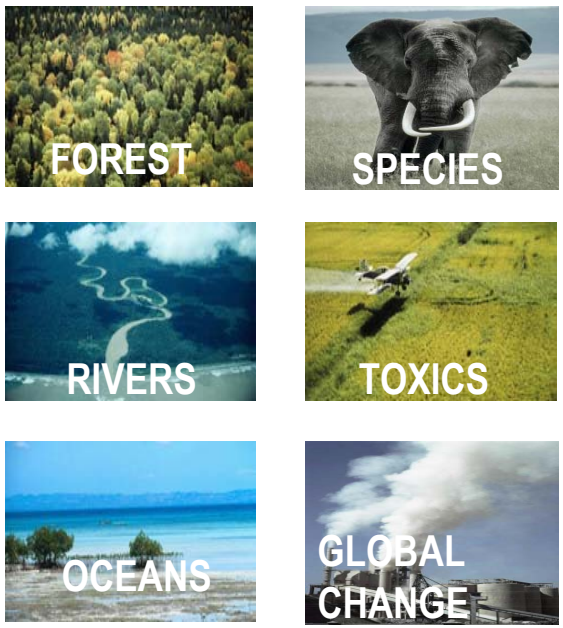
Evaluation and monitoring of long term restoration projects in the Mediterranean

Abstract

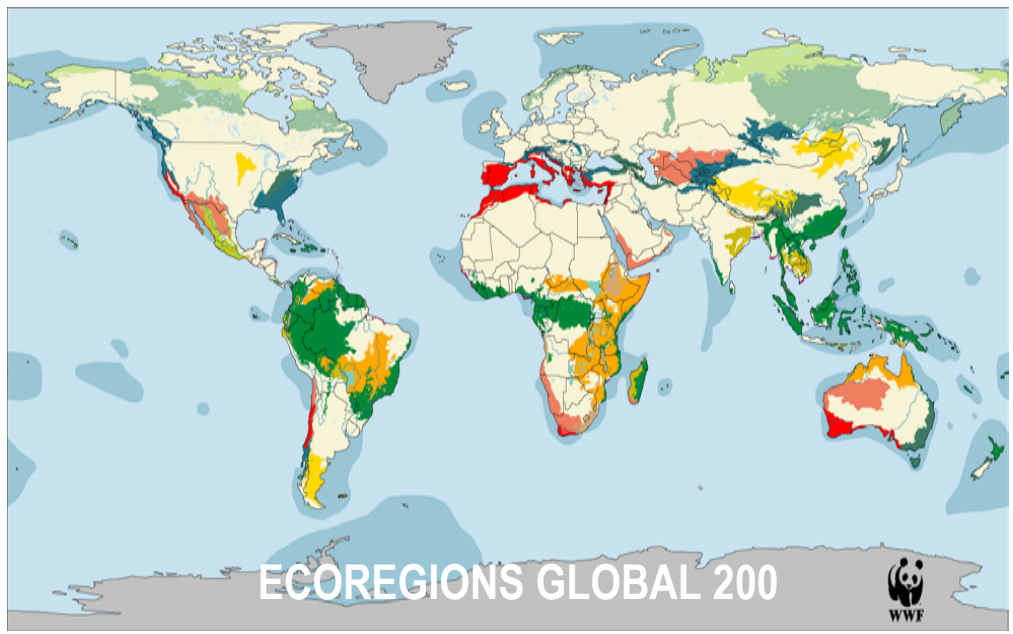
1) Introduction
2) (REACTION framework - S. Bautista)
3) REACTION in time and space
4) Epoch 3 : 1990-… - Ecological restoration
5) Epoch 2 : 1950-1990 – Afforestation for wood production
6) Epoch 1 : 1860-1930 - Afforestation for erosion control...
7) Evaluation 120 years after afforestation : a case study (France)
8) Final discussion

WWF CONSERVATION PRIORITIES

6 TOPICS



PRIORITY ECOREGIONS ?



6 THEMES + WHERE = CONSERVATION PRIORITIES

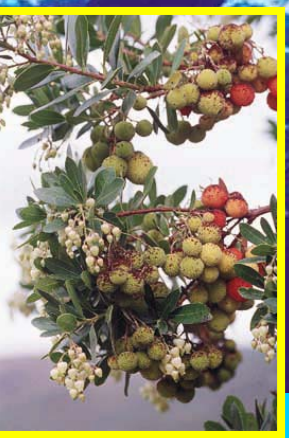
WWF
forests priorities

Protect
Biodiversity
Protected areas

Management
silvilcuture
Ecocertification

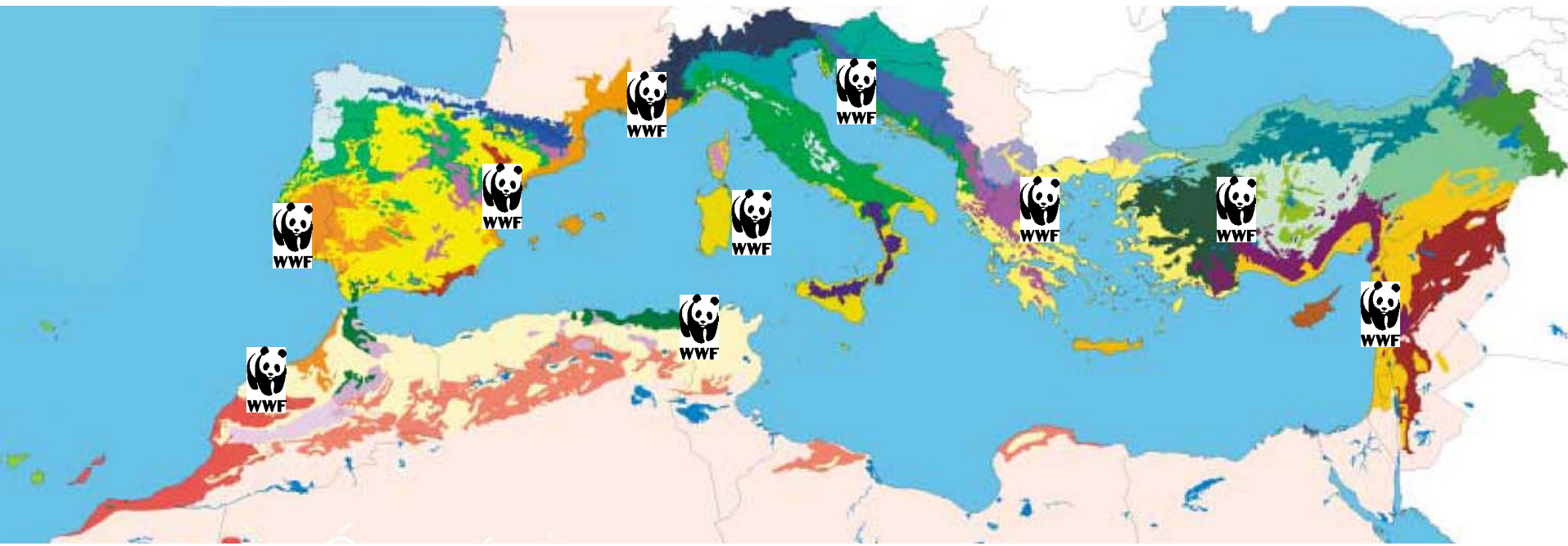
Restore
Forest biodiversity,
human well-bing

300 forest hotspots in the Med



WWF at work for forests issues

Protect, Manage, <u>Restore</u>



WWF, 2001

Evaluation and monitoring of long term restoration projects in the Mediterranean

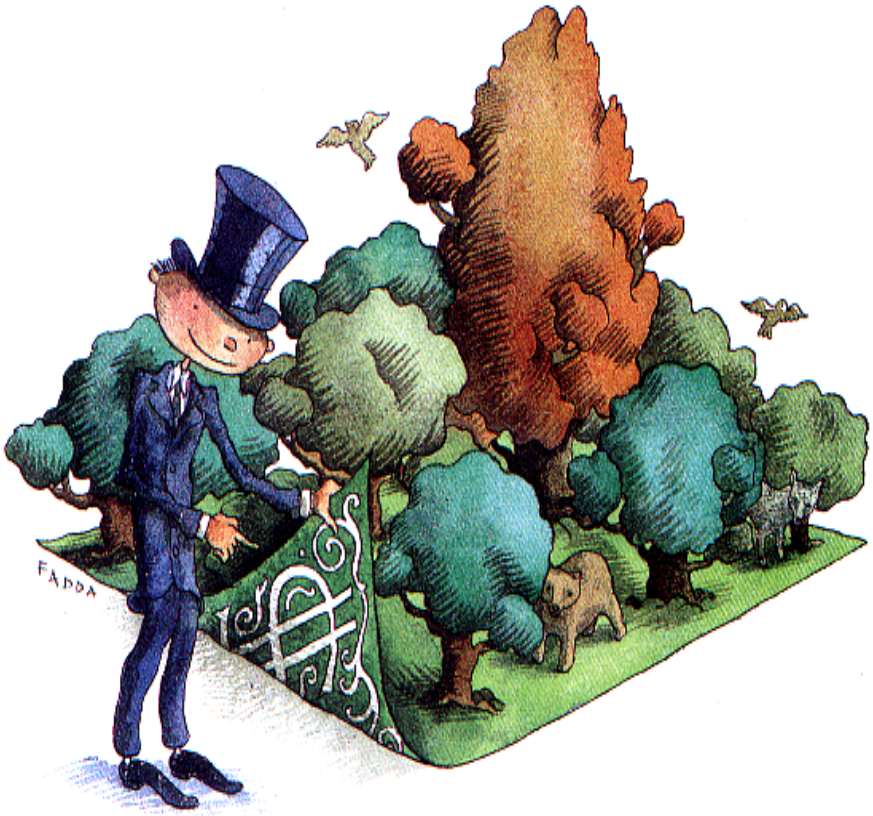
Why it is compulsory evaluate and monitor ?

- Confirm restoration hypothesis and choices
- Proceed to fine-tuning management actions
- Adapt restoration actions to changes
- Prove to stakeholders that investment is worthwhile (should continue)

What to evaluate and monitor ?

- Silvicultural aspects
- Ecological aspects : biodiversity, naturalness, ecological integrity
- Trends in key threat/pressures
- Environmental benefits
- Livelihoods and well-being
- other political/economical/social relevants aspects

Beyond technical or ecological evaluation



How
to evaluate and monitor ?

- A pertinent set of criteria
- At pertinent scales (several)
- Each indicator should be SM(a)RRT :

  Simple,
  Measurable,
  Reliable,
  Relevant,
  Timely

- A framework (see REACTION questionnaire)

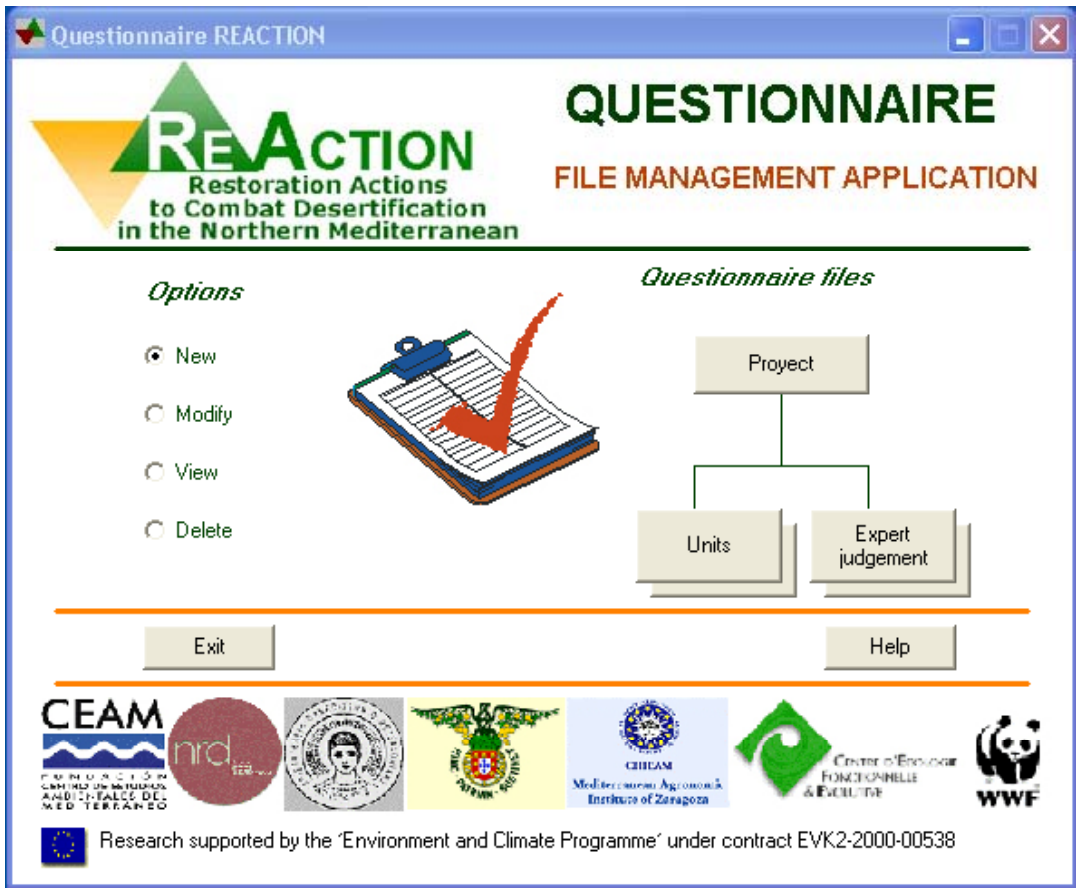
TOOLS
to evaluate and to monitor

- reference or target systems
- landscape and ecosystem attributes
- photographs, mapping, notes, studies…
- (socio-economical attributes)
- restoration plans
- restoration databases

(www.unep-wcmc.org/forest/restoration/database ; www.gva.es/ceam/reaction/)

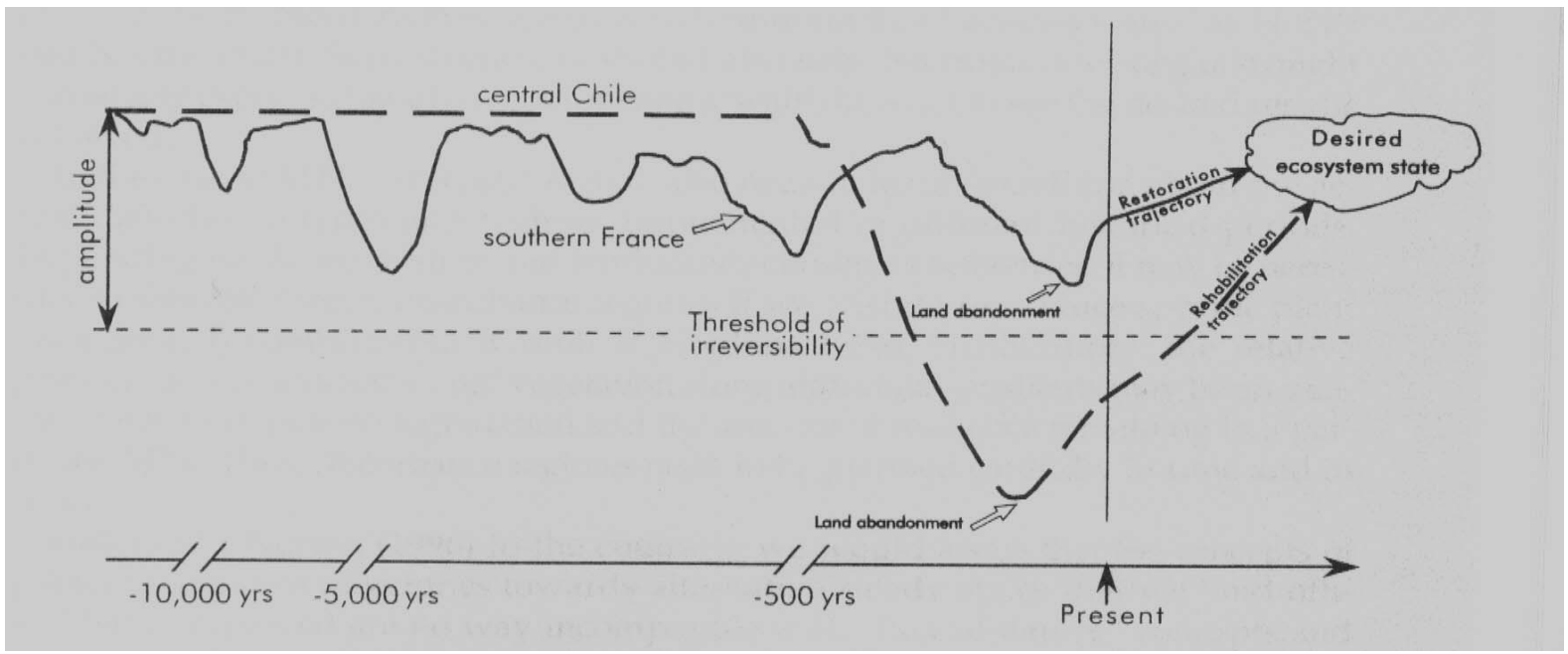
- tested criteria and indicators

REACTION framework
S. Bautista



REACTION in time ?

1860 to now



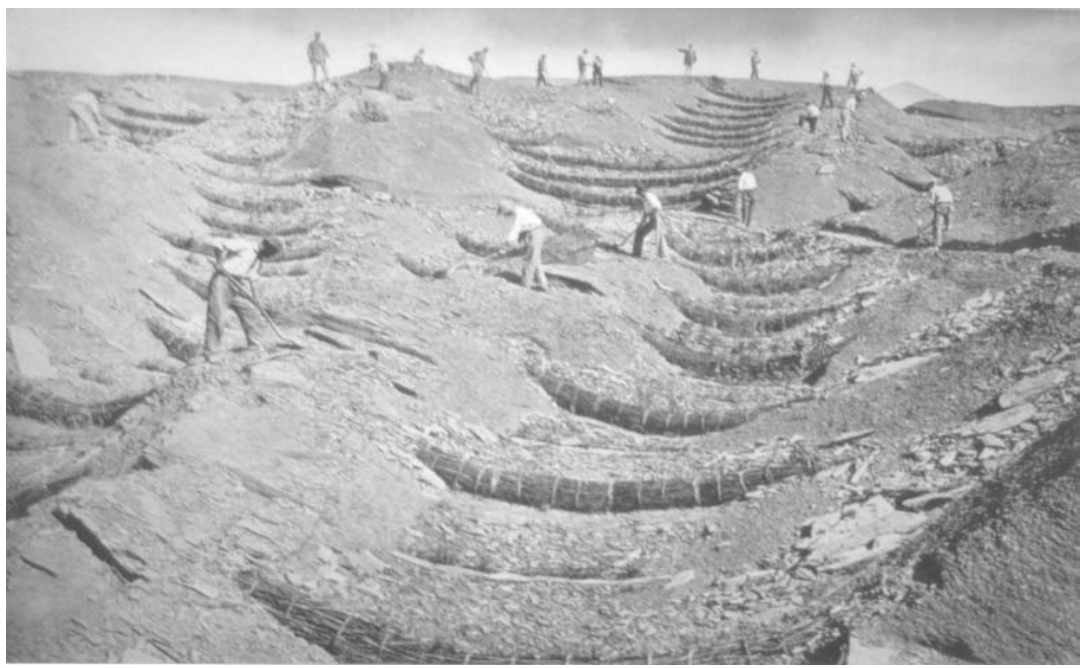
Aronson, J., Le Floc'h E. 1996. Restoration ecology, 4(4) : 327-333

Epoch 1 : 1860-1930

Afforestation of watersheds for erosion control...

Threats

- over-grazing
- over-havesting
- erosion
- desertification
- poverty



Haute-Provence, 1860

Epoch 2 : 1950-1990 (locally still active)

Afforestation for wood production

Threats/problems

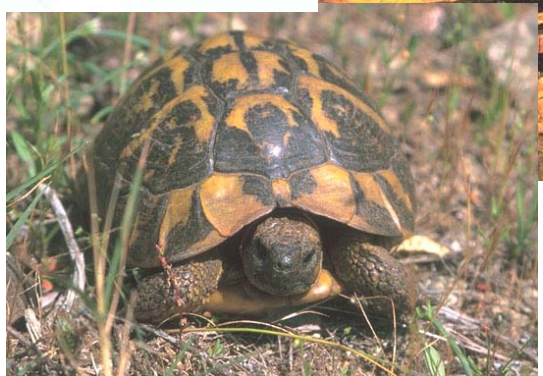
- fires
- lack of commercial value

Epoch 3 : 1990-…

Ecological restoration
(and the use of natural dynamics)

Threats

- Species and habitat loss
- land abandonment
- infrastructure building, urbanisation and tourism
- global warming



REACTION
in space ?

WWF, 2001

GREECE

Stratoni, Halkidiki

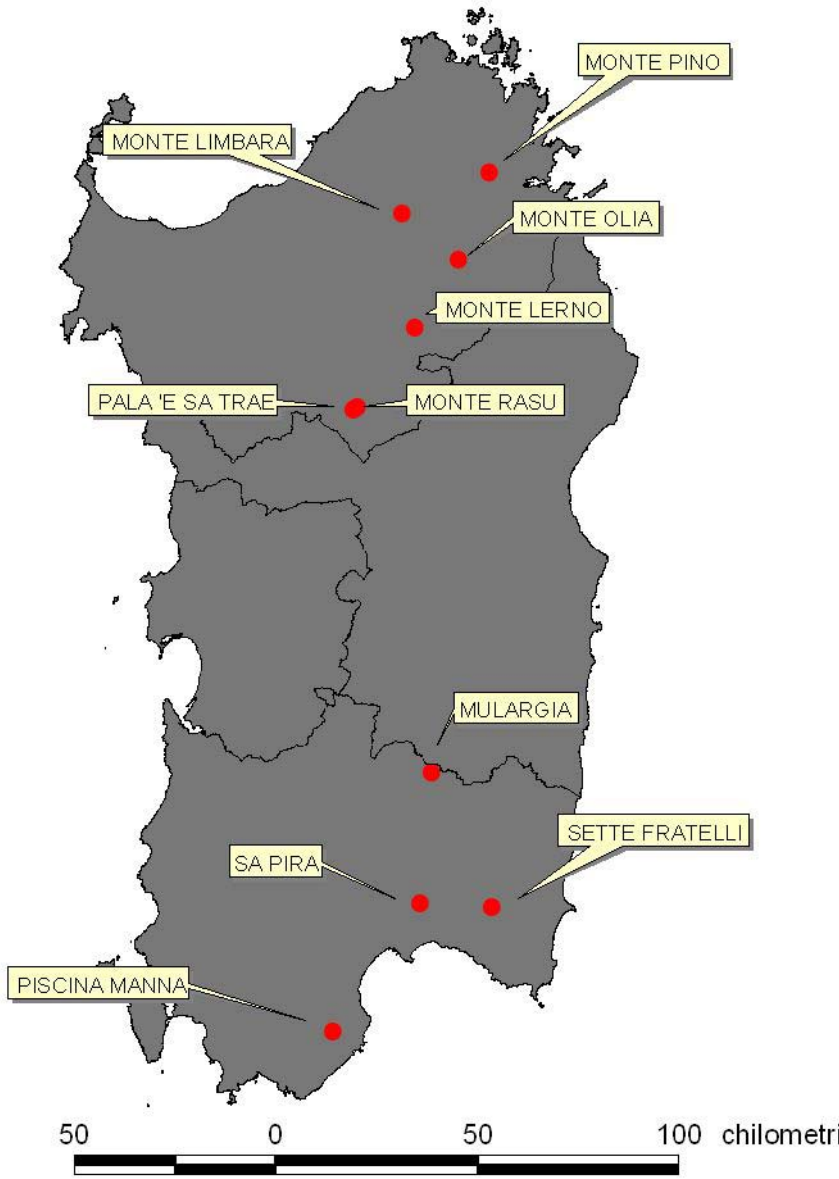
Dadia, Thrace

Kedrinos Lofos, Thessaloniki

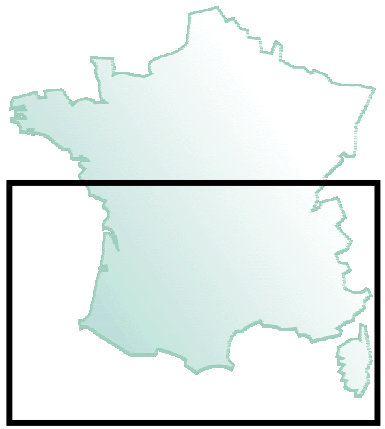
Taxiarchis, Halkidiki

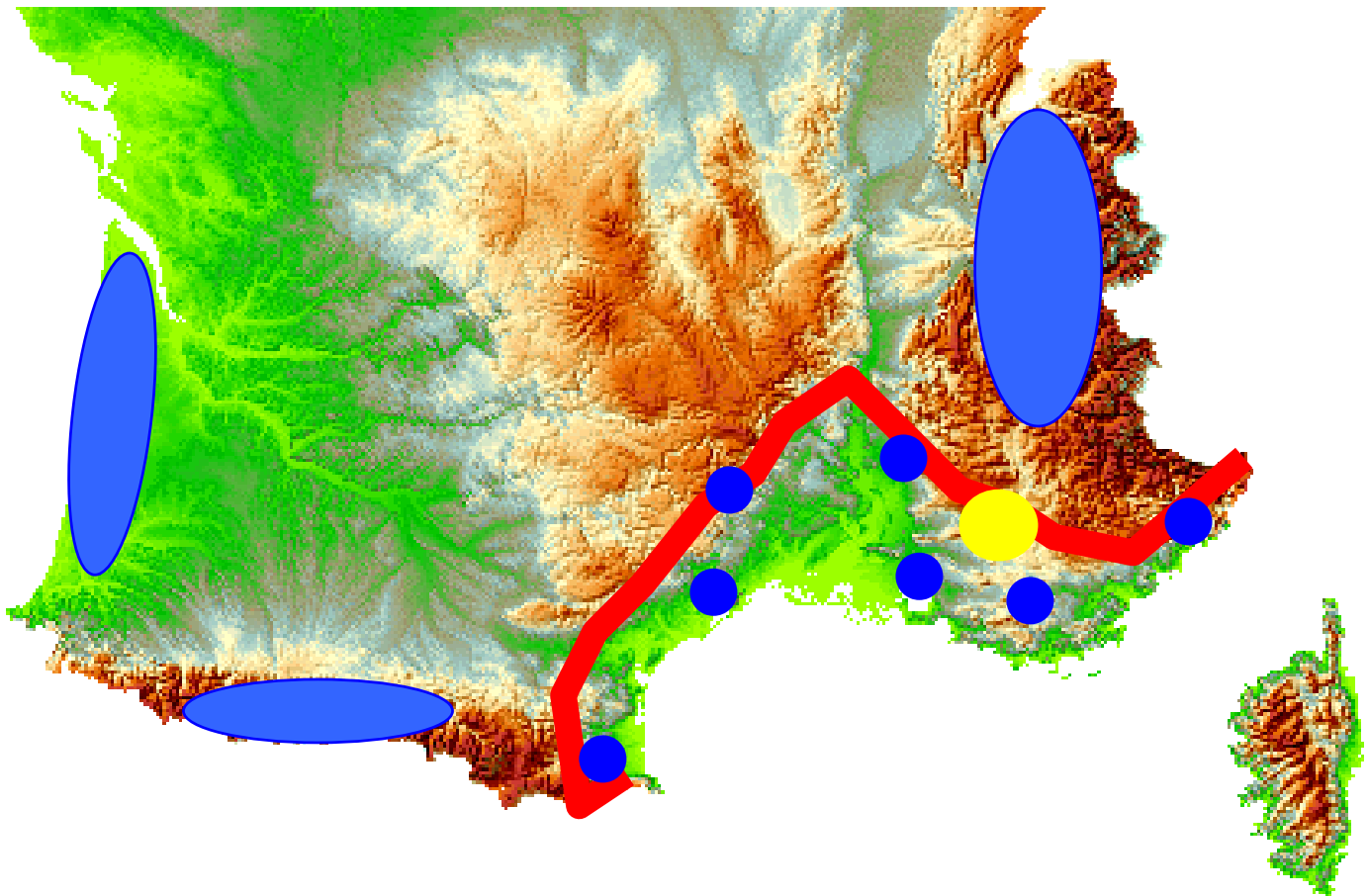
Sardinia (Italia)

- 10 different success cases of Pinus plantation
- A few restored sites through natural dynamics
- implemented from 1901 to 1965
- for economically and environmental reasons

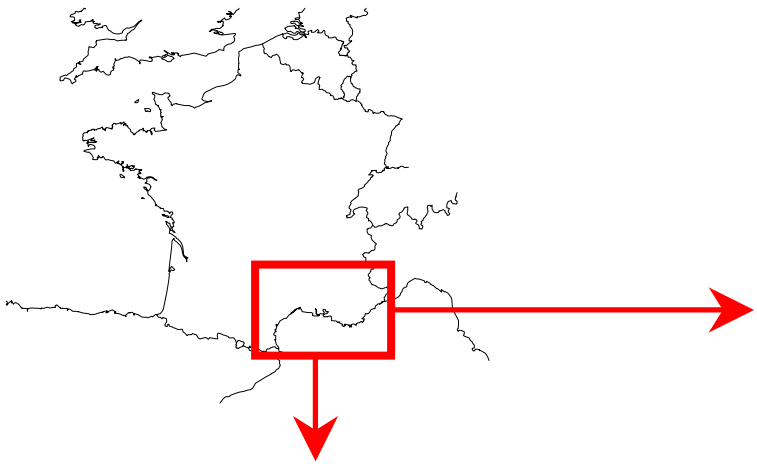


Forest restoration in France

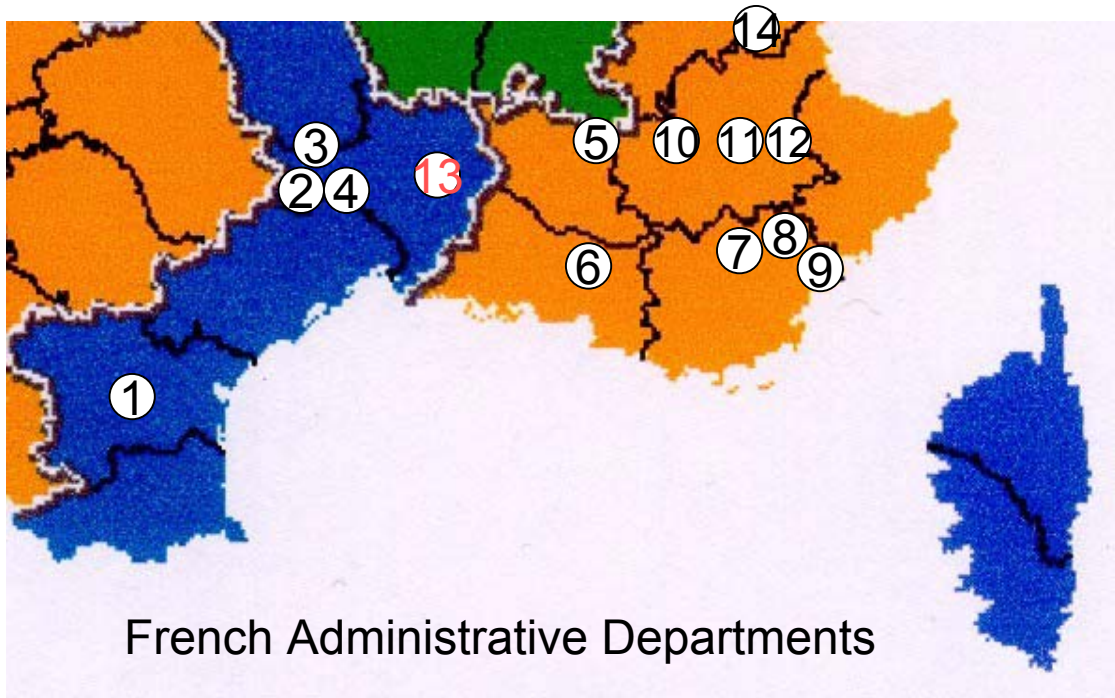




France



Forest cover



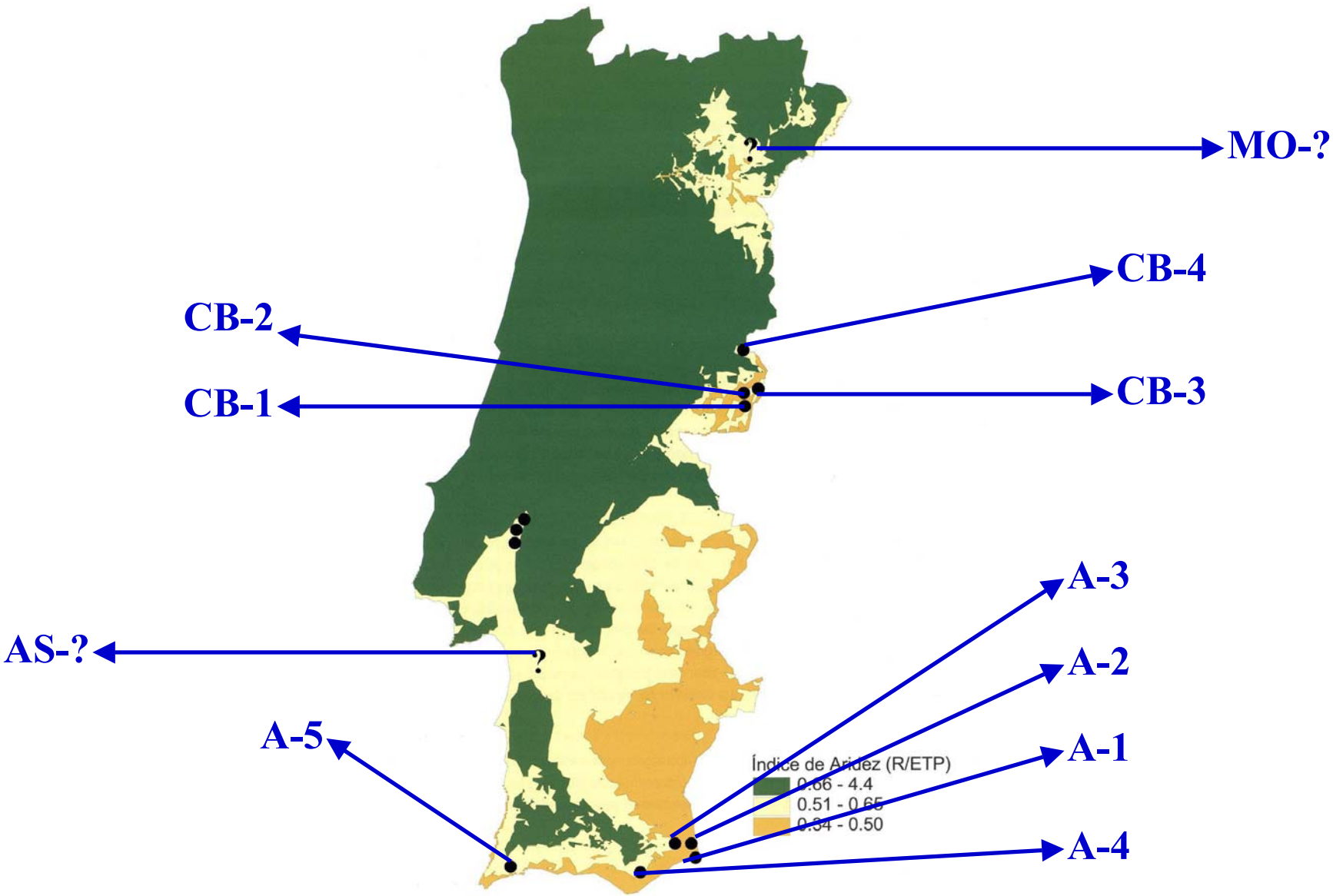
French Administrative Departments

1-Rialsesse
2-La Vis
3- Aigoual
4- La Fage
5- Mount Ventoux
6- Mt. Sainte-Victoire
7-Palayson
8 - Montmeyan
9 - Esterel
10 - Saignon
11 - Brusquet
12 - Laval
13 - Belvezet Plateau
14 – Riou Bourdoux

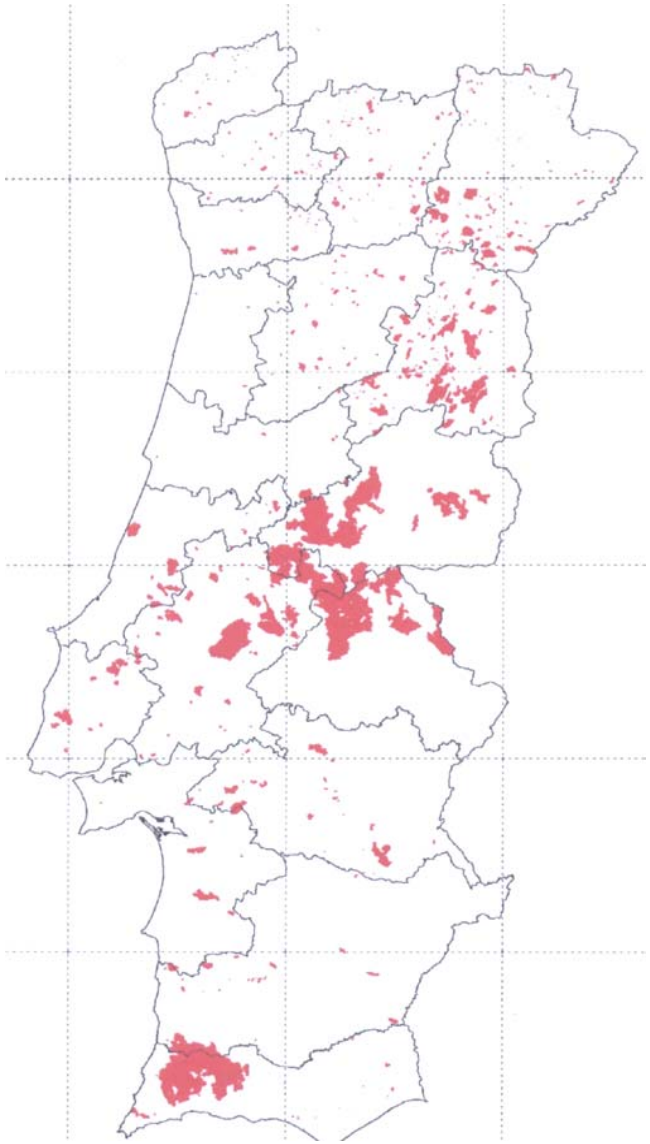
Spain

- 4 in Andalucia
- 4 in Murcia (including Sierra Espuna)
- 1 in Valencia Region
- 1 in Aragon

Portugal


MO-?
CB-4
CB-2
CB-1
CB-3
A-3
AS-?
A-2
A-5
A-1
A-4
Índice de Aridez (R/ETP)
0.66 - 4.4
0.51 - 0.65
0.34 - 0.50

FOREST FIRES 2003



(Source: DGRF, 2004)

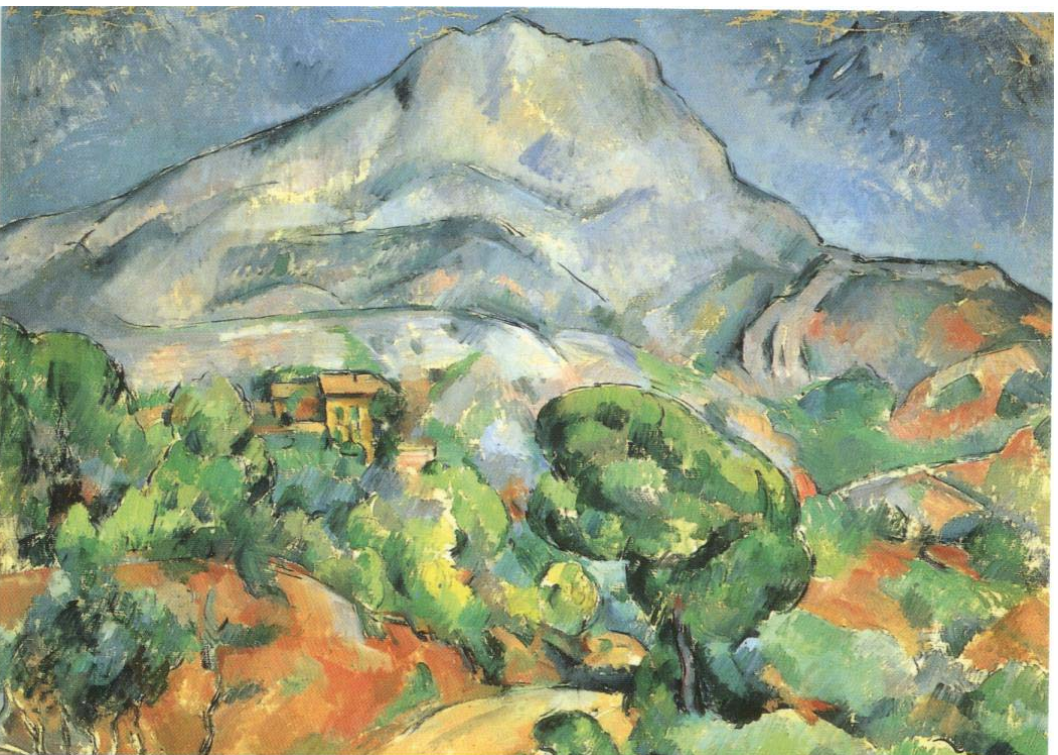
Epoch 3 : 1990-… (some older)

Ecological restoration and the use of natural dynamics

Restoring a cultural landscape after fire : Cézanne's *Montagne Sainte-Victoire* (France)

Restoring Cézanne's *Montagne Sainte-Victoire* after fire

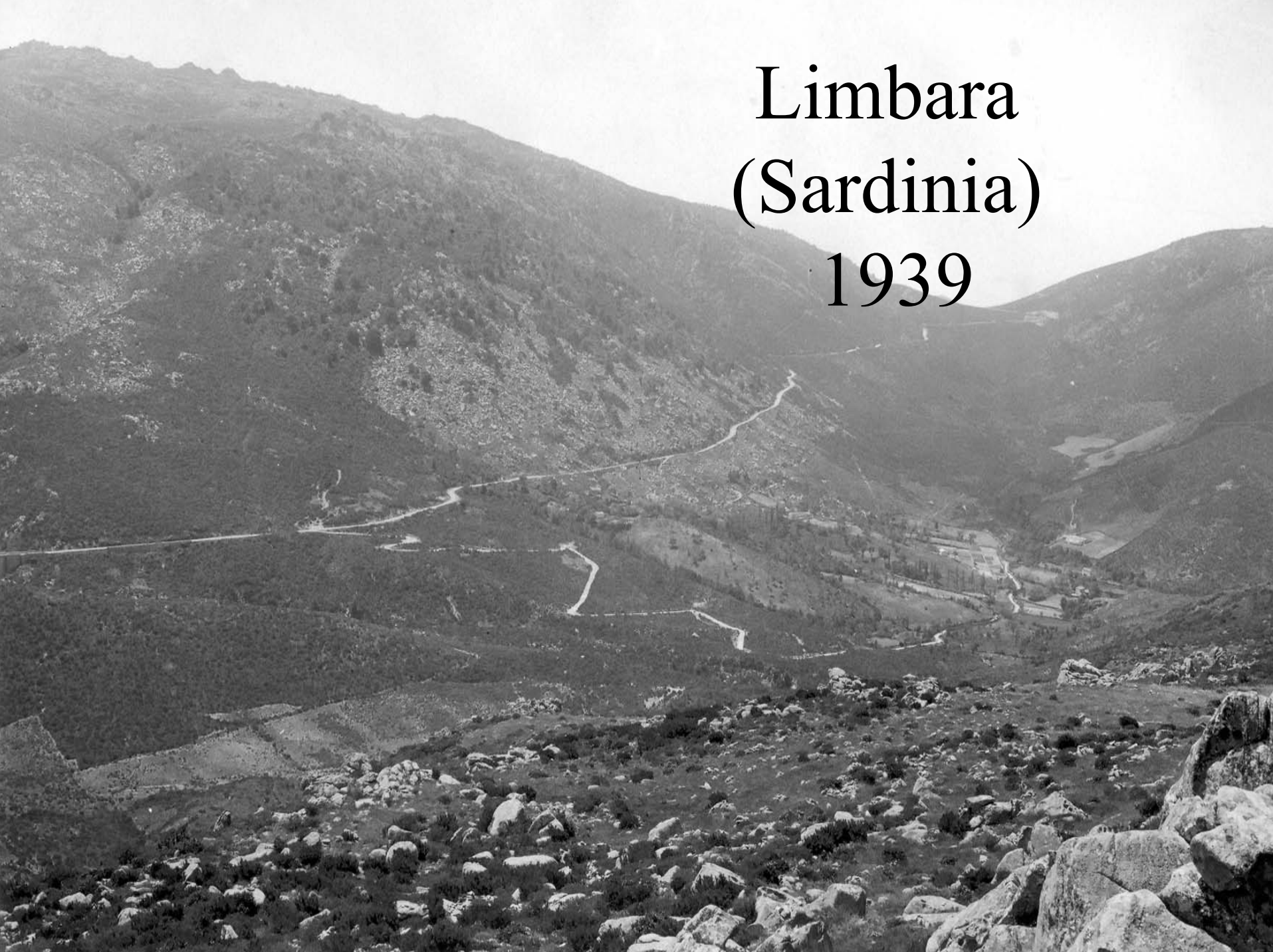
- Forest restoration vs. cultural monument ?



- Restoration could take advantages of cultural stakes when ecologically appropriate
  - aesthetic landscapes
  - areas protected for religion
  - sustainable traditional land-use
  - Historical/cultural landscape

Restoration through natural dynamics in sardinian mountains (Italia)

M.Lerno Bilozze (Sardinia)
1939-2004


Limbara
(Sardinia)
1939


Limbara
(Sardinia)
2004

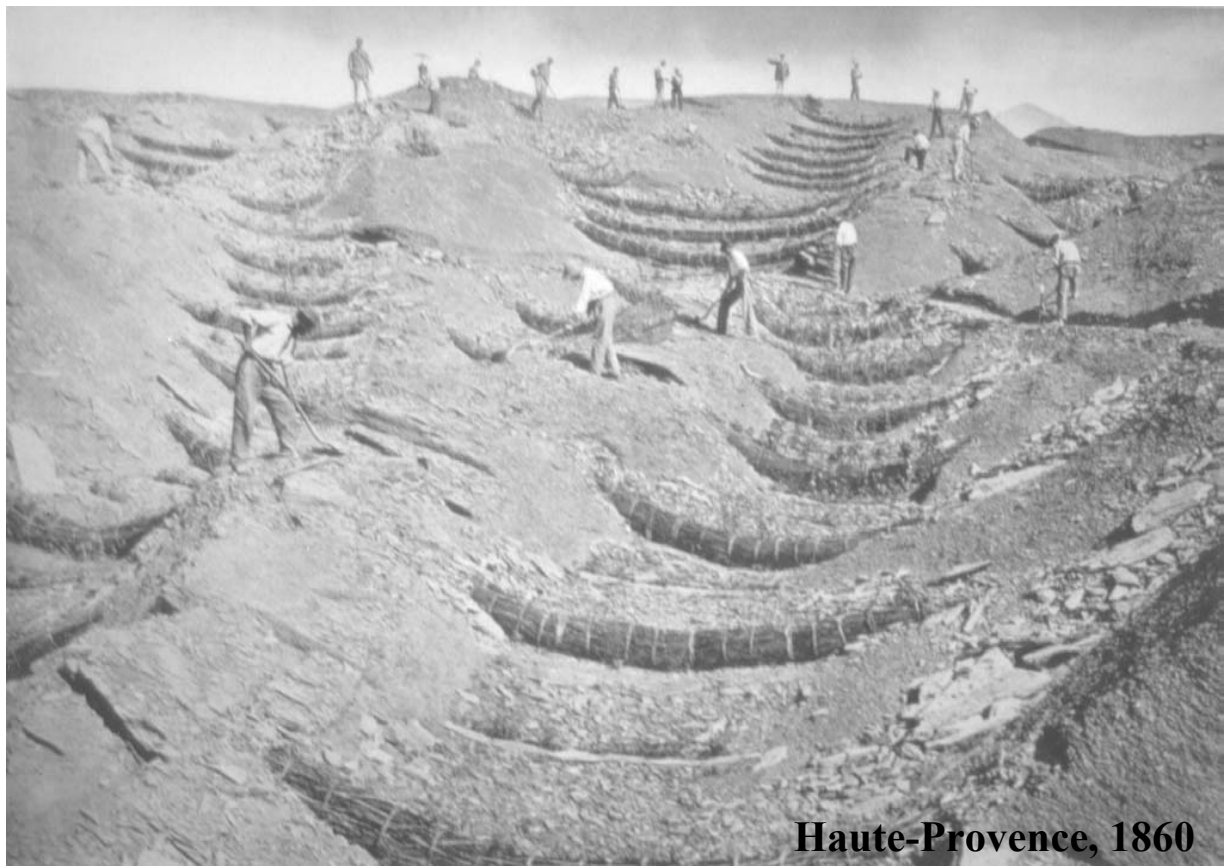
Epoch 2 : 1950-1990 (locally still active)

Afforestation for wood production

Afforestation in Stratoni, Northeastern Halkidiki (Greece)

Epoch 1 : 1860-1930

Afforestation of watersheds for erosion control...



Haute-Provence, 1860

Stabilized littoral sand dunes in northern Sardinia at Platamona (Sardinia)

MILIZIA NAZIONALE FORESTALE

COMANDO CENTURIA DI SASSARI

SASSARI: Sabbie litoranee in corso di sistemazione.


1930s

MILIZIA NAZIONALE FORESTALE

1ª Coorte Autonoma

COMANDO CENTURIA DI SASSARI

Foci Coghinas (Castelsardo-Sedini)

Rimboschimento, previo imbrigliamento delle sabbie litoranee.

Anno XVII E. F.

Afforestation for watershed restoration in Sierra Espuna (Spain)

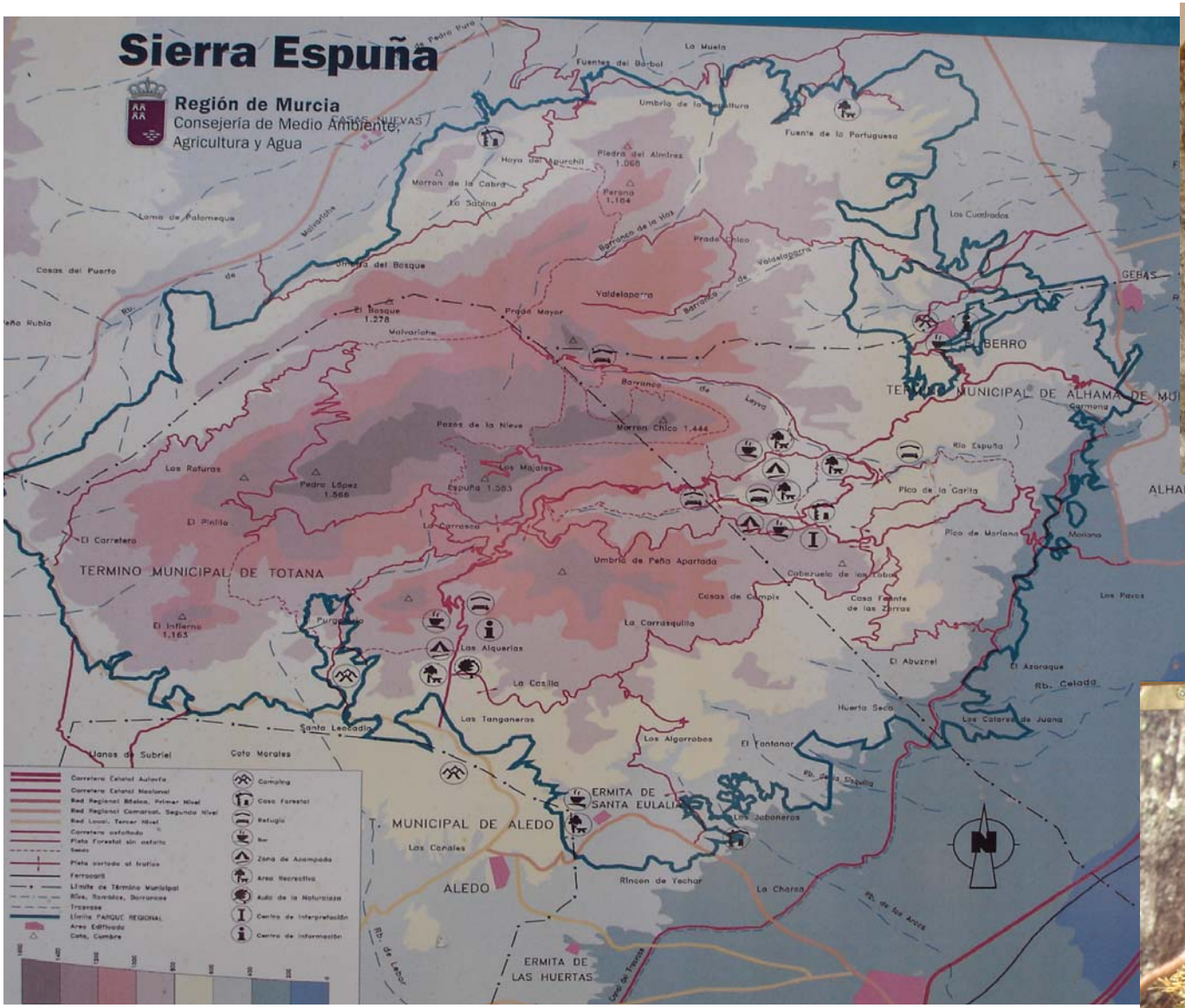
Project	Sierra Espuña
Objectives	Soil erosion control
Surface (ha)	625
Year	1890
Species	*Pinus halepensis, Pinus nigra, Quercus ilex*
Soil preparation technique	Manual hole
Questionnaire	In progress

(Today Regional Park)

MINISTERIO DE MEDIO AMBIENTE

CEAM
FUNDACIÓN CENTRO DE ESTUDIOS AMBIENTALES DEL MEDITERRANEO


Los bosques y la erosión
Miles de plantas sujetando el suelo
NO TOQUE LA ARENA
D. Ricardo Codorníu y Stárico, artífice de la repoblación forestal de Sierra Espuña.


Sierra Espuña
Región de Murcia
Consejería de Medio Ambiente,
Agricultura y Agua
TERMINO MUNICIPAL DE TOTANA
T. MUNICIPAL DE ALEDO
ALEDO
ERMITA DE SANTA EULALIA
ERMITA DE LAS HUERTAS
Umbría de Peña Apartada
Morron Chico 1.444
Espuña 1.583
Pedro López 1.566
El Infierno 1.163
El Berro
Pico de la Carita
Pico de Morlana
Rincon de Yechar
Los Canales
Los Algorrobes
Las Tanganeras
La Casilla
Las Alquerias
La Carrasquilla
Umbría de la Fuentes
Fuente de la Portuguesa
Piedra del Almirez 1.066
Perona 1.184
Morron de la Cabra
La Sabina
Loma de Palomeque
Umbría del Bosque
El Bosque 1.278
Prado Mayor
Valdelaperra
Barranco de la Hoz
Prado Chico
Los Cuadrados
Pozos de la Nieve
Los Majales
Las Refuras
El Pinillo
El Carretero
La Carrasca
Cabezuelo de los Cabos
Casas de Campix
Casa Fuente de las Zorras
Los Pavos
El Abuznel
El Azaraque
Rb. Celada
Huerta Seca
Los Calares de Juana
El Tontanar
Los Jabaneros
La Charca
Santa Leocadia
Manos de Subriel
Coto Morales
Rb. de Lebor
Rb. de las Arcas
Rb. de la Sisalera
Camping
Casa Forestal
Refugio
Bar
Zona de Acampada
Area Recreativa
Aula de la Naturaleza
Centro de Interpretación
Centro de Información
Carretera Estatal Autovía
Carretera Estatal Nacional
Red Regional Básica. Primer Nivel
Red Regional Comarcal. Segundo Nivel
Red Local. Tercer Nivel
Carretera asfaltada
Pista Forestal sin asfalto
Sendo
Pista cortada al trafico
Ferrocarril
Límite de Término Municipal
Ríos, Ramblas, Barrancos
Trasvase
Límite PARQUE REGIONAL
Area Edificada
Cota, Cumbre

Restoring forest cover for erosion control
Haute-Provence (France)

Forest restoration advances 130 years after reforestation on badlands

Introduction

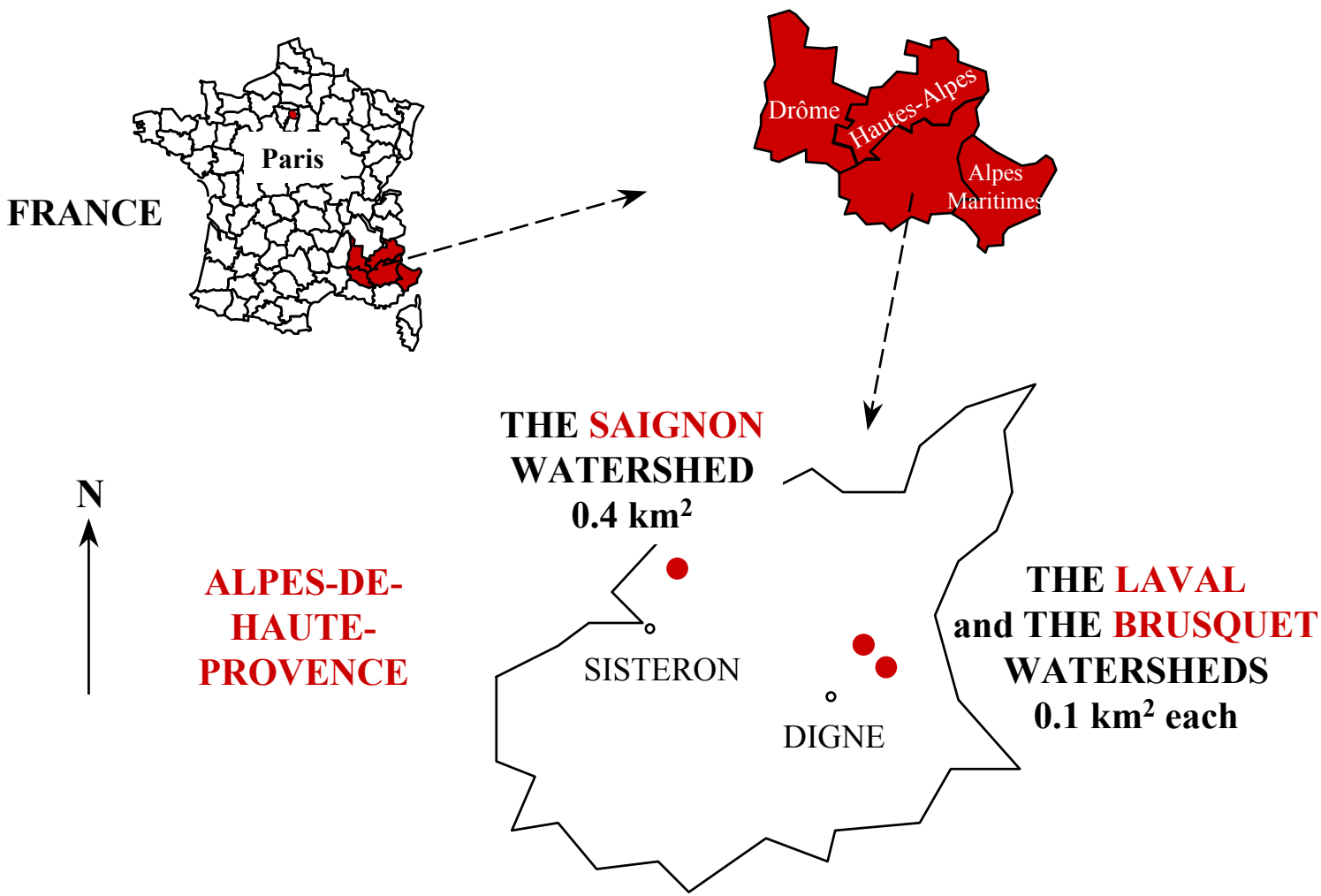
Some results

- ➔ Ecological trajectories
- ➔ Forest restoration advances
- ➔ Functional analysis : 3 vital attributes
  - ➔ **biological activity of soils**, **tree diversity** and **pests**

Conclusion

- ➔ Ecological diagnosis
- ➔ Implications for monitoring

Introduction



Forest restoration goals in 1860

	Ecological	Economical	Social	Cultural
Goals	Erosion control	Protection Desertification	Jobs	None
Key elements	Civil eng. Pioneers	Land purchase expropriation	Imposed policy	None
Success criteria	Erosion control	No data	Local jobs	None
Elements for sustainable management	No data	No data	No data	none

1876

Ecological trajectories

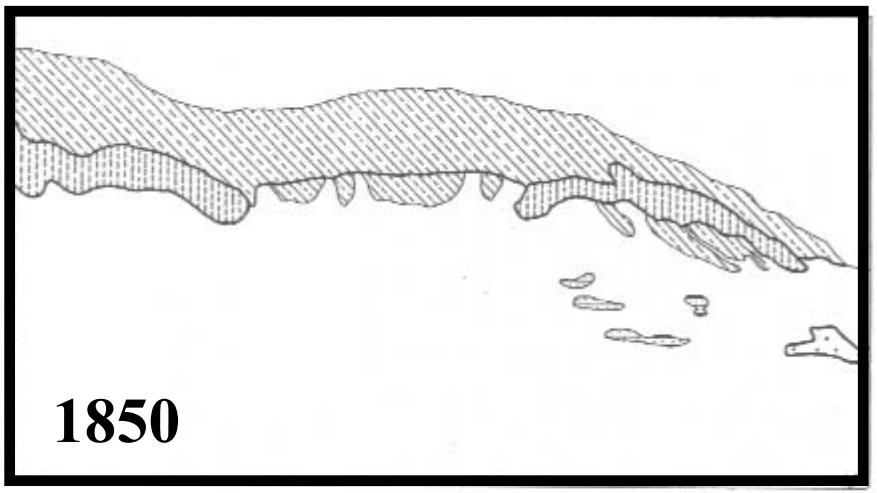
- Long term ecological trajectories
  - from pollen and charcoal analysis
  - from cadastral maps
  - from old photographs and landscape interpretation

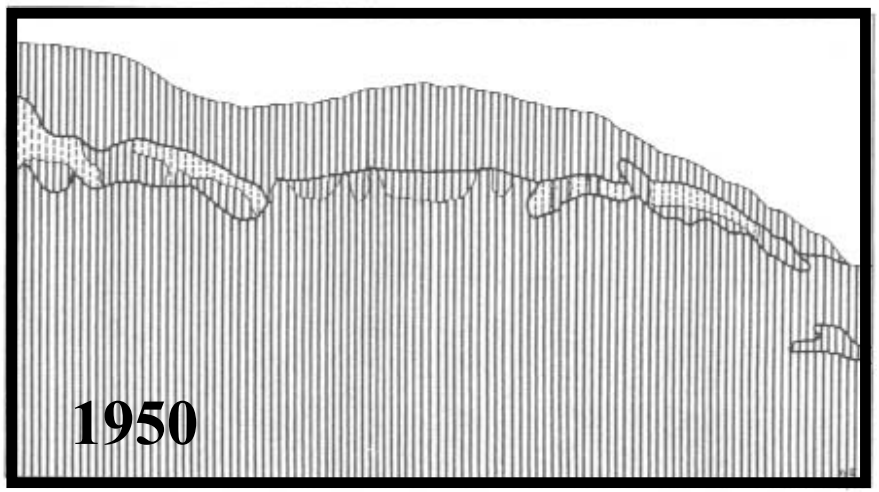
Restoration trajectory

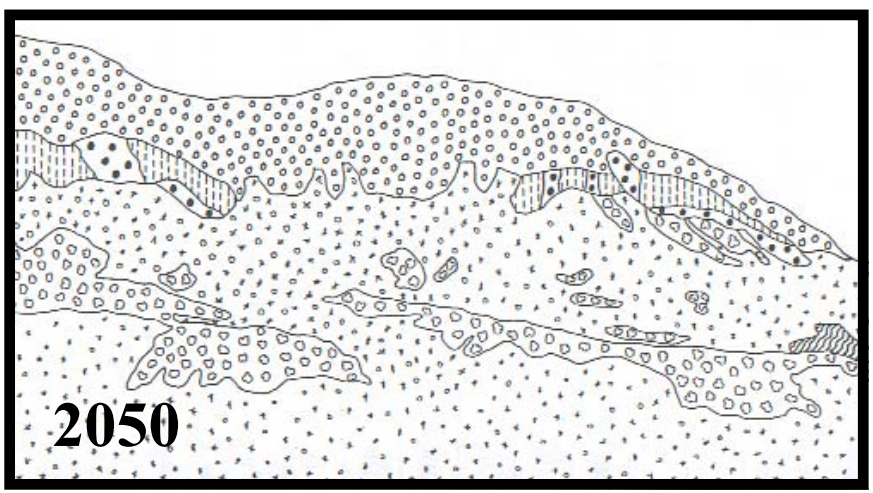
?

2050

Restoration trajectory







Ecological trajectory

Type of vegetation	1836	1948	1995	2042
Degraded and eroded lands	**≈ 52**	**32**	**24**	**18**
scree		1.19	0.72	0.43
clear "lavandaie"		2.86	2.55	1.99
badlands with no grasses or shrubs		**19.03**	**5.01**	**1.75**
badlands colonized less than 50 %		5.41	8.76	5.48
badlands colonized more than 50 %		3.10	6.69	8.47
Grasslands and shrubs	**≈ 40**	**38**	**20**	**14**
grasslands		9.79	0.16	0.18
grassland colonized by shrubs		15.84	10.11	7.11
Heath		12.42	9.63	6.78
Wetlands	0	0	1.03	0.88
Woodlands	**8**	**30**	**55**	**67**
pionneer stands		4.62	7.40	6.03
Austrian pine		**19.19**	**32.24**	**17.77**
mature broadleaved stands		**6.45**	**14.09**	**30.54**
mixt stands		0	1.83	12.77

Restoration process

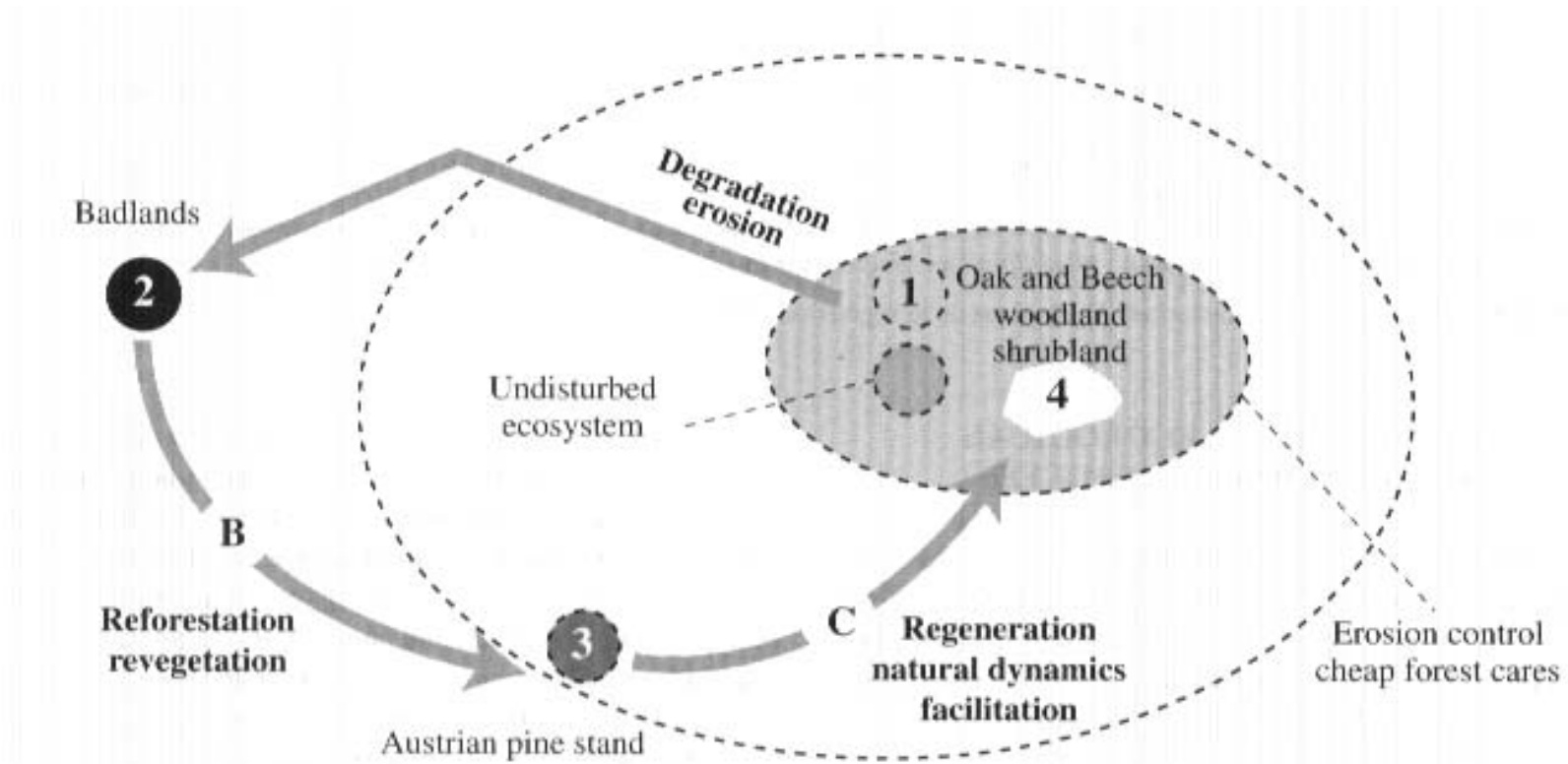


FIG. 2.– The framework of forest restoration in south-western Alps : from rehabilitation of badlands (1860-1930) to natural dynamics facilitation (1930-2030).

Vallauri, D. 1998. Ecologie, 29(1-2) : 329-332

Forest restoration goals in 1995

	Ecological	Economical	Social	Cultural
Goals	Erosion control	Protection	Jobs Recreation	History of change
Key elements	Native dynamics	Cheap & integrated in dev. plans	Open the forests	Memory of degradation
Success criteria	Functional integrity	Management costs		Awareness
Elements for sustainable management	Mixed forest	Subsidies	No data	none

Evaluation of forest restoration advances

Component analysed

- Soils
- Plant communities
- Forest stands
- Tree growth

Soil restoration advances

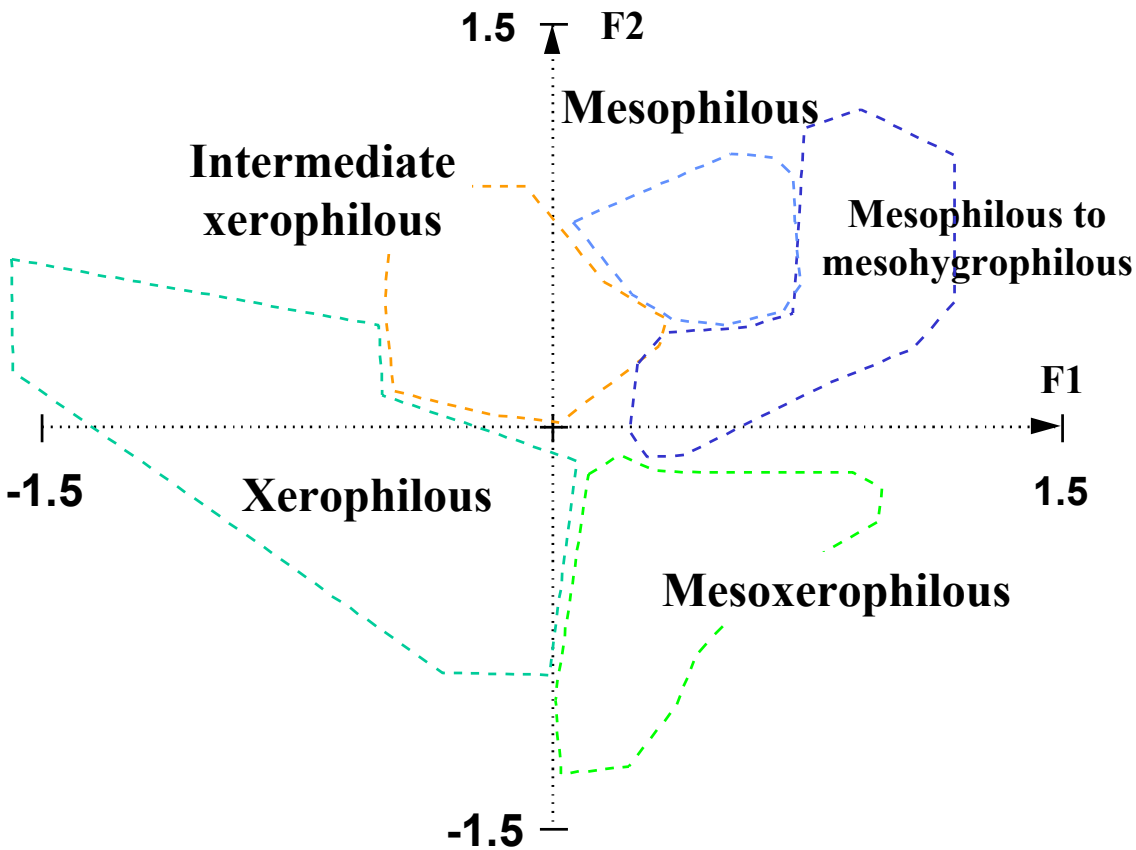
Soil depth : mean 40 cm

$7 < pH < 8$

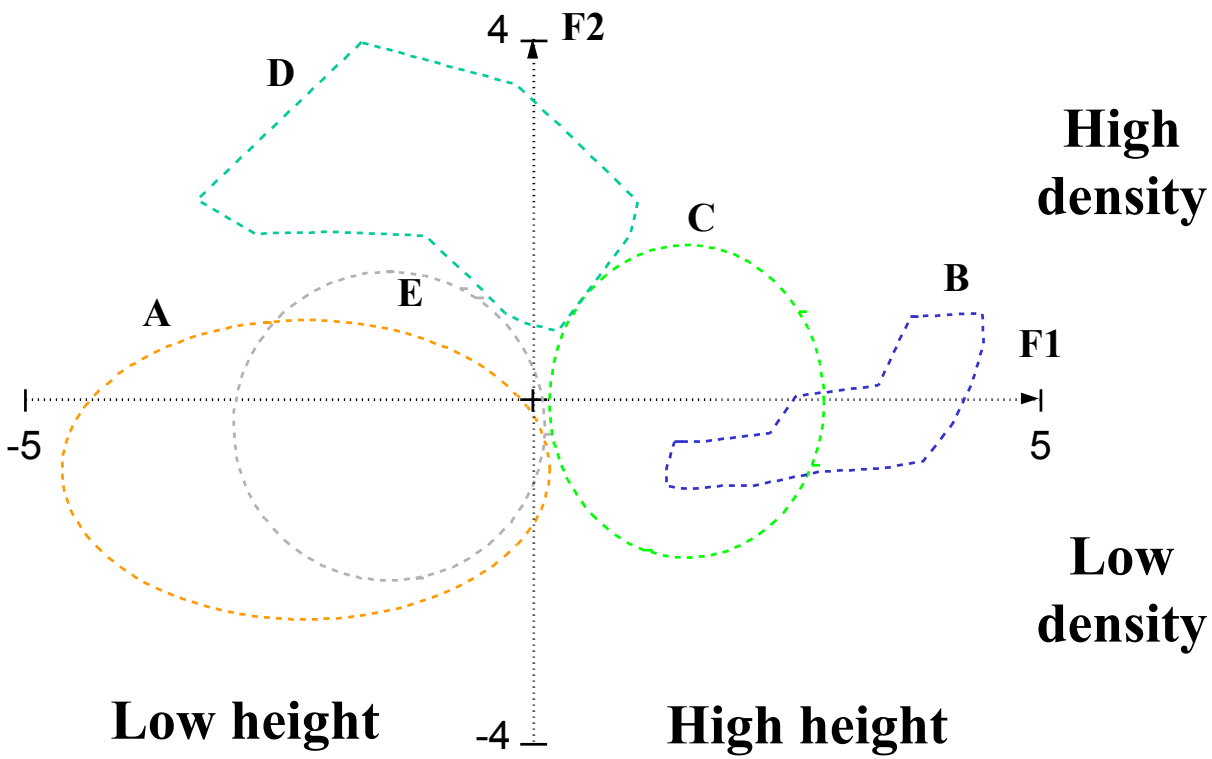
Hcl +++

Humus layer : dysmull

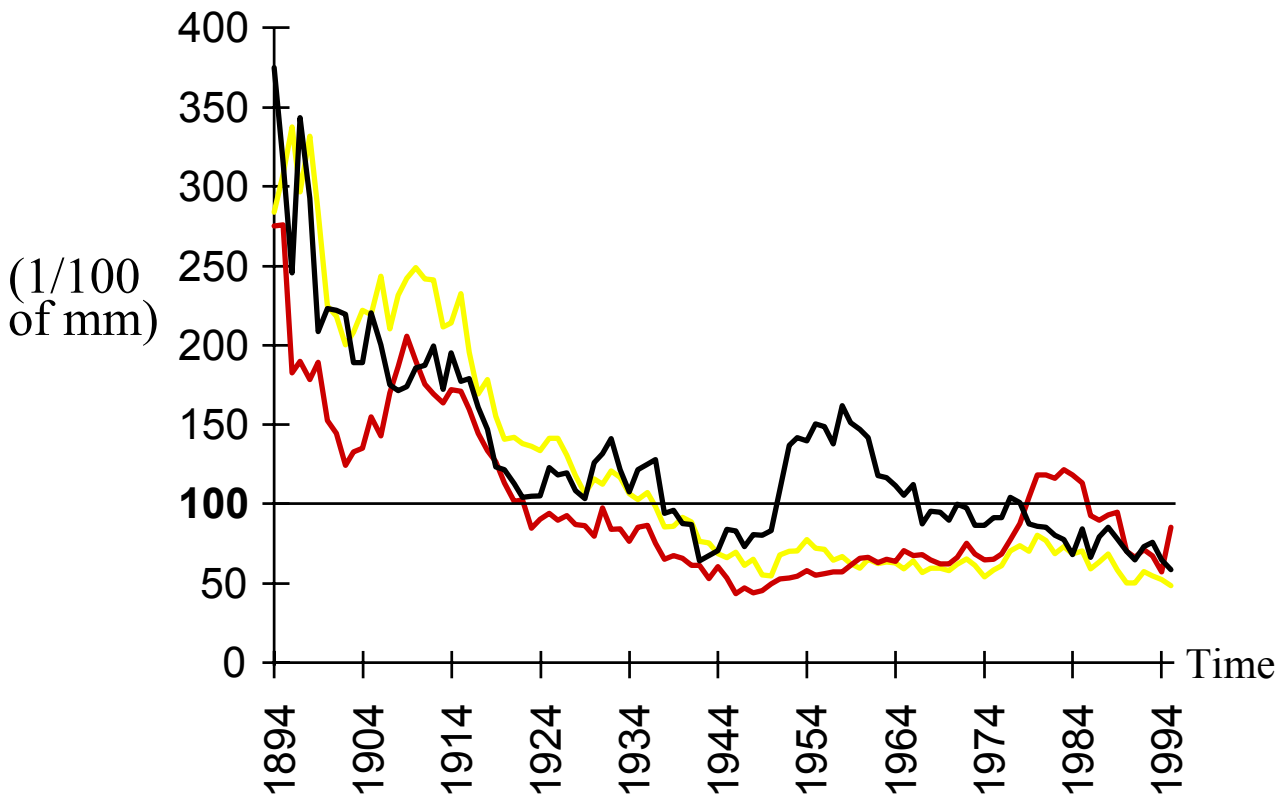
Plant communities restoration advances



Forest stands restoration advances



Tree growth


400
350
300
250
200
150
100
50
0
(1/100 of mm)
Time
1894
1904
1914
1924
1934
1944
1954
1964
1974
1984
1994

Rehabilitated ecosystems : viability and dynamics

Ecological viability = 1 x 2

- Integrity

which elements are still missing ?

- Functionning

does the system work well ?

Rehabilitated ecosystems : viability and dynamics

Investigation of
3 potential constraints through 3 vital attributes

- Soil fertility
- Forest stands regeneration
- Pests

- Earthworm population dynamics
- Tree and seedling diversity
- Leafy mistletoe dynamics (*Viscum album* L.)

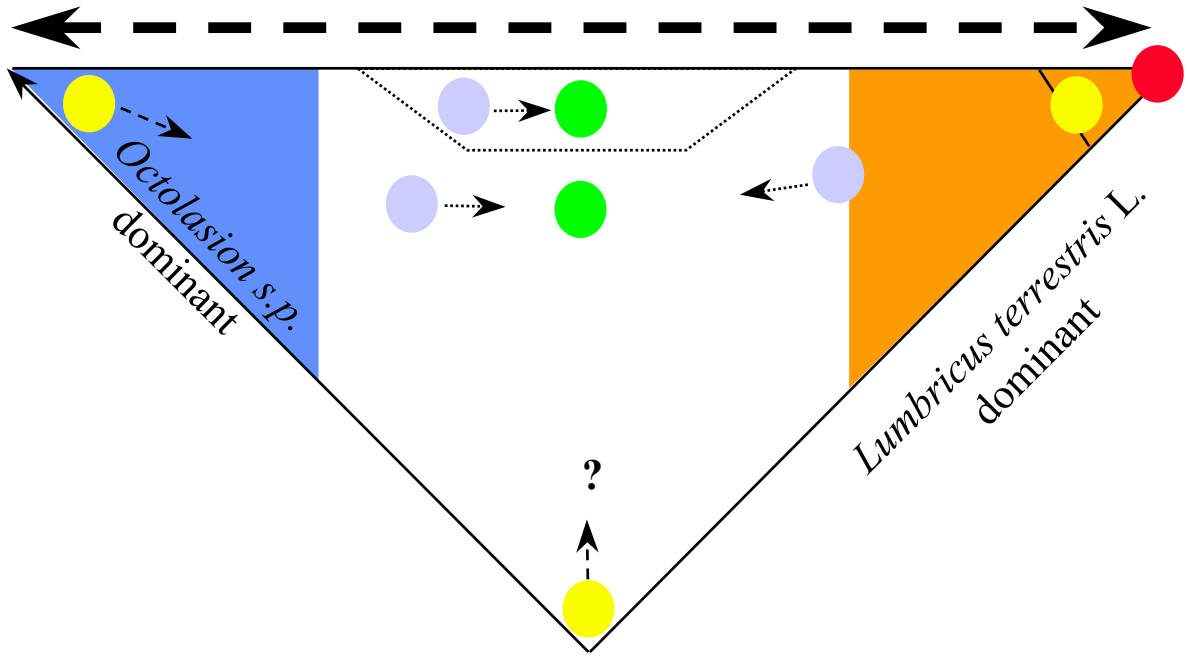
Earthworms
130 years after rehabilitation

- 12 species
- 2 key-stone species : *Lumbricus terrestris*, *Octolasion cyaneum*
- 1 à 49 / m2, 1 à 27 g / m2, low individual growth
- epi-anecic and endogeic species
- density of juvéniles > adults
- 6 earthworm associations
- dynamics by *L. terrestris* and *O. cyaneum*

Earthworms
130 years after rehabilitation

North-oriented slopes, thin marly soils

South-oriented slopes, thin marly soils



Mesophilous type of site, deep marly soil

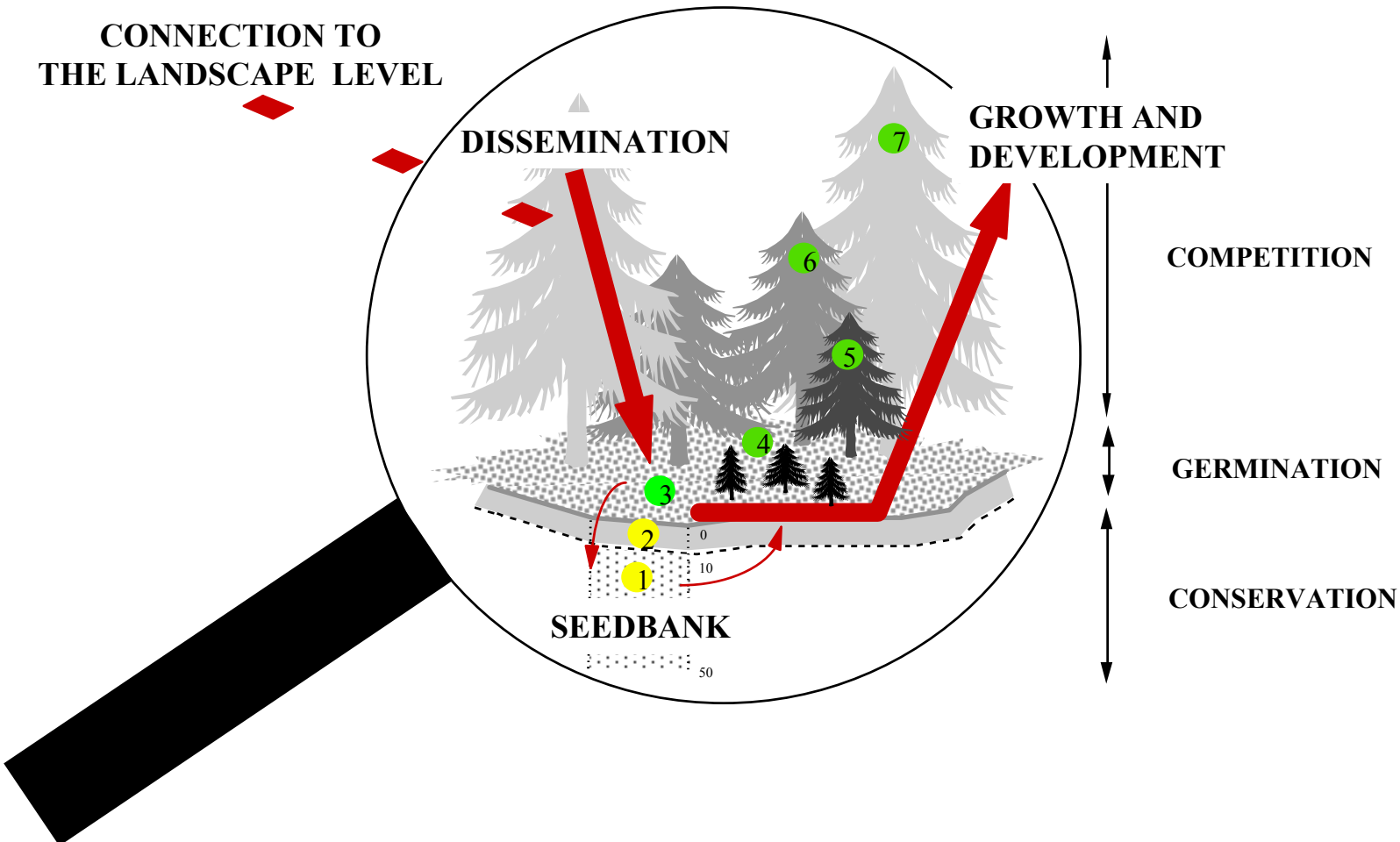
Stage with mesofauna

Initial earthworm stage (Dysmull)

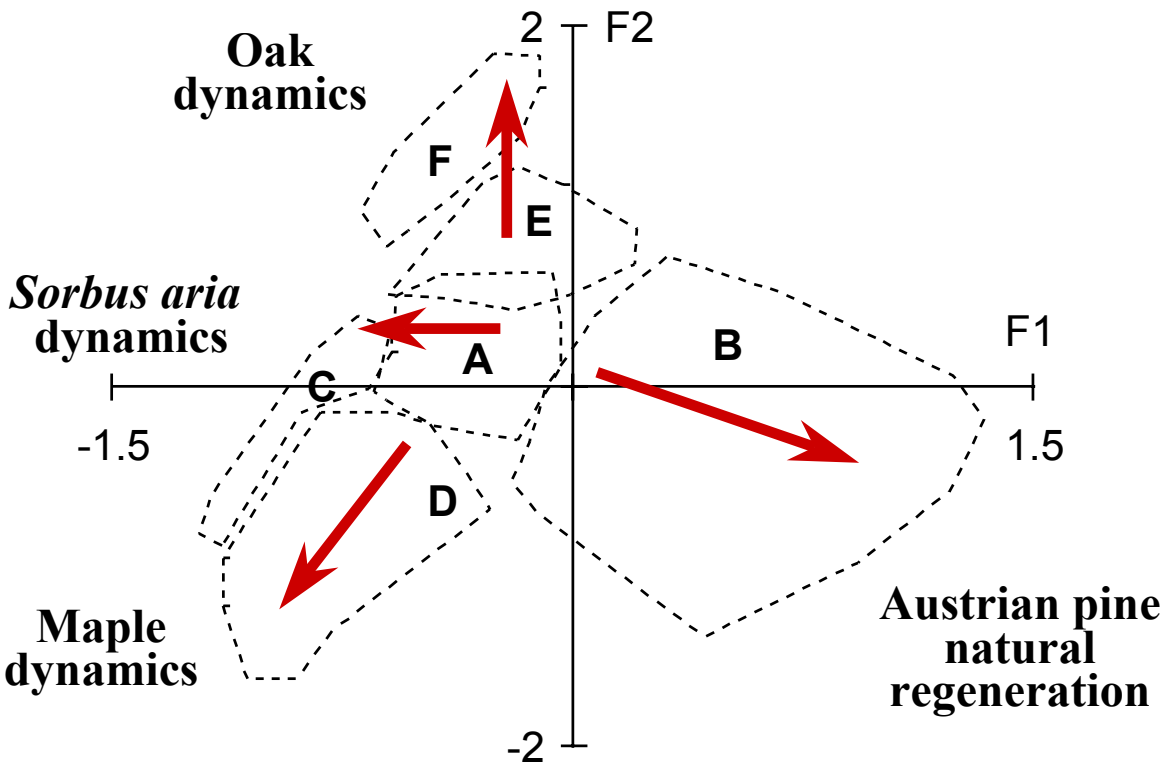
Advanced earthworm stage (Dysmull à Oligomull)

Mature earthworm stage (Oligomull à Mésomull)

Tree diversity
130 years after rehabilitation



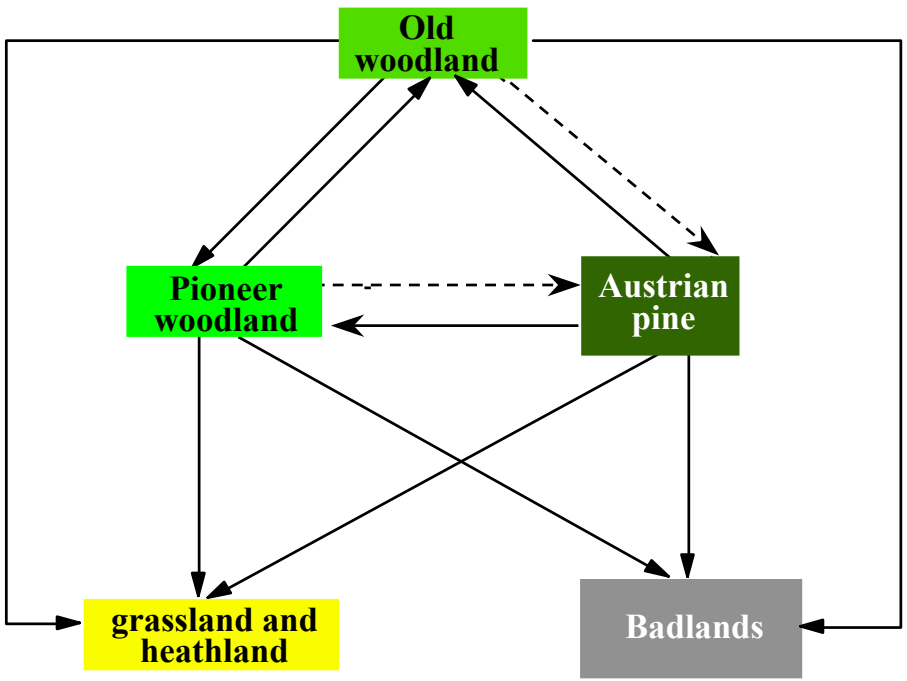
Tree diversity
130 years after rehabilitation



at community level

➔ the dynamics of most of the broadleaved species are not limited by the type of site

Tree diversity
130 years after rehabilitation



at landscape level

➔ Full connection is recent

➔

Dissemination towards the restored ecosystems is low due to stand structure

Sensitivity to pests 130 years after rehabilitation

- Unknown on Austrian pine
- Recent and high level of infestation
- High tree mortality

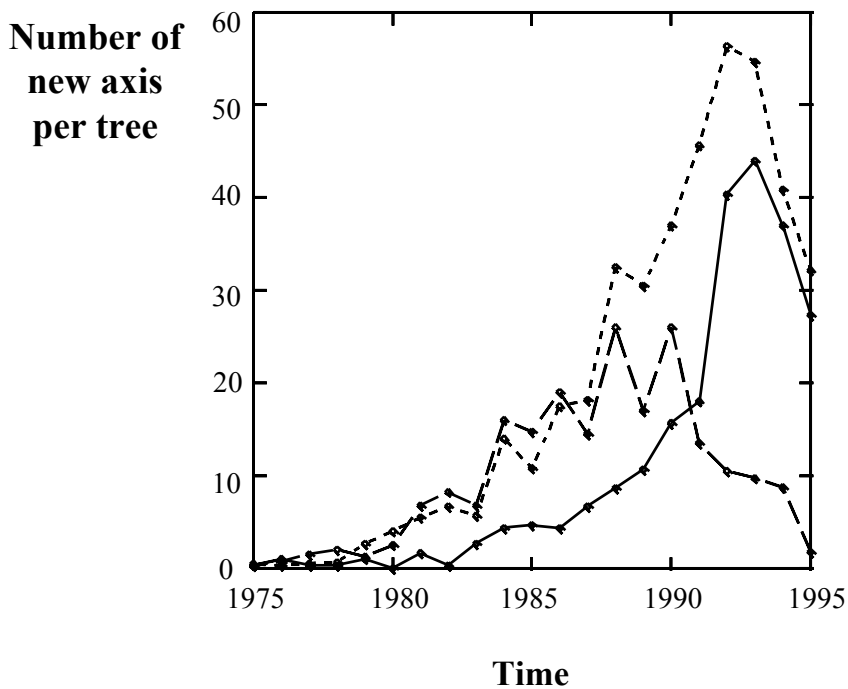
Sensitivity to pests 130 years after rehabilitation

- Unknown on Austrian pine
- Recent and high level of infestation
- High tree mortality

Number of axis : **64 to 720**

Mean age : **4.9 to 9.9 years**

Year of the maximum infestation : **1986 to 1995**



Ecological diagnosis

- Success criteria : functional integrity
  - Biodiversity
  - Resilience and resistance to disrturbances, pests, ...
  - Long-term dynamics
- How to assess success criteria ?
  - Test several life organisation levels
  - Consider long time periods
  - Identifying vital attributes and key populations
  - Diagnosis regularly renewed

Conclusion for forest managers

- step in carefully
  - no erosion
  - shelterwood felling, small patches
- mimic natural processes
  - restore tree diversity
  - favour native broadleaved species and natural regeneration
  - manage mistletoe as an element of biodiversity
- speed up restoration, anticipate problems
  - thinning in the youngest stands
  - prepare the sylviculture of mixt stands
  - pilot the stands toward the target ecosystems (oak and beech forest)

CONCLUSION
AND PERSPECTIVES