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# Use of archives and historical maps to analyse landscape evolution with spatial indicators

## Application on a French coastal wetland

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## Introduction

1. Littoral and French Atlantic coastal wetlands context
2. Geohistorical approach
3. Fields studied

## Methods

1. Data sources and land-use/land-cover creation
2. Spatial indicators
3. Data analysis method

## First results

1. Landscape classification
2. Trajectories identification
3. Zoom on Saint-Brevin marshes

## Discussion

## Prospects



Coastline can be defined as a interface area between continental space and maritime area (Lévy et Lussault, 2013). It is a shifting space in the short term with tides and in the long-terme due to variations in sea levels (Lageat, 2019)

- Coastline, especially coastal wetlands, are recent shapes (Verger, 2009)
- Formerly named « empty land » (« territoire du vide ») (Corlay , 1995), coastline are now described with heavy land pressure due to their attractiveness.
- French Atlantic coastals wetlands have been the place of major shifts in terms of land-use/land-cover and landscapes.

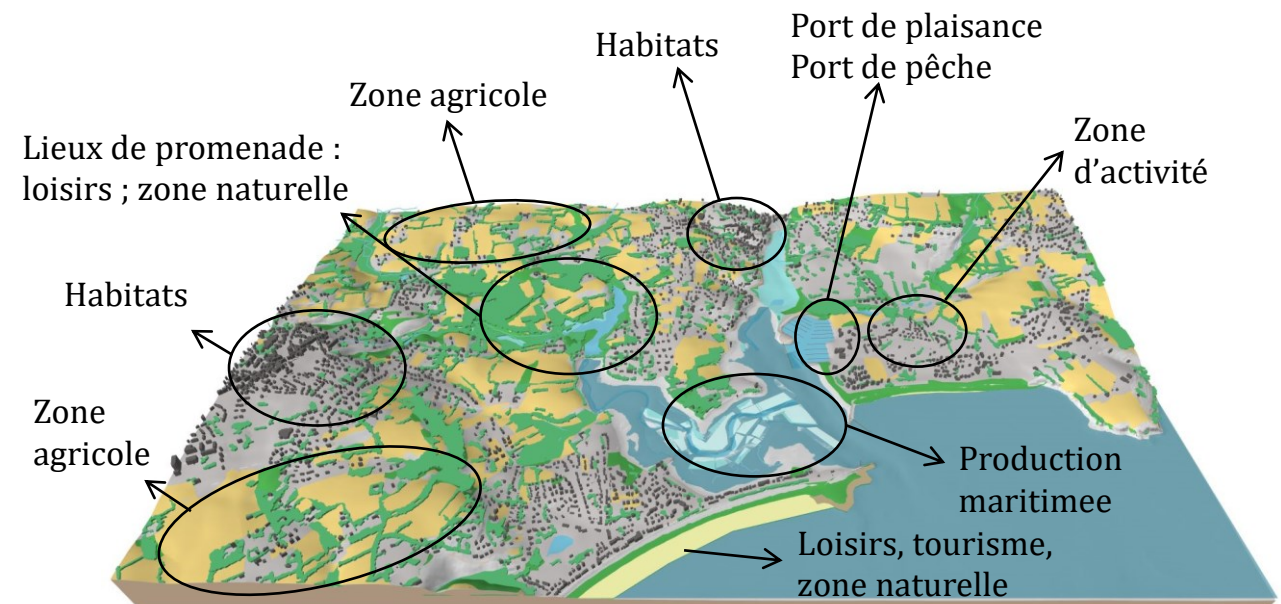


Figure 1 : Land-uses on a coastal wetland in Brittany : l'anse et étangs de Penfoulic (Source : BD TOPO IGN®, © Litto-MOS 2008 - Ministère en charge de l'environnement ; Léa Paly)

“Landscape means an area, as perceived by people, whose character is the result of the action and interaction of natural and/or human factors” (art.1a, European Landscape Convention).

Landscape is a social interpretation of nature « Le paysage est une interprétation sociale de la nature » (Bertrand G., 1968).

- Landscape trajectories of coastal wetlands have been punctuated by natural and social events.
- Managements of these natural areas are often complex due to land-use conflicts.
- Currently, climate change is considered as a real threat to coastal wetlands and their landscape.
- Prospective approaches are developed in order to have a long-term vision of developments of these spaces which undergo multiple pressures.
- Archiverments of prospective approaches need retrospective studies in order to be able to imagine future evolution of wetlands and their responses to specific planning, management, practices, etc.

Geohistoire (~historical geography) is an intellectual approach of events studied through different times with geographer's tools (Grataloup, 2015)

It allows the identification of pace of changes (permanence, inertia, forced trajectoires, etc.) and their meanings of which the present time is the end (Jacob-Rousseau, 2009)

On coastal wetlands on which historical depth has mainly contributed to their current landscape, this research aims to understand how the geohistory of landscape provides elements of understanding on these anthroposystems.

This communication is about the use of a geohistorical methodology

***What trajectories can be identified through a geohistorical approach and more specifically the use of archives with geomatic tools ?***

## 1. Littoral and French Atlantic coastal wetlands context

## 2. Geohistorical approach

## 3. Fields studied

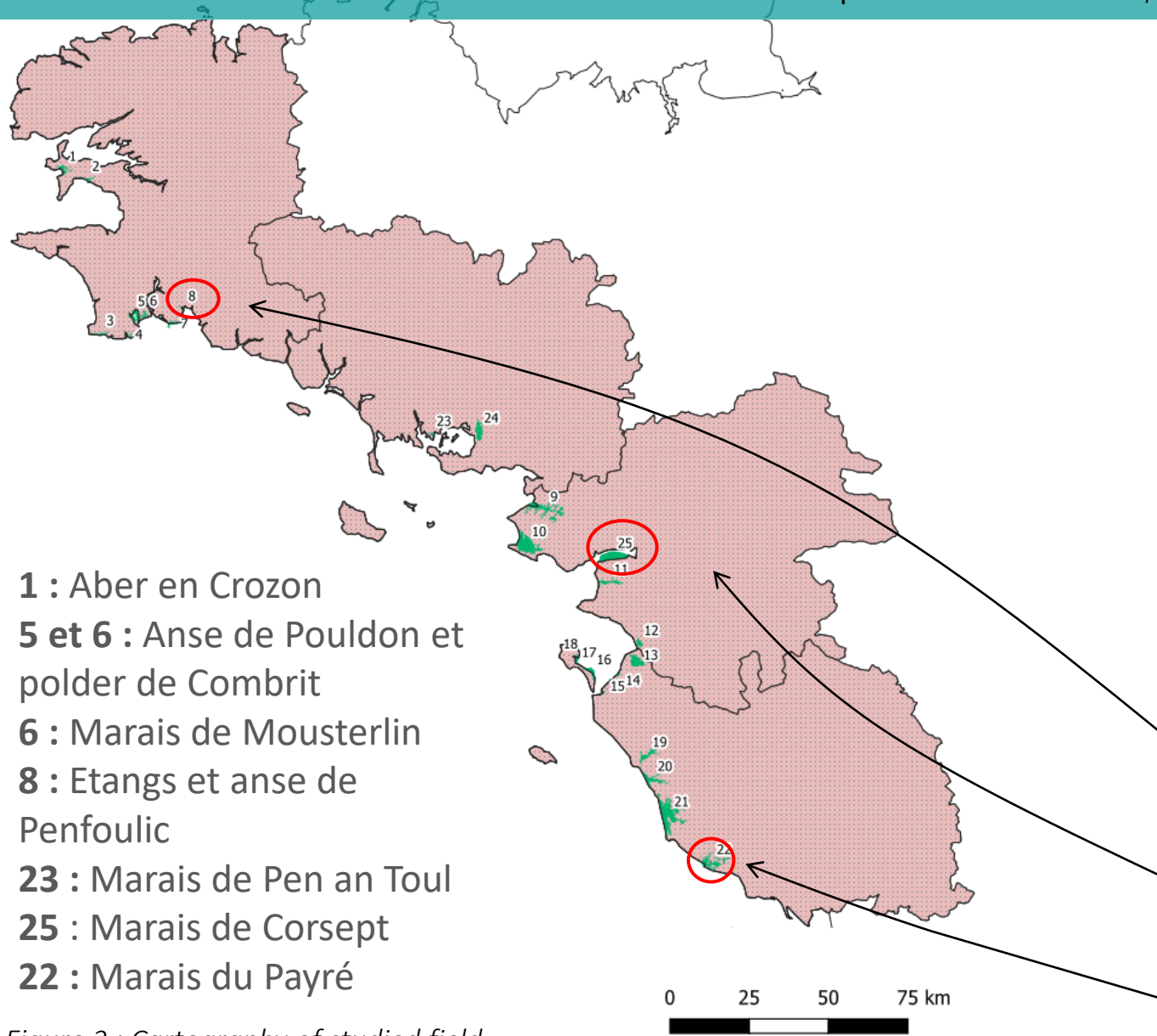
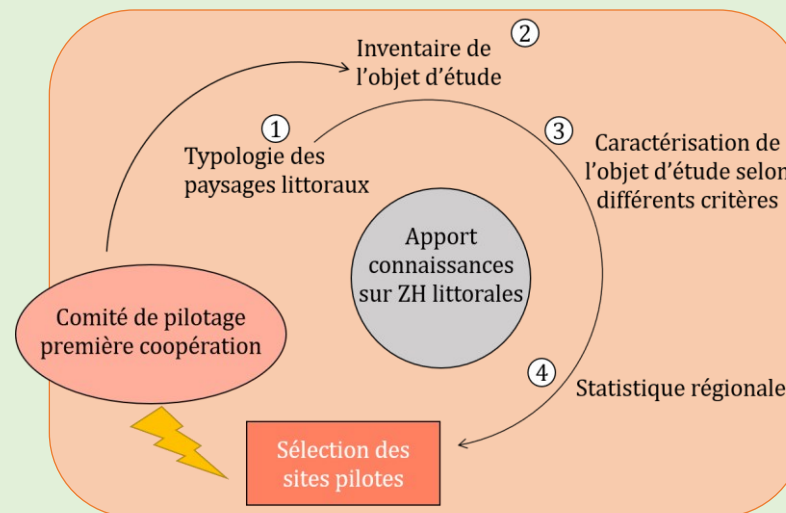


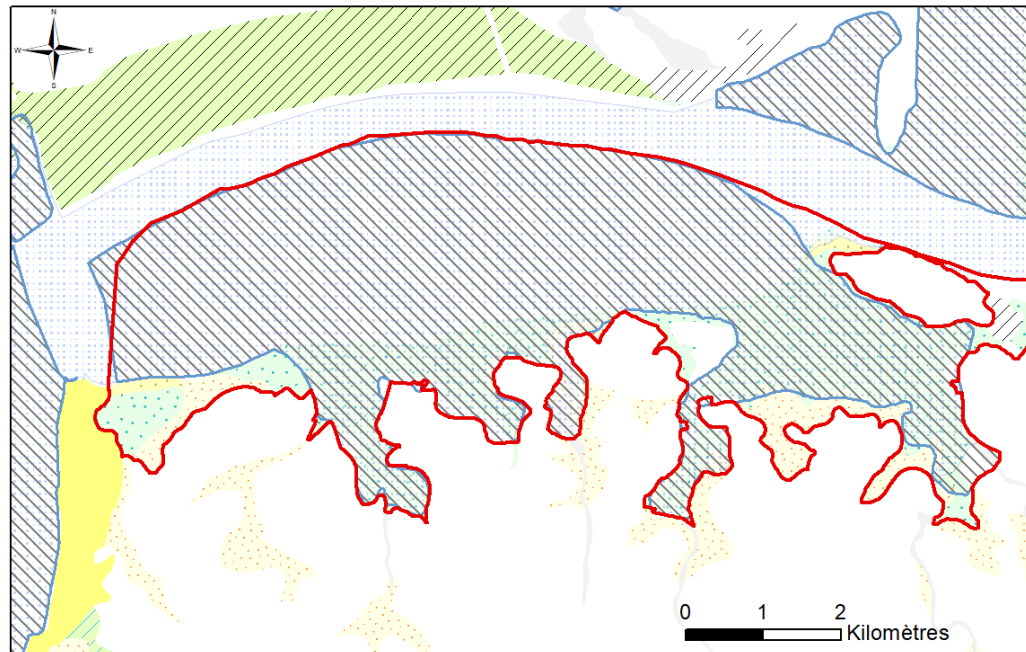
Figure 2 : Cartography of studied field  
 (Source : IGN®, © INPN ; Léa Paly)



Three fields are reviewed through a geohistorical approach

- Ponds and Penfoulic cove  
Les étangs et anse de Penfoulic
- Corsept marshes  
*Les marais de Corsept*
- Payré marshes  
*Les marais du Payré*





### Légende

Site\_Corsept

ZPS :Zone de Protection Spéciale

ZSC : Zone Spéciale de conservation

### Couches géologiques

X, Formations anthropiques, remblais - 1

X/FMz, Formations anthropiques, remblais sur alluvions fluvio-marines de l'estuaire de la Loire - 2

Mzb, Alluvions marines, vases "bri" - 3

D, Formations dunaires - 8

C, Colluvions indifférenciées - 15

Fz, Alluvions récentes et actuelles, colluvions de fond de vallon, Holocène - 35

FMz, Alluvions fluvio-marines de l'estuaire de la Loire, vases et sables, Holocène - 36

FzD, Levées sableuses des berges de la Loire, Holocène - 37



Figure 3 : Localisation of Corsept marshes, Loire atlantique and delimitation of site perimeter based both on geology and protection zones  
(Source : IGN®, © BRGM, © INPN ; Léa Paly)

1. Data sources and land-use/land-cover creation

2. Spatial indicators

3. Data analysis method

⚡ Crisis, major shift



Coumes engineer map (1850)



geo.data.gouv.fr

Land-use/Land cover data

IPLI\*

LITTOMOS \*

OCS-GE \*

\*IPLI : Inventaire Permanent du littoral

\*LITTOMOS : update of IPLI

\*OCS-GE : Occupation du sol grande échelle



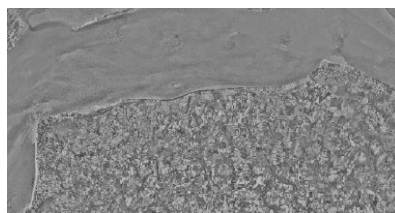
Brittany coast's map

1776



Napoleonic cadastre plan

1820-40



Aerial photograph

1952

1977

2000-2006

2013

Use of iconographic data as old maps and their written

Land planning

Patrimonialization

Storm

Use of textual archives to understand localised changes

Figure 4 : Scheme of geo-historical approach with geomatics' tools and historical maps (Léa Paly)



1. Data sources and land-use/land-cover creation

2. Spatial metrics calculation

3. Data analysis method

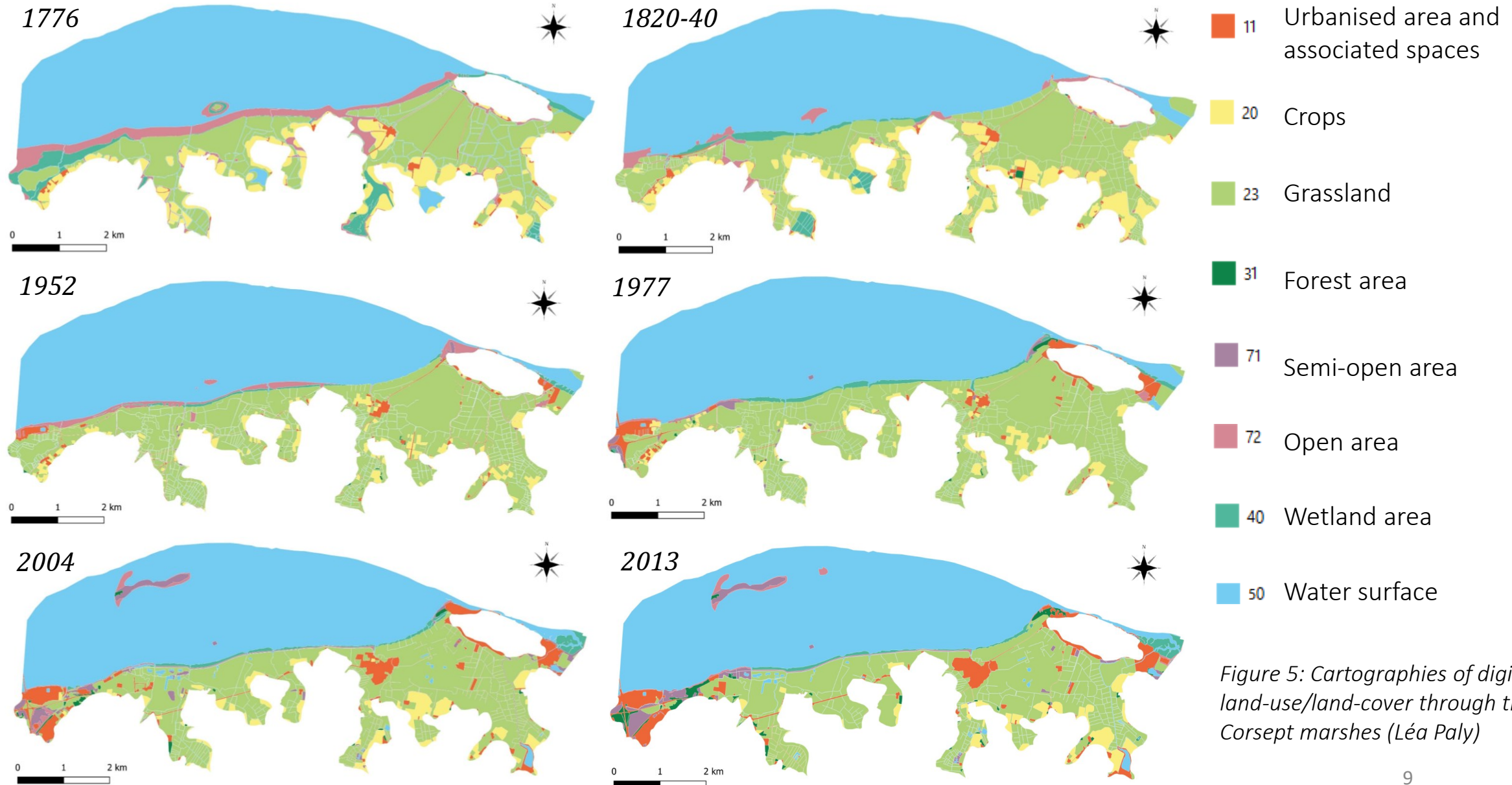


Figure 5: Cartographies of digitalised land-use/land-cover through time on Corsept marshes (Léa Paly)

### Landscape structure metrics :

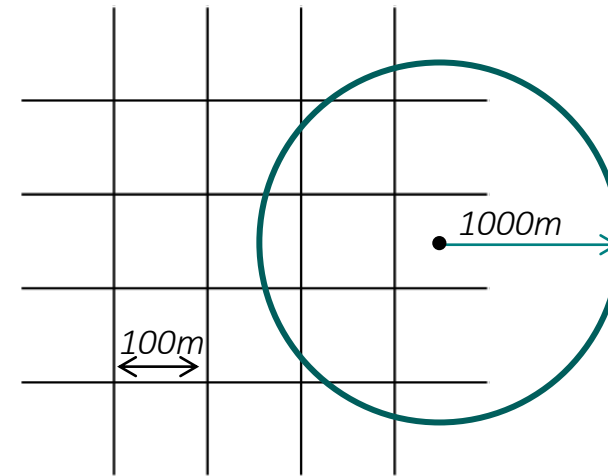
- Distance from coastline (Min)
- Distance from watercourse (Min)
- Elevation (mean/standard-deviation)
- Slope (mean/standard-deviation)
- % of visual on the sea (Viewshed)

### Connectivity and form metrics :

- $AI(x)$  : Pixels agrégation of type of land-use/land-cover
- $E-11(x)$  : interface length between couple of pixels between 11 (urban) and others type of land-use/land-cover
- $E-50(x)$  : interface length between couple of pixels between 50 (water) and others type of land-use/land-cover
- $E-40(x)$  : interface length between couple of pixels between 40 (wetland) and others type of land-use/land-cover

### Composition landscape metrics :

- Mean Patch Size, MPS (landscape level)
- % of land-use/land-cover
- Number of patch of 50 (water body)
- Hydraulic density
- SHDI (Shannon)



Calculation of landscape metrics with a moving windows on a 100 meter grid

(except for structure metrics and hydraulic density)

| ID (mesh) | Variable 1 | Variable 2 | ... | Variable n |
|-----------|------------|------------|-----|------------|
| 1 at t    | x          | x          | ... | x          |
| 2 at t    | x          |            |     |            |
| 3 at t    | x          |            |     |            |
| ...       |            |            |     |            |
| 1 at t+1  |            |            |     |            |
| 2 at t+1  |            |            |     |            |
| 3 at t+1  |            |            |     |            |
| ...       |            |            |     |            |
| 1 at t+n  |            |            |     |            |
| 2 at t+n  |            |            |     |            |
| 3 at t+n  |            |            |     |            |

Figure 6: Graphic of calculation method of landscape and spatial metrics

## Principal component analysis (PCA)

(30 quantitative variables, 8 quanti.sup and 1938 individuals)

Variables reduction by identification of representative variable describing principal dimensions



## Hierarchical Ascendant Classification on the results of PCA (HCPC)

(pre-treatment using K-means,  $kk=100$ )

Identification of landscape clusters



Identification of landscape trajectories

What sequence of clusters does the individual 1 have ?

## PCA and HCPC realised with R and FactoMineR package

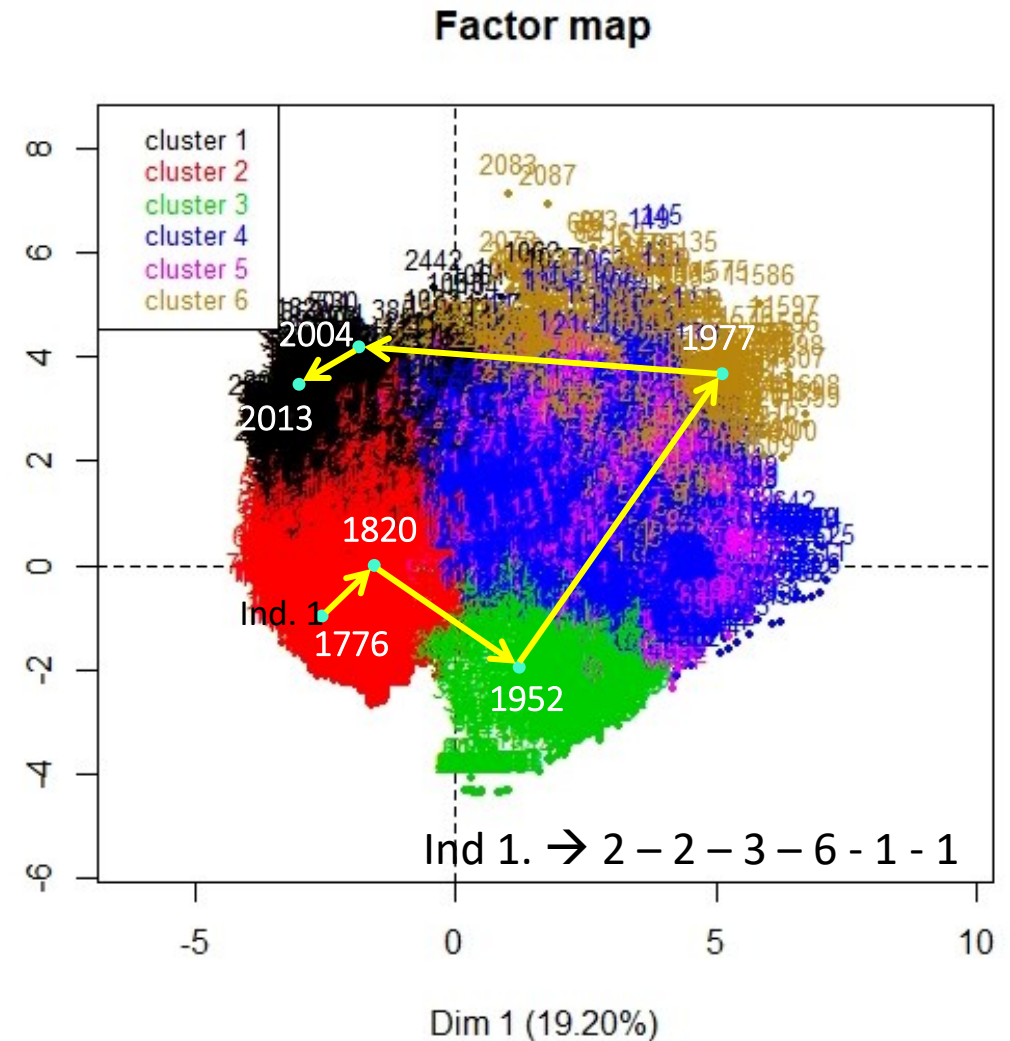


Figure 7: Graphic of analysis method to represent landscape trajectories



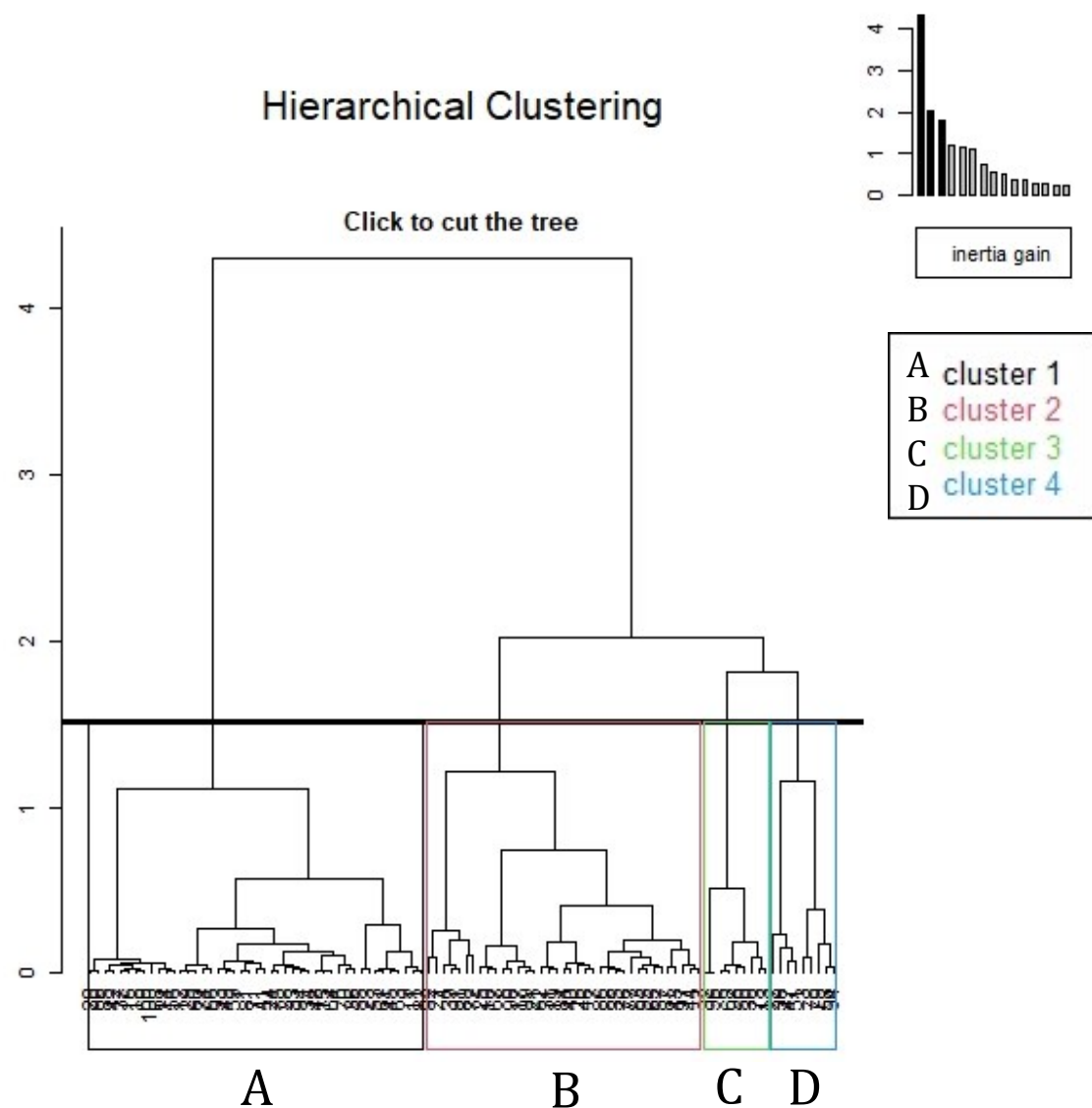


Figure 8: Dendrogram results from hierarchical clustering, selection of 4 clusters

*Interpretation has been realised with the PCA and the description of clusters given with FactoMineR package using tests of Student*

Cluster A : **Agrarian landscape**, composed of compact crops and grassland areas close to a dense hydrographic network. These areas are close to urban surfaces.

Cluster B : **Open and wet shoreline landscape**, composed of compact wetlands and open areas in contact with water and grassland. This landscape, rather uniform, has a large view on the Loire river.

Cluster C : **Open and wetland landscape**, composed of compact wetlands in contact with grassland, and open areas which are both in contact with shoreline or/and water bodies. It forms a diversified landscape.

Cluster D : **Narrowed and urbanised landscape**, composed of closing landscape as semi-open vegetation or forest areas and urbanised areas close to the water and the Loire river.

1. Landscape classification

2. Trajectories identification

3. Zoom on Saint-Brevin marshes

| NB/NATURE<br>TRAJECTOIRE | 1776 - 1820 | 1820-1952 | 1952-1977 | 1977-2004 | 2004-2013 |
|--------------------------|-------------|-----------|-----------|-----------|-----------|
| 1                        | C-A         | A-B       | B-D       | D-D       | D-D       |
| 2                        | C-C         | A-A       | A-D       | B-B       | B-B       |
| 3                        | B-B         | C-A       | C-D       | A-D       | B-D       |
| 4                        | C-B         | C-C       | B-B       | C-D       | C-D       |
| 5                        | A-C         | C-B       | A-A       | C-C       | A-C       |
| 6                        | A-A         | B-B       | A-C       | B-C       | A-A       |
| 7                        |             | A-C       | C-C       | B-D       | A-D       |
| 8                        |             | B-C       | C-B       | A-C       | C-A       |
| 9                        |             |           | C-A       | A-A       | C-C       |
| 10                       |             |           | B-C       | C-A       | C-B       |
| 11                       |             |           |           | C-B       | B-C       |
| 12                       |             |           |           | D-C       | D-B       |
| 13                       |             |           |           | D-B       | D-C       |
| 14                       |             |           |           |           | D-A       |

92 unique trajectories are obtained

Trajectory analysed between two periods become more complex

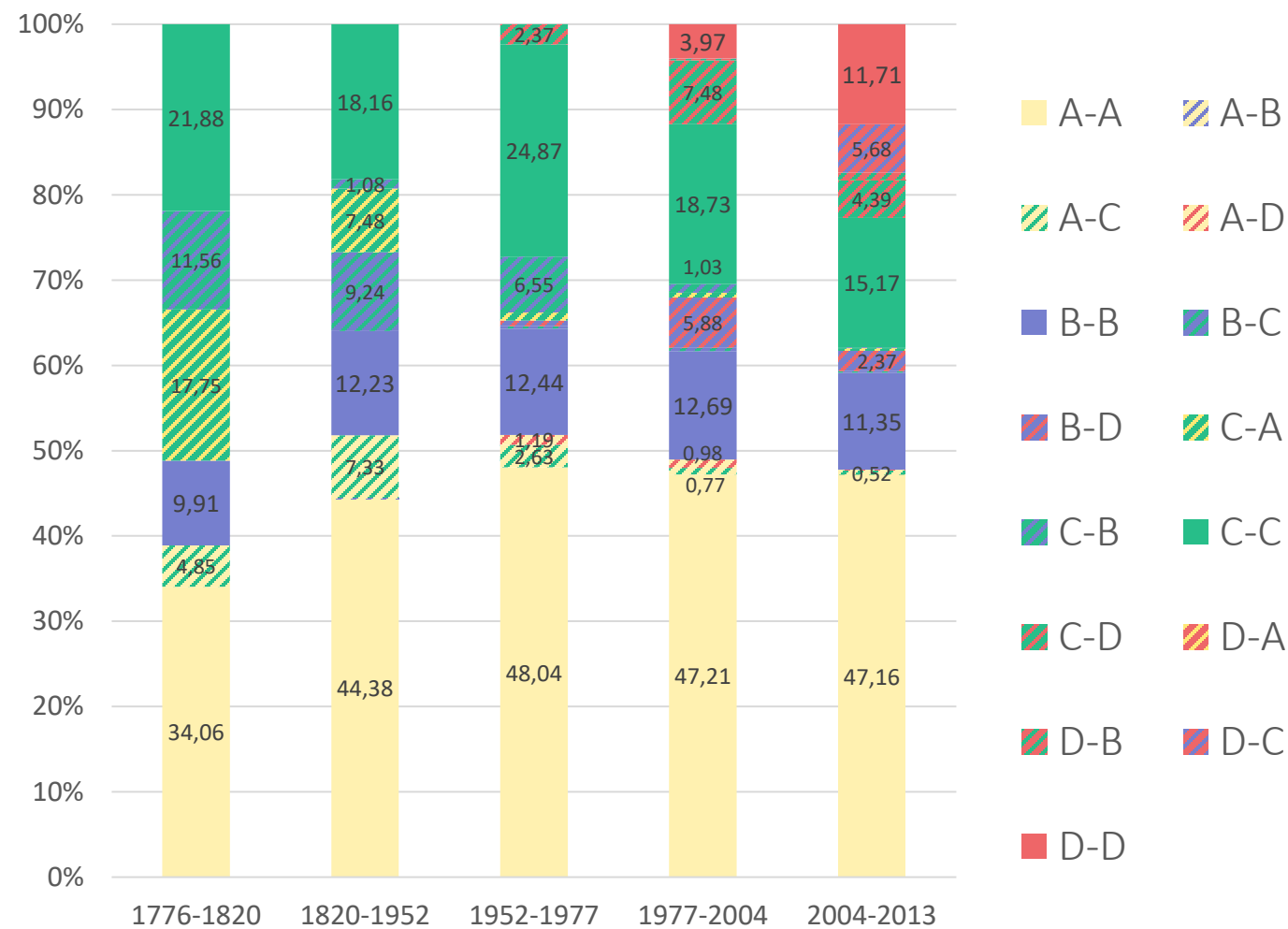


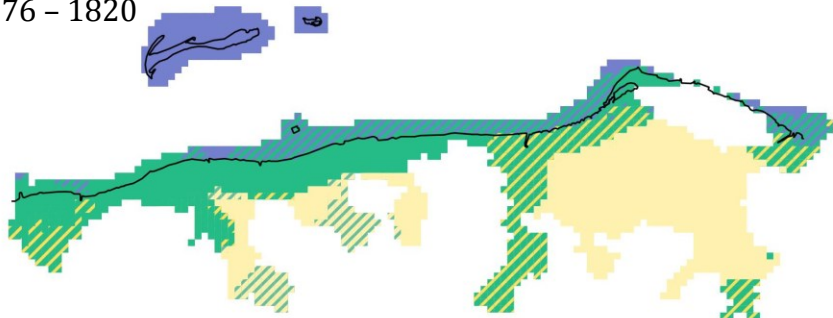
Figure 9: Graphic of % of categories of trajectories identified between two time on Corsept marshes

1. Landscape classification

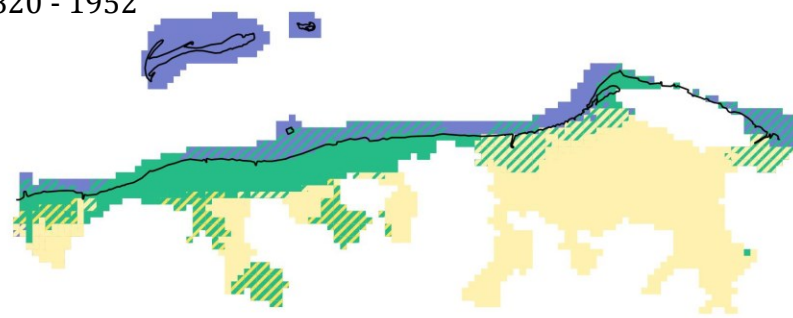
2. Trajectories identification

3. Zoom on Saint-Brevin marshes

1776 - 1820



1820 - 1952

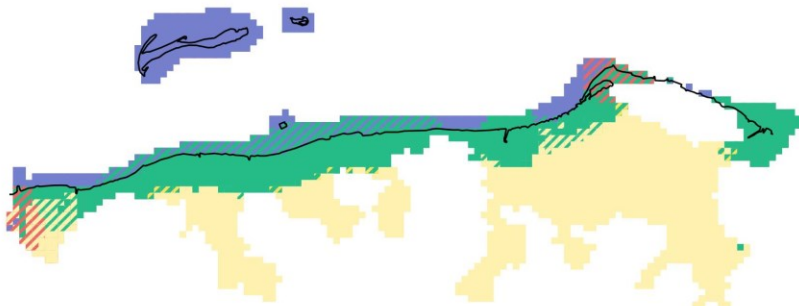


- Wetlands landscape transformed into agrarian landscape.

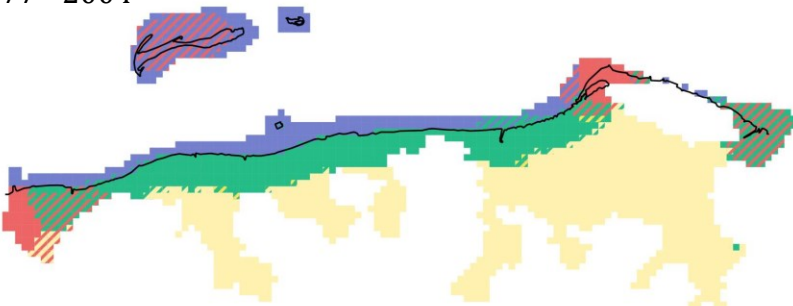
- Apparition of closed landscape in 1952.

- Expansion of closed and urbanised landscape near the shoreline.

1952 - 1977



1977 - 2004



## LEGENDES

## CLUSTERS TRAJECTORIES

A-A

A-B

A-C

A-D

B-B

B-A

B-C

B-D

C-C

C-A

C-B

C-D

D-D

D-A

D-B

D-C

— Shoreline

Figure 10: Cartography of categories of trajectories identified between two time on Corsept marshes (Léa Paly)

0 1 2 3 km



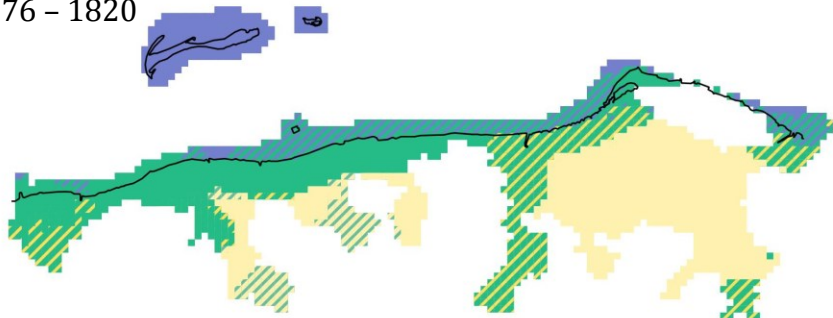


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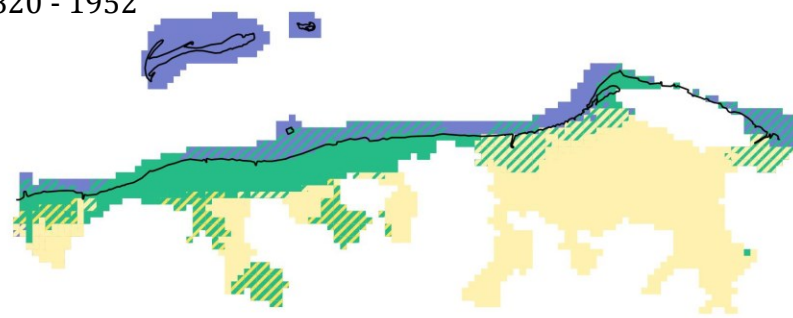
2. Trajectories identification

3. Zoom on Saint-Brevin marshes

1776 - 1820



1820 - 1952

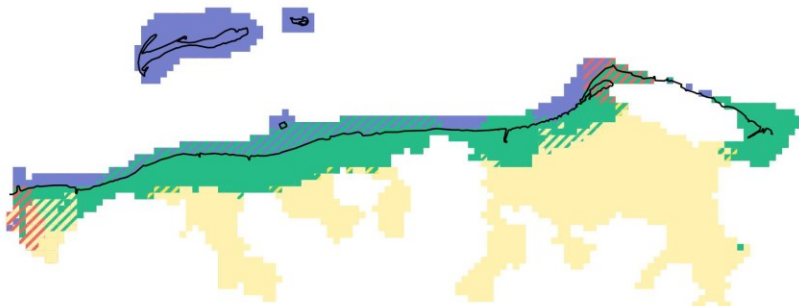


- Wetlands landscape transformed into agrarian landscape.

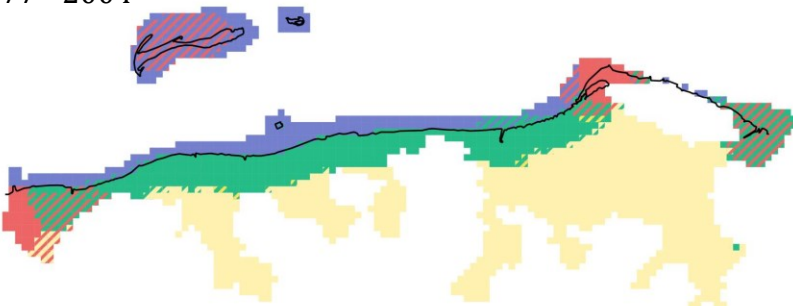
- Apparition of closed landscape in 1952.

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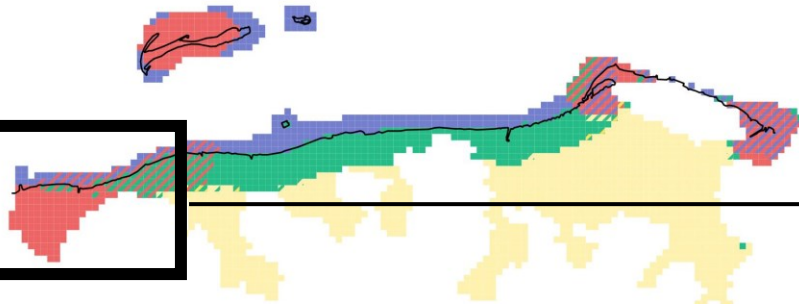
1952 - 1977



1977 - 2004



2004 - 2013



## LEGENDES

## CLUSTERS TRAJECTORIES

A-A

A-B

A-C

A-D

B-B

B-A

B-C

B-D

C-C

C-A

C-B

C-D

D-D

D-A

D-B

D-C

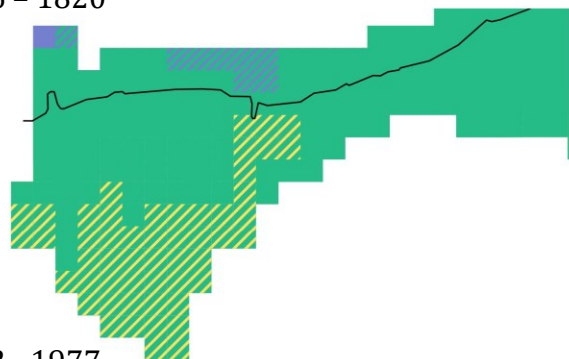
Shoreline

Figure 10: Cartography of categories of trajectories identified between two time on Corsept marshes (Léa Paly)

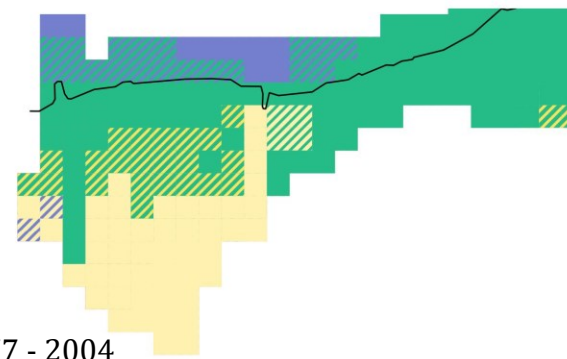
**Switching areas :**  
**Saint-Brevin marshes**

0 1 2 3 km

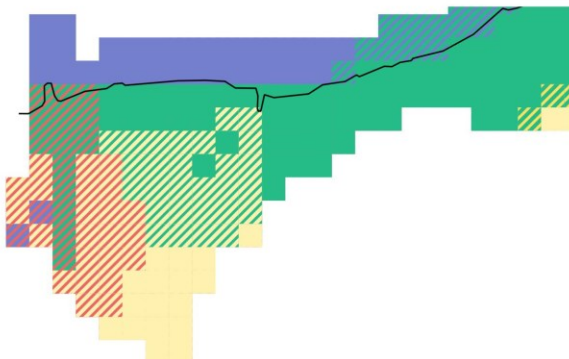
1776 - 1820



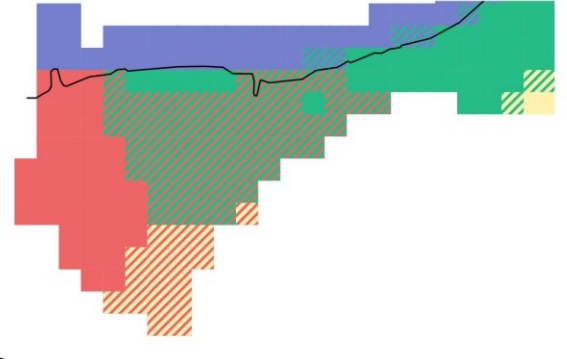
1820 - 1952



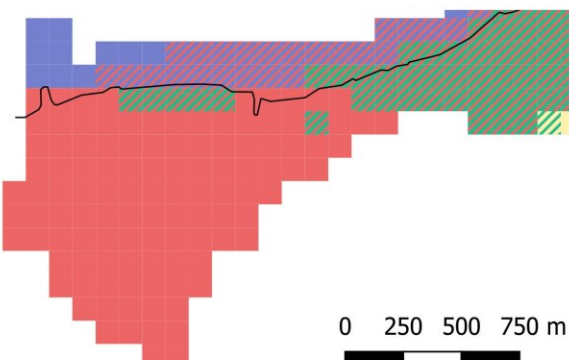
1952 - 1977



1977 - 2004



2004 - 2013

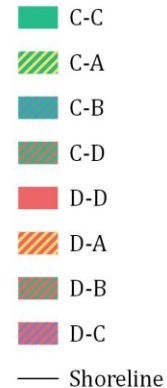
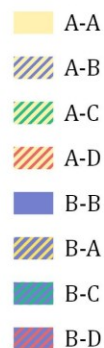


0 250 500 750 m



## LEGENDES

## CLUSTERS TRAJECTORIES



- Salt-marshes fluctuation between 1776 and 1820
- Wetlands transformation into agrarian landscape between 1776 and 1952
- Landscape closure between 1952 and 1977 due to urban and vegetal growth
- Between 1977 and 2013, landscape closure continue mainly due to urban growth

→ Transformation of a natural wetland landscape into a agrarian landscape (draining) and into an urban and closed landscape.

Figure 11: Cartography of categories of trajectories identified between two time on Saint-Brevin marshes (Léa Paly)

Trajectories are reliant on the quality of old map. In 1776 and 1820, no semi-opened areas have been found, we can question the reality of this fact or the inaccuracy of data.

This method is also reliant on the number of clusters we choose. With 6 clusters, agrarian landscape is divided into a grassland dominant agrarian landscape or into a arable dominant landscape.

Trajectories are more complex. With 6 clusters, we have 136 unique landscape trajectories.

Sequence analysis (« classification » on landscape clusters obtained with ACP and HCPC) on these 136 trajectories will allow a better understanding and representation of these trajectories.

| NB/NATURE<br>TRAJECTOIRE | 1776-1820 | 1820-1952 | 1952-1977 | 1977-2004 | 2004-2013 |
|--------------------------|-----------|-----------|-----------|-----------|-----------|
| 1                        | B2-B2     | B2-B1     | B1-D      | D-D       | D-D       |
| 2                        | C-B2      | B2-B2     | B2-D      | B1-B1     | B1-B1     |
| 3                        | C-A2      | B2-A2     | A2-D      | B2-D      | D-B1      |
| 4                        | B1-B1     | A2-B2     | B1-B1     | A2-D      | B2-D      |
| 5                        | B2-B1     | B1-B1     | B2-B2     | B2-B2     | B2-B1     |
| 6                        | C-A1      | A2-A2     | A2-A2     | B1-B2     | A2-D      |
| 7                        | C-C       | A1-B2     | B2-A2     | A2-B2     | A2-A2     |
| 8                        | C-B1      | A1-A2     | A2-B2     | A2-A2     | A2-B1     |
| 9                        | B2-C      | C-B2      | B2-B1     | B2-B1     | B2-A2     |
| 10                       | B2-A2     | C-B1      | B1-B2     | B2-A2     | B2-B2     |
| 11                       | B1-B2     | B1-B2     | A1-A2     | A2-A1     | A1-A2     |
| 12                       | A2-B2     | C-A2      | C-B2      | B1-D      | D-B2      |
| 13                       | A2-A2     | B1-A2     | C-C       | D-B1      | A2-B2     |
| 14                       | A1-A1     | A1-A1     |           | C-D       | D-A2      |
| 15                       | B2-A1     | B2-C      |           | B2-C      | B1-D      |
| 16                       | A1-B2     | A2-C      |           |           | A2-A1     |
| 17                       | A1-A2     | B1-C      |           |           | B1-B2     |
| 18                       | A1-C      |           |           |           | A1-A1     |
| 19                       | A2-C      |           |           |           | B1-C      |
| 20                       | A2-A1     |           |           |           | D-C       |
| 21                       |           |           |           |           | C-C       |



Interviews with Corsept marshes users will provide a vision of landscape evolution of this wetlands and will be compared with the reality of archives.

This analysis can be useful :

- In ecology if we want to study a part of a field with a specific trajectory
- In restauration project : we can make better scenarios of futur evolution with restrospective knowledges
- It is replicable in France for the XIXe to the XXIe centuries because napoleonic plan is available at national scale.
- However, XVIIIe century data are scattered and not always disposable.

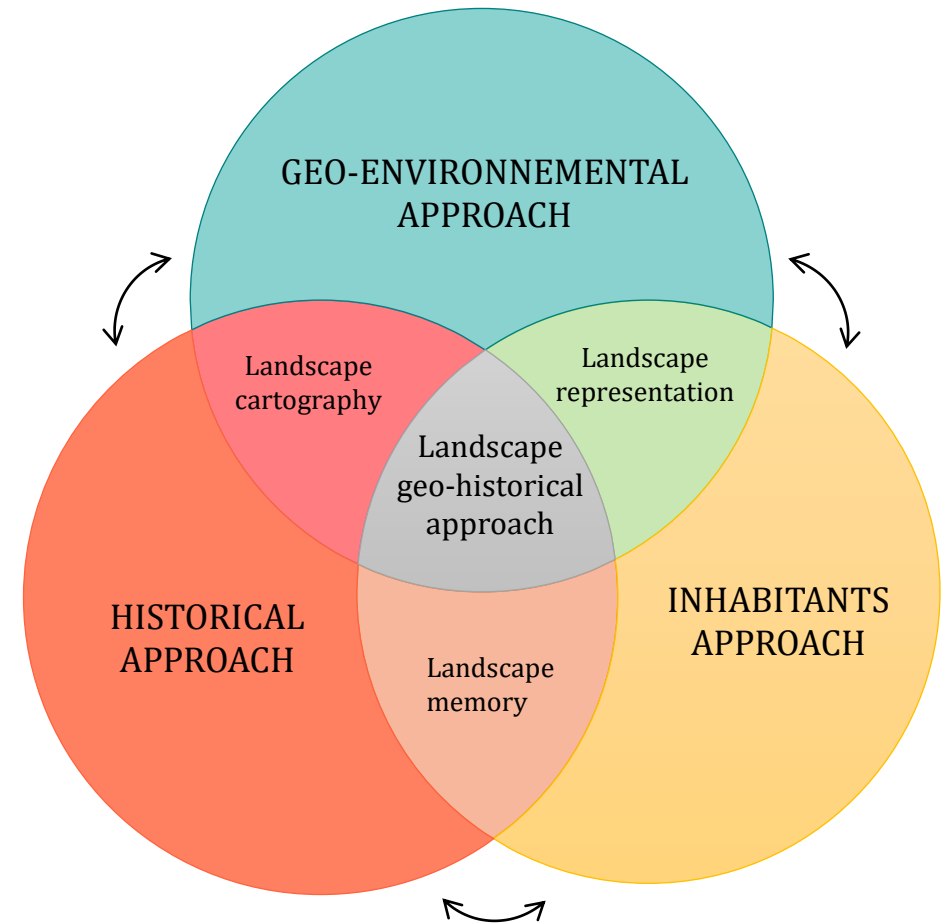


Figure 12 : Scheme of overall approaches used in this PhD research to investigate landscape geo-historical approach



Thanks for your attention !

