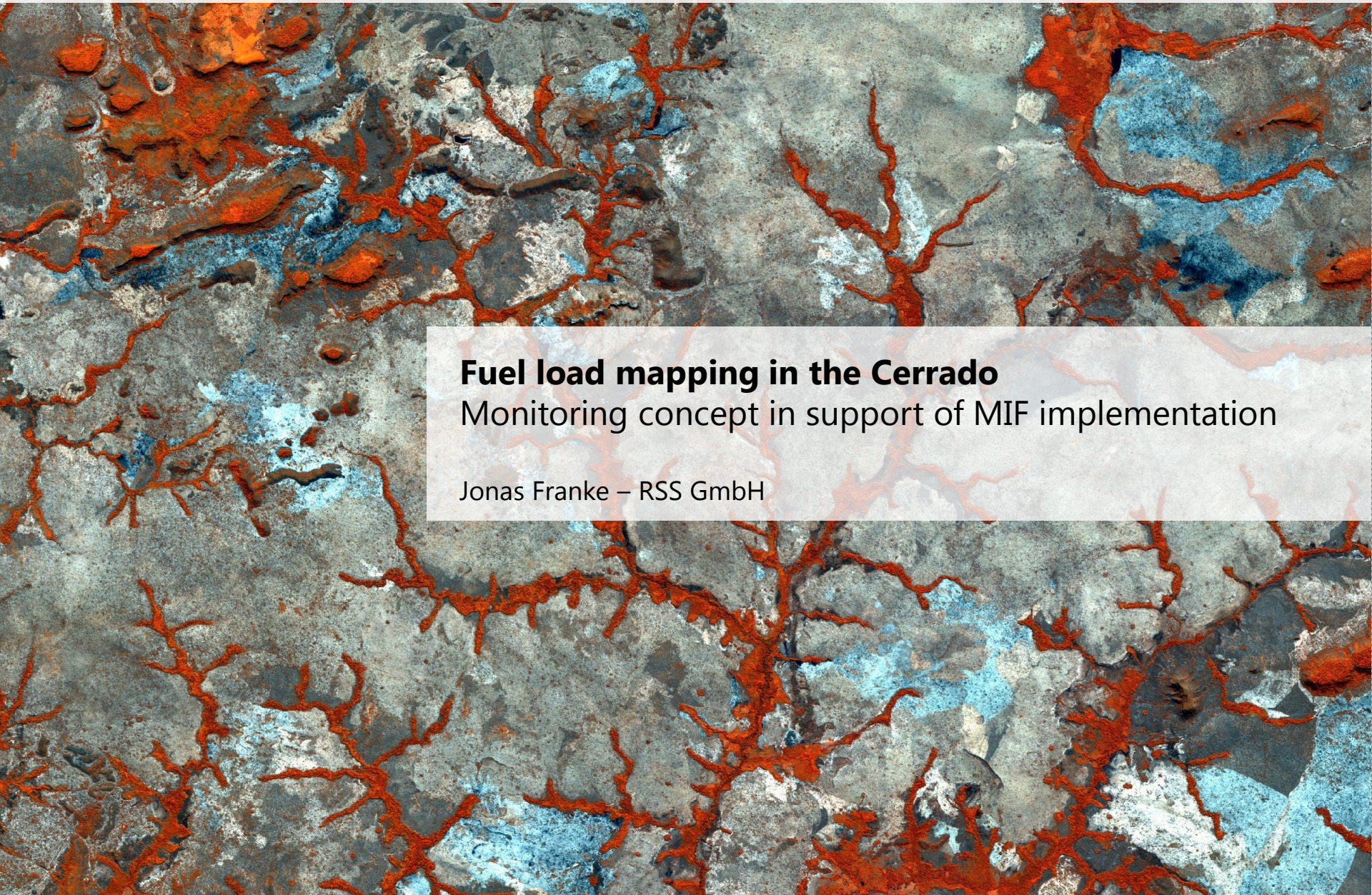


Fuel load mapping in the Cerrado

Monitoring concept in support of MIF implementation

Jonas Franke – RSS GmbH

Prevention, Control and Monitoring of Fires in the Cerrado


Photo: C. Moreira

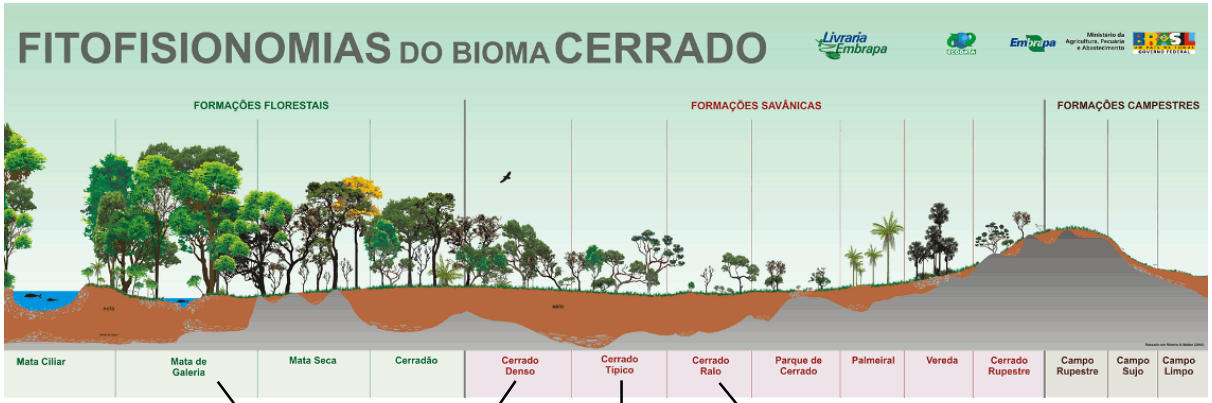

Photo: V. Oliveira


Photo: L. Milano/ICMBio

Cerrado

- **Most biodiverse savannah in the world,** containing **5% global biodiversity**
- **2nd largest biome in South America**, occupying almost 25% of the Brazilian territory
- **Globally significant carbon sink**
- **Brazil's agricultural reserve**, responsible for more than 50% of agricultural production
- Responsible for **40% CO_2 emissions** resulting from changes in land use in Brazil

Cerrado types and their biomass ranges



Source: www.wwf.org.br

>130 t/ha

29.9–71.9 t/ha*

20.9–58.0 t/ha*

12.6–39.1 t/ha*

3.8–16.6 t/ha*

*Ottmar et al. (2001): Stereo Photo Series for Quantifying Cerrado Fuels in Central Brazil – Volume I

Photos: J. Franke

Prevention, Control and Monitoring of Fires in the Cerrado

Prevention

- Participative protected area management
- Environmental education
- Alternatives to the use of fire
- Fuel management (early/prescribed burning)

Preparedness & Suppression

- Training brigades and managers
- Operation & Protection Plans
- Fire breaks
- Equipment

Biodiversity conservation and climate protection

Monitoring

- Burned area
- GHG emissions
- Deforestation
- Vegetation structure

Research

- Fire ecology
- Impact of fire (management) on biodiversity
- Impact of fire (management) on biomass and climate

Prevention, Control and Monitoring of Fires in the Cerrado

Integrated Fire Management (IFM)


Photo: V. Oliveira

Fragmenting larger areas by creating a network of fire breaks or by creating patches of burned areas

- Reduces the areas affected by high-intensity fires
- Facilitates fire suppression
- Provides habitat for small mammals in fragments


Photo: L. Milano/ICMBio

Applying low-intensity, early burning practices to avoid late season, high-intensity fires results in

- Reduced loss of biomass (greater carbon stock)
- Reduced GHG emissions and promotes biodiversity

Early burning


Photo: C. Baringo Fonseca

- Low-intensity fires
- Low impact biodiversity
- Reduce fuel load to avoid late season, high-intensity burning
- Low risk of dispersion

Late burning

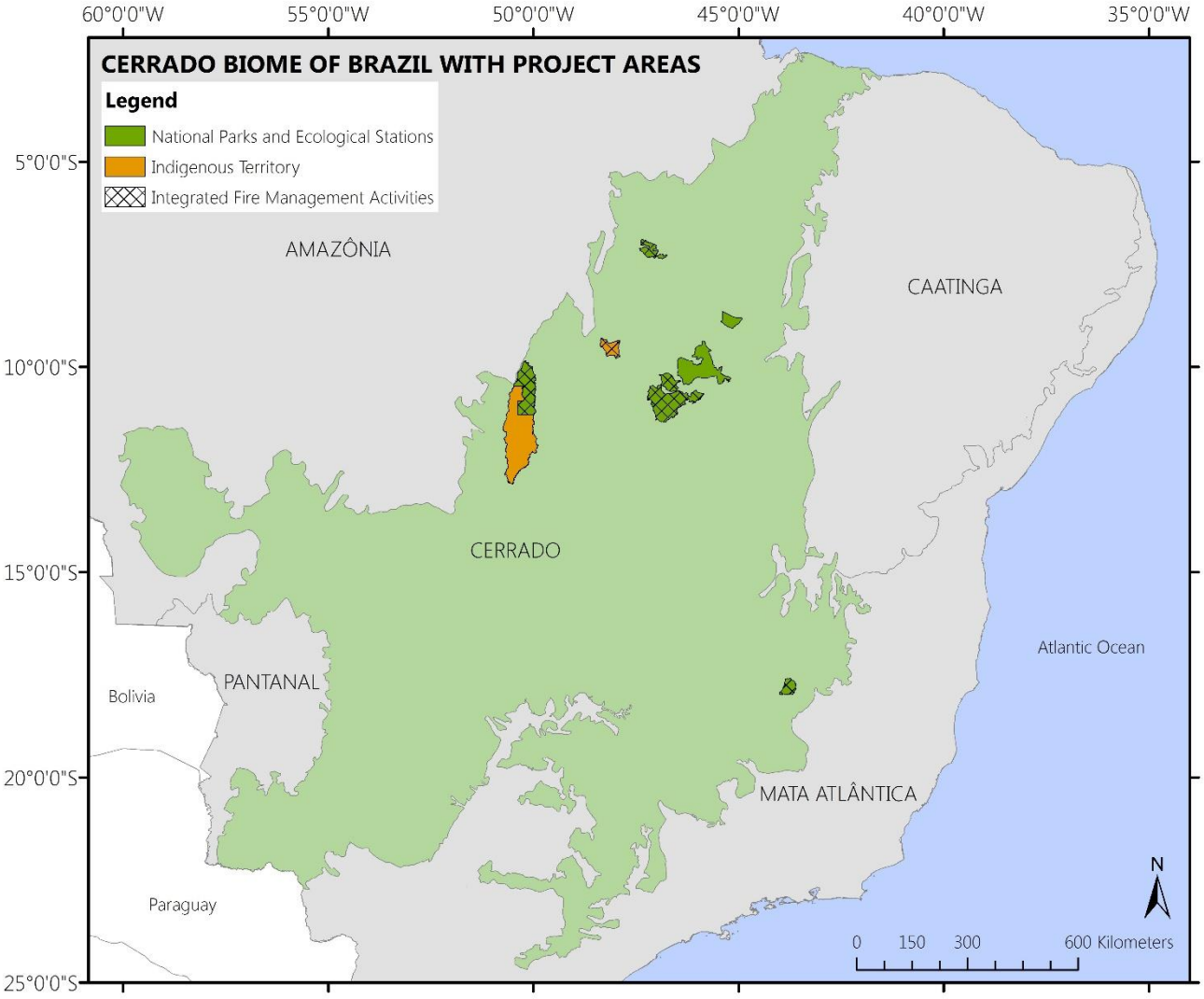

Photo: C. Barradas/ICMBio

- High-intensity fires
- Damaging for biodiversity
- Greater loss of biomass
- High risk of dispersion; difficult to contain

Planning and implementation of IFM and prescribed burning activities require information on the distribution and amount of fuel loads

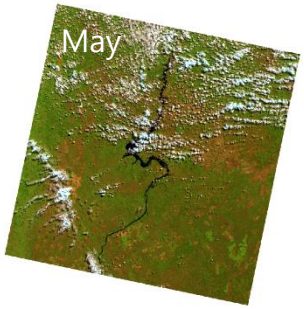
Prevention, Control and Monitoring of Fires in the Cerrado

Pilot areas



How to support MIF through remote sensing?

„Early dry season" image
Landsat 8

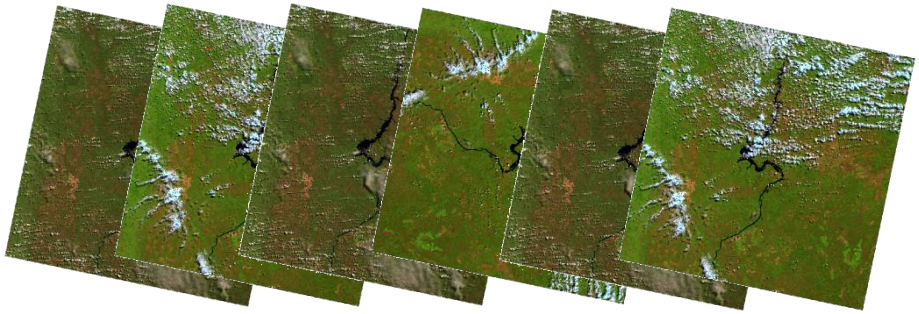


Spectral Mixture Analysis (RSS)

Estimation of dry biomass (Fuel load maps)

Basis for planning of controlled fires

Monitoring of fires in the dry season
16 days cycle of Landsat



Interpretation of time series (Park Managers)

Updated information on fire locations and burned areas

Monitoring of controlled- and wildfires

„Late dry season" Image
Landsat 8

Spectral Mixture Analysis (RSS)

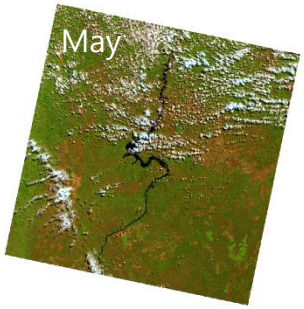
Estimation of dry biomass (Fuel load maps)

Evaluation of MIF and planning of next year

April | May | June | July | Aug | Sep | Oct

How to support MIF through remote sensing?

„Early dry season“ image
Landsat 8



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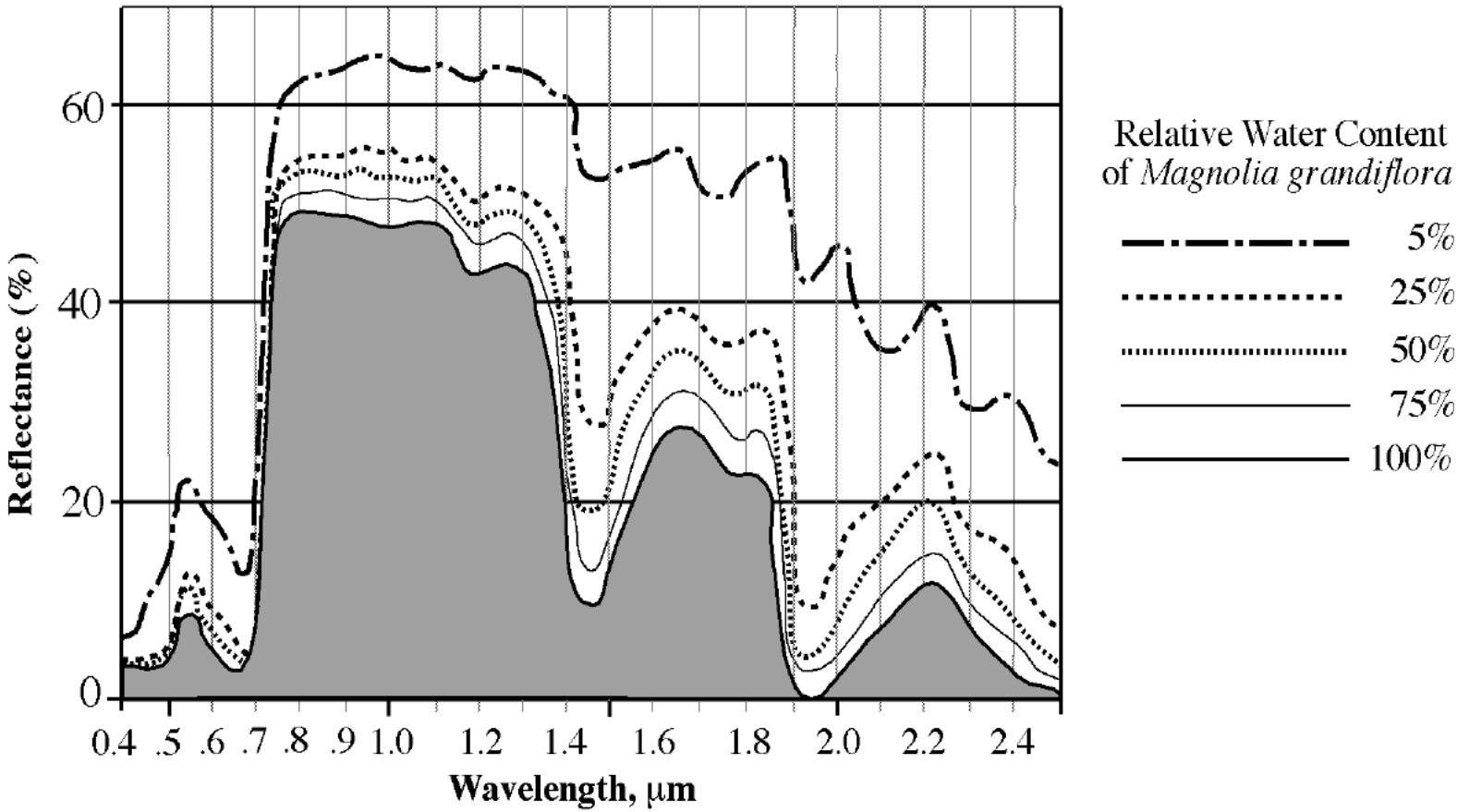
Leaf optical properties

Leaf's spectral response to reduced water content

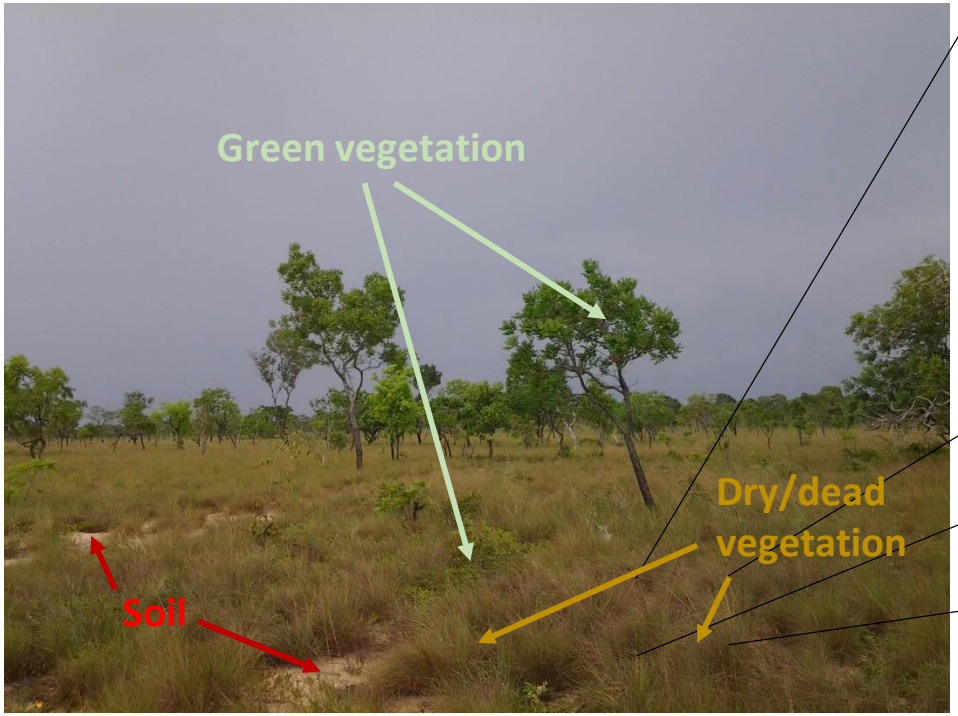


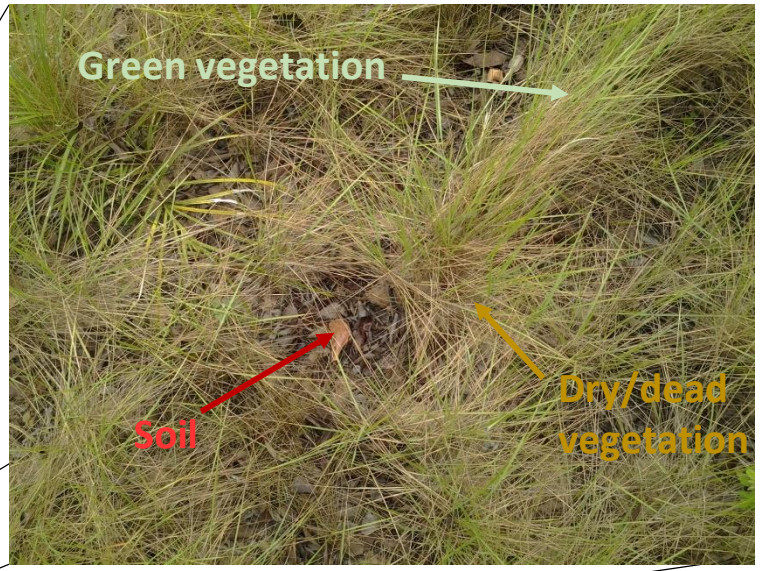
Source: Jensen (2007)

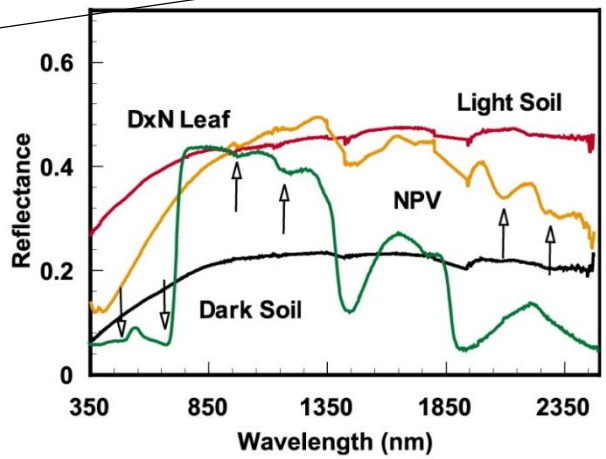
Estimation of dry biomass – fuel load mapping

Cerrado consists mainly of three spectral components:

- Green vegetation
- Dry/dead vegetation
- Soil



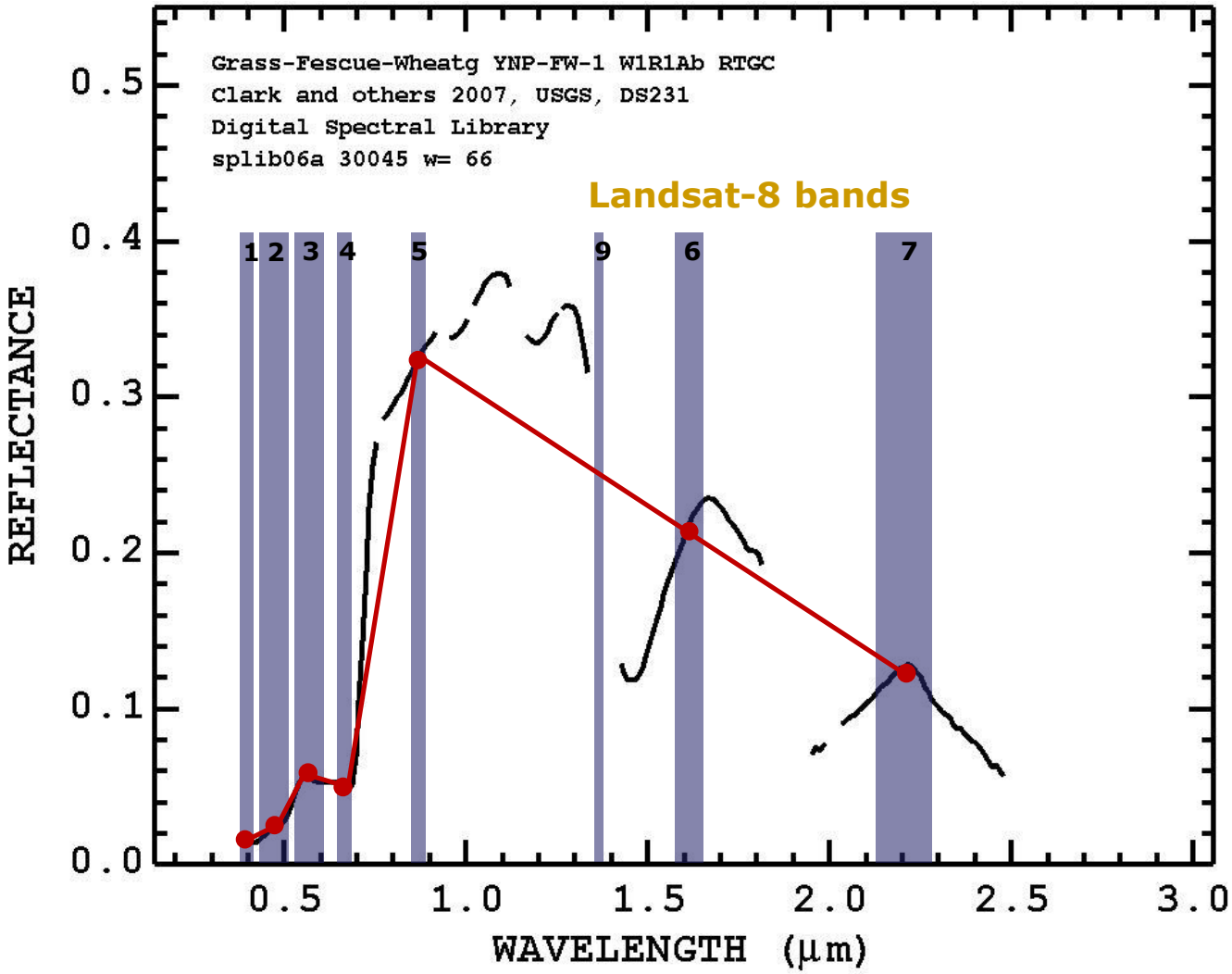




→ Mixed Pixel Problem

Spectral Signatures / Endmembers

Spectral signature from the USGS spectral library: example grass



Source: http://speclab.cr.usgs.gov/spectral.lib06/ds231/datatable.html

Spectral Signatures / Endmembers

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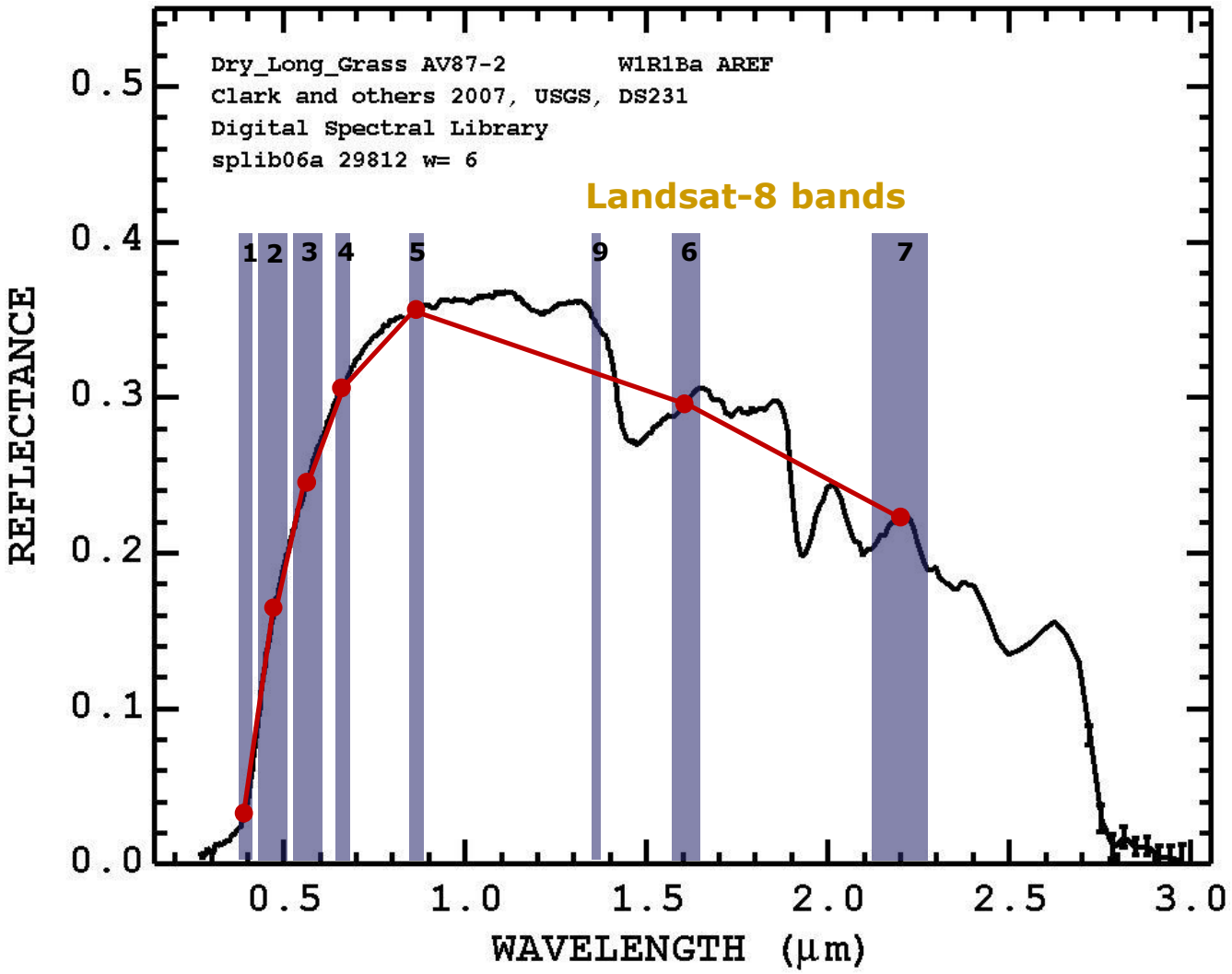


Source: http://speclab.cr.usgs.gov/spectral.lib06/ds231/datatable.html

Spectral Mixture Analysis

- Is an advanced image exploitation tool designed to detect materials that are smaller than an image pixel
- It adresses the „mixed pixel problem“

Advantages:

- Identifies objects/materials that are smaller than the spectral resolution of the sensor
- Identifies specific materials in mixed pixels
- Can be used for many types of applications
- Scene-to-scene transferable spectral signature
- It can detect and identify materials covering an area as small as 20% of a pixel

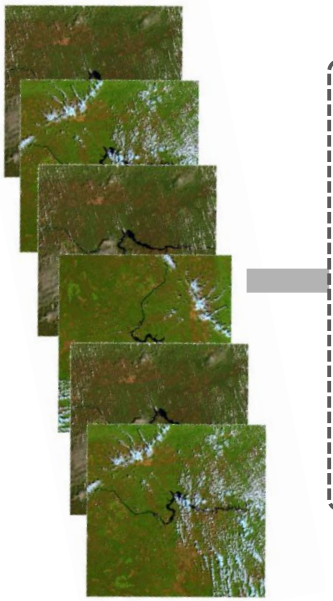
Mixture Tuned Matched Filtering (MTMF)

- MTMF only needs one defined endmember spectrum
- It is a partial unmixing, in which the known signature is matched by a matched filter calculation
- The MTMF required a minimum noise fraction transformed image and a MNF-transformed endmember spectrum
- Result is a grey-scales matched filtering fraction image (with physical meaning) representing the estimated relative degree to which each pixel machted the reference spectrum
- Additionally a grey-scale infeasibility image generated by a mixture tuning calculation, which estimates the likelihood that a pixel, in spite of its high MF-fraction values represents unknown endmembers

➔ Low infeasibility values and with high fraction values indicate a good endmember match

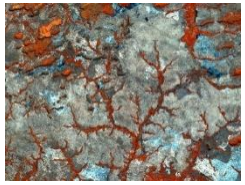
Methodology

Landsat-8 time series
Jan. 2014 to March 2015 (14/28)
All images with <50% cloud cover



ATM correction

High-resolution RapidEye image



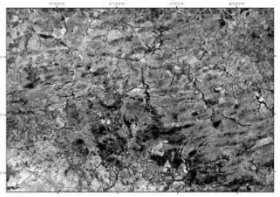
Endmember Selection (GV, NPV, Soil)

MNF Transformation

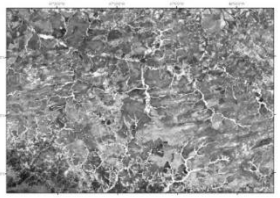
Mixture Tuned Matched Filtering

Matched Fraction Images

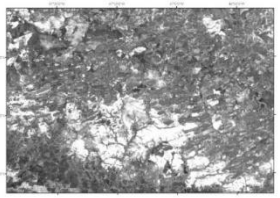
Dry veg (NPV)



GV



Soil

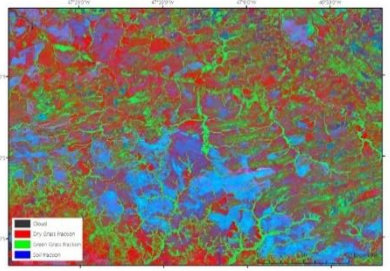


R

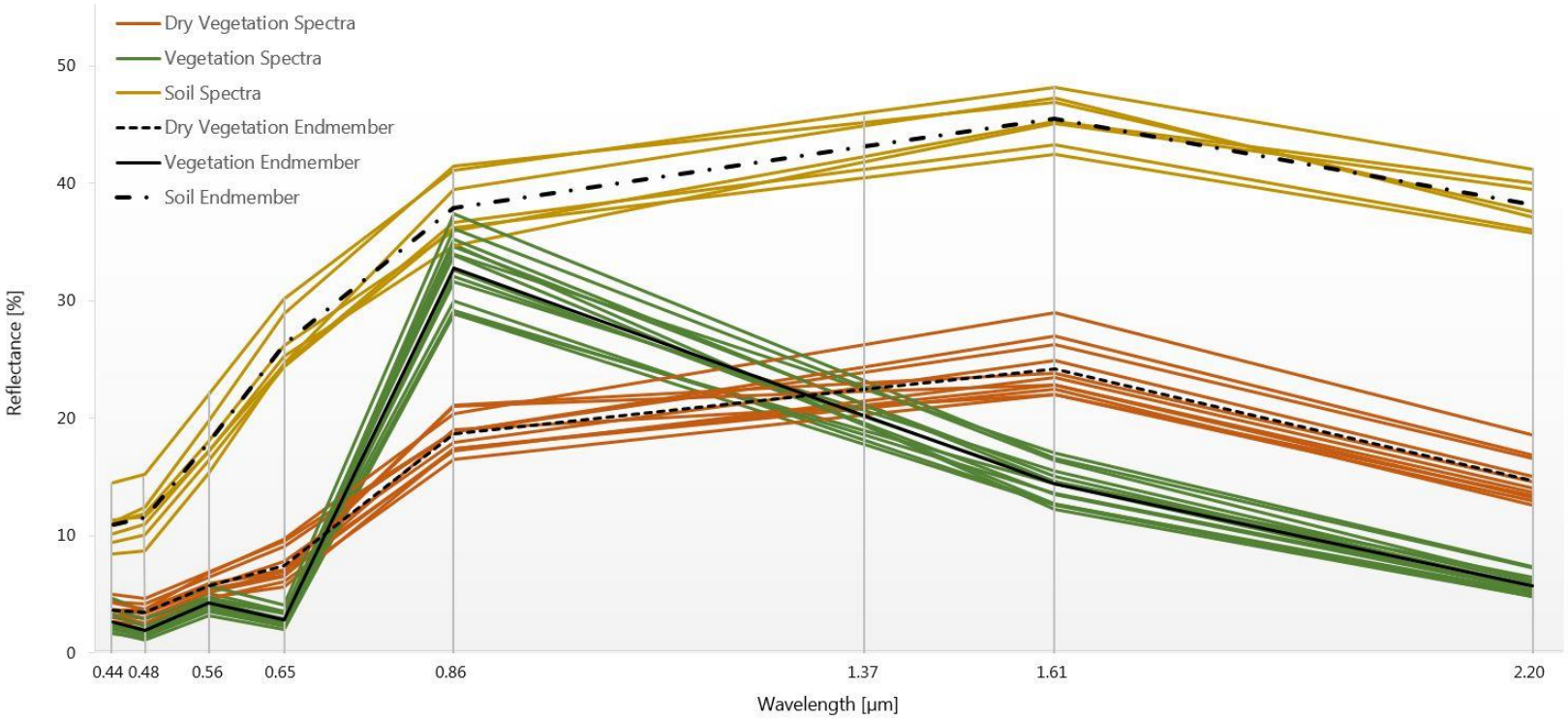
G

B

Fuel Load Maps



Endmember Selection

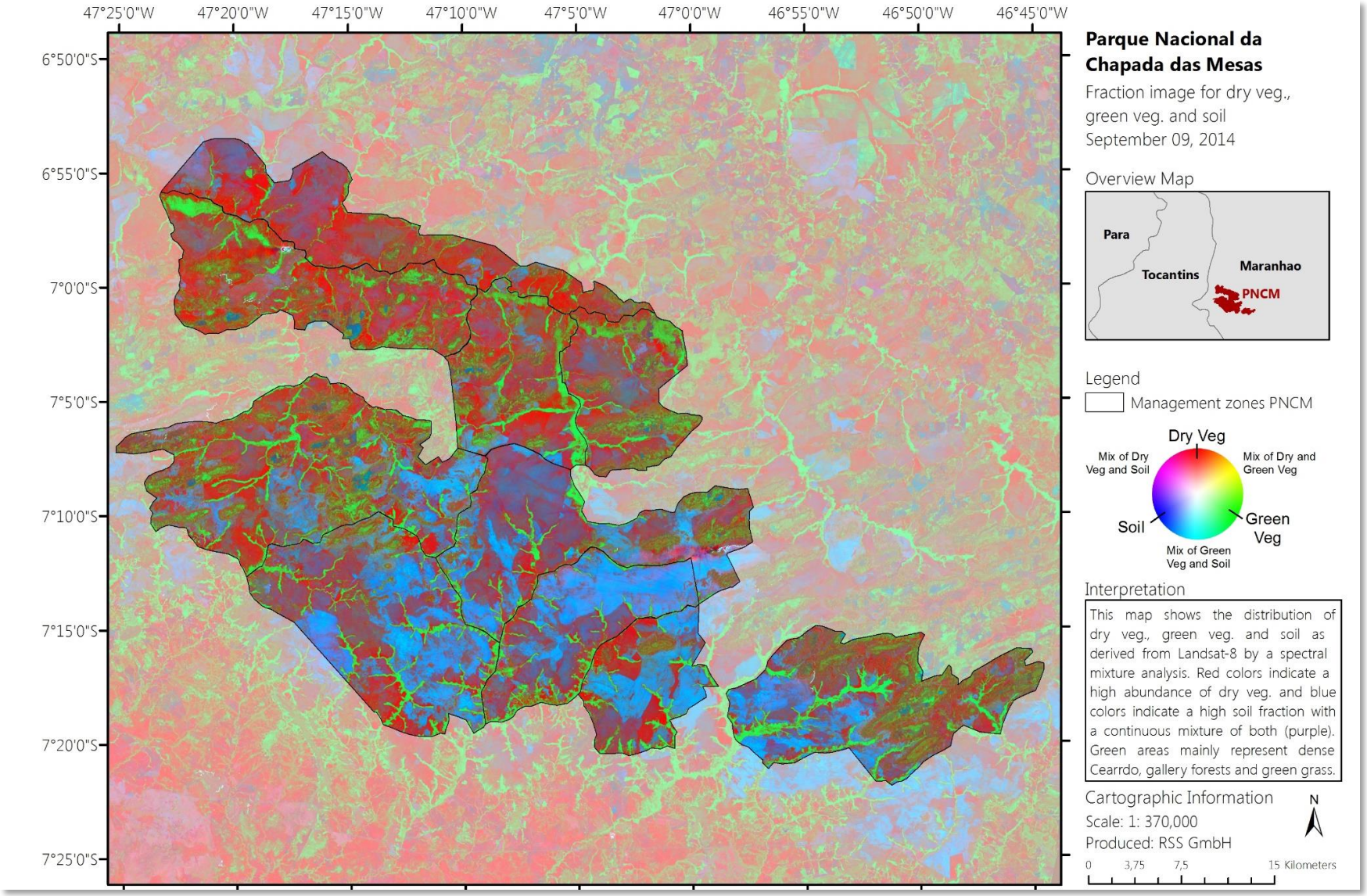


Results

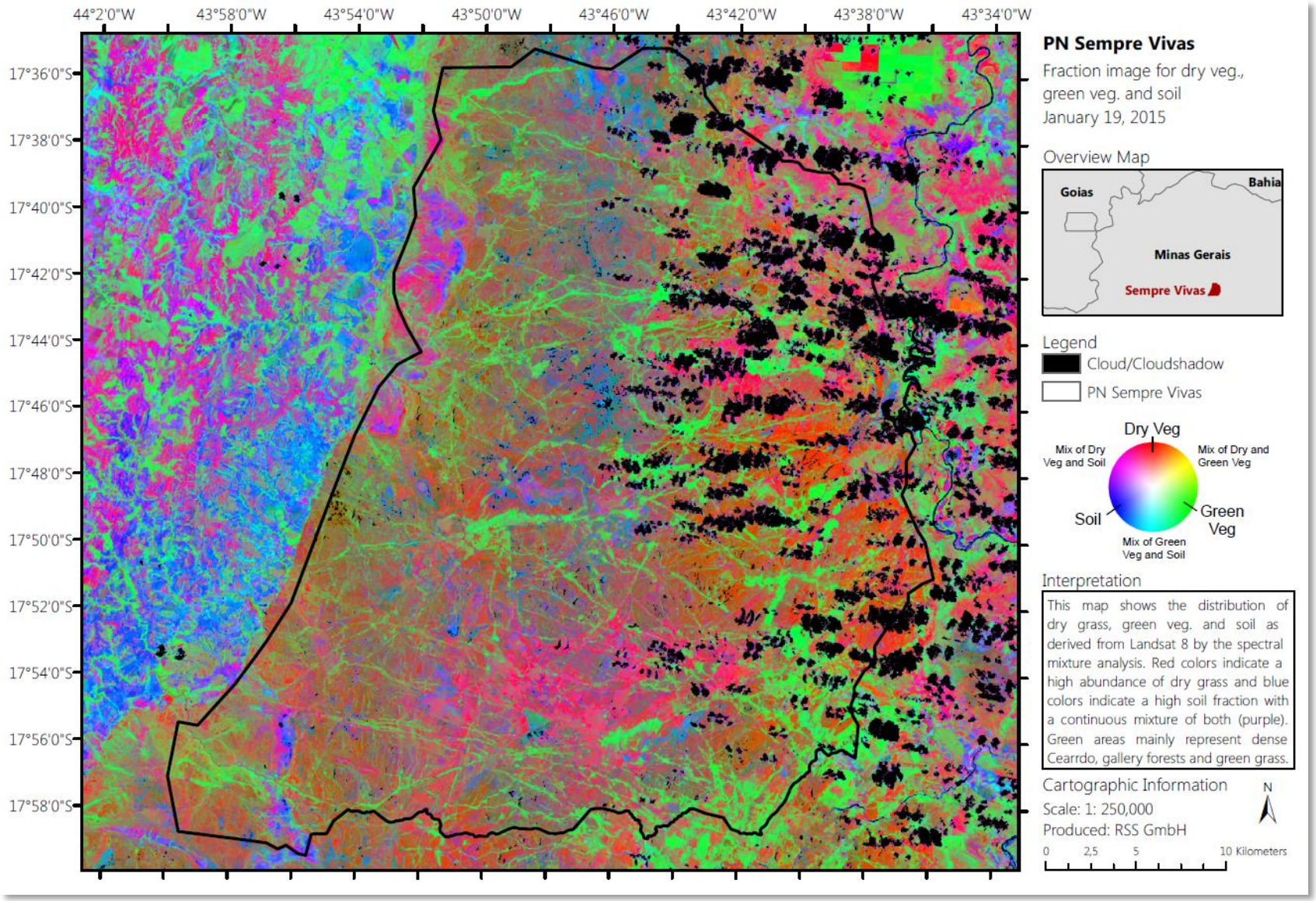
Fuel Load Maps have been provided supporting the implementation of IFM in protected areas:

- PN da Chapada das Mesas
- PN do Araguaia
- PN Sempre Vivas
- Parque Estadual do Jalapão
- Estacao Ecologica Serra Geral do Tocantins
- Terra Indígena Xerente
- APA Jalapão

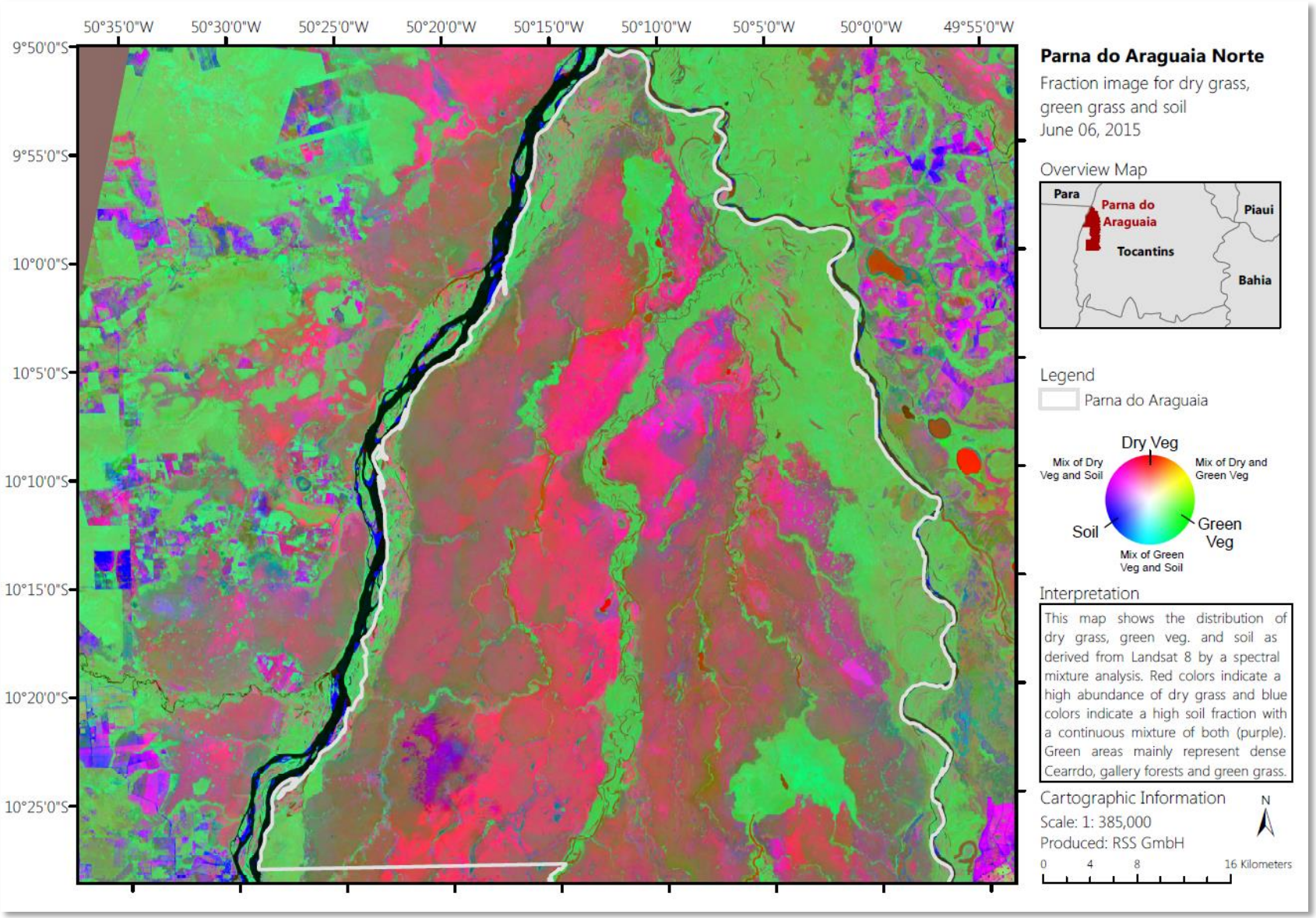
Results



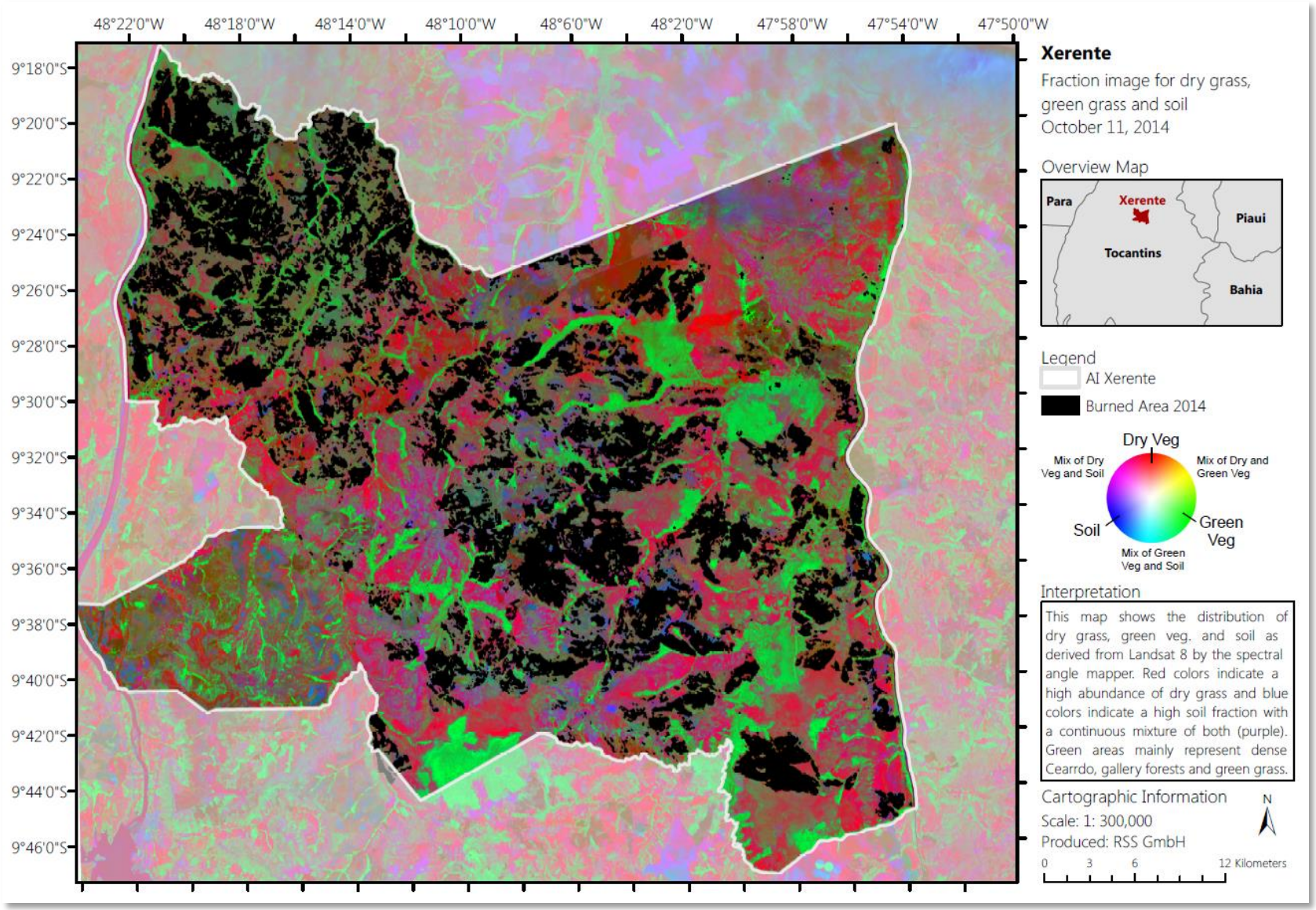
Results



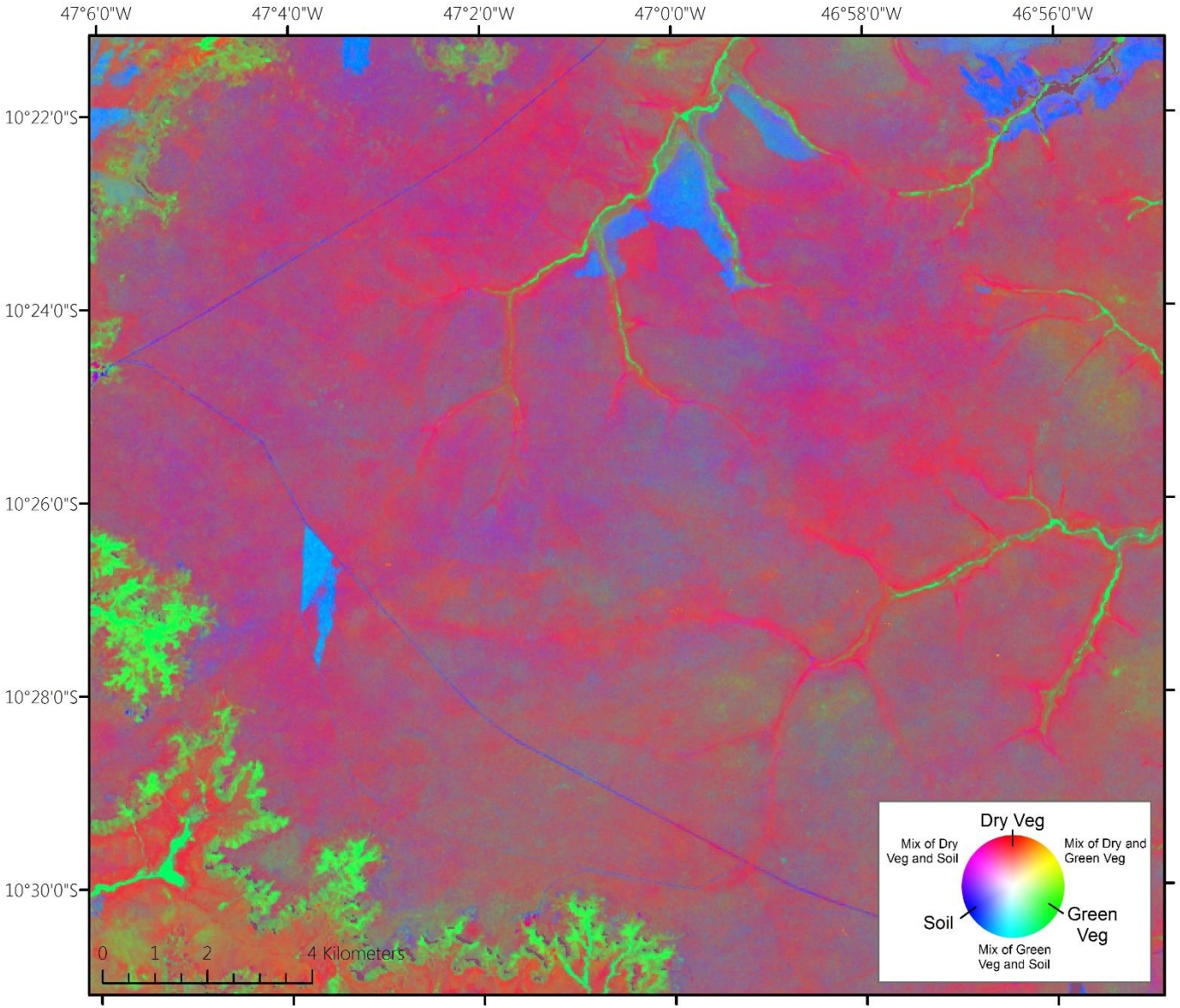
Results



Results

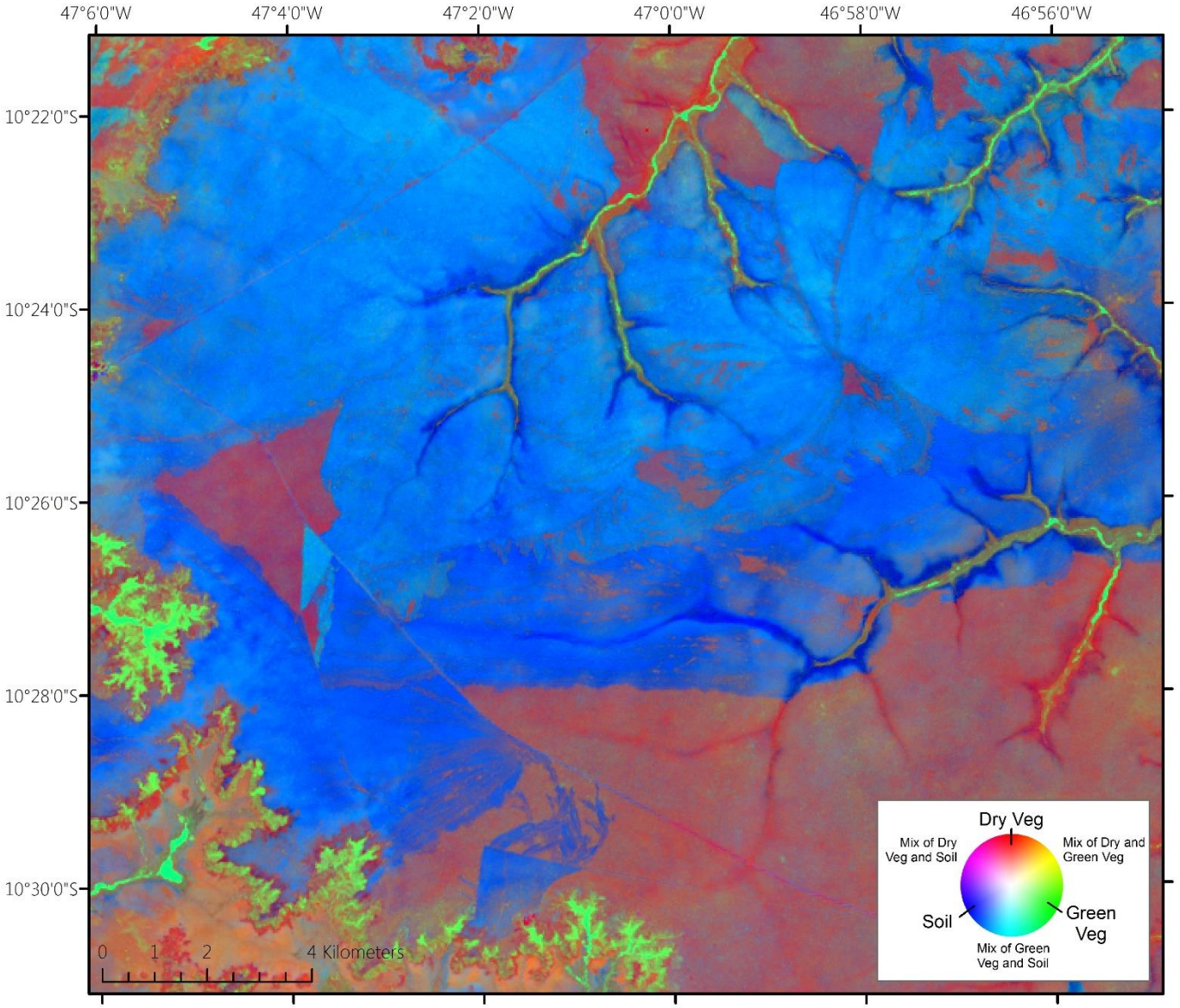


Early dry season fuel load map (PEJ)



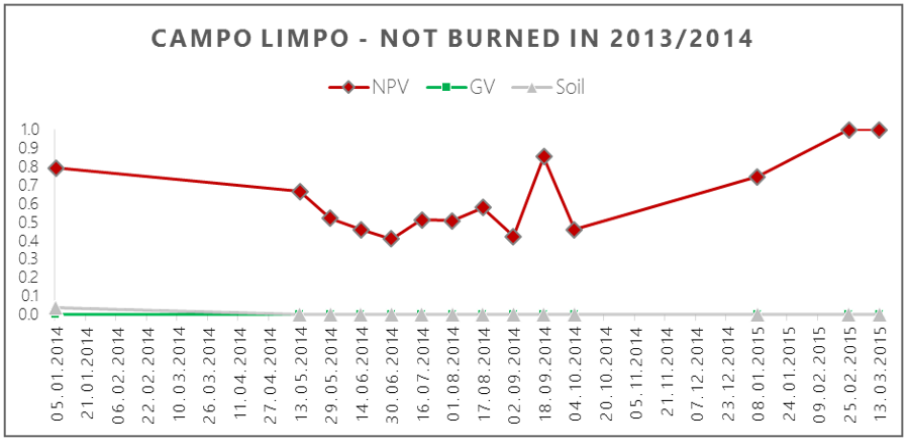
Dr. Jonas Franke

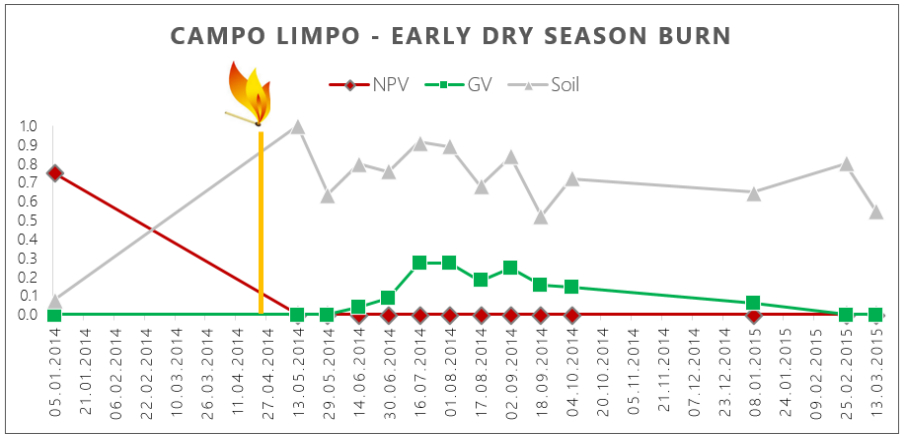
Late dry season fuel load map (PEJ)

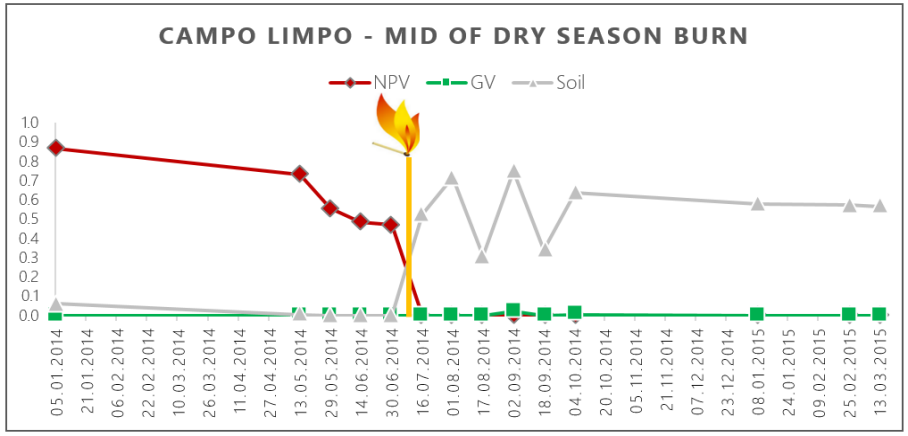


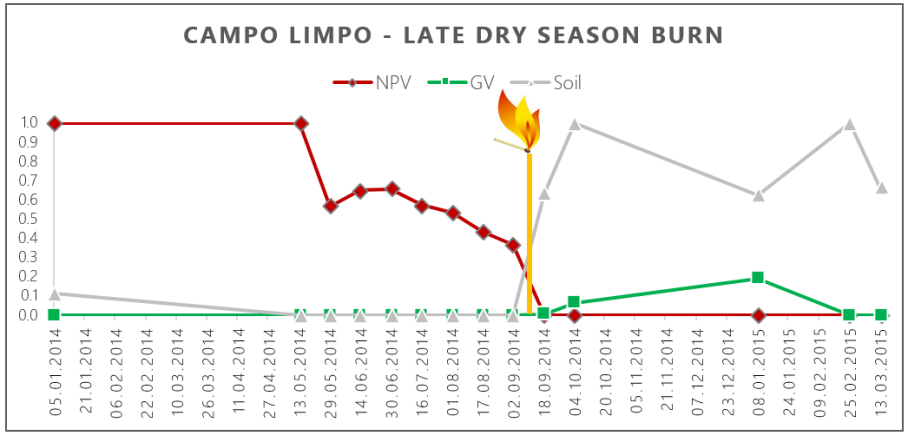
Results

Fuel Load Time Series

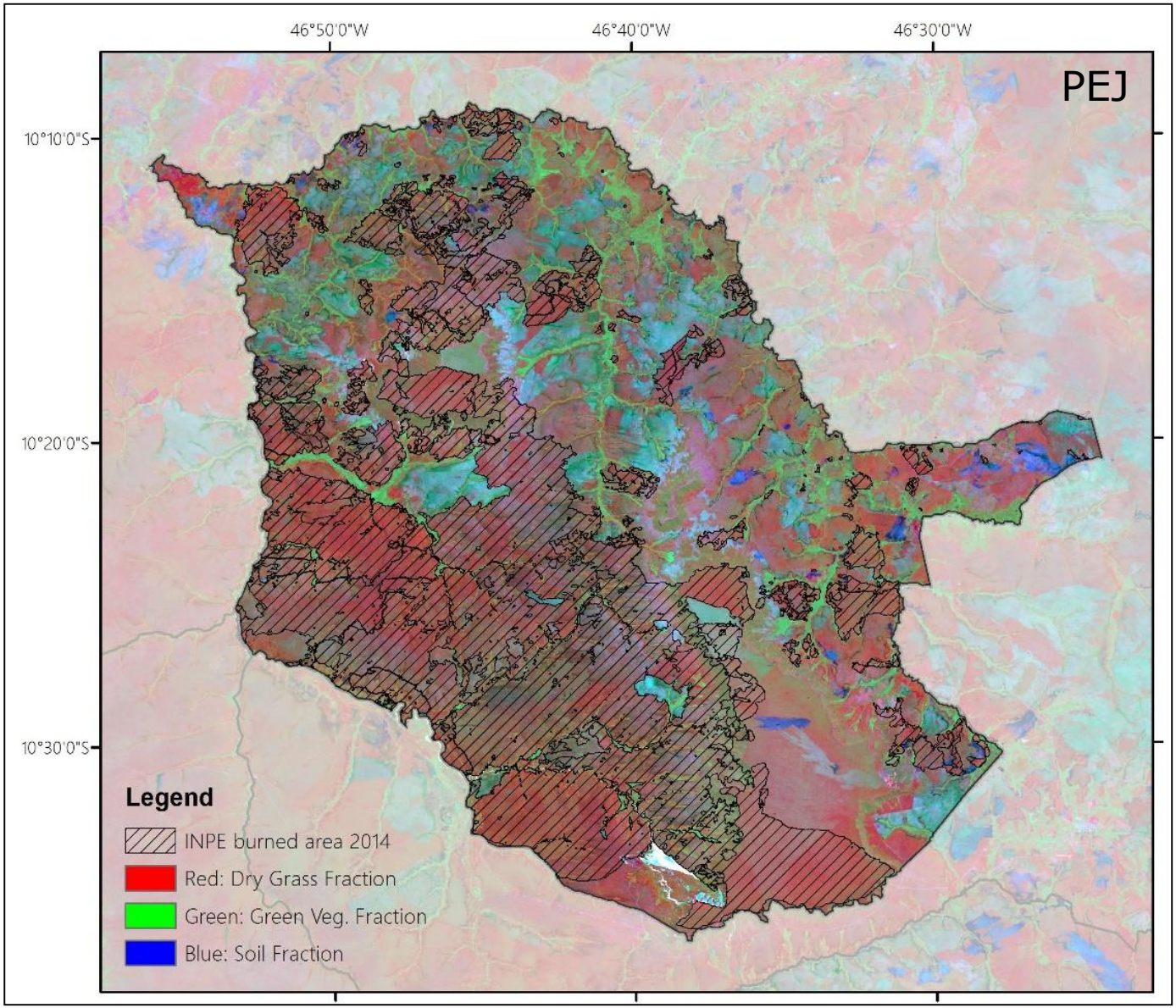








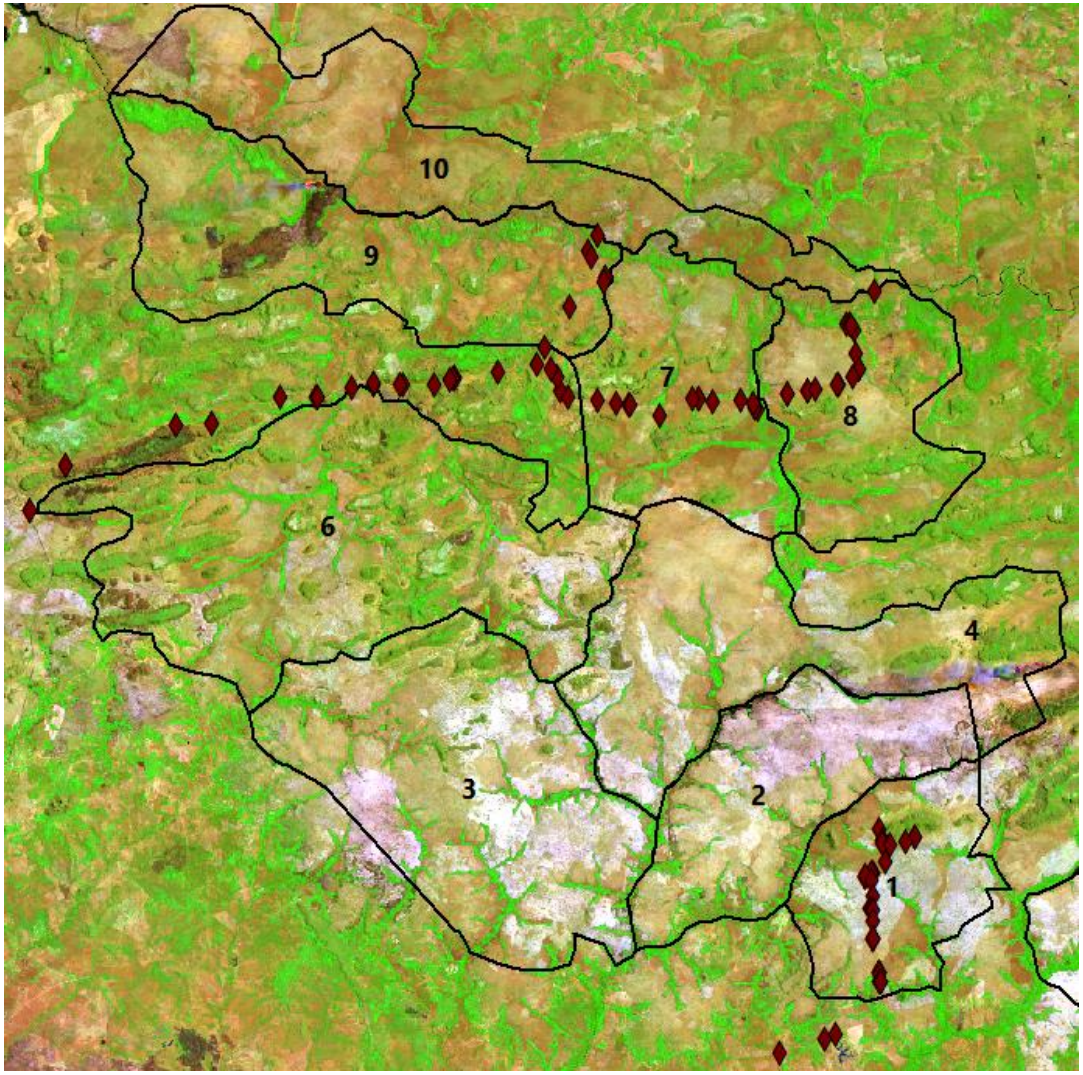
Validation of fuel load estimates with INPE burned areas



Validation of fuel load estimates with ground truthing

119 GPS pictures on 30.10.2014 and 02.11.2014

PN Chapada das Mesas



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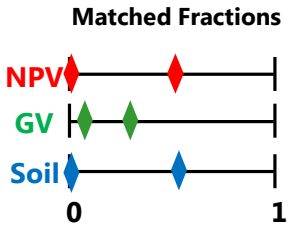
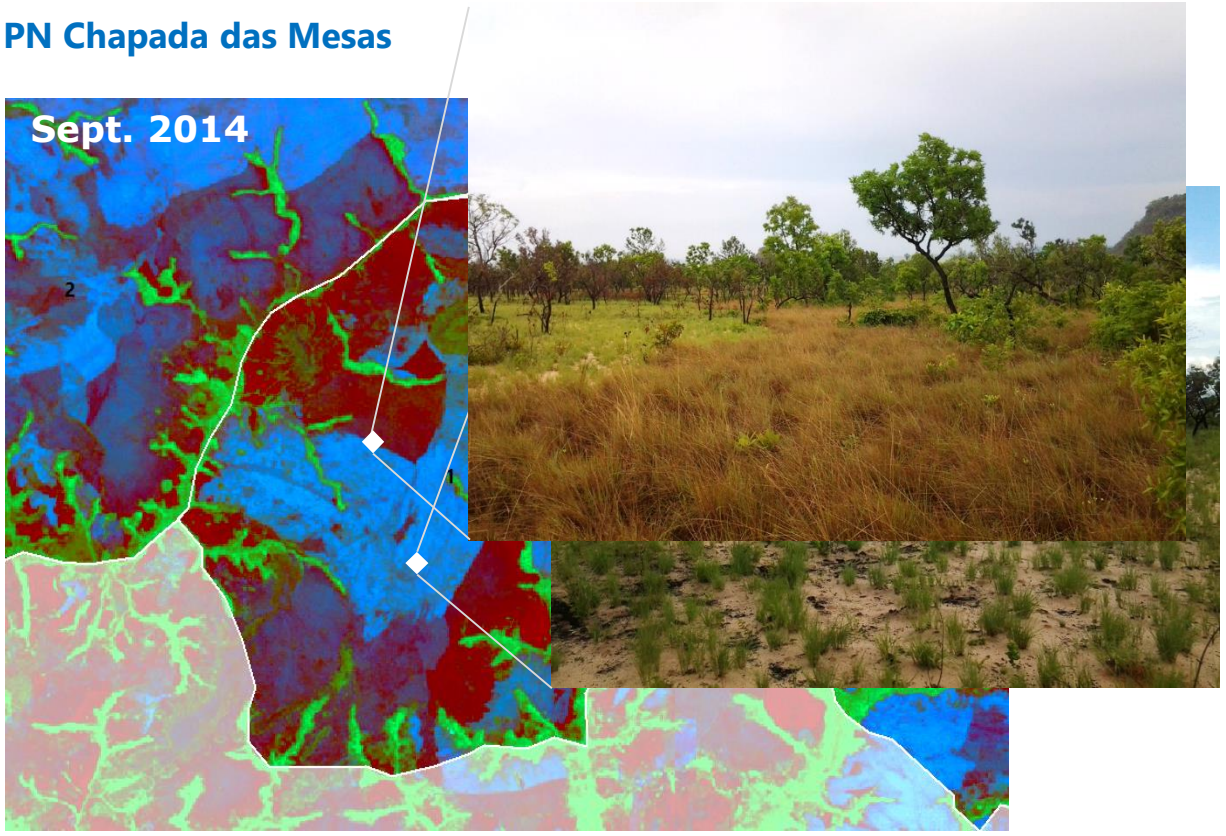


In-situ biomass data

Pre-fire biomass (grass layer):
0.46 – 0.74 kg/m²

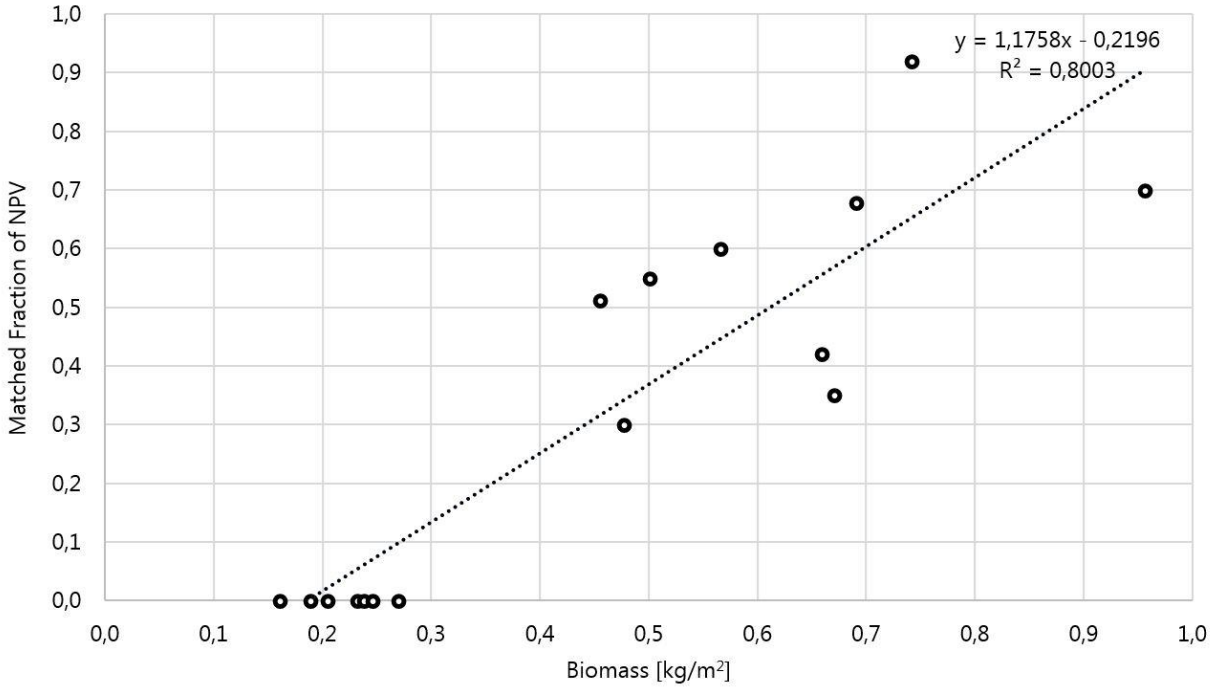
Post-fire biomass (grass layer):
0.15 – 0.18 kg/m²

PN Chapada das Mesas



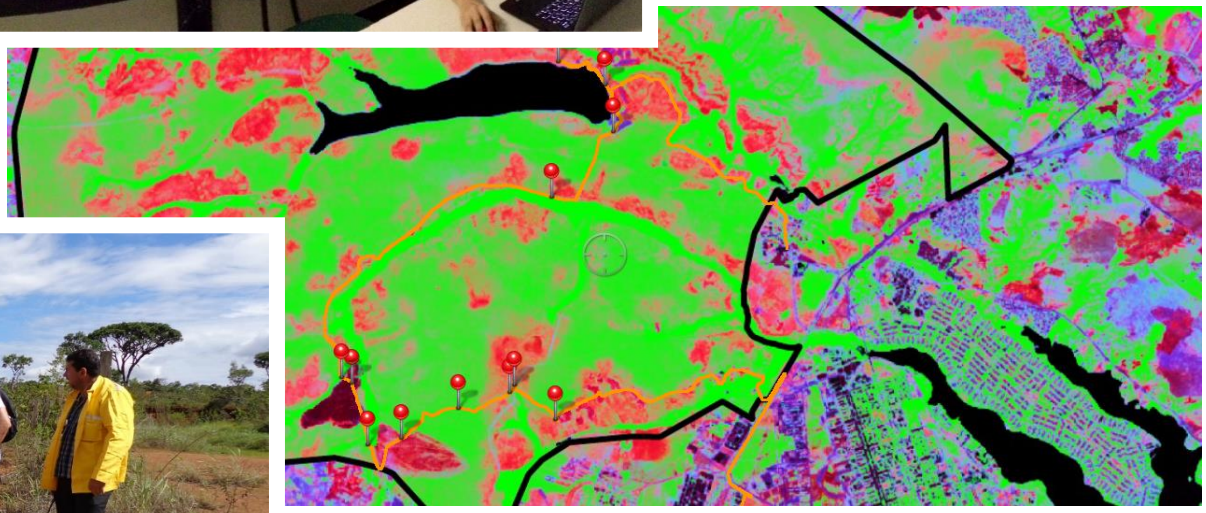
First calibration of fuel load estimates with in-situ biomass data

- Field data on pre- and post-fire biomass [kg/m^2] was collected in June/July 2014 by Universidade de Brasília.
- At each sample location, all biomass with a diameter ≤ 6mm was collected in 5 plots of 0.5m x 0.5m and afterwards dried and weighted.
- The average values of each location were compared with the fuel loads derived from the previous (for pre-fire samples) or next (for post-fire samples) OLI image in order to test a calibration of the results.
- In total, 16 samples could be used for validation with explicit GPS recordings and cloud-free conditions in the Landsat images.



Fuel load map training at ICMBio

Validation in PN Brasilia



Conclusions

- Fuel load mapping using Landsat-8 was demonstrated as an effective tool in support of IFM
- SMA is a well proven methodology, with results that directly supported IFM planning
- These maps are useful to identify areas with high fire risk, assess the fuel load variation, assess the remaining fuel load after a fire, to better understand fire behaviour and could improve emission estimates
- Fuel load maps were/are the planning base for controlled early burning activities in 2014/2015
- In order to establish this approach as an operational instrument of IFM, key staff of federal instutions (ICMBio, MMA, IBAMA etc.) was trained on fuel load mapping
- Sentinel-2 will provide additional data for an improved time series analysis
- The approach is transferable to other Savanna ecosystems

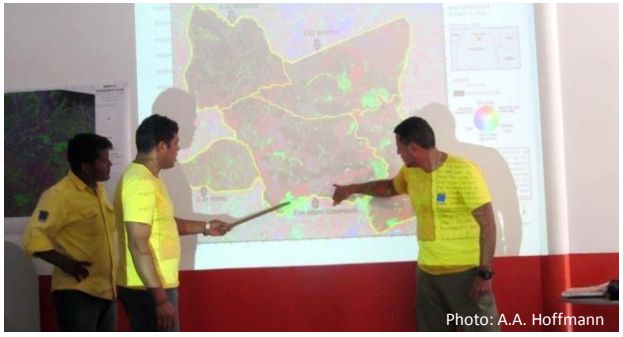


Photo: A.A. Hoffmann