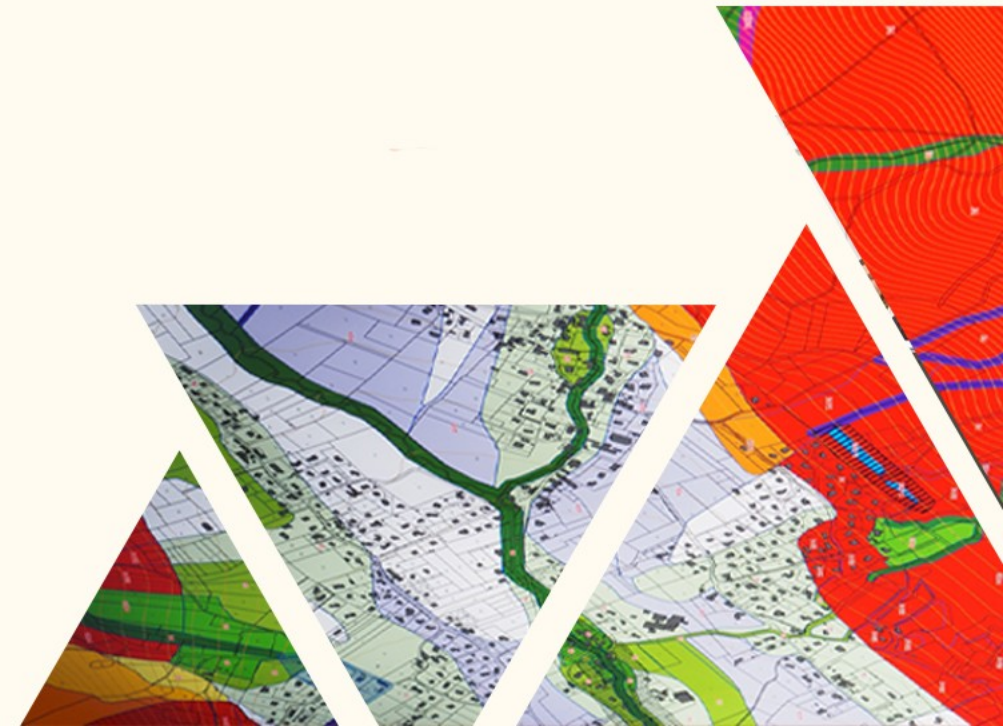




Forests and multiple risks

Eric RIGOLOT, INRAE-URFM, Avignon

INRAE



Presentation outline

RISK
Summer
School
2024

• Risks related to forest fires

- Application of the IPCC risk framework
 - ✓ Risk components
 - ✓ Risk assessment and risk management
- Daily forest fire hazard
 - ✓ The Firelihood model
 - ✓ Projections of forest fire activities for France

• Multi-risks related to forests

- Conceptual frameworks and terminology
- Some examples
 - ✓ Examples in the forest domain
- X-RISKS target project from PEPR FORESTT



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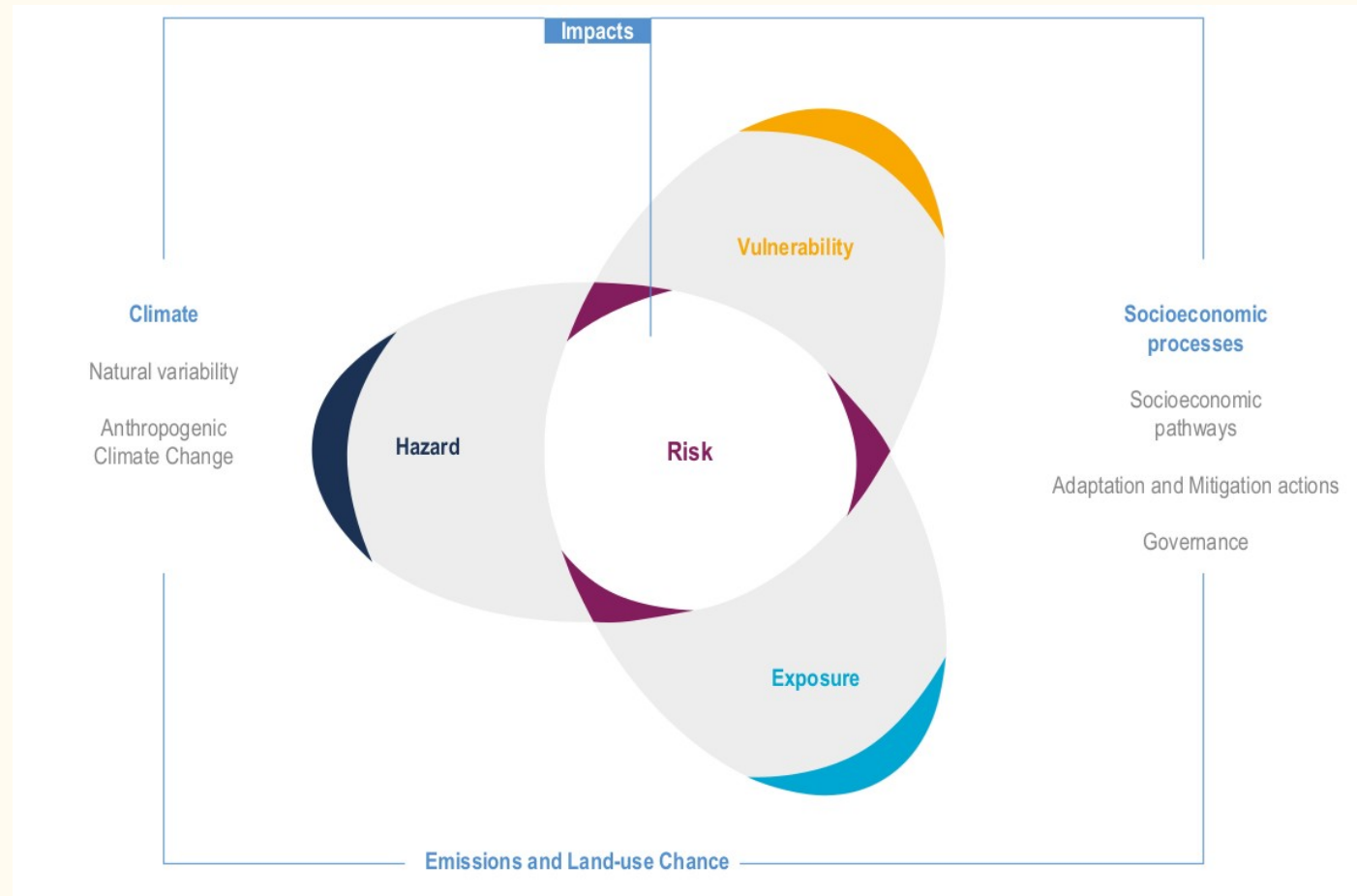
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The IPCC concept of risk (2014)

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[IPCC-AR6-WGII, 2022]

Forest fire risks

Risk components



Fire occurrence

- meteorology
- vegetation sensitivity
- fire ignition

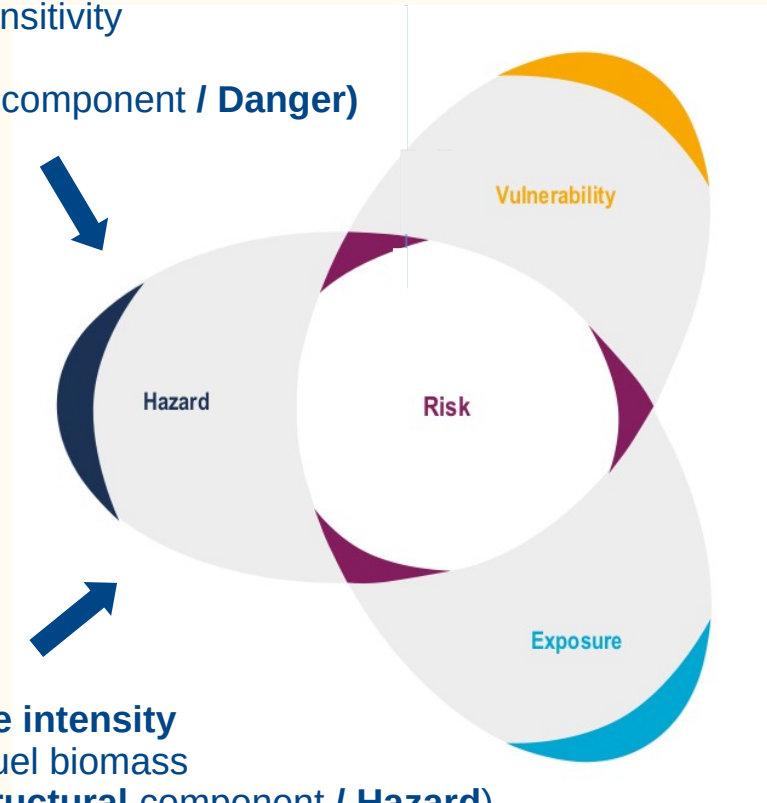
(**conjunctural** component / **Danger**)



Fire intensity

- Fuel biomass

(**structural** component / **Hazard**)



Forest fire risks

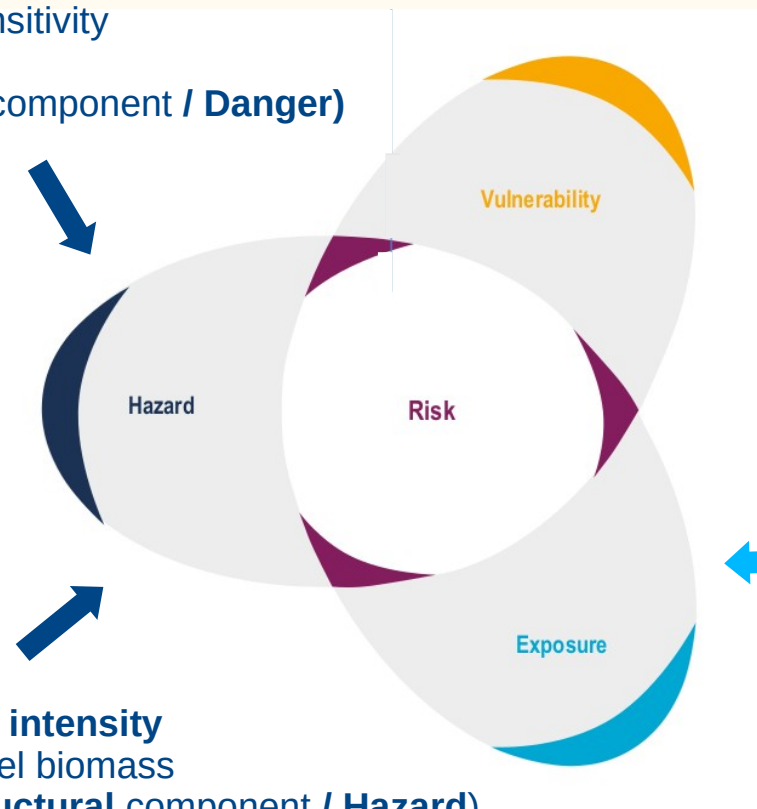
Risk components

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Fire occurrence

- meteorology
- vegetation sensitivity
- fire ignition

(conjunctural component / Danger)

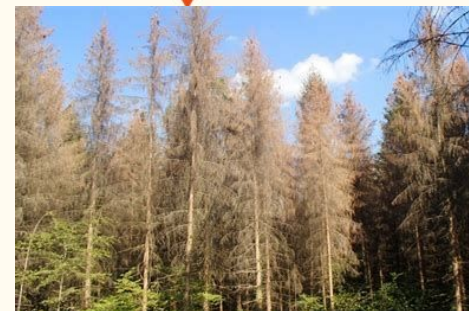


Fire intensity

- Fuel biomass

(structural component / Hazard)

Forest and its services
Human infrastructure
Human lives



Forest fire risks

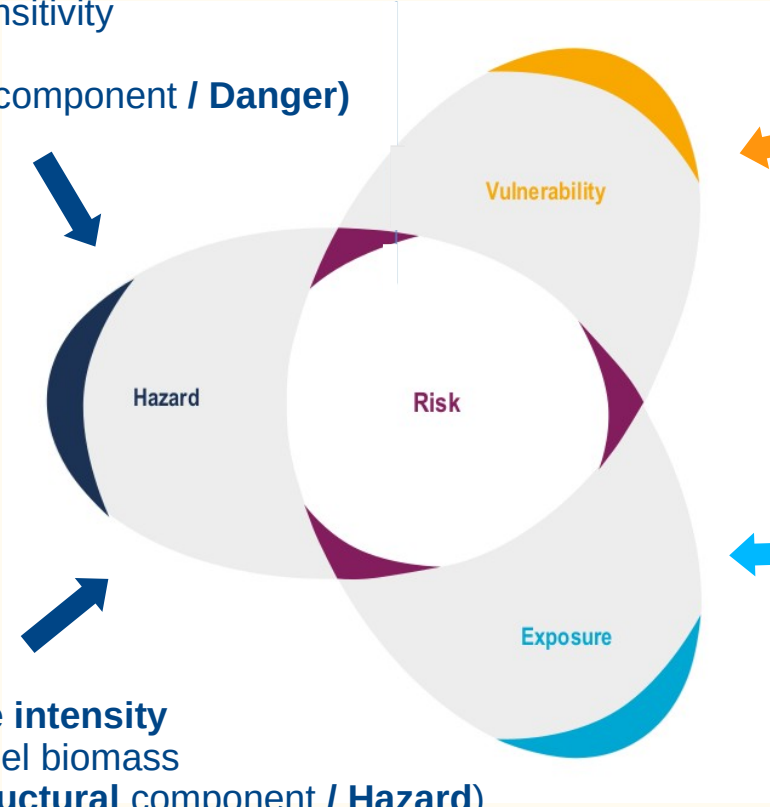
Risk components



Fire occurrence
- meteorology
- vegetation sensitivity
- fire ignition
(conjunctural component / Danger)



Fire intensity
- Fuel biomass
(structural component / Hazard)



Forest: structure, composition and health
Buildings: construction methods
Human lives: level of exposure

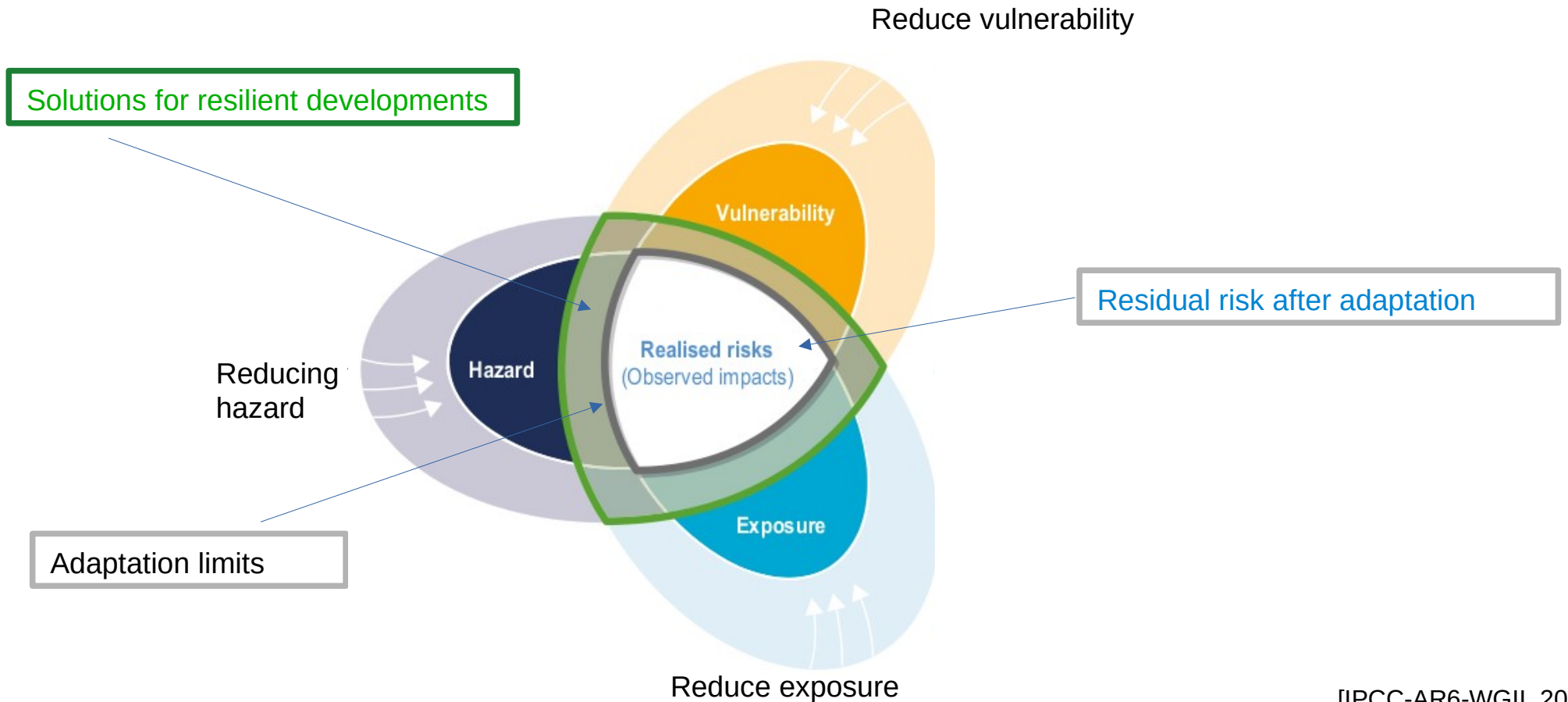


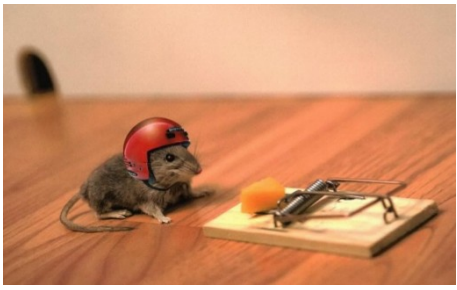
Forest and its services
Human infrastructure
Human lives





Forest fire risks management





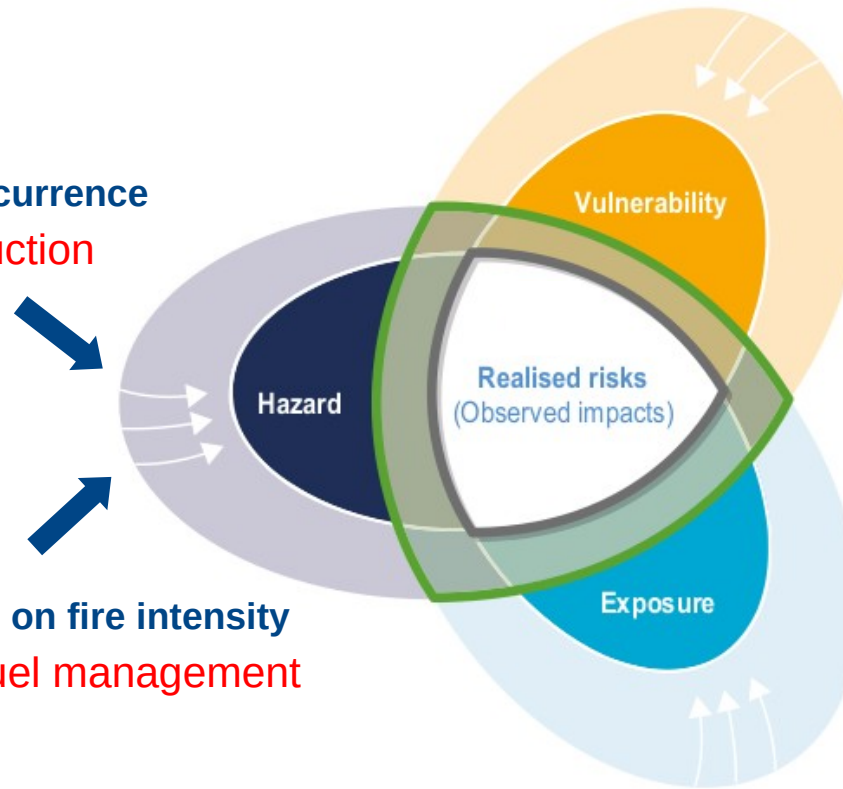
Forest fire risks management

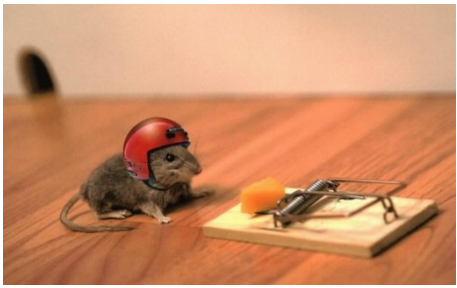


Acting on fire occurrence
Ex. Ignition reduction



Acting on fire intensity
Ex. Fuel management





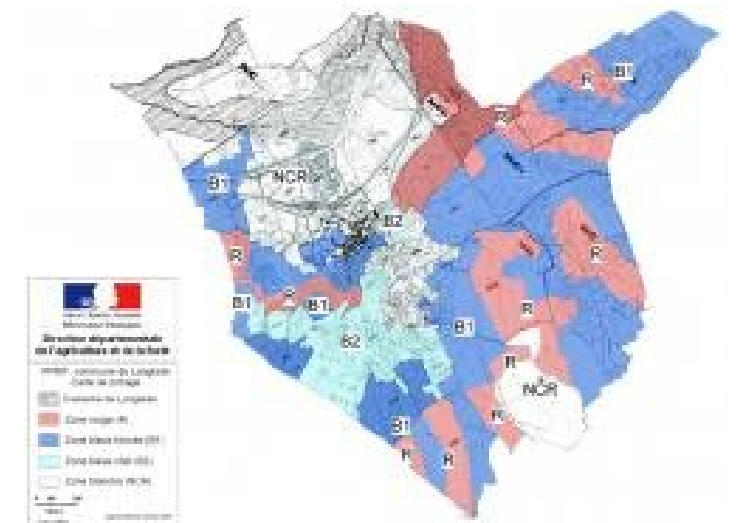
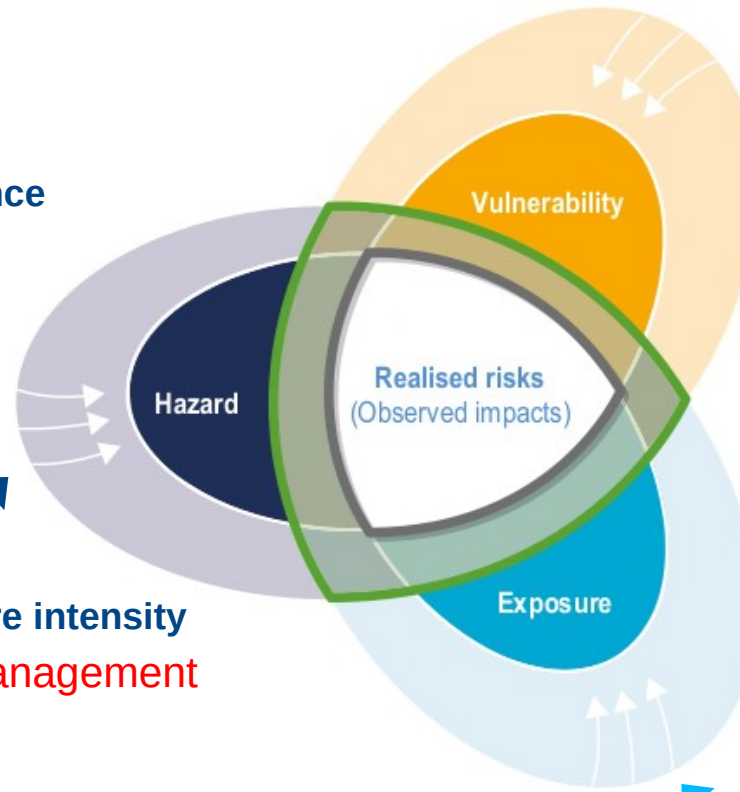
Forest fire risks management



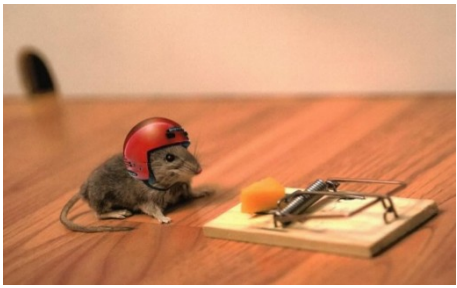
Acting on fire occurrence
Ex. Ignition reduction



Acting on fire intensity
Ex. Fuel management



Limiting exposed stakes
Ex. Controlling urban development
in risk-prone areas

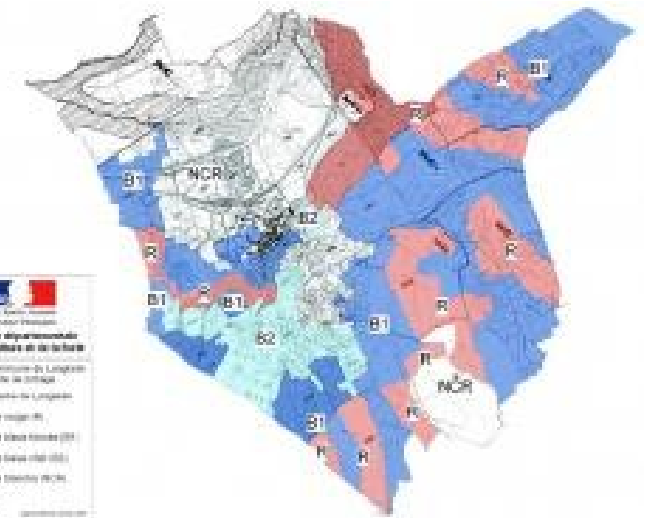


Forest fire risks management



Reducing vulnerability

Ex. Building preparedness/protection



Limiting exposed stakes

Ex. Controlling urban development in risk-prone areas



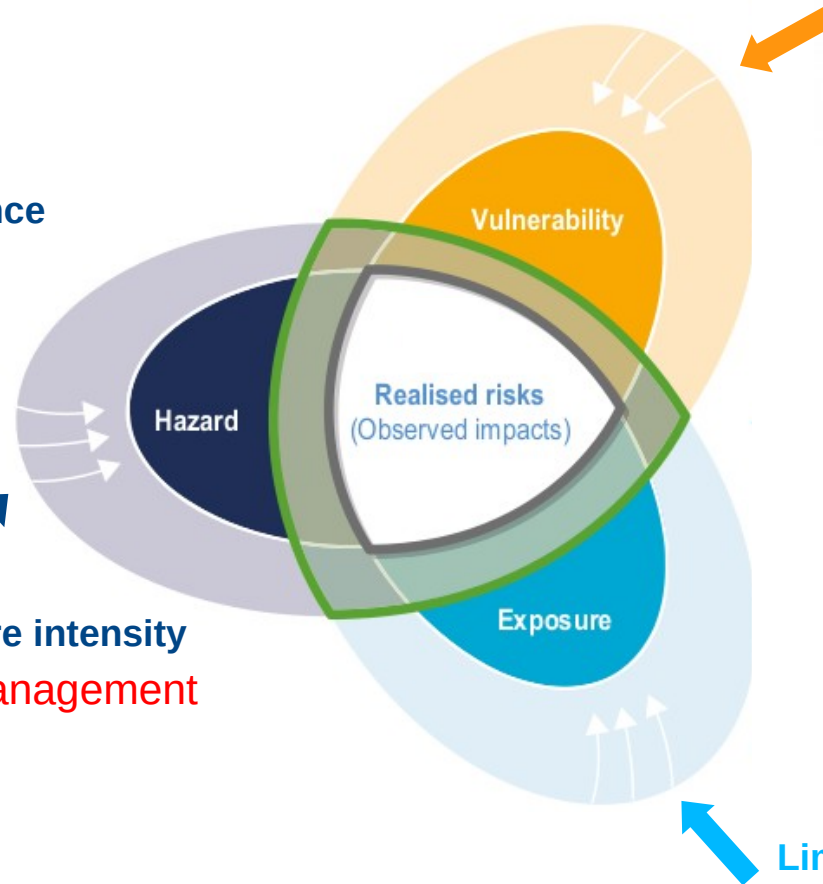
Acting on fire occurrence

Ex. Ignition reduction



Acting on fire intensity

Ex. Fuel management



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• Multi-risks related to forests

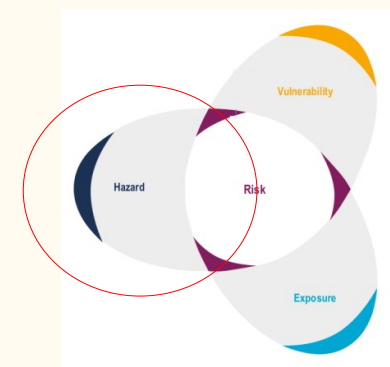
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Fire activity projections for France

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- **Climate change** induces meteorological changes in temperature, relative air humidity and daily precipitation patterns that **affect forest fires**.
- Two main **mechanisms**:
 - Meteorological drought => dry / dying vegetation
 - Deficit of water vapour in the air => drier dead vegetation
- These changes result in more **flammable and combustible** communities:
 - Easier fire ignitions / faster, more intense fires
 - Changes in fire activity (number and size)
- **Key questions**:
 - What is the magnitude of the effects? What is/will be the pace of change?
 - Which territories will be affected? What are the foreseeable trajectories for each of them?

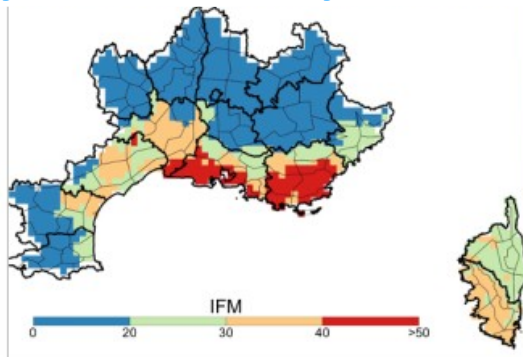


Fire activity projection using the Firelihood approach

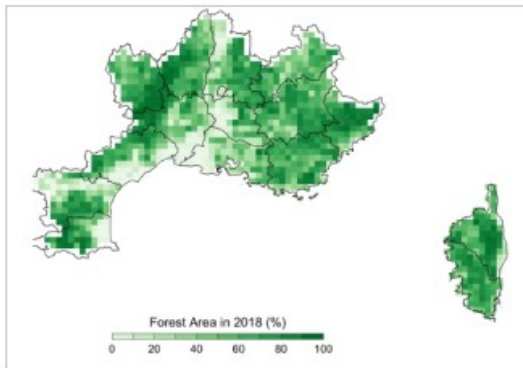
[Pimont et al. 2022 Forêt Méd. 3 : 163-168]

(a) Input data

Cyclical factor: Daily FWI 8km

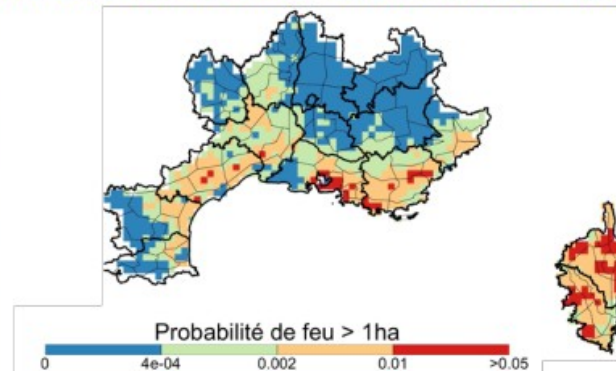


Structural factor: forest area

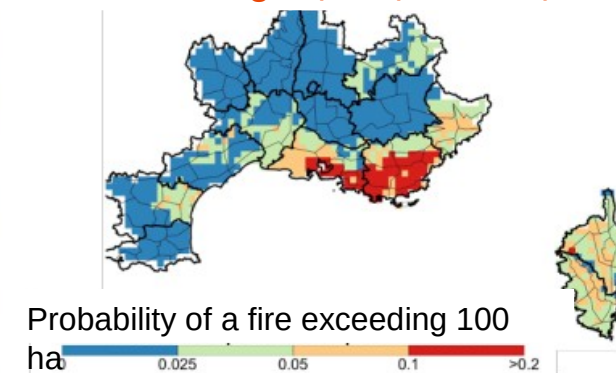


(b) Probabilized daily output

Occurrence: probability of fire > 1ha per pixel



Probability of one of these fires exceeding 10, 100, 1000 ha, etc



(c) Future fire activities

For each climate series,

the model simulates 300 "realizations" of potential fire activity in the form of lists of fires with their date, location and size, whose characteristics are analyzed.

(d) Analyses

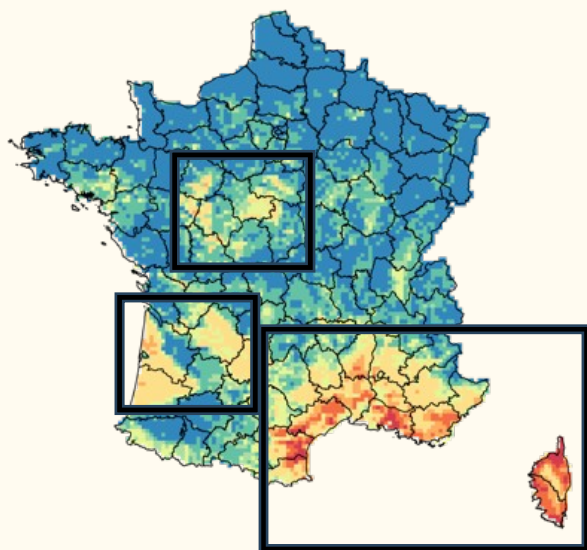
- Projections for Prométhée area
- Future expansion and intensification of risk area
- Lengthening and intensification of the summer fire season
- Impacts on the ecosystem
- Impacts on fire management

Trend for whole France

Simulation of the occurrence of fires > 20 ha based on daily FWI, projected between 2000 and 2100, according to RCP4.5 and RCP8.5 scenarios, on a national scale.

Number of fires > 20 ha:

Projection 2001-2020 (RCP 8.5)

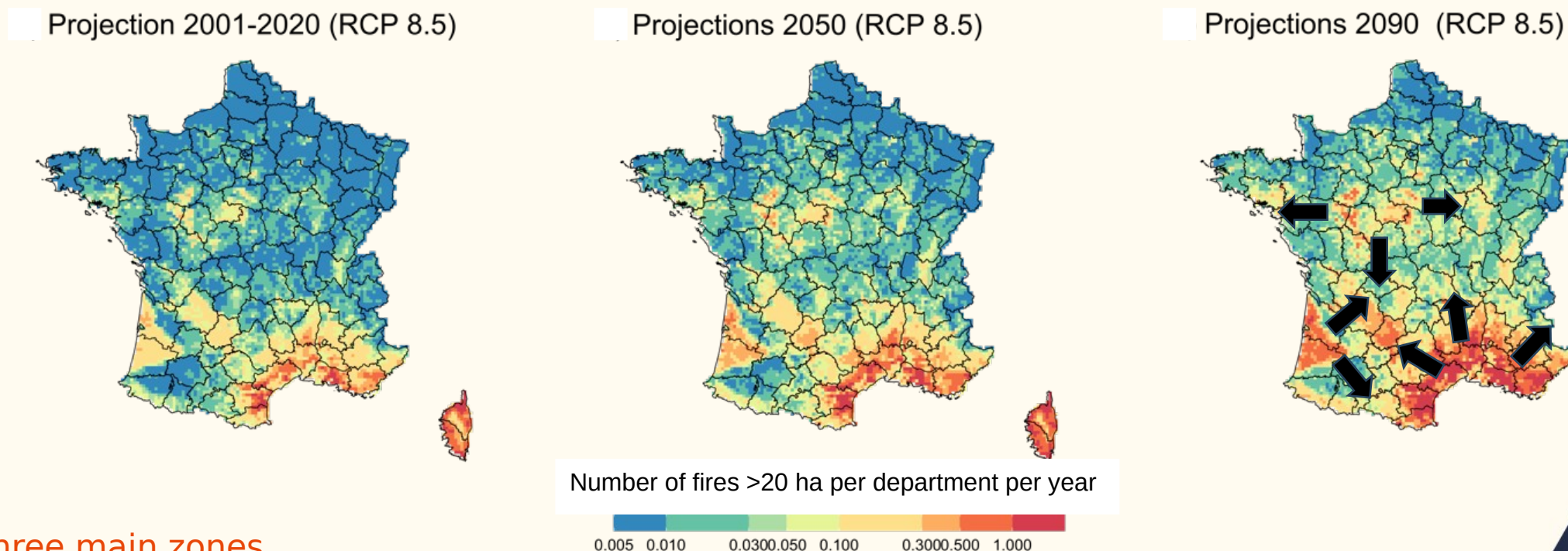


- Three main zones

Trend for whole France

Simulation of the occurrence of fires > 20 ha based on daily FWI, projected between 2000 and 2100, according to RCP4.5 and RCP8.5 scenarios, on a national scale.

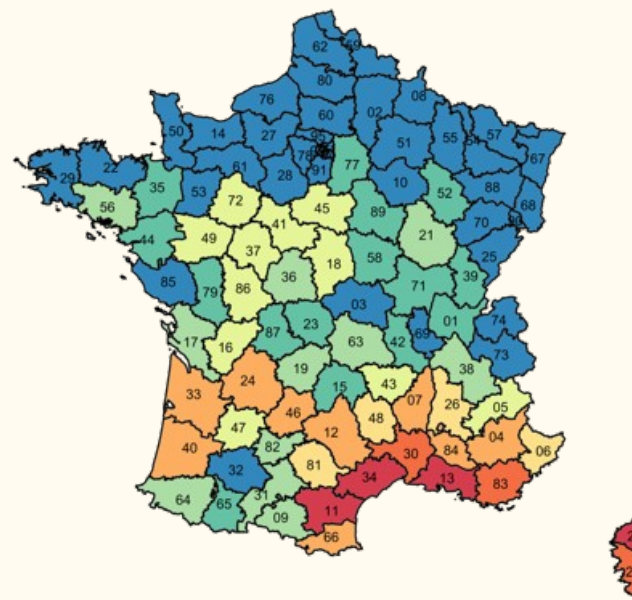
Number of fires > 20 ha: +25% in 2030, +60% in 2050, +200% in 2090 under RCP 8.5



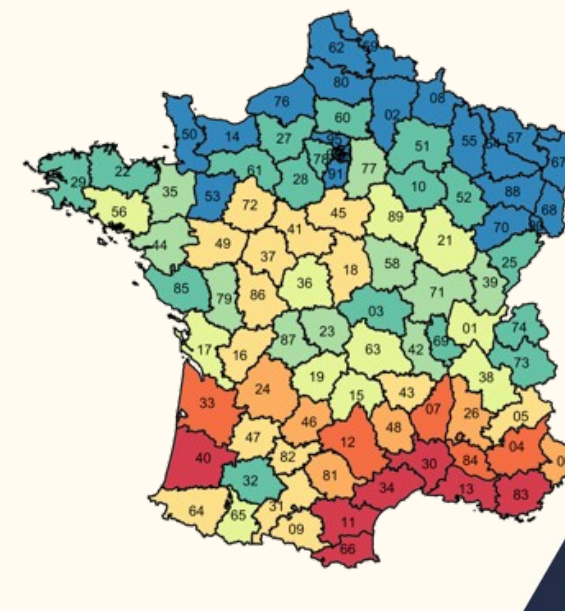
- Three main zones
- The three zones tend to converge

Trend for whole France

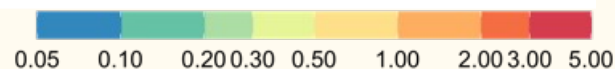
Projections 2050 (RCP 8.5)



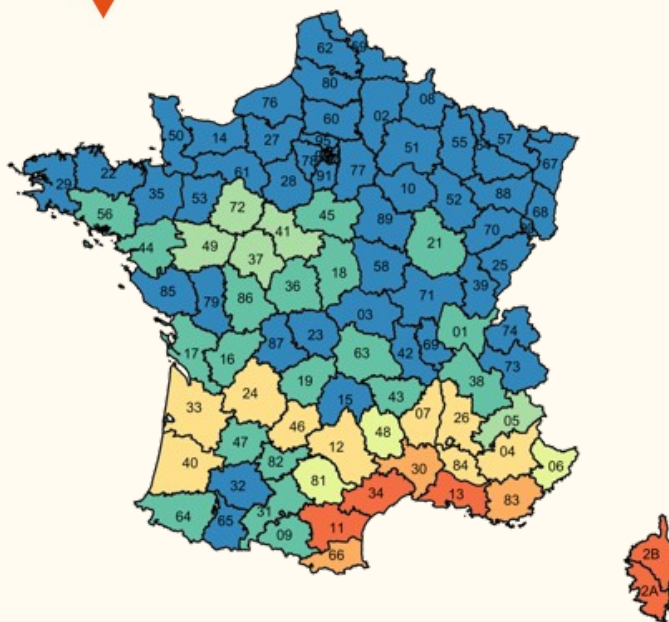
Projections 2090 (RCP 8.5)



Number of fires >20 ha per department per year



Projection 2001-2020 (RCP 8.5)



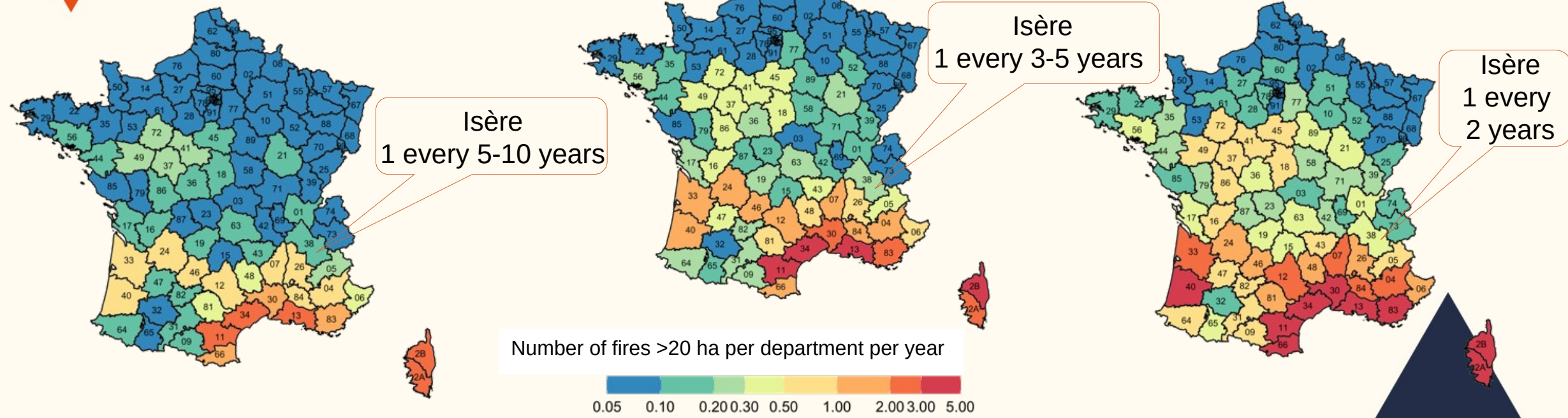
- Projections change the hierarchy relatively little
- The départements with the highest increases (in relative terms) are more likely to be in the expansion zones than in the historical cores of the three zones: South-East: 12, 48, 81, 43, 09, 31 and 01; South-West: 46, 64, 31, 19 and 65; "Centre-Ouest": 18 and 45.

Trend for whole France

Projections 2050 (RCP 8.5)

Projection 2001-2020 (RCP 8.5)

Projections 2090 (RCP 8.5)



- Projections change the hierarchy relatively little
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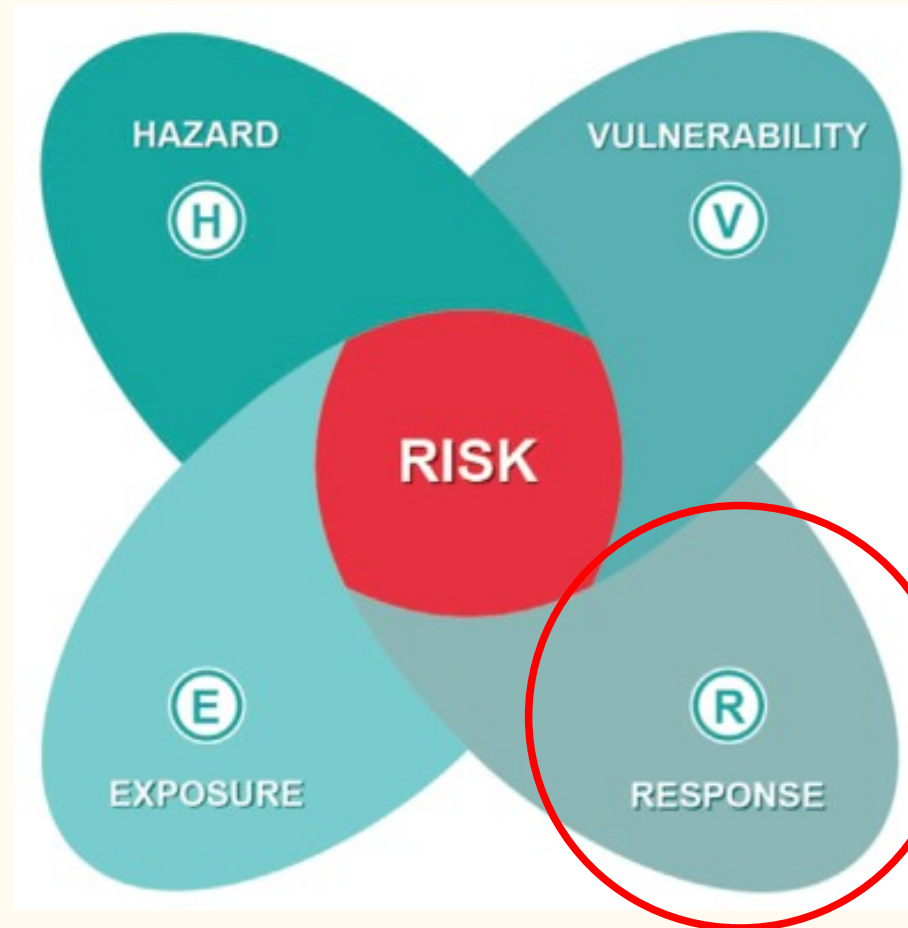
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IPCC's new conceptual risk scheme

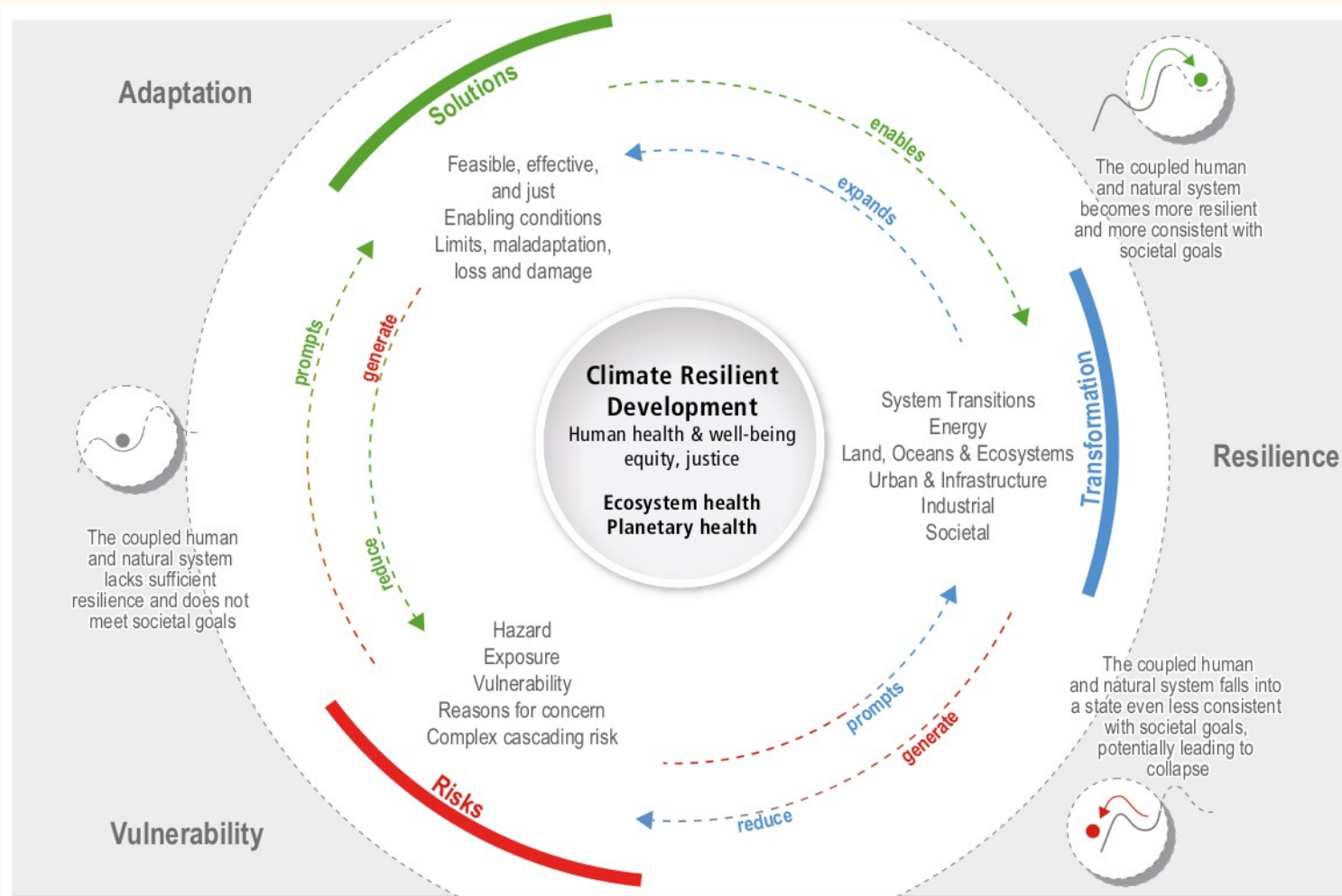
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[Simpson et al. 2021. One Earth]

The place of risk in the IPCC's integrative vision

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[IPCC-AR6-WGII, 2022]

Terminology for complex risks

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Table 1. Complex risk terms with and without an IPCC definition

[Simpson et al. 2021. One Earth]

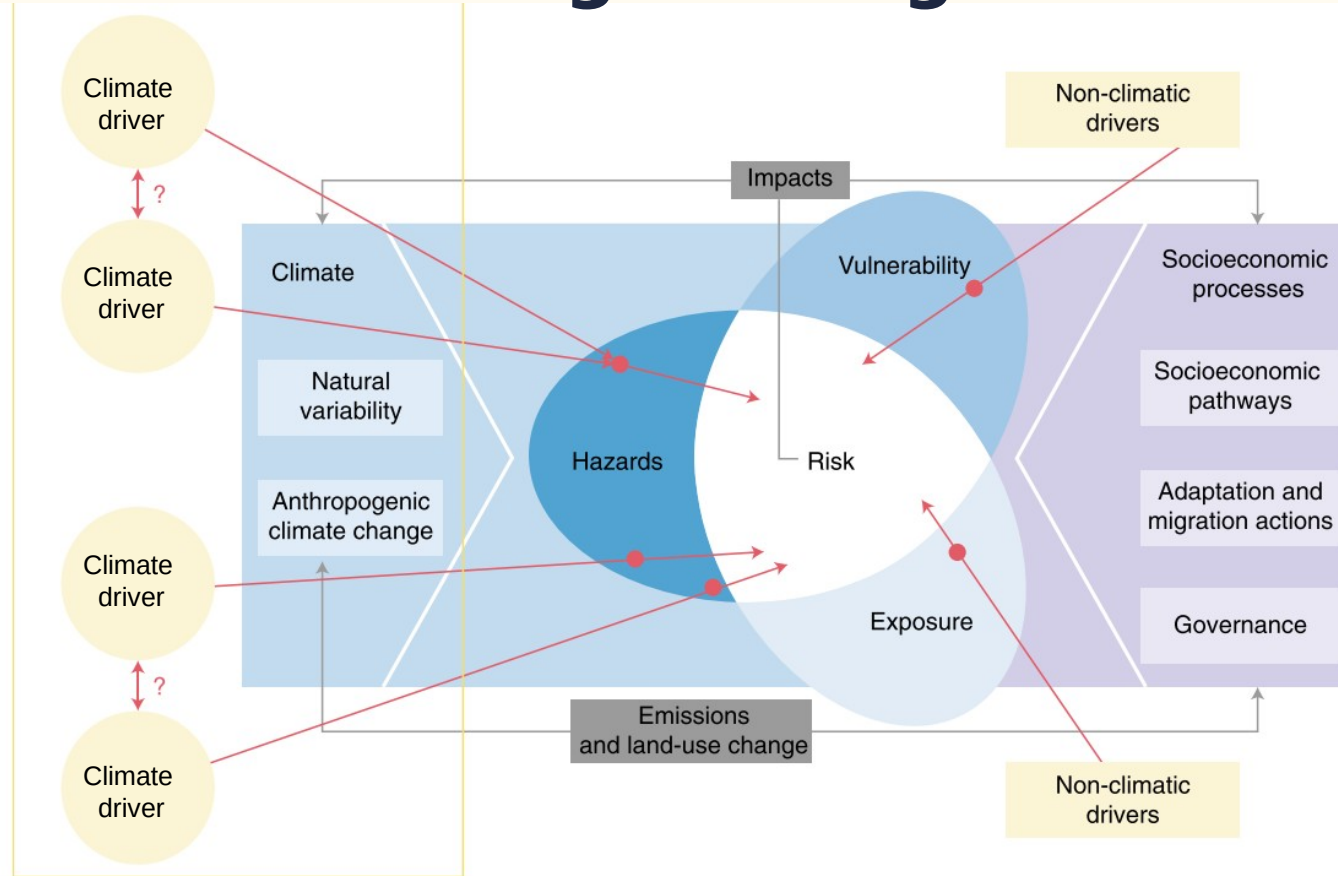
Types of complex risk with IPCC definition

Compound risk	compound risks arise from the interaction of hazards, which can be characterized by single extreme events or multiple coincident or sequential events that interact with exposed systems or sectors ²⁸ [IPCC-SR, Annex I-Glossary, 2018]
Emergent risk	a risk that arises from the interaction of phenomena in a complex system; for example, the risk caused when geographic shifts in human population in response to climate change lead to increased vulnerability and exposure of populations in the receiving region ²⁹ [Field et al, 2014. (Cambridge University Press)]

Types of complex risk with no IPCC definition

Aggregate risk	the accumulation of independent determinants of risk ³⁵ [Bansal & Ochoa, 2012]
Amplified risk	the substantial enhancement of background risk through combination or concentrations of determinants of risk in time or space ³⁶ [Li et al., 2016. https://doi.org/10.1038/srep28161]
Cascading risk	one event or trend triggering others; interactions can be one way (e.g., domino or contagion effects) but can also have feedbacks; cascading risk is often associated with the vulnerability component of risk, such as critical infrastructure ^{1,22,37,38} [Lawrence et al., 2020. Clim. Risk Manage.]
Interacting risk	the combinations of hazards and their reciprocal influences between different factors and coincidences among environmental drivers ³⁸ [Pescaroli & Alexander, 2018. Risk Analysis]
Interconnected risk	the complex interactions among human, environment, and technological systems with physical interdependencies that are closely linked with interconnected social interactions ³⁸
Interdependent risk	complex systems involve interactions and interdependencies that cannot be separated and lead to a range of unforeseeable risks ³⁹ [Cavallo & Ireland, 2014. Int. J. Disaster Risk Reduction]
Multi-risk	the whole risk from several hazards, taking into account possible hazards and vulnerability interactions entailing both multi-hazard and multi-vulnerability perspectives ⁴⁰ [Terzi et al., 2019. J. Environ. Manage]
Systemic risk	systemic risk results from connections between risks (networked risks), where localized initial failure could have disastrous effects and cause, at its most extreme, unbounded damage ⁴

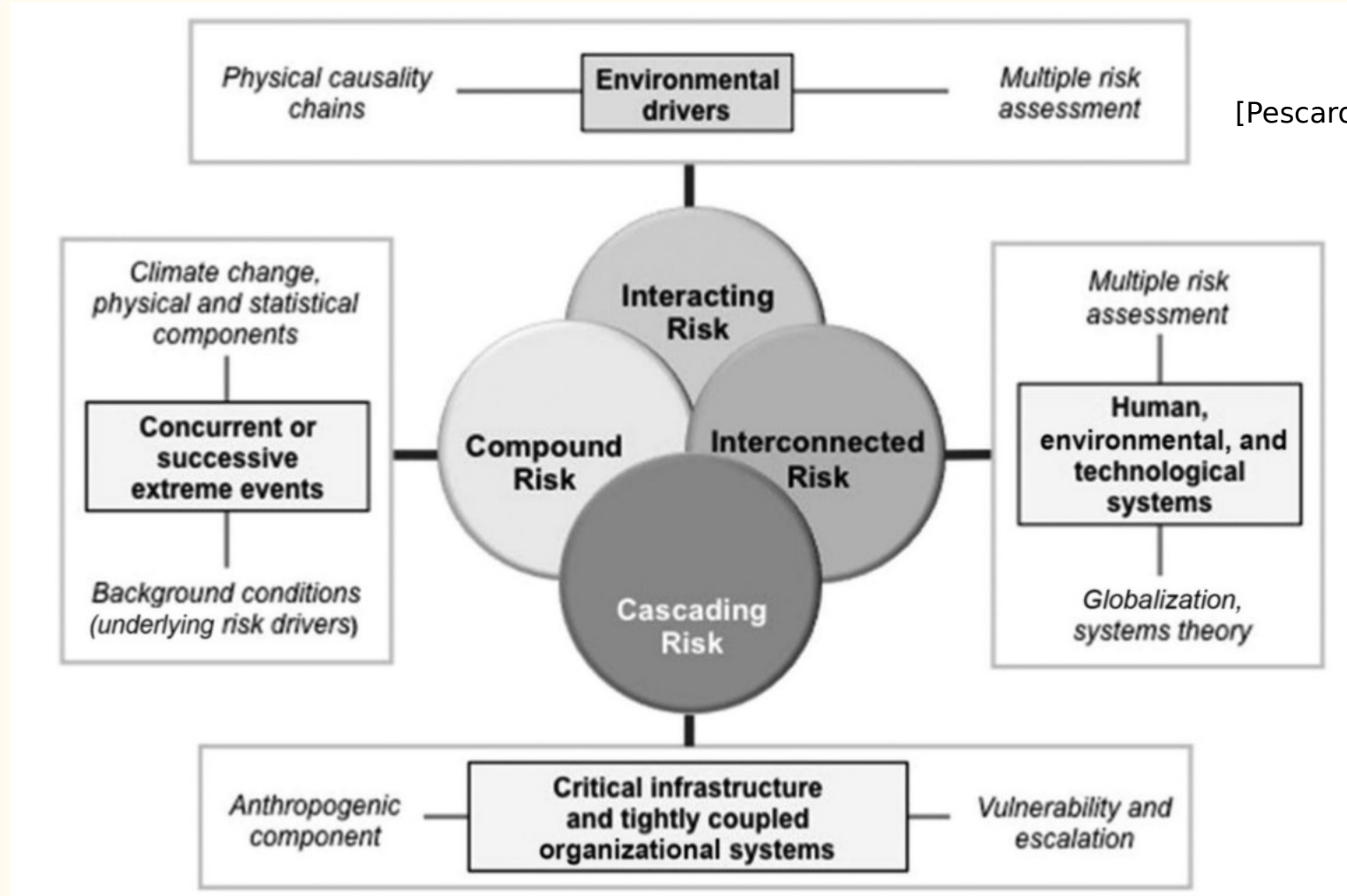
Notions of compound event: combination of processes leading to a significant impact



[Zscheischler et al, 2018]

Fig. 1 | Extended risk framework. Multiple climatic drivers cause one or multiple hazards leading to societal and environmental risk. The climate drivers (which may vary from local-scale weather to large-scale climate modes, represented by yellow circles) and/or hazards may be mutually dependent. Non-climatic drivers related to vulnerability and exposure may also contribute to risk. Background risk figure adapted from ref. ⁹⁶, IPCC.

Multirisks: A framework for compound, interacting, interconnected and cascading risks



[Pescaroli & Alexander, 2018]

Increasing complexity of risk interactions

[IPCC-AR6-WGII, 2022, adapted from Simpson et al. 2021]

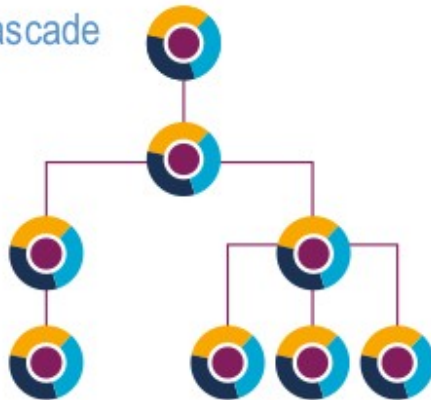
(a) Compound: unidirectional



(b) Compound: bidirectional



(c) Cascade



(d) Aggregate



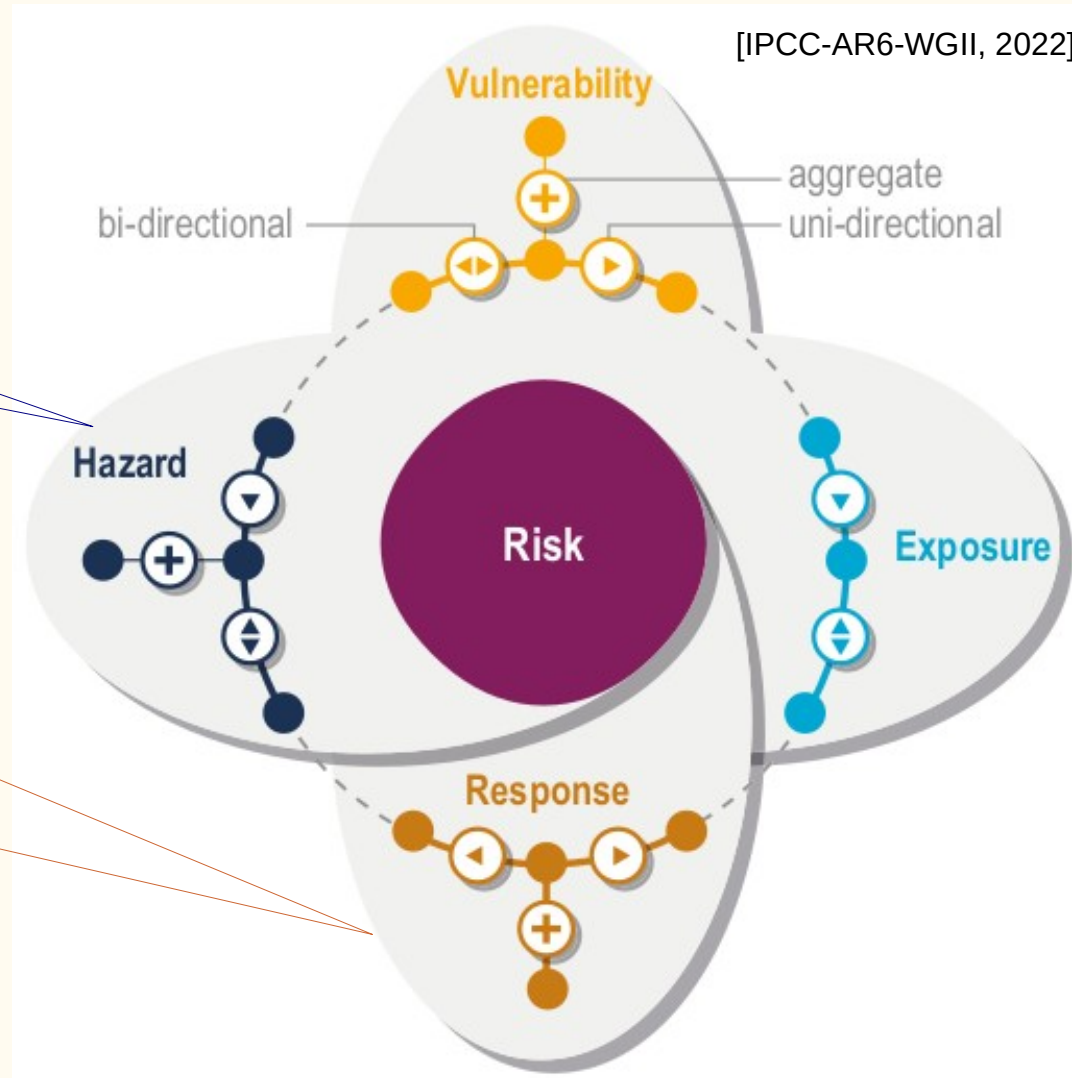
Colour definition of wheels corresponding to the Risk Propeller:



IPCC AR6 additions to the risk propoller

Compound effects
can be applied to each
risk component

Highlighting the risks associated
with adaptation and mitigation
responses



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2018 Fire disaster in the seaside town of Mati, Greece

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[Simpson et al. 2021. One Earth]



2018 heatwaves in Europe: risks to infrastructure



[Simpson et al. 2021. One Earth]

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Consider risk components to move towards a multi-risk approach in forest

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Biotic hazards

Pests, diseases, ...

Abiotic hazards

Drought, fire, wind
storm, heat waves, ...

Exposure and impacts

economic, ecological (ES),
dieback, mortality, loss of
productivity, of biodiversity,
wood quality, ...



Vulnerability factors

soil fertility, soil
nutrients, soil
compaction, tree
species, forest
genetic resources

Risk management and forest adaptation

Fuel management
Pruning, Thinning,
Sanitary felling,
Salvage harvesting

Study case: risk cascade in Landes de Gascogne

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Study case: risk cascade in Landes de Gascogne

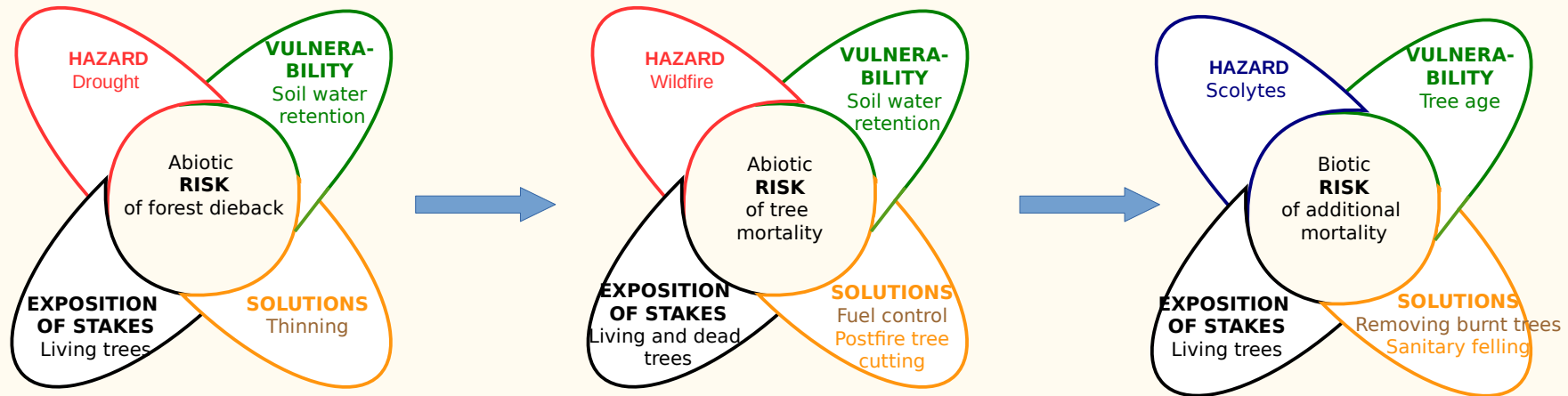


Spring 2022

Summer 2022

Winter 2022/2023

Spring 2023 – Summer 2023 => 2024



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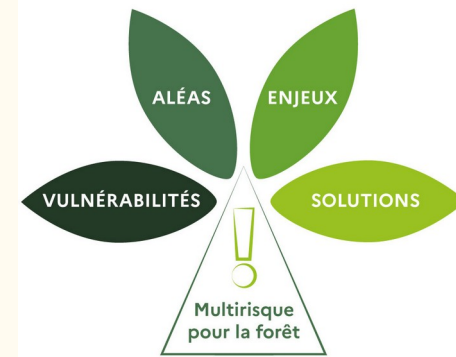
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X-RISKS: Analysis and Management of Multiple Risks in Forest Social-ecological systems



- Coordination: INRAE
- Partnership:
- Project duration: 6 years
- Funded by the National Research Agency (ANR): 5 M€



A target project of PEPR FORESTT

<https://www.pepr-forestt.fr/>



X-RISKS: Analysis and Management of Multiple Risks in Forest Social-ecological systems



Objective: Integrate the “multiple risks” dimension into societal and scientific issues related to forest management.

Through several research axis:

- Understand and define the **concept** of multi-hazard in forestry
- Improve **monitoring** of multiple risks, their interactions and impacts
- Develop comparative approaches to **modeling** multiple risks, to explore their consequences and impacts on management methods
- Improve understanding of the **perception** of multiple risks and vulnerabilities by different stakeholders
- Identify appropriate **governance and management strategies** to prevent or limit multiple risks, taking into account the necessary trade-offs.



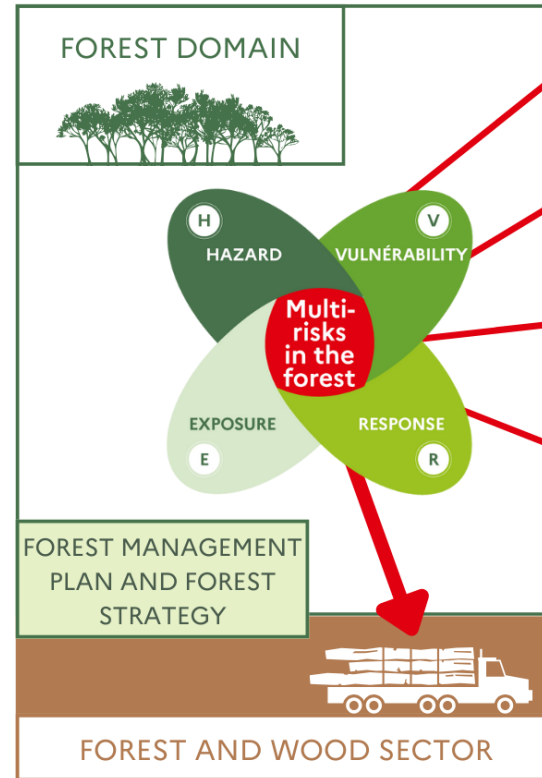
X-RISKS: Analysis and Management of Multiple Risks in Forest Social-ecological systems



- Stand level solutions**
- Technical sequences (sylviculture, fuel control ...)
 - Genetic diversity
 - Species mixture

- Landscape and massif level solutions**
- Landscape fragmentation
 - Species mixture
 - Insurances

PORTFOLIO OF INTEGRATES SOLUTIONS



Wildland urban interface

PPRif
PLU

Electrical power transmission grid

EPTG defense plan against major incidents

Road / railway networks

Road network safety plan

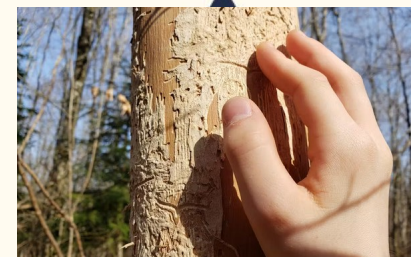
Other sectors

- Massif and regional level solutions**
- Gouvernance
 - Organisation
 - Post crisis management to mitigate impacts on wood sector
 - Post crisis to mitigate next risk

Take home messages

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- IPPC framework fits well with both risk and multirisk approaches
 - Enables a useful **analytical breakdown** of risk
- **Exposed stakes**
 - the **main input** for risk assessment?
 - **Multi-stakes** is already a multi-risk vision
 - the **perimeter** taken into account determines multi-risk assessment
- **Solutions**, a key component of multirisk assessment and management
 - Towards an **integrated** vision of multirisk management



Thank you for your
attention !

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