



USE OF REMOTE SENSING FOR MONITORING WETLAND PARAMETERS RELEVANT TO BIRD CONSERVATION

AURELIE DAVRANCHE

TOUR DU VALAT

ONCFS

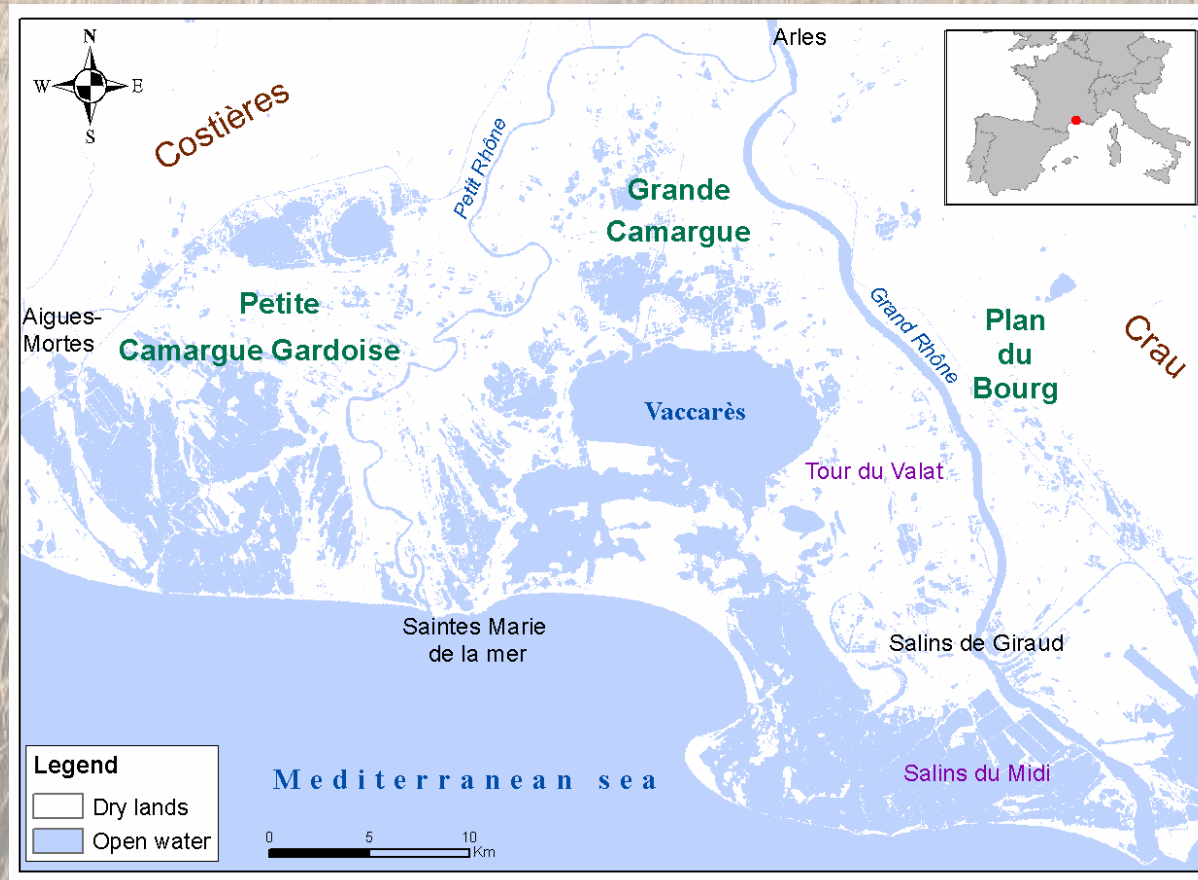
UNIVERSITY OF PROVENCE – AIX-MARSEILLE 1

UFR « Sciences géographiques et de l'aménagement »

University - CNRS 6012 E.S.P.A.C.E

Camargue : Rhône river delta

Dynamic system: water and sediment inputs from the Rhône and the sea



90 000 ha of natural habitats mostly wetlands

2/3 on relatively small private estates

Socio-economic activities and natural habitats

**Rice
growing**

**Reed
harvesting**

**Waterfowl
hunting**

**Cattle
grazing**

Water management
input of freshwater in brackish marshes
modification of the hydroperiod
division of the marshes into smaller dyked units

Influence on floristic composition and vegetation biomass

Changes in bird habitat

Main objective

Global loss of biodiversity

Proliferation of invasive species

Necessity to monitor the management and the health state of these marshes

Reserve managers and stakeholders are in needs of management advices

Development of reliable and replicable remote sensing tools for wetland monitoring

A fragmented configuration within a large geographical area: monitoring based on repeated ground measures difficult

Remote sensing: good potentialities for wetlands spatial analysis

Specific objectives

These tools will help to :

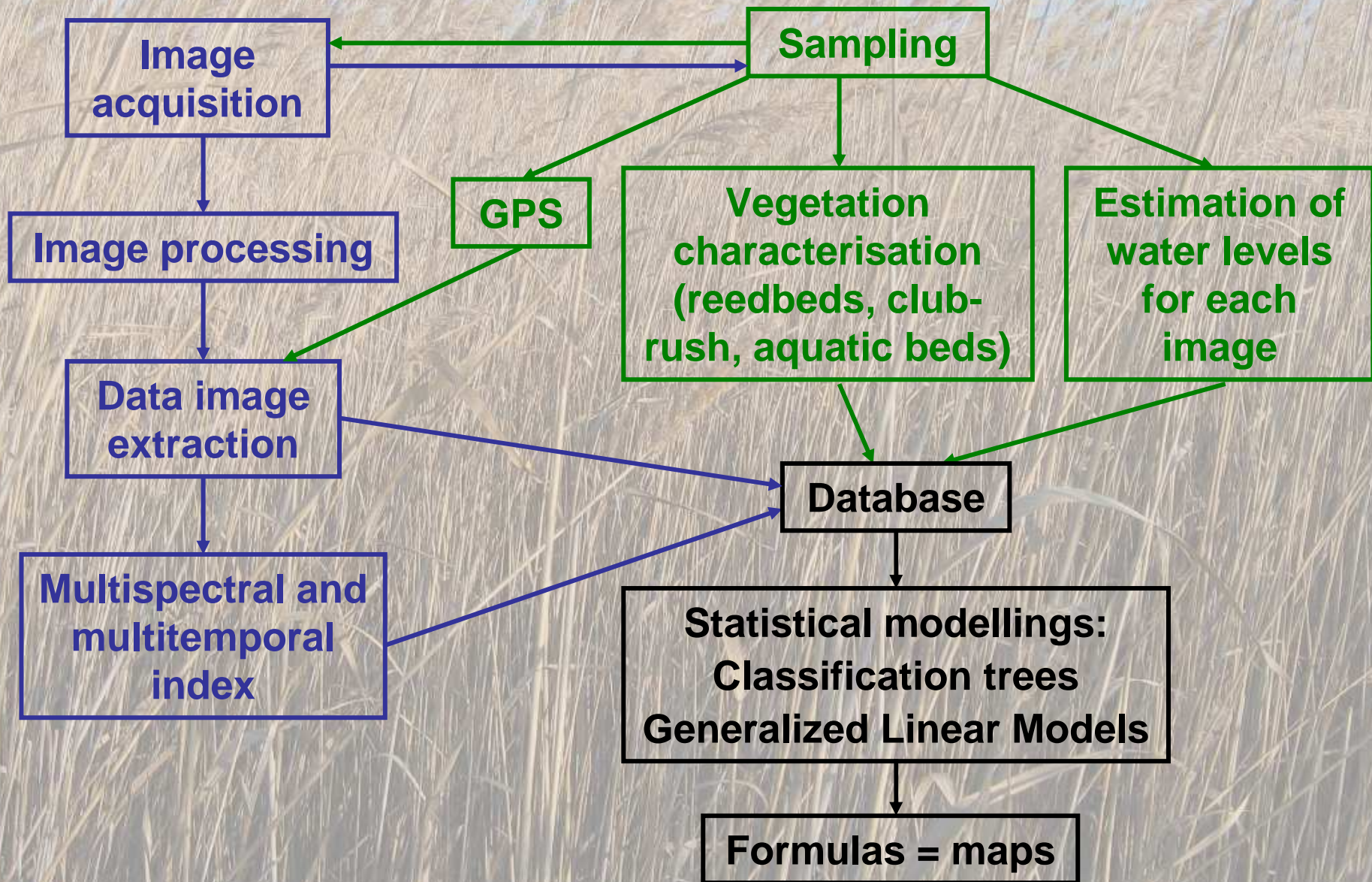
- ▶ map the vegetation of Camargue marshes (common reed, club-rush, aquatic beds) to follow their spatial evolution over time



- ▶ map flooded areas irrespective of vegetation density to follow their spatial evolution monthly

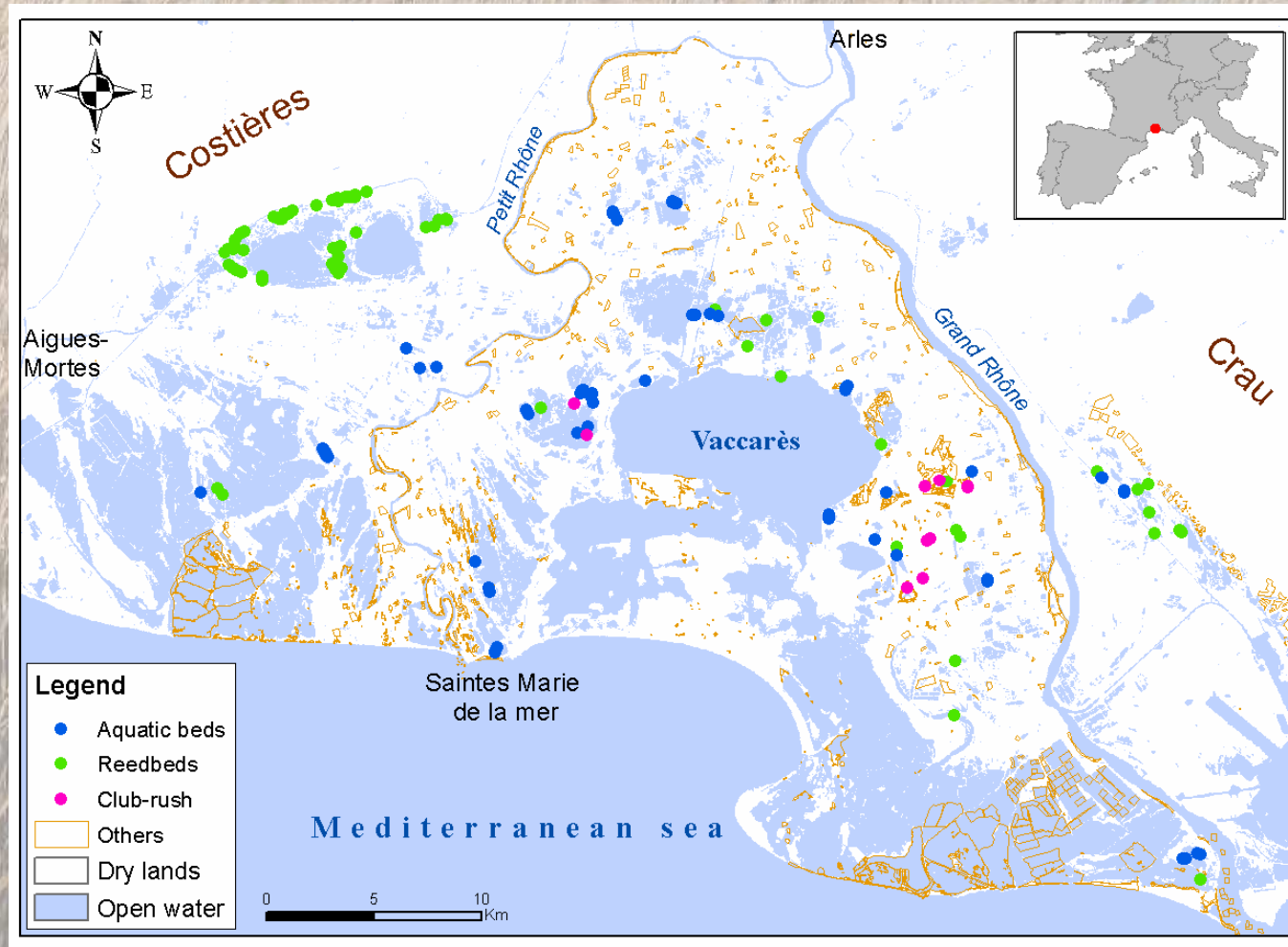
- ▶ map vegetation parameters that are associated with ecological requirements of vulnerable birds in reed marshes

Methodology



Sampling

Fields campaigns : reedbeds, club-rush, aquatic beds, water levels, GPS

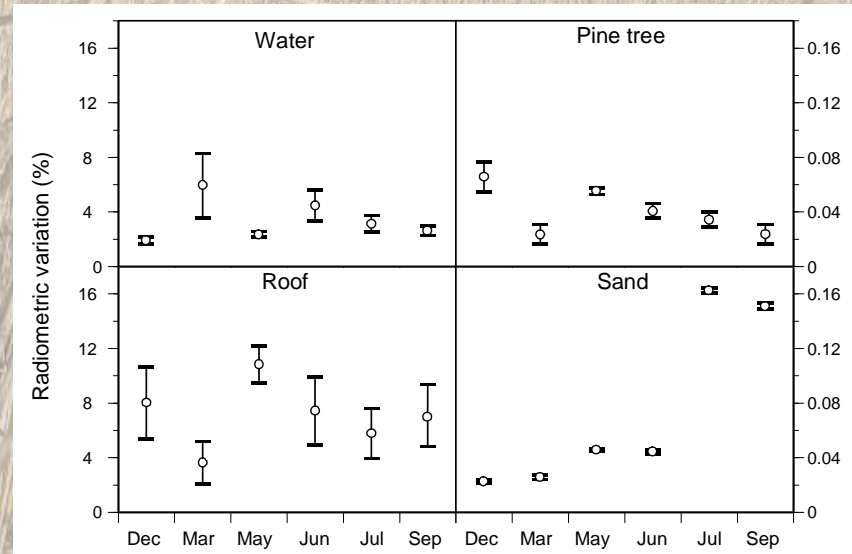


Digitalizations : Others

Image processing: radiometric normalization

6S atmospheric model vs. pseudo-invariant features (PIF)

Similarity index (Euclidian distance): Estimation of radiometric variation of PIF

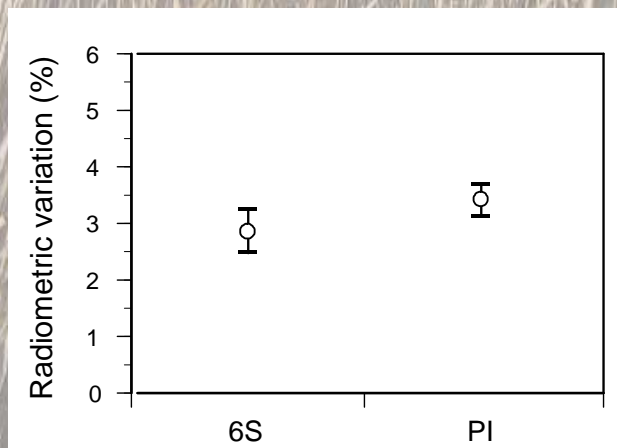


Each PIF varies at least once over the year



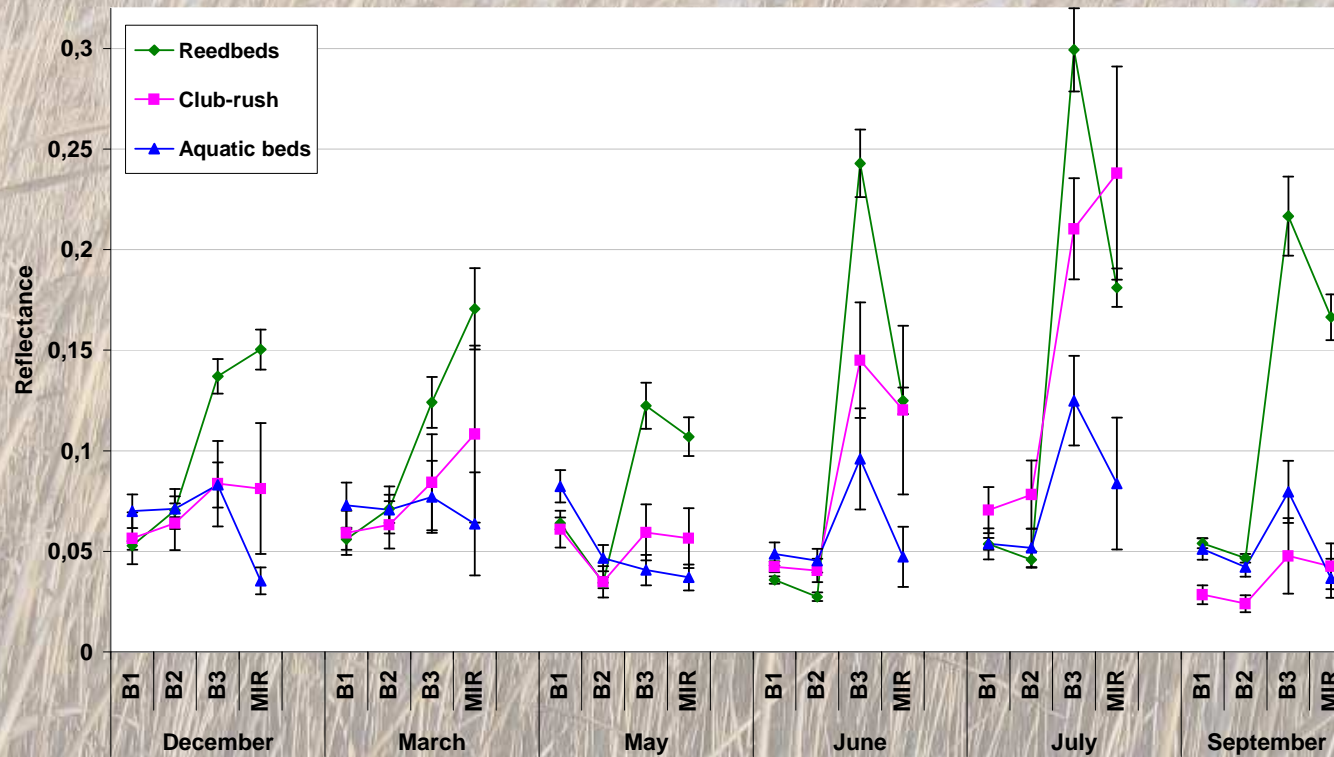
Necessity of different types of PIF

6S does not take into account this variation for the correction



Variation significantly lower with 6S

Spectral variations



Influence of :

- phenology
- pluviometry
- water management

➔ Natural and artificial phenomena characterizing Camargue wetlands require a multispectral and multitemporal imagery for their monitoring

Statistical modelling : two approaches

1 - Qualitative approach : presence/absence

- Presence of reed, club-rush and aquatic beds
- Presence of water in differing conditions of vegetation density

→ **Classification trees**

2 - Quantitative approach : prediction of continuous variables

- Diagnostic parameters of reedbeds
- Quality for reed harvesting
- Suitability for vulnerable reed birds species (passerines, Purple heron, Eurasian bitterns)

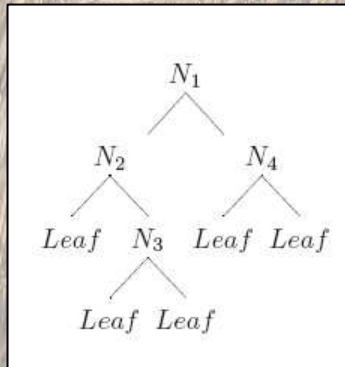
→ **Generalized Linear Models**

Classification tree algorithm

Rpart based on the algorithm CART (classification and regression tree)
Breiman et al, 1984; implemented in R.

Method

Recursive partitioning based on gini index



Binary tree

Advantages

Hierarchical classification strategy:
easy interpretation of results

Optimal for presence/absence

Cross-validation (k-fold)

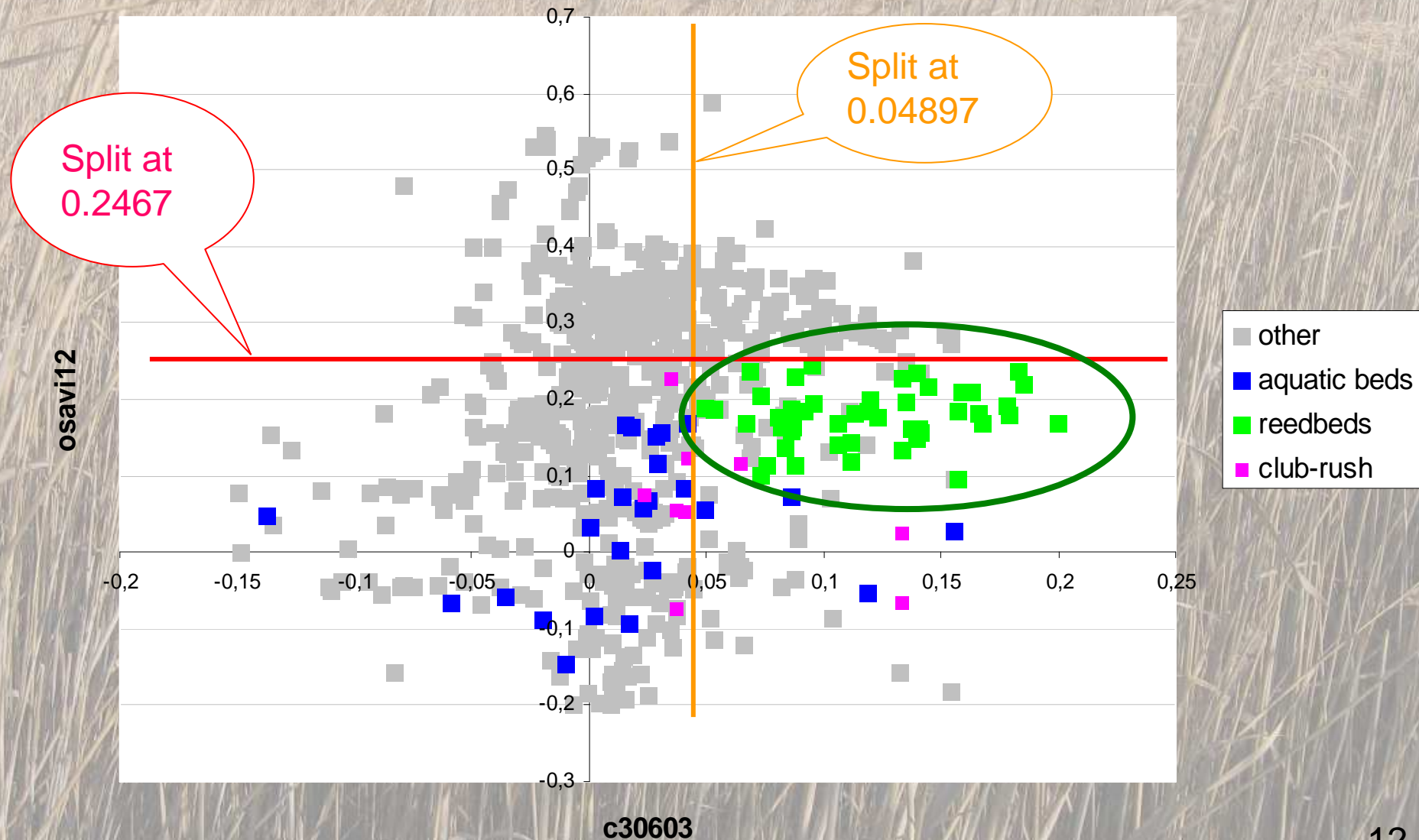
Small samples and reproducibility

Prior parameter

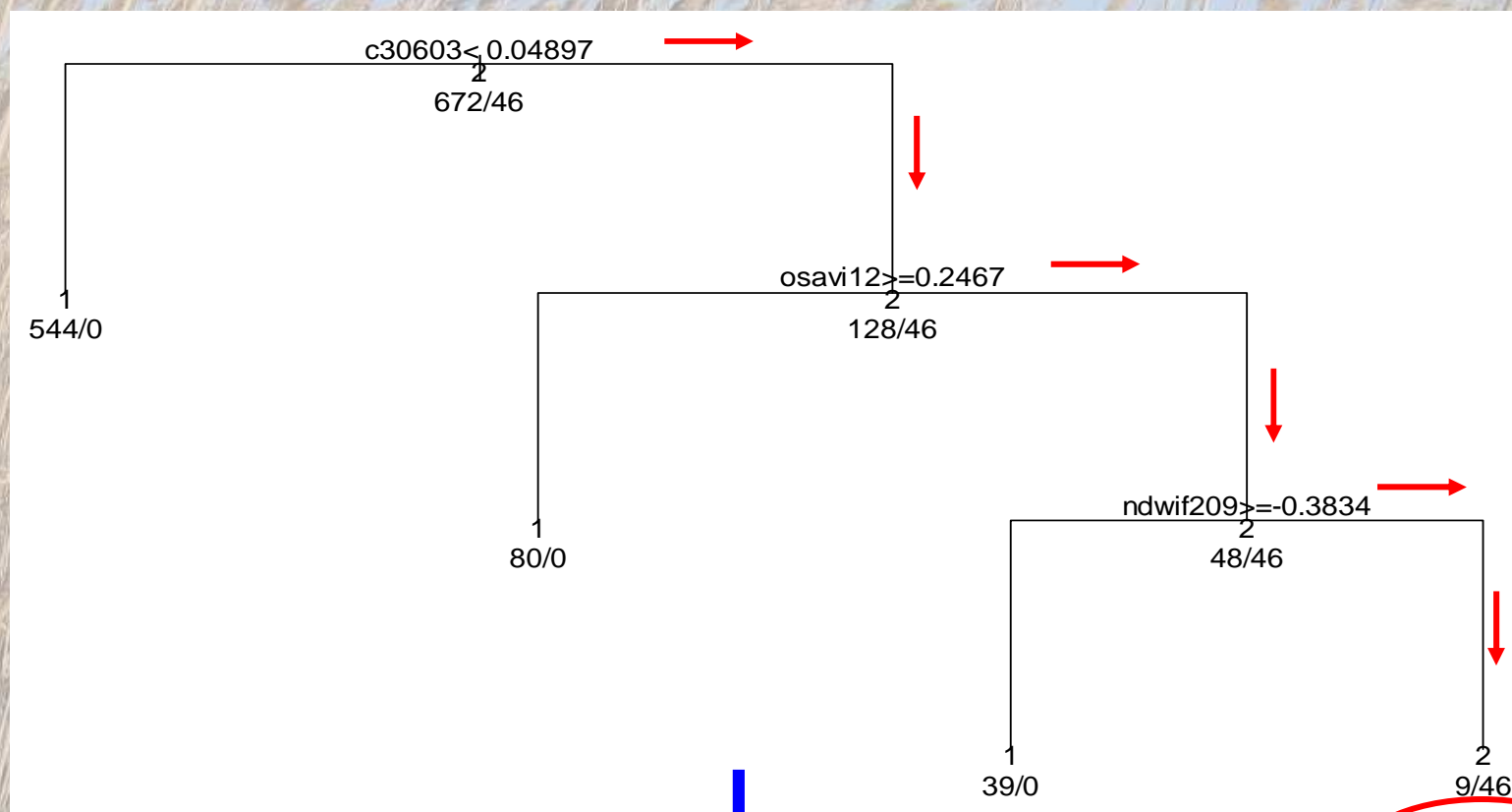
Unbalanced samples

Recursive partitioning

A two-dimension example with two variables selected for reedbeds classification



Tree: example for reedbeds classification



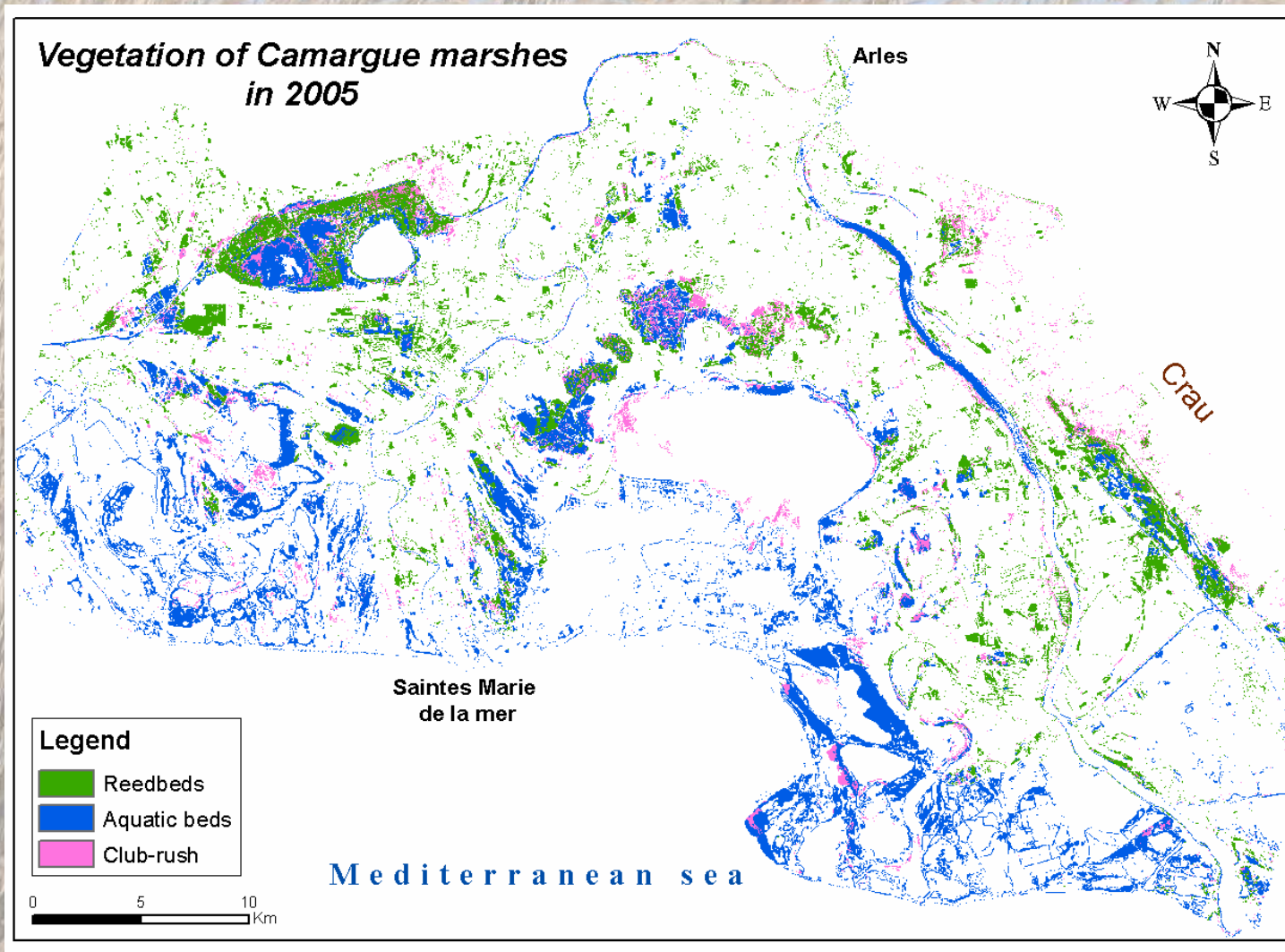
Reedbeds

Formula

Presence of reedbeds = $c30603 \geq 0.04897$ & $OSAVI12 < 0.2467$ & $NDWIF209 < -0.3834$

Map

Maps resulting from the formula



Combination of three maps: reedbeds, club-rush and aquatic beds in Camargue

Classification accuracy and validation

Classification accuracy (%) for the 3 types of marsh vegetation in Camargue:

	2005	2006
Reedbeds	91,9	92,6
Club-rush	93	
Aquatic beds	88,3	84,9

Acquisition in October instead of September + extremely small class ?

Aquatic beds in brackish marshes mixed with Club-rush + acquisition in October?

Classification accuracy (%) for flooded areas in 2006:

	All marshes	Open marshes	Vegetated marshes
Flooded areas	76	86	70

Best results: first half of the year and reed height < 188 cm

Generalized Linear Models (GLM)

Equation for p descriptive variables: $Y = a_1x_1 + a_2x_2 + \dots + a_ix_i + \dots + a_px_p + b$

Model selection : Coefficient of determination : R^2

▶ $R^2 = 1 \rightarrow 100\%$ variance explained

▶ R^2 increases with the number of variables

→ **Best model : maximum R^2 with minimum number of variables**

Variable selection : Forward stepwise (FSW)

▶ Sequence of F-tests (Fischer statistic) : inclusion and exclusion of « statistically significant » descriptive variables

▶ End: when no additional variable contribute to increase significantly the variance explained

→ **Problem : the first variables selected have a big influence on the resulting model**

→ **Pre-selection of descriptive variables necessary**

Variables pre-selection

Criteria for pre-selection : stability

- ▶ Spectral response: correlation between two consecutive years
- ▶ Mean spectral response : no significant difference between two consecutive years



20 of the 90 variables are pre-selected !



- 1 - What is the efficiency of these variables for modelling reedbed parameters ?**
- 2 - What is the minimum number of images required for modelling reedbed parameters ?**

Percentage of explained variance

Reedbed parameters	One descriptive variable = one date	Two dates	Best model = multirate
Height of stems	44	54	66
Number of dry reeds	-	59	61
Panicles number	-	38	47
Number of green reeds	-	35	60
Ratio dry/green	-	-	56
Percentage of open areas	-	50	60

Best predicted parameter: height of stems

Best models : validation in 2006

Percentage of explained variance (* $p=0.05$, ** $p=0.01$, *** $p=0.001$) :

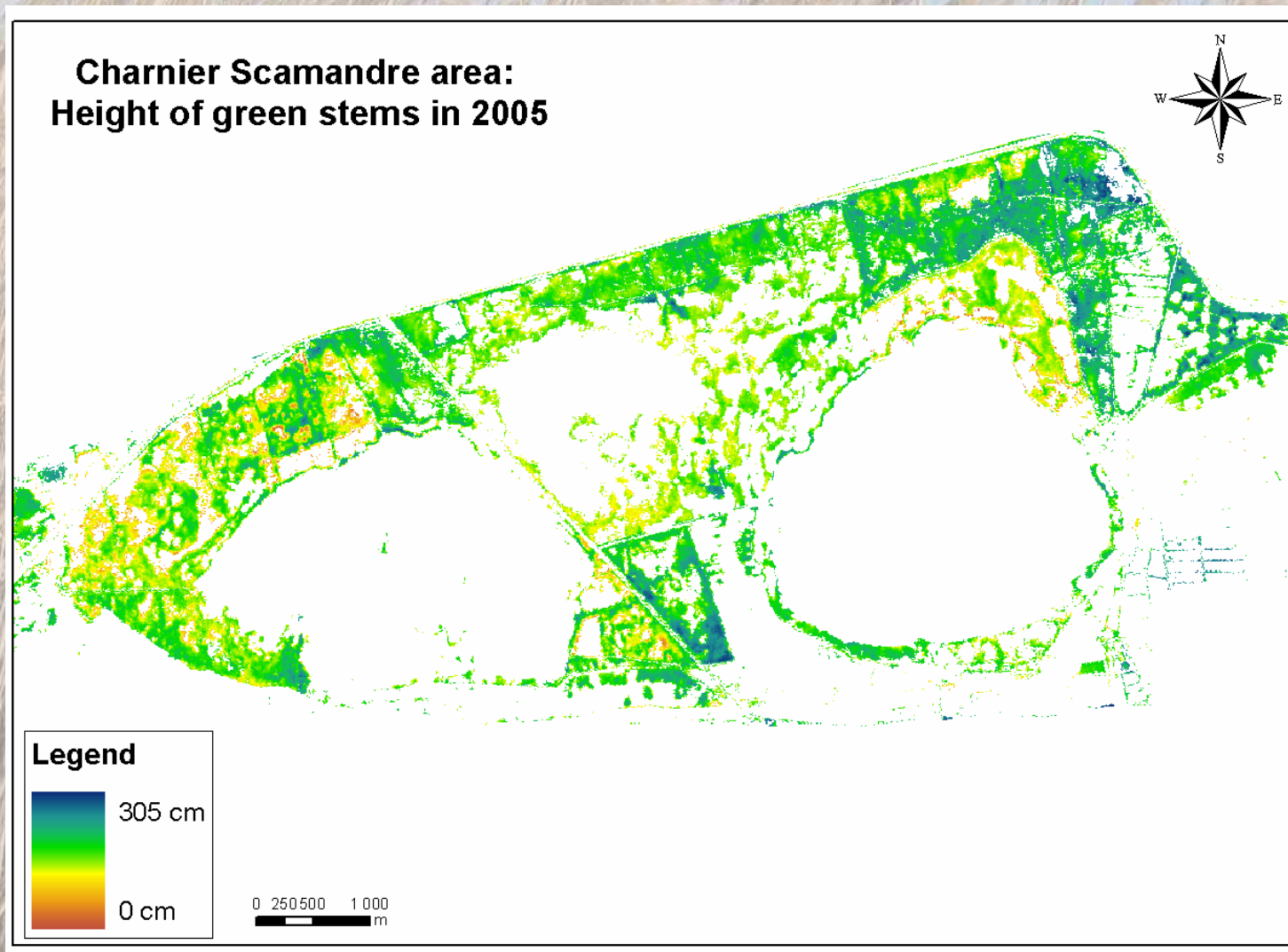
	2005	2006
Height of green reeds	66***	46***
Number of dry reeds	61***	30**
Panicles number	47***	19*
Number of green reeds	60***	1
Ratio dry/green	56***	43***
Percentage of open areas	60***	17*

Number of panicles: binomial distribution → Rpart?

Green reeds: bi-modal distribution → GAM?

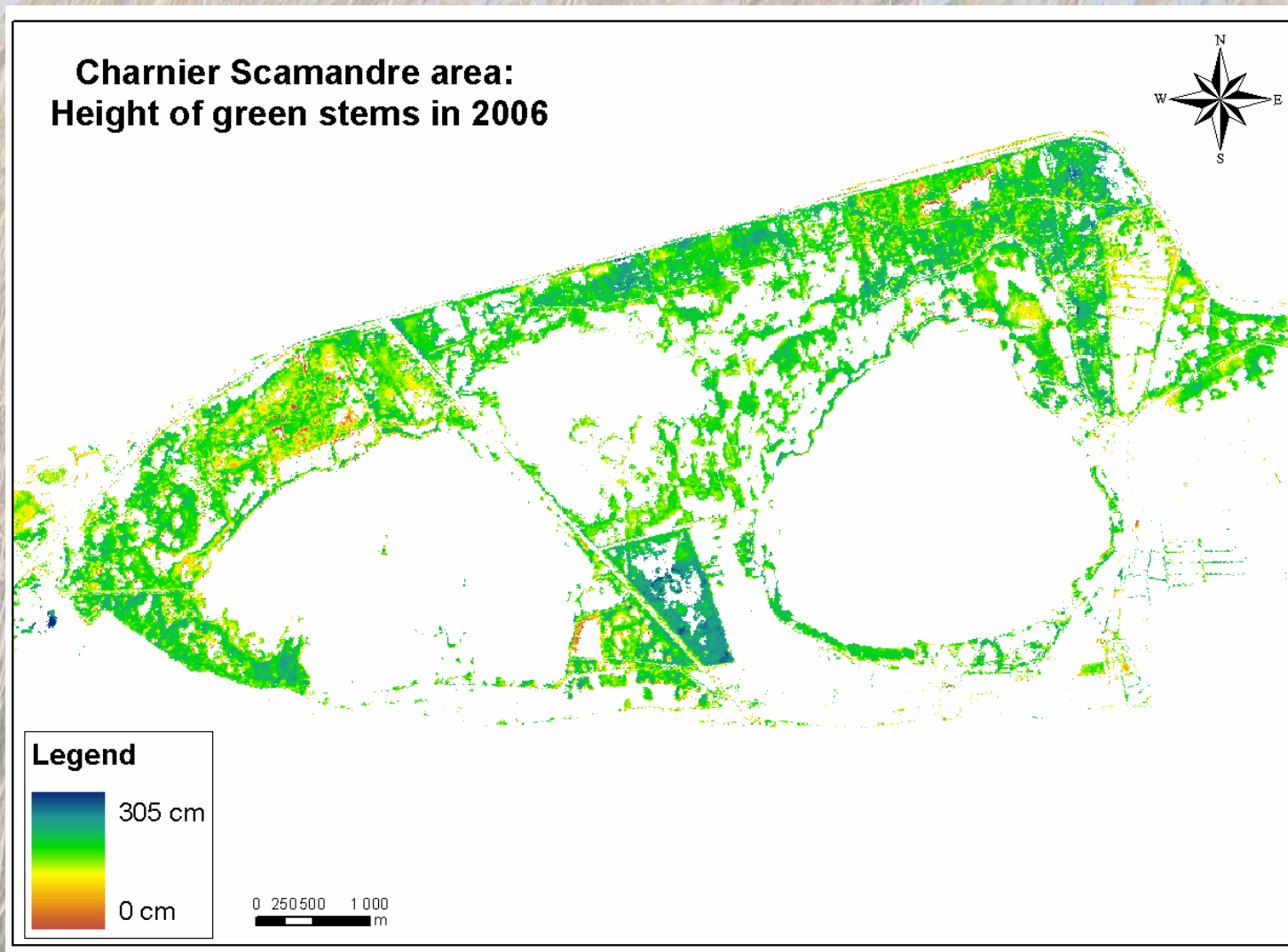
% of open areas: methodological imprecision

Application for monitoring: reedbeds evolution



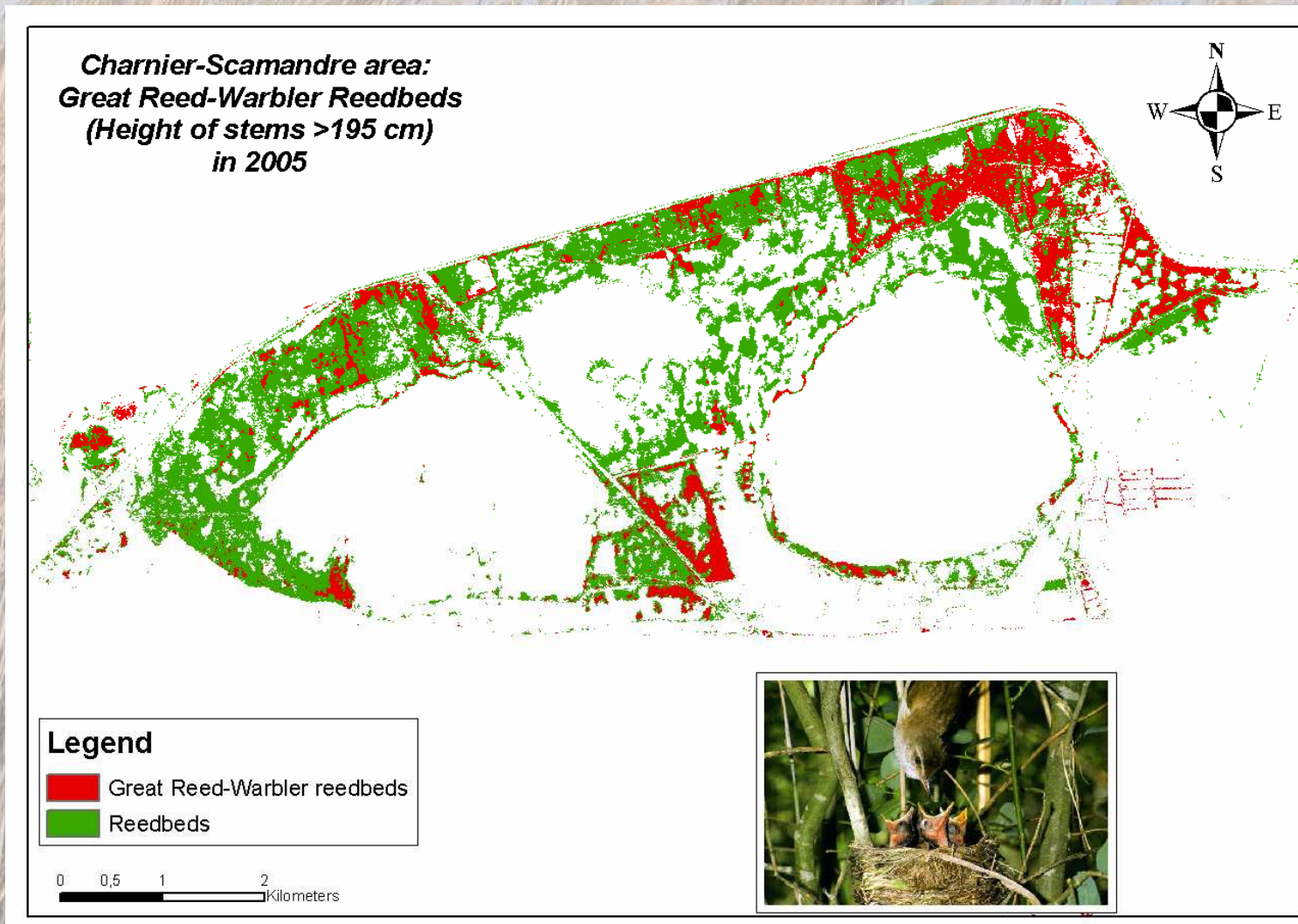
Influence of water management, salinity...

Application for monitoring: reedbeds evolution



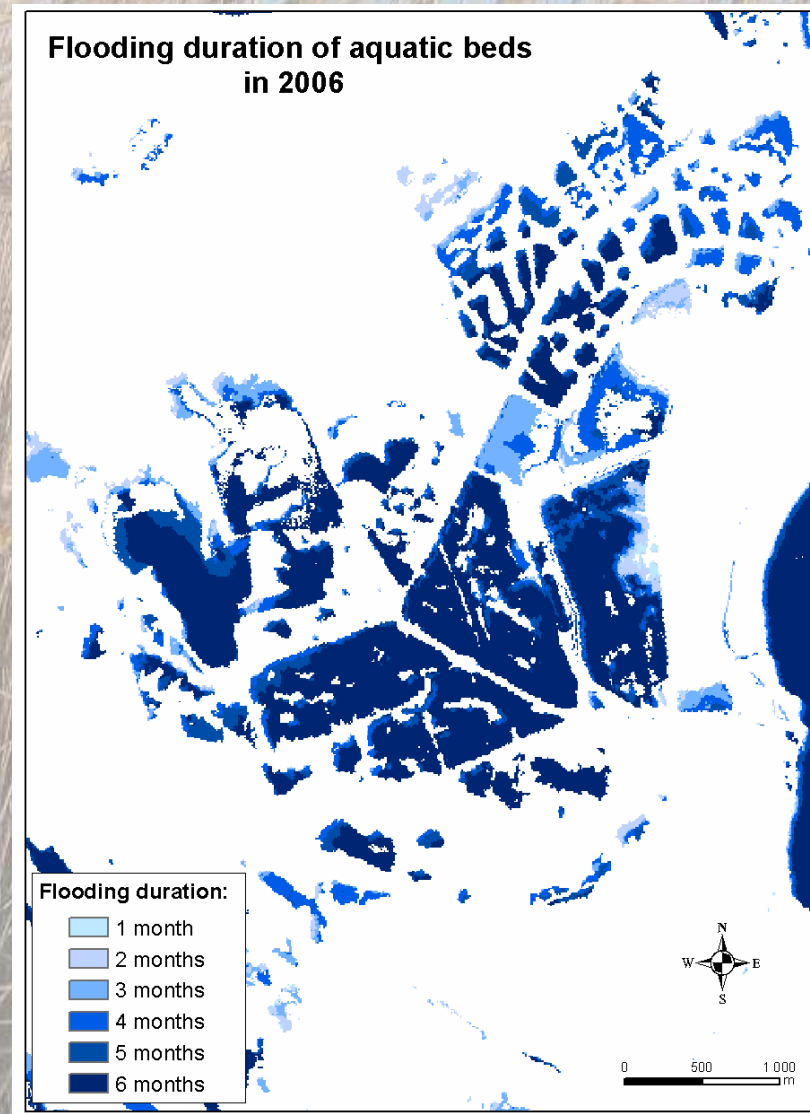
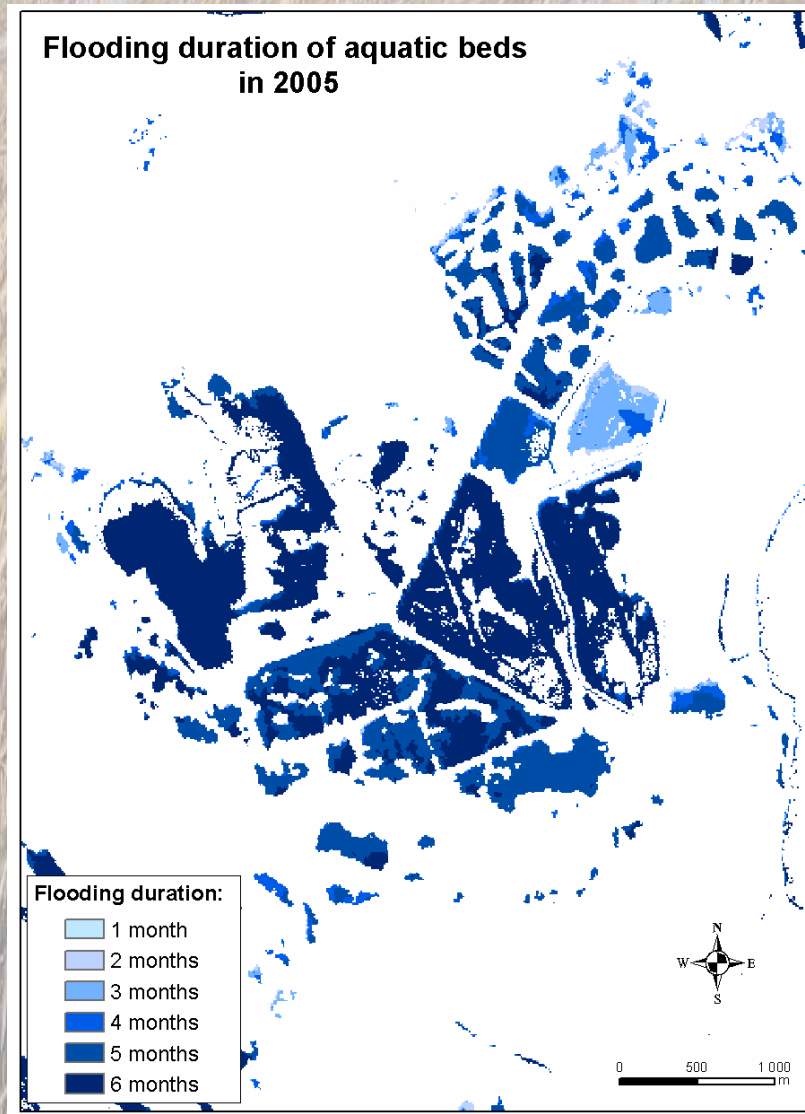
Influence of water management, salinity...

Application for monitoring: Birds habitats



Great Reed-Warbler reedbeds: height of stems >195 cm

Application for monitoring: flooding duration



Influence of water management on aquatic beds

Conclusion

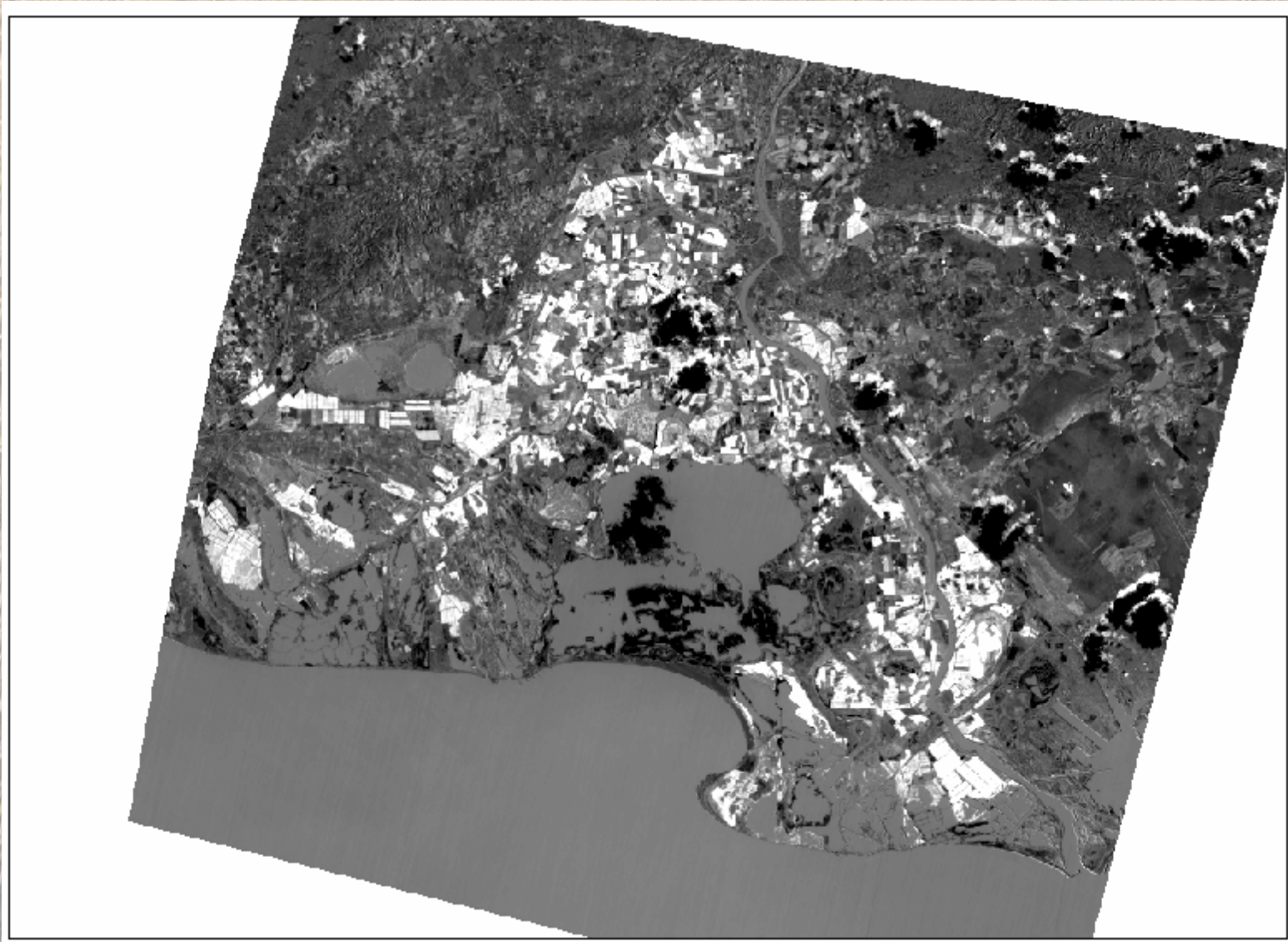
- ▶ **Remote sensing and statistical modelling for wetland monitoring : sustainability, precision, affordability**
- ▶ **SPOT 5: multispectral and multitemporal modes optimal for wetland monitoring on large areas**
- ▶ **Roles reversed : field campaigns as a complementary tool for wetland monitoring with satellite remote sensing**

Perspectives: improvements

- ▶ **More descriptive variables : TC wetness, index differences**
- ▶ **Additional field campaigns to monitor reed harvesting**
- ▶ **Monitoring of water levels with the IME**
- ▶ **Number of panicles and green reeds : Rpart? GAM?**
- ▶ **Automatization of the methodology: simplicity for managers**

Perspectives: other applications

▶ Rice cultivation:



Perspectives: other applications

► Rice cultivation:

PNRC:
digitalization
of rice fields

