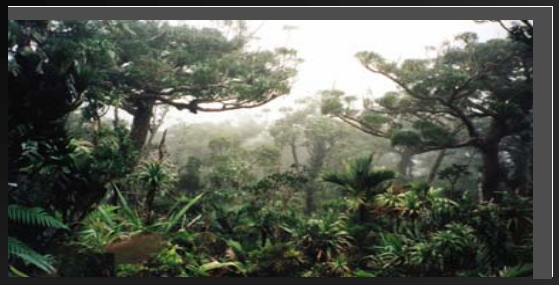
Preservation and ecological restoration in tropical mining environments

Thirty years of ecological restoration of the New Caledonian mining sites

Photos : J-M Sarrailh

Objectives of the presentation

- To situate the ecological restoration process in context of New Caledonia (more a diagnosis than an assessment)
- To propose a framework for studying and improving ecological restoration process
- To advocate the intest of studying ecological systems in order to improve revegetation technologies



What is ecological restoration ?

Definition of the Society for Ecological Restoration (SER) :

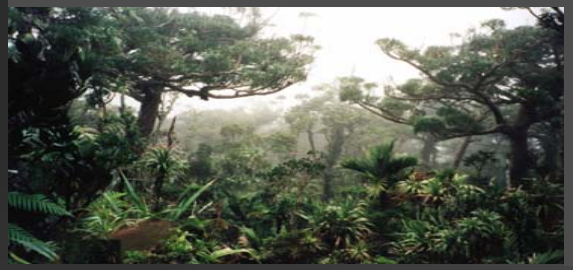
The intentional alteration of a site to establish a defined indigenous, historic ecosystem. The goal of this process is to emulate the structure, functioning, diversity, and dynamics of the specified Ecosystem.

La transformation intentionnelle d’un milieu pour y rétablir l’écosystème considéré comme indigène et historique. Le but de cette intervention est de revenir à la structure, la diversité et la dynamique de cet écosystème.

A complement of definitions

(French)

Ecological restoration



Restauration écologique

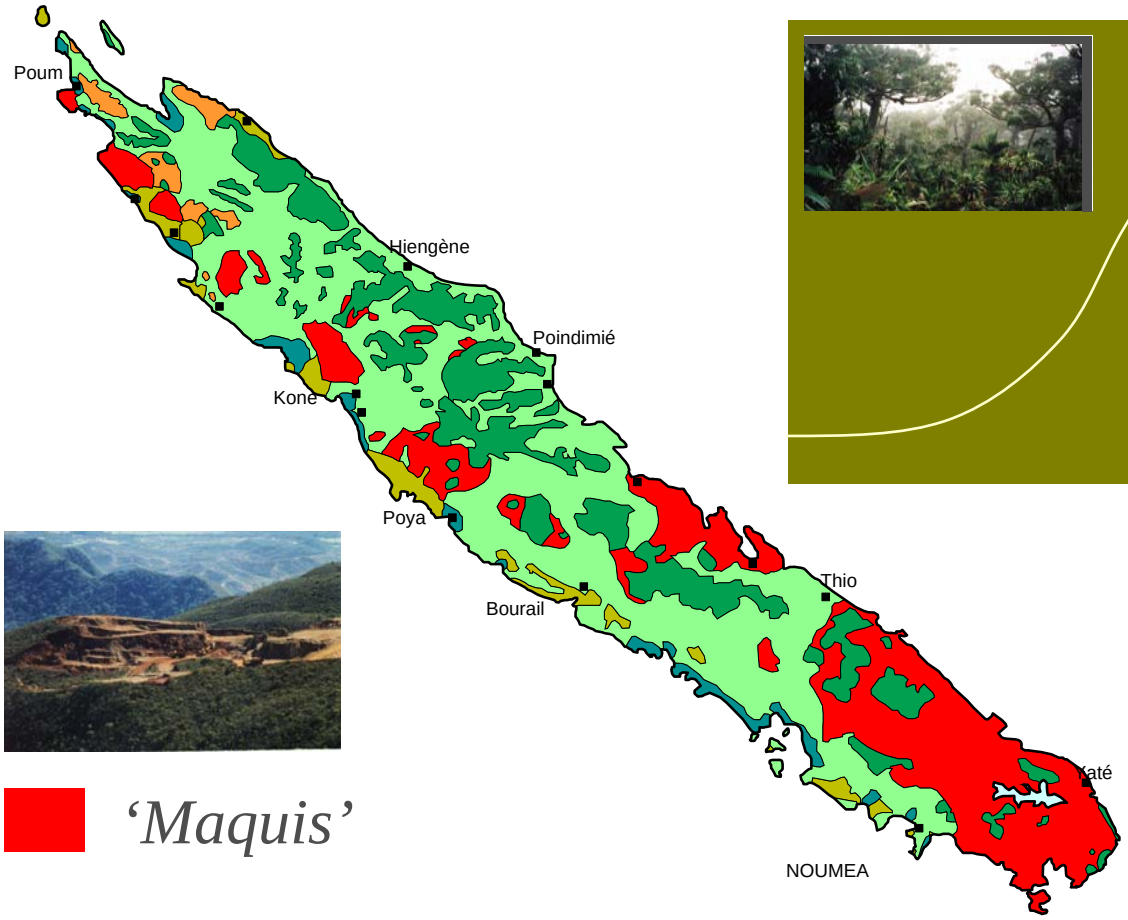
Rehabilitation

Réhabilitation

Reallocation

Réaffectation

The ‘maquis’ formation



A wide panel of natural constraints for ecological restoration

- Toxicity (but at which level are the solutions of heavy metals present in the rhyzosphera ?)
- A probably high deficiency of hydric availability
- A lack of available N, P, K (where does nitrogen comme from ?)
- Disharmony : a possible lack of functional groups (e.g. pionners)

Pionners or large niche-breadth species ?

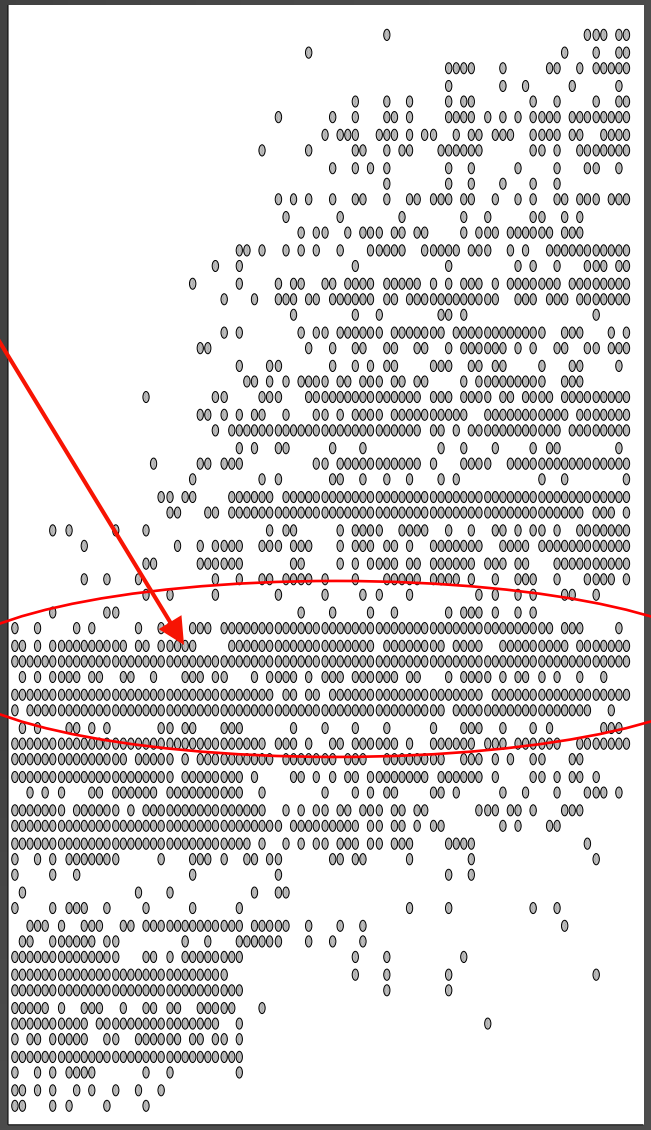
Grevillea exul

COA analysis of phytosociological data

Species

Forest

Plots studied



Species

A wide panel of natural constraints for ecological restoration

- A probably high vulnerability of micro-organisms
- A concentration of chemical and biological fertility in the upper centimeters of soils
- High slopes

Evolution of soil and land conservation in France and french oversea territories

(France) Promulgation of a law of RTM	1882
Soil Conservation Service (SCS)	1935
Soil Defense and Restoration (DRS)	1940
(France) Promulgation of a law (Mines in French oversea territories)	1954
First experiments for revegetation of mining soils in New Caledonia	1970

A short historical background in New Caledonia

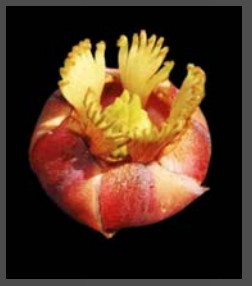
- 1876 : first mining in New-Caledonia : little impacts
- After the 2nd world war : mechanization of exploitation (much more impacts) with bulldozers let by Americans
- First impacts (soil erosion) deplored in 1953
- 1970s : the necessity appeared to restore the devasted mining sites
- The first trial of revegetation was realized in 1971 in Plaine des Lacs.

Main objectives of ecological restoration of mining sites in New Caledonia

- Control of run off and erosion
  (conservation of lagoon, water quality)


- Conservation of biodiversity





- Conservation of landscapes

  (scenic beauty, tourism)

The objectives need to be clarified

- **To reduce the erosion and runoff**
  … (at which level ?)
- **To restore the ecosystems**
  … (considering which recosystems of reference ?)
- **To restore biodiversity**
  … (at which level and after how many years ?)
- **To restore scenic beauty**
  … (following which criterias ?)

… with flexibility and realism **(Ehrenfeld, 2000)**

Evolution of methods of revegetation in New Caledonia

KIND OF SPECIES

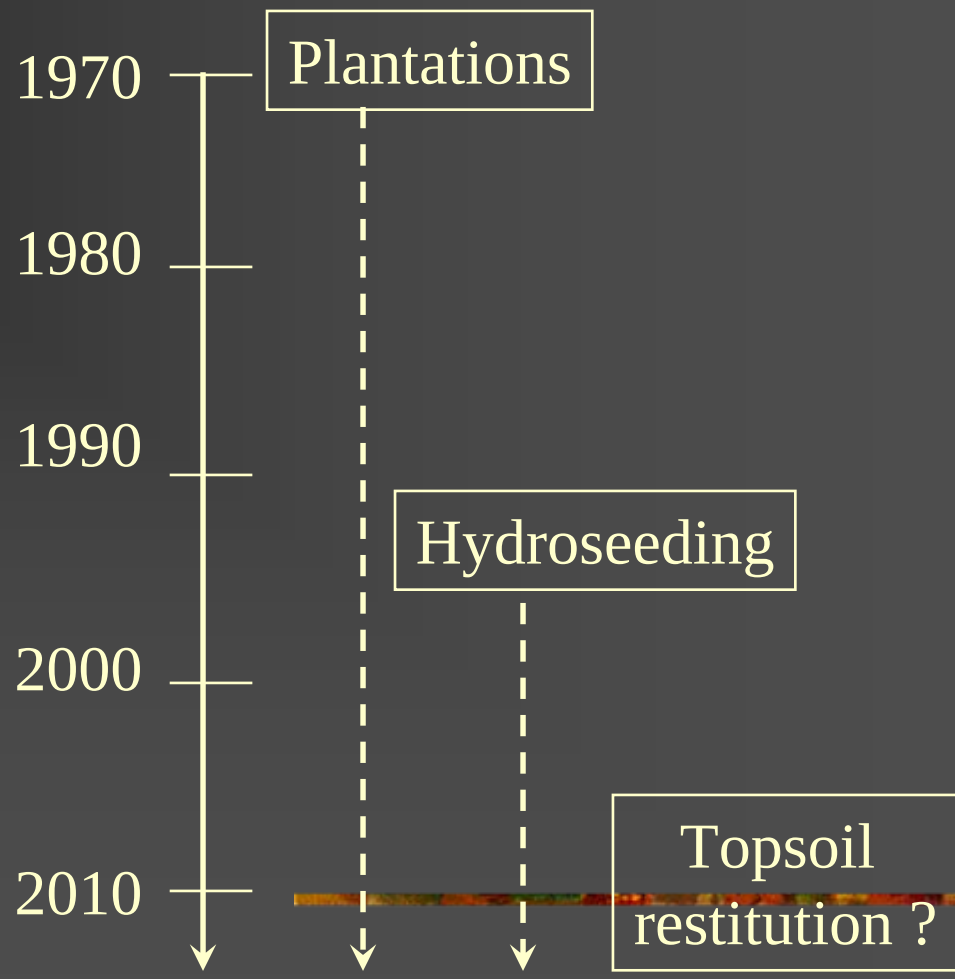
Exotic species
(a failure + pbs of invasion)

Native ubiquitous
species of lowlands

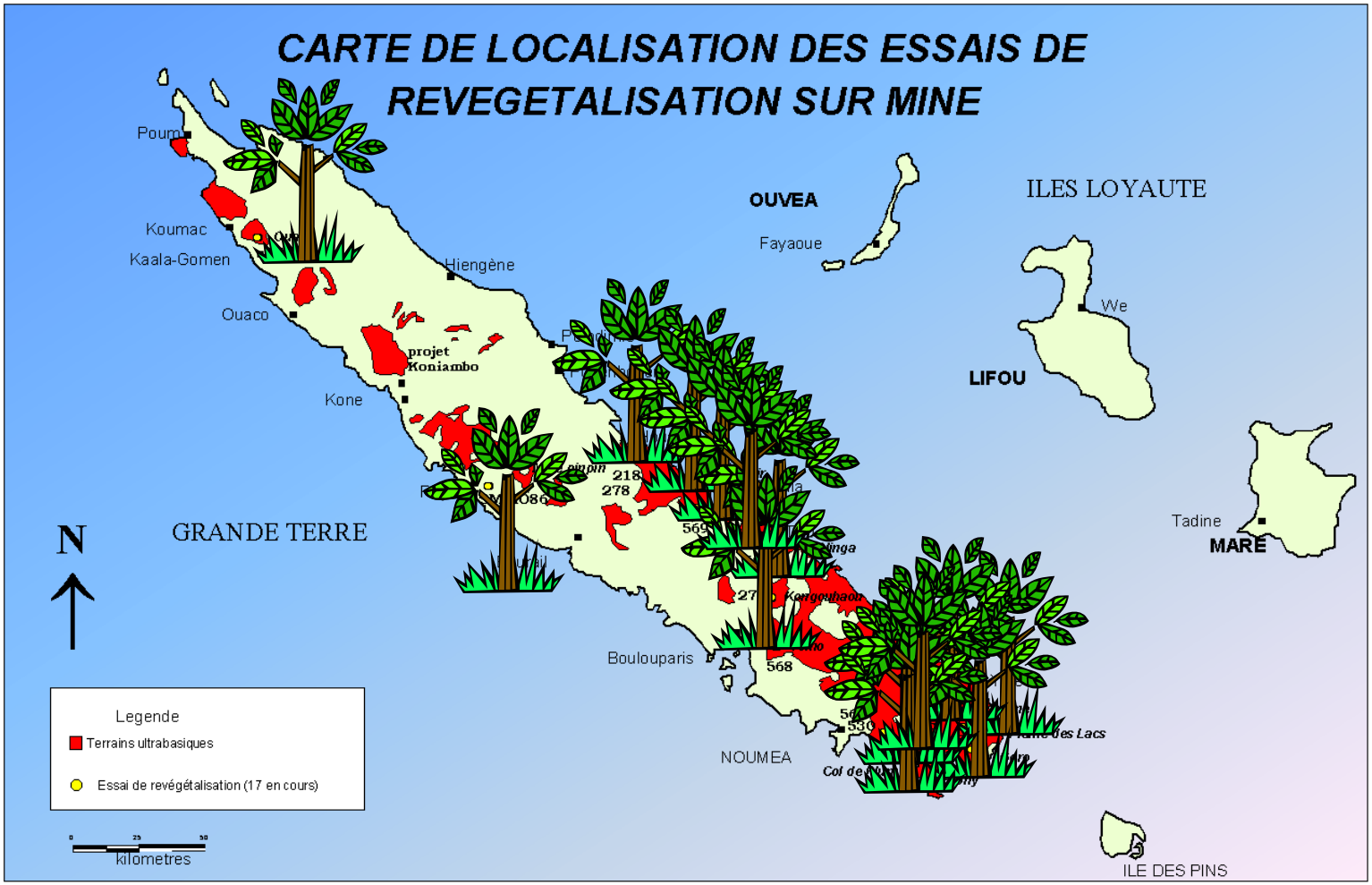
Native plants from maquis

Other organisms ?

TEHNOLOGIES



Trials of revegetalisation in New Caledonia during the 30 late years



Trial

A short assessment of revegetation

- A mainly phytotechnic approach

Plantations : a mainly phytotechnic approach

Improving seedlings production

Decompaction

Improving Plantation technics

Improving chemical fertility

A short assessment of revegetation

- A mainly phytotechnic approach
- **A failure in using exotic species**

A failure of using exotic species

Utilization of *Acacia spirorbis*

Objective	Use of *Acacia*
Ecological restoration	No
Rehabilitation	No
Reallocation	Yes

A short assessment of revegetation

- A mainly phytotechnic approach
- A failure in using exotic species
- **Hydroseeding : more links between ecological studies and phytotechnics**

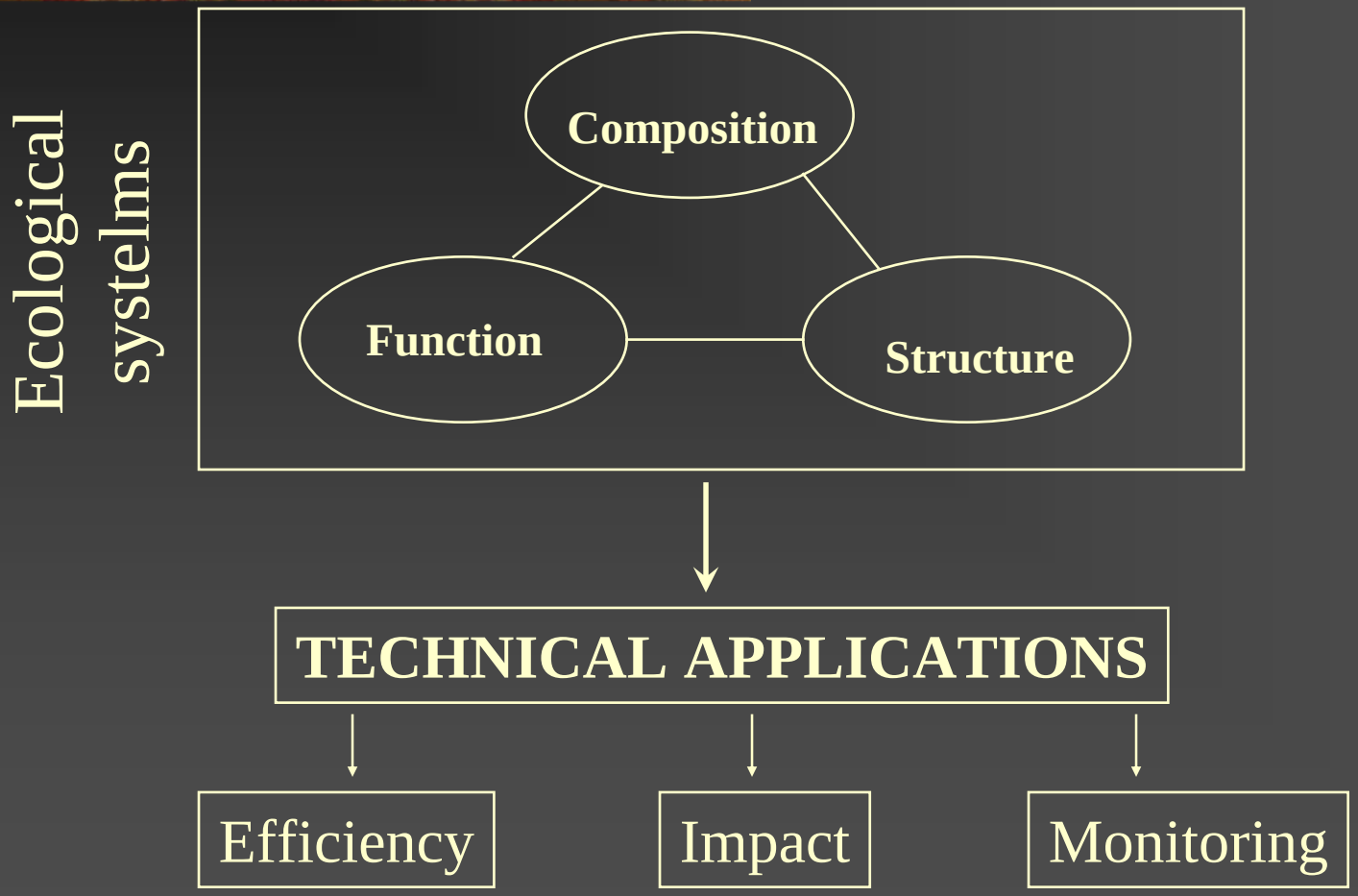
Hydroseeding : linking ecology and phytotechnics

A short assessment of revegetation

- A mainly phytotechnic approach
- A failure in using exotic species
- Hydroseeding : more links between ecological studies and phytotechnics
- **Topsoil management : more and more links between ecological studies and phytotechnics**

Topsoil management :
more and more links between ecology and revegetation

Long and complete ecological studies are inevitable



RESEARCH ON ECOLOGICAL SYSTEMS

COMPOSITION
Diversity
Dynamics
Abundance
STRUCTURE
Patches
Connectivity
Heterogeneity
Toposequence
FUNCTION (flows between elements)
Water
Mineral nutrients
Plants and animals
Dispersion
Disturbance processes

→

TECHNIQUES OF REVEGETATION

Plantation of seedlings

Hydroseeding

Topsoil restitution

Study of ecological systems in mining sites in New Cal.

COMPOSITION

Diversity	+++
Dynamics	0+
Abundance	+

STRUCTURE

Patches	0
Connectivity	0
Heterogeneity	0
Toposequence	+

FUNCTION (flows between elements)

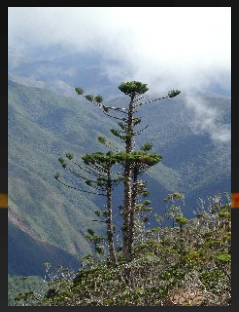
Water	+
Mineral nutrients	0+
Plants and animals	0
Dispersion	0+
Disturbance processes	+

A need for a hierarchical approach

‘Complexity in ecology is not so much a matter of what occurs in nature as it is a consequence of how we choose to describe ecological situations’

Allen &Hoekstra (1992)
Toward a unified ecology.

Main levels of organization of biodiversity



LANDSCAPE — 0

ECOSYSTEM — 0-+

COMMUNITY — ++

SPECIES — +++

Increasing difficulty

Knowledge

Main tools of research on ecological systems

LANDSCAPE

Remote sensing
GIS
Spatial statistics
Landscape modelling

ECOSYSTEM

Habitat measures
Resource inventories

COMMUNITY

Dynamics modelling
Niche breadths
Community-habitat modelling

SPECIES

Species-habitat modelling
Dynamics modelling
Population viability analysis

Conclusion : the statement of ecological restoration in mining sites of New Caledonia

- A considerable lack of knowledge of ecological systems

→
- empirical processes of revegetation
- long-term effects not assessed
- no possibility of assessment or monitoring

- An increasing participation of mining societies to research efforts (funding mostly transfert of technologies)

- An increasing structuration of research activities in ecological systems of ultramafic lands

In a next future…

- Constitution of a ‘Nickel Pole’
- Links out of New Caledonia (Australia)
- More participation of mining societies to research
- A new reglementation

As a short summary…

Native species of ultramafic soils

1-2 %

Native species used

100 %

Whole areas bared by mining

0.8 %

Area revegetated

100 %