Island BIOLOGY
La Réunion 8-13 JULY 2019

Supporting sustainable land-use policies with Systematic conservation planning in New Caledonia.

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PROVINCE SUD

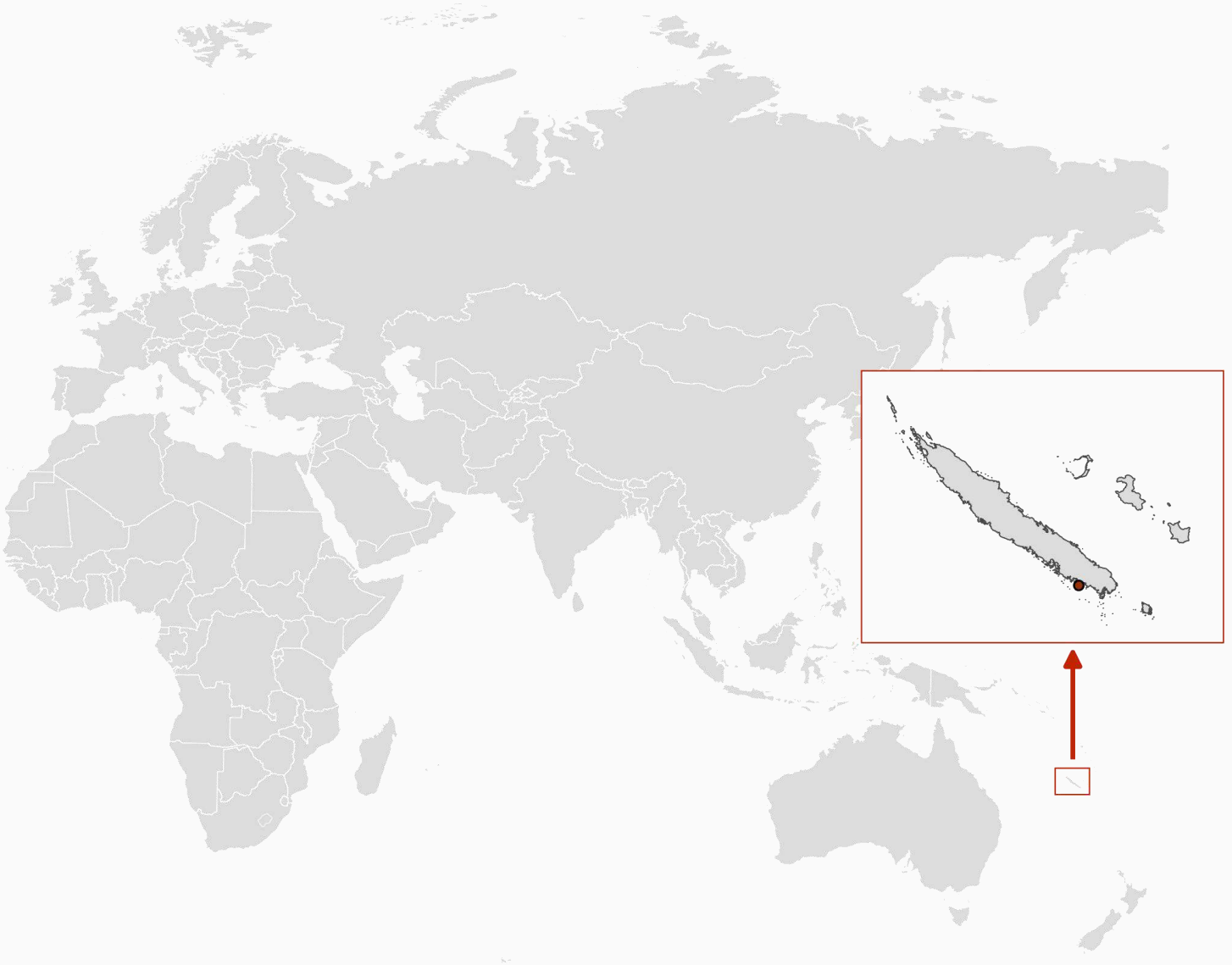
AMAP

cirad LA RECHERCHE AGRONOMIQUE POUR LE DÉVELOPPEMENT

UNIVERSITÉ MONTPELLIER

IMT Mines Albi École Mines-Télécom

New Caledonia, the smallest biodiversity hotspot in the world



New Caledonia, the smallest biodiversity hotspot in the world

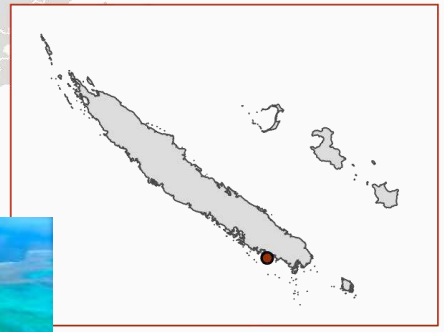
e.g. Terrestrial flora :

More than 3380 vascular plant species, ~76% of endemism !

A high β-diversity.









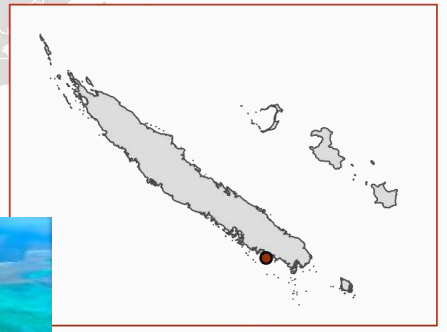
New Caledonia, the smallest biodiversity hotspot in the world

Main theats :

Bushfires (24 145 ha burnt in 2017).

Mining (~20 000 ha degraded, 300 000 ha in mining concessions).

Invasive species (e.g. deer, cat, rat...).



How to efficiently protect this natural heritage ?

Find trade-offs between nature conservation and socioeconomic development.

Complex and diverse problematics on the same territory.

A need for decision support from environmental managers.

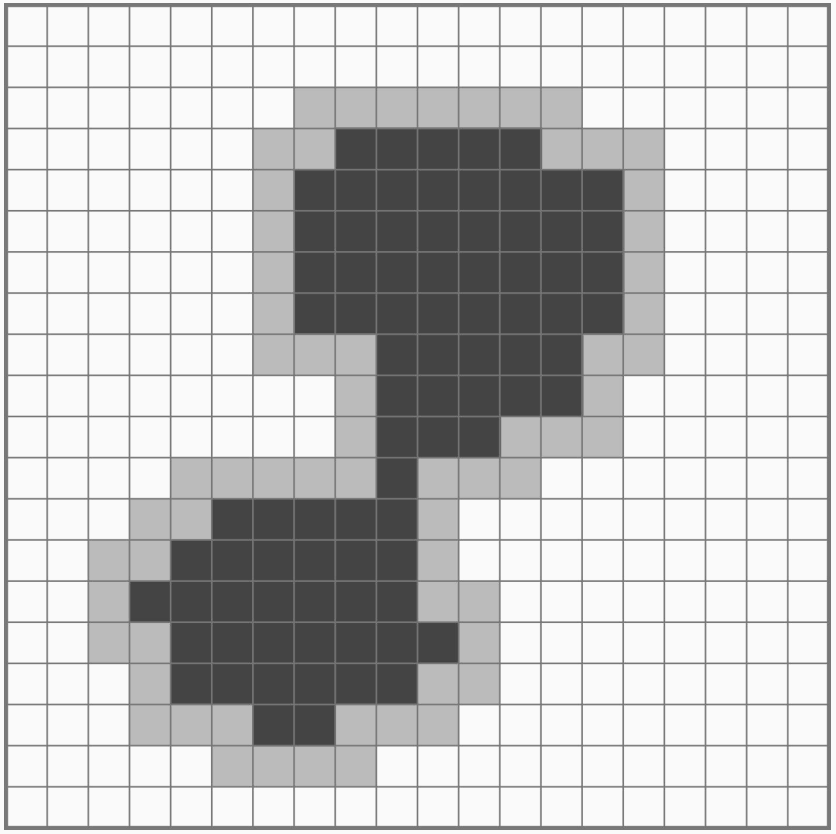
Systematic conservation planning (SCP)

Reserve selection and design.

A spatial **partitioning** problem

Can we **partition** the geographical for sustainable land-use policies ?

By **identifying**:



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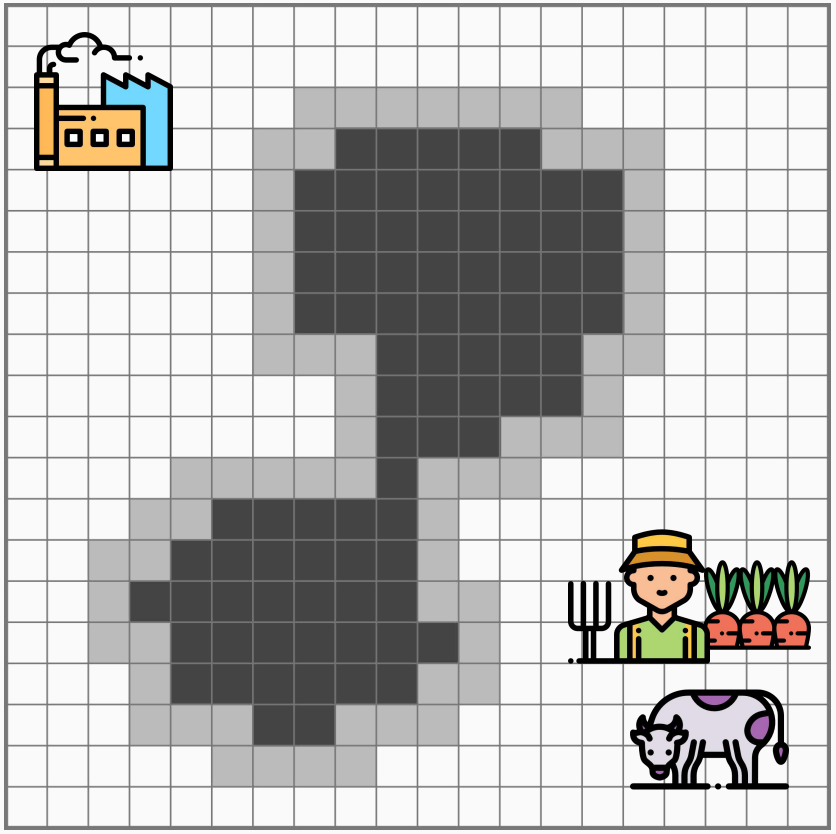

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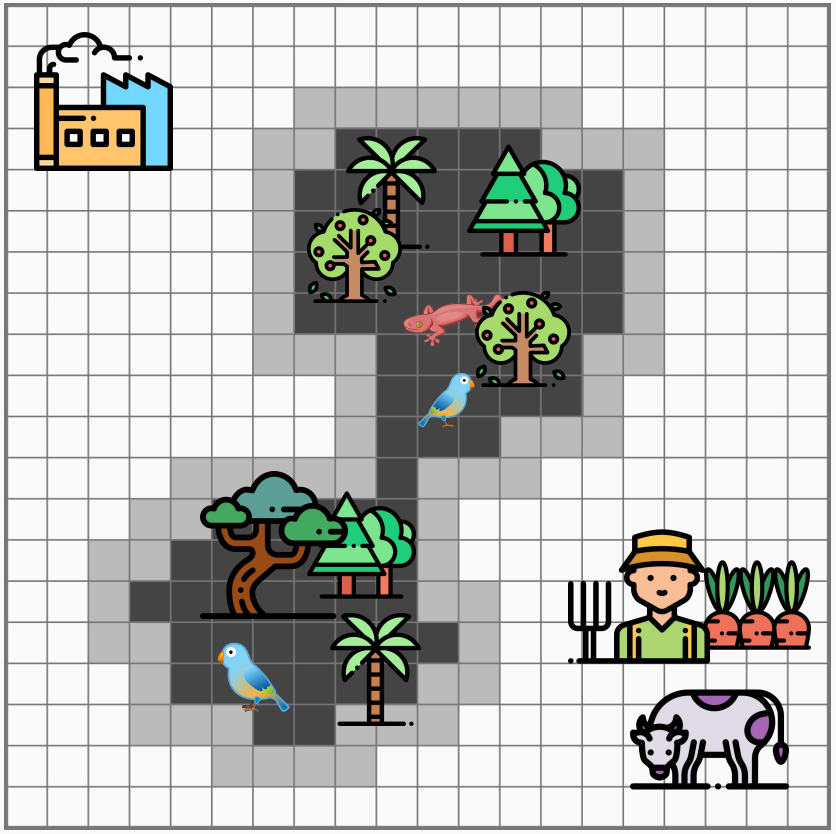

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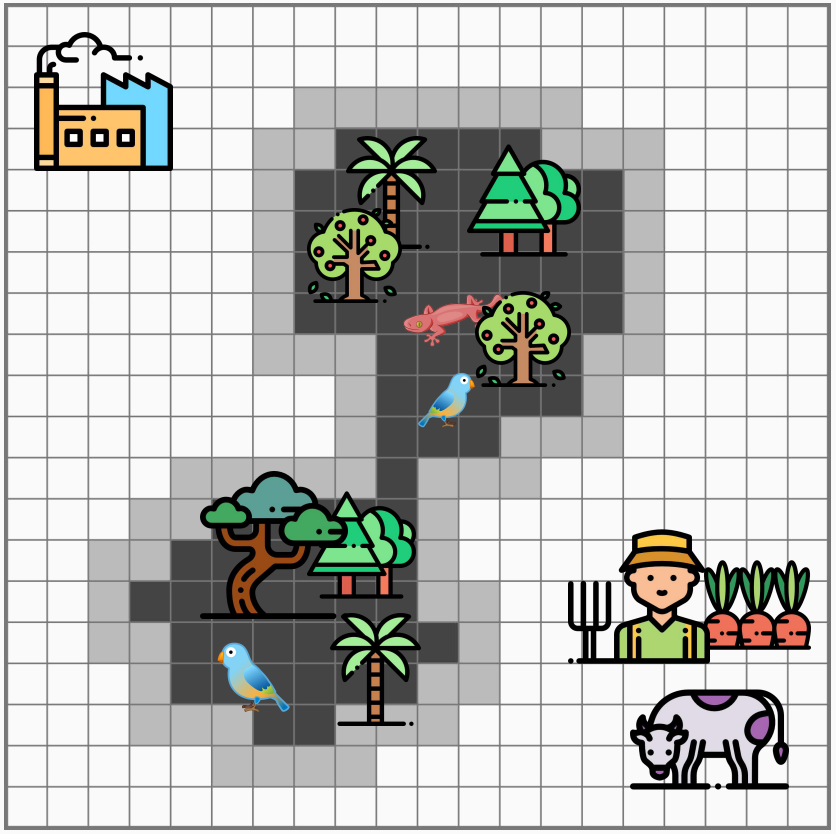
→ In a **balanced** way.

- A difficult combinatory problem.
- Heterogeneous constraints

  Coverage, connectivity, buffer zone...
- A high variety of questions and contexts.



Current approaches

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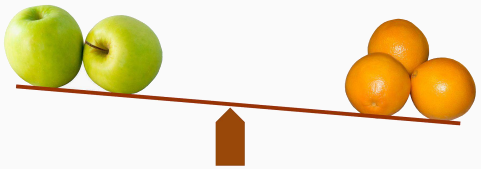
- **Scoring methods :**

  Cannot catch complementarity

  do not really solve the problem.



[Kirkpatrick 1983]

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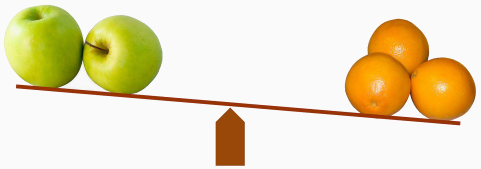

- **Heuristics and metaheuristics** :

  Fast.

  Problems are simplified few guarantees.

ZONATION
Conservation planning software

MARXAN
conservation solutions

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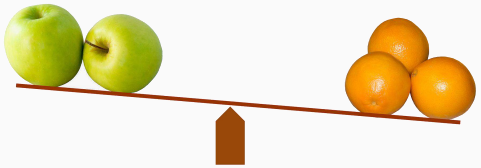

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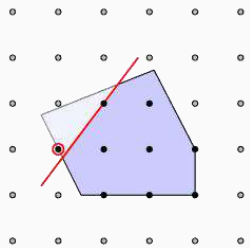
  Exact approach.

  Non-linear constraints (e.g. connectivity) are difficult to integrate.



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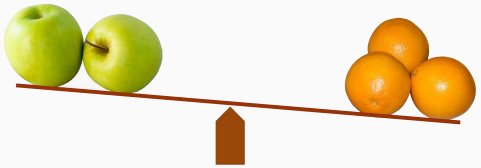

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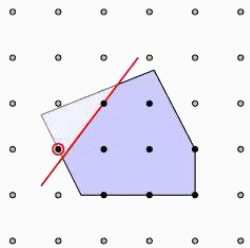
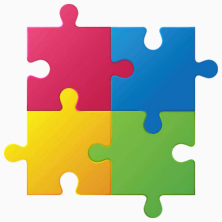
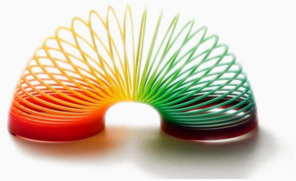


- Each existing approach address a **limited subset of problems**.

There is a lack for more **generic** and **flexible** models.





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Our approach : Constraint-based

SCP aspects are embedded into **mathematical constraints**.

Systematic conservation planning question Combination of constraints.

[Justeau-Allaire et al. 2018] *Unifying Reserve Design Strategies with Graph Theory and Constraint Programming*. CP 2018.
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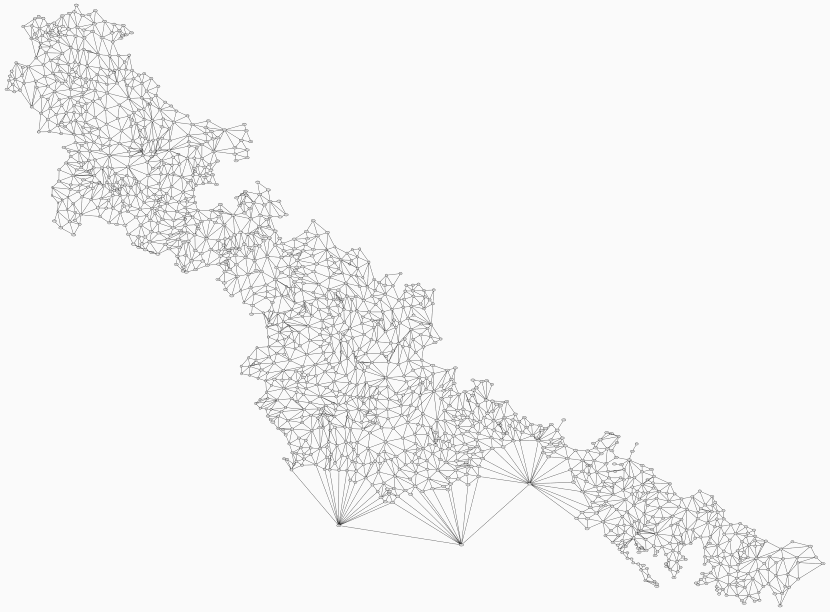

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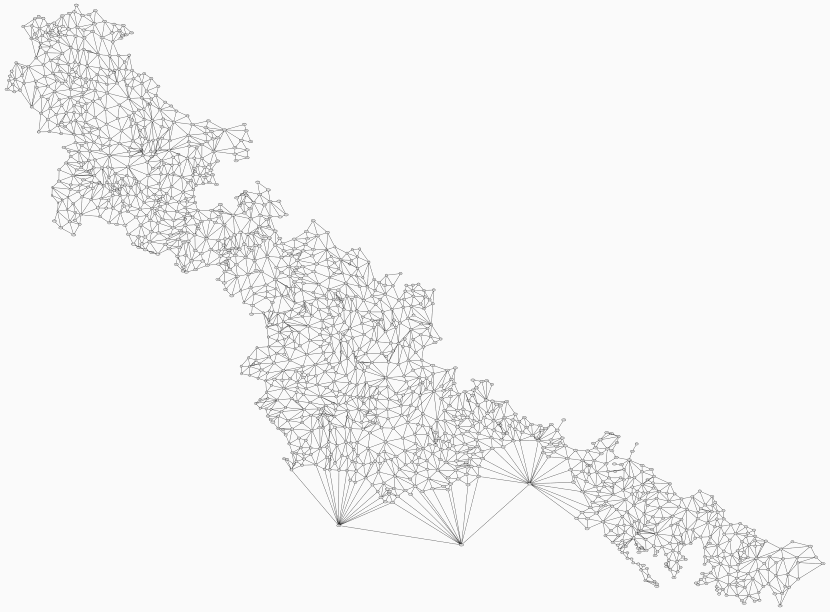

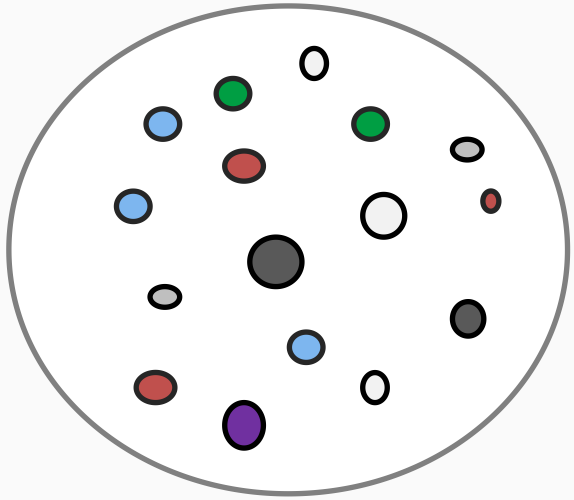

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Our approach : Two synchronized complementary models

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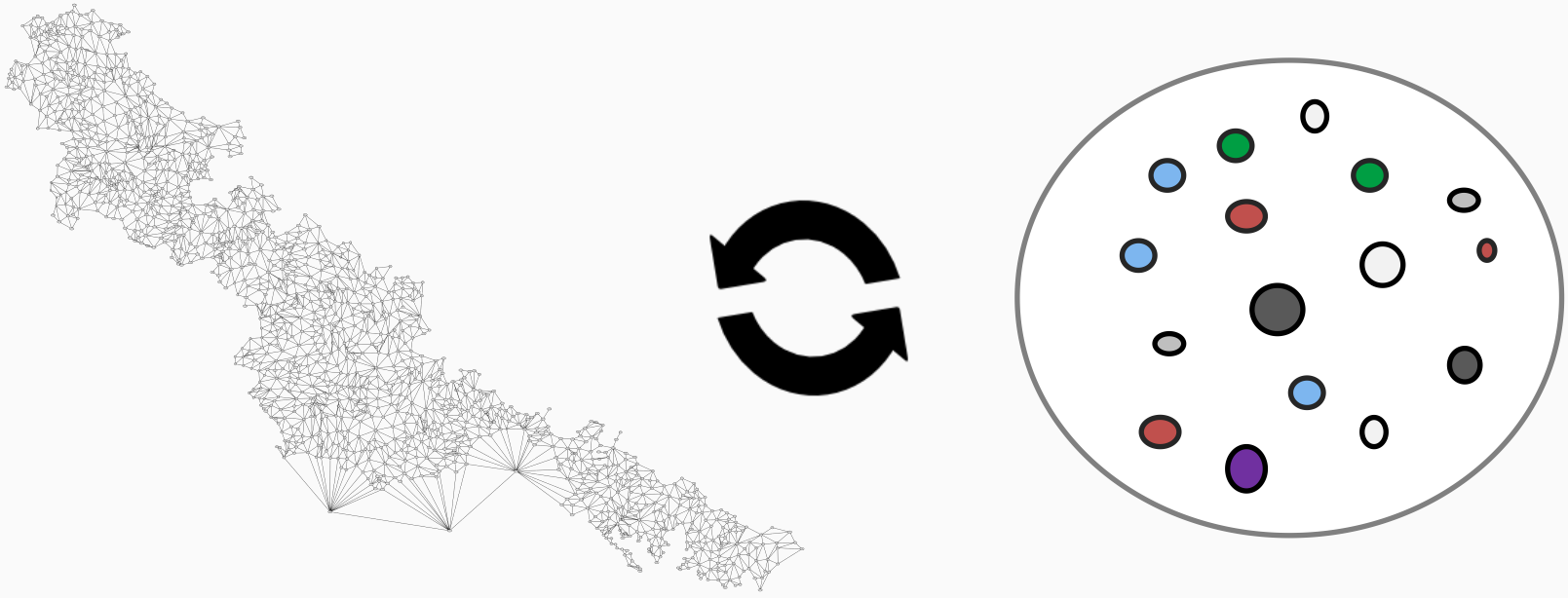
- A graph model to express spatial constraints.
- A set model to express covering constraints.
- Channeling constraints to synchronize both models.



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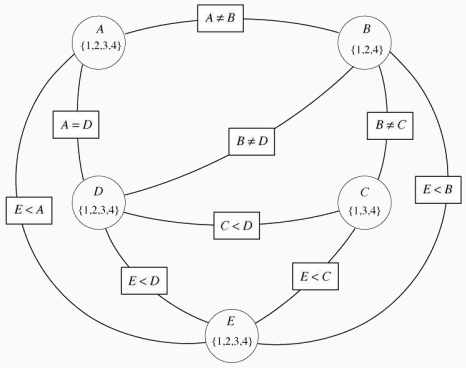
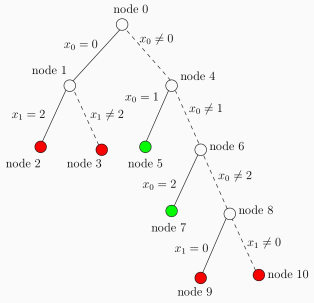
- CP : Prune search space with constraint reasoning and propagation.
- Within the scope of Artificial Intelligence : Automated Reasoning.





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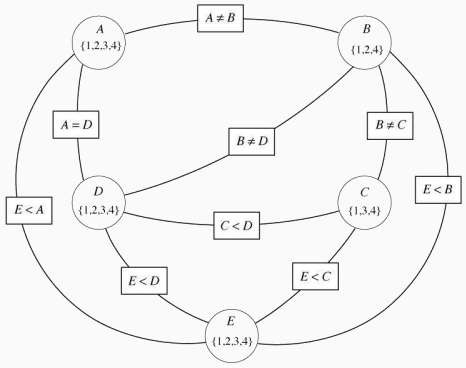

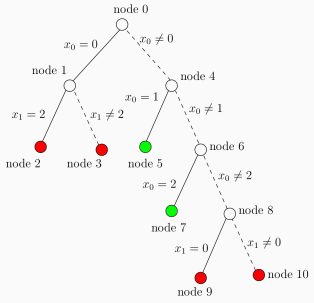

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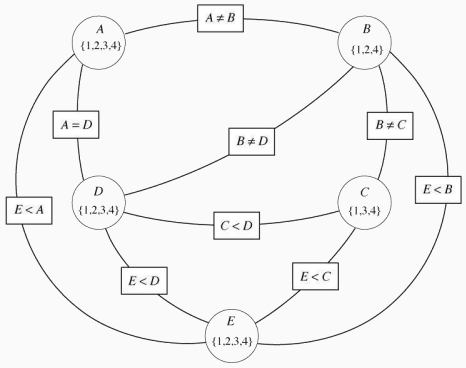
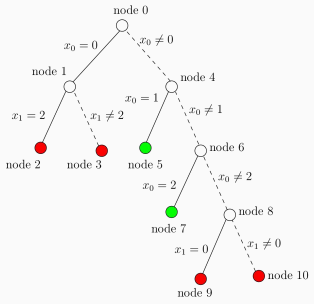
\- Few guarantees on runtime.
\- Still explorative : many improvements to be done.





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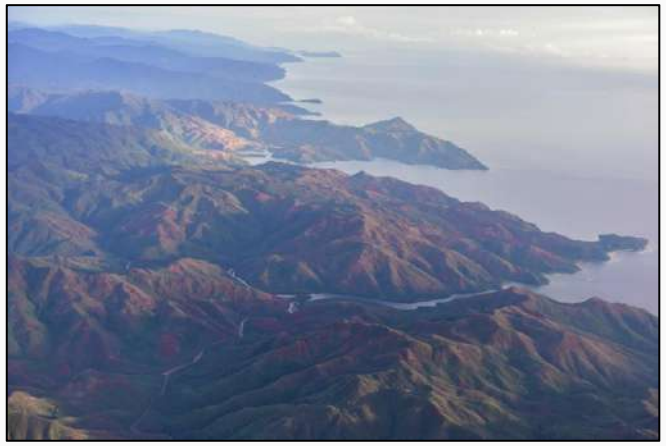

The “Côte Oubliée” project

- A large area in the **south-east of New Caledonia**.
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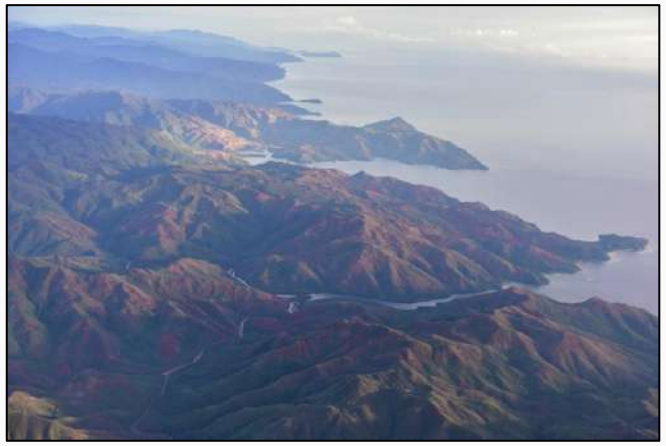
GOUVERNEMENT DE LA NOUVELLE CALÉDONIE

SÉNAT COUTUMIER DE LA NOUVELLE-CALÉDONIE



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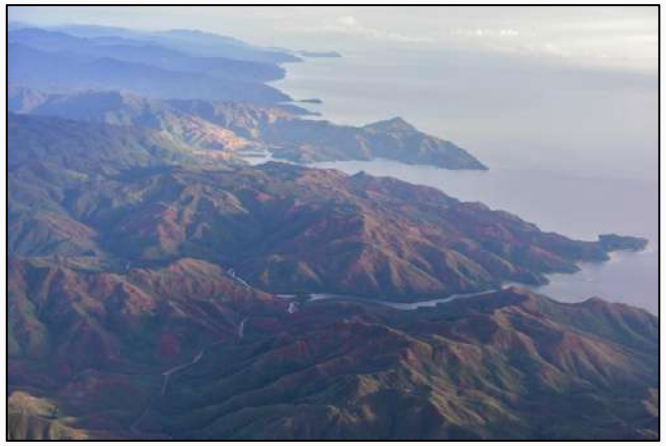

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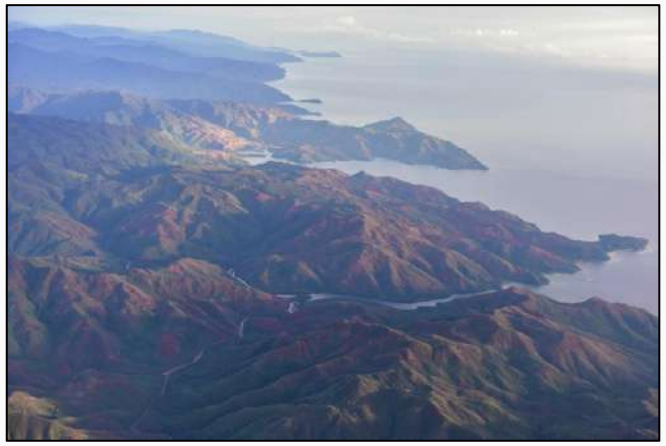

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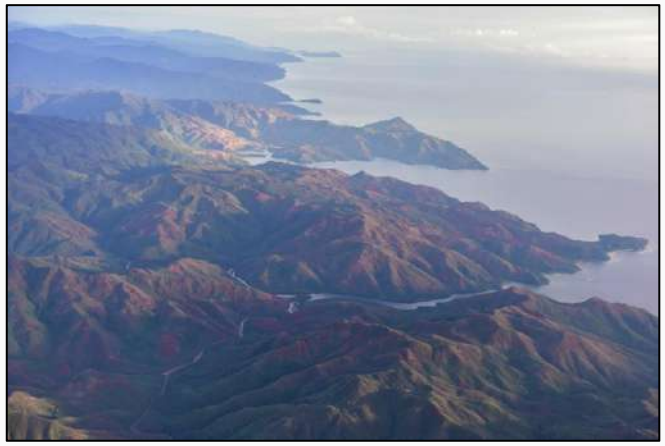

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- **April 2019** : The Côte Oubliée provincial park is created by the South Province.
  93 000ha (terrestrial) + 27 000ha (marine).

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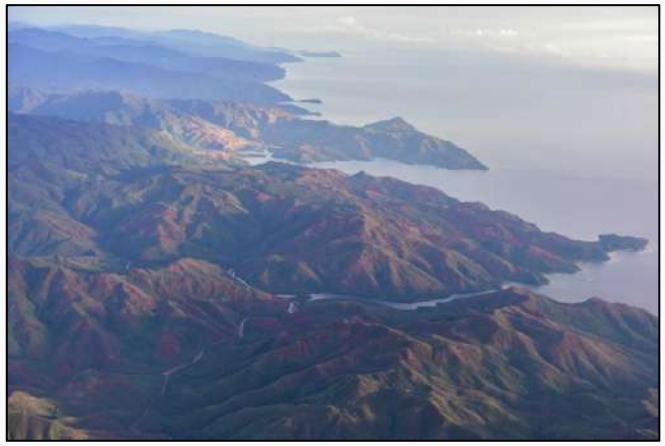


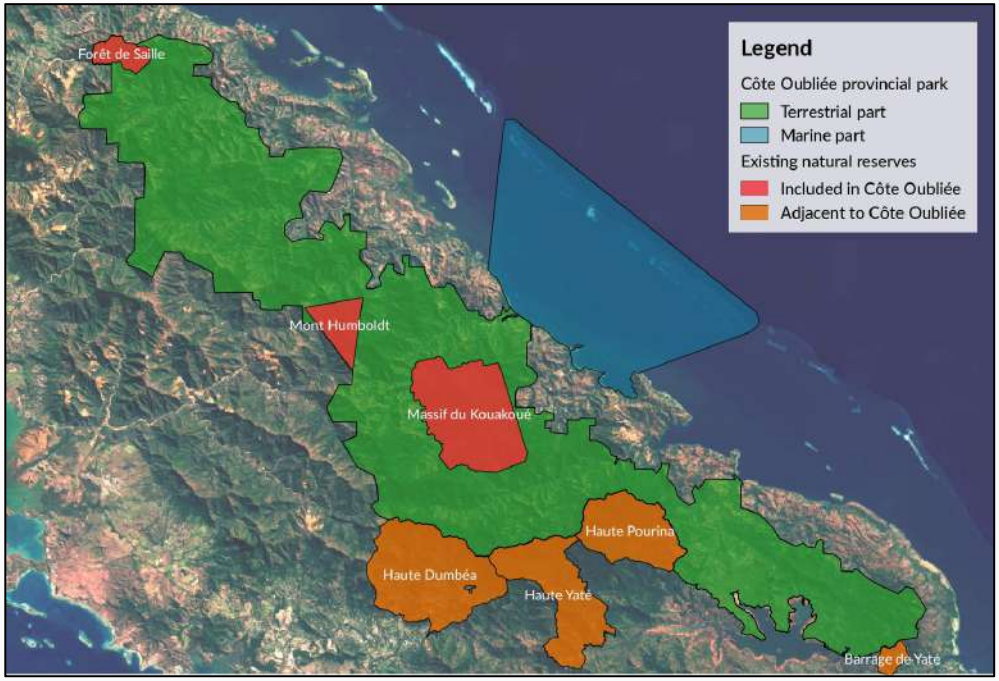
The “Côte Oubliée” project

Level of protection

Integral Reserve

Natural Reserve

Provincial Park



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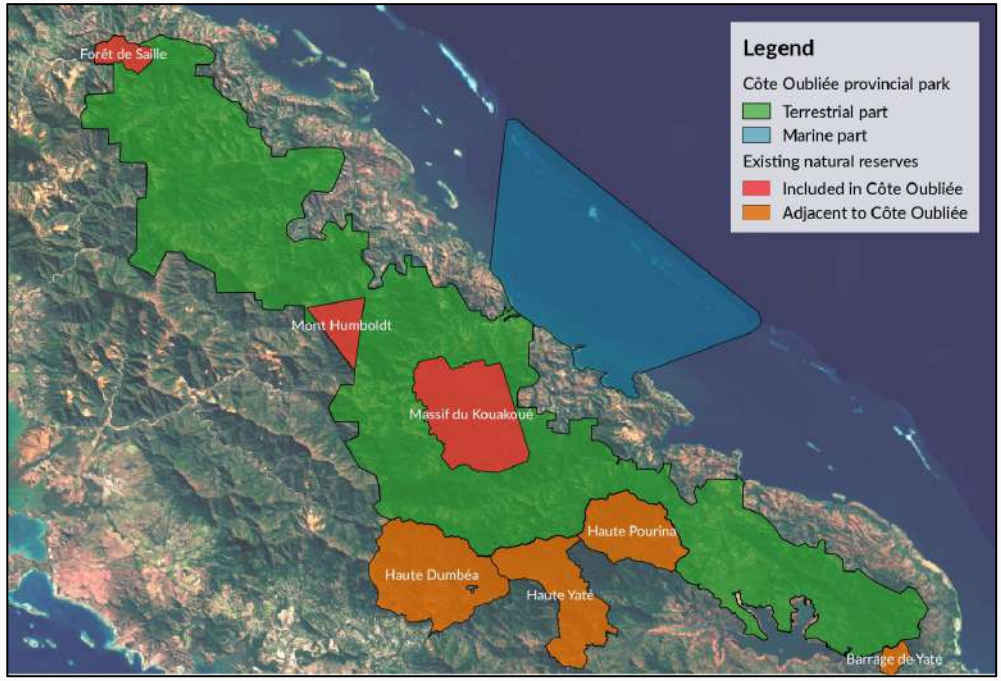

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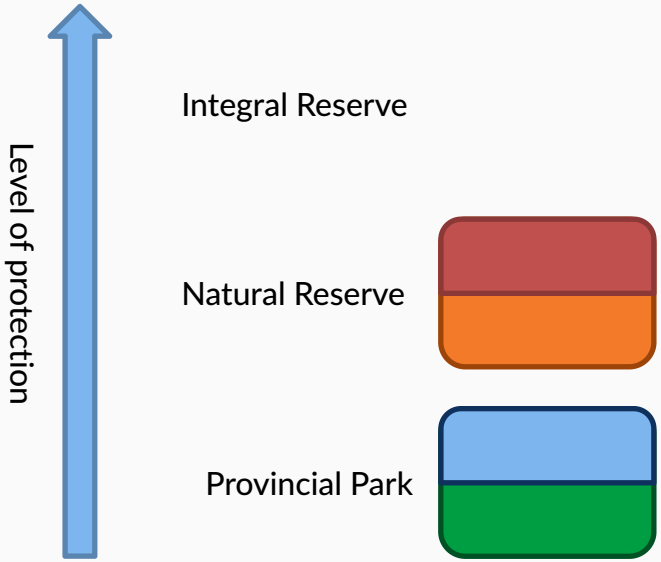
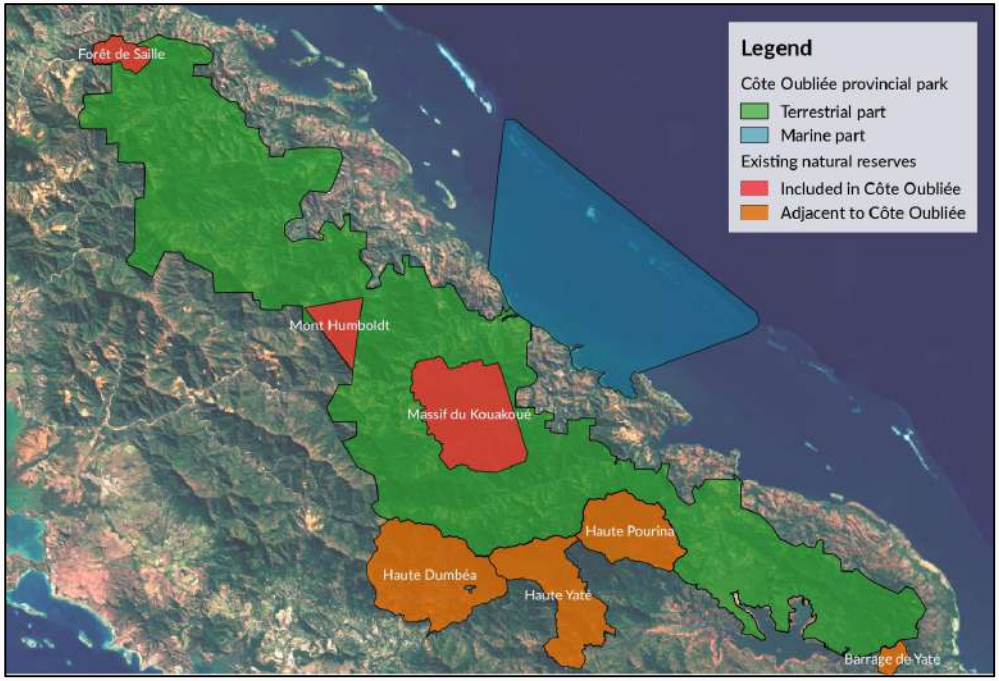
Collaboration with the **Province Sud (DENV)** to provide **decision support**.





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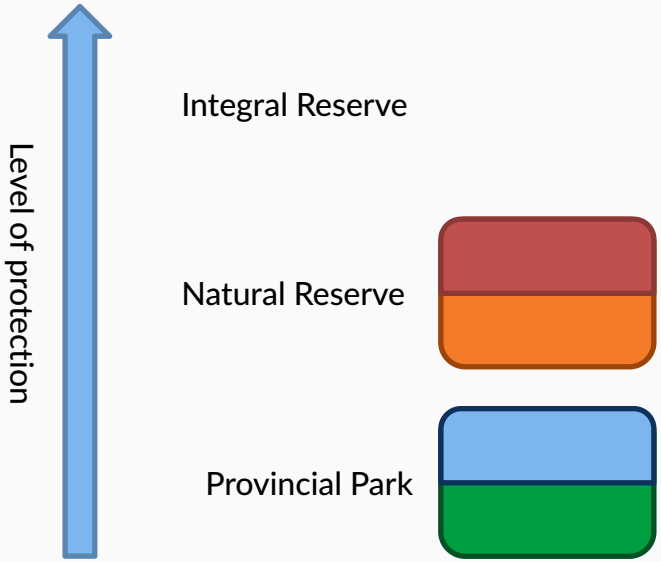
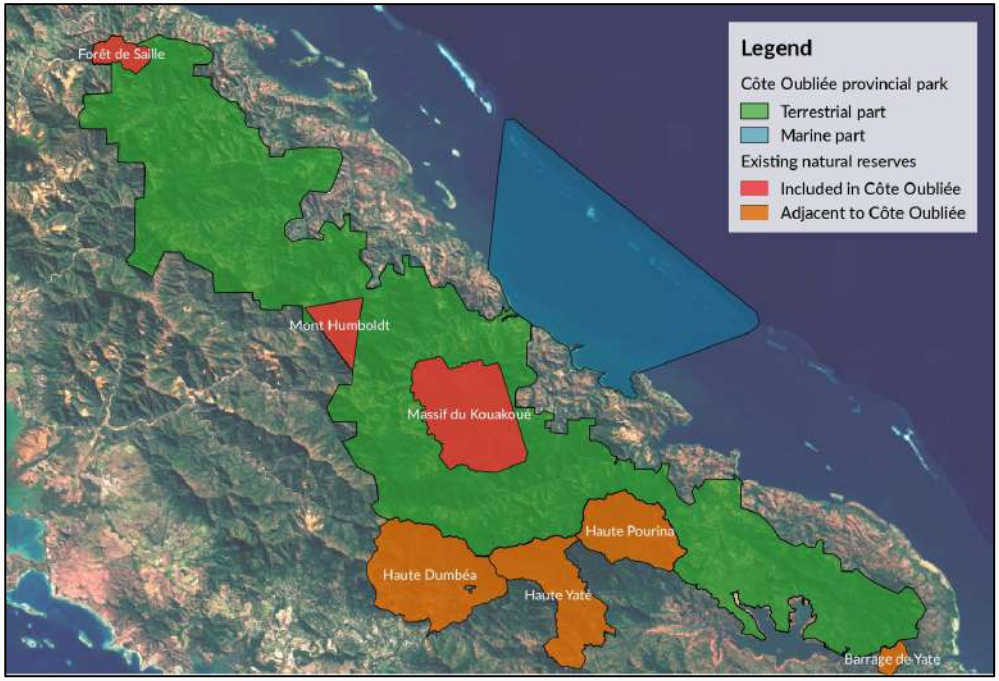
Aims: Identify prioritary areas for:

→ Connectivity (forest habitat + between existing reserves).

→ Environmental and Biodiversity conservation.

→ Ecosystemic services.



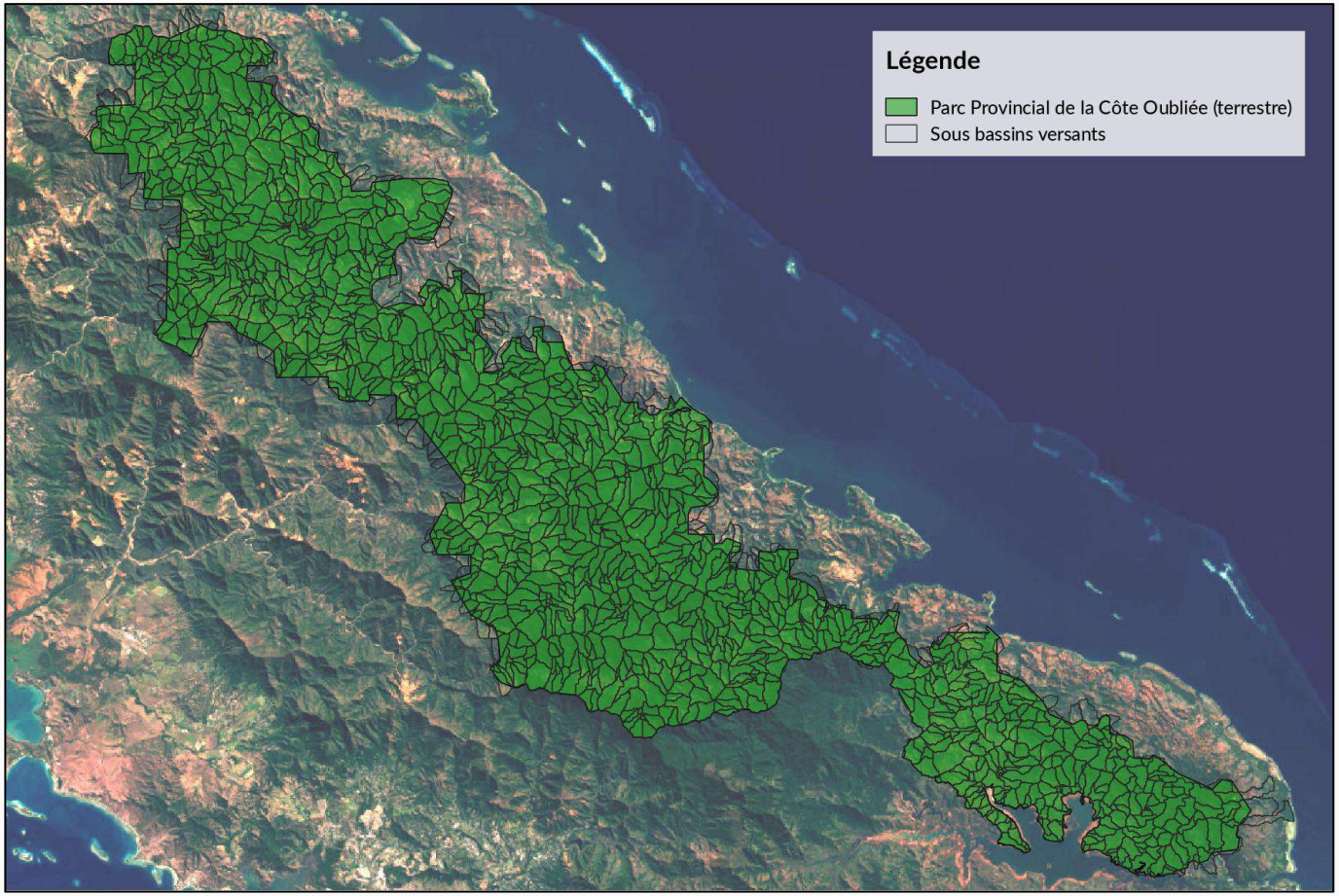


Preliminary results

An iterative questioning approach.

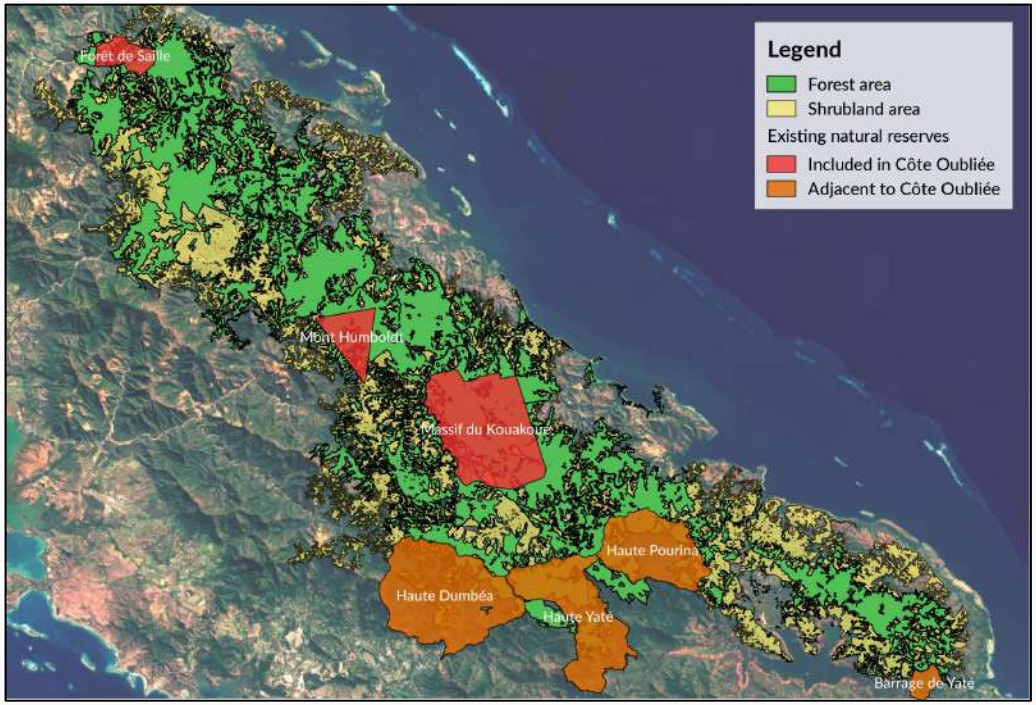
Subwatersheds as selection units

- Protection of the integrity and function of ecosystem processes on a subwatershed scale.
  [Klein et al. 2009, l'Oeil 2016].



Scenario 1.1 - Structural connectivity between existing reserves

- Input data : Forest coverage.
- Problem : Extend existing reserves such that they are all connected by forest.



Scenario 1.1 - Structural connectivity between existing reserves

- Input data : Forest coverage.
- Problem : Extend existing reserves such that they are all connected by forest.

  Answer : Not possible.

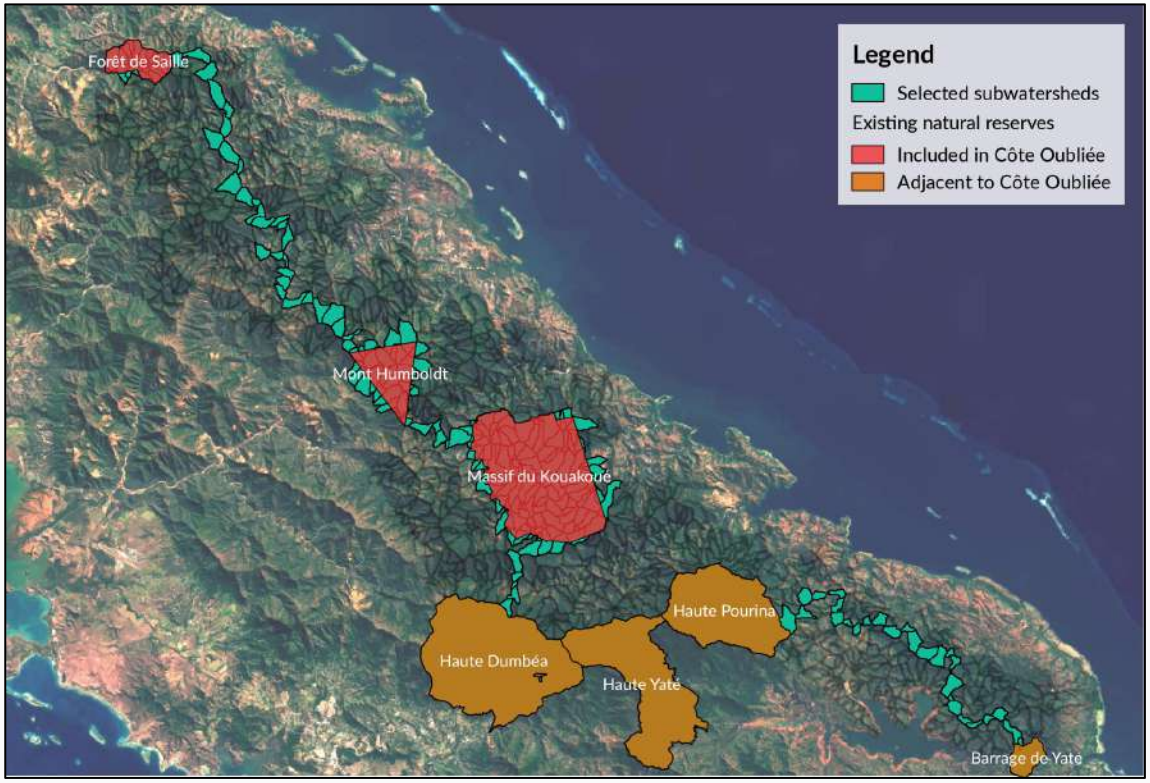
Scenario 1.2- Structural connectivity between existing reserves

- Problem : Can we connect existing reserves using ≤ 20% of the provincial park area ?

Scenario 1.2- Structural connectivity between existing reserves

- Problem : Can we connect existing reserves using ≤ 20% of the provincial park area ?

  Answer : Yes, below a 6 530 ha (~8% [1]) solution.



[1] of total provincial park area

Scenario 2 - Connectivity, Diversity and Integral Reserves

Input data :

Forest coverage;

Problem : Can we achieve 1.2 and :

Maximize the forest area;

Scenario 2 - Connectivity, Diversity and Integral Reserves

Input data :

- Forest coverage;
- Occurrences of Red List species;

Problem : Can we achieve 1.2 and :

- Maximize the forest area;
- Cover every Red List species;

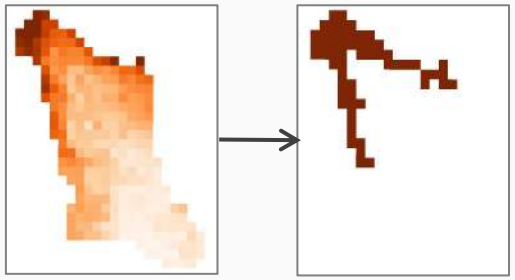
Scenario 2 - Connectivity, Diversity and Integral Reserves

Input data :

- Forest coverage;
- Occurrences of Red List species;
- SDMs of 335 tree species;

Problem : Can we achieve 1.2 and :

- Maximize the forest area;
- Cover every Red List species;
- Include ≥ 400 ha of suitable area for each tree species;



[Liu et al. 2005]
[Gurutzeta et al. 2014]
[Pouteau et al. 2019]

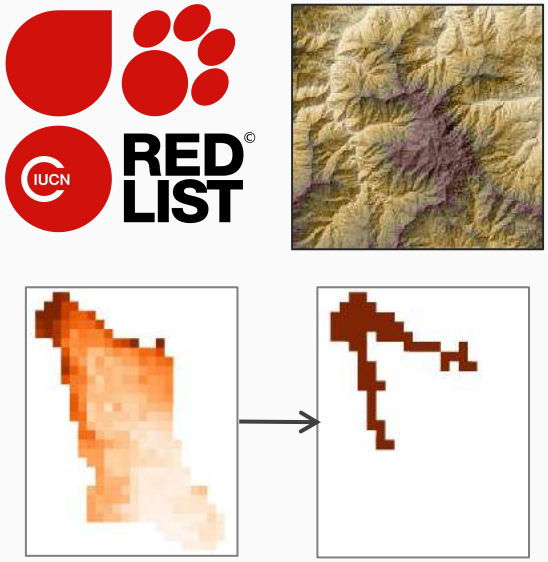
Scenario 2 - Connectivity, Diversity and Integral Reserves

Input data :

Forest coverage;
Occurrences of Red List species;
SDMs of 335 tree species;
Elevation (DEM).

Problem : Can we achieve 1.2 and :

Maximize the forest area;
Cover every Red List species;
Include ≥ 400 ha of suitable area for each tree species;
Identify integral reserve areas (climate refugia):
surrounded by natural reserve;
covering ≥ 90% of area ≥ 1100m ?



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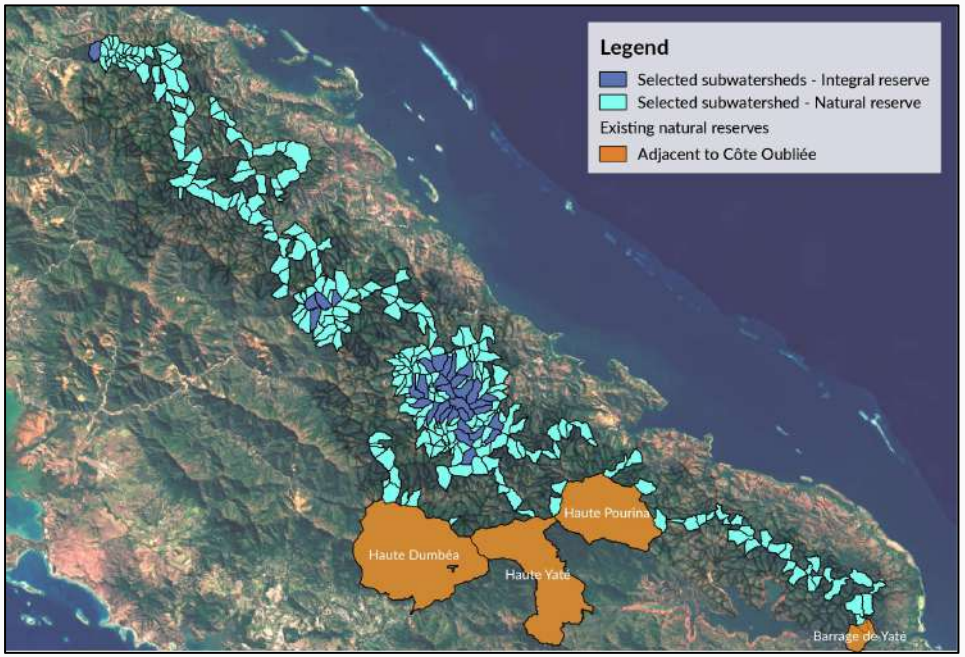
covering ≥ 90% of area ≥ 1100m ?

Answer :

Yes, here a 17 305ha (20%[1]) solution with 13 213ha (~27.4%[2]) of forest.



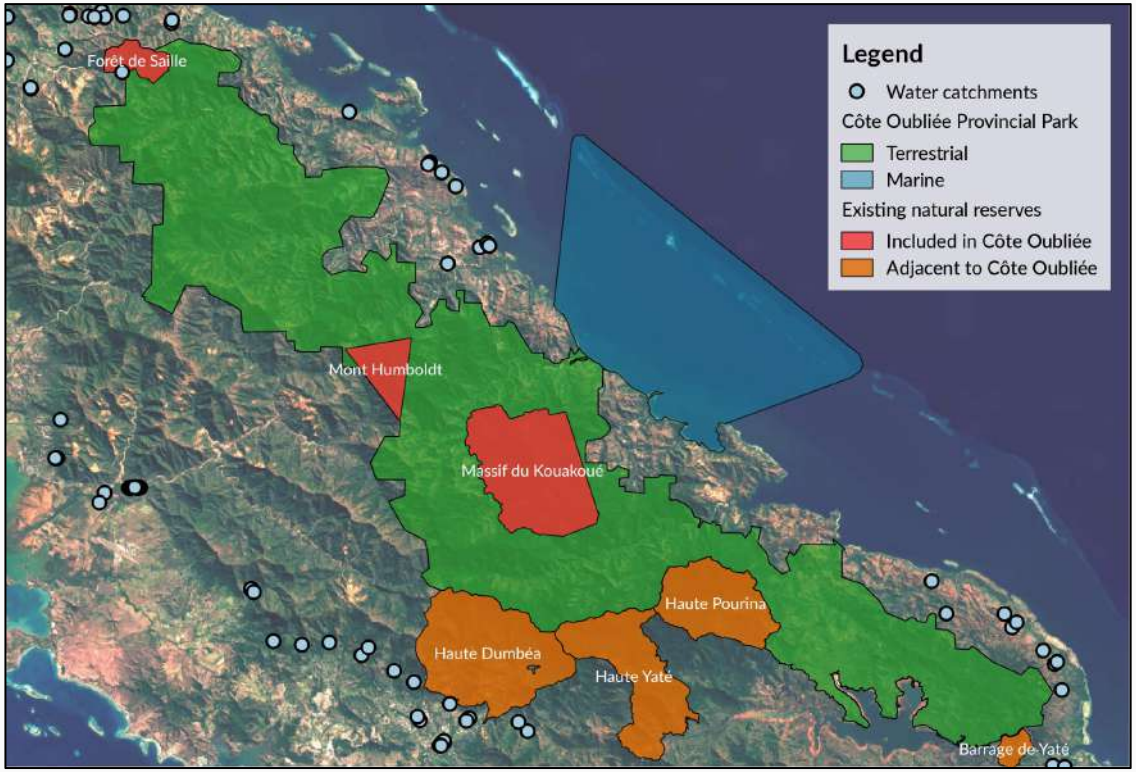
[1] of total provincial park area
[2] of total provincial park forest area

Perspectives

- Ecosystemic services

  Can we also protect subwatersheds alimenting freshwater catchment ?

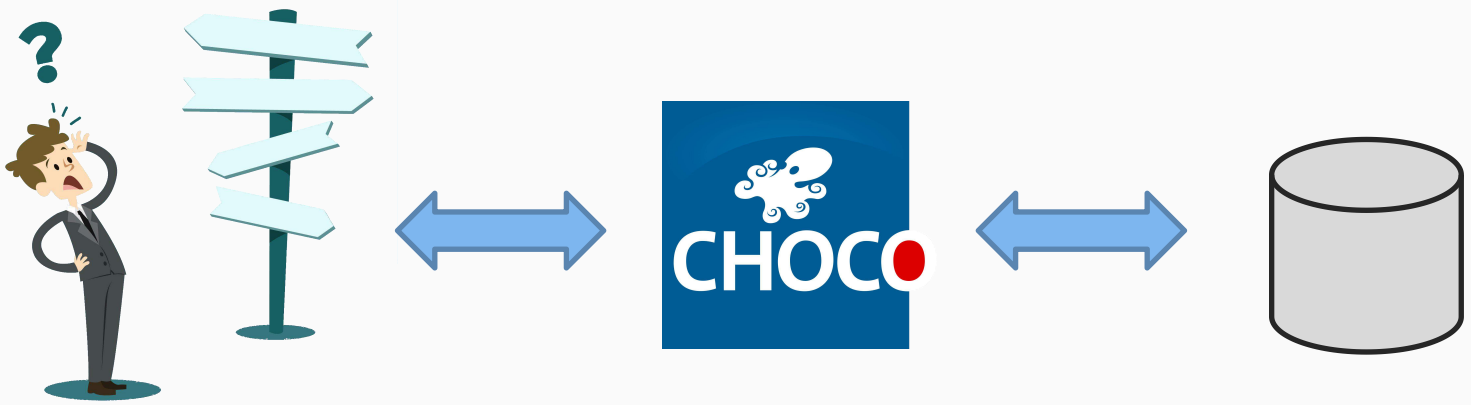
  Missing data : directed graph representing connections between subwatersheds.



Conclusion : A iterative **decision support** approach

- The model is an **exchange support** between managers and scientists.
- At each step:

  We state a problem and try to solve it with the model.
  According to the results, we **refine** it or **enrich** it.



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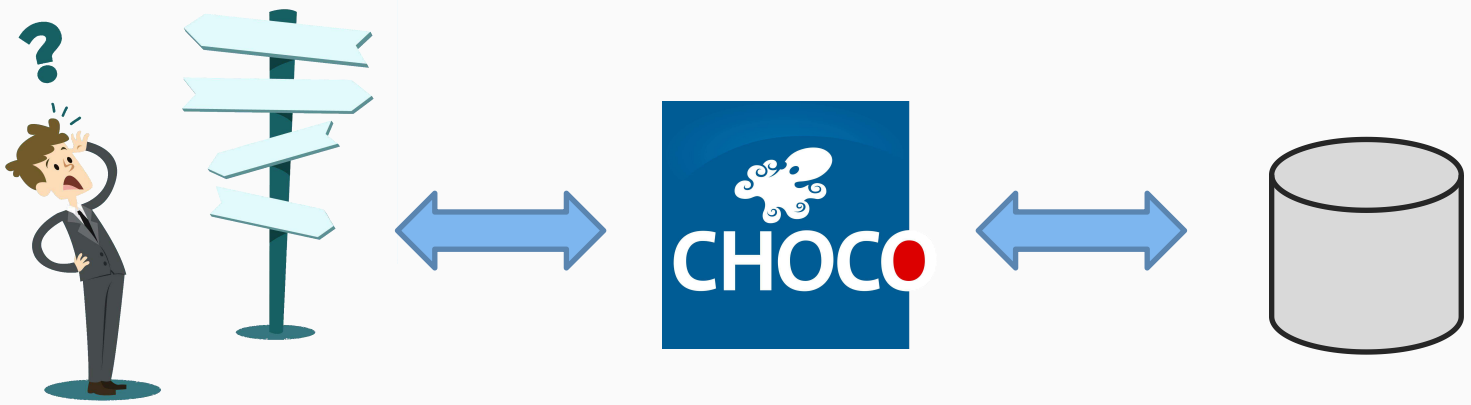
- The model is an **exchange support** between managers and scientists.
- At each step:

  We state a problem and try to solve it with the model.
  According to the results, we **refine** it or **enrich** it.

Take home message :

- The model is not a decision-making tool but a **decision support tool**.

  Ecological data is incomplete and innacurate.
  Produced maps only are a projection based on available data.
- What it does best: give a critical look at the data and the questions.



Thank you for listening !

Questions ?

Many thanks to :

Philippe Birnbaum
Nicolas Rinck
Thomas Ibanez
Christophe Botella
The NCPIPPN Team
Xavier Lorca
Emmanuel Coutures
Robin Pouteau
Philippe Vismara
and all of you !

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Island BIOLOGY La Réunion 8-13 JULY 2019