Remote sensing of aquatic and palustral invasive plants: The case of *Ludwigia grandiflora* (water primrose)

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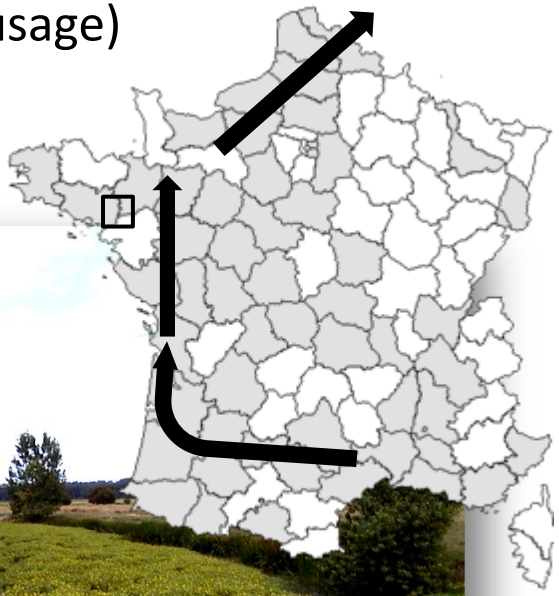
Background:

Contamination of the Vilaine basin since 1980

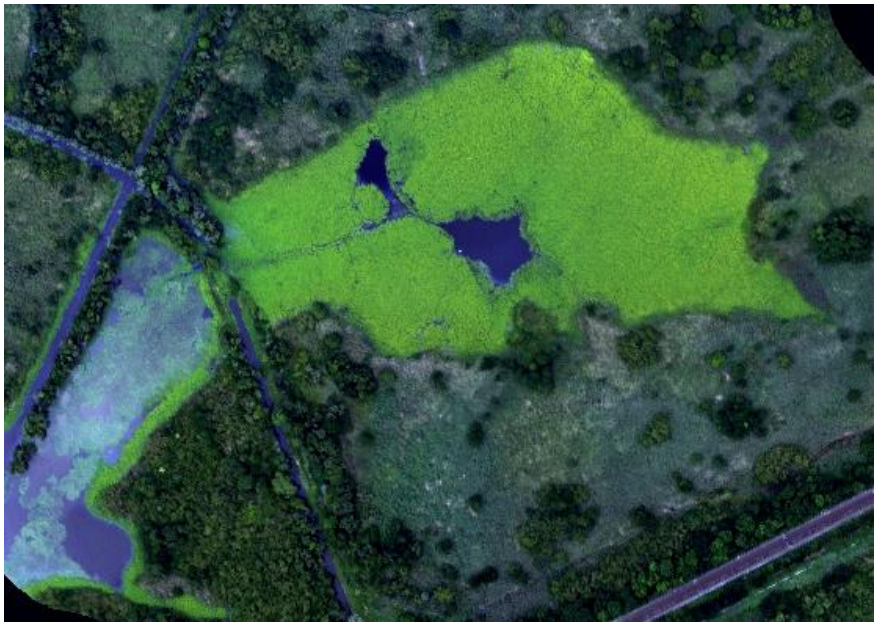
Extension in streams (shallow with little current)

Accelerated development related to water quality (nitrate phosphorus)

Rapid eutrophication of the environment (biodiversity, usage)



Reproduction by seeds and cuttings
Transportation by the hydrographic network
High adaptability to different environments:
Emergence of a terrestrial form



Management method:

Containing extensions: intervention on the expansion fronts

Pulling out vegetation systematically in some cases (moats, large canopies) (expensive)

General objectives

- Understand the relationship between vegetation and the physical environment

- Assessing the risk of disseminating

- Optimizing the control methods

Objectives of the study

Evaluate the potential of remote sensing for

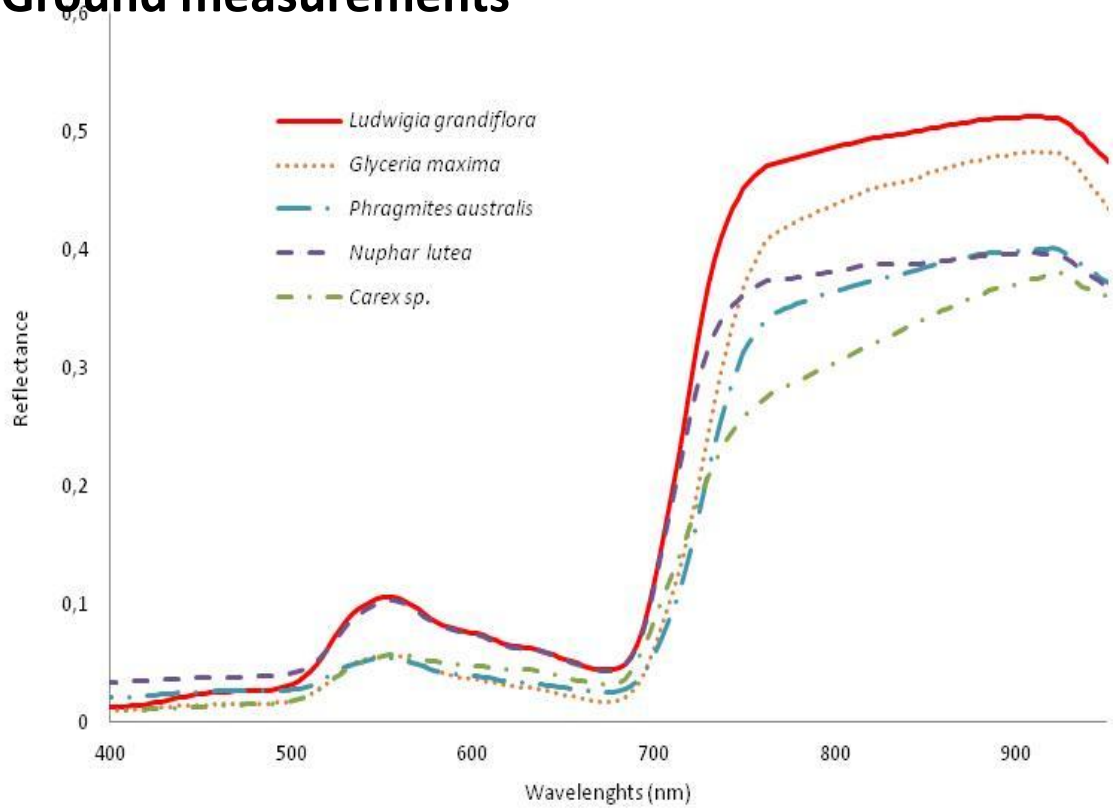
- Establishing a diagnosis of the condition of water bodies and streams

- Characterizing the vegetation

Feasibility of remote sensing :

Radiometric information and aquatic plant species :

Ground measurements

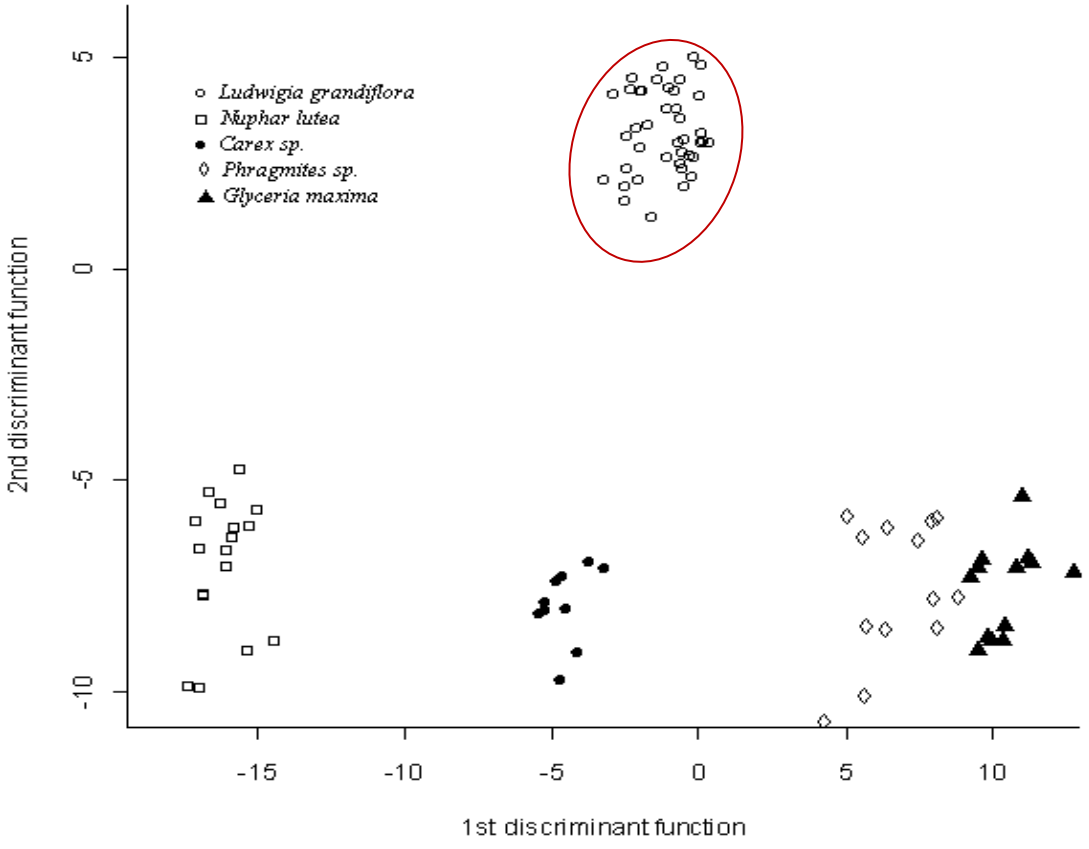


Average field reflectance spectra of *L.grandiflora*, *G. maxima*, *P. australis*, *N. lutea* and *Carex sp.*.

Feasibility of remote sensing :

Radiometric information and aquatic plant species

Two-dimensional linear discriminant analysis of reflectance spectra
(best results with 8 spline functions)



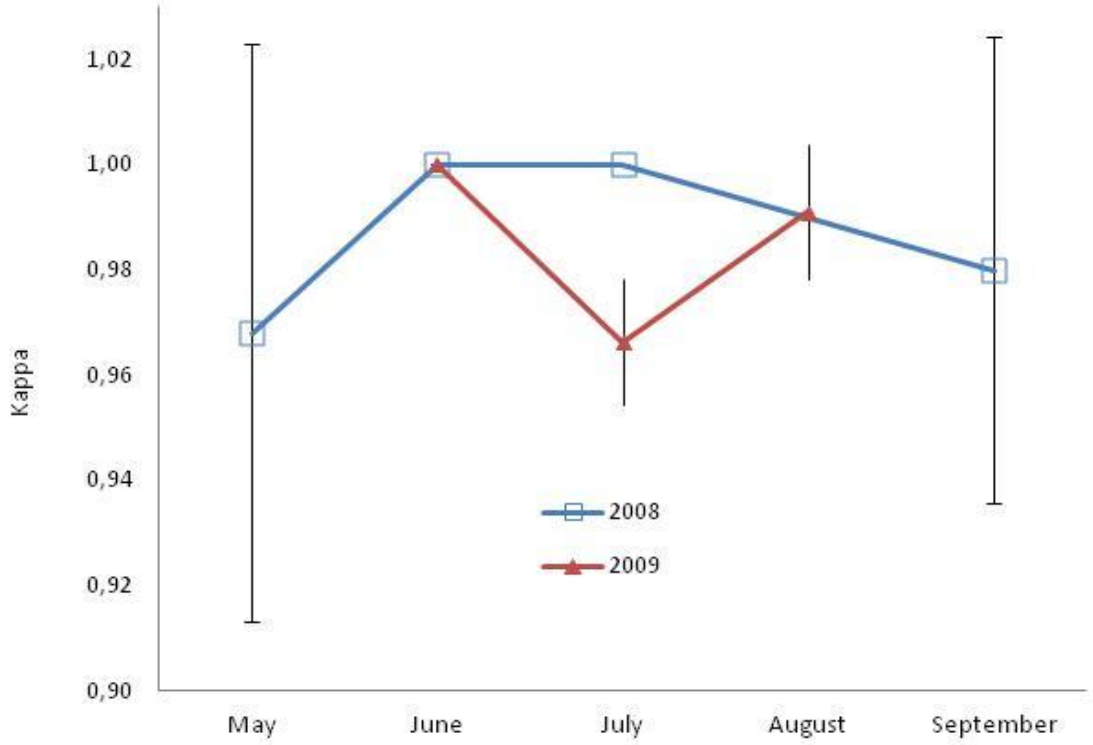
At the same date : polymorphism

Intra-site variability > Inter-site variability

Feasibility of remote sensing :

Radiometric information and aquatic plant species

Two-dimensional linear discriminant analysis of reflectance spectra



Optimum period of year to discriminate aquatic vegetation

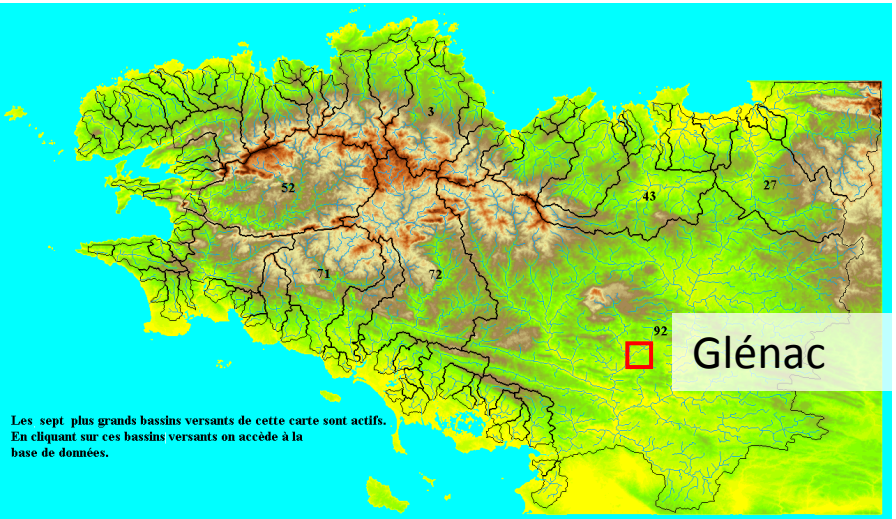
Means and standard deviations of the kappa coefficient of the 2DLDA

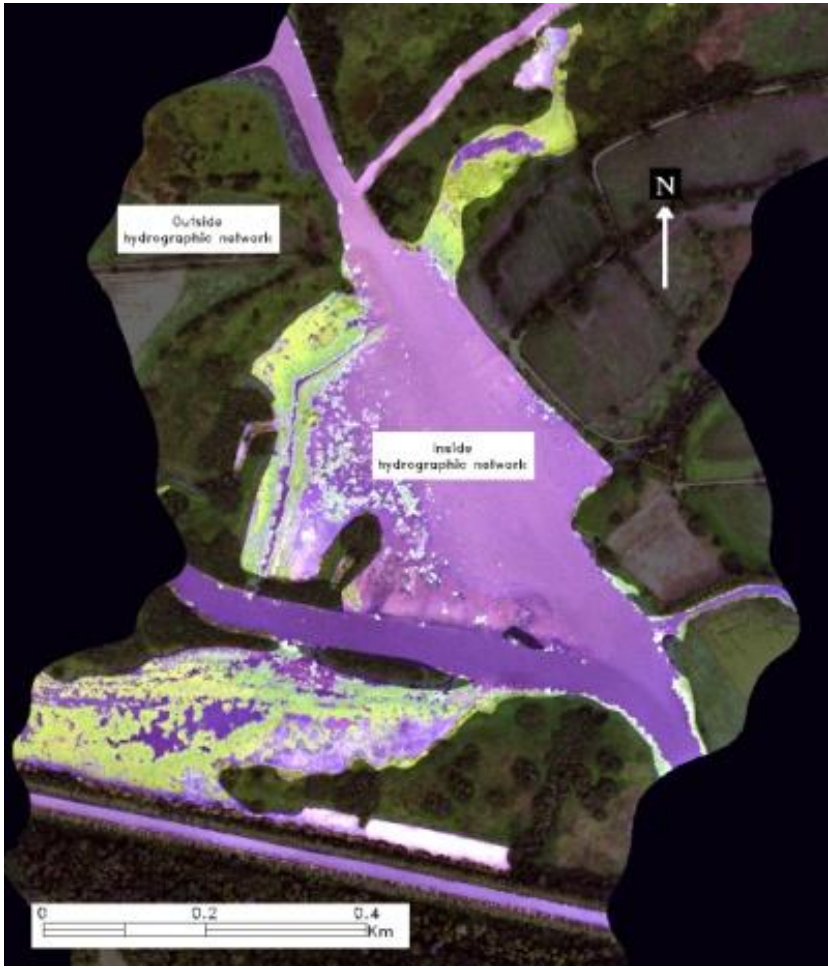
Feasibility of remote sensing : Image classification

Hyperspectral Images

Airborne HySpex VNIR-1600
400-1000 nm in 160 spectral bands
Full-Width Half-Maximum (FWHM) of 4.5 nm
Pixel size 1m x 1m

September 13, 2010
Experimental site : Glénac (56)



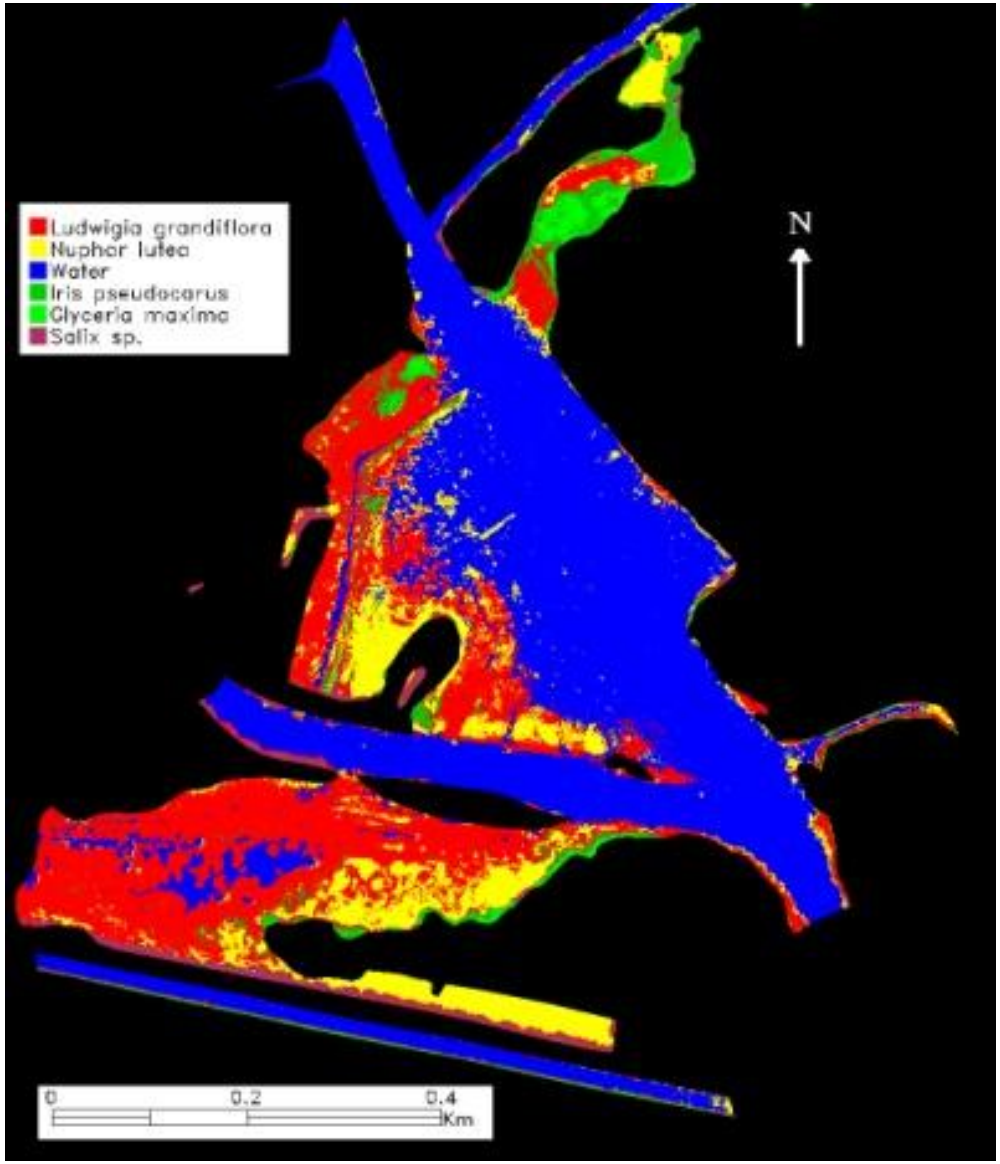


Feasibility of remote sensing : Image classification

Hyperspectral Images

Best results with the maximun likelihood classifier (MLH) after applying the minimum noise fraction (MNF) (10 bands)

Overall accuracy = 99.3%
Overall kappa coefficient = 0.990

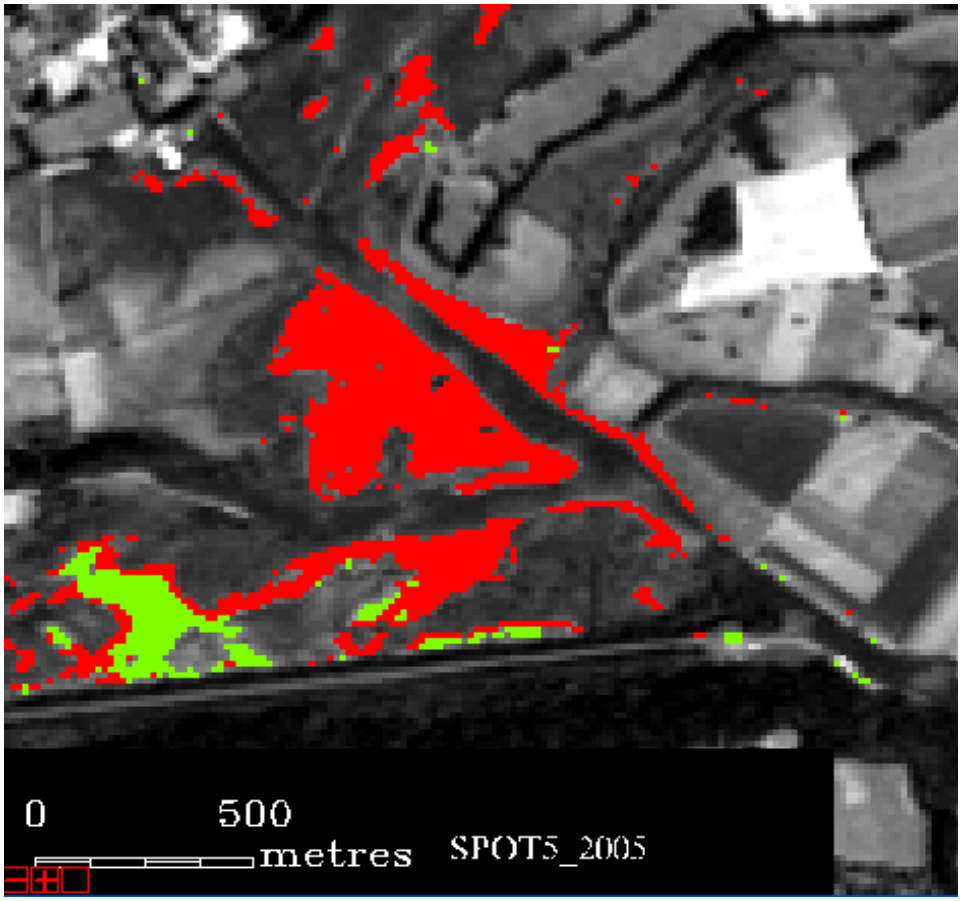


Feasibility of remote sensing : Image classification

Satellite Images

SPOT 5 image
Pixel size 10m x 10m

Best results with the maximun likelihood classifier (MLH)



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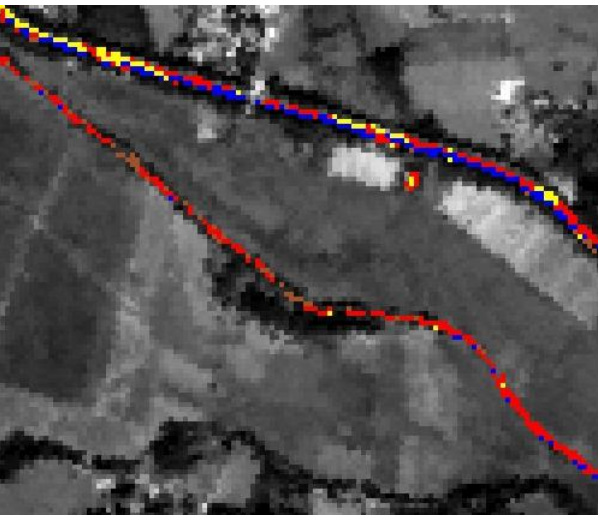
Water primrose

Other floating-leaved aquatic vegetation

Large canopies are correctly identified

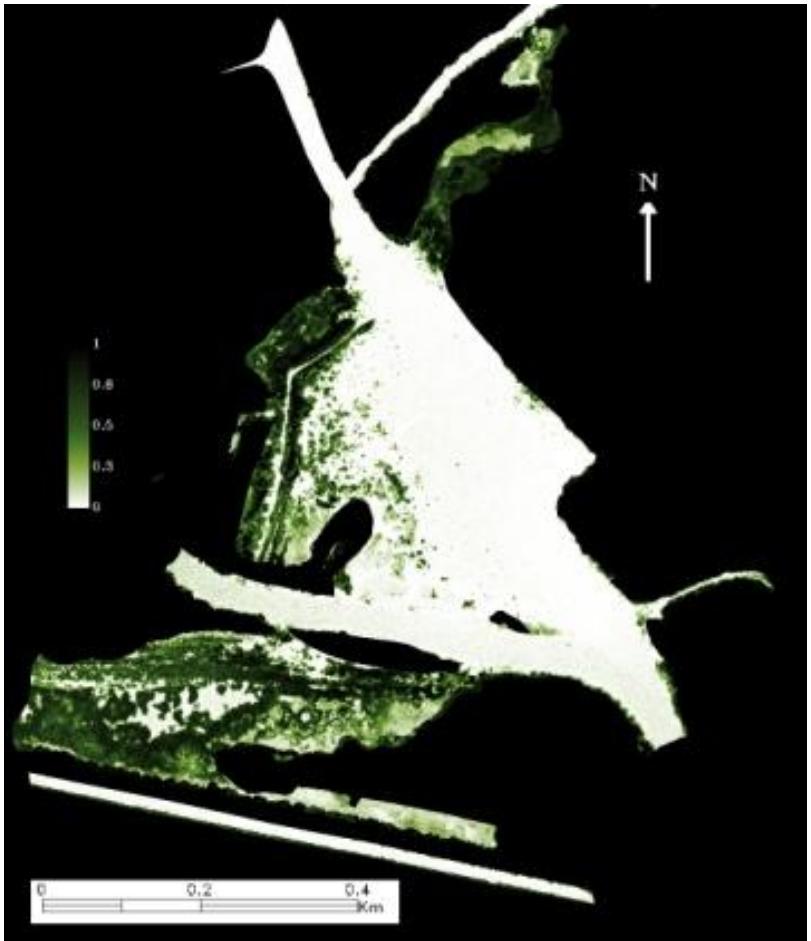


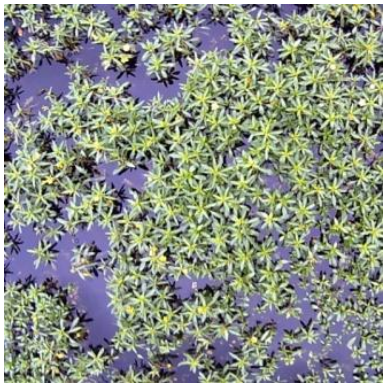
confusion for riparian vegetation and narrow streams

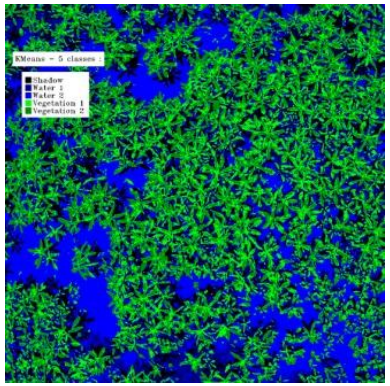
Feasibility of remote sensing : Biophysical variables

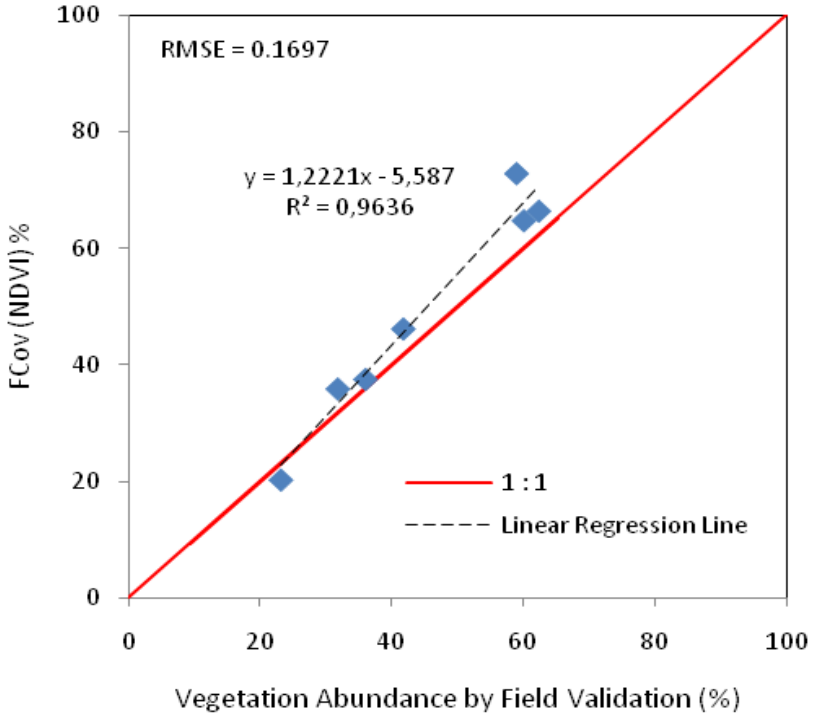
Fractional Vegetation Cover (FVC)

$$FVC = \left(\frac{NDVI - NDVI_{water}}{NDVI_{\infty} - NDVI_{water}} \right)^2$$





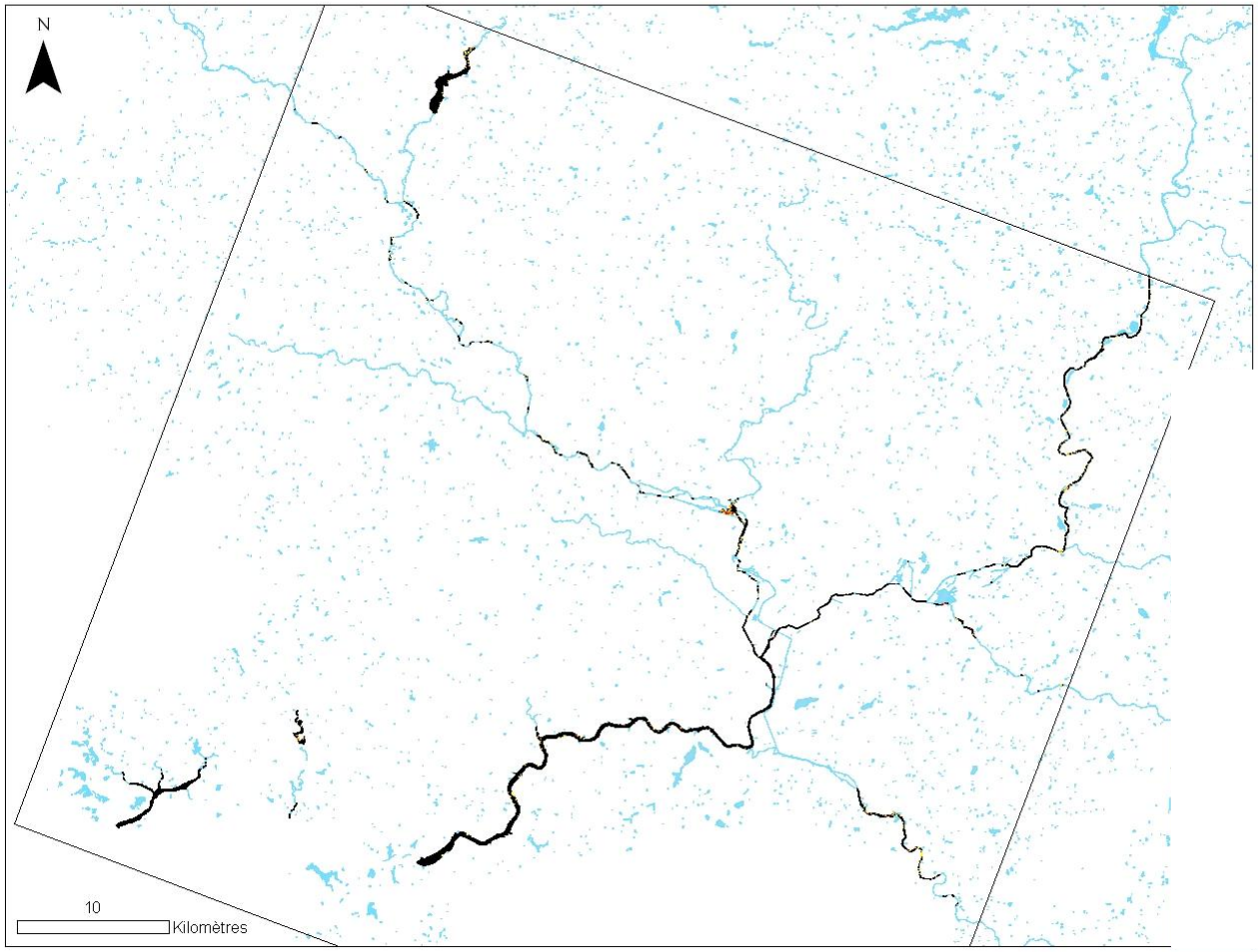




Diagnosis of the condition of water bodies and streams

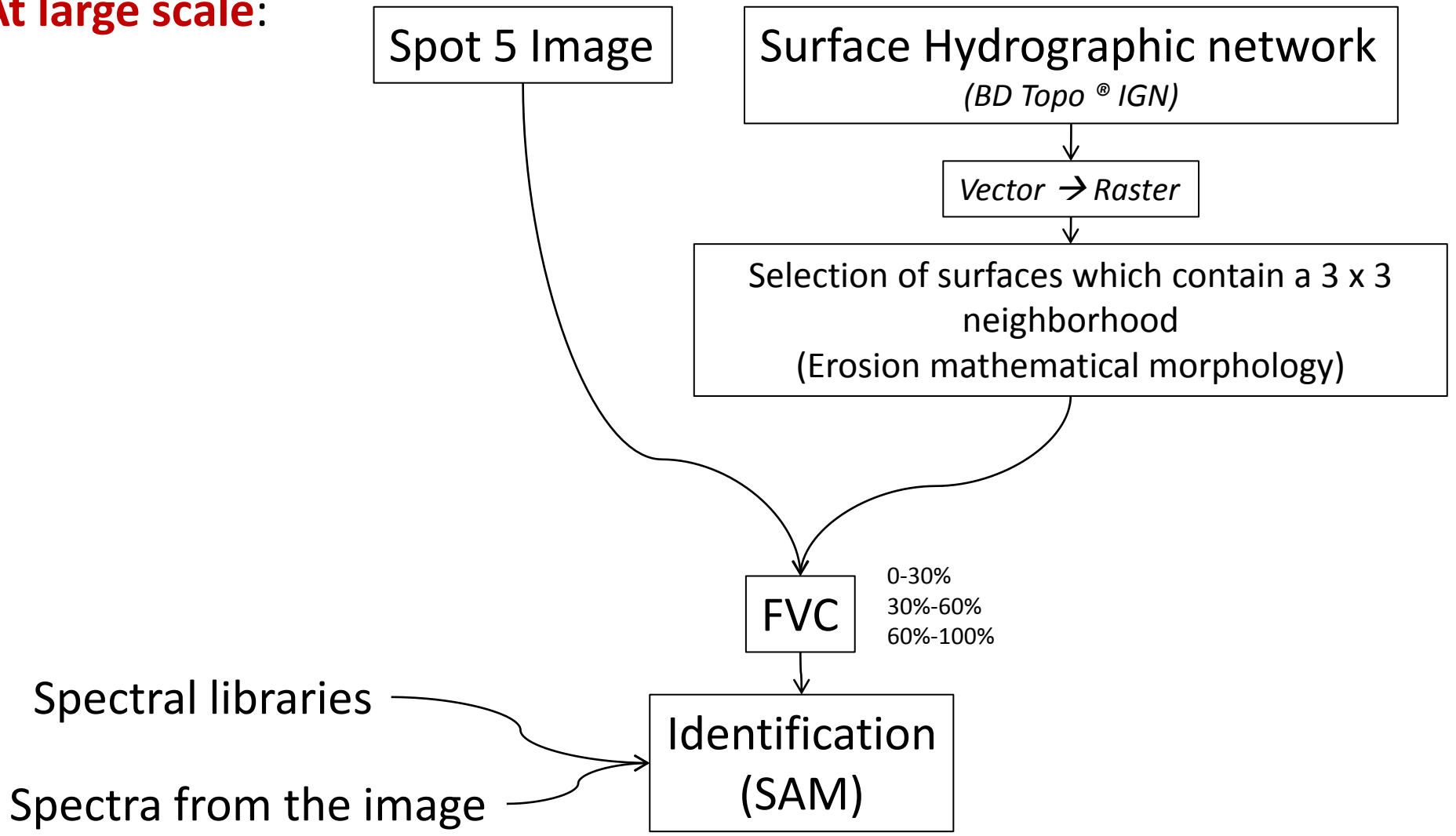
At large scale:

Identification of the water primrose on the Vilaine basin
Water bodies and streams *(SPOT 5, September 2010)*



Diagnosis of the condition of water bodies and streams

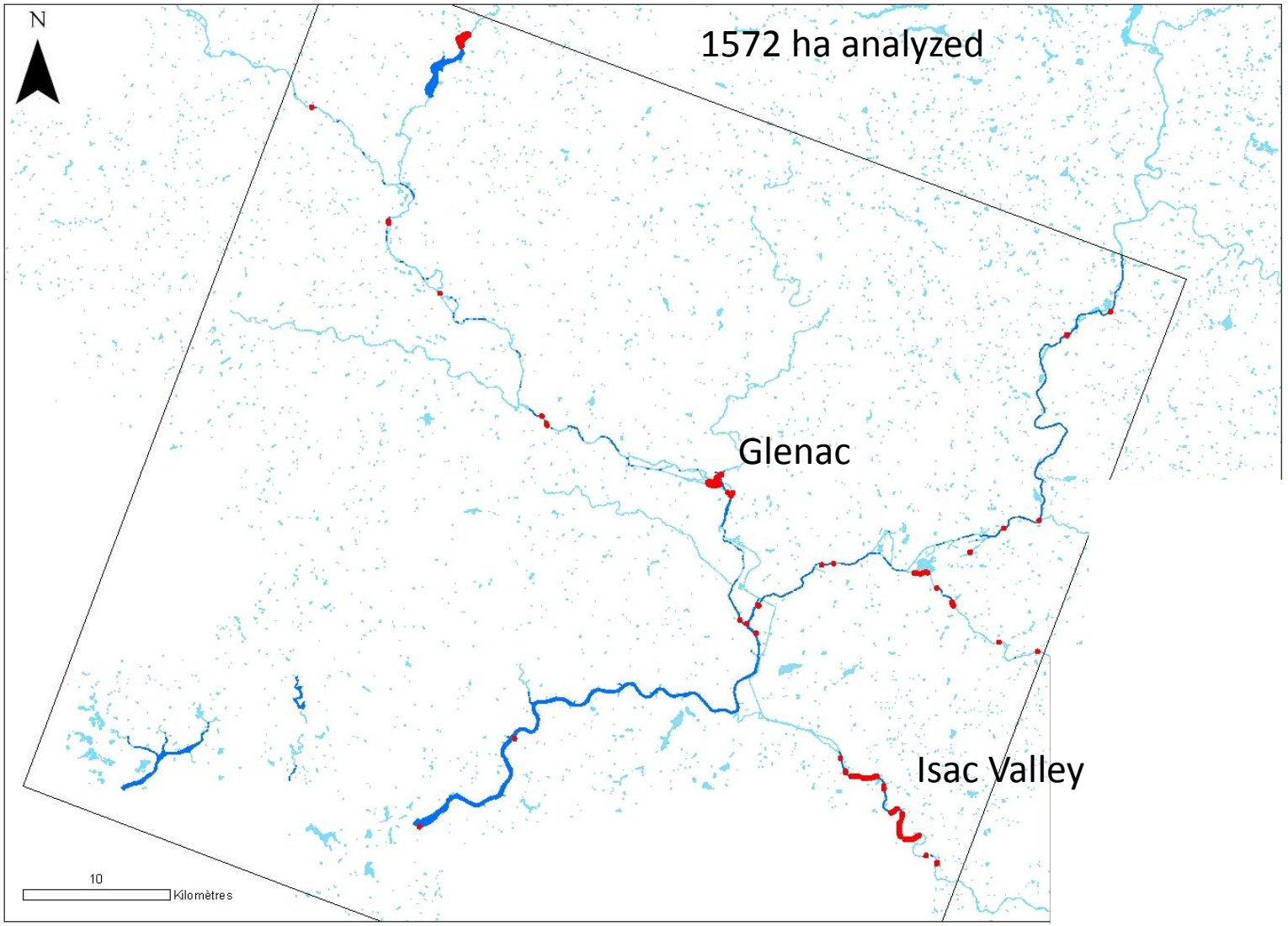
At large scale:



Diagnosis of the condition of water bodies and streams

At large scale:

Sections of streams with a FVC greater than 60%



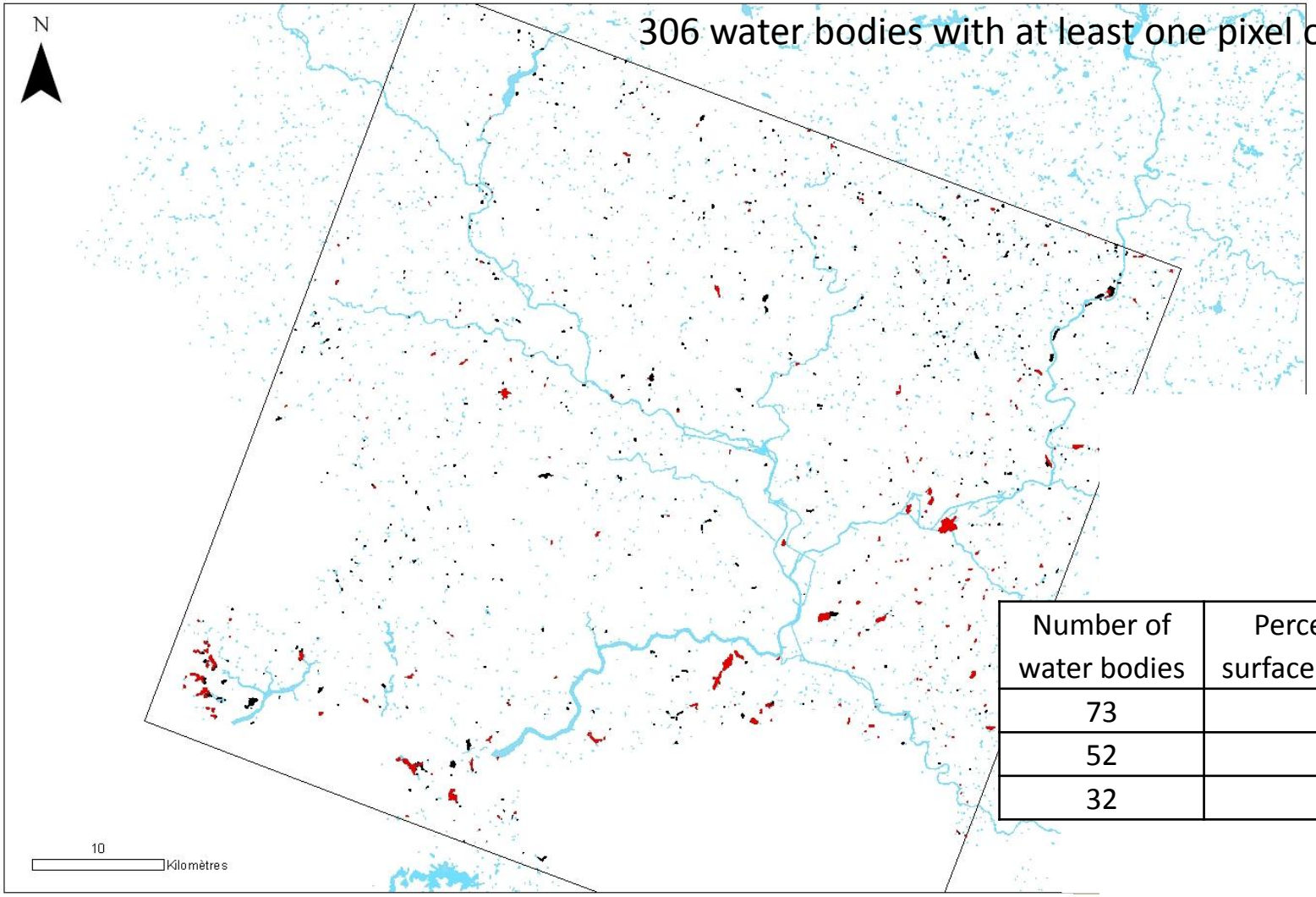
Diagnosis of the condition of water bodies and streams

At large scale:

Water bodies with a FVC greater than 60%

1112 selected water bodies

306 water bodies with at least one pixel or FVC> 60%



Number of water bodies	Percentage of the surface with FVC> 60%
73	50%
52	70%
32	90%

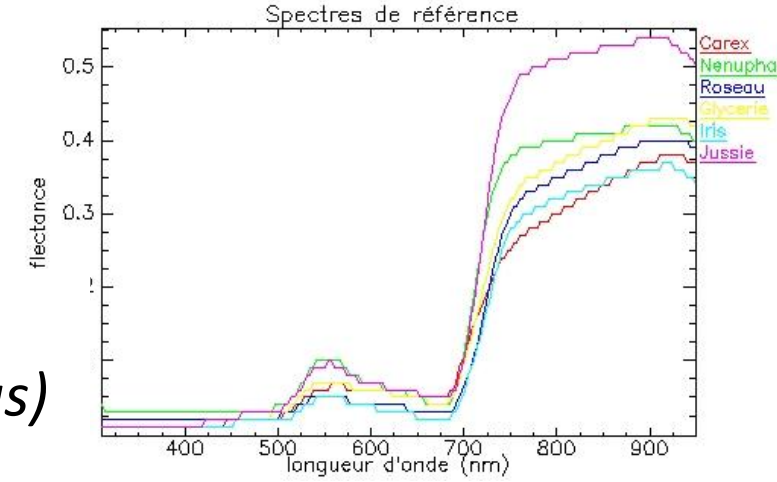
Diagnosis of the condition of water bodies and streams

At large scale:

Identification of vegetation on water bodies

Validation by ground observation or expert knowledge of sites:

276 observation points



→From spectral libraries; SAM Method

With the Spot Image *(September 2010)*

***87% accuracy** (without the riparian areas)*

Confusions between Water primrose and Nuphar

(an accurate atmospheric correction is necessary)

→From spectral libraries; SAM Method

(spectra from a spectral Library)

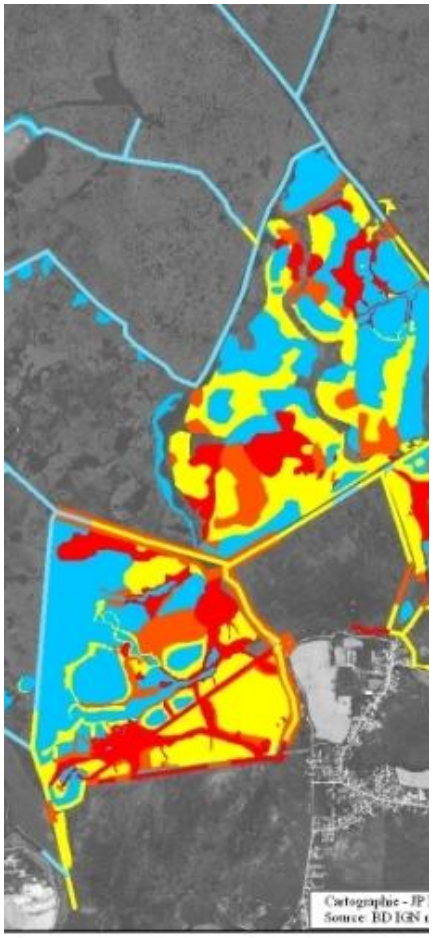
With the Hyspex image *(September 2011)*

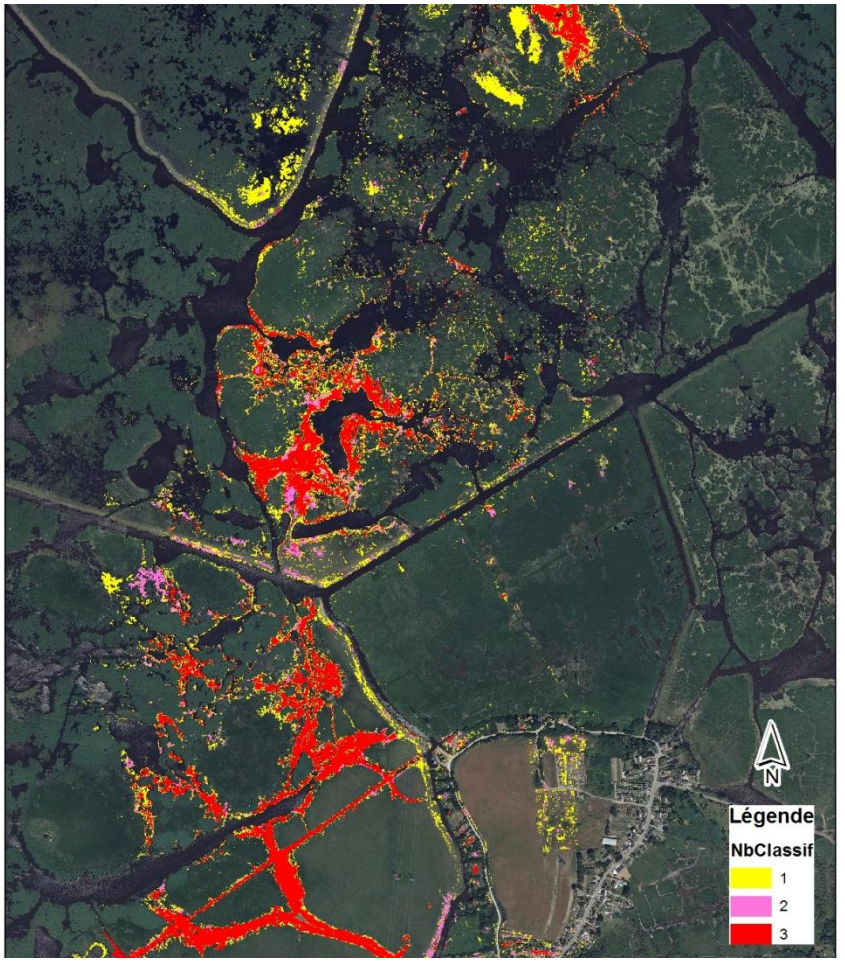
***100% accuracy** (without the riparian areas)*

Diagnosis of the condition of water bodies and streams

At fine-scale:

Brière marshes: Site accessibility; Distribution of vegetation

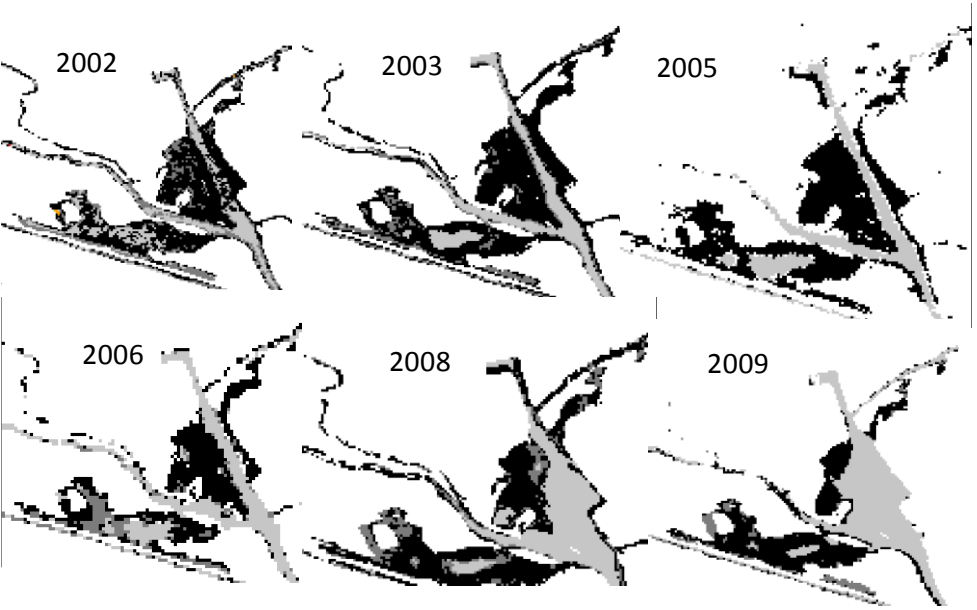




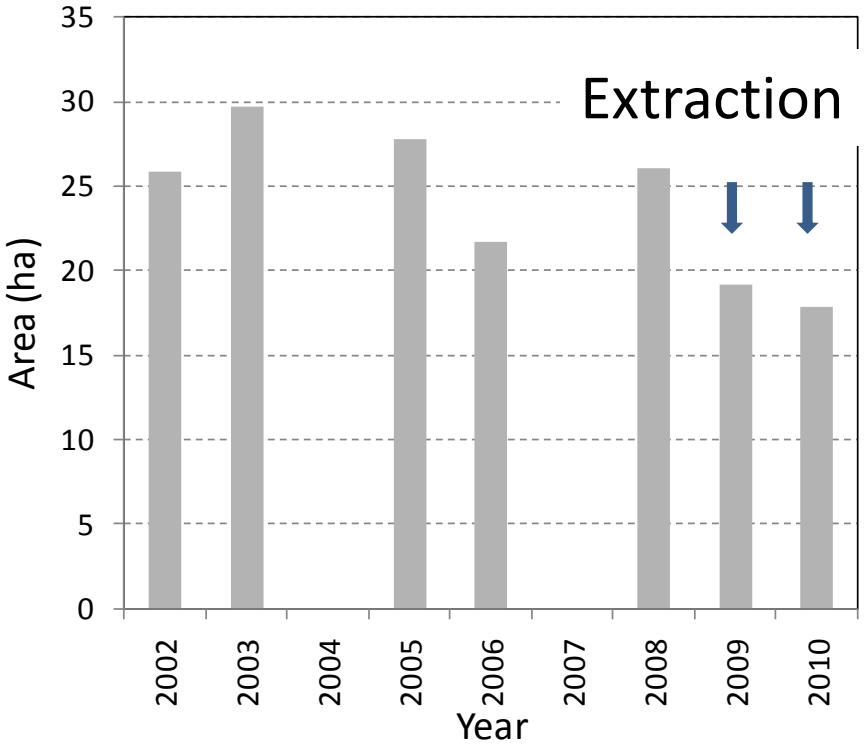
Hyspex Image, September, 2011, Maximum likelihood classifier

Interannual monitoring

Example of the Glenac site



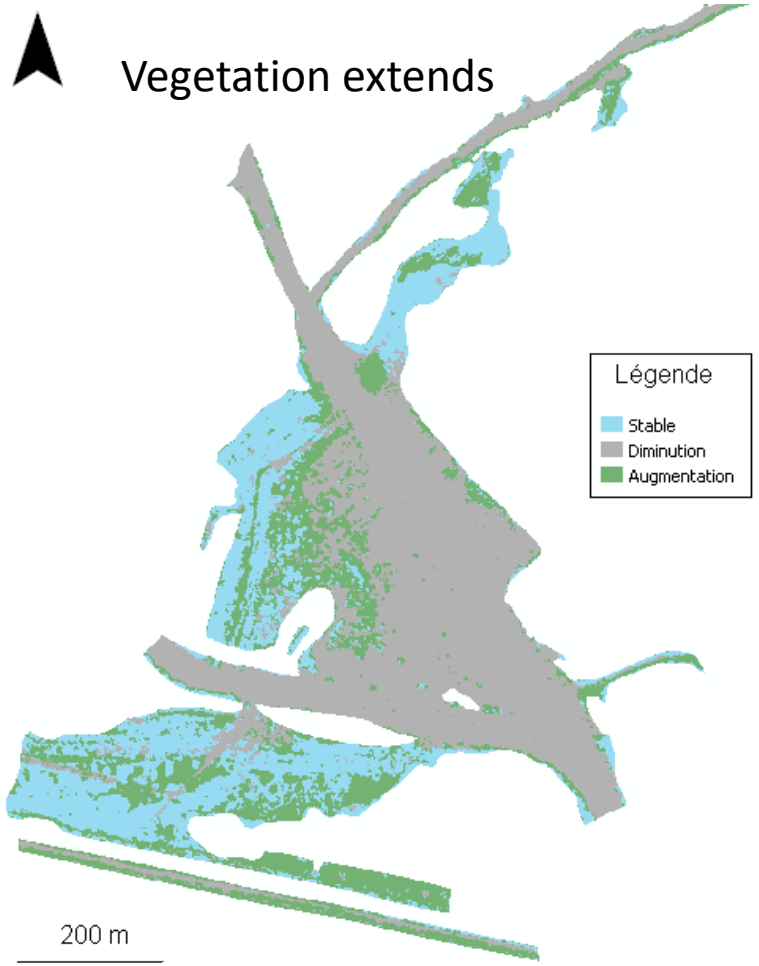
Acquisition date	Satellite
2002/09/24	Spot5
2003/08/10	Spot5
2005/07/12	Spot5
2006/07/13	ASTER
2008/10/10	Spot5
2009/08/19	Spot5
2010/09/02	Spot5



Interannual monitoring

Change detection : Hyspex image 2010 – 2011

(MNF + Maximum likelihood classifier)



NDVI Evolution

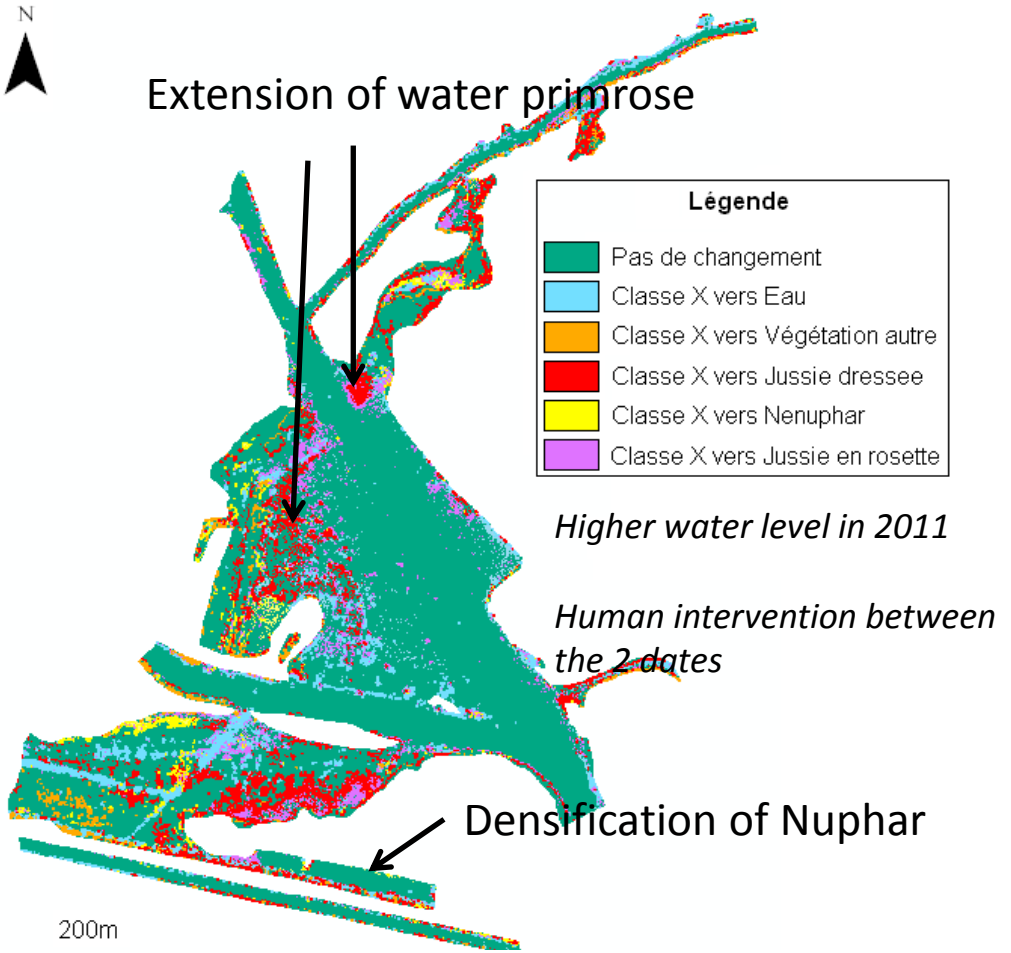


Image changes between 2010 and 2011

Prospects

Canopies description with biophysical variables *(in progress)*

From spectral Indices

LAI : Leaf Area Index	*LAI(NDVI)*
Cab : Chlorophyll a&b concentration	*Cab(R750; R705; R550)*
Cw : Water content	*Cw(NDII); Cw(NDWI)*
Dry biomasse	*DB(NDVI)*
FVC : Fractional Vegetation Cover	*FVC(NDVI)*

→Validation

→ Non-transferable methods in aquatic environment

From radiative transfer model : Prospect Sail

(With ACTIMAR, N. Bellec, M. Lennon)

→Coherent first results; Validation

Simultaneous use of both approaches (Indices + radiative transfer)

Prospects

- Canopies description with biophysical variables *(in progress)*

- Extension to other aquatic plant species
  (Egerie dense; Myriophylle du Brésil, …)

- Extension to the terrestrial form of water primrose
  (Lidar + object-oriented classifier)

- Analyze the performance of new sensors (Pleiades)