estimating curing from multispectral data on a single date;
4. **Examination of satellite time series** analysis techniques to optimise the utility of spectral techniques, evaluated using NDVI as a single reference index;
5. Evaluation of the synthesis of the recommended spectral approach with the recommended temporal approach;
6. Surveying users on their needs for the presentation and delivery of curing data products;
7. Establishment of a pilot system for the delivery of curing maps to state agencies, based on a number of test algorithms;
8. Gathering of **feedback** from end users of the curing data concerning the delivery mechanism, data format and accuracy at the regional scale;
9. Summary of feedback and the development of recommendations for an operational mapping system for grassland curing.

Objectives

- To **record** the grassland life cycle (annual and perennial grasses)
- **Validate** ground-based curing observation and satellite-derived curing data (possible satellites; MODIS, Landsat and/or Himawari)
- Investigate the **efficacy** of Spectral Reflectance Sensors NDVI Loggers and handheld multispectral cameras
- **Integrate** satellite derived curing data into Grassland Fire Danger Index

Introduction

- Grass is the most common fuel type in Australia.
- For the purpose of predicting fire spread, grasslands can be divided into five broad groups (Tropical, Tussocks, Hummock, Improved Pastures, and Crop lands)
- The process of dying and drying out is known as ***grass curing***
- Annual and Perennial grasslands in general go through an annual cycle where the plant germinates or produces new shoots, grows, flowers and dies

Annual grassland September vs December 2016

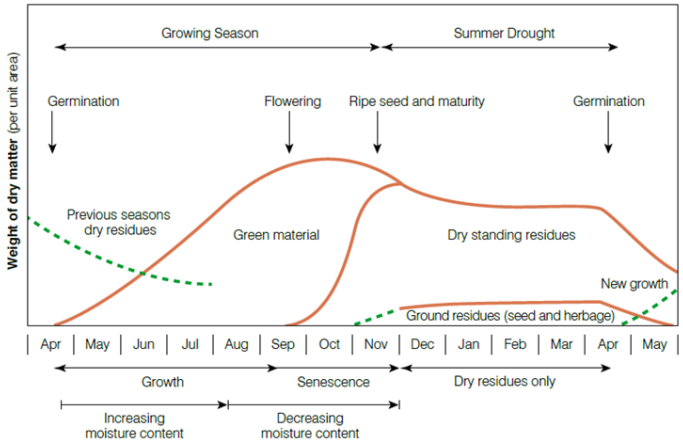
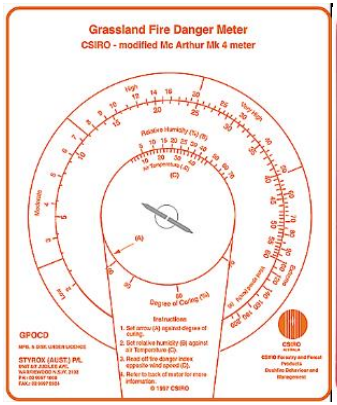


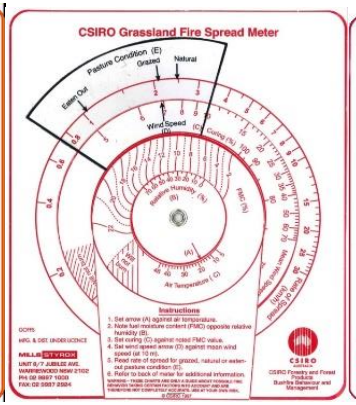
Figure 1.2 *Life cycle of annual grassland near Adelaide (South Australia) (Parrot 1964)*

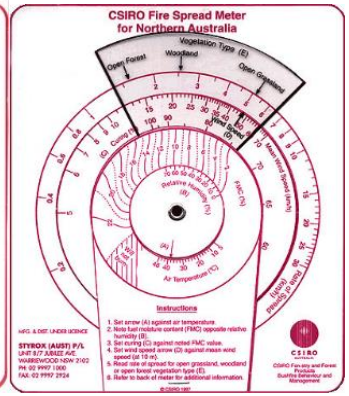
Perennial grassland September vs December 2016

Introduction

- Main Characteristics:
  - The continuity of the fuel bed > ability to spread
  - The height of the grass > flame height
  - Fuel load > fire intensity
- The ***rate*** of curing varies with grass type, soil type, soil moisture and daily evaporation. The ***state*** of curing has major effect on fire spread
- **The Grassland Fire Danger Meter** employs only one fuel variable, degree of curing. Combined with temperature, relative humidity and wind speed, this gives an index of the degree of difficulty of suppressing fire







- Previous curing ground sampling included
  - destructive sampling,
  - levy rod and
  - visual based observations,

  these methods however can be costly, time consuming, subjective and not practical over large areas

NDVI – CURING?

The Normalized Difference Vegetation Index (NDVI) is an index of plant "greenness" or photosynthetic activity.

Satellite image – 250 m resolution MODIS imagery

NDVI is an input into the Grassland Curing – Algorithm C (modified - landgate)

$$\textbf{Algorithm C} = 100 - \frac{(100 \times (NDVI - NDVImin))}{(NDVImax - NDVImin)}$$

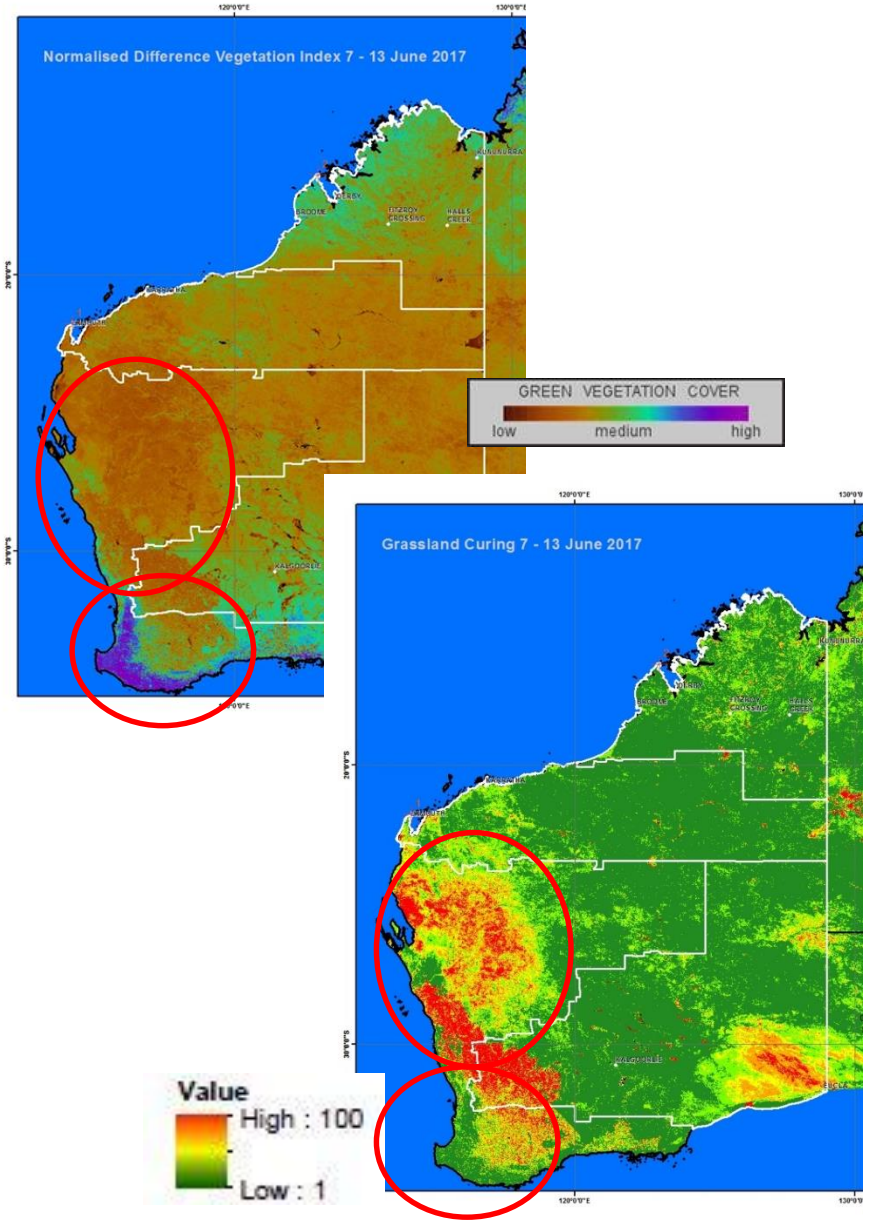
Where:

NDVI = 250 m resolution maximum value MODIS NDVI composite for the week of interest.

NDVImax = maximum detected NDVI value at a location since 2004.

NDVImin = minimum detected NDVI value at a location since 2004

Inverse relationship between NDVI and Curing



NDVI and Curing composite derived from 250m MODIS satellite images

Methodology

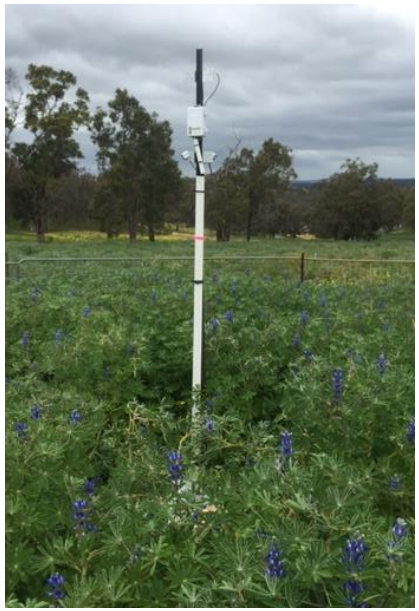
Site selection

- Relatively flat topography, majority grassland, minimum trees and livestock

Instruments include

- 3 NDVI Data loggers (Toodyay, Woodridge, and Broome)
- 10 sites for multispectral circuits, and
- **Latest MAPIR – NDVI camera**

Methodology – Data Logger

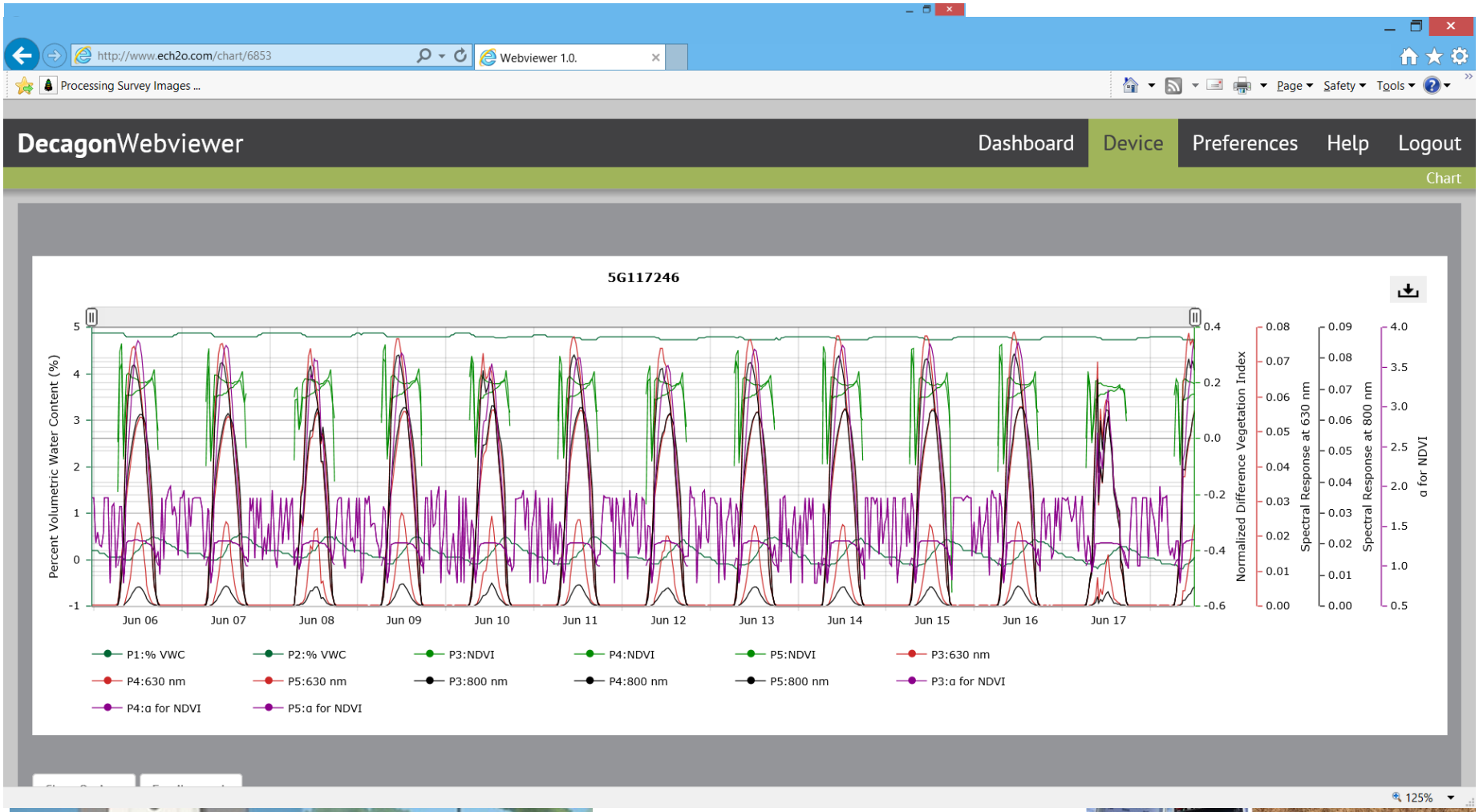


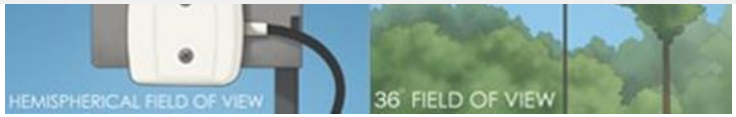
Data logger in West Toodyay

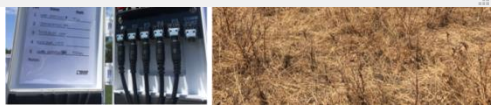
Data logger in Woodridge

Data logger in Broome

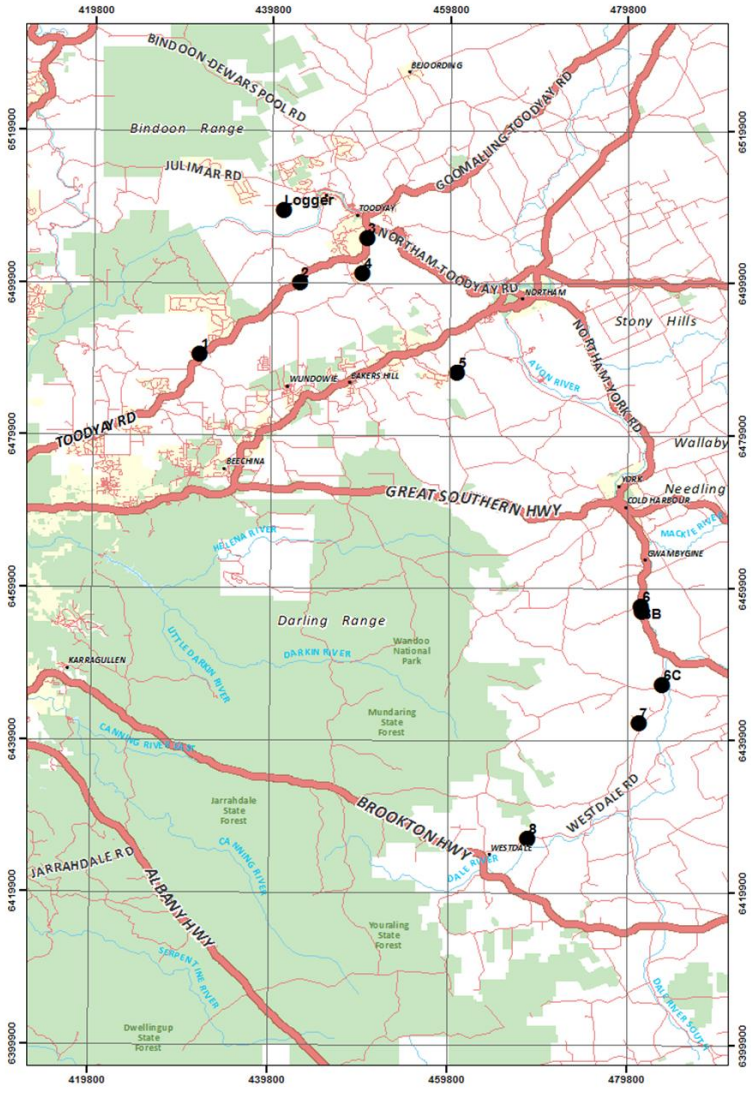
Results - Spectral Reflectance Sensor (SRS) NDVI Loggers



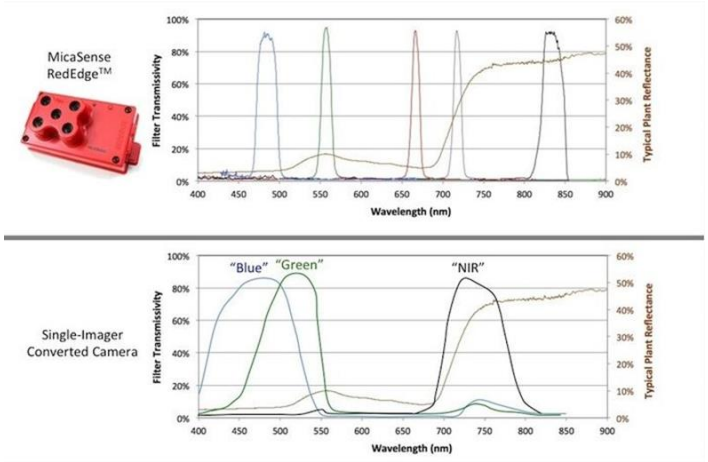




Methodology – Multispectral Camera



- 5 bands;
  - Blue (centre wavelength 475 nm)
  - Green (centre wavelength 560 nm)
  - Red (centre wavelength 668 nm)
  - Red Edge (centre wavelength 717 nm)
  - Near Infrared (centre wavelength 840 nm)
- Multispectral camera will capture grassland spectral signature approximately every 20km along the road reserve within goldfields/midlands and great southern regions, on weekly basis.
- Prior to image capture, camera will be calibrated using Calibrated Reflectance Panel. This panel is necessary to compensate for the lighting conditions at the time of image capture.



Multispectral Camera

REDEDGE RAW IMAGE BAND ORDER

IMG_0500_1.tif (Blue)

IMG_0500_2.tif (Green)

IMG_0500_3.tif (Red)

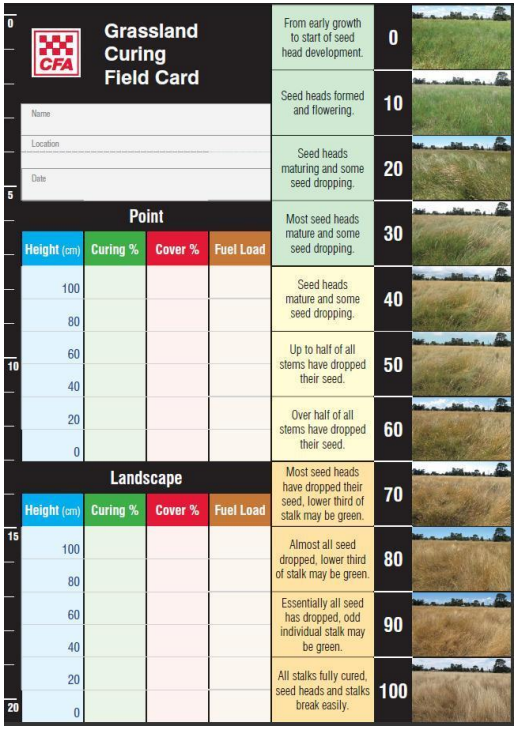
IMG_0500_4.tif **(Near Infrared)**

IMG_0500_5.tif **(Red Edge)**

13 September 2016 – Site 7

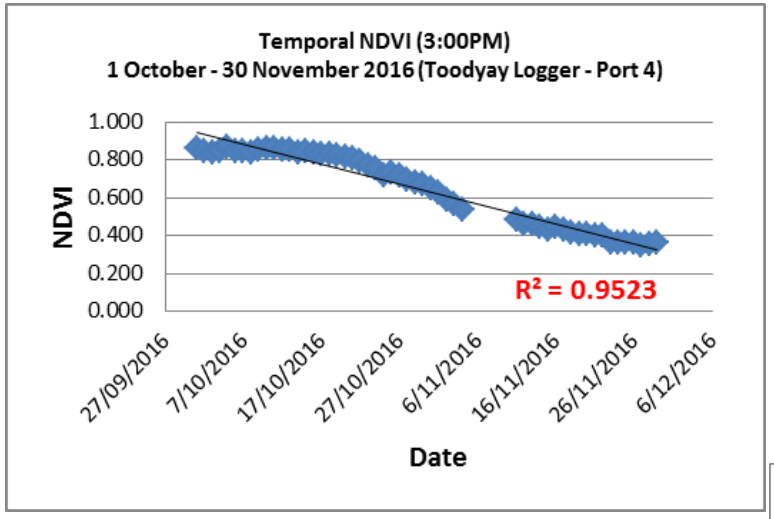
Methodology - Visual guide

13 September 2016 – Site 7



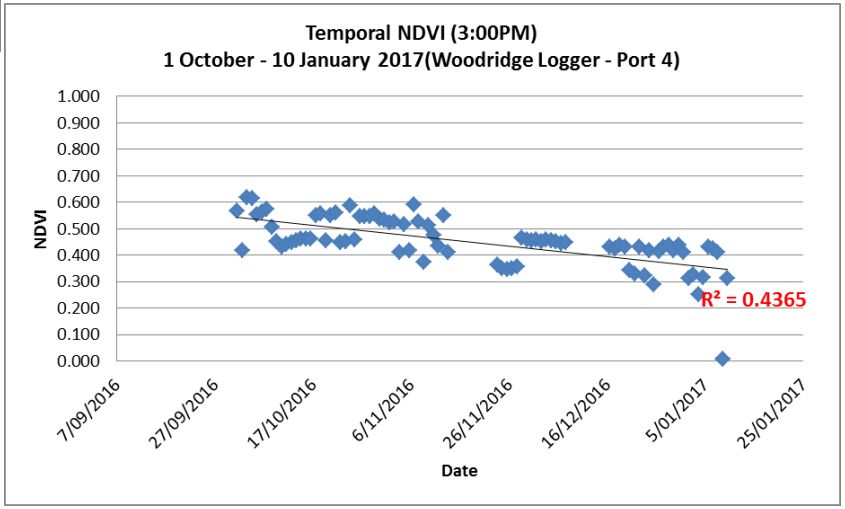
4 November 2016 – Site 7

Results – NDVI Logger



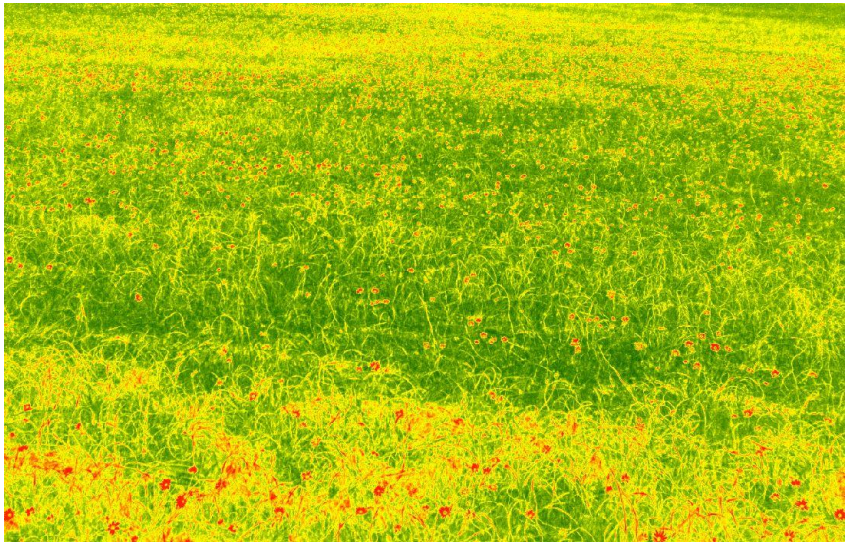
Toodyay – Annual Grass

Daytime NDVI 15:00 from September to December 2016
From SRS-NDVI Loggers



Woodridge – Perennial Grass

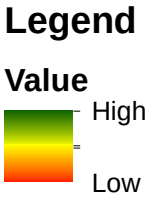
Results - Multispectral Camera (NDVI / Curing)



13 September 2016 – Site 7
NDVI = 0.7
Curing = 39

Linear regression (NDVI to curing algorithm)
= 124.71 – (121.4 x NDVI)

This algorithm assumes that the level of greenness (NDVI) varies inversely with curing



17 November 2016 – Site 7
NDVI = 0.1
Curing = 100

Results - Visual guide

13 October 2016

Results – Curing
(MODIS VS Visual Observation)

13 September 2016 (Site 1)

13 September 2016 (Site 4)

11 November 2016 (Site 4)

13 September 2016 (Site 5)

17 November 2016 (Site 1)

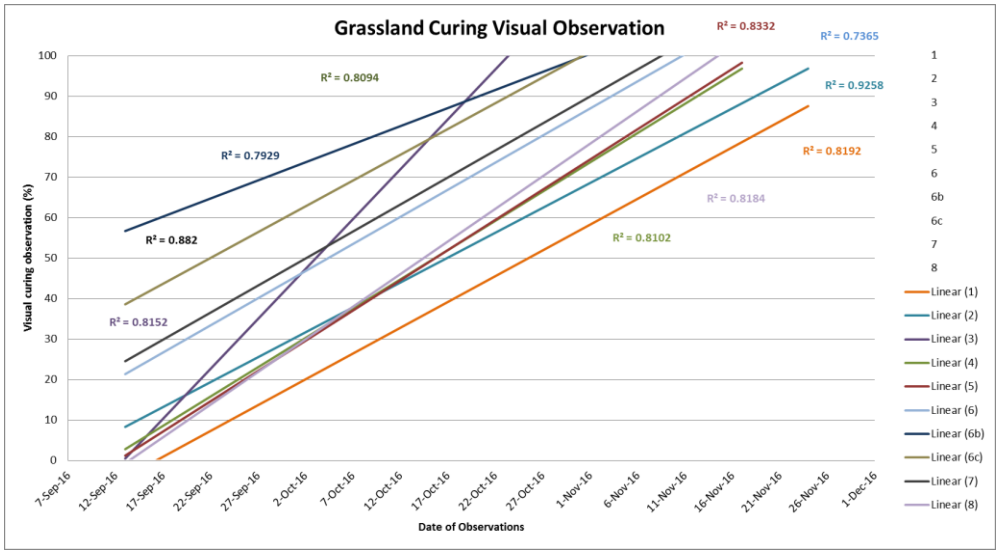
11 November 2016 (Site 5)

13 September 2016 (Site 2)

13 September 2016 (Site 6)

11 November 2016 (Site 2)

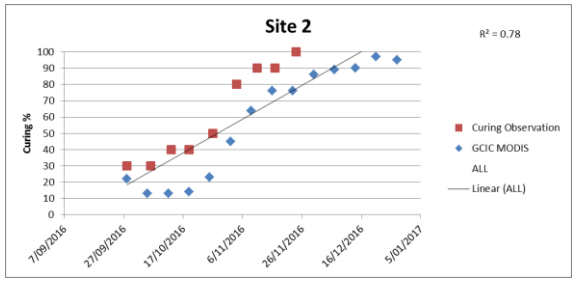
11 November 2016 (Site 6)

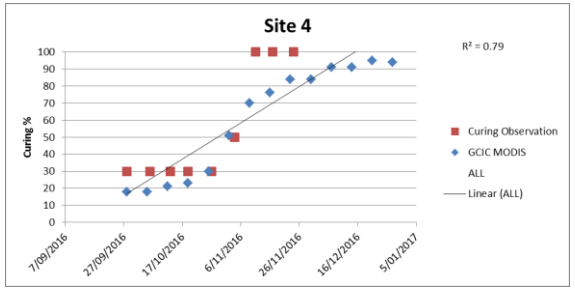


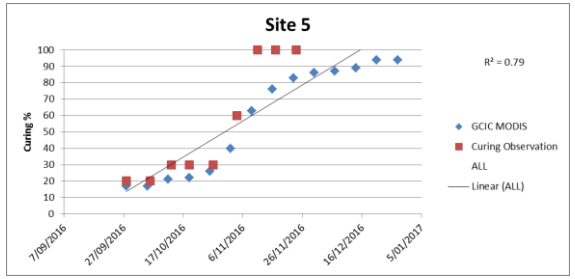
13 September 2016 (Site 6B)

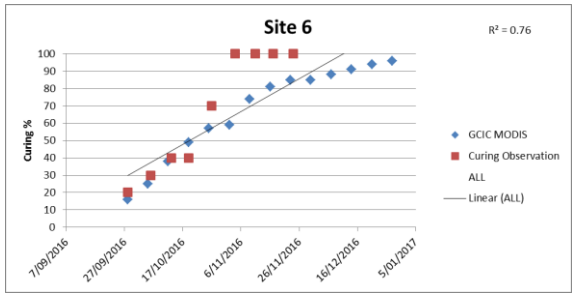
11 November 2016 (Site 6B)

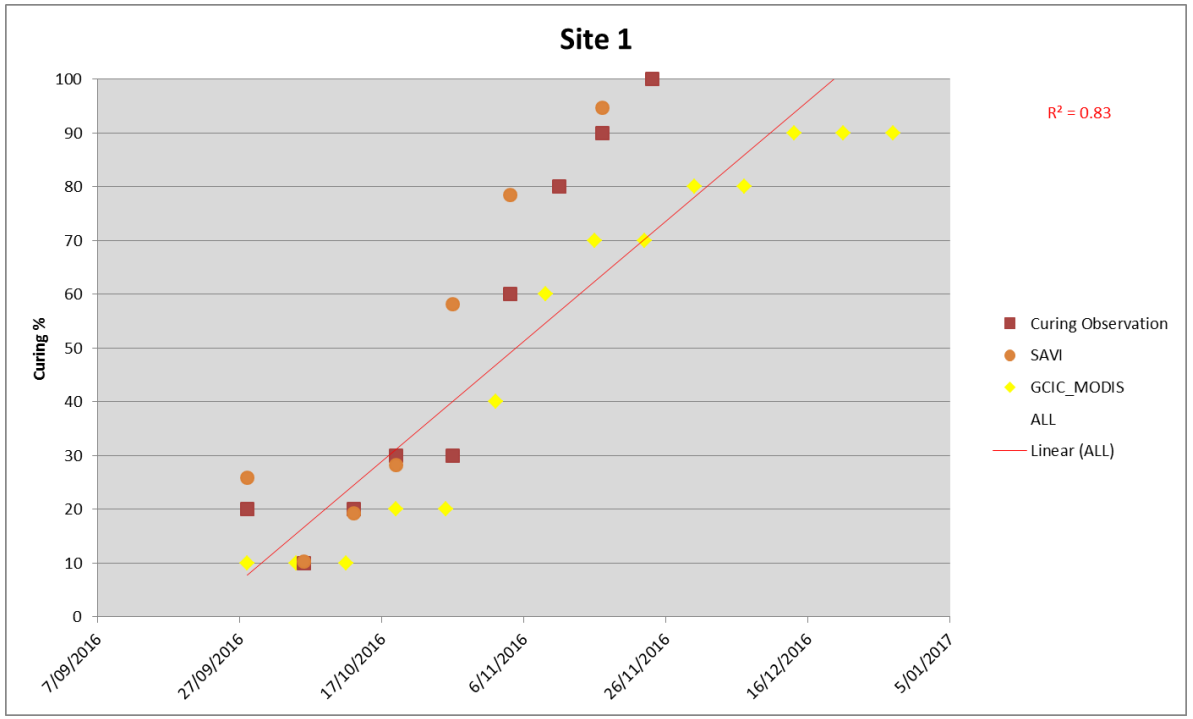
Results – Curing

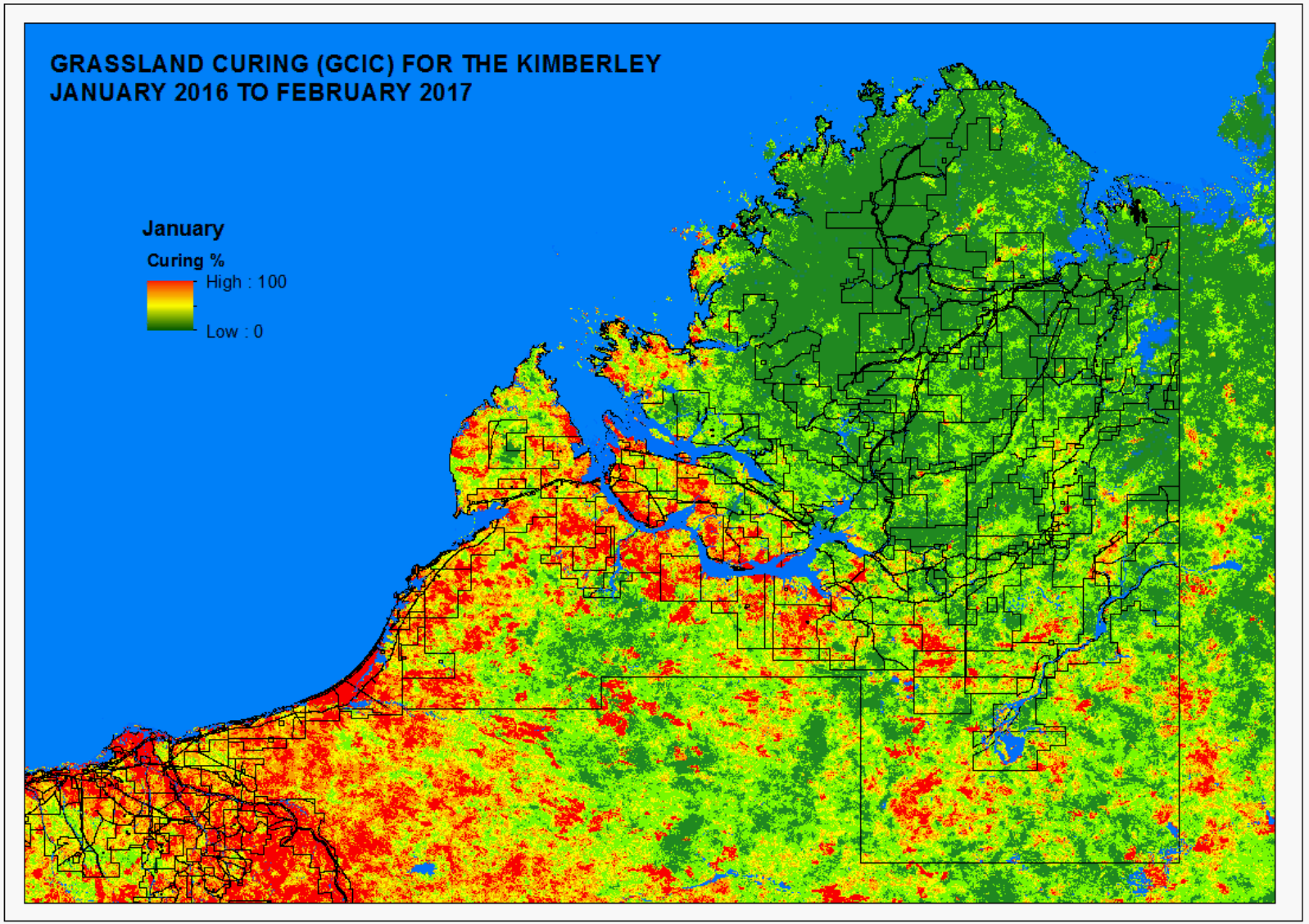




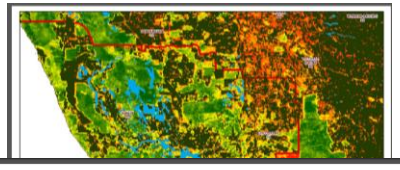


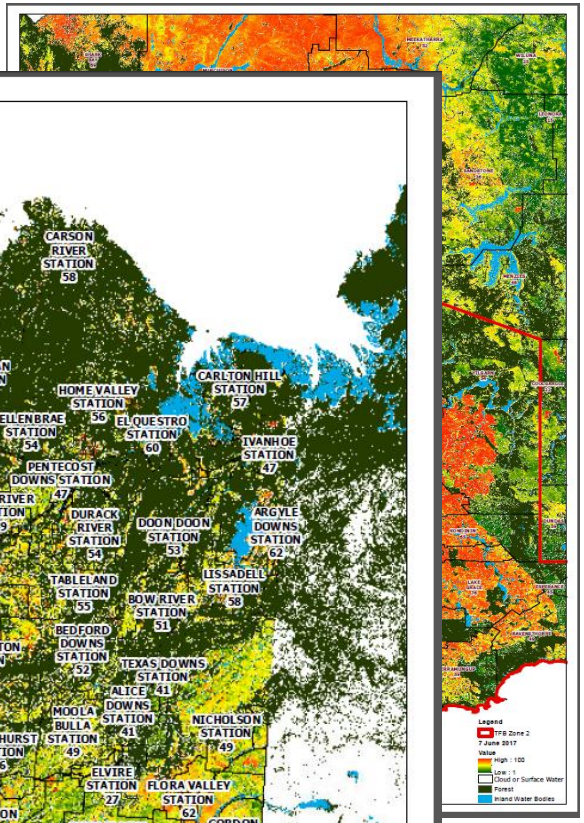





GRASSLAND CURING (GCIC) FOR THE KIMBERLEY
JANUARY 2016 TO FEBRUARY 2017
January
Curing %
High : 100
Low : 0

Products



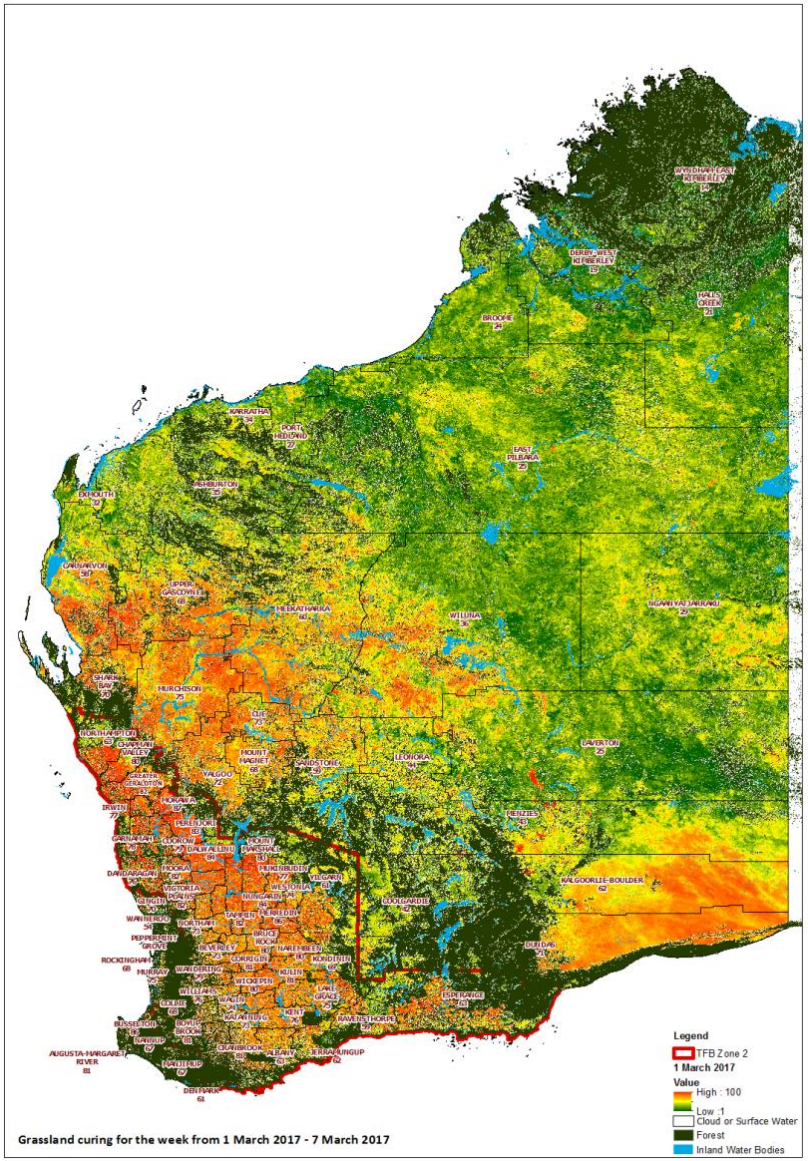


Legend
Forest
Inland Water Bodies
Wednesday 14 June 2017
Value
High : 100
Low : 1
CARSON RIVER STATION 58
THEDA STATION 71
DOONGAN STATION 68
HOME VALLEY STATION 56
CARLTON HILL STATION 57
DRYSDALE RIVER STATION 54
ELLENBRAE STATION 54
EL QUESTRO STATION 60
IVANHOE STATION 47
PENTECOST DOWNS STATION 47
MT ELIZABETH STATION 52
GIBB RIVER STATION 49
CHARNLEY RIVER STATION 55
DURACK RIVER STATION 54
DOON DOON STATION 53
ARGYLE DOWNS STATION 62
MT BARNETT STATION 67
MEDA STATION 50
MARION DOWNS STATION 56
TABLELAND STATION 55
LISSADELL STATION 58
COUNTRY DOWNS STATION 47
YEEDA STATION 49
NAPIER DOWNS STATION 51
MT HOUSE STATION 64
BOW RIVER STATION 51
MOWANJUM STATION 43
BEDFORD DOWNS STATION 52
KILTO STATION 52
MORNINGTON STATION 55
TEXAS DOWNS STATION 41
BROOME COMMON 45
ROEBUCK PLAINS STATION 50
MT ANDERSON STATION 42
BLINA STATION 50
LEOPOLD DOWNS STATION 62
BROOKING SPRINGS STATION 51
ALICE DOWNS STATION 41
LIVERINGA STATION 49
FOSSIL DOWNS STATION 61
MOOLA BULLA STATION 49
NICHOLSON STATION 49
THANGOO STATION 40
DAMPIER DOWNS STATION 34
MYRODDAH STATION 39
JUBILEE DOWNS STATION 58
MT AMHURST STATION 46
MT PIERRE STATION 57
FRAZIER DOWNS STATION 37
KALYEEDA STATION 50
CHRISTMAS CREEK STATION 57
ELVIRE STATION 27
FLORA VALLEY STATION 62
MOWLA BLUFF STATION 20
NERRIMA STATION 45
GOGO STATION 50
LOUISA DOWNS STATION 50
RUBY PLAINS STATION 34
GORDON DOWNS STATION 45
MILLIJIDEE STATION 37
BULKA STATION 37
LAMBOO STATION 33
NITA DOWNS STATION 37
CHERRABUN STATION 45
LARRAWA STATION 35
STURT CREEK STATION 38
MANDORA STATION 56
ANNA PLAINS STATION 49
MADIGAN STATION 35
CARRANYA STATION 32
DE GREY STATION 49
WALLAL DOWNS STATION 37
BILLILUNA STATION 45
PARDOO STATION 31
STRELLEY STATION 39
LAKE GREGORY STATION 51
BOODARIE STATION 46
COONGAN STATION 34
MUCCAN STATION 44
INDEE STATION 26
EGINBAH STATION 37
YARRIE STATION 41
WARRAWAGINE STATION 45
MALLINA STATION 56
KANGAN STATION 33
PANORAMA STATION 45
CORUNNA DOWNS STATION 38
HOOLEY STATION 53
Grassland

Future work

While the efficacy of the NDVI loggers and multispectral camera has been achieved and MODIS weekly composite GCIC curing validated, there are a few areas that can be improved:

- Extend quantitative ground measurement to northern part of Western Australia,
- Modify the curing input, NDVI weekly composite derived from MODIS images to 50th or 75th percentile or real-time data instead of maximum NDVI and continuing with masking and updating “persistent green” and water bodies
- Derivation of NDVI from geostationary satellite Himawari-8, which is updated every 10 minutes and targeting daytime NDVI values (around 13:00) to produce curing



Grassland curing for the week from 1 March 2017 - 7 March 2017

Seeking endorsement for regular informal feed back from Regions via email to environment@dfes.wa.gov.au on:

- The performance of the maps for decision support, noting that the average value is given for a whole local government area,
- The ability of the index colours to identify distinct areas as higher or lower curing values (Aurora / FESMaps)

Questions