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Spanish Ministry of Environmental Affairs
Polytechnical University of Madrid (UPM)

Fluvial dynamics and biodiversity of riparian systems

from theory to applications

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CNRS
UMR 5600 Environnement - Ville - Société
Lyon, France

Contents

- Fundamental aspects on the interactions between channel geometry and riparian forest
- Elements for designing the WFD restoration program

I. Fundamental aspects on the interactions between channel geometry and riparian forest

- What is the riparian area?
  - Main characteristics
  - Biodiversity
- How is it affected by channel dynamics in human environments?
  - Reach scale
  - Catchment scale

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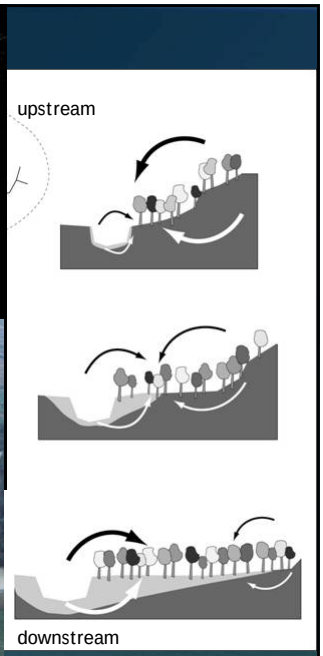
Main characteristics : channel and groundwater proximity

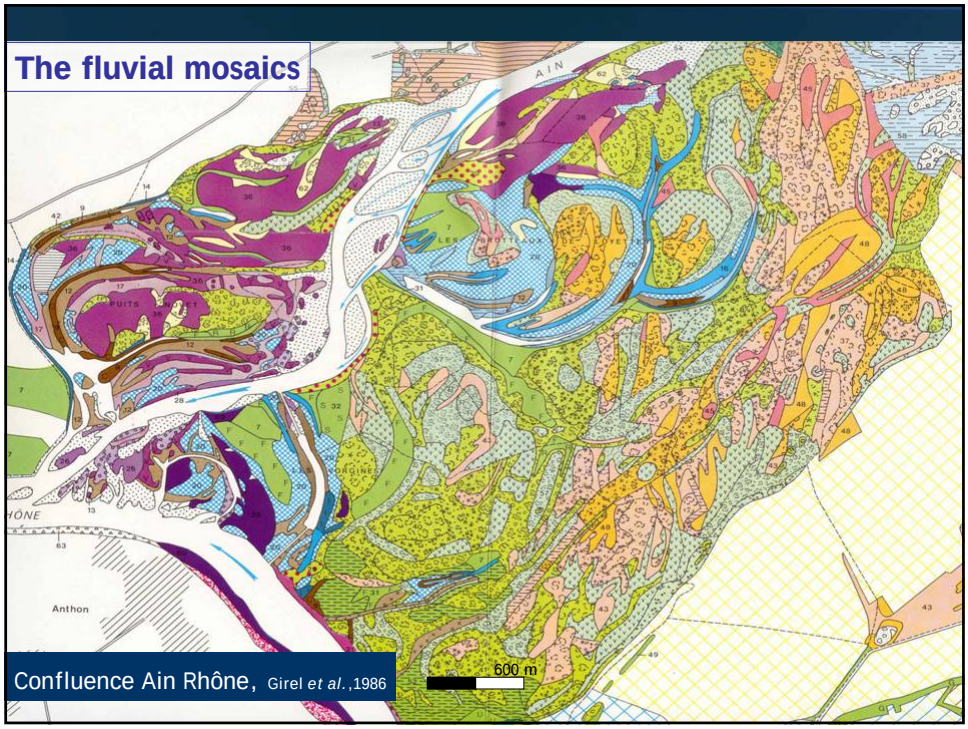
- water, sediments, nutrients, and propagules supply during floods
- physical disturbance

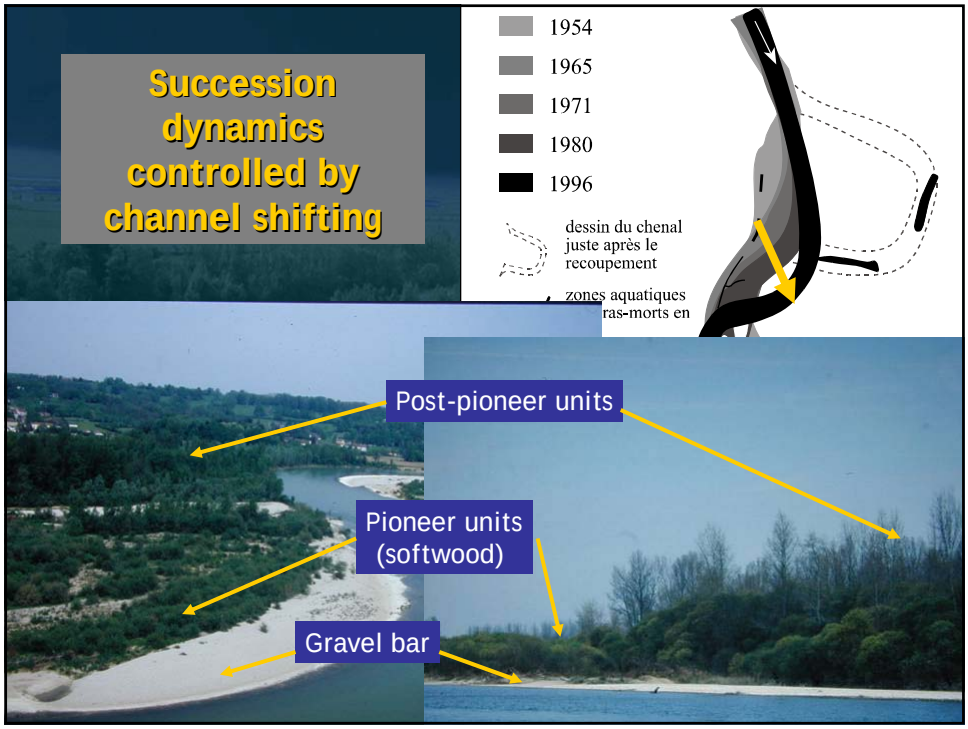
Salix sp. on gravel bar

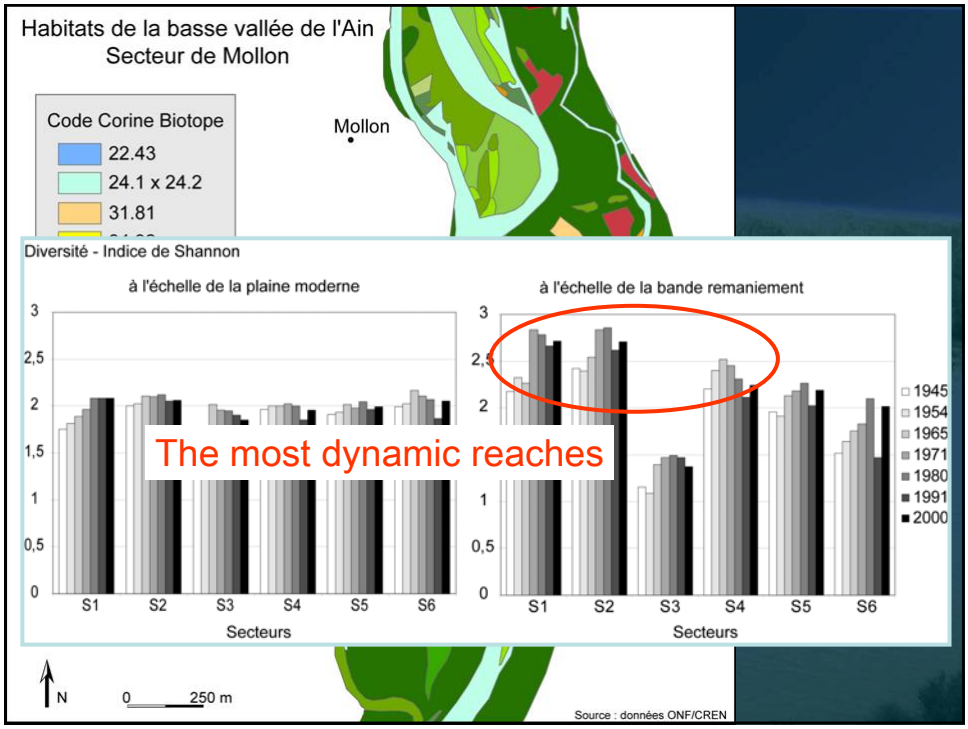
Alnus glutinosa, permanent water

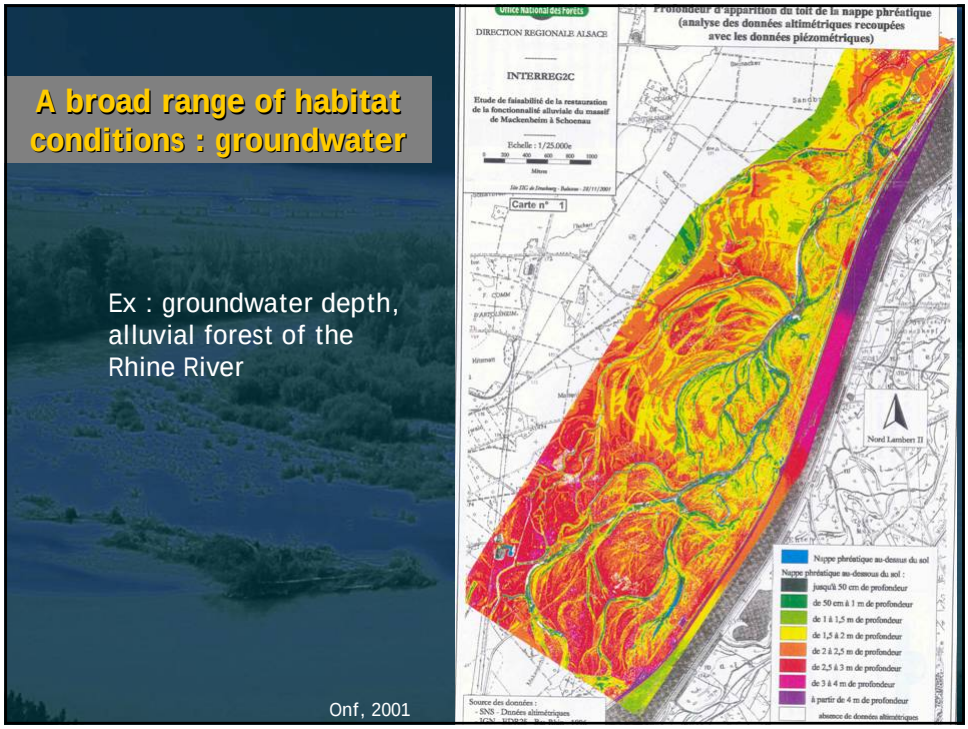
A specific vegetation

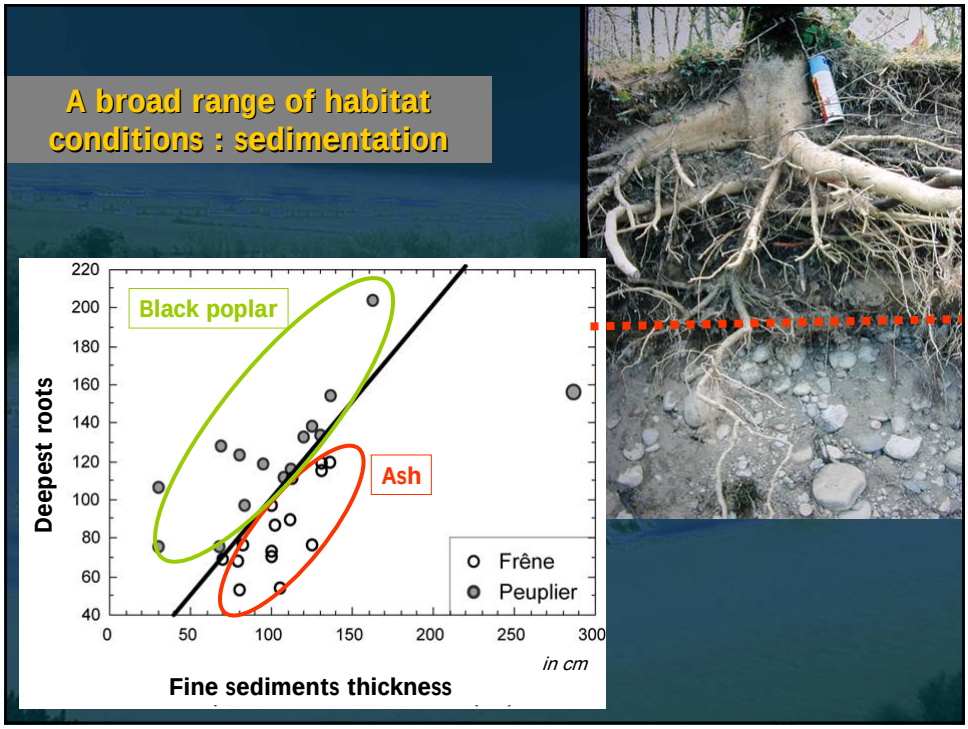


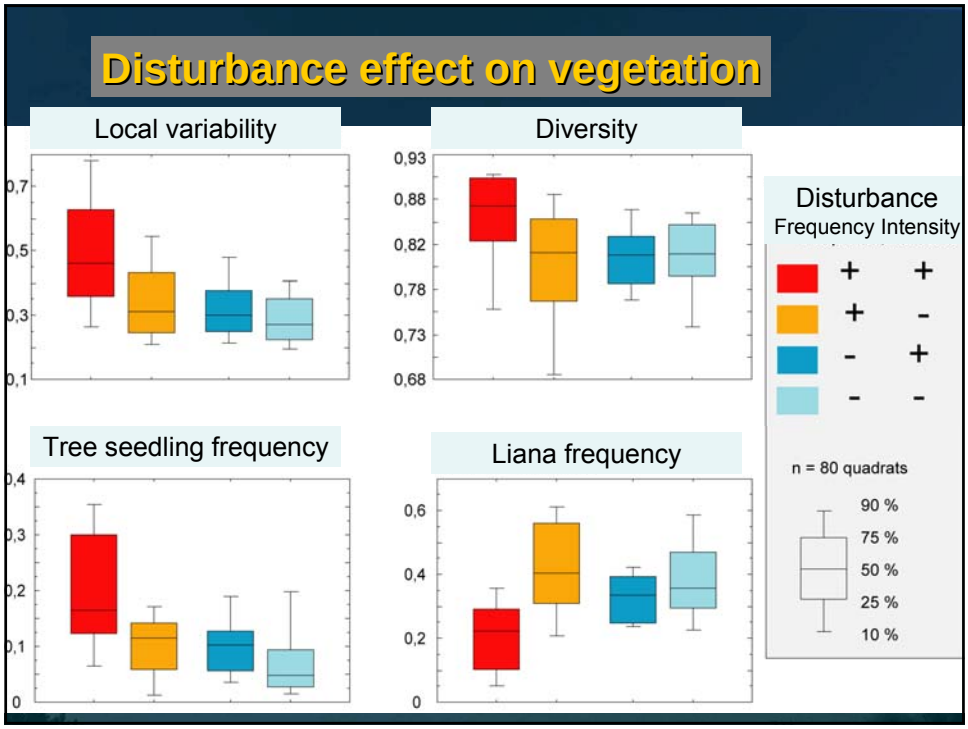

The fluvial mosaics
AIN
RHÔNE
Anthon
600 m
Confluence Ain Rhône, Girel et al.,1986


Succession dynamics controlled by channel shifting
1954
1965
1971
1980
1996
dessin du chenal juste après le recoupement
zones aquatiques ras-morts en
Post-pioneer units
Pioneer units (softwood)
Gravel bar

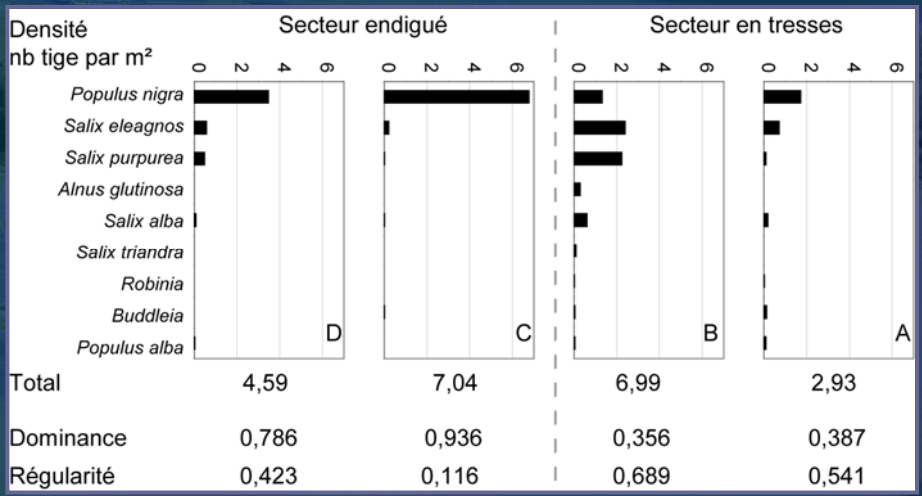

Habitats de la basse vallée de l'Ain
Secteur de Mollon
Code Corine Biotope
22.43
24.1 x 24.2
31.81
Mollon
Diversité - Indice de Shannon
à l'échelle de la plaine moderne
à l'échelle de la bande remaniement
The most dynamic reaches
1945
1954
1965
1971
1980
1991
2000
S1
S2
S3
S4
S5
S6
Secteurs
N
0
250 m
Source : données ONF/CREN


A broad range of habitat conditions : groundwater
Ex : groundwater depth, alluvial forest of the Rhine River
Onf, 2001
DIRECTION REGIONALE ALSACE
INTERREG2C
Carte n° 1
Profondeur d'apparition du toit de la nappe phréatique (analyse des données altimétriques recoupées avec les données piézométriques)
Nappe phréatique au-dessus du sol
jusqu'à 50 cm de profondeur
de 50 cm à 1 m de profondeur
de 1 à 1,5 m de profondeur
de 1,5 à 2 m de profondeur
de 2 à 2,5 m de profondeur
de 2,5 à 3 m de profondeur
de 3 à 4 m de profondeur
à partir de 4 m de profondeur


A broad range of habitat conditions : sedimentation
Black poplar
Ash
Deepest roots
Fine sediments thickness
in cm
Frêne
Peuplier
220
200
180
160
140
120
100
80
60
40
0
50
100
150
200
250
300

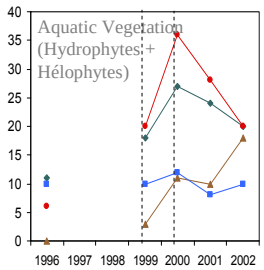

Disturbance effect on vegetation
Local variability
Diversity
Tree seedling frequency
Liana frequency
Disturbance
Frequency Intensity
n = 80 quadrats
90 %
75 %
50 %
25 %
10 %

species richness (TSR) varies
from 20 to 23 in the braided islands
against 12 to 14 in islands located in the embanked reach

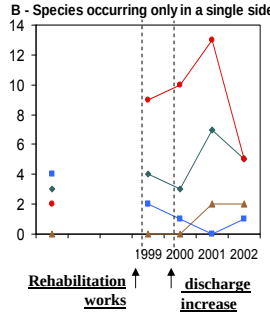


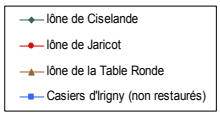
From C. Amoros et al., 2005

A- Total species number in each side-channel



B - Species occurring only in a single side-channel





Control site

Monitoring of aquatic vegetation

The restored former channels of the old Rhône of Pierre Bénite

I. Fundamental aspects on the interactions between channel geometry and riparian forest

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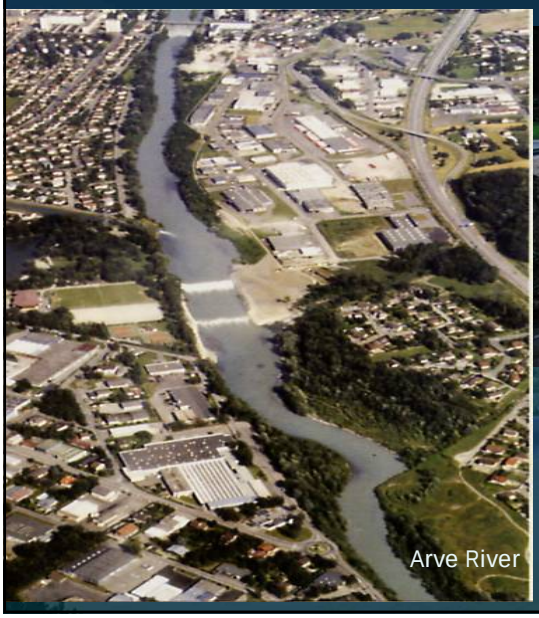
  - Catchment scale

Human pressure – Urbanization



Human pressure - Artificial plantations

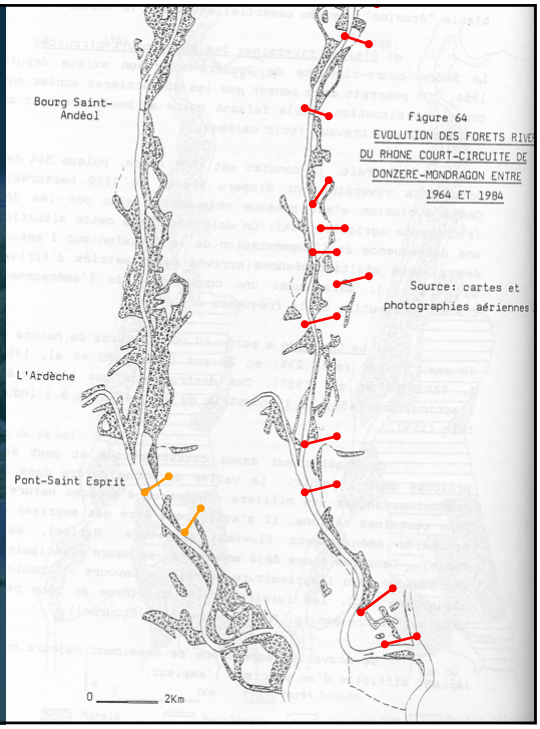
influence of human activities on structure (the Rhône)

=> fragmentation

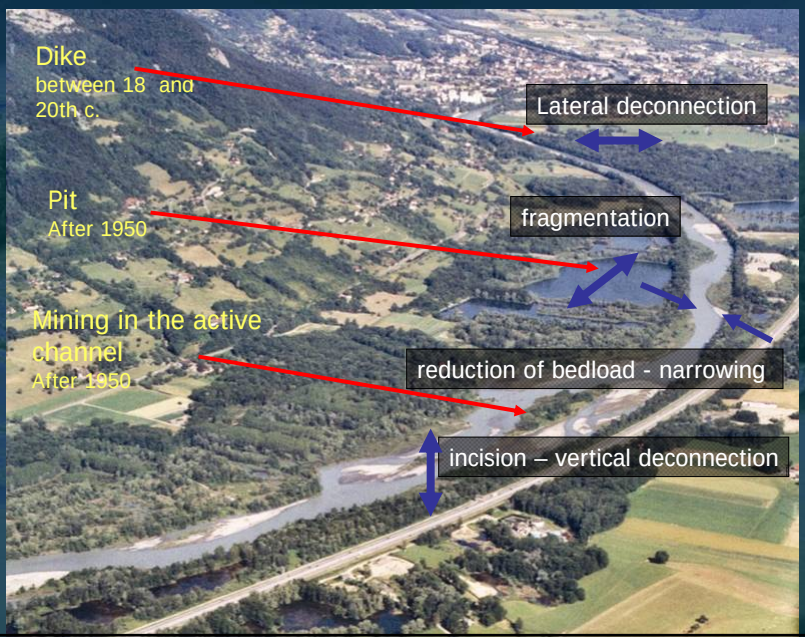
In 1964

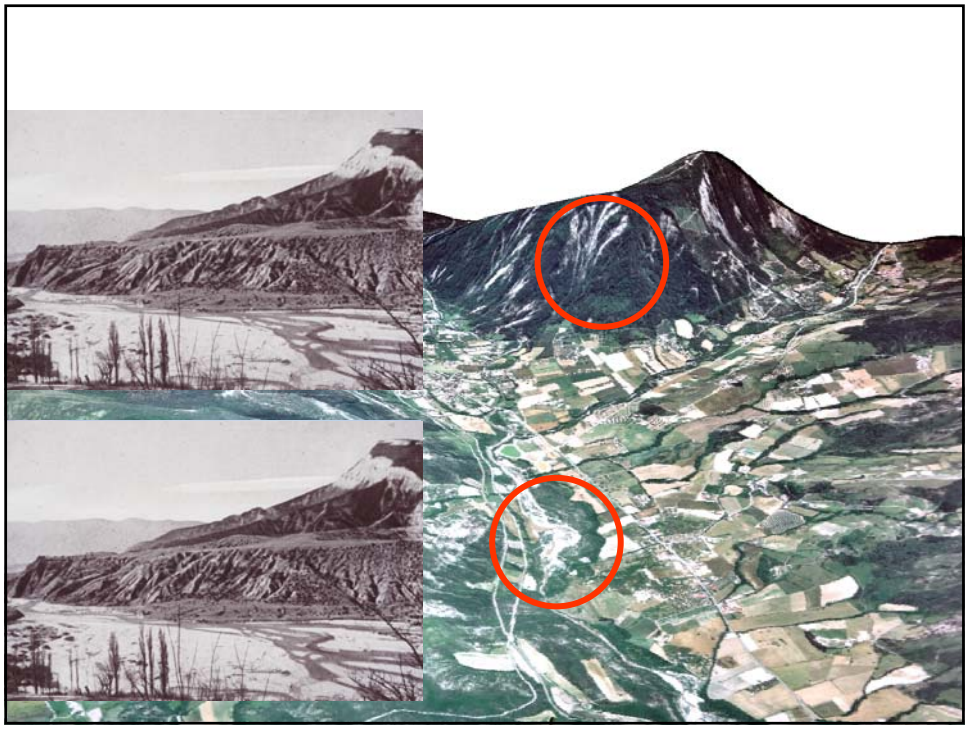
In 1984

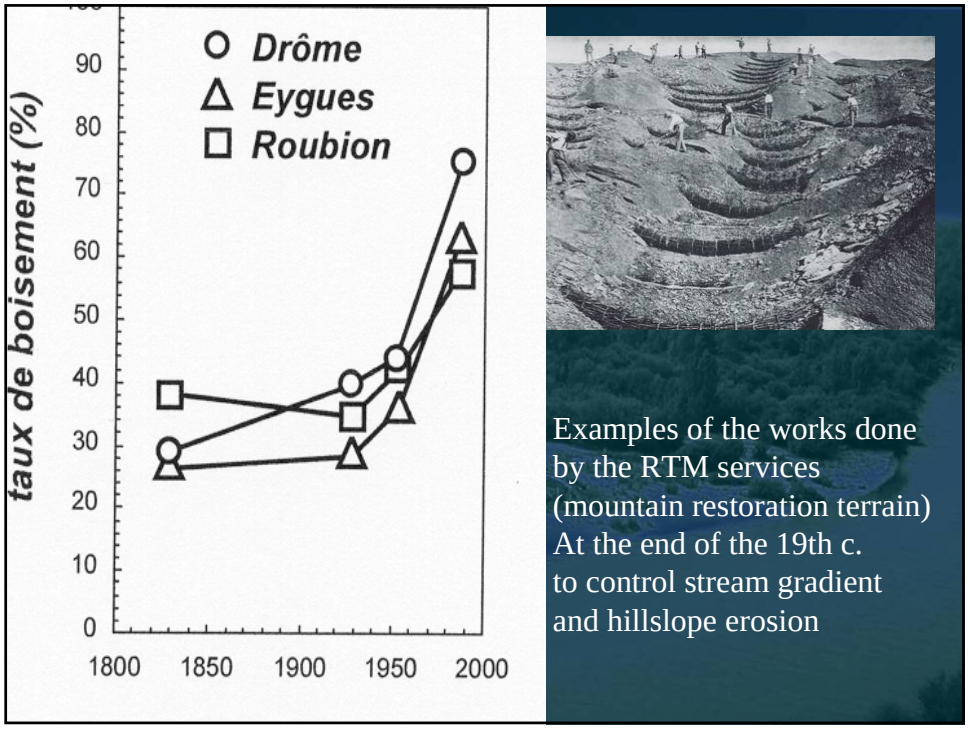
D 'après Michelot 1989



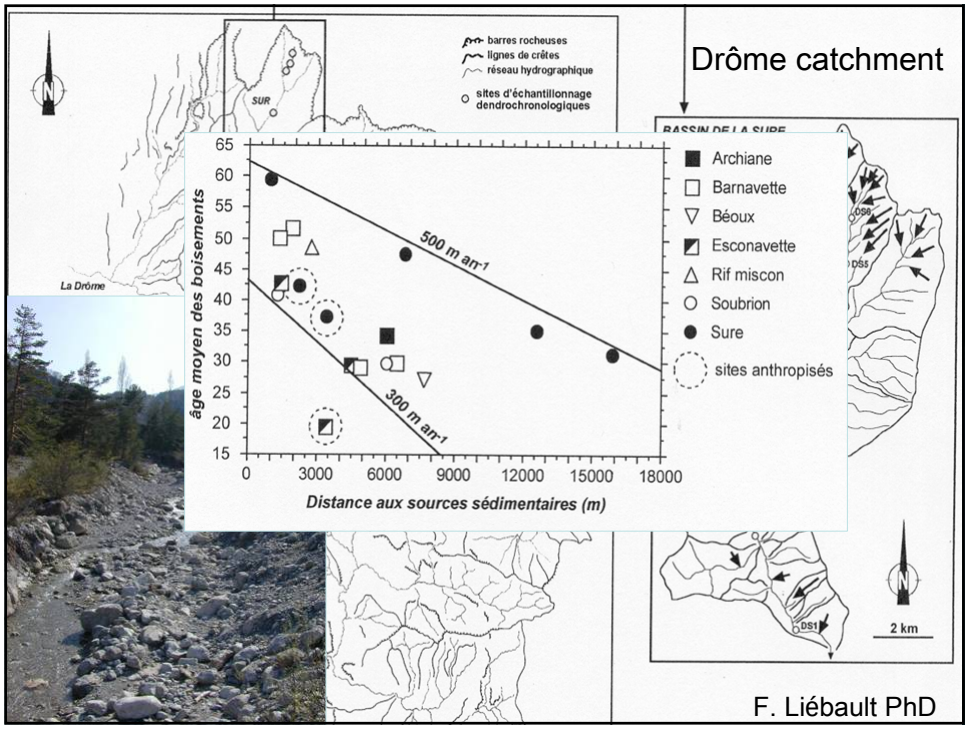
Human impacts along the Arve, France

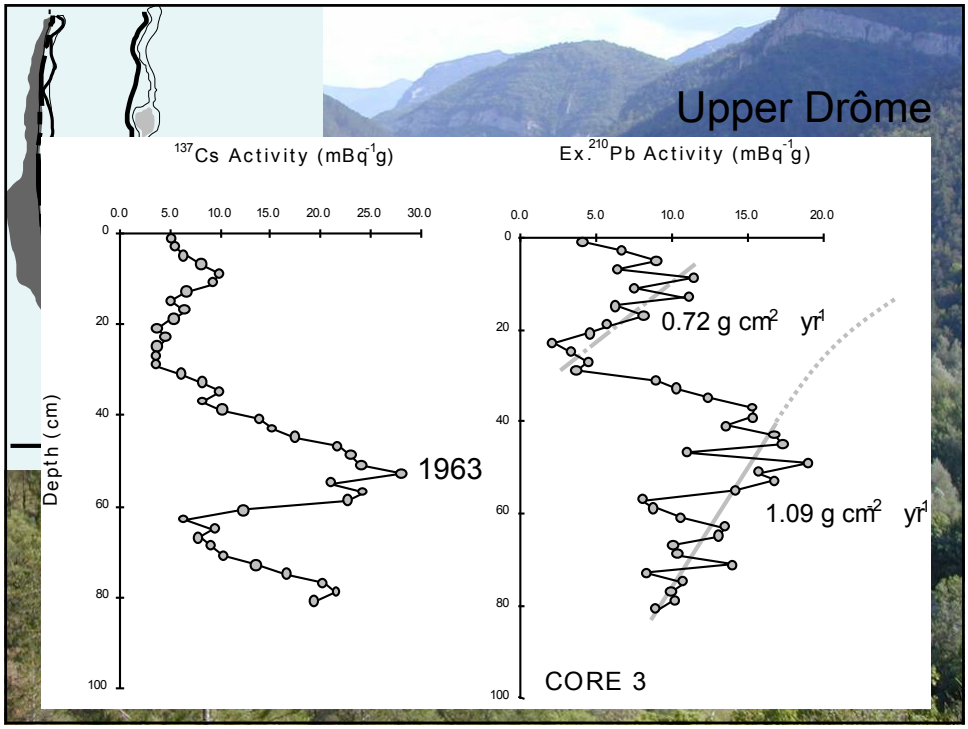


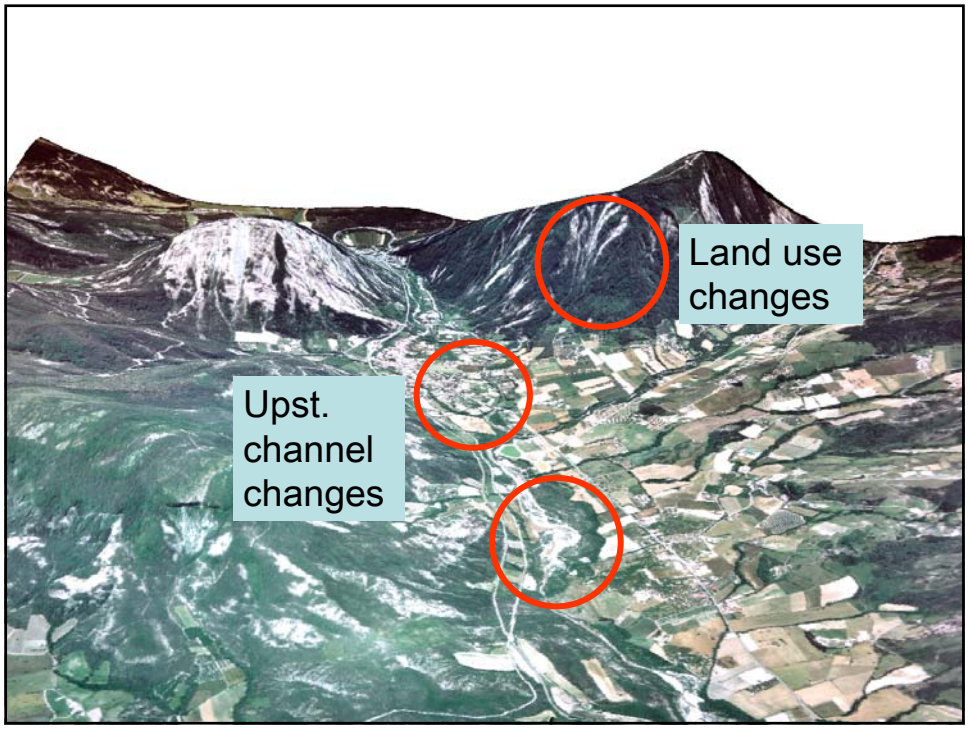


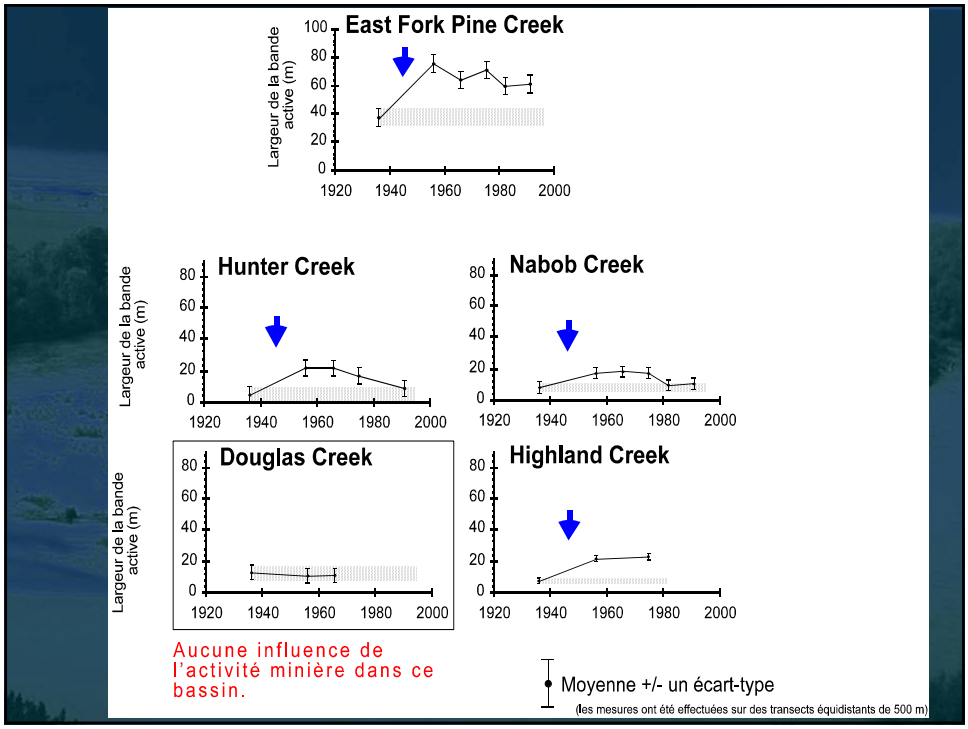


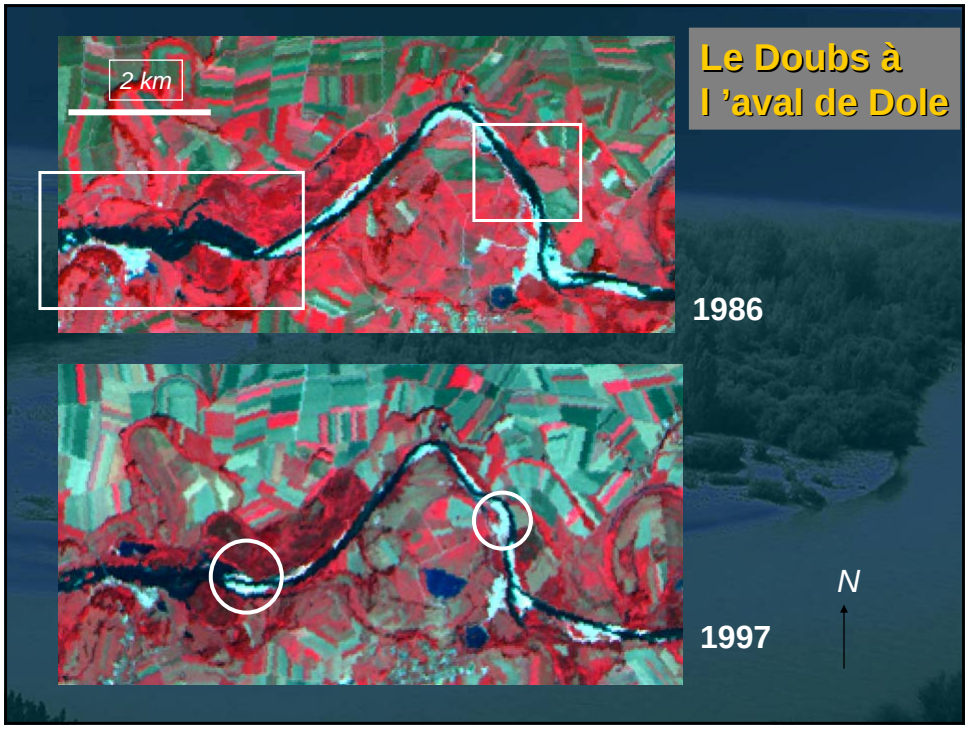
Examples of the works done by the RTM services (mountain restoration terrain) At the end of the 19th c. to control stream gradient and hillslope erosion

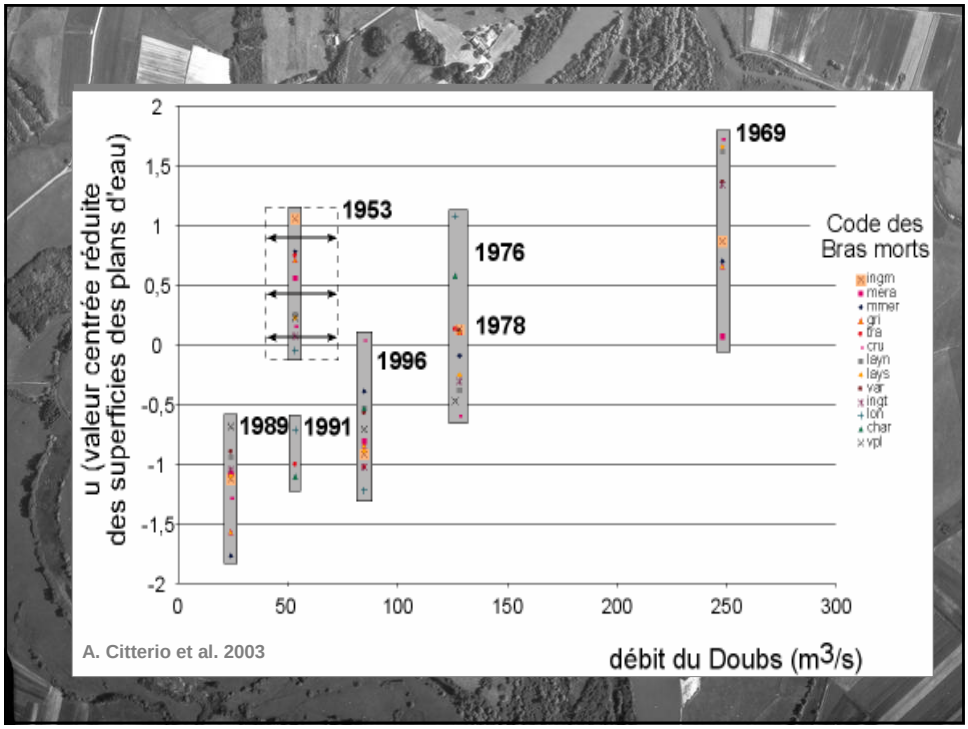


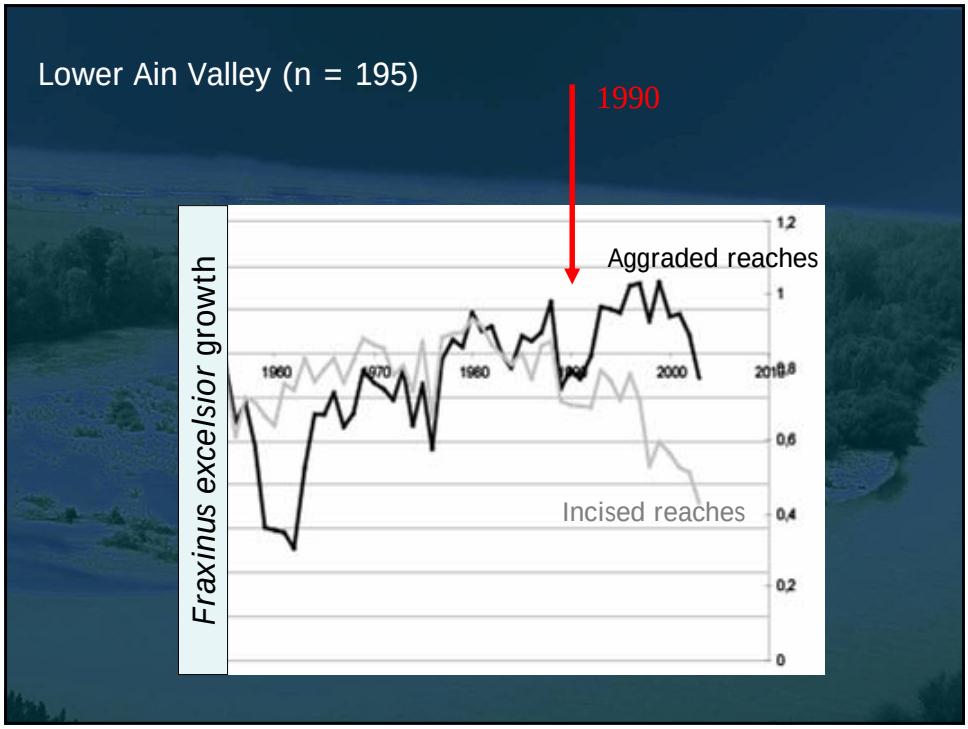

Upper Drôme
137Cs Activity (mBq-1g)
Ex.210Pb Activity (mBq-1g)
Depth (cm)
1963
0.72 g cm2 yr1
1.09 g cm2 yr1
CORE 3


Land use changes
Upst. channel changes

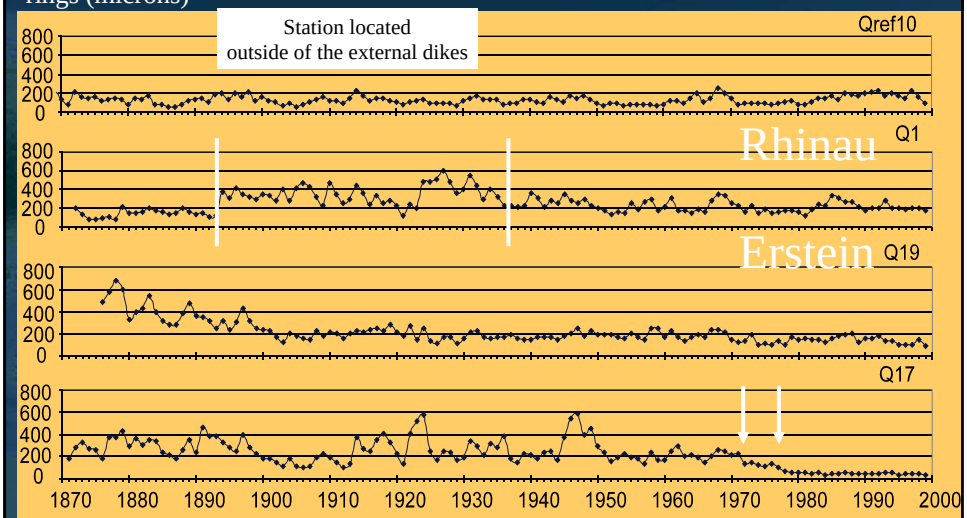

East Fork Pine Creek
Largeur de la bande active (m)
100
80
60
40
20
0
1920
1940
1960
1980
2000
Hunter Creek
Nabob Creek
Douglas Creek
Highland Creek
Aucune influence de l'activité minière dans ce bassin.
Moyenne +/- un écart-type
(les mesures ont été effectuées sur des transects équidistants de 500 m)


2 km
Le Doubs à l 'aval de Dole
1986
1997
N


u (valeur centrée réduite des superficies des plans d'eau)
2
1,5
1
0,5
0
-0,5
-1
-1,5
-2
0
50
100
150
200
250
300
1953
1969
1976
1978
1996
1989
1991
Code des Bras morts
débit du Doubs (m3/s)
A. Citterio et al. 2003


Lower Ain Valley (n = 195)
1990
Fraxinus excelsior growth
Aggraded reaches
Incised reaches
1960
1970
1980
2000
1,2
1
0,8
0,6
0,4
0,2
0

Effect of channel regulation on the Oak growth along the Rhine



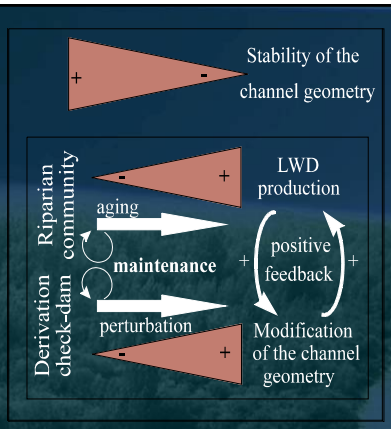
1996 1960

Changes in cut-off dynamics because of floodplain afforestation

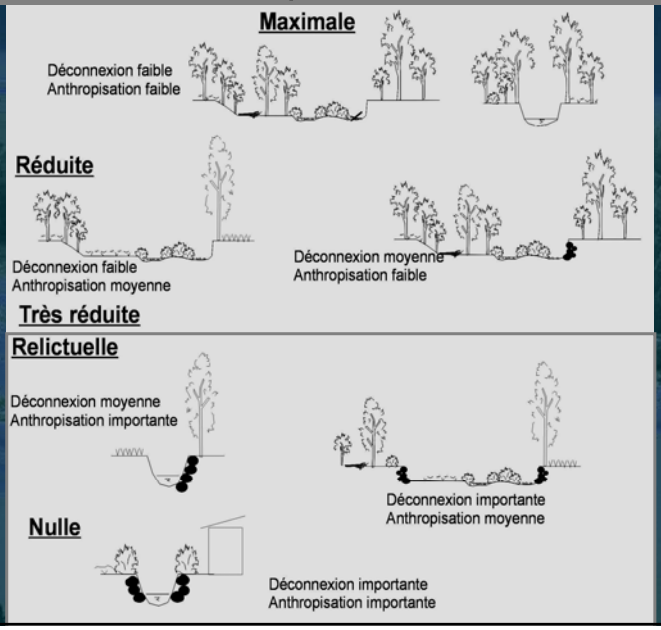
The Doulon and the Cronce, two tributaries of the Allier :

- increase of mortality in *Alnus* community,
- abandoned derivation check dam,

- increase in LWD input,
- channel widening



Unheritage and funtionnal value of the riparian forests



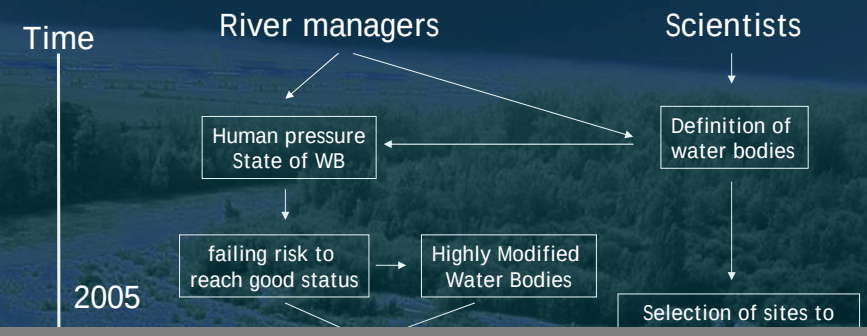
-Structure

- Loss in connectivity (vertical, horizontal)

II. Elements for designing the WFD restoration program

- Riparian zones and WFD
  - Not a metrics … for evaluating if we reach a good ecological status
  - A compartment on which we can act… for reaching a good status
- Guiding ideas for implementing the WFD
  - Reference state versus pristine state
  - Static versus dynamic
  - Local diversity versus long term diversity
  - Balancing ecosystem improvement and other stakes (risk management)

Schedule for defining the program of measures in France

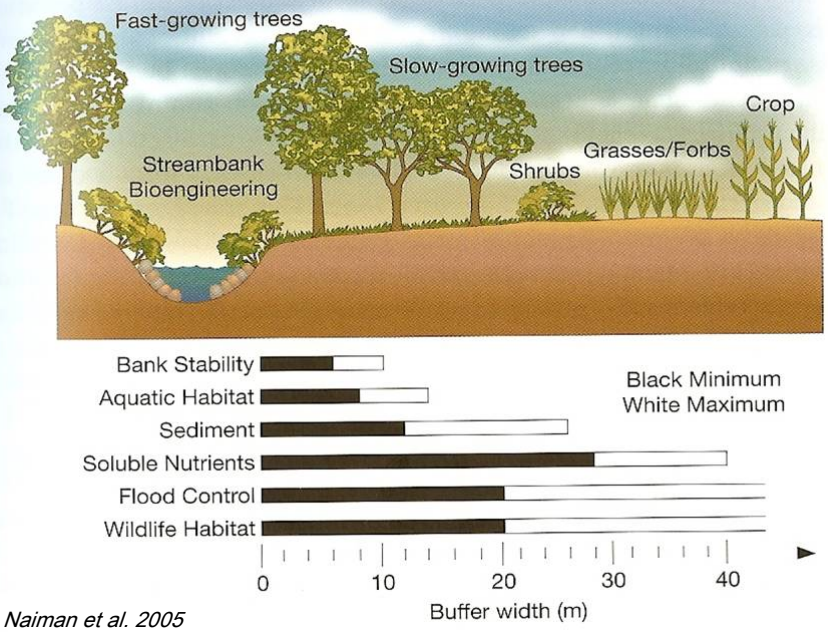


Metrics for assessing the efficiency of measures :

= invertebrates (IBGN amélioré – au genre/espèce Usseglio Metz),
= fish (CSP pêche par ambiance),
= macrophytes (Diren),
= diatoms (niveau taxonomique poussé – espèce possible)
= physico-chimistry (nutriments+micropolluants 6 surveys per yr, 12 pesticides)

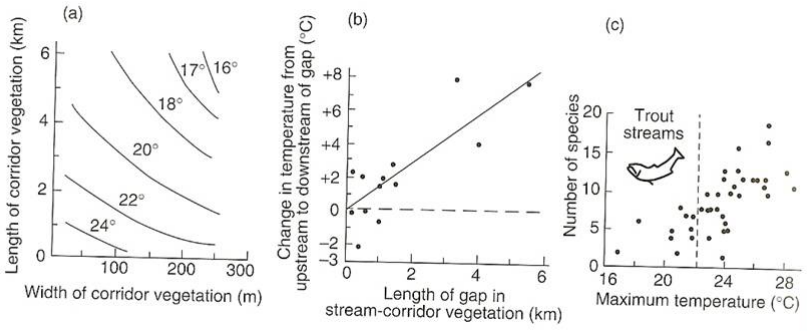
2015

Restoration of riparian corridors for aquatic habitat



Naiman et al. 2005

Riparian corridor and temperature



a) Effect of upstream veg. Corridor of variable length on predicted stream t°
b) Change in t° according to the length of the gazp in rip. Veg.
c) Fish species richness related to t°

40 streams, southern Ontario
(Barton et al. 1985 in Naiman et al. 2005)

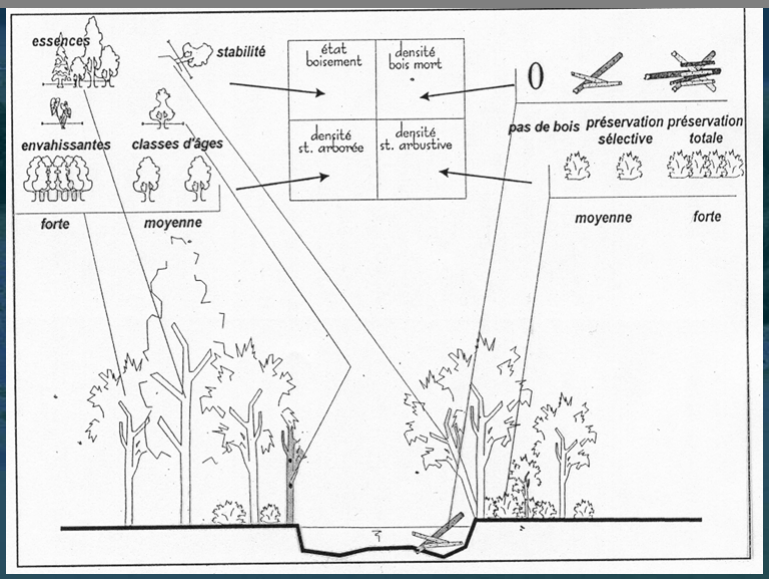
Number *fish*

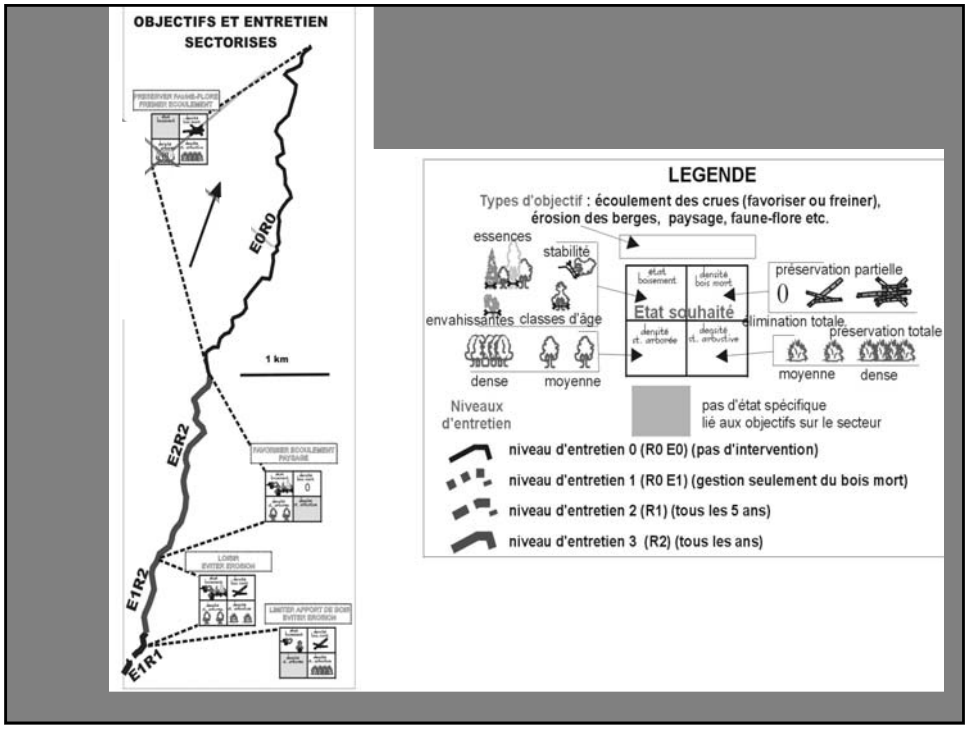
Carmel river, Californie, USA, 2003 (Photo by D. Smith)

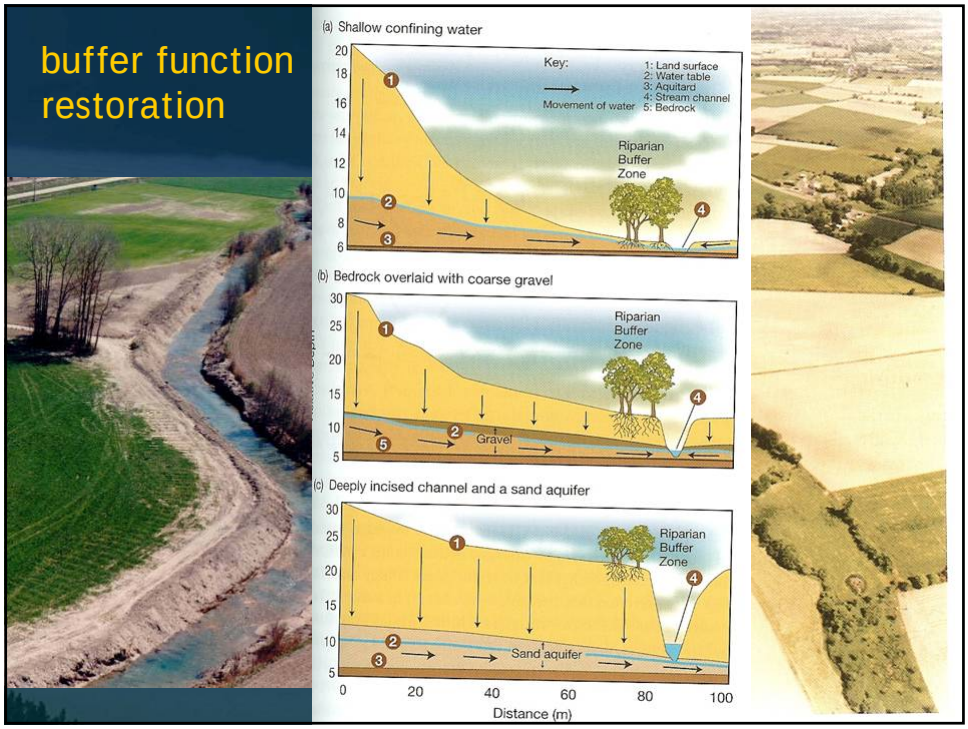
fish abundance and diversity
Case of the cyprinid zone

Source: Thévenet, 1998

Mitigate the impact of vegetation maintenance : define objectives




OBJECTIFS ET ENTRETIEN
SECTORISES
E0R0
E2R2
E1R2
E1R1
1 km
LEGENDE
Types d'objectif : écoulement des crues (favoriser ou freiner), érosion des berges, paysage, faune-flore etc.
essences
stabilité
envahissantes
classes d'âge
dense
moyenne
Etat souhaité
préservation partielle
élimination totale
préservation totale
moyenne
dense
Niveaux d'entretien
pas d'état spécifique lié aux objectifs sur le secteur
niveau d'entretien 0 (R0 E0) (pas d'intervention)
niveau d'entretien 1 (R0 E1) (gestion seulement du bois mort)
niveau d'entretien 2 (R1) (tous les 5 ans)
niveau d'entretien 3 (R2) (tous les ans)


buffer function restoration
(a) Shallow confining water
Key:
Movement of water
1: Land surface
2: Water table
3: Aquitard
4: Stream channel
5: Bedrock
Riparian Buffer Zone
(b) Bedrock overlaid with coarse gravel
Gravel
(c) Deeply incised channel and a sand aquifer
Sand aquifer
Distance (m)

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  - Reference state versus pristine state
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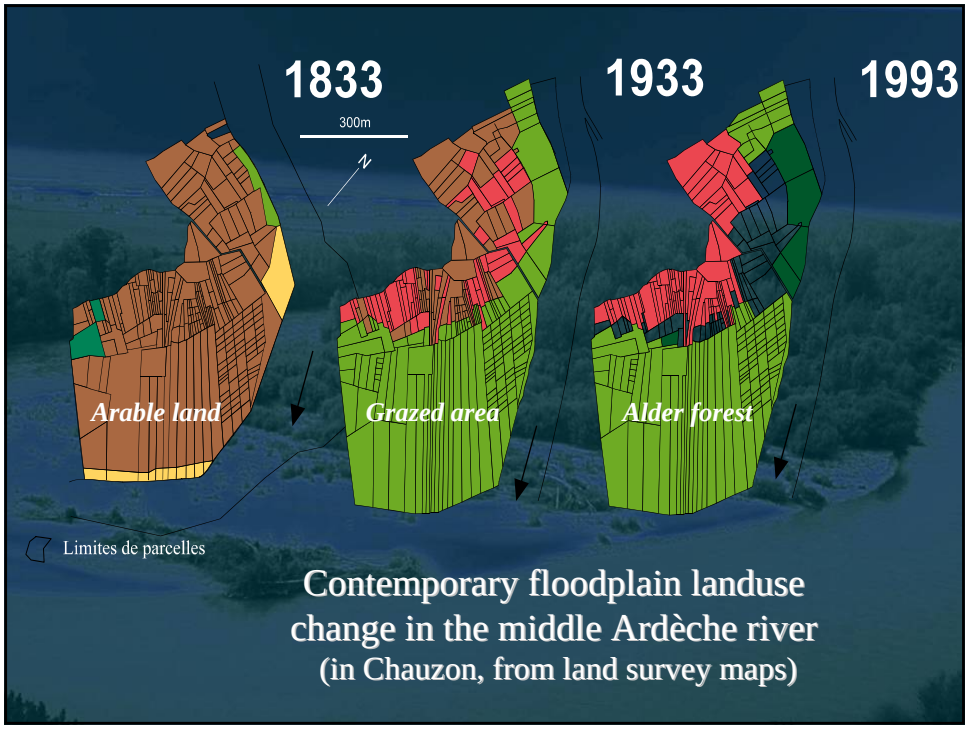
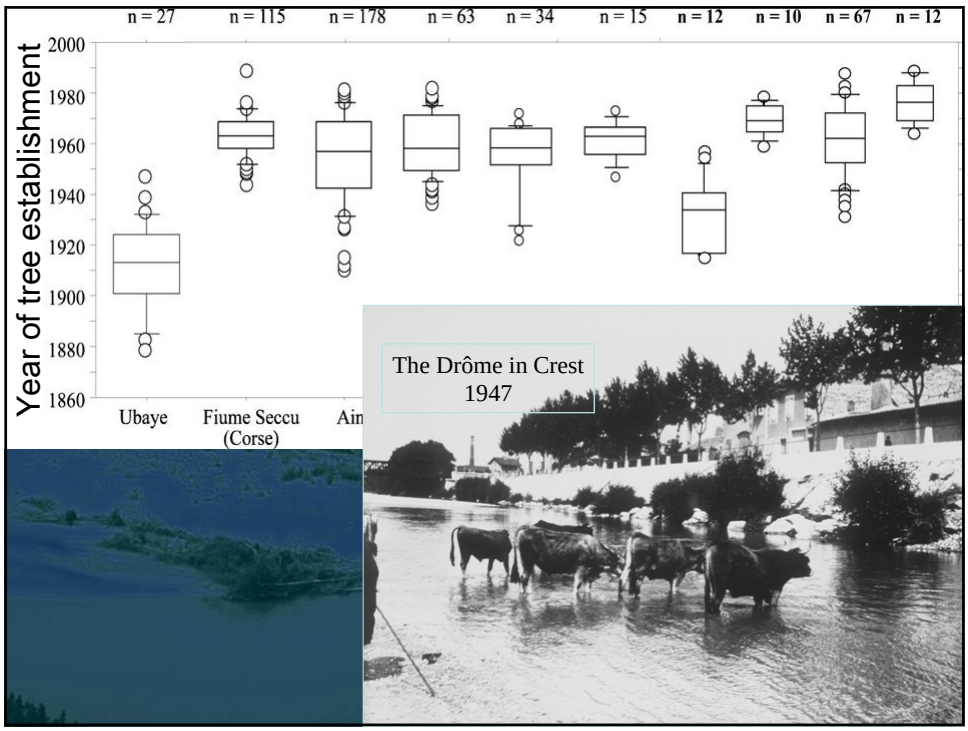
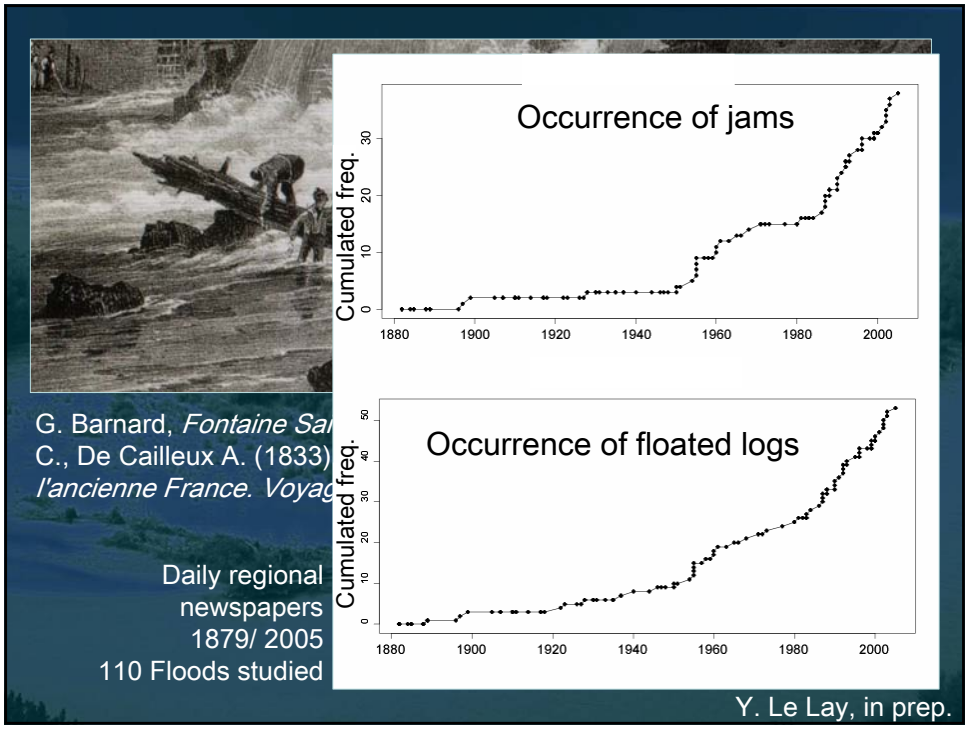


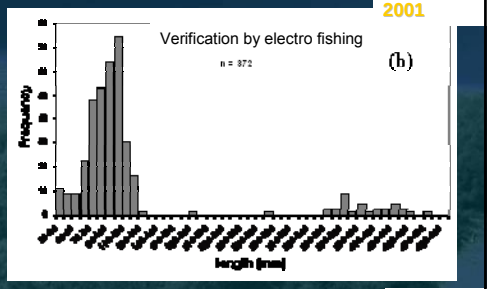
Contemporary floodplain landuse change in the middle Ardèche river
(in Chauzon, from land survey maps)

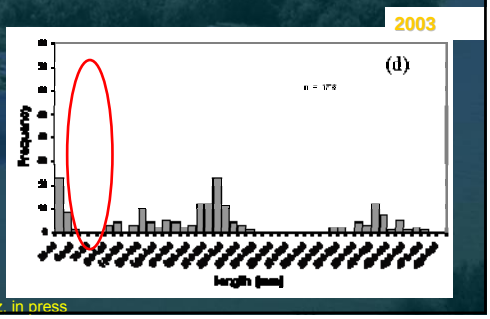

n = 27
n = 115
n = 178
n = 63
n = 34
n = 15
n = 12
n = 10
n = 67
n = 12
Year of tree establishment
2000
1980
1960
1940
1920
1900
1880
1860
Ubaye
Fiume Seccu (Corse)
Ain
The Drôme in Crest
1947


G. Barnard, *Fontaine Sa*
C., De Cailleux A. (1833)
l'ancienne France. Voyag
Daily regional newspapers
1879/ 2005
110 Floods studied
Occurrence of jams
Cumulated freq.
0
10
20
30
1880
1900
1920
1940
1960
1980
2000
Occurrence of floated logs
Cumulated freq.
0
10
20
30
40
50
1880
1900
1920
1940
1960
1980
2000
Y. Le Lay, in prep.

Consider the dynamic behavior of rivers (self-restoring processes rather than « gardening »)

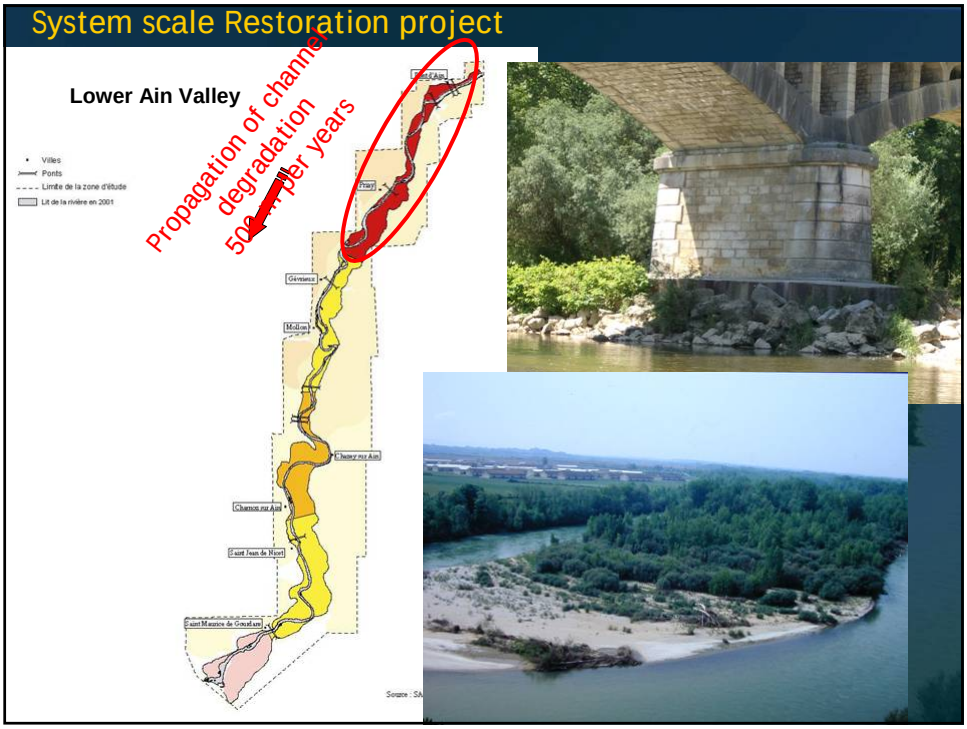
Sulm River



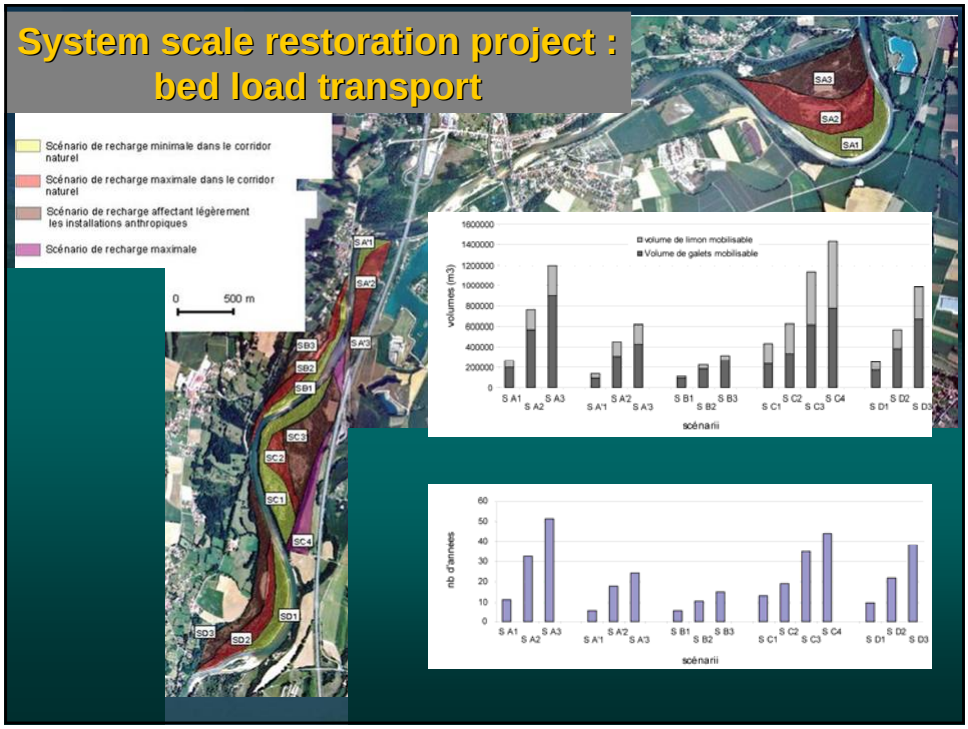


Habersack & Hauer, 2004; Hauer, Unfer, Habersack, Schmutz, in press

System scale Restoration project



System scale restoration project : bed load transport



Béoux river - work in 2000

J. Lejot, 2004

Prevent rather than repair

Tagliamento River

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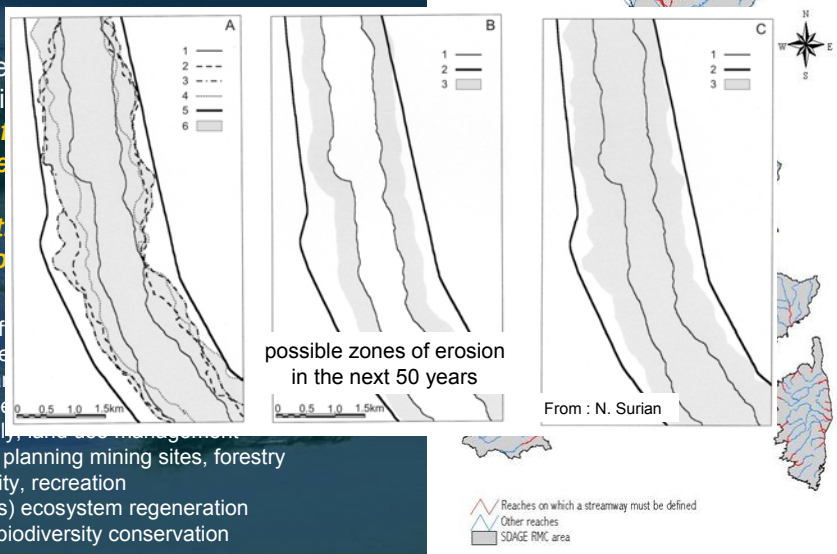
and biodiversity conservation

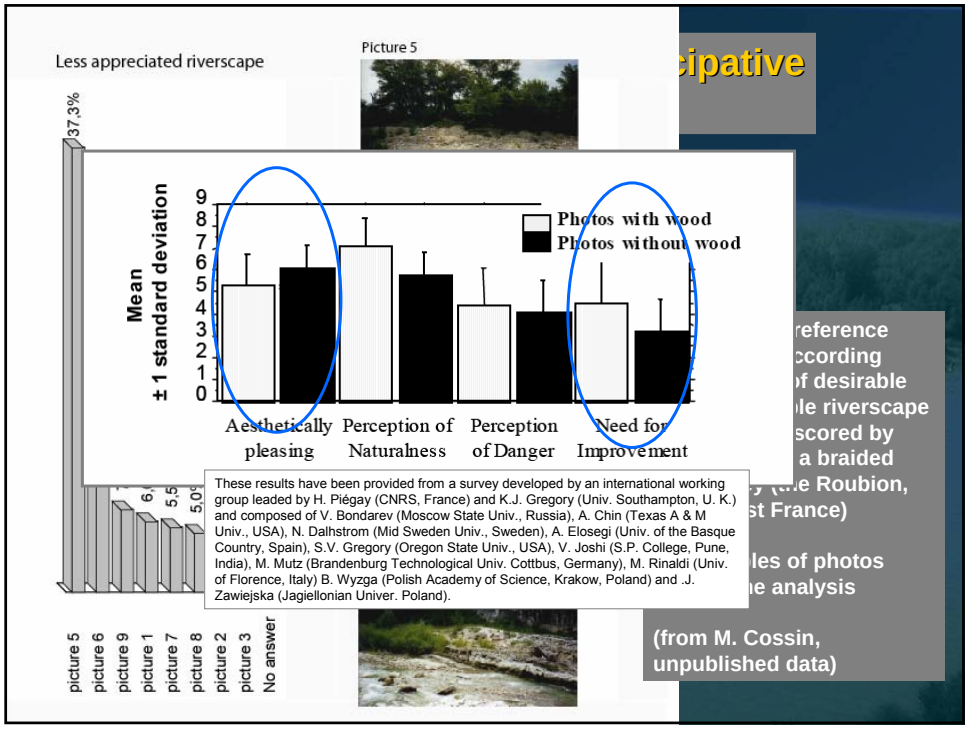


possible zones of erosion
in the next 50 years

From : N. Surian

Balancing ecosystem improvement and other stakes

G.R. Bezzola, ETH, Zürich



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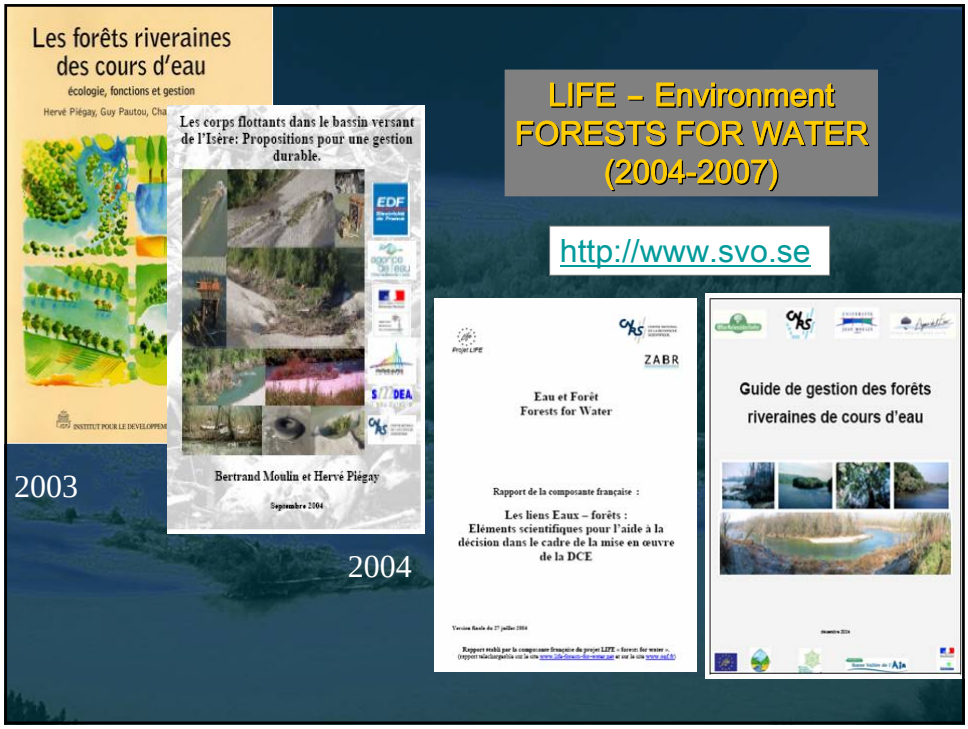
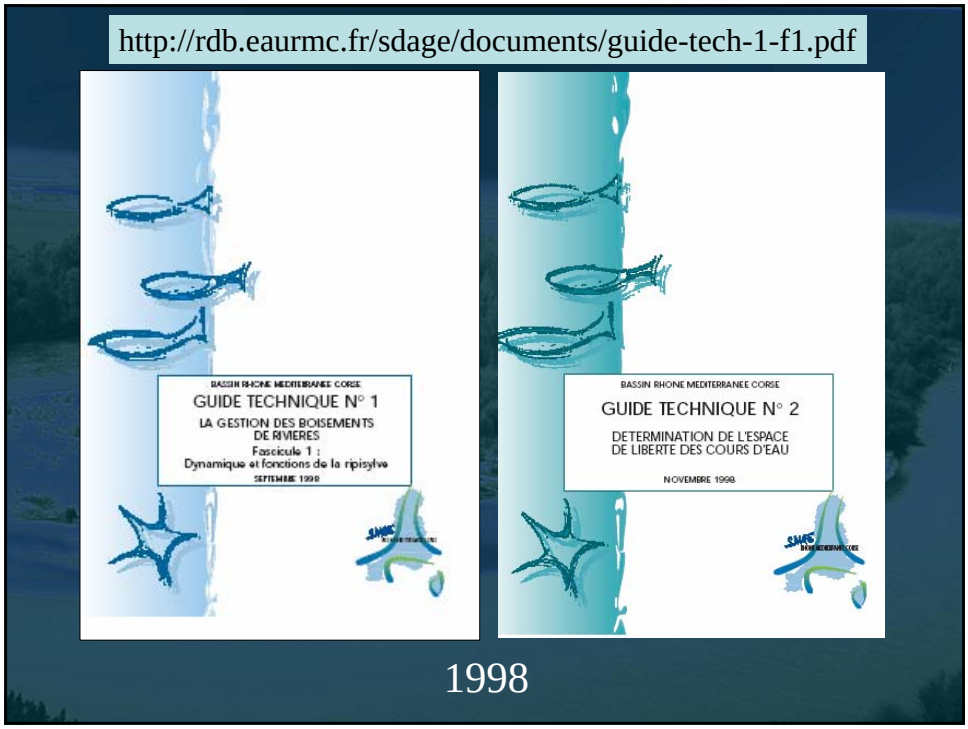
(from M. Cossin, unpublished data)

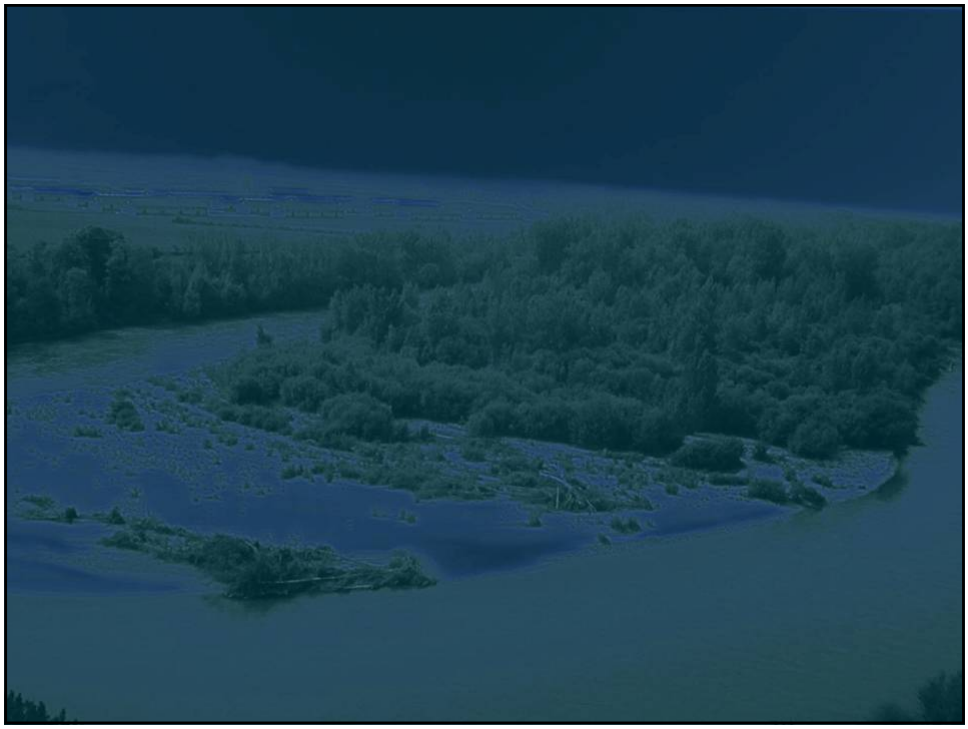
Conclusions

- Clear challenge : acting on the riparian features to reach a good ecological status
- WFD can be successful in a long term perspective if
  - = targeted and planned
  - = thought at appropriate geog. and temp. scales
  - = focused on processes rather than on structures
  - = accepted and balanced
- Sustainable development = living with Nature and using its immediate benefits (good and services)

  (≠ fighting against Nature)


Les forêts riveraines des cours d'eau
écologie, fonctions et gestion
Hervé Piégay, Guy Pautou, Cha
INSTITUT POUR LE DEVELOPPEM
2003
Les corps flottants dans le bassin versant de l'Isère: Propositions pour une gestion durable.
Bertrand Moulin et Hervé Piégay
Septembre 2004
2004
LIFE – Environment
FORESTS FOR WATER
(2004-2007)
http://www.svo.se
ZABR
Eau et Forêt
Forests for Water
Rapport de la composante française :
Les liens Eaux – forêts :
Eléments scientifiques pour l'aide à la décision dans le cadre de la mise en œuvre de la DCE
Guide de gestion des forêts riveraines de cours d'eau


http://rdb.eaurmc.fr/sdage/documents/guide-tech-1-f1.pdf
BASSIN RHONE MEDITERRANEE CORSE
GUIDE TECHNIQUE N° 1
LA GESTION DES BOISEMENTS DE RIVIERES
Fascicule 1 :
Dynamique et fonctions de la ripisylve
SEPTEMBRE 1998
BASSIN RHONE MEDITERRANEE CORSE
GUIDE TECHNIQUE N° 2
DETERMINATION DE L'ESPACE DE LIBERTE DES COURS D'EAU
NOVEMBRE 1998
1998



Disturbance effect on vegetation

Biomass destruction

Substrate removal