Using modeling approach as a decision support tool in French forest management in context of climate change

Marion Jourdan

Presentation for TED4LAT

INRAE

UMR Silva

Part II

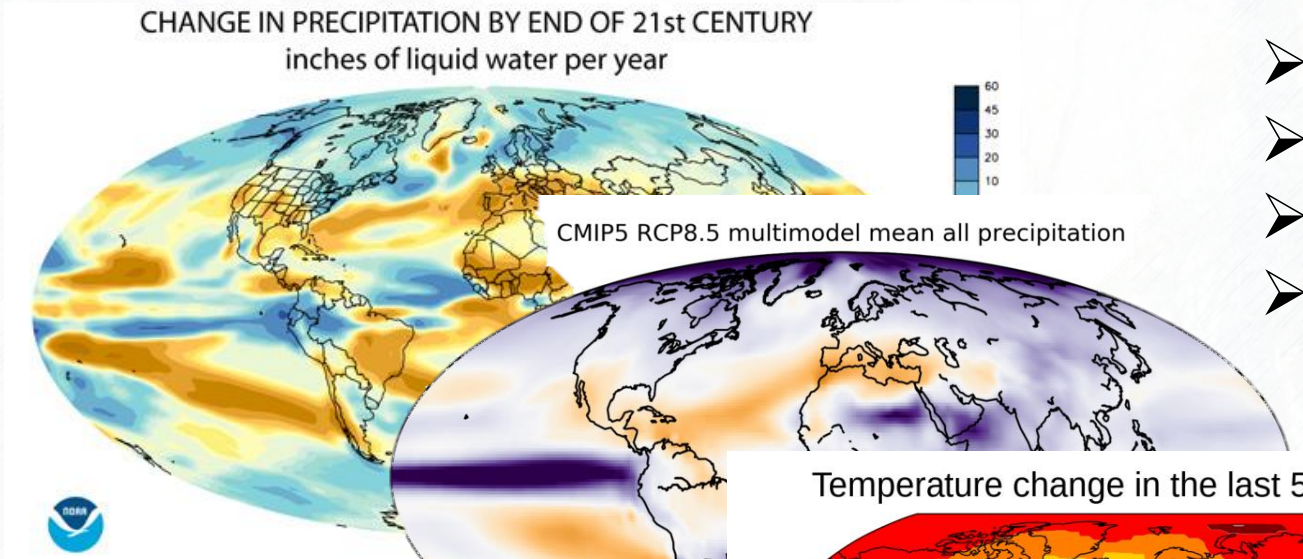
Using modeling approach as a decision support tool in French forest management in context of climate change

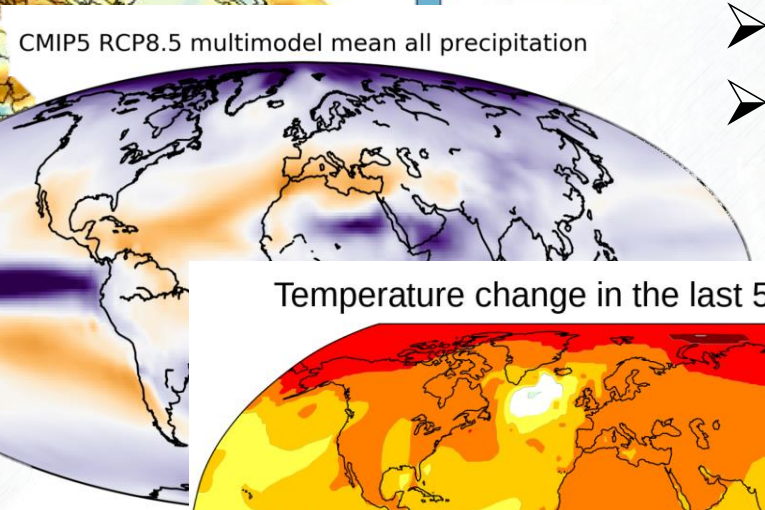
Part I

Example of research work

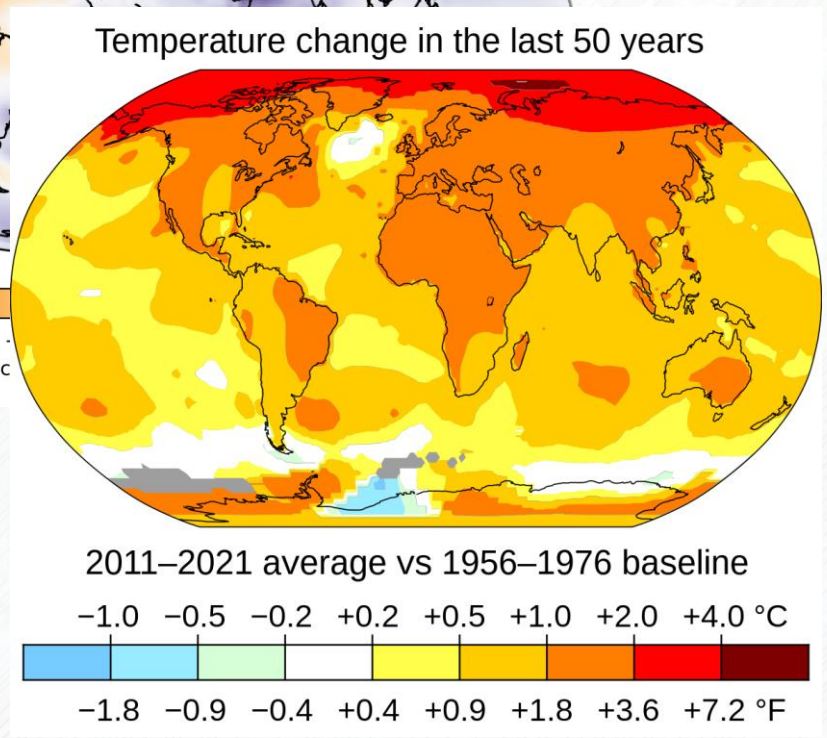
Part III

Global change context

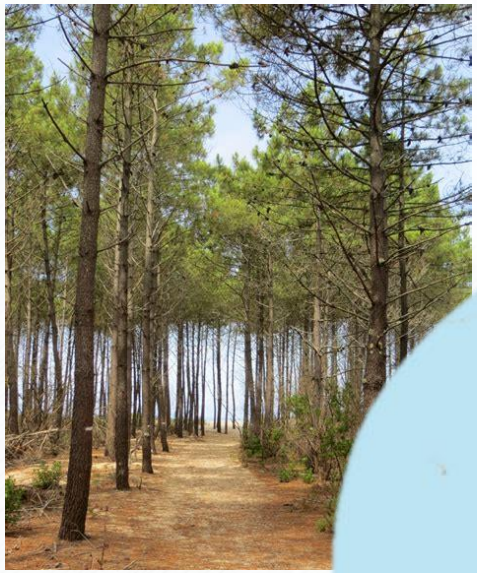


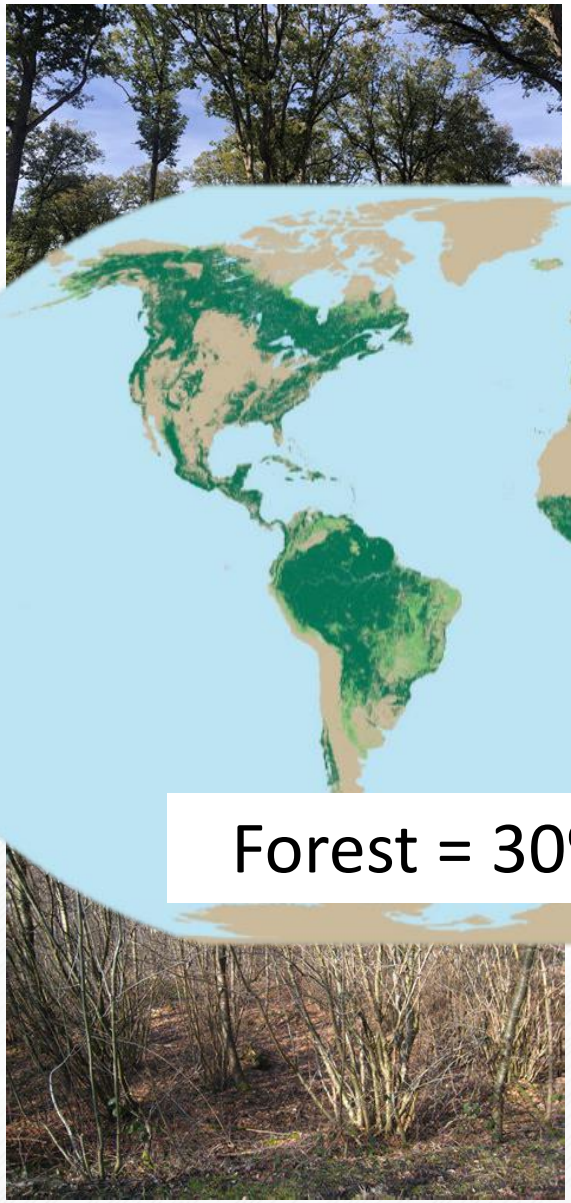


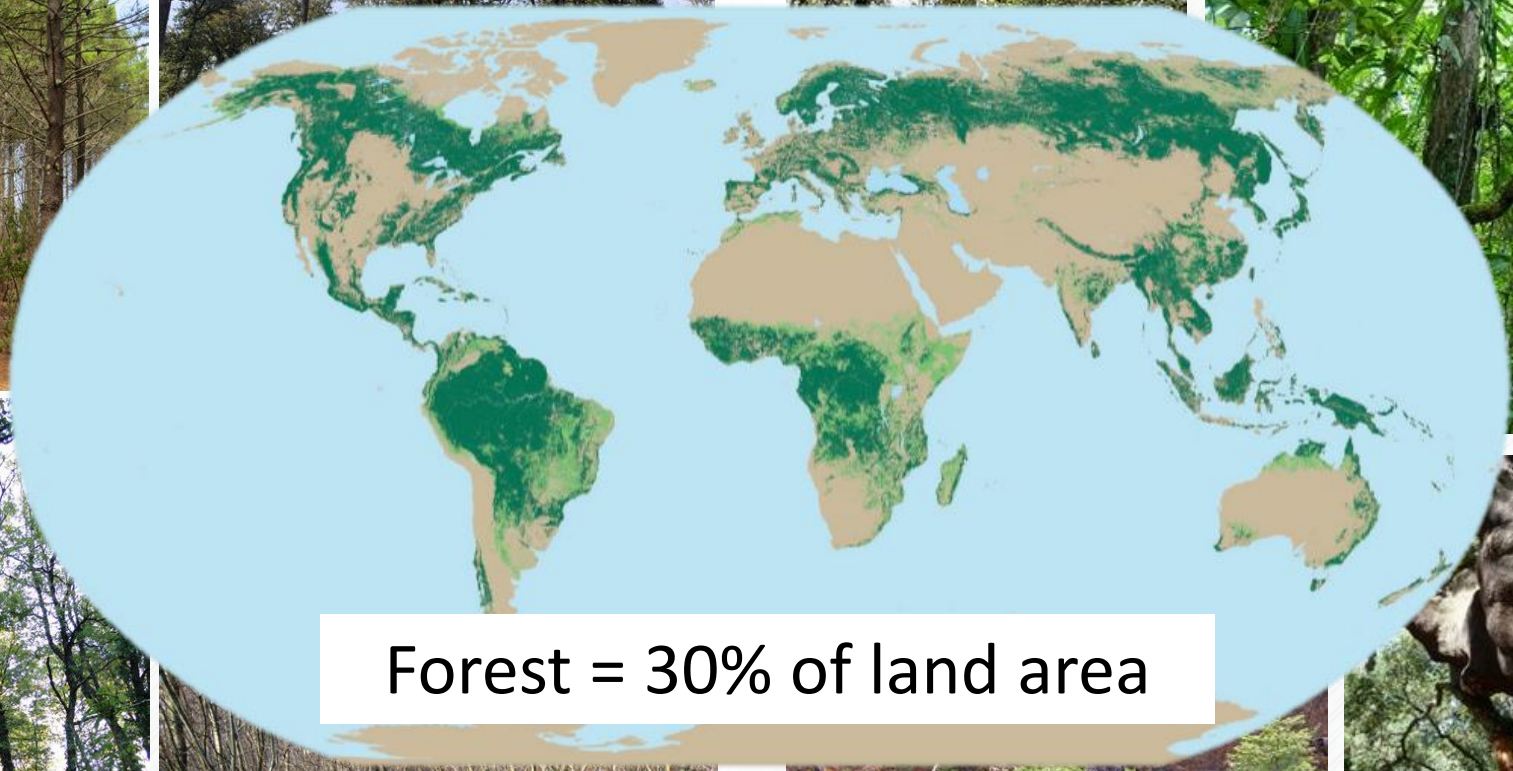
- Stronger/more frequent drought
- Higher temperature
- More extreme event
- Pathogen attacks



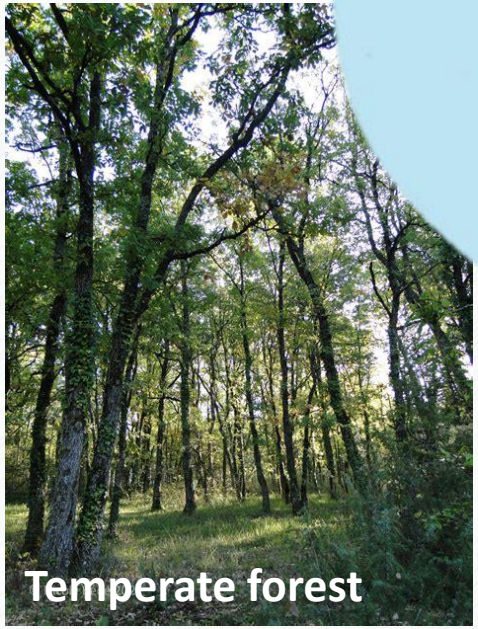
Forest around the world



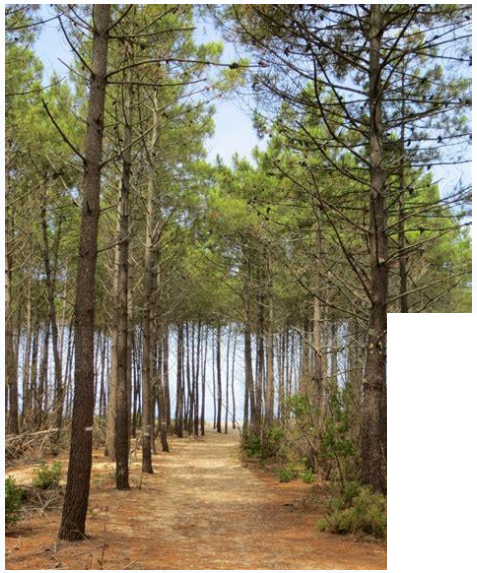




Forest = 30% of land area



Forest around the world

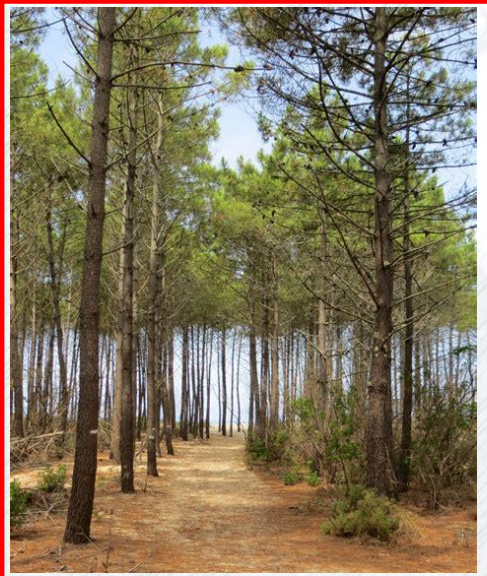


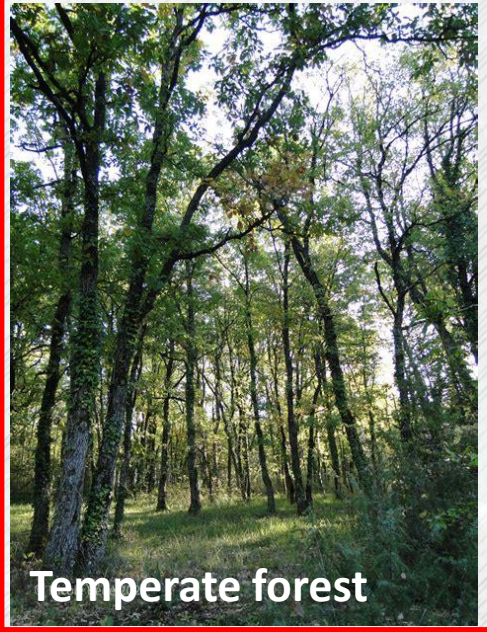
High structural diversity

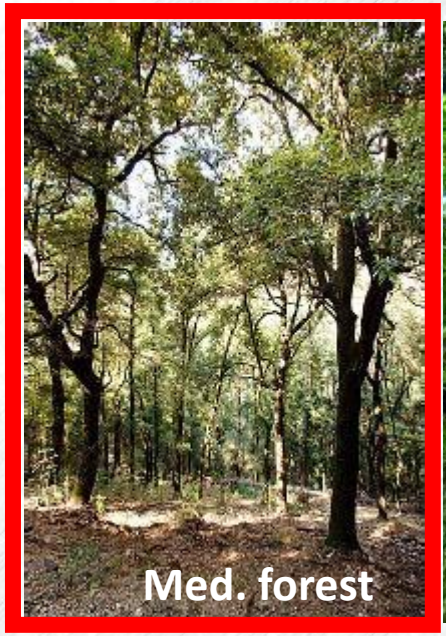
High species diversity

High biomes diversity

Forest around the world



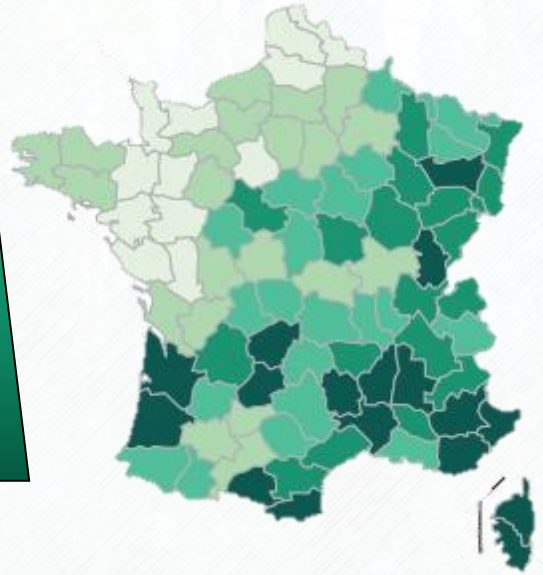




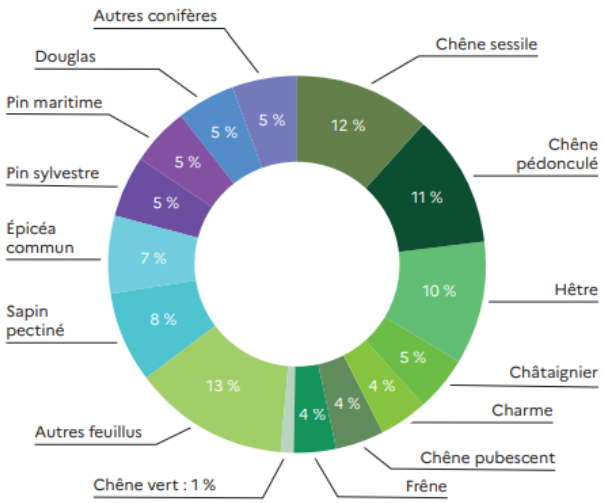
French forest

17,3 Mha

31%



1/3 Coniferous **2/3 hardwoods**

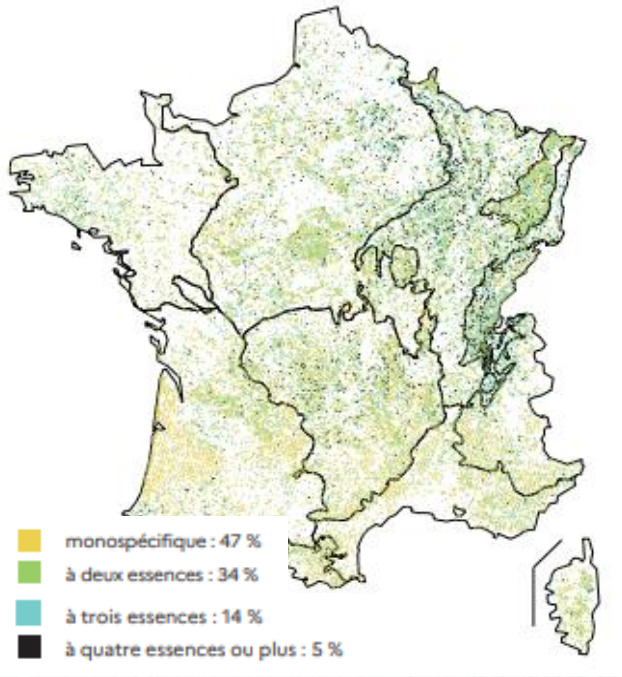


67 % de feuillus | **33 % de résineux**

8 essences principales

2700 Mm^3

47% monospecific stand



73 species

30 000 species

120 species

378 000 emplois

60 000 entreprises en France

Source : France Bois Forêt

2,8 milliards de m³ : volume des arbres vivants sur pied en forêt hexagonale

+ 50 % en 30 ans

Source : IGN memento Inventaire forestier 2023

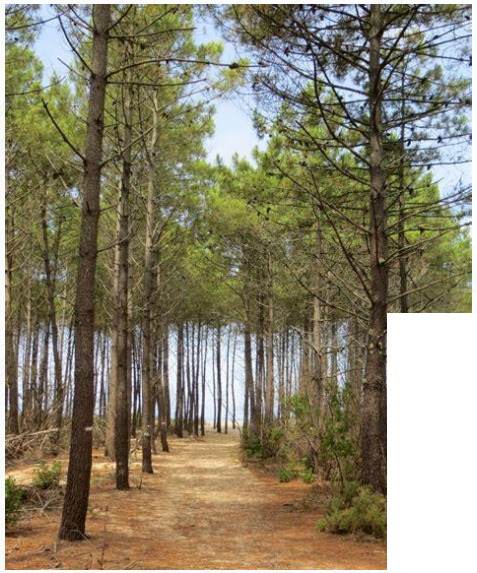
CHAQUE ANNÉE

87,8 millions de m³ d'accroissement naturel

51,4 millions de m³ de bois récoltés

Source : ONF

Forest around the world



High structural diversity

High species diversity

High biomes diversity

High diversity of use

Forest services and Society

*"**Ecosystem services** (ES) are the ecological characteristics, functions, or processes that **directly** or **indirectly** contribute to **human wellbeing**: that is, the benefits that people derive from functioning ecosystems"*

Costanza et al (1997)

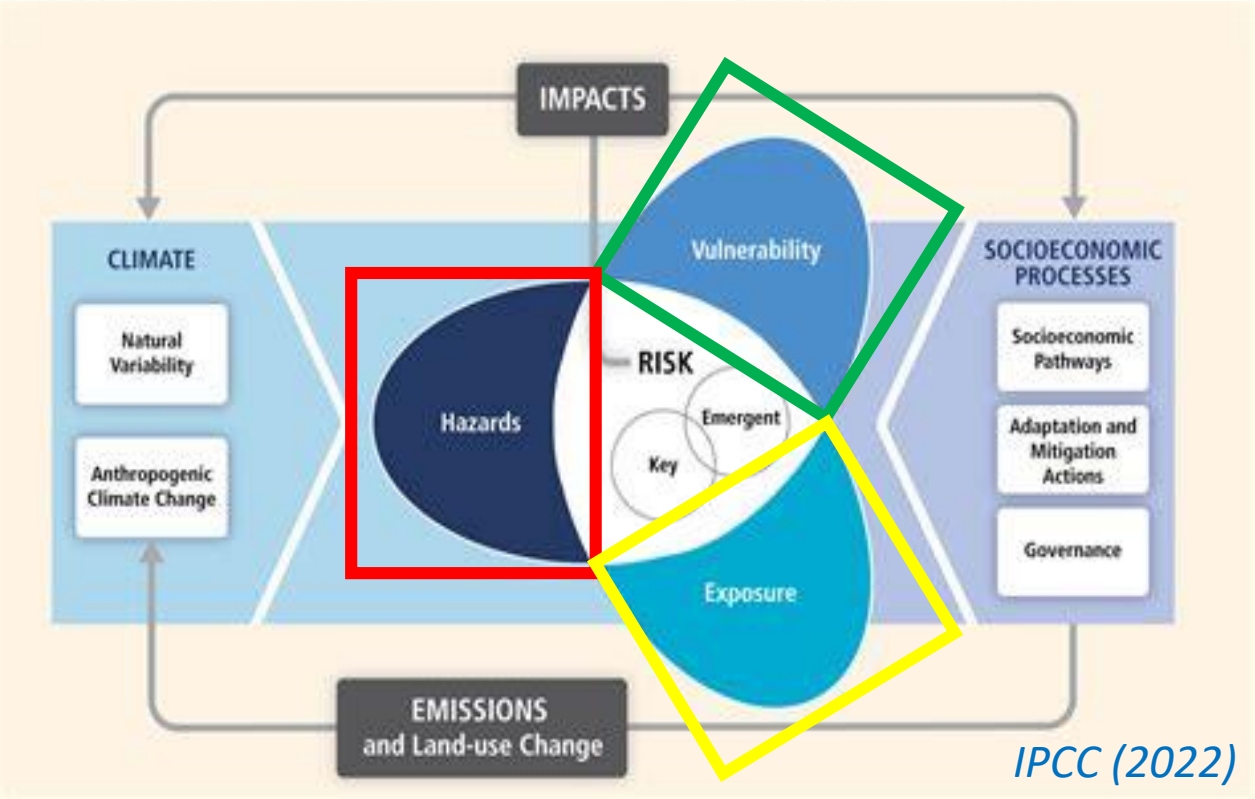
Human population protection

Wood production

Mental and physical health

Others species habitat

Risks in forest



IPCC (2022)

Multiple ecosystem services
→ **higher exposure** to impacts

Vulnerability factor are multiple :

- Lack of water
- Too high temperature
- Forest pathogen

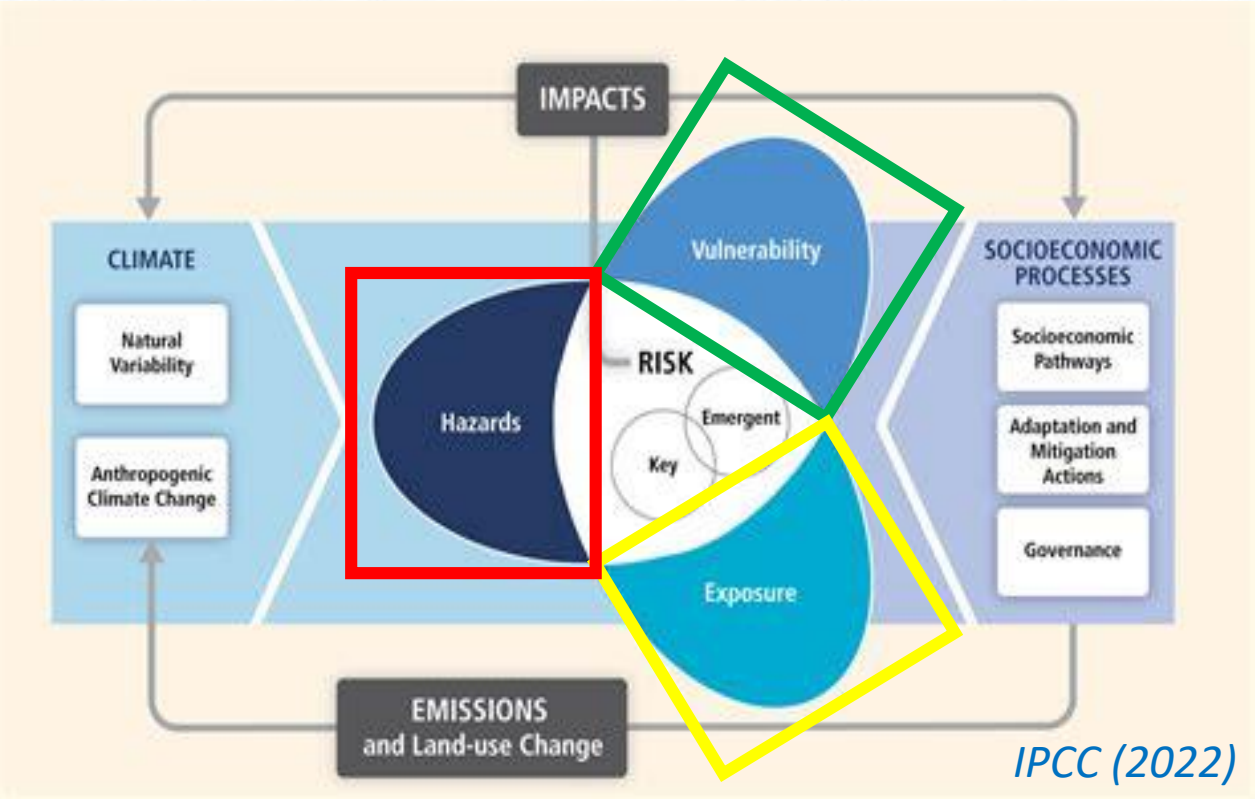
…

Increasing frequency of hazards :

- Fire
- Drought
- Pathogen attack

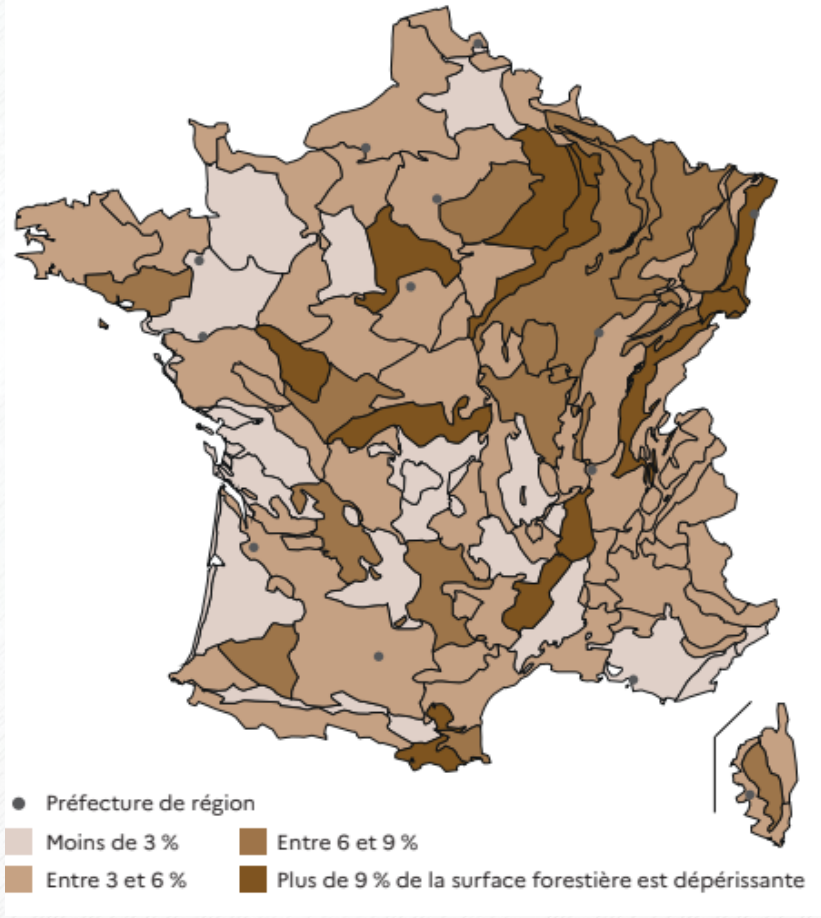
Risks in forest

Increasing risk for forest ecosystems functioning



IPCC (2022)

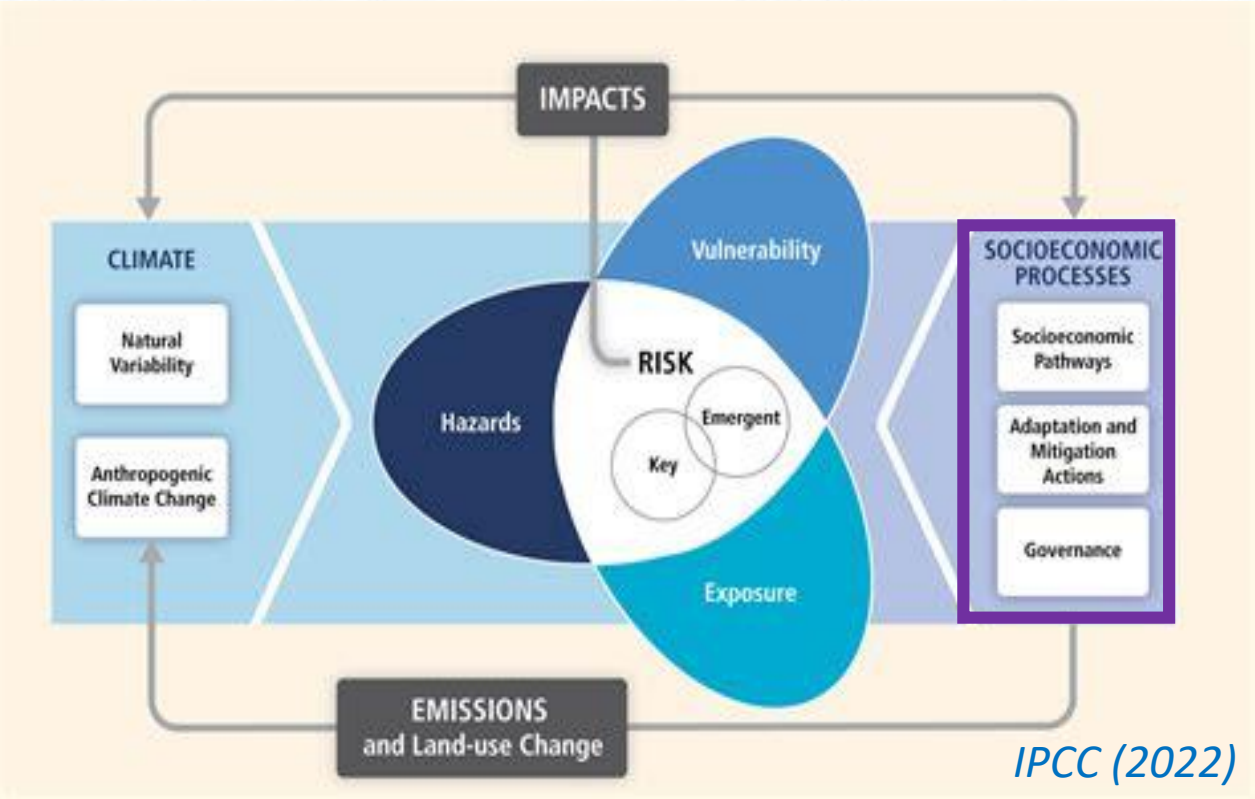
Percent of forest dieback



IGN, 2023

Risks in forest

Increasing risk for forest ecosystems functioning



IPCC (2022)

Forest management : A lever?

From governance…

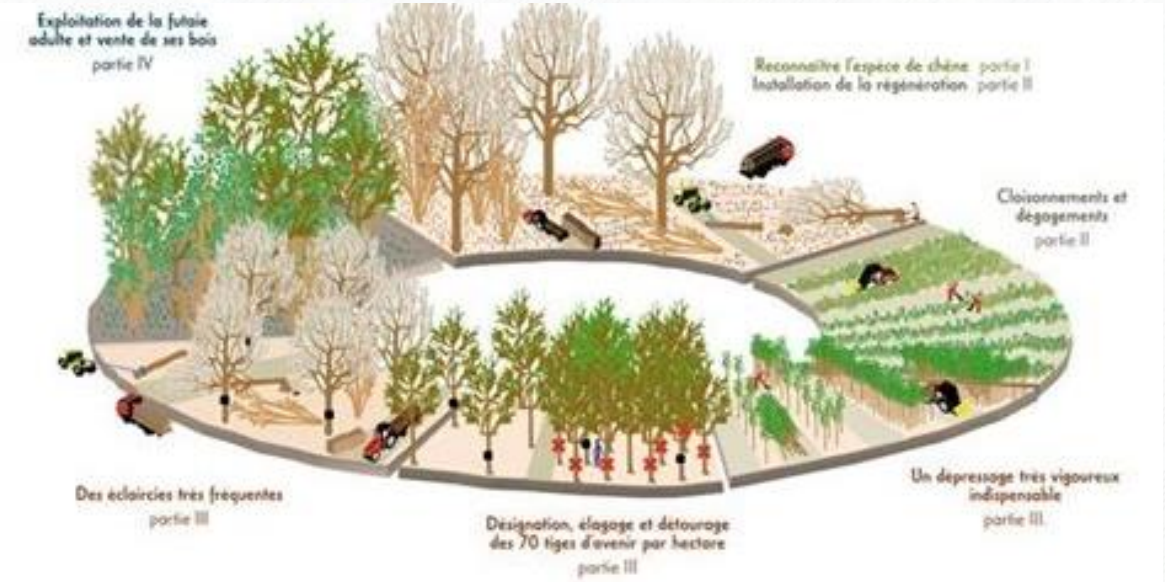
…to technical itinerary choices

Forest management transition

*"The practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the **regeneration, management**, utilization, and **conservation** of forests to meet specified goals and objectives while maintaining the productivity of the forest. Particularly, that branch of forestry concerned with the overall **administrative, economic, legal**, and **social aspects** and with the essentially scientific and **technical** aspects, especially silviculture, protection, and forest regulation. Includes management for **aesthetics**, fish, **recreation**, urban values, **water, wilderness, wildlife, wood products**, and other forest resource values."*

UBC (2009)

- **What do we act on? When do we act?**



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UBC (2009)

- **What do we act on?**
- **How do we act?**

Forest management transition

Act on :

- renewal type
- plantation species
- plantation density
- soil preparation
- protection type

- forest structure
- forest composition
- intervention frequency

Young stage and forest renewal

Adult stage

Forest management transition

*"The practical application of biological, physical, quantitative, managerial, economic, social, and policy principles to the **regeneration, management**, utilization, and **conservation** of forests to meet specified goals and objectives while maintaining the productivity of the forest. Particularly, that branch of forestry concerned with the overall **administrative, economic, legal**, and **social aspects** and with the essentially scientific and **technical** aspects, especially silviculture, protection, and forest regulation. Includes management for **aesthetics**, fish, **recreation**, urban values, **water, wilderness, wildlife, wood products**, and other forest resource values."*

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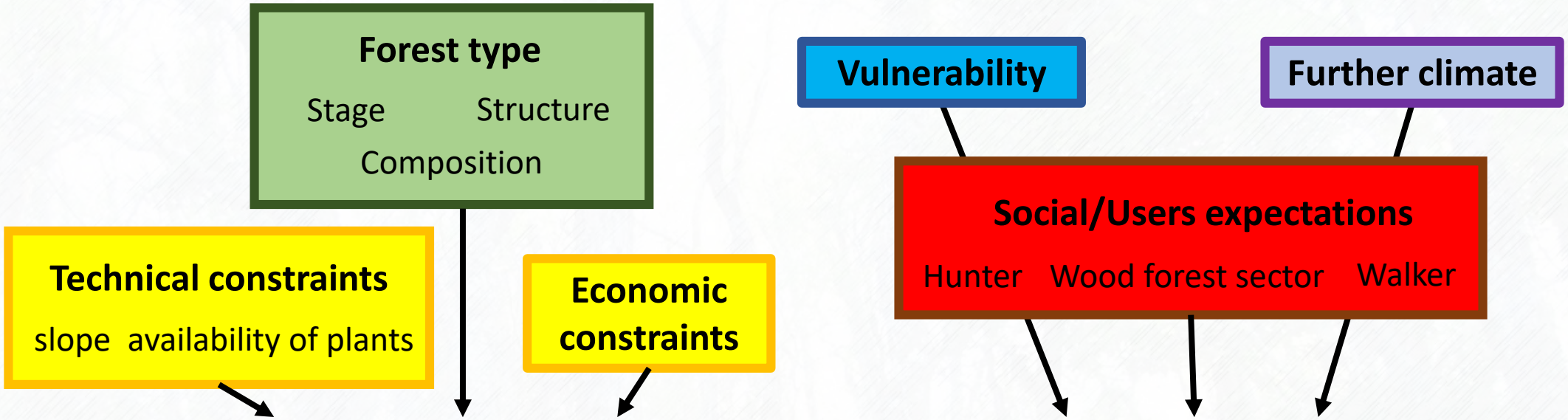
- **How do we act?**
- **Why do we act?**

Forest management transition

What are relevant forestry choice **in CC context**?

Forest management transition



What are relevant forestry choice **in CC context**?

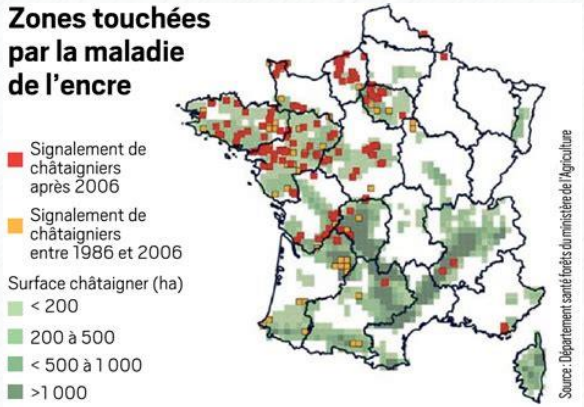
Major problems

- Several time scales
- Changing context
- Changing expectations

Forest management transition

- Actual management can be limited and even harmful

Structure choice

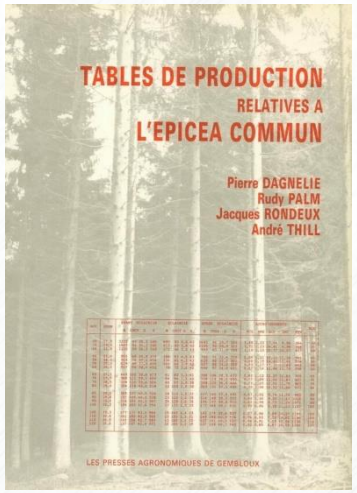


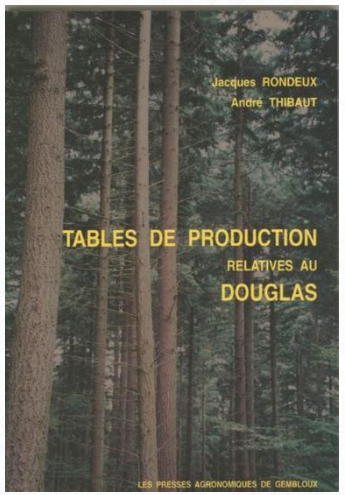
Species choice

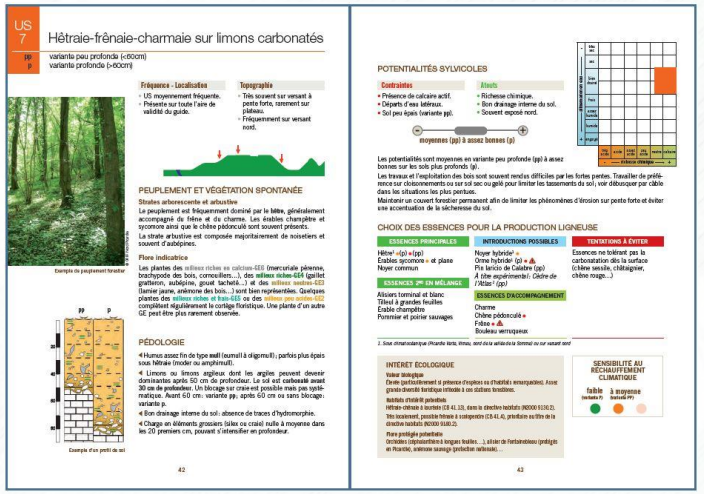
Need tools to help decision makers

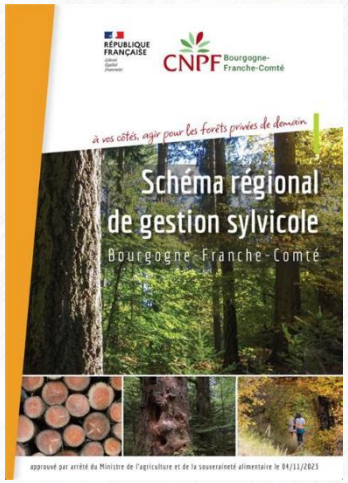
Need tools in forest management

Production tables, soil fertility keys, regional forest management plan…









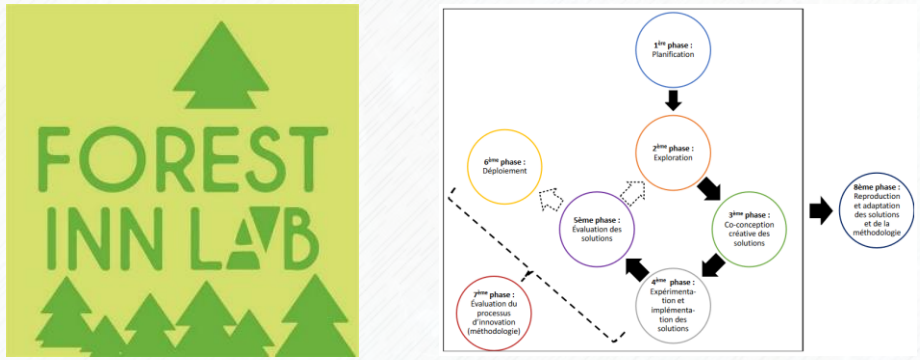
Allow to plan →
- Wood resource collect
- Forestry intervention

→
- organize thinning
- forestry work
- dimensioning wood sectors
- dimensioning forestry plant sector

Need tools in forest management

New tools/framework proposed by forest research

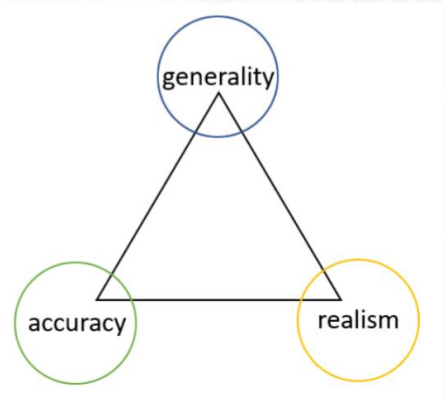
Integration of more forest actors in process decision



Arnould (2021)

https://www.youtube.com/watch?v=XhhKdiWLT68&ab_channel=GIPEcofor

Modeling approach



Levin (1966)

Need tools in forest management

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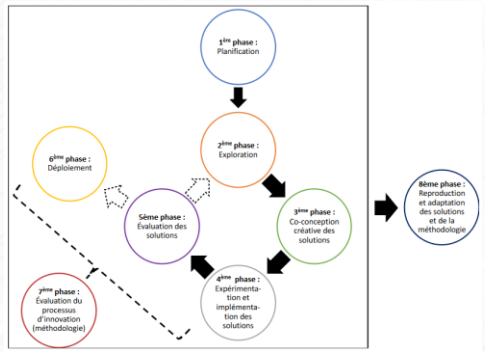

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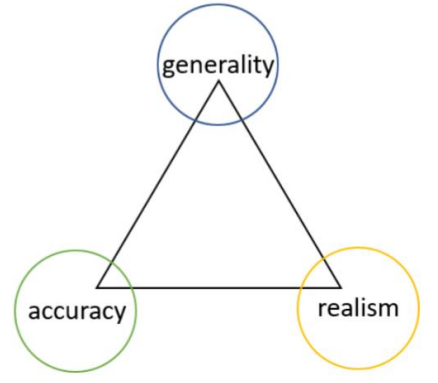
Modeling approach

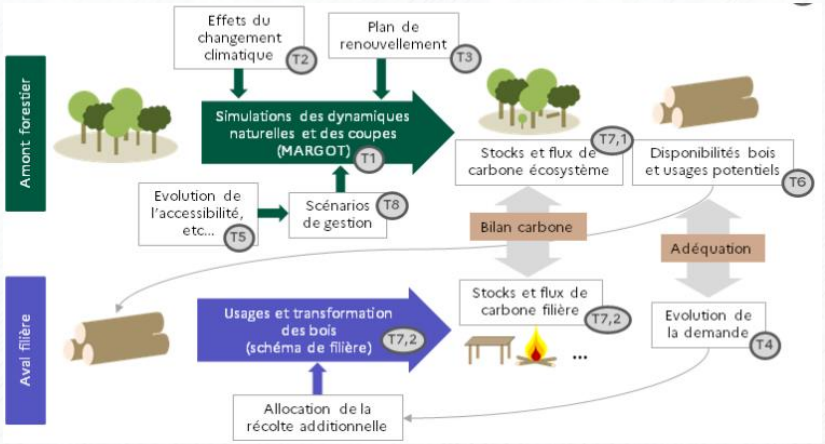


Levin (1966)

Use of modeling tools in forest management

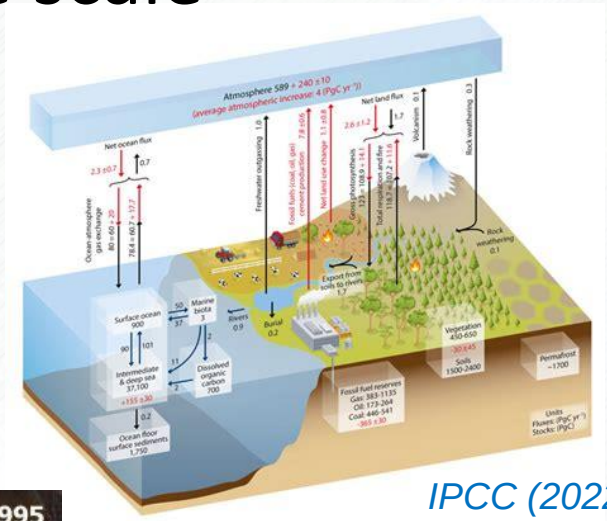
Model results help decision maker at large scale

National reports



Global with

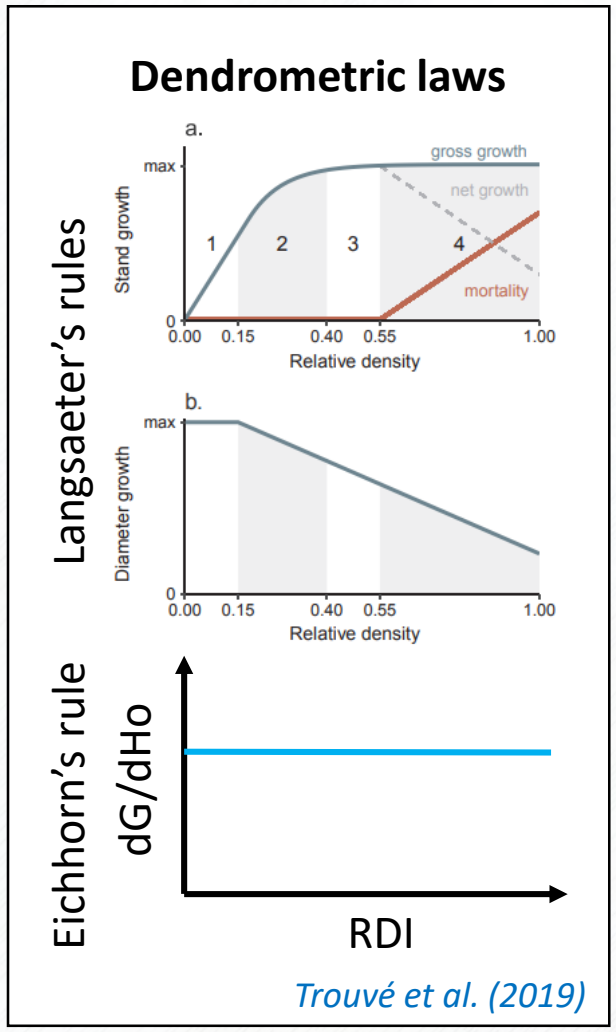
IPCC reports



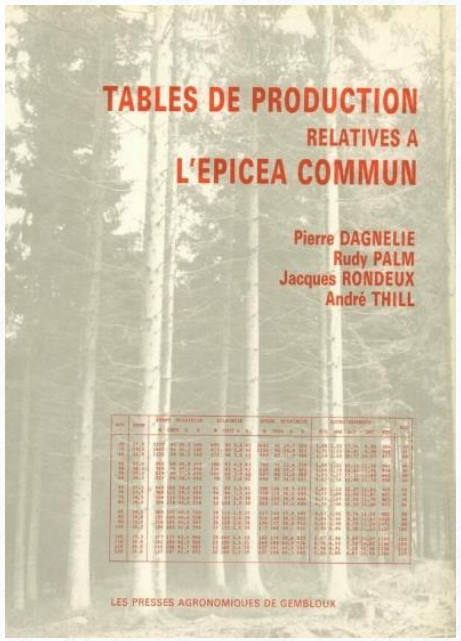
IPCC (2022)

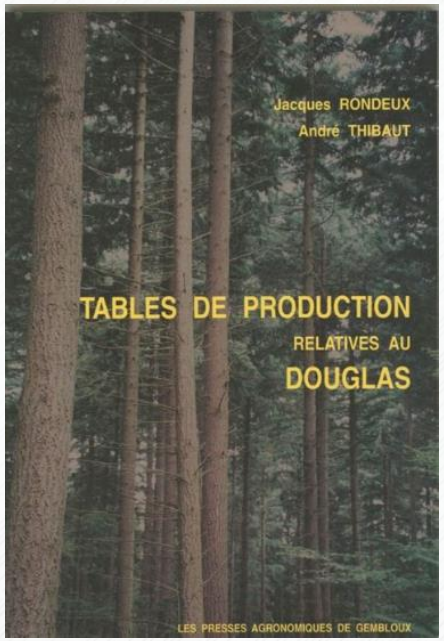
Use of modeling tools in forest management

From old modeling approaches…



Trouvé et al. (2019)





Use of modeling tools in forest management

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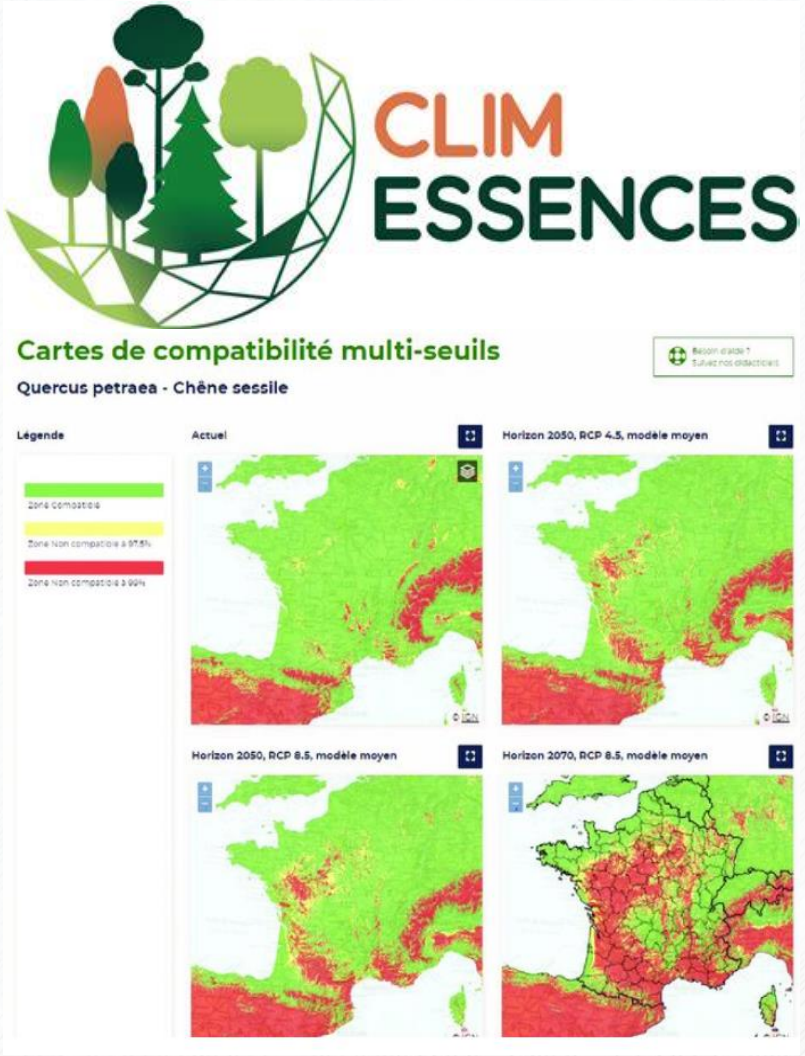


https://climessences.fr/node/2

Access to :

- bank of already simulated maps
- compatibility level in context of CC

Operational dimension :

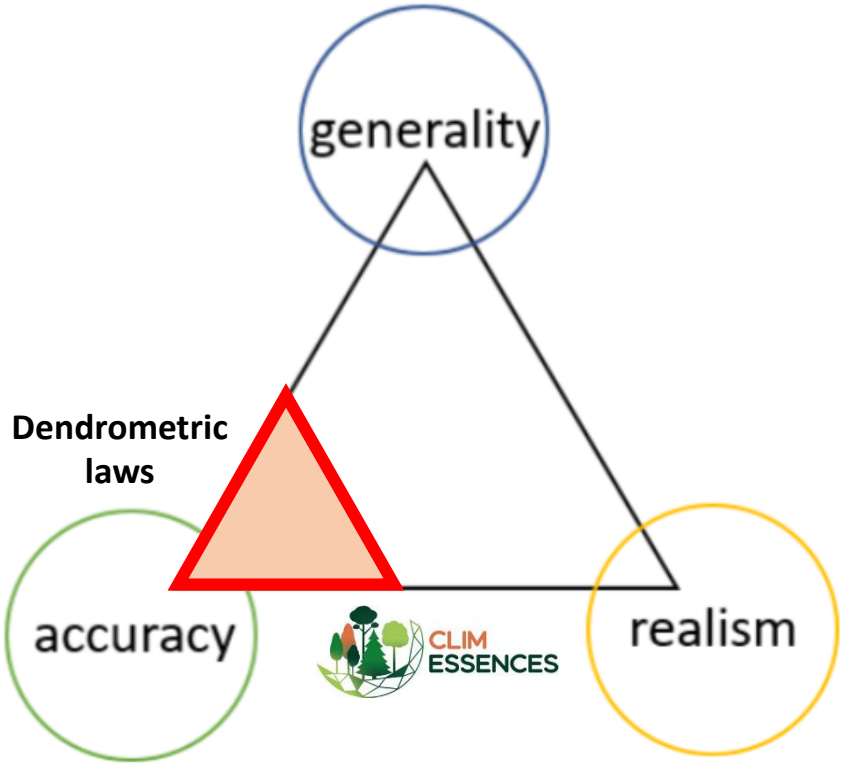
- Offers training before use
- Need no input data
- Very simplified model

Use of modeling tools in forest management

Levins' triangle (1966)

Desirable features... but trade-offs

- concept model, formal models
- "mechanistic" models: mathematical models, top-down logic
- "empirical" models: math./stat. models, bottom-up logic



Environnemental variables <-> Ecosystem responses

Use of modeling tools in forest management

From old modeling approaches…

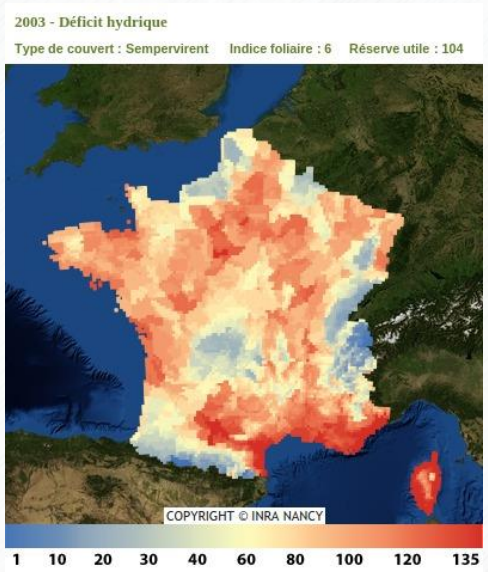
https://appgeodb.nancy.inra.fr/biljou/fr/

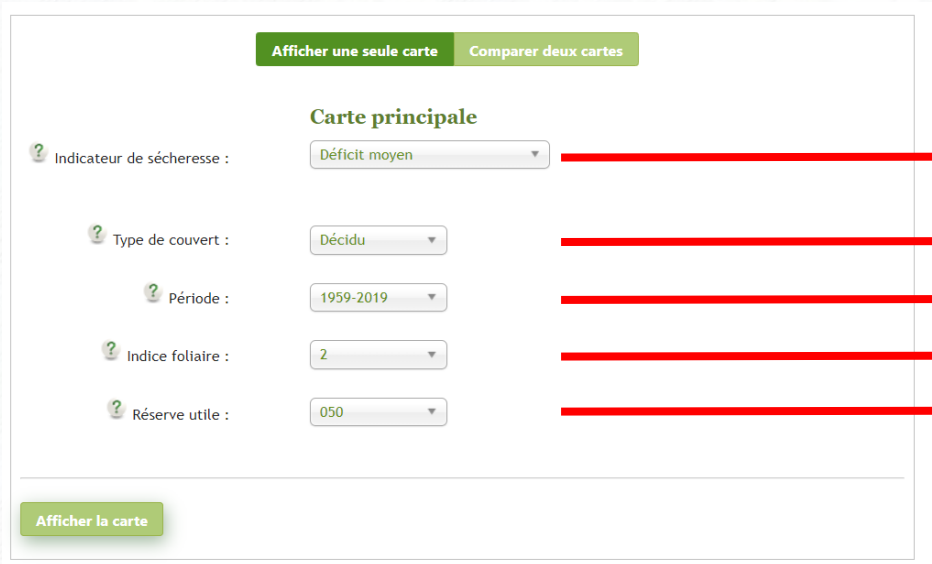
Access to :

- bank of already simulated maps
- drought indicators

Operational dimension :

- Offers training before use
- Need to know LAI





Drought indicator

Forest type

period

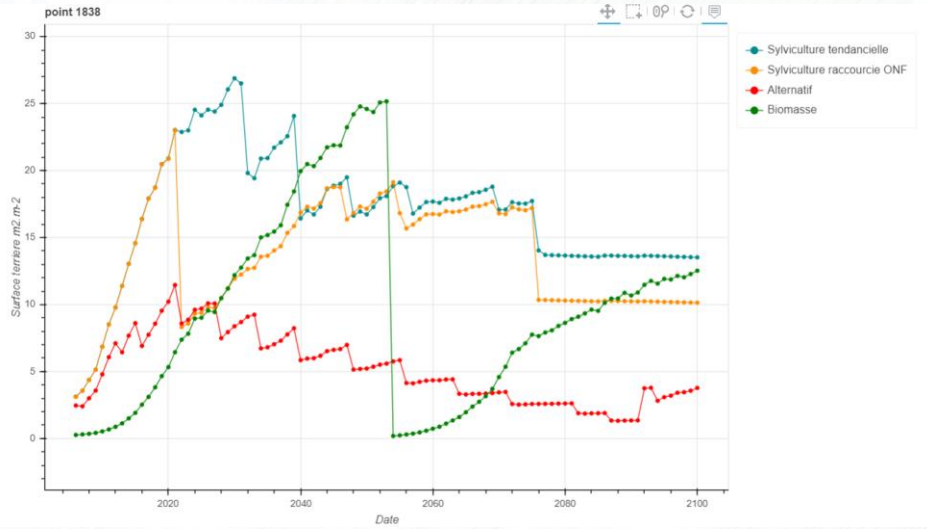
LAI

WUE

Use of modeling tools in forest management

…To new modeling approaches!

https://forets21.inra.fr/pelican3.1/



Stand metrics

Species

Period

- Climate
- Soil
- Forest itinerary

Just some combination already fixed

Use of modeling tools in forest management

Levins' triangle (1966)

Desirable features... but trade-offs

- concept model, formal models
- "mechanistic" models: mathematical models, top-down logic
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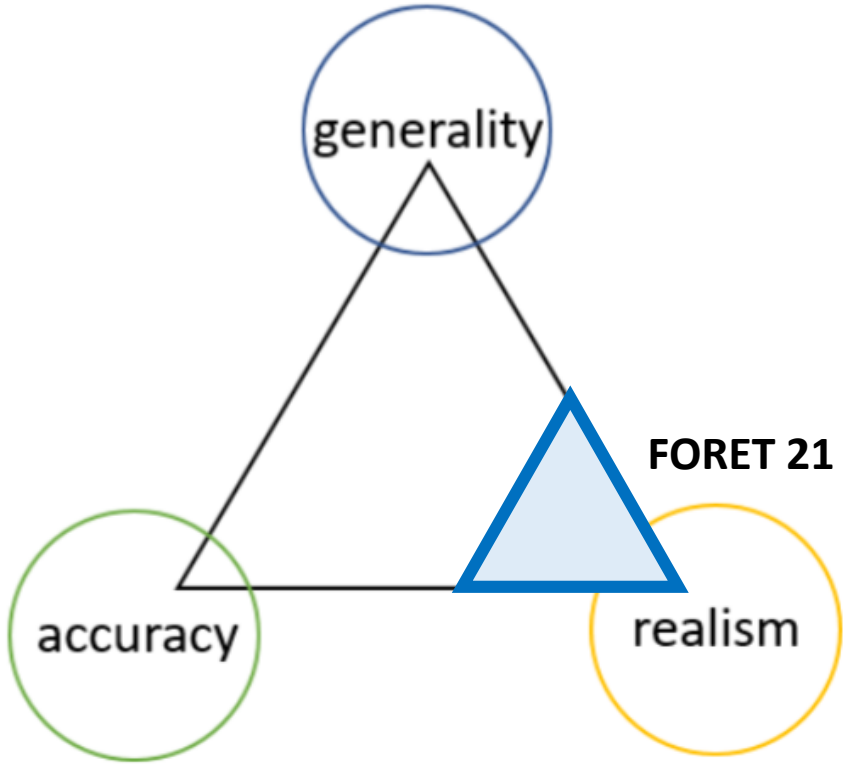


New generation of modeling tools are based on mechanistic models

Use of modeling tools in forest management

Expert evaluation

Socio-economic data

- Institutional documents
- Interview
- Living lab

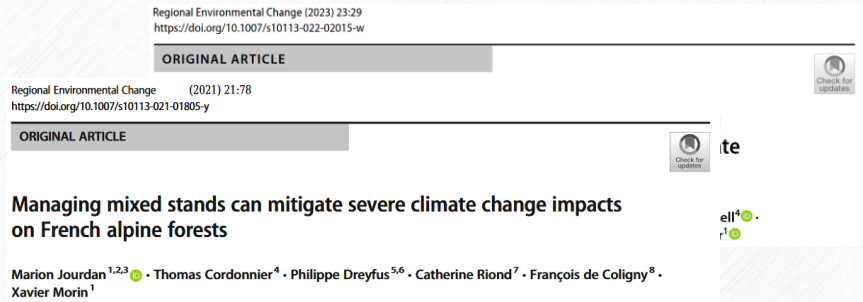
Management scenario → **Management module** + Edaphic data + Climate data

- Systematic simulations

Model 1

Model 3

Model 2


Regional Environmental Change (2023) 23:29
https://doi.org/10.1007/s10113-022-02015-w

ORIGINAL ARTICLE

Regional Environmental Change (2021) 21:78
https://doi.org/10.1007/s10113-021-01805-y

ORIGINAL ARTICLE

Managing mixed stands can mitigate severe climate change impacts on French alpine forests

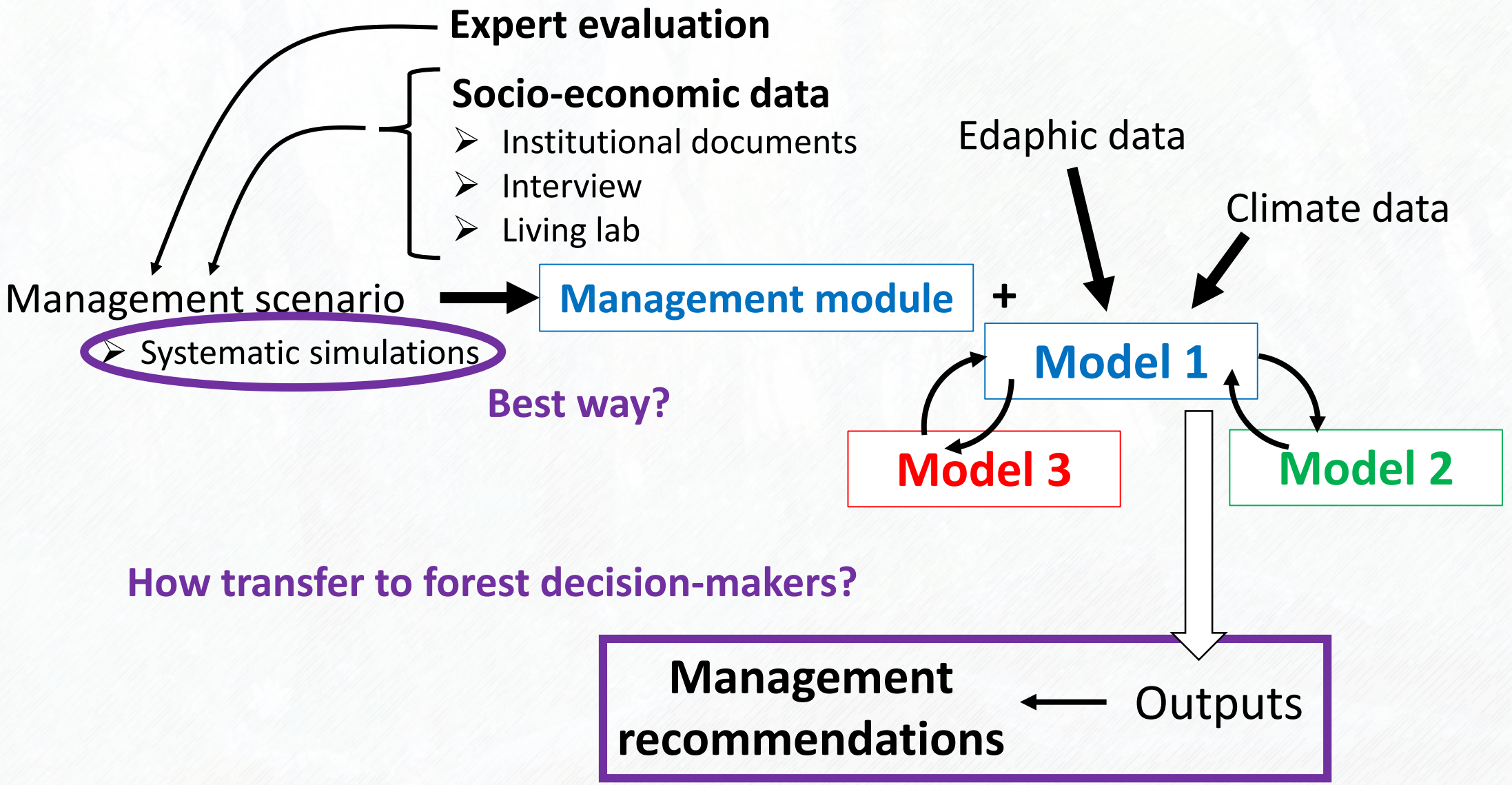
Marion Jourdan [1,2,3] · Thomas Cordonnier [4] · Philippe Dreyfus [5,6] · Catherine Riond [7] · François de Coligny [8] · Xavier Morin [1]

Jourdan et al. (2021), Thrippleton et al. (2023)

- MOPROF (APR GRAINE, 2019-22)
- FORET 21
- FISSA (ANR, 2021-25)

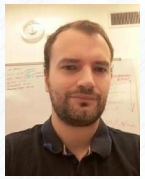
Outputs → **Management recommendations**

Use of modeling tools in forest management



Control theory – mecanistic modeling - DAPP





Need of civil society:

- Decision-making tool for innovative solutions, integrating multiple risks in forest
- Takeover by stakeholders of these tools

Objective: To propose a range of innovative management scenarios, by developing a generalizable decision-making tool based on forest modeling.

Mecanistic model

+

Decisional method

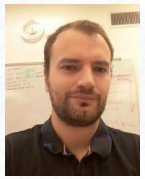
+

Visualisation tool

Join with actor consultation

Control theory – mecanistic modeling - DAPP





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Malara et al. (in prep)

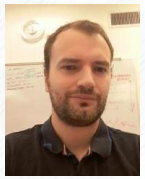
Mecanistic model + **Decisional method** + **Visualisation tool** = **Gap-model**

Decisional method + **Visualisation tool** = **Control theory**

Join with actor consultation

Control theory – mecanistic modeling - DAPP





Need of civil society:

- Decision-making tool for innovative solutions, integrating multiple risks in forest
- Takeover by stakeholders of these tools

Objective: To propose a range of innovative management scenarios, by developing a generalizable decision-making tool based on forest modeling.


- *Alice Roy PhD*
- *Clémentine de Montgolfier PhD*

Mecanistic model = **Gap-model**

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Decisional method = **Control theory**

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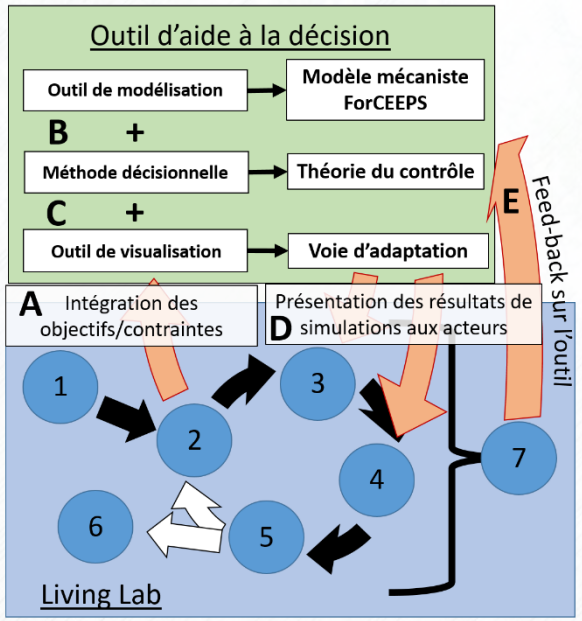
Visualisation tool = **DAPP**

Join with actor consultation = **Living Lab**

Control theory – mecanistic modeling - DAPP



Work in progress

Promising potential:

- Work at different scales
- With different levels of complexity
  - Social aspects
  - Ecosystem functioning
  - Management

Technical challenges:

- Use control theory with complex system
- Transfer of this modelling approach to manager

Numerous operational questions:

- How to manage your forest property in a multifunctional manner in the context of climate change?
- How to manage a multi-owner forest massif in a concerted and multifunctional manner?

➢ *Alice Roy PhD*

➢ *Clémentine de Montgolfier PhD*

Conclusion and perspectives

Forest functioning ⟺ Forest management

→ **Complex system**

Multiples historic tools are available

But changing climatic and socio-economic context ⇨ increasing complexity

→ Need new tools : modeling approaches can be solutions

→ Need further development with help of forest actors

Use model in operational conditions :

- Living Lab
- practical training

Think about modeling practices with forest managers :

- COLIBRI project

AFORCE

Thank you

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