Montpellier– 2019/03/29

Monitoring agrosystems to understand agricultural landscapes

Monitoring agricultural landscapes to understand agrosystems

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Bégué A., Betbeder J., Bellon B., Almeida C., Baudry J.

Introduction

Landscape Agronomy

(Benoit et al., 2012)

Landscape Ecol (2012) 27:1385–1394
DOI 10.1007/s10980-012-9802-8

PERSPECTIVE

Landscape agronomy: a new field for addressing agricultural landscape dynamics

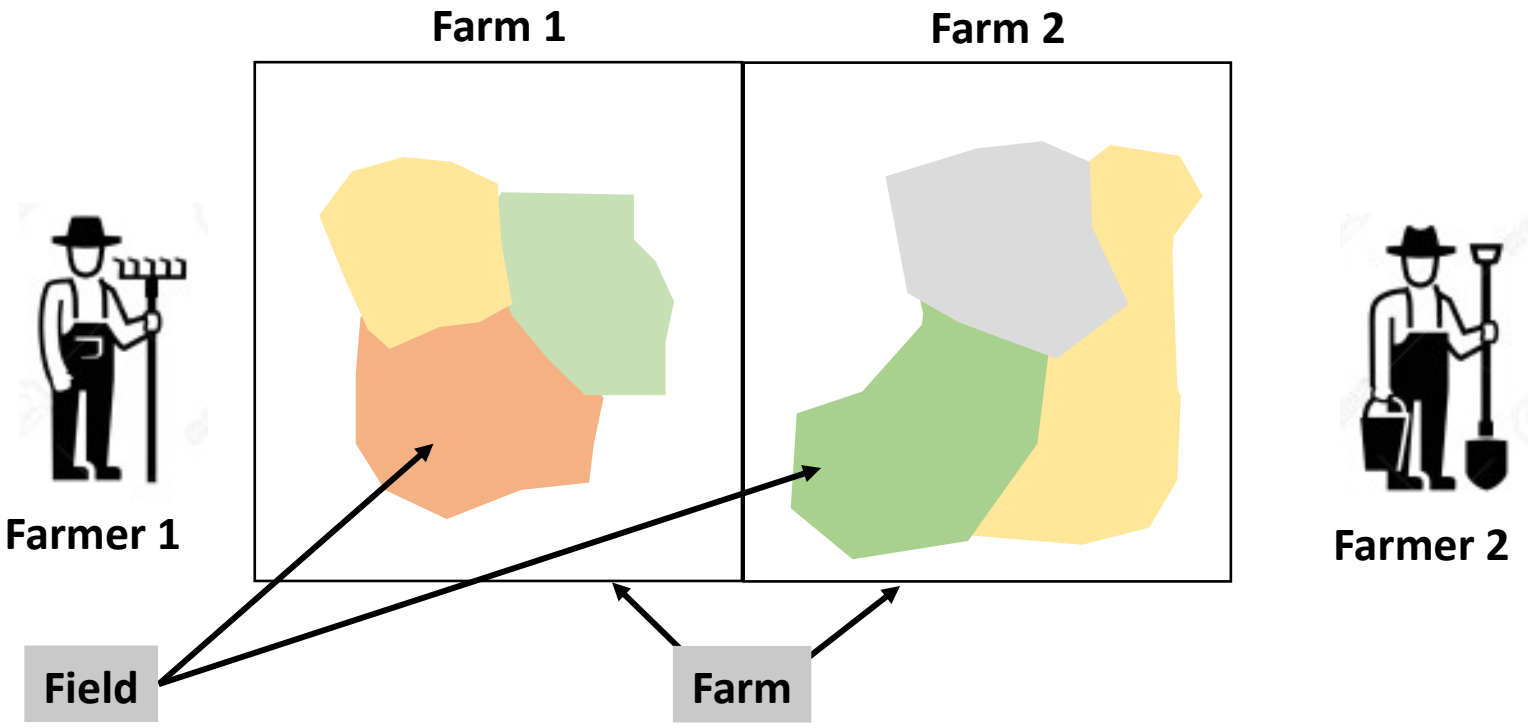
Marc Benoît · Davide Rizzo · Elisa Marraccini · Anna Camilla Moonen · Mariassunta Galli · Sylvie Lardon · Hélène Rapey · Claudine Thenail · Enrico Bonari

Introduction

Agronomy

aims at delivering operative knowledge to the farmers and their organizations

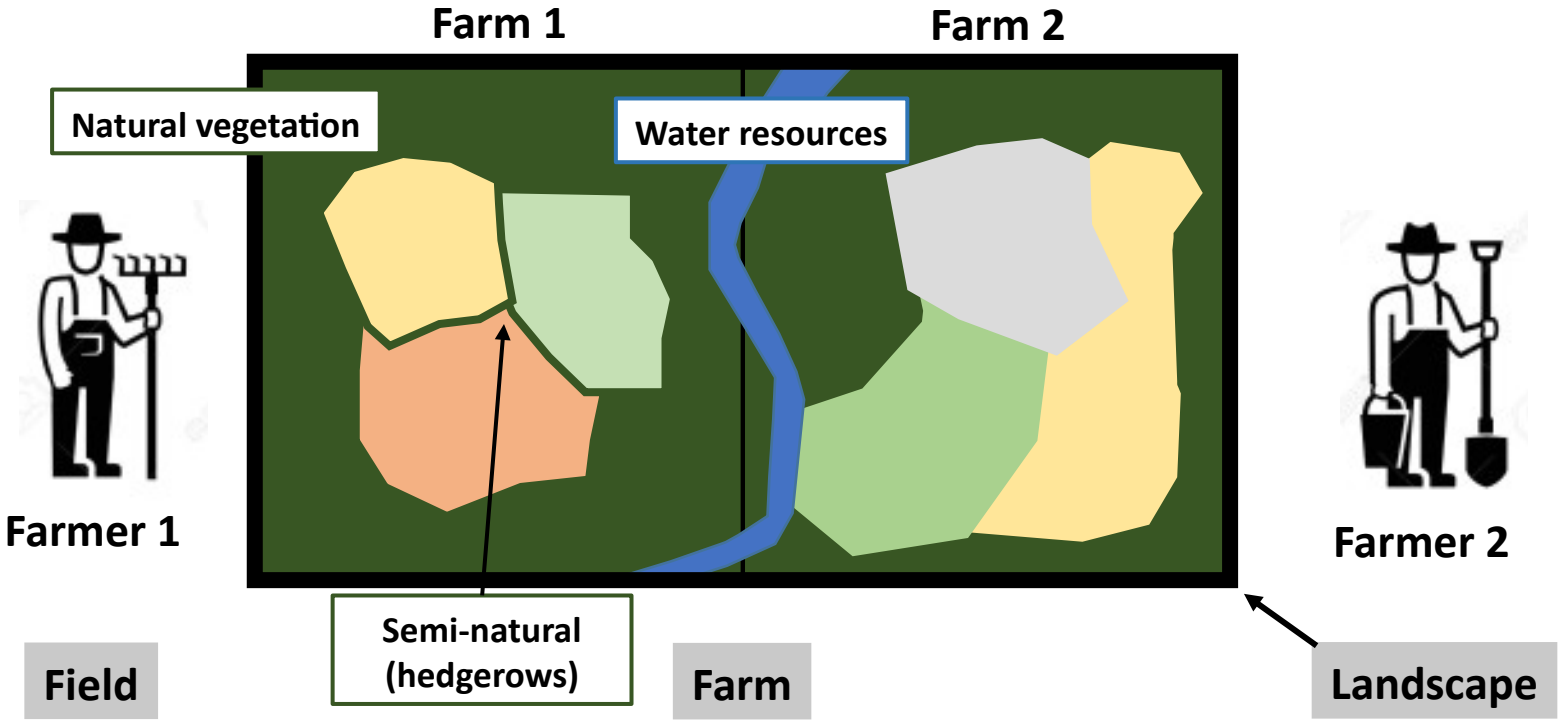
(Deffontaines et al. 1995; Cavazza 1996; Benoît et al. 2007).



Introduction

Landscape

is the system where farmers interact with both natural and social resources through the management of their fields and of the associated features.



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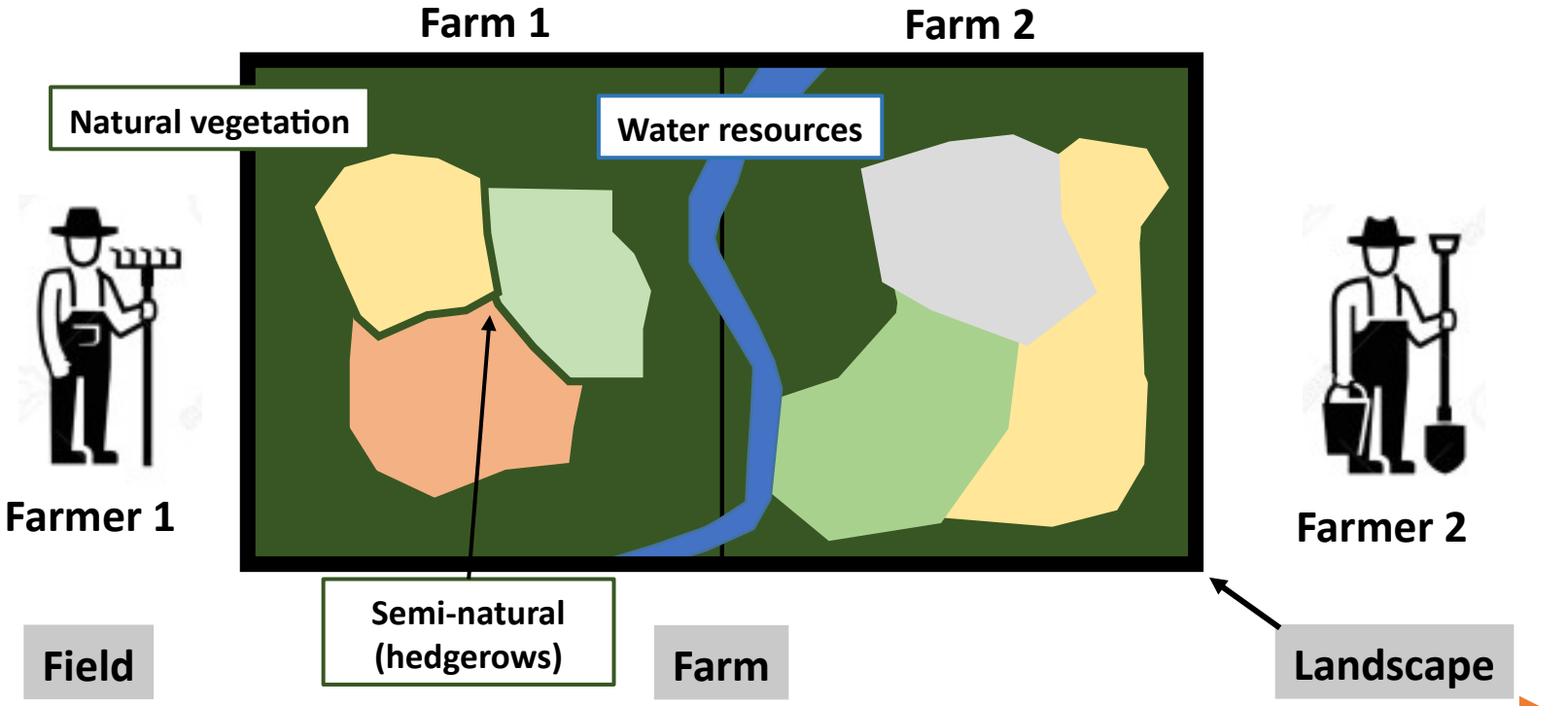
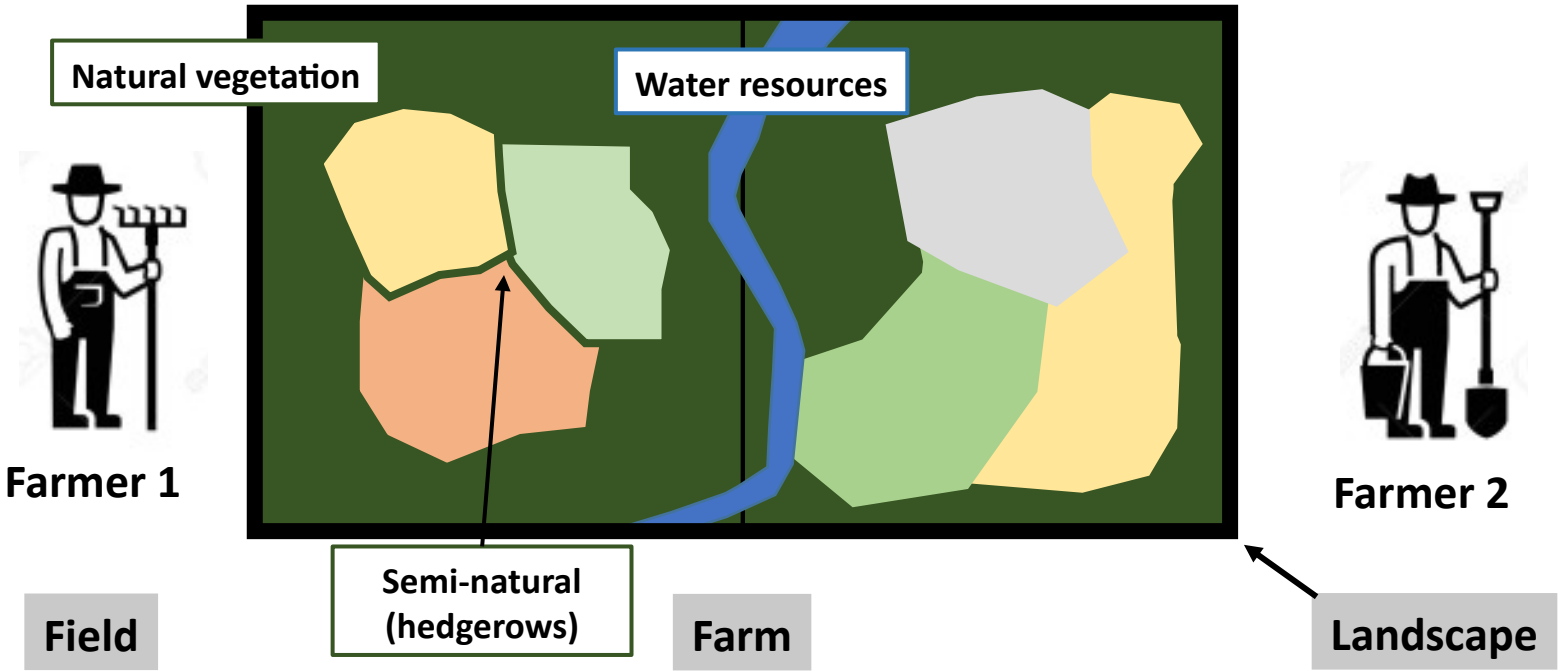


Introduction

Landscape Agronomy

1) landscape patterns
   are designed by farming practices and natural resources
2) landscape patterns and natural resources
   are drivers for farming practices



Introduction

Landscape Agronomy

1) landscape patterns are designed by farming practices
2) landscape patterns and natural resources are drivers for farming practices

Main research issues

1) To characterize landscape patterns based on farming practices

2) To understand the drivers of farming practices for a better assessment of current landscape patterns

3) To assess the impacts of farming practices on ecosystem services to improve the design of future agricultural landscapes

What place for remote sensing?

High to Very High

Moderate

Broad

Spatial resolutions

Farming practices

Spatial scale

Field

Farm

Landscape

Agronomy

Landscape Agronomy

What place for remote sensing?

High to Very High

Moderate

Broad

Spatial resolutions

Farming practices

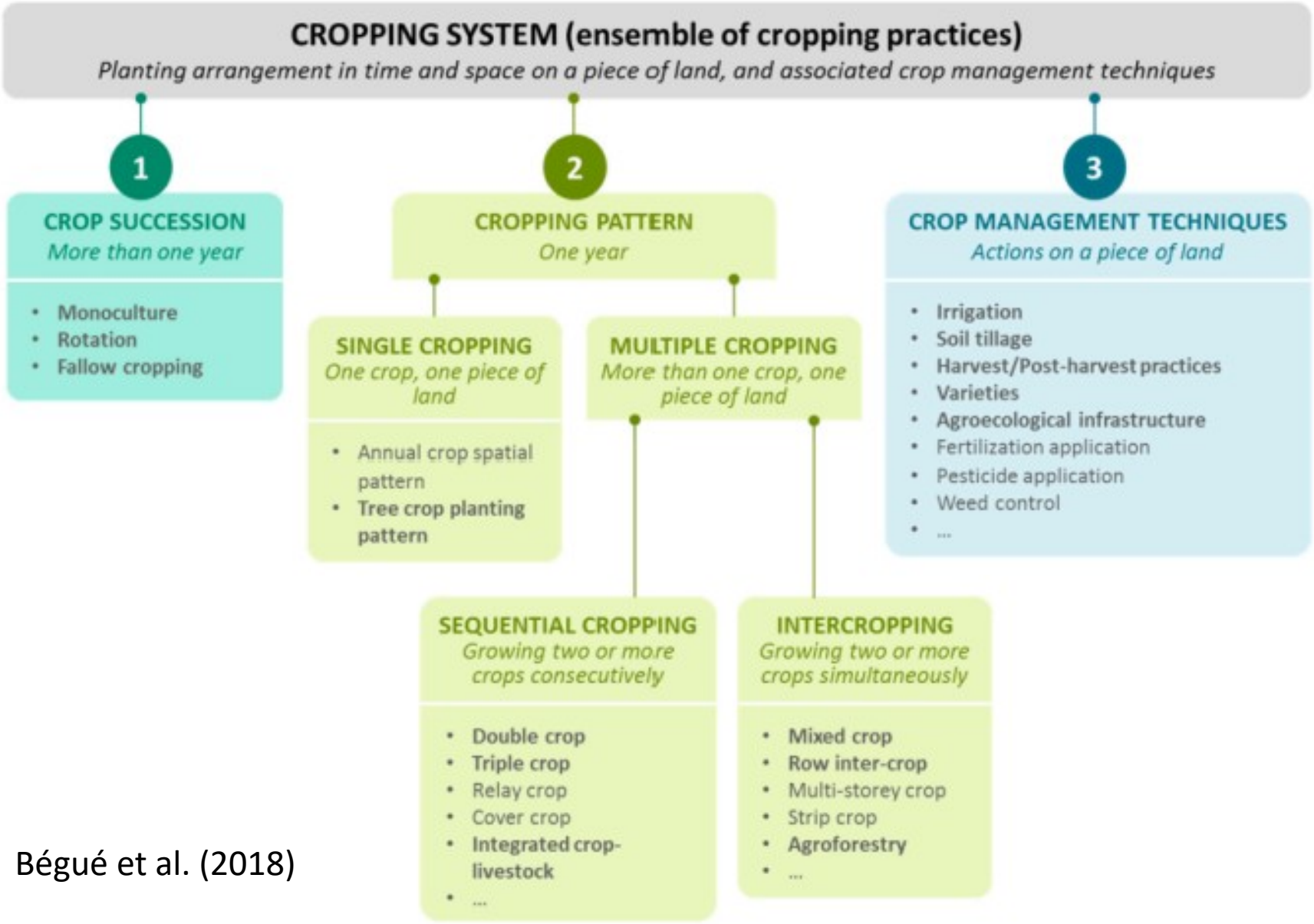
Spatial scale

Field

Farm

Landscape

Monitoring cropping systems



Bégué et al. (2018)

Monitoring cropping systems

TABLE 5.2 Literature Examples of Use of Remote Sensing for Mapping Cropping Practices

Cropping Practice	Crop (Sensor)	Example of Studies
Crop variety	Sugarcane (Hyperion)	Galvao et al. (2005)
	Sugarcane (Landsat)	Fortes and Dematte (2006)
Double cropping	Soybean and others (MODIS)	Arvor et al. (2011)
	Cereals (MODIS)	Qiu et al. (2014)
Harvest date	Sugarcane (SPOT)	Lebourgeois et al. (2007)
	Sugarcane (SPOT)	El Hajj et al. (2009)
Sowing date	Soybean (MODIS)	Maatoug et al. (2012)
Harvest mode	Sugarcane (Landsat, DMC)	Aguiar et al. (2011)
	Sugarcane (Landsat, CBERS)	Goltz et al. (2009)
Irrigation	Various crops (MODIS)	Gumma et al. (2011)
	Wheat (FORMOSAT, ASAR)	Hadria et al. (2009)
	Review	**Ozdogan et al. (2010)**
Crop residue	Various crops (Landsat)	Pacheco et al. (2006)
	Review	**Zhang et al. (2011)**
Tillage	Wheat (FORMOSAT, ASAR)	Hadria et al. (2009)
	Various crops (Landsat)	Sullivan et al. (2008)
Row orientation and width	Vineyard (aerial photos)	Delenne et al. (2008)
	Olive groves (QuickBird)	Amoruso et al. (2009)
	Orchards (Ikonos)	Aksoy et al. (2012)
	Vineyard, cereals (aerial photos)	Lefebvre et al. (2011)

Note: References in bold are review papers.

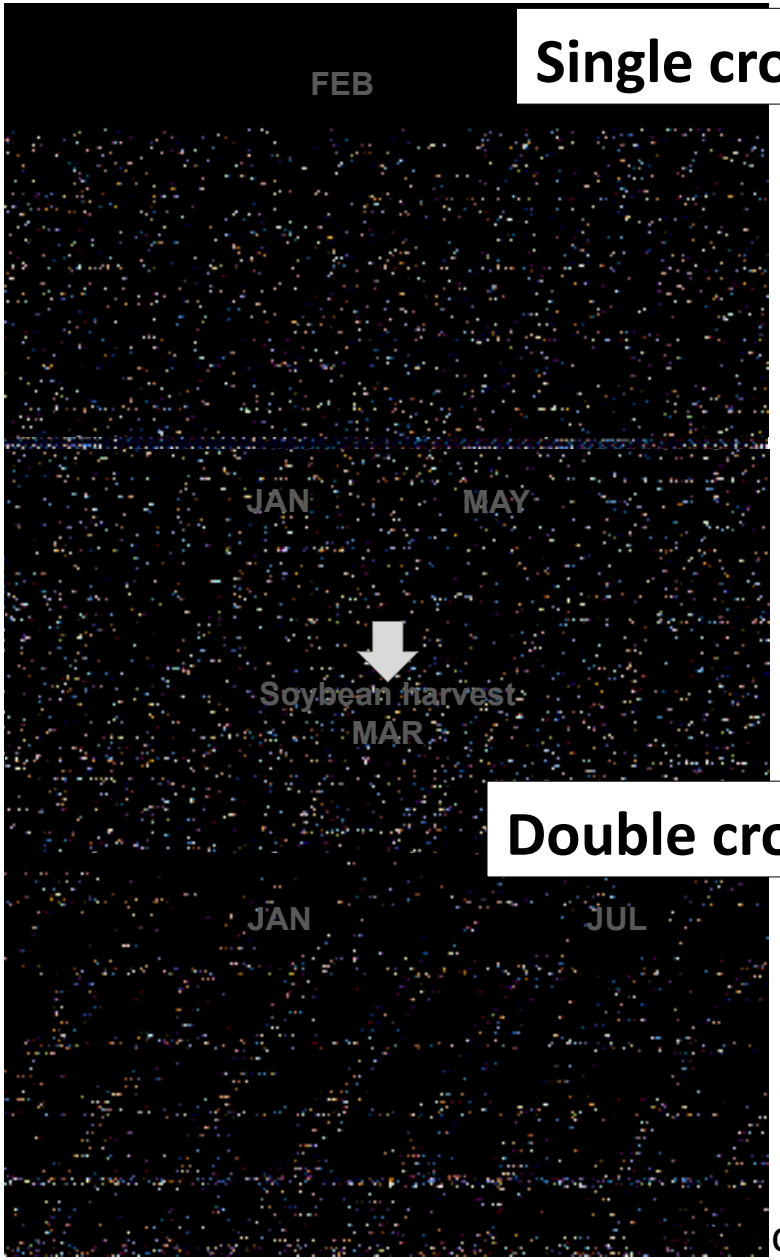
Bégué et al. (2015)

Monitoring cropping systems

Cropping intensity

Soybean-cereal double cropping system

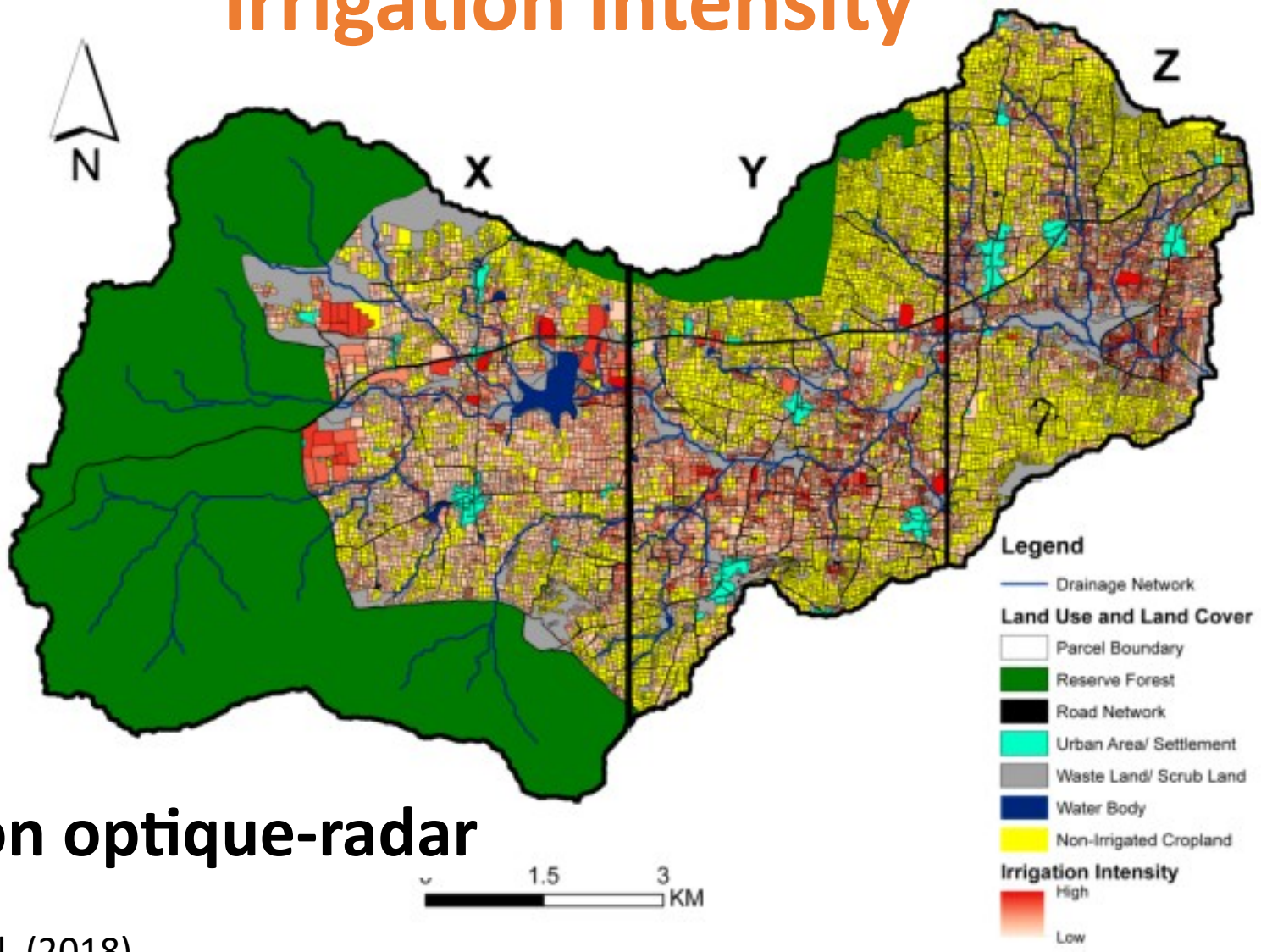
Rice-Soybean double cropping system



on (2017)

Monitoring cropping systems

Irrigation intensity



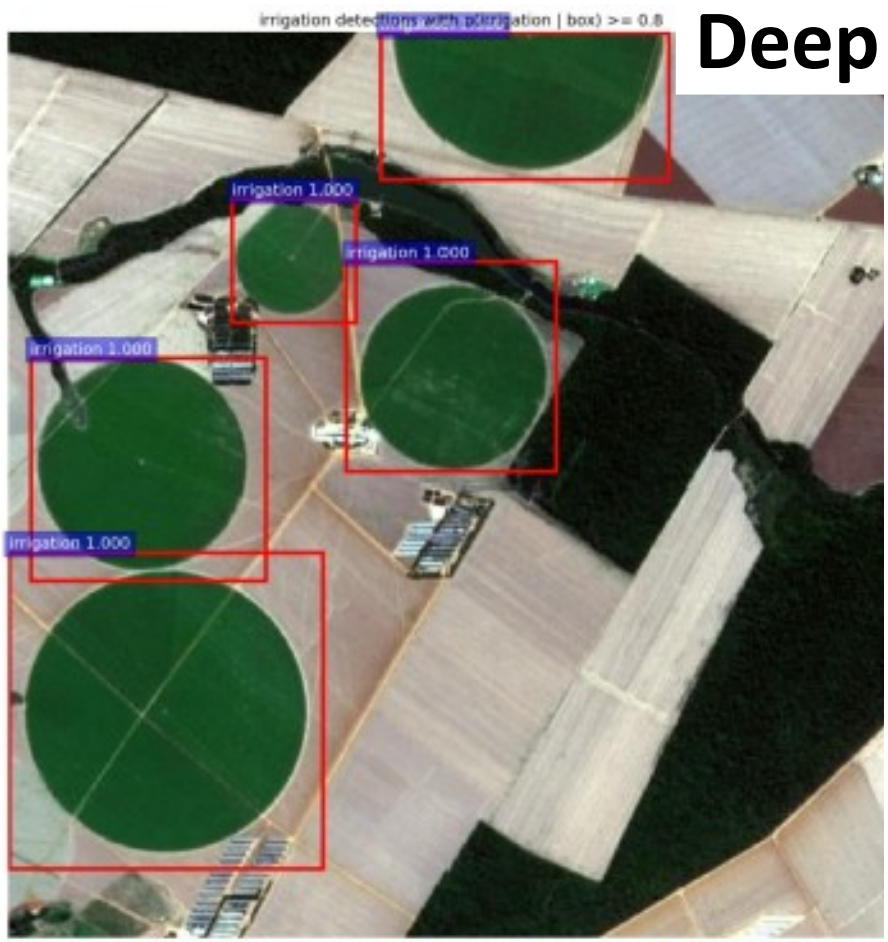
Fusion optique-radar

Kumar et al. (2018)

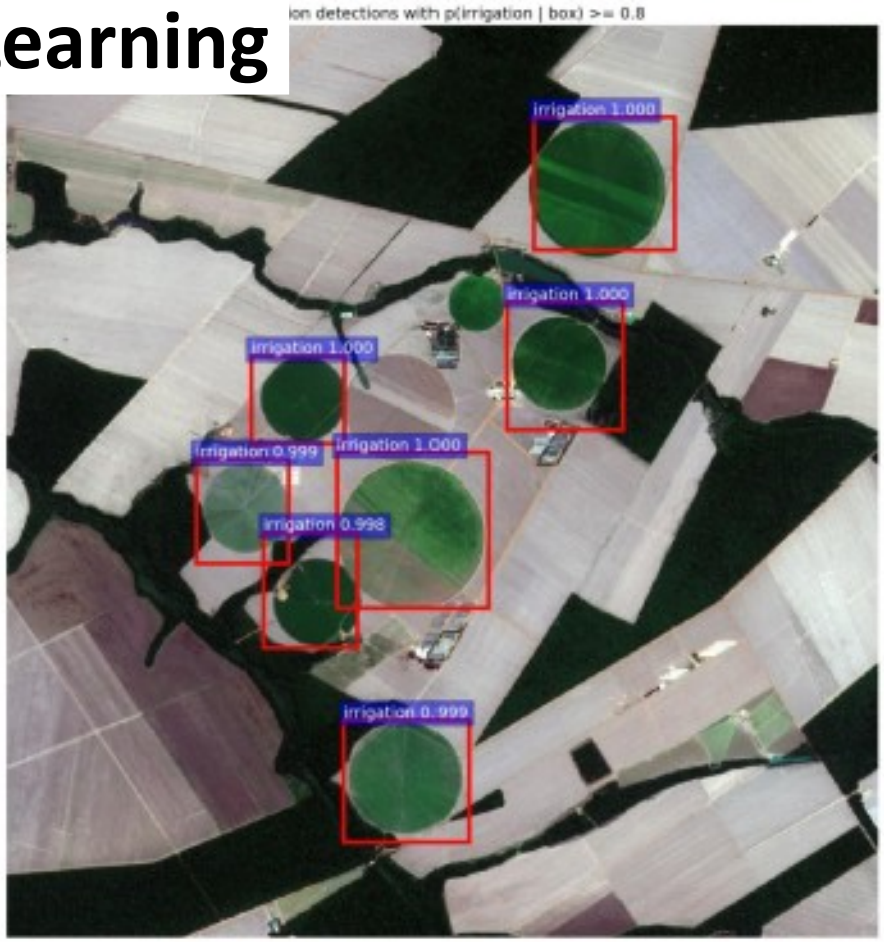
Monitoring cropping systems

Central pivots

Deep Learning



Sentinel 2



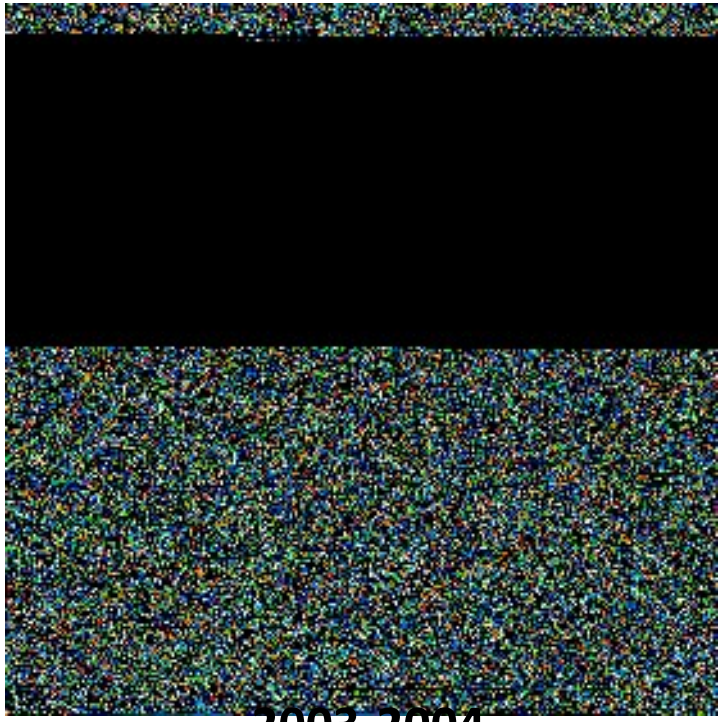
Landsat 8

Tang et al. (unpubl.

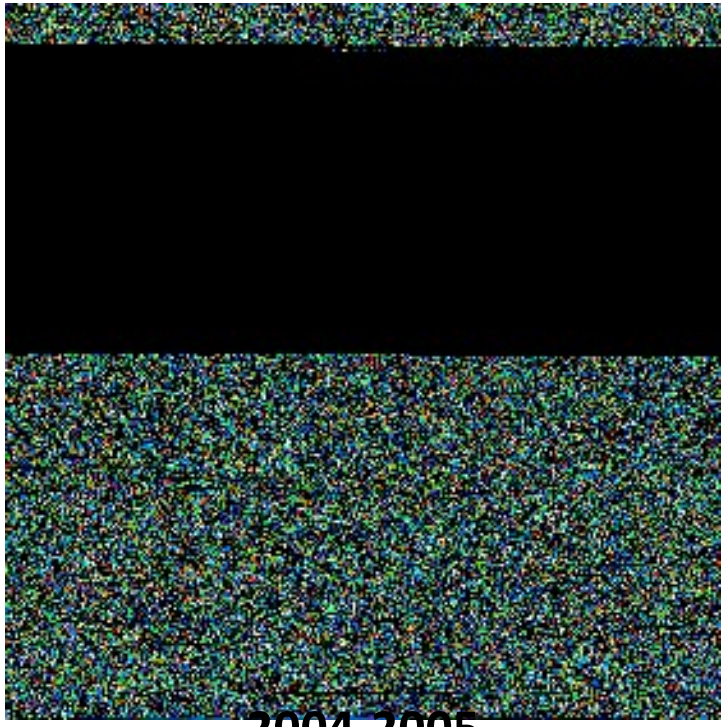
Monitoring cropping systems

Sowing dates

Lucas do Rio Verde



2003-2004



2004-2005

Very anticipated sowing date

Optimal sowing date

Anticipated sowing date

Late sowing date (after Nov, 15th)

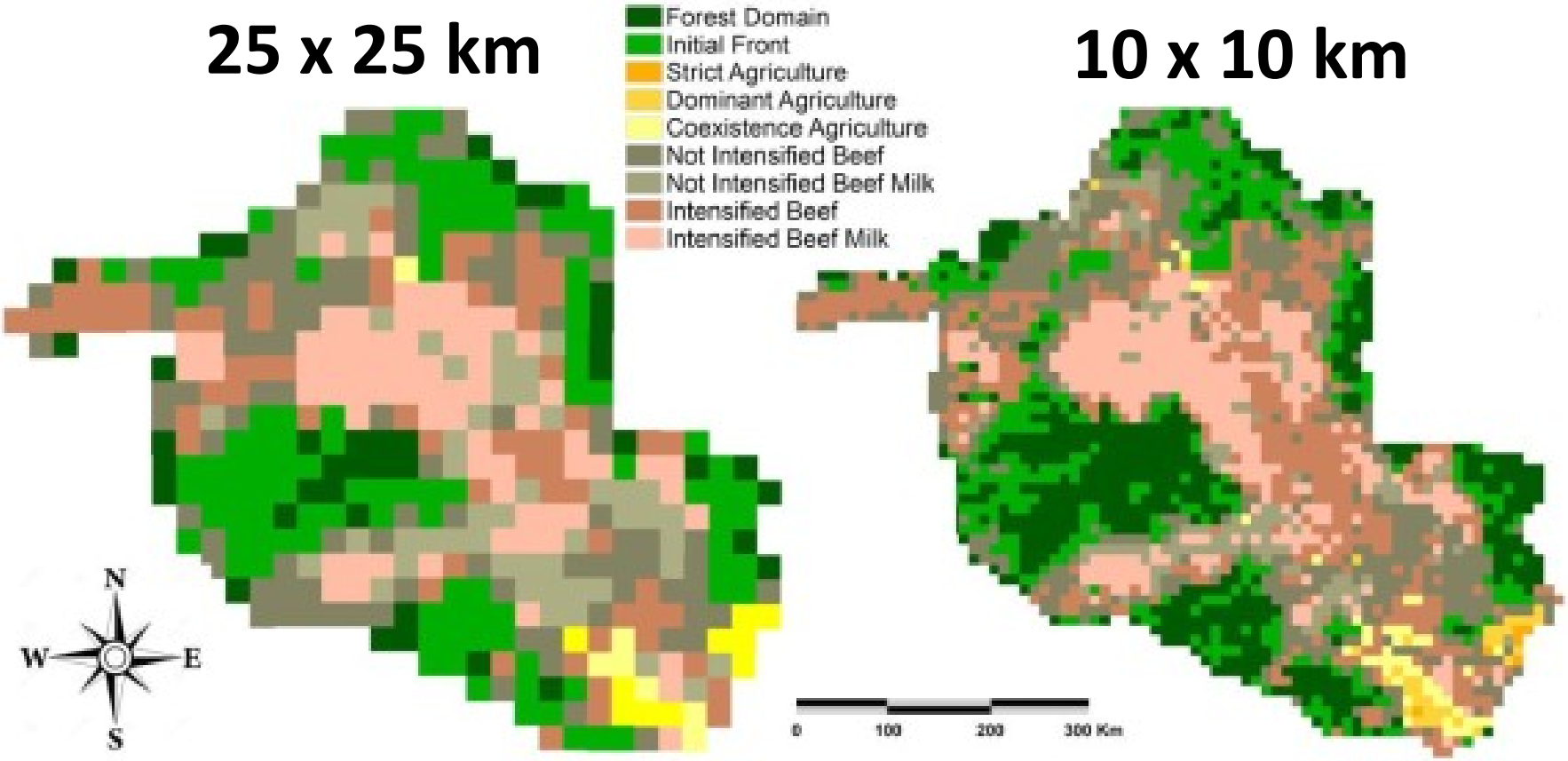
What place for remote sensing?

From farming practices to landscape patterns

How to delineate landscape units?

Delineating landscape units

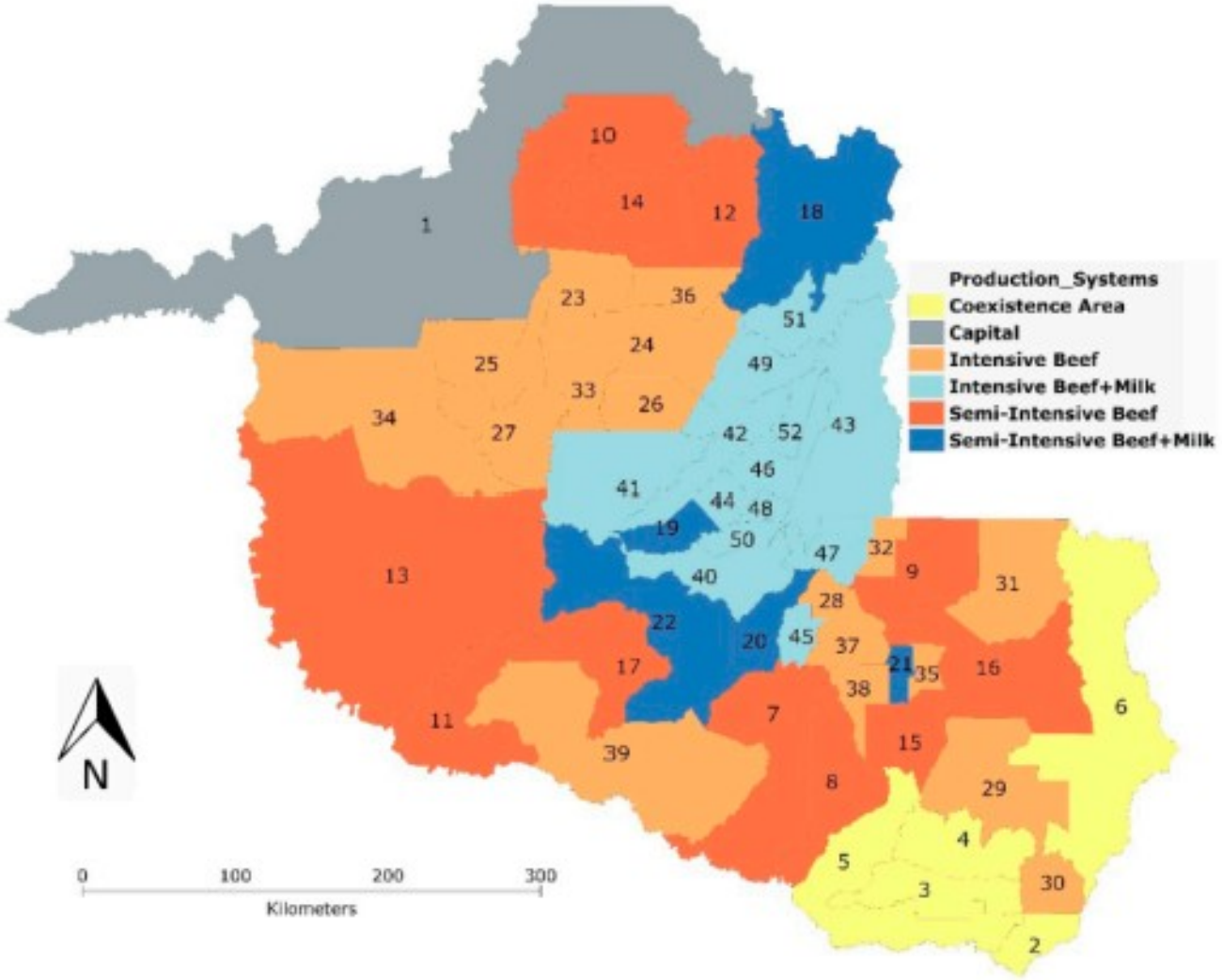
Regular grid



Almeida et al. (2016)

Delineating landscape units

Administrative units



Almeida et al. (2016)

Delineating landscape units

Image objects derived from segmentation

DATA

MODIS NDVI 16-days composites annual time series

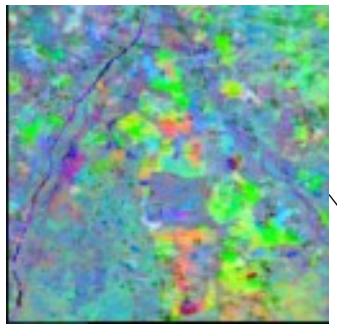
Oct 2014 – Sep 2015
23 composite images
250m spatial resolution

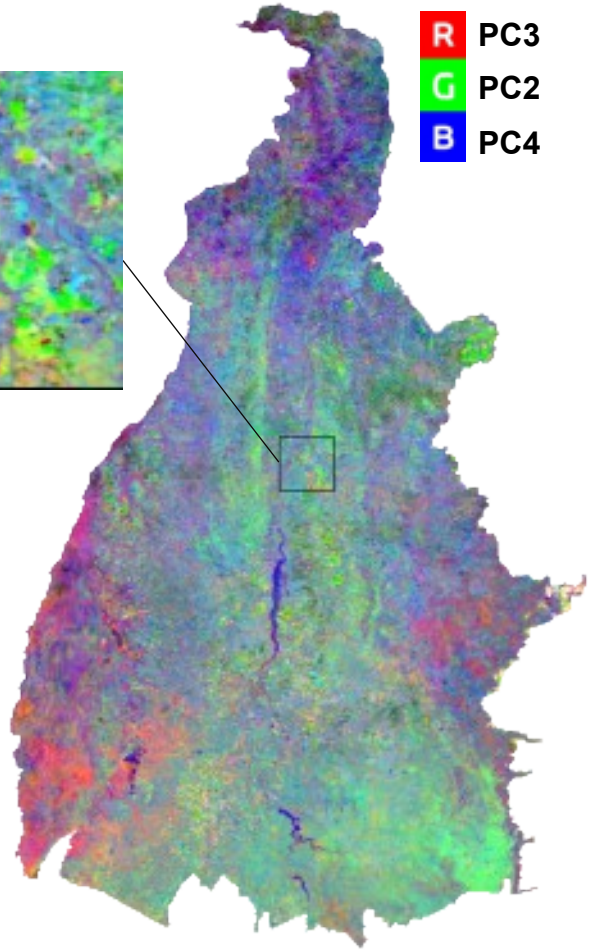
PROCESSING

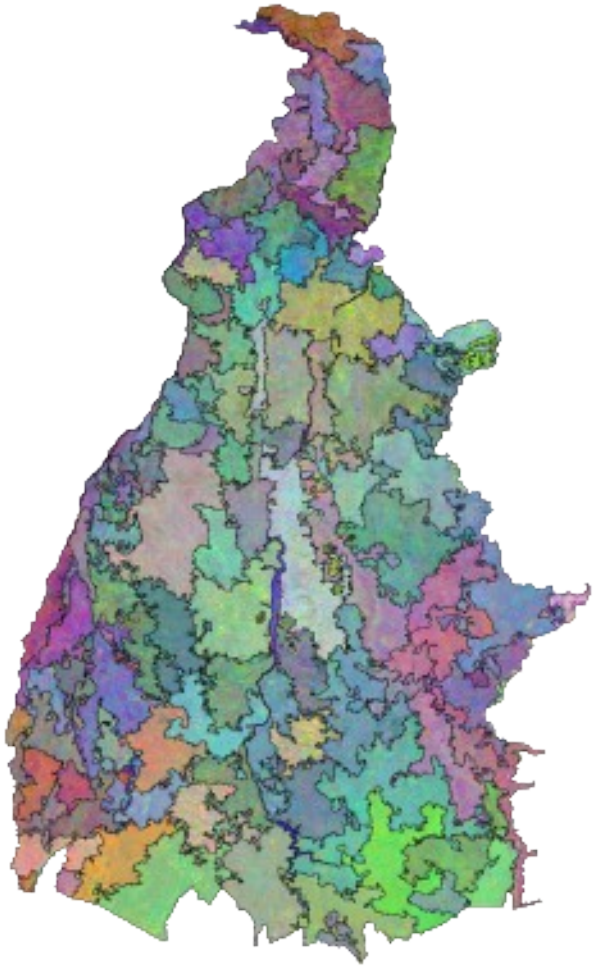
Principal Component Analysis (PCA)
Radiometric features = PC2 – PC20

RESULT

Multiresolution segmentation
eCognition Developer 9.0







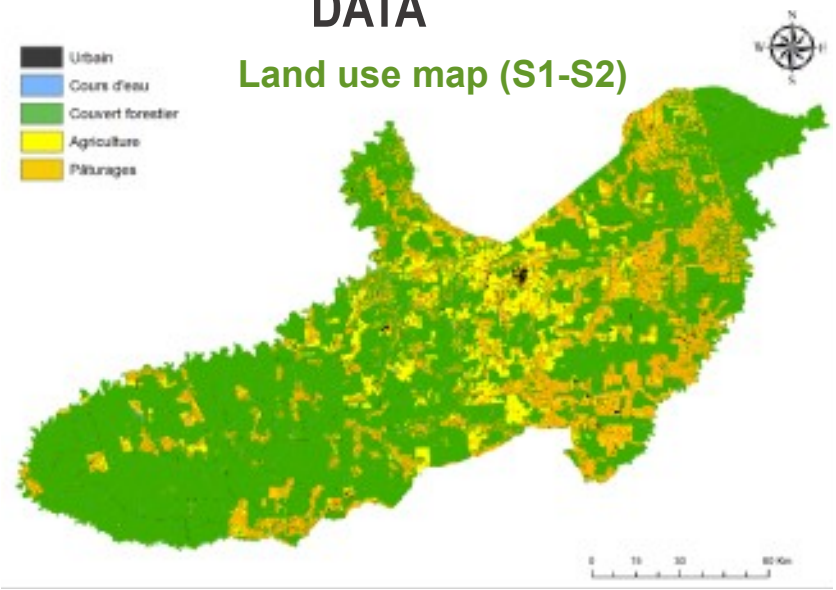
Phénologie (intrannuelle)

Bellon (2017)

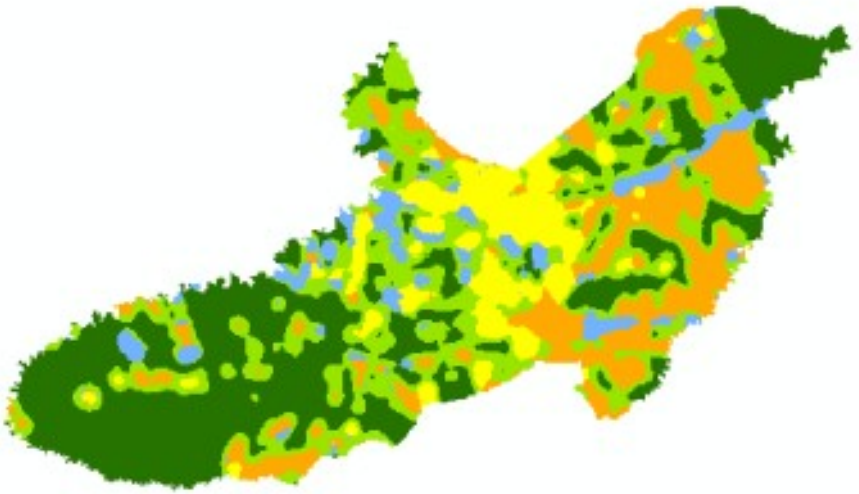
Delineating landscape units

Clustering of landscape metrics

DATA



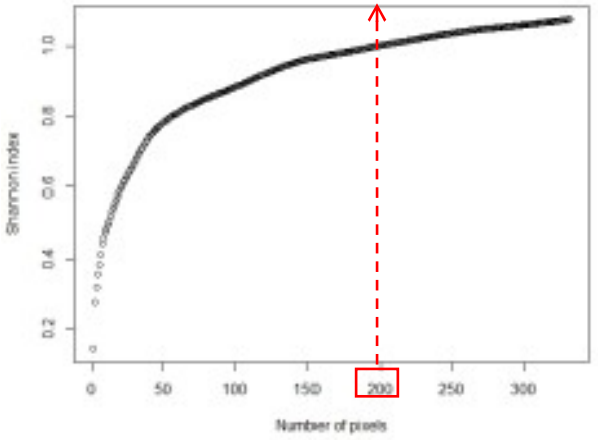
RESULT



Betbeder, unpublished

PROCESSING

- Define the window scale (Shannon index = f(window size)
- Sliding window computing several landscape metrics (structure+composition)
- Clustering : ACP and Kmeans classification



What to look for inside landscape units

Main research issues

1) To characterize landscape patterns based on farming practices

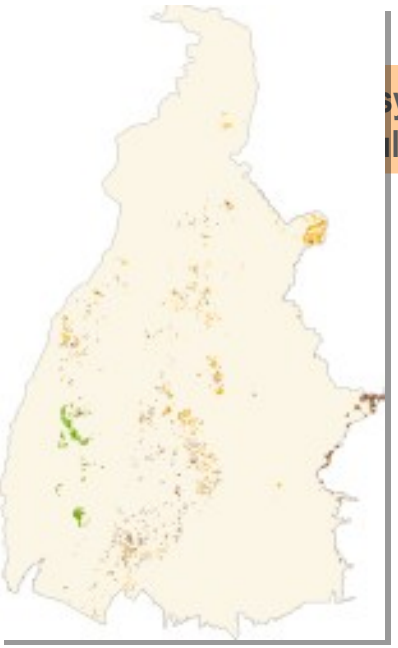
2) To understand the drivers of farming practices for a better assessment of current landscape patterns

3) To assess the impacts of farming practices on ecosystem services to improve the design of future agricultural landscapes

Characterizing landscape patterns

Characterizing landscape patterns

Based on cropping systems…



systèmes
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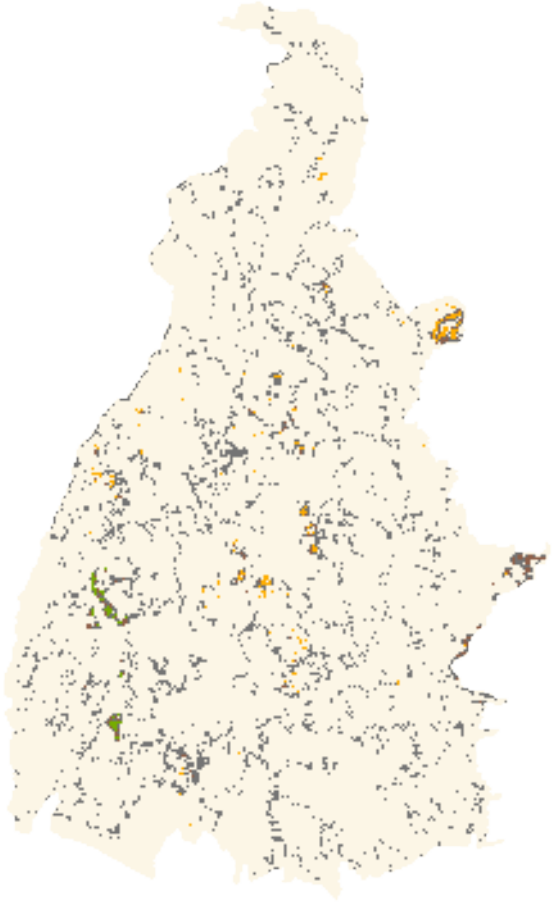
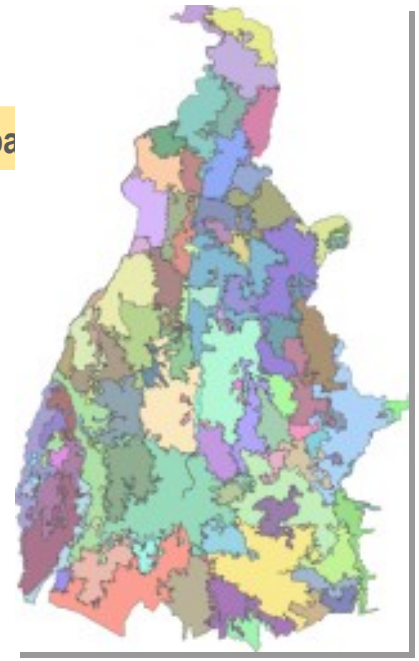


Unités de pa

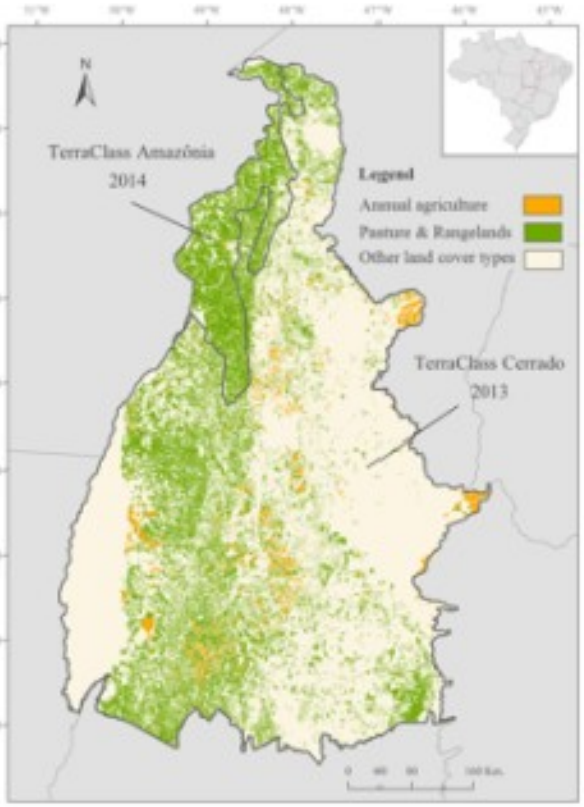


Bellon (2017)

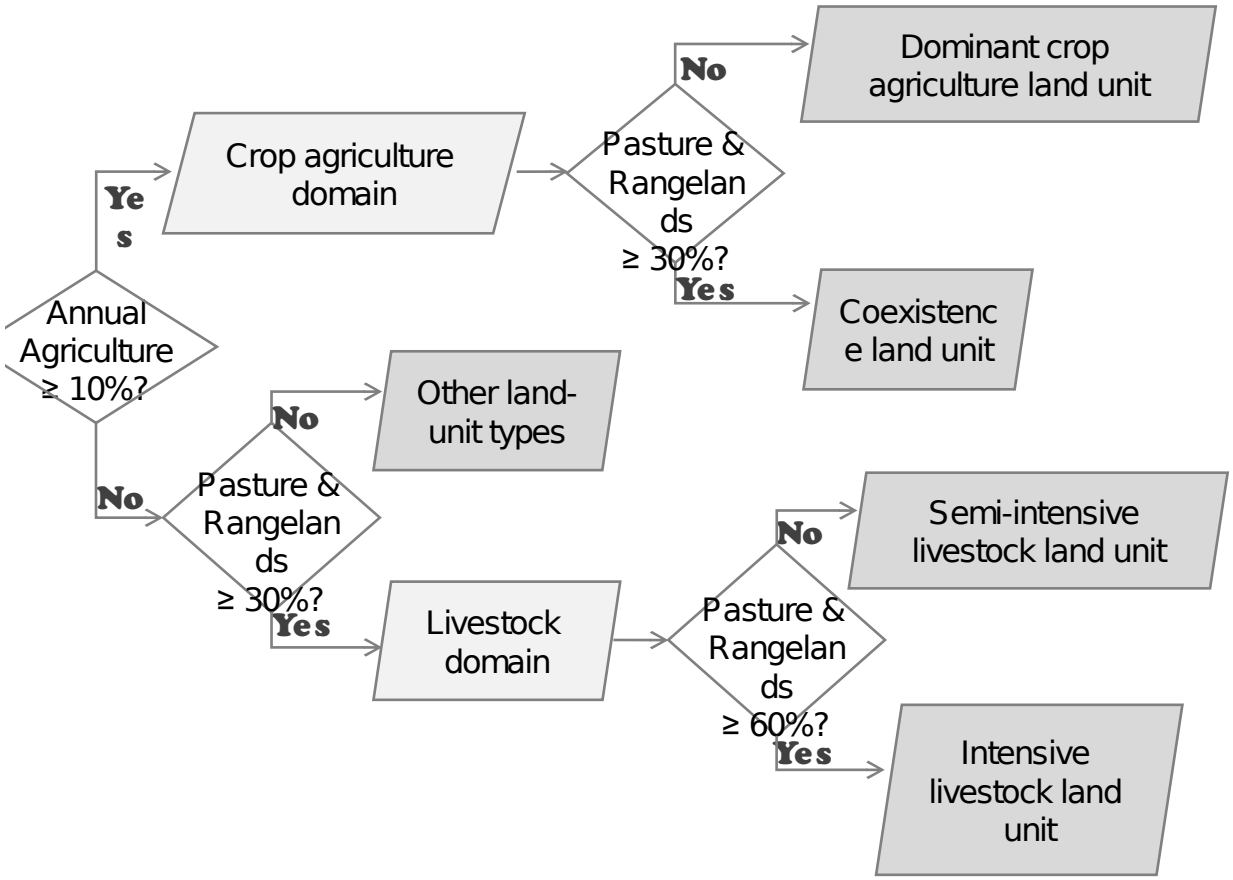
Characterizing landscape patterns

… and information on natural habitats

TERRAClass Amazonia et Cerrado



Bellon (2017)



Characterizing landscape patterns

… and information on natural habitats

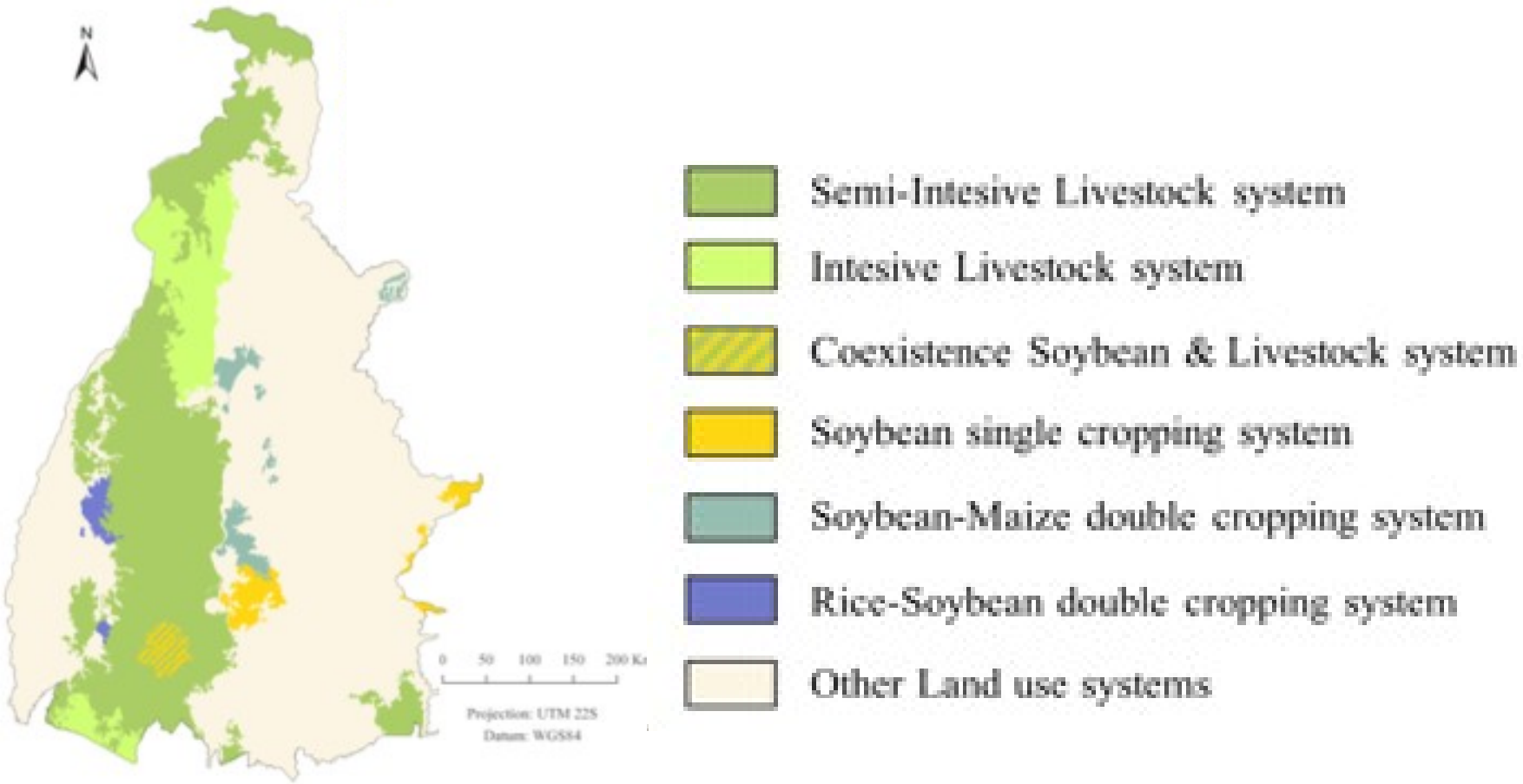
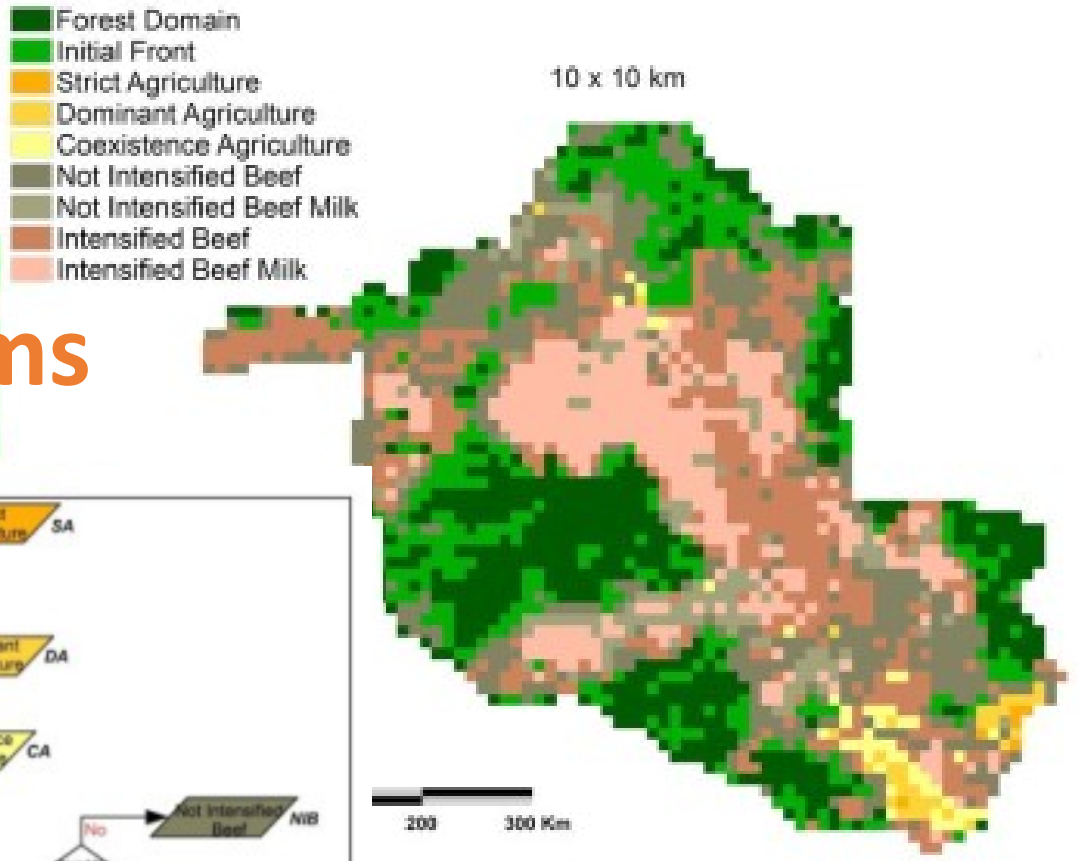


Figure 8. Map of the main agricultural land-use systems (ALUS) of the Tocantins state in the 2013-2014 growing season.

Bellon (2017)

Characterizing landscape patterns

From land use to Agricultural systems



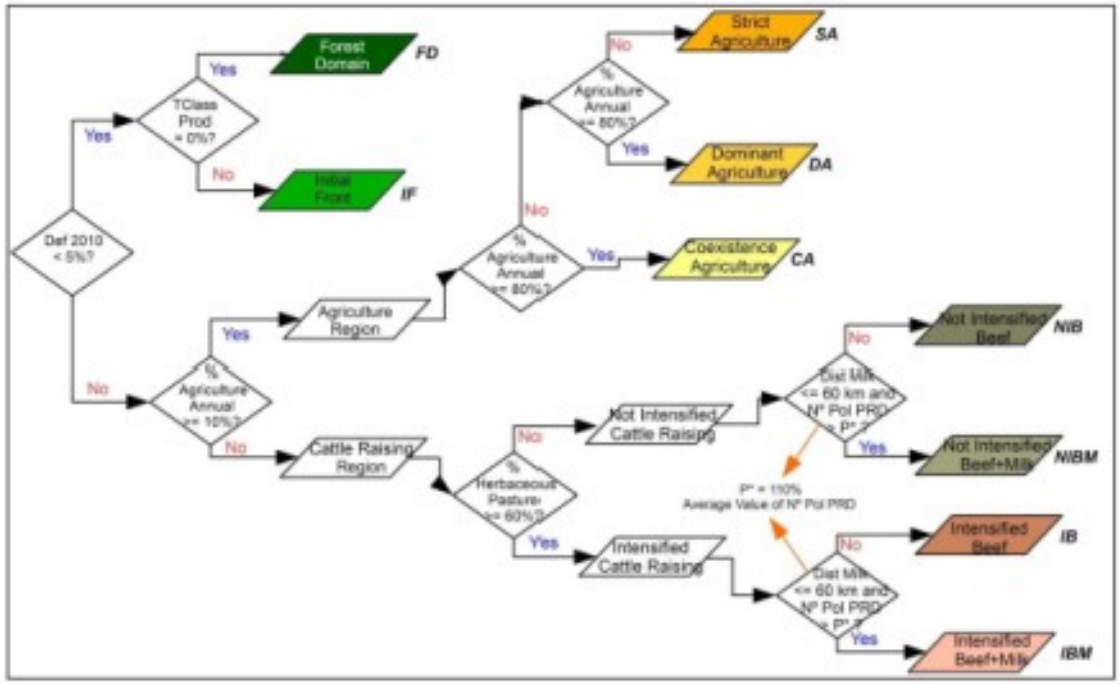


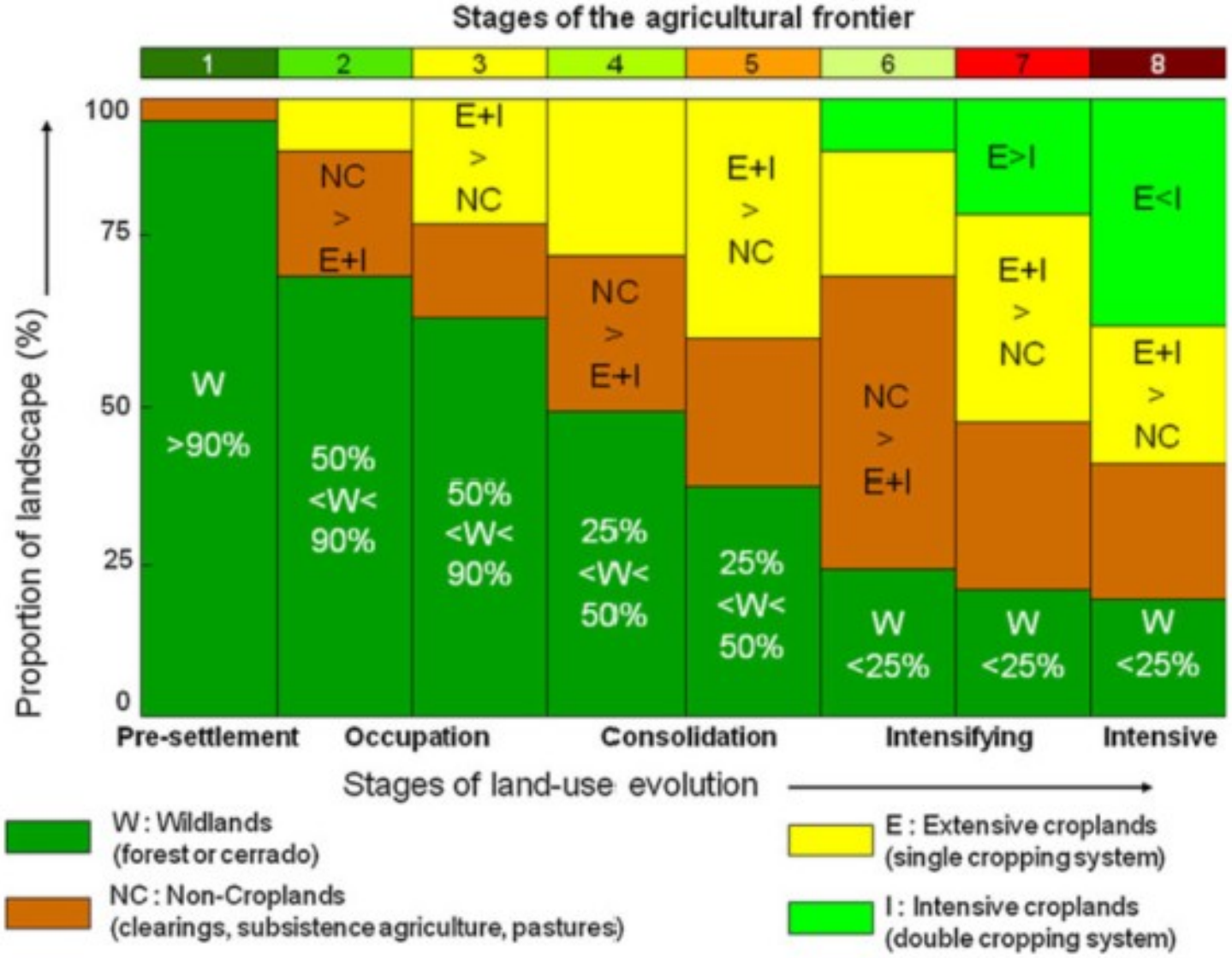
Figure 2 – Decision tree adopted to identify the agropastoral production systems at the cellular level.

Intégration de données extérieures (socio-économiques par exemple)

Almeida et al. (2016)

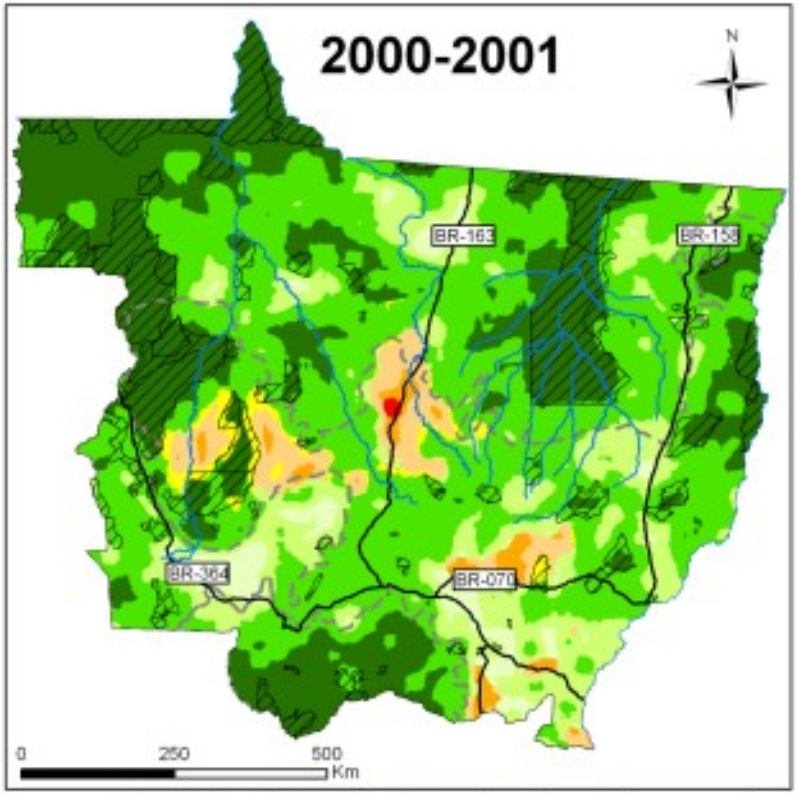
Characterizing landscape patterns

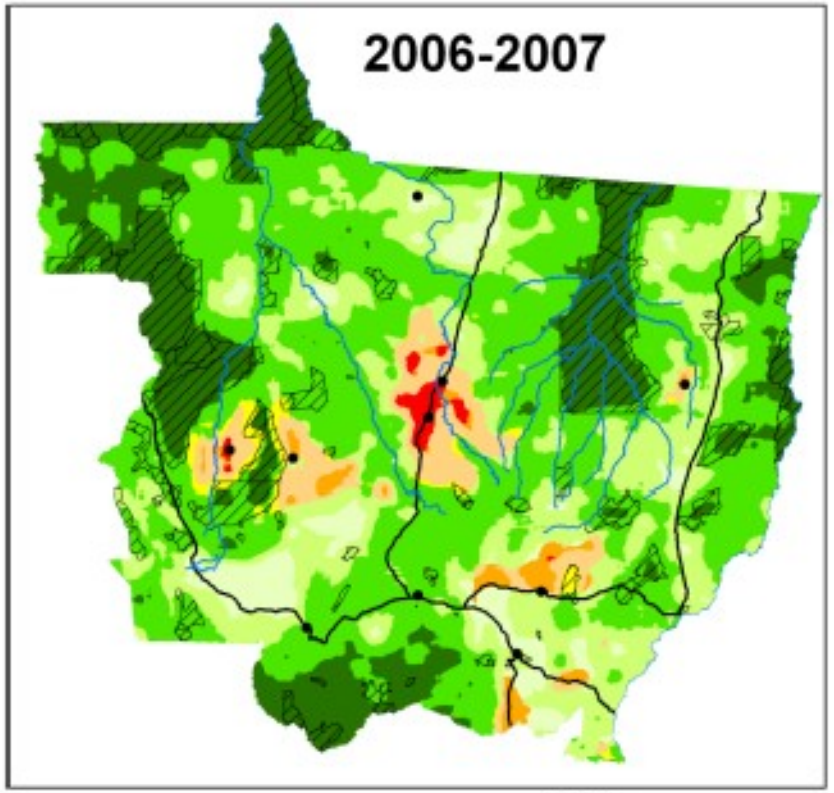
Monitoring the agricultural frontier



Characterizing landscape patterns

Monitoring the agricultural frontier





Paysages dominés par espaces naturels, pâturages et agriculture traditionnelle

- Espaces naturels
- Espaces naturels majoritaires
- En cours de conversion (pâturages et agri. trad)
- Pâturages et agri. traditionnelle majoritaires

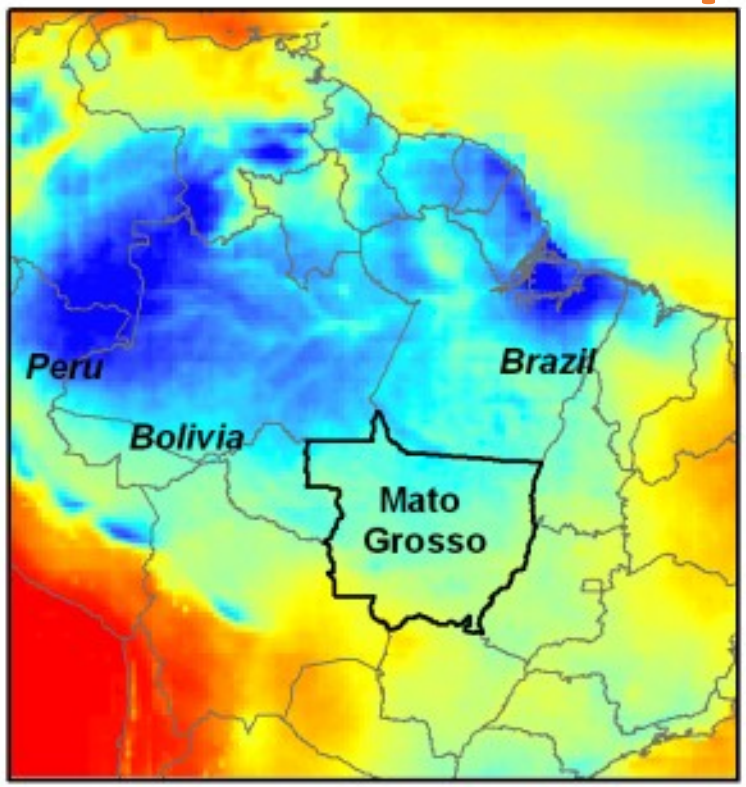
Paysages dominés par agriculture « latifundiaire »

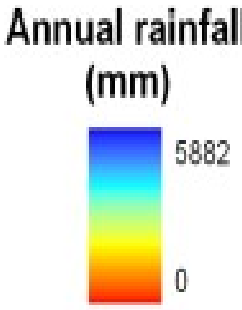
- En cours de conversion à agriculture extensive
- Agriculture extensive majoritaire
- Agriculture extensive en cours d'intensification
- Agriculture intensive

Drivers of landscape patterns

Drivers of landscape patterns

Climate to explain agri. intensification

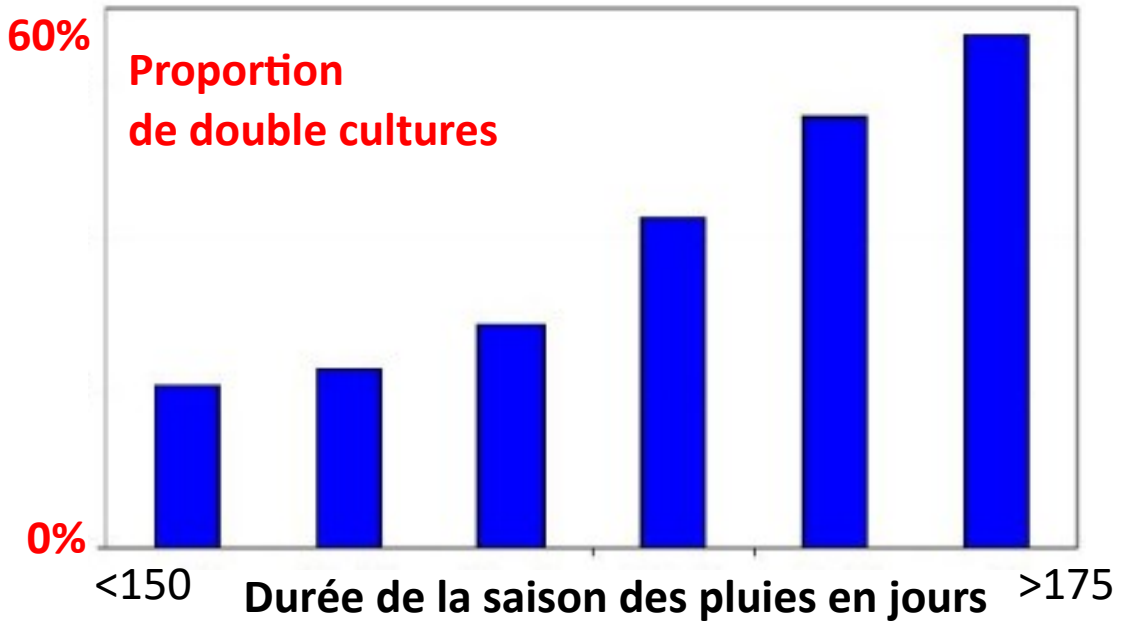




Suivi des précipitations par satellite (TRMM)

Longue saison des pluies
=
pratiques agricoles intensives (double cultures)

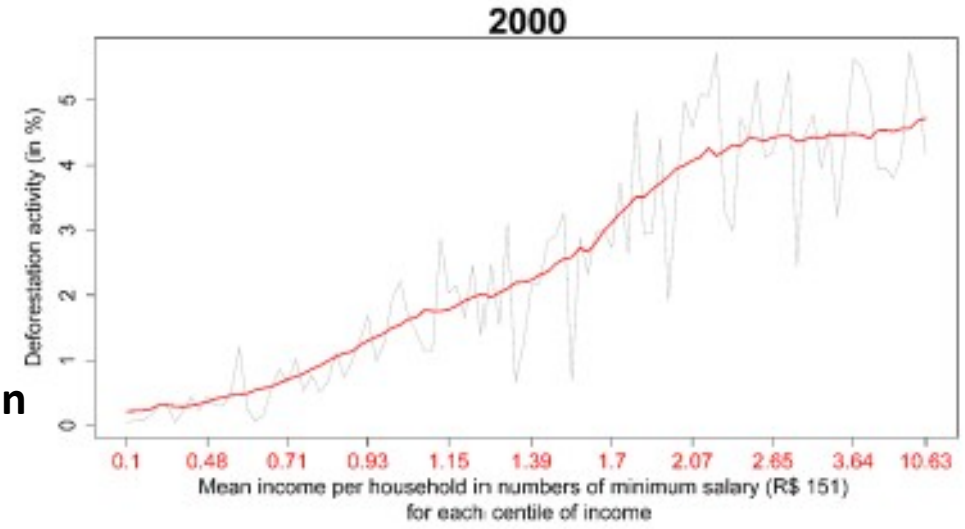
Intensification agricole Vs Pluviométrie



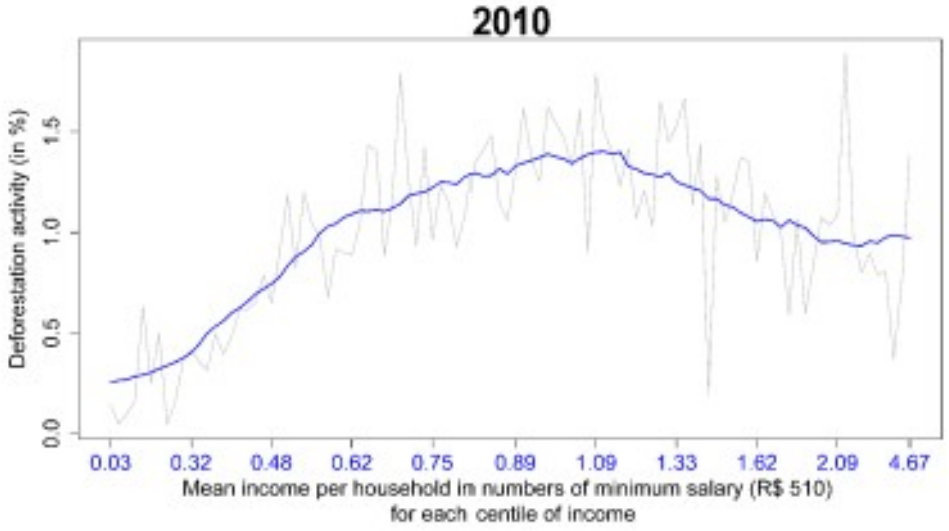
Drivers of landscape patterns

Socio-economic development vs deforestation

Deforestation Activity (in % of in a grid cell)



High income = High deforestation



High income = Moderate deforestation

Improve the design of agricultural landscapes

The importance of (semi-)natural habitats in agricultural landscapes

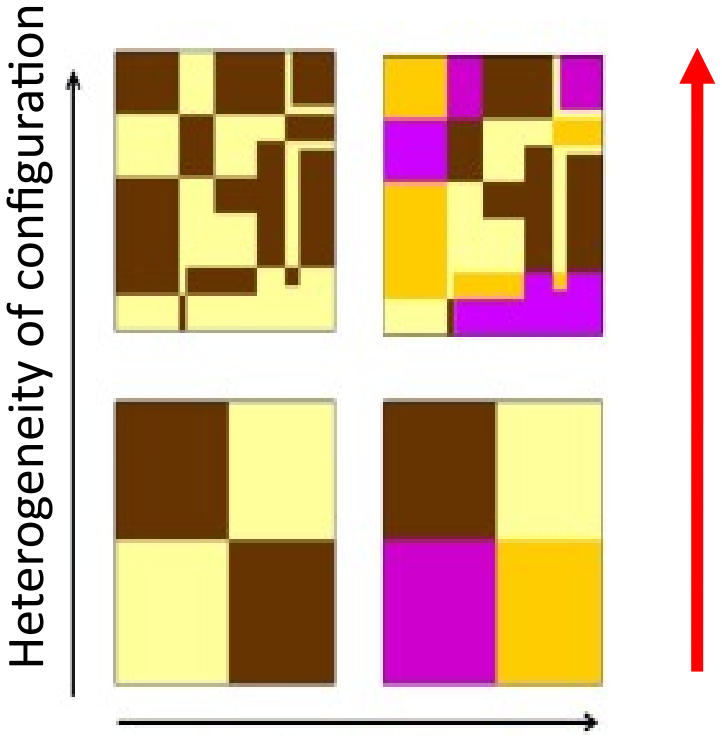
Improve the design of agricultural landscapes

The concepts and metrics developed from the “landscape mosaic representation”

Heterogeneity : landscape composition and configuration

Fragmentation & Connectivity

Improve the design of agricultural landscapes

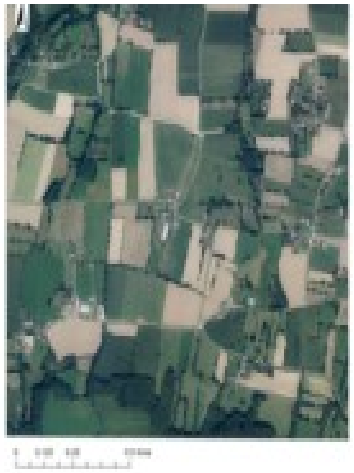


Elements are more fragmented (connectivity among patches of one element decreases)

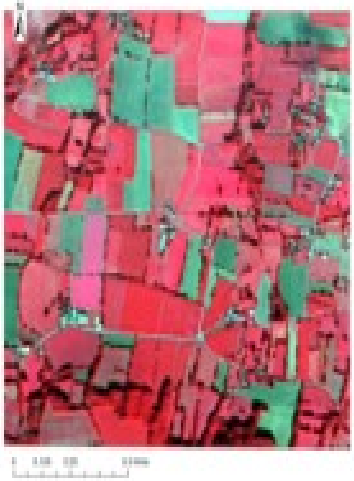
Interfaces, therefore interactions between different elements increases

A higher diversity of resources

Hedgerows

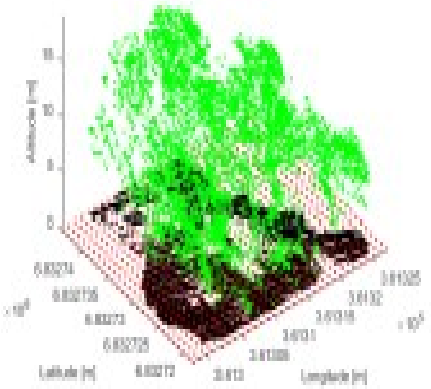


(1) Aerial photographs



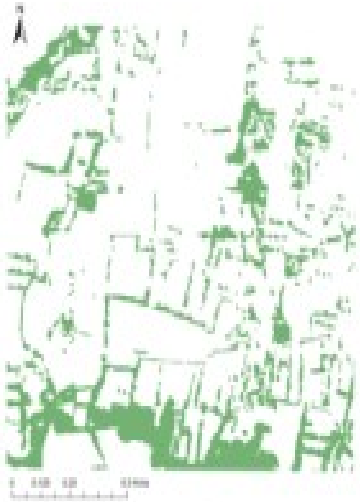
(2) SPOT-5

(3) TerraSAR-X



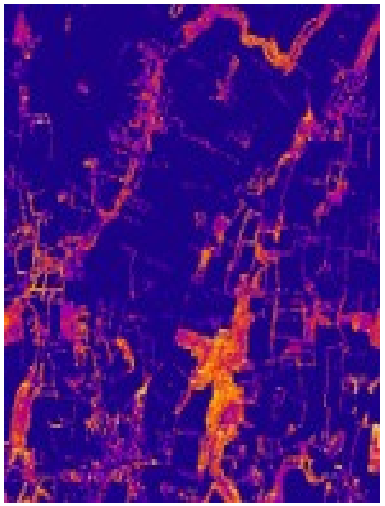
(4) LIDAR data

Hedgerow map from aerial photographs (Lines)



Hedgerow map from SPOT-5 (Object without internal structure)

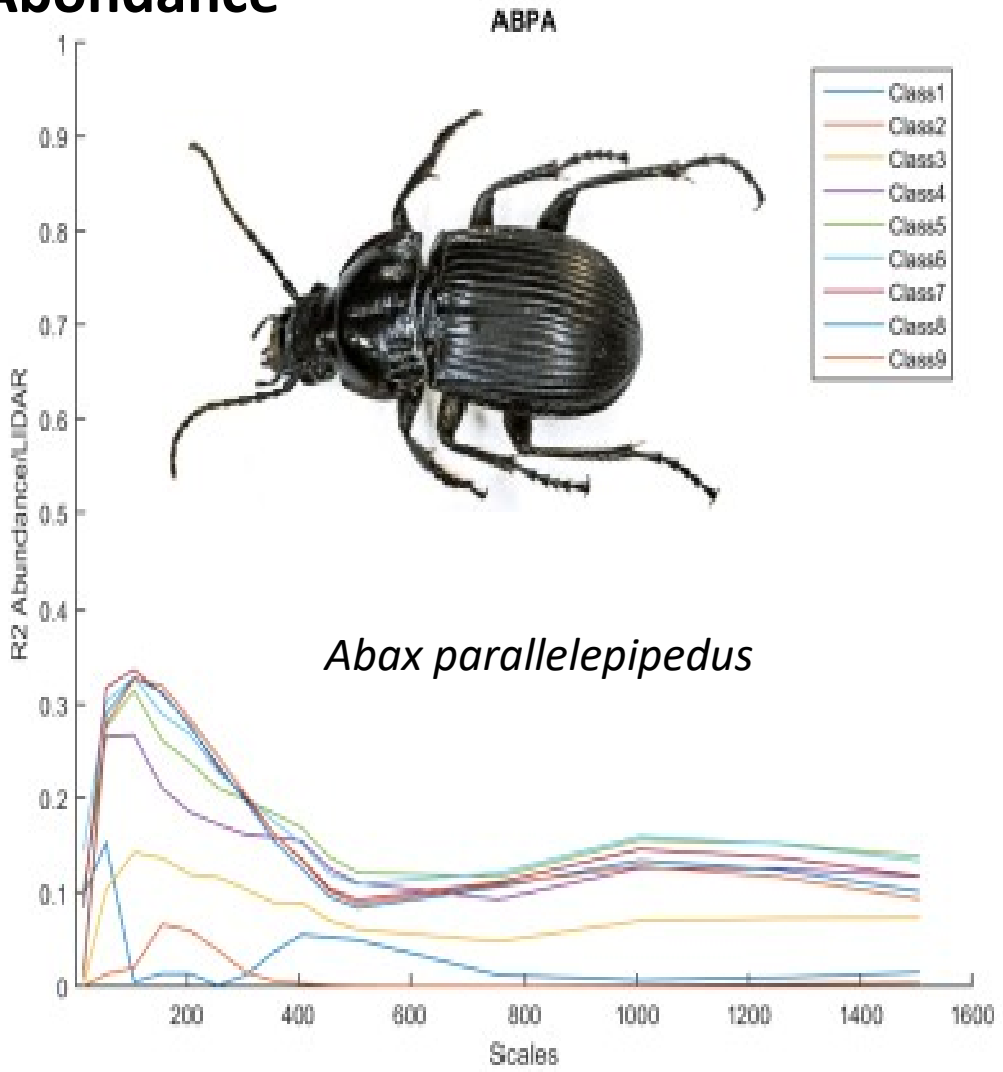
Hedgerow map from TerraSAR-X (Object with internal structure)



Hedgerow map from LIDAR data (object with internal structure)

Hedgerows

R^2 Abondance



Abax parallelepipedus

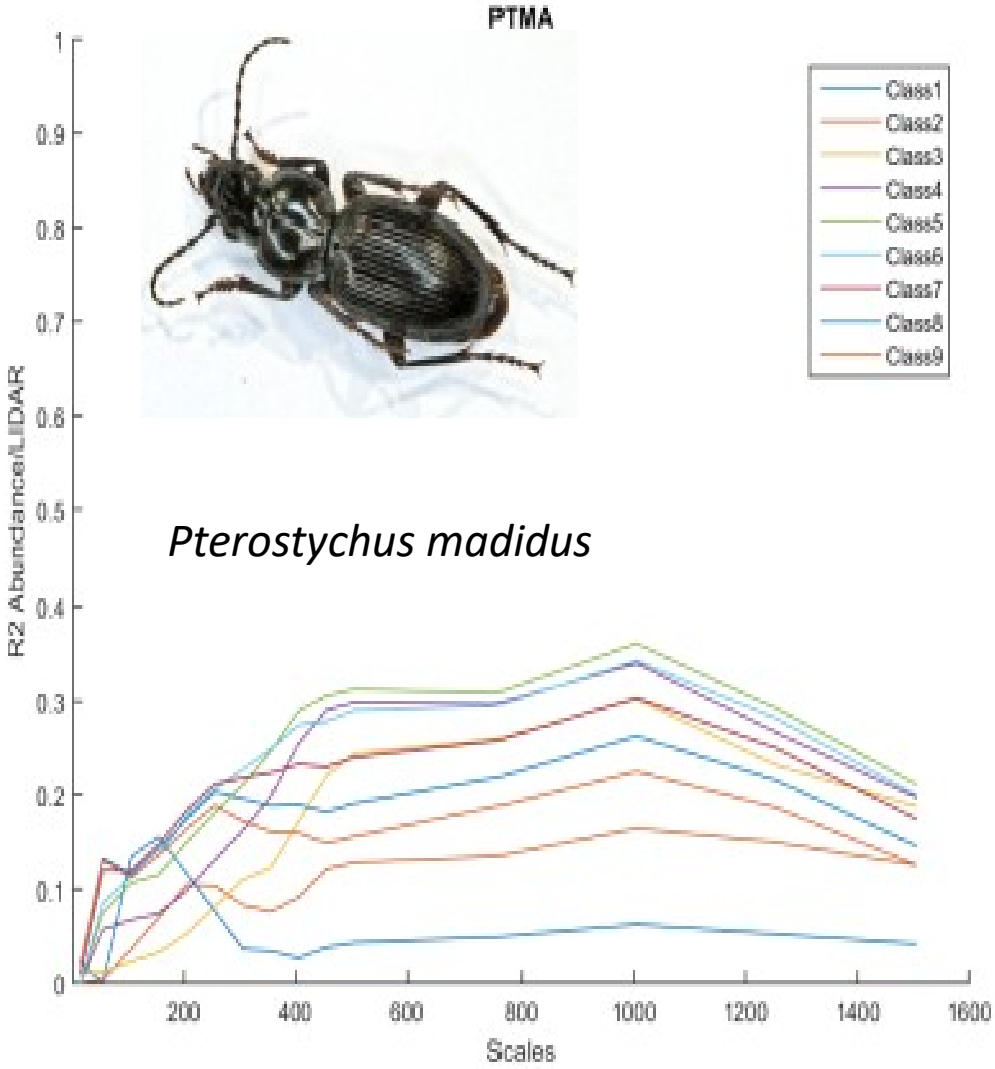
Class1: Hedgerows with low canopy cover

Class9: Hedgerows with high density cover

LIDAR variables : classes taking into account pixels with more and more point density

Spatial scale

Hedgerows

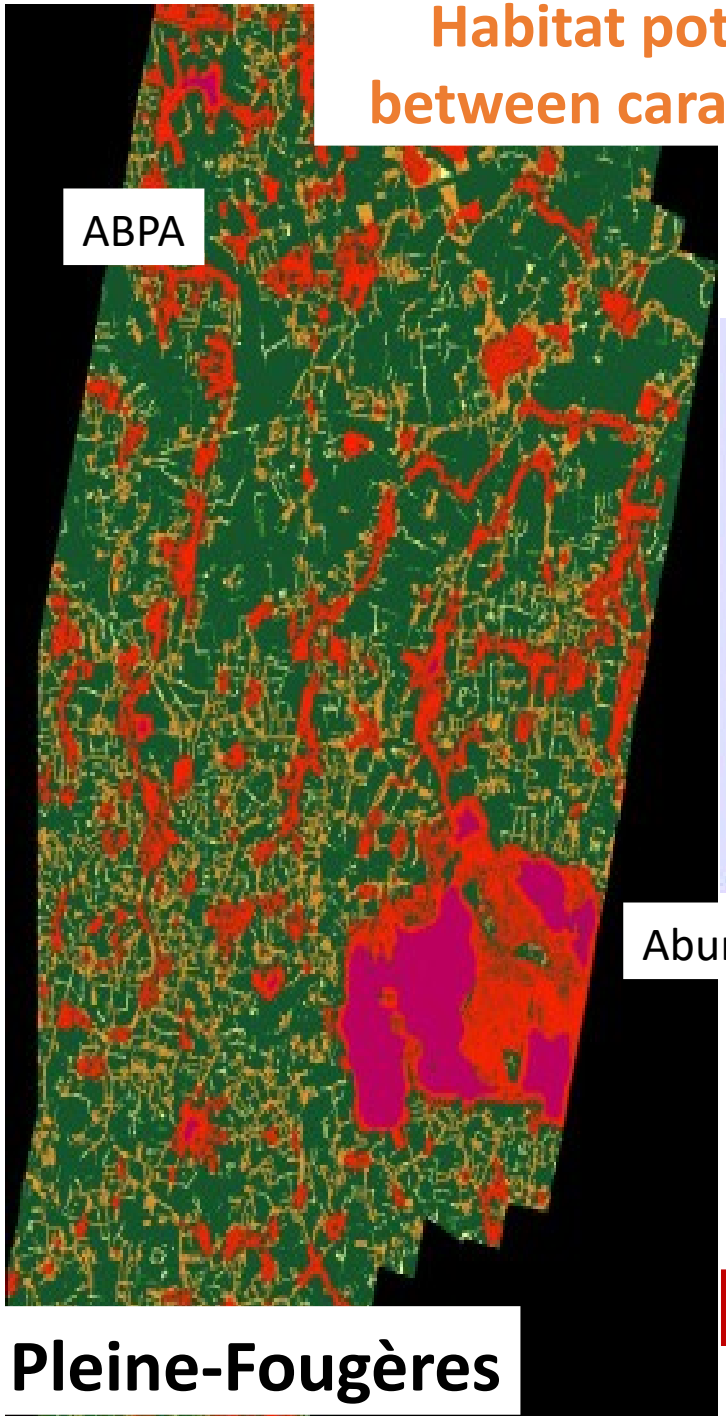


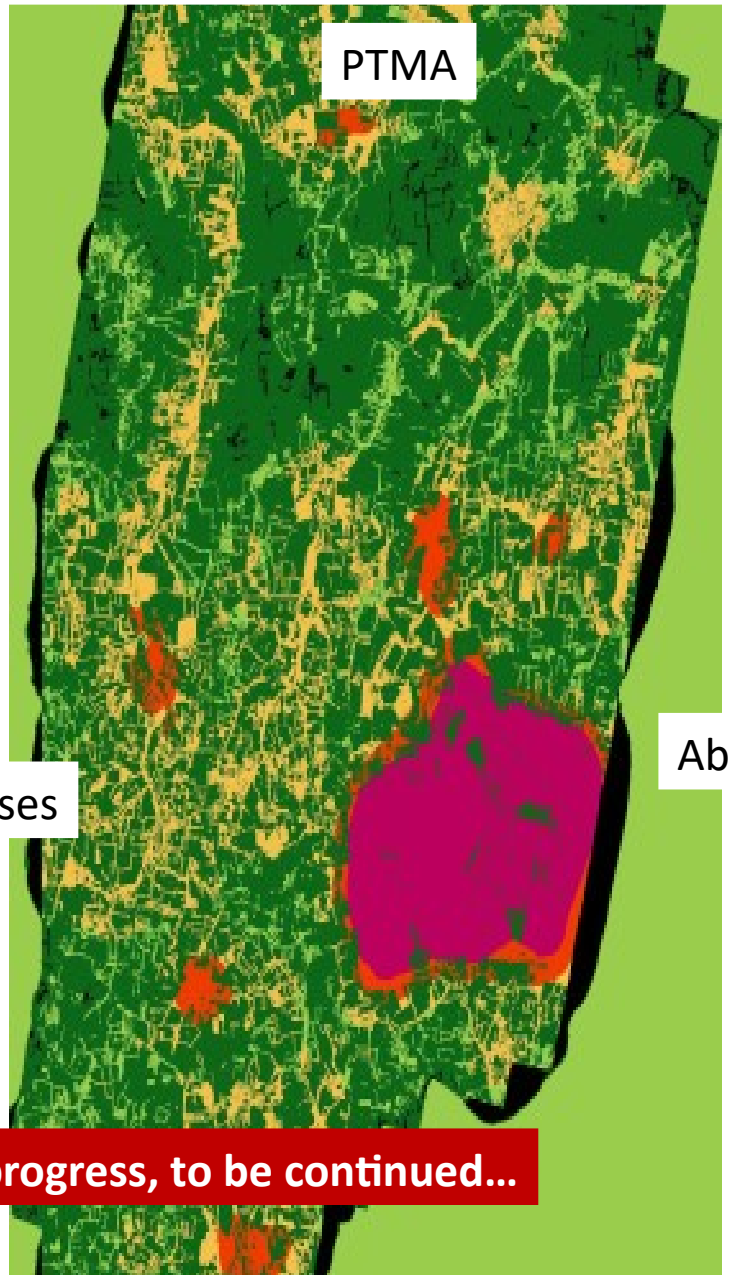
Pterostychus madidus

Class1: Hedgerows with low canopy co

Class9: Hedgerows with high density cover

Habitat potential derived from the relationship between carabid abundance / LIDAR for two species

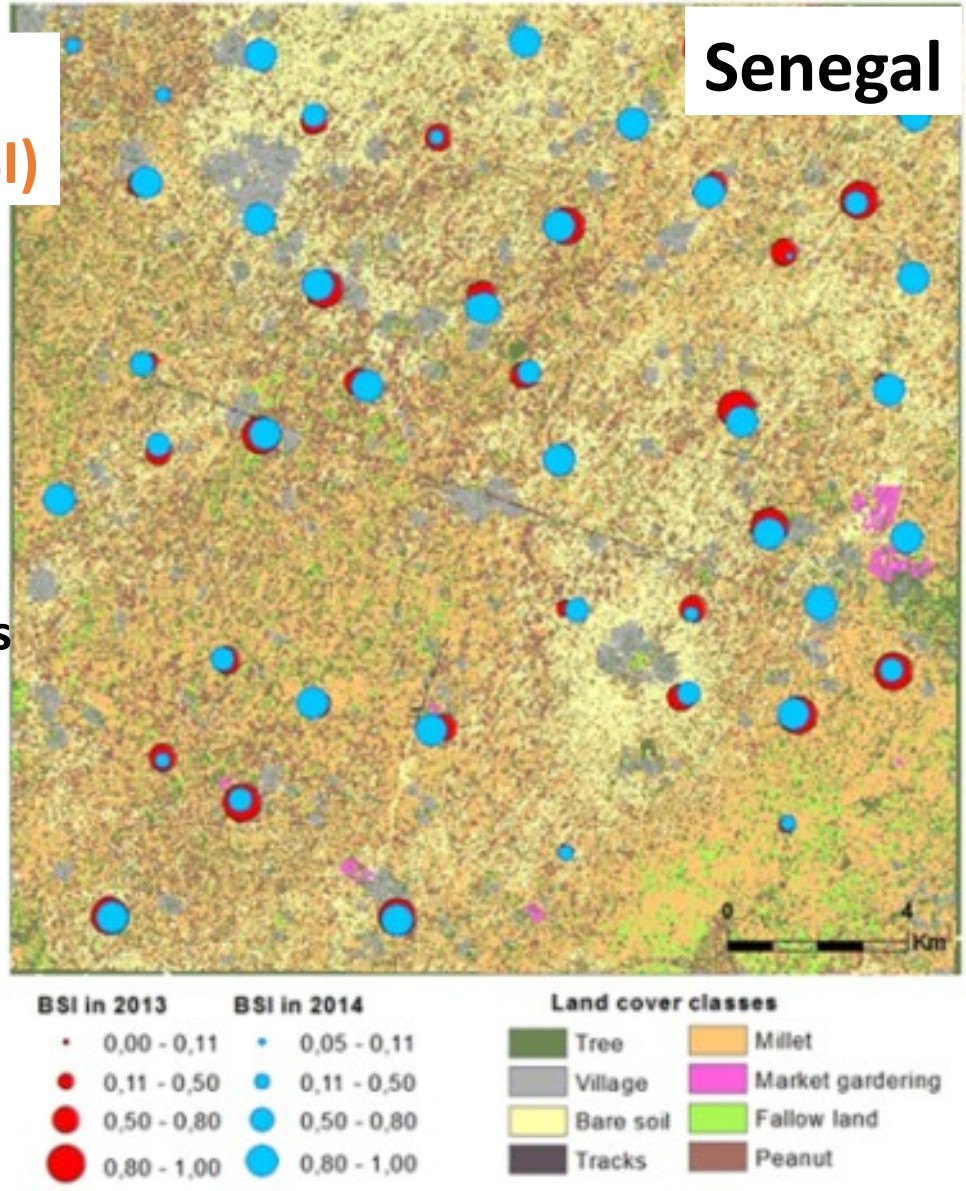




WORK in progress, to be continued…

Landscape diversity for biological control

Relationship between land cover and a biocontrol service index (BSI)

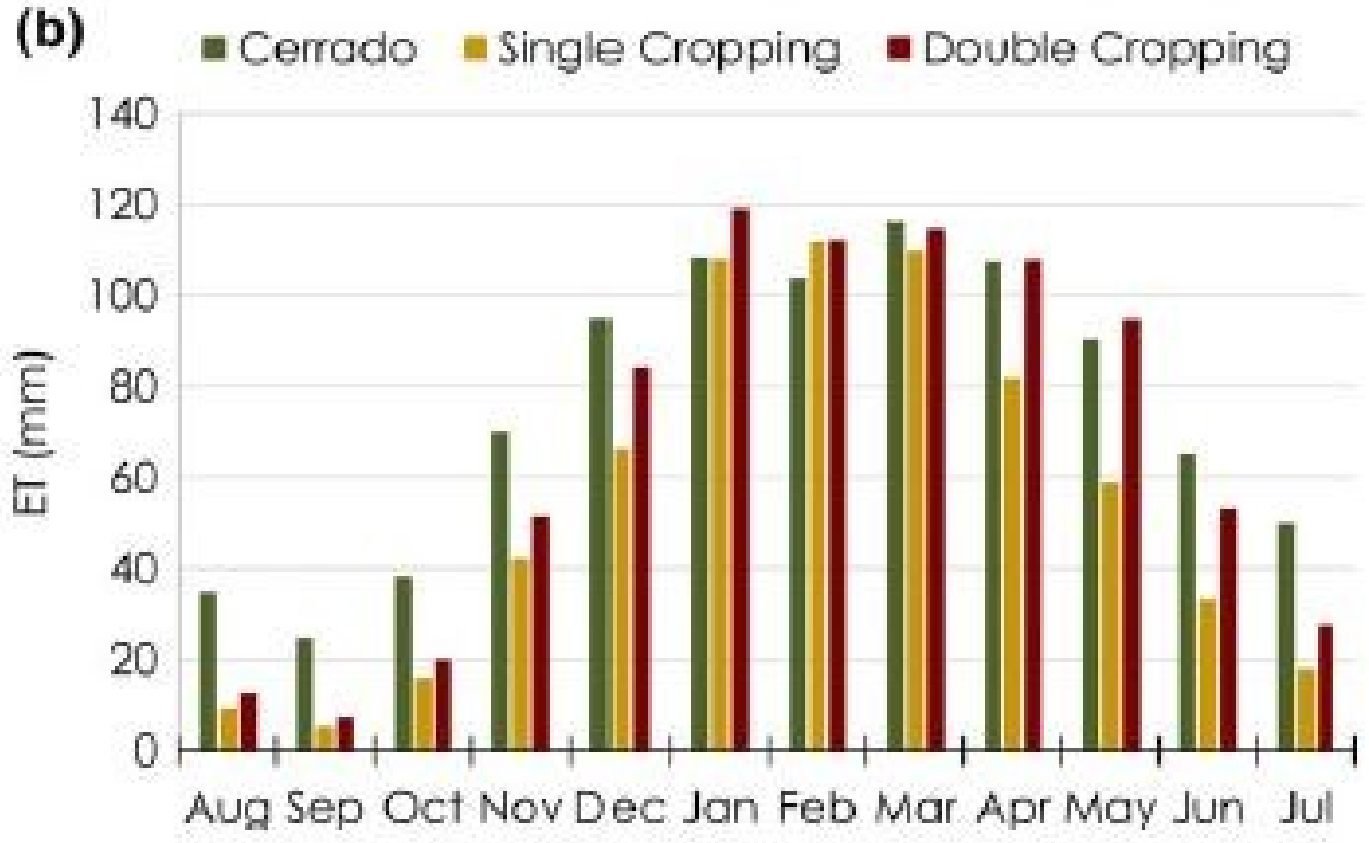


BSI is mainly explained by :
The landscape diversity index (SHDI)
The tree density index (TPDI)
at a 1750 m radius around sampling sites

⇒semi-natural vegetation, i.e. trees, must be maintained to enhance biocontrol of *H. albipunctella*. (mineuse du mil)

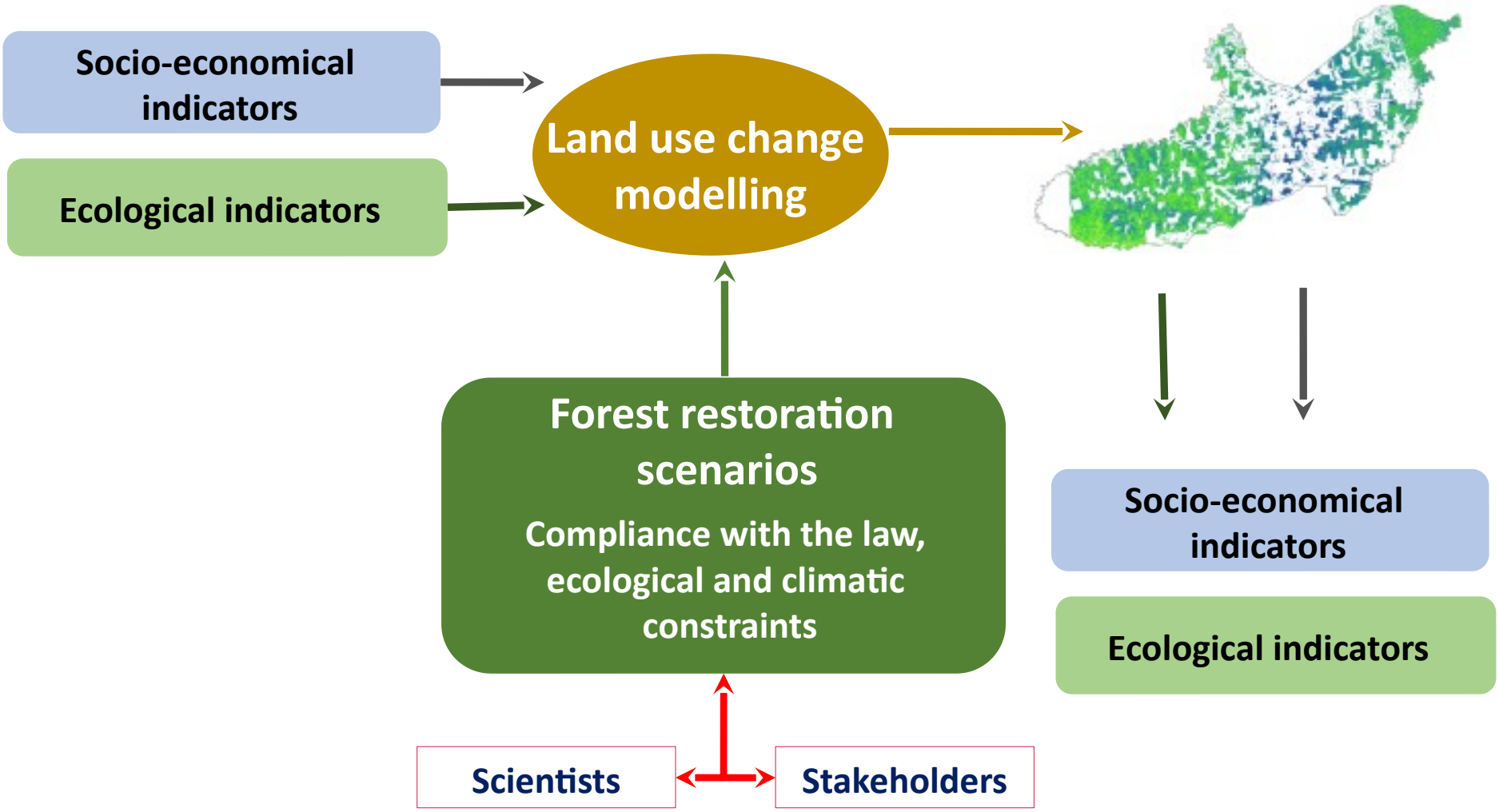
Agri landscapes to mitigate climate change

Double cropping to compensate the evapotranspiration (ET) loss from croplands



Spera et al. Global Change Biology 2016

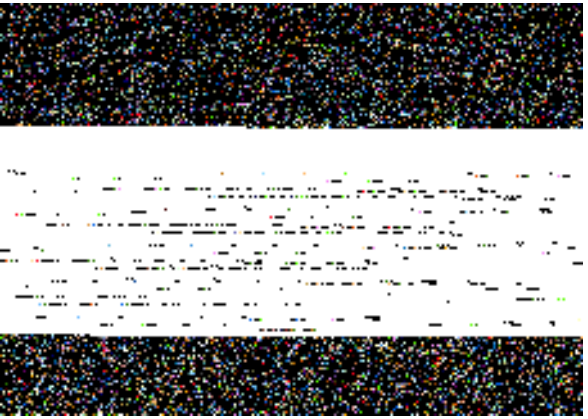
Forest restoration



Forest restoration

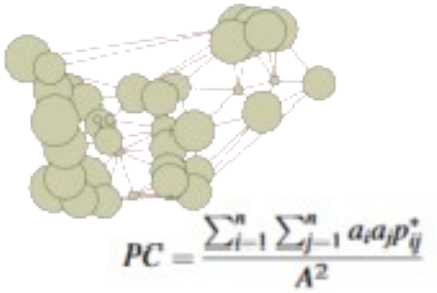
Ex: Indicateurs écologiques

Land use map



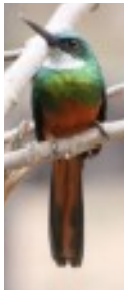
Resistance surface modeling
(based on species ecology)

Connectivity modeling
(PC index)

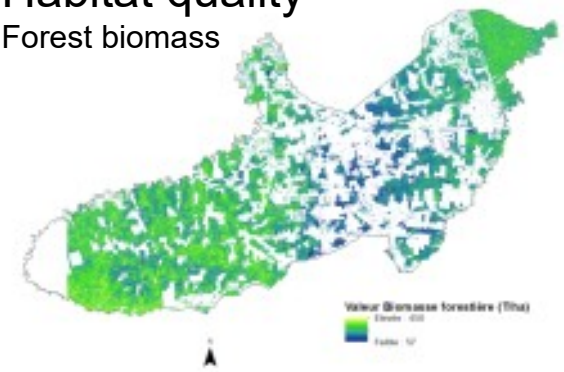


Saura and Pascual-Hortal 2007

Virtual forest species
(e.g. birds, beetles)



Habitat quality
Forest biomass



WORK in progress, to be continued…

Limits/Perspectives

Limits/Perspectives

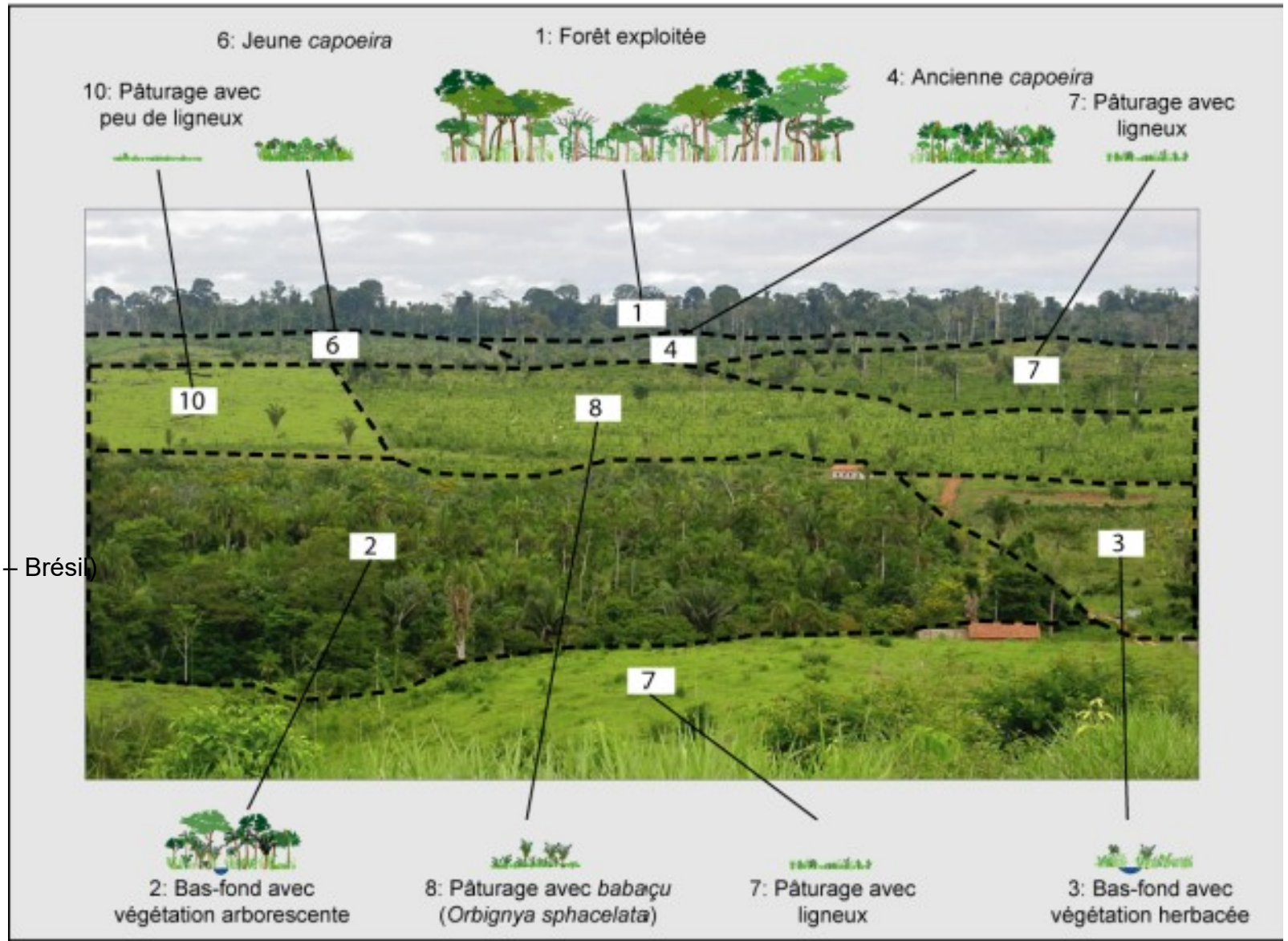
The limits of land cover maps: several blind spots

1) No difference between patches of the same type of land cover
2) Little consideration for internal heterogeneity within patches
3) Little consideration for vegetation phenology
4) Abrupt interfaces between patches of different types.

Changes in the interface between maize and wheat within a cropping sea

Limits/Perspectives

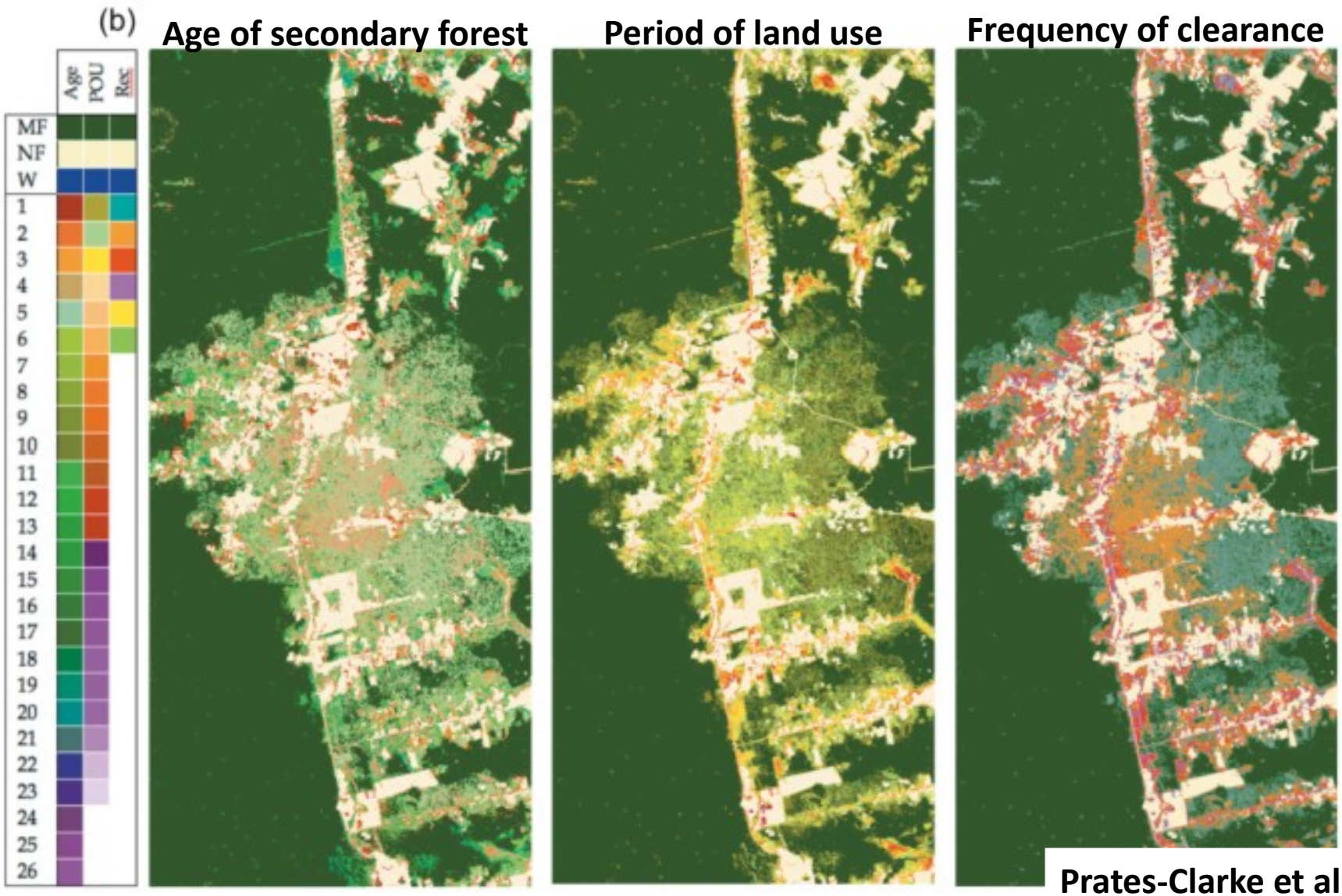
Deal with spatial gradients?



Benfica (Para – Brésil)

Limits/Perspectives

Temporal landscape metrics



Prates-Clarke et al. 2009