

European Forest Institute (Bonn) - Scientific seminar

Assessing the impact of management strategies at multiple scales on timber production, carbon stocks and biodiversity of Belgian forests under climate change pressure

21.03.2023

Violette Van Keymeulen

Phd thesis director : Gauthier Ligot

PhD initiation context

« Five-year plan for forestry research and popularization 2019-2024 »



Action 3.4b

Build a methodological approach and a tool to compare multifunctional management scenarios at the scale of forest, taking into account risks.



Background informations

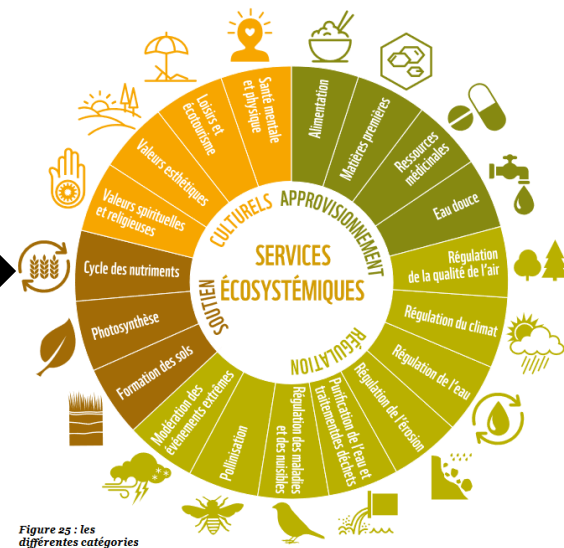
Biophysical process and structure

Ecological function

Ecosystem services

Benefits

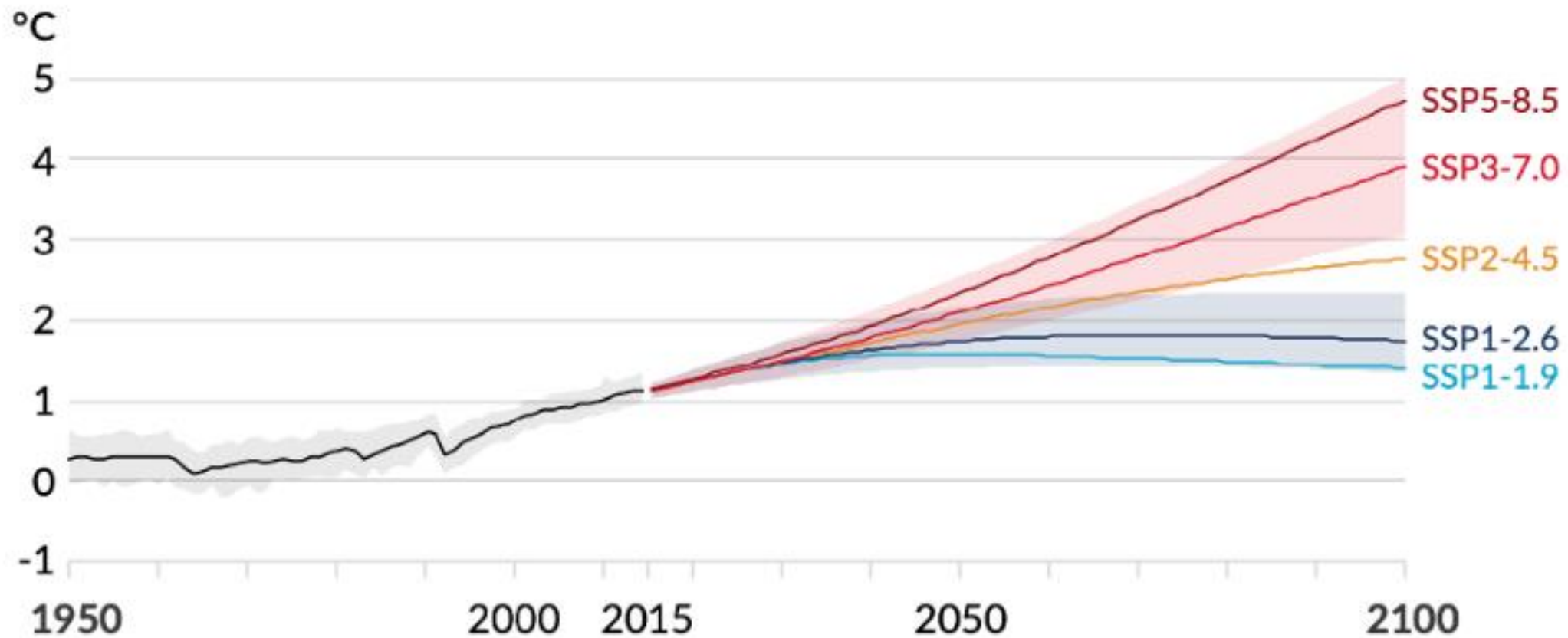
Values



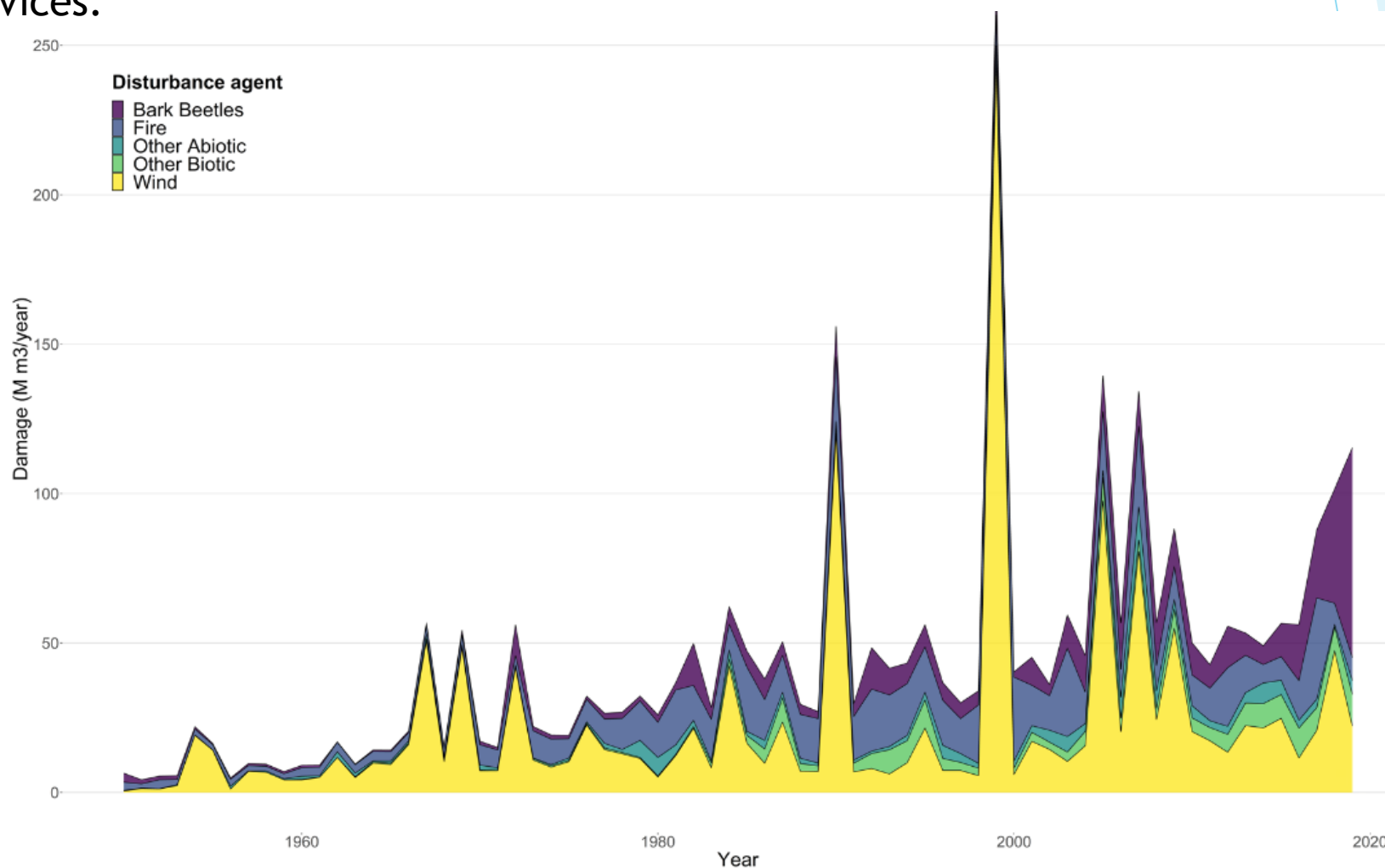
Biosphere Anthroposphere



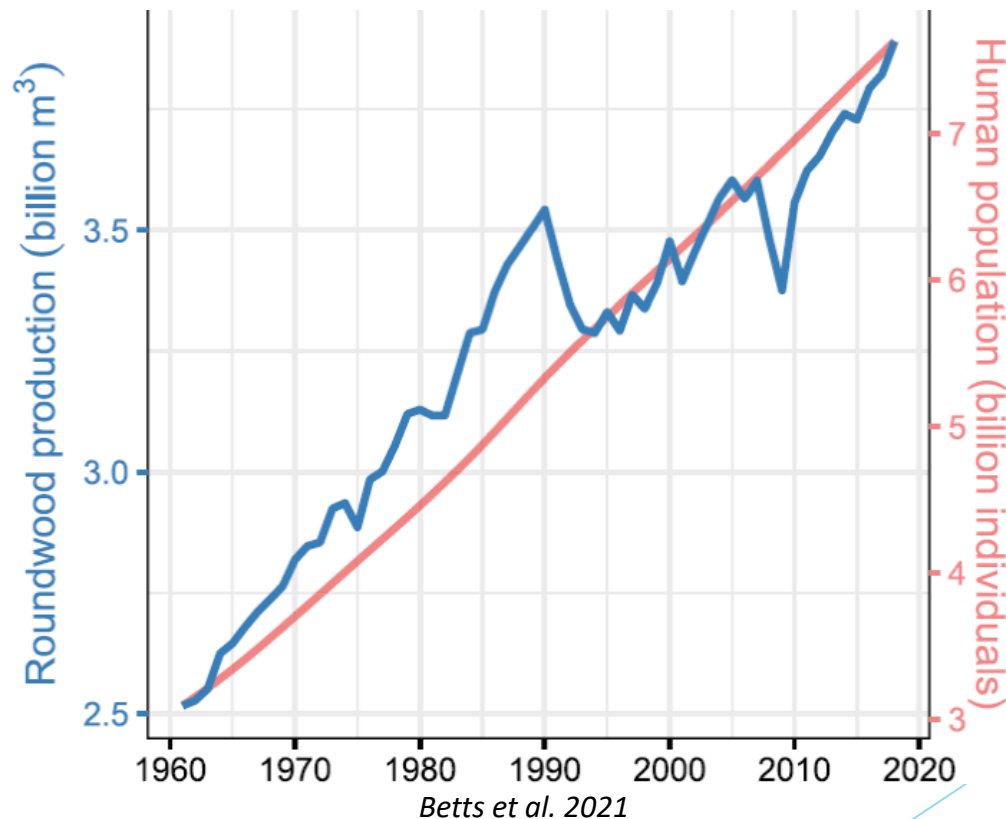
- Climate change will affect ecosystem services supply and we are facing uncertainty about frequency and severity of risks that are coming



- Climate change will affect ecosystem services supply and we face uncertainty about frequency and severity of risks that are coming
- Disturbances could intensify in the future and interact with climate change in modulating ecosystem services.



- Climate change will affect ecosystem services supply and we face uncertainty about frequency and severity of risks that are coming
- Disturbances could intensify in the future and interact with climate change in modulating ecosystem services.
- The homogenization of forests led by human through forest management and timber harvesting has globally decrease the forests resilience.



Sustainability Science (2022) 17:2013–2029
<https://doi.org/10.1007/s11625-022-01111-4>



ORIGINAL ARTICLE



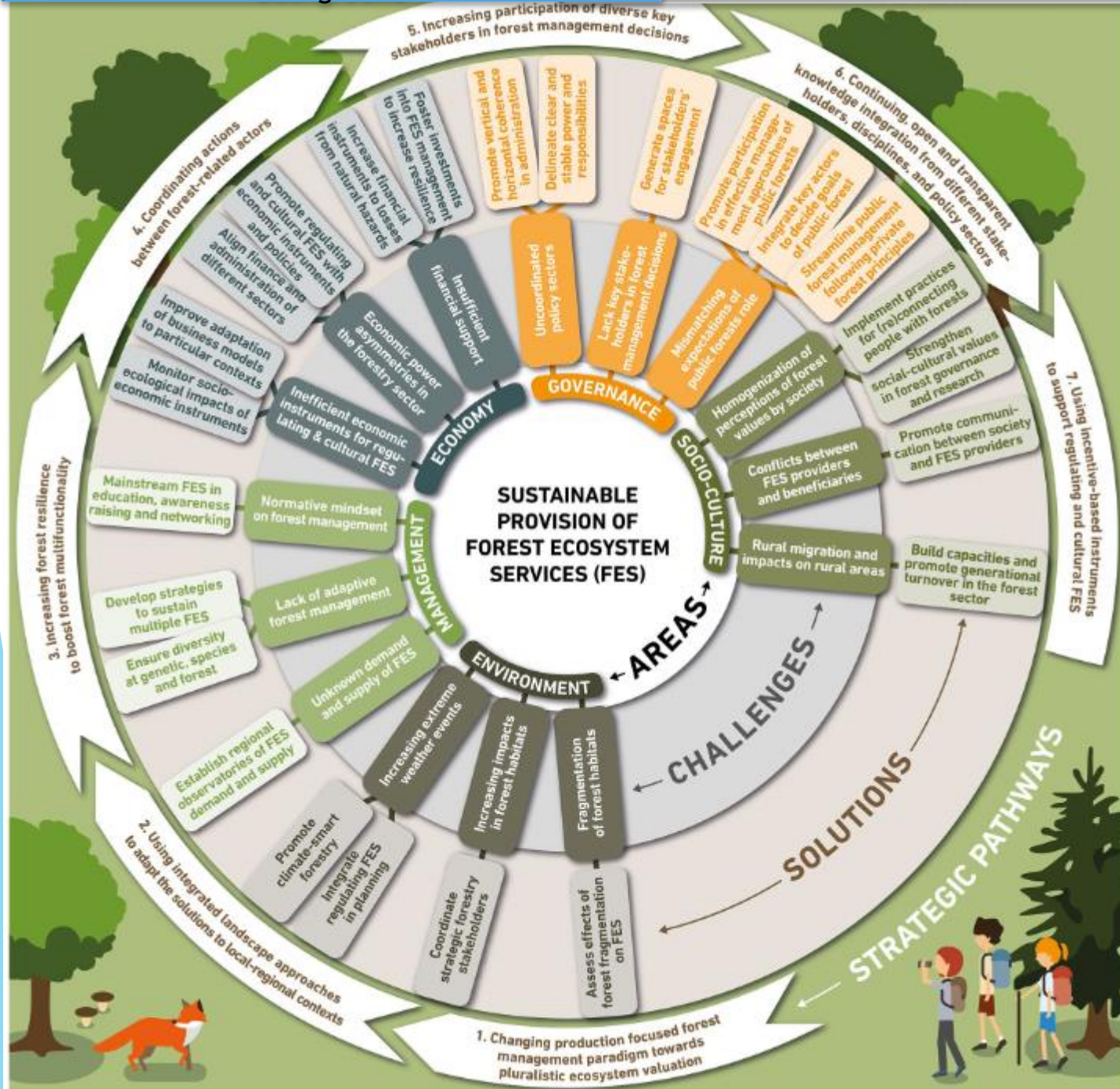
Scanning the solutions for the sustainable supply of forest ecosystem services in Europe

M. Hernández-Morcillo¹ · M. Torralba^{2,3} · T. Baiges⁴ · A. Bernasconi⁵ · G. Bottaro⁶ · S. Brogaard⁷ · F. Bussola⁸ · E. Díaz-Varela⁹ · D. Geneletti¹⁰ · C. M. Grossmann¹¹ · J. Kister¹² · M. Klingler¹³ · L. Loft¹⁴ · M. Lovric¹⁵ · C. Mann¹ · N. Pipart¹⁶ · J. V. Roces-Díaz¹⁷ · S. Sorge¹ · M. Tiebel¹⁸ · L. Tyrväinen¹⁹ · E. Varela²⁰ · G. Winkel²¹ · T. Plieninger^{2,3}

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Abstract

Forests are key components of European multifunctional landscapes and supply numerous forest ecosystem services (FES) fundamental to human well-being. The sustainable provision of FES has the potential to provide responses to major societal challenges, such as climate change, biodiversity loss, or rural development. To identify suitable strategies for the future sustenance of FES, we performed a solution scanning exercise with a group of transdisciplinary forest and FES experts from different European regions. We identified and prioritized fifteen major challenges hindering the balanced provision of multiple FES and identified a series of potential solutions to tackle each of them. The most prominent challenges referred to the increased frequency and impacts of extreme weather events and the normative mindset regarding forest management. The respective solutions pointed to the promotion of forest resilience via climate-smart forestry and mainstreaming FES-oriented



- We need solutions to increase forest resilience
- We need solutions to deal with tradesoff between ecosystem services and ensure forest multifunctionality

Research plan

A literature review

About solutions to increase forest and ecosystem services resilience

A research question

About solutions to increase forest / ecosystem services resilience AND ensure multifunctionality

A new simulator

Adapted to belgian forests, forest scale and considering drought

A strategy to increase resilience : Ensure diversity at multiple scales



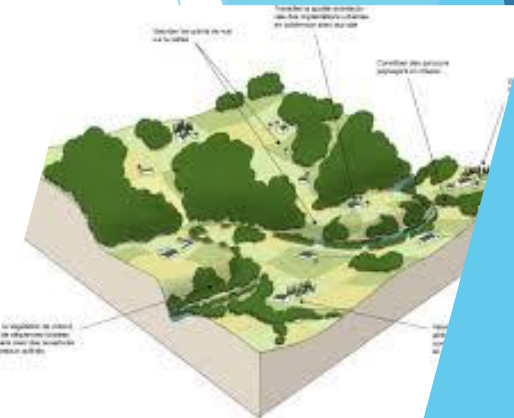
Tree



Stand



Multi-stands (forest)



Landscapes

DOI: 10.1111/conl.12829

PERSPECTIVE

Conservation Letters
A Journal of the Society for Conservation Biology
WILEY

For the sake of resilience and multifunctionality, let's diversify planted forests!

Christian Messier^{1,2} | Jürgen Bauhus¹
Lander Baeten⁶ | Nadia Barsoum⁷ |
Jeannine Cavender-Bares¹⁰ | Els Dhiedt¹¹
Dominique Gravel¹³ | Joannès Guillen¹⁴
Andrew Hector¹⁷ | Bruno Héroult¹⁸ |
Holger Kreft^{21,22} | Simone Mereu^{23,24}
Alain Paquette² | John D. Parker²⁷ |
Catherine Potvin³¹ | Peter B. Reich^{32,33}
Florian Schnabel^{3,5} | Kris Verheyen⁶
Delphine Clara Zemp^{20,21,37}

Curr Forestry Rep
DOI 10.1007/s40725-017-0064-1

FOREST ENTOMOLOGY (E BROCKERHOFF, SECTION EDITOR)

Tree Diversity Drives Forest Stand Resistance to Natural Disturbances

Hervé Jactel¹ · Jürgen Bauhus² · Johanna Boberg³ · Damien Bonal⁴ · Bastien Castagneyrol¹ · Barry Gardiner⁵ · Jose Ramon Gonzalez-Olabarria⁶ · Julia Koricheva⁷ · Nicolas Meurisse⁸ · Eckehard G. Brockerhoff⁹

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The greater resilience of mixed forests to drought mainly depends on their composition: Analysis along a climate gradient across Europe



Received: 4 February 2021 | Accepted: 4 May 2021

DOI: 10.1111/1365-2664.13912

RESEARCH ARTICLE

Journal of Applied Ecology
BRITISH ECOLOGICAL SOCIETY

Mixing tree species at different spatial scales: The effect of alpha, beta and gamma diversity on disturbance impacts under climate change

Julius Sebald^{1,2} | Timothy Thrippleton^{3,4} | Werner Rammer² |
Harald Bugmann³ | Rupert Seidl^{1,2,5}

¹ Institut des Sciences de la Forêt tempérée (ISFORT), Université de Bordeaux

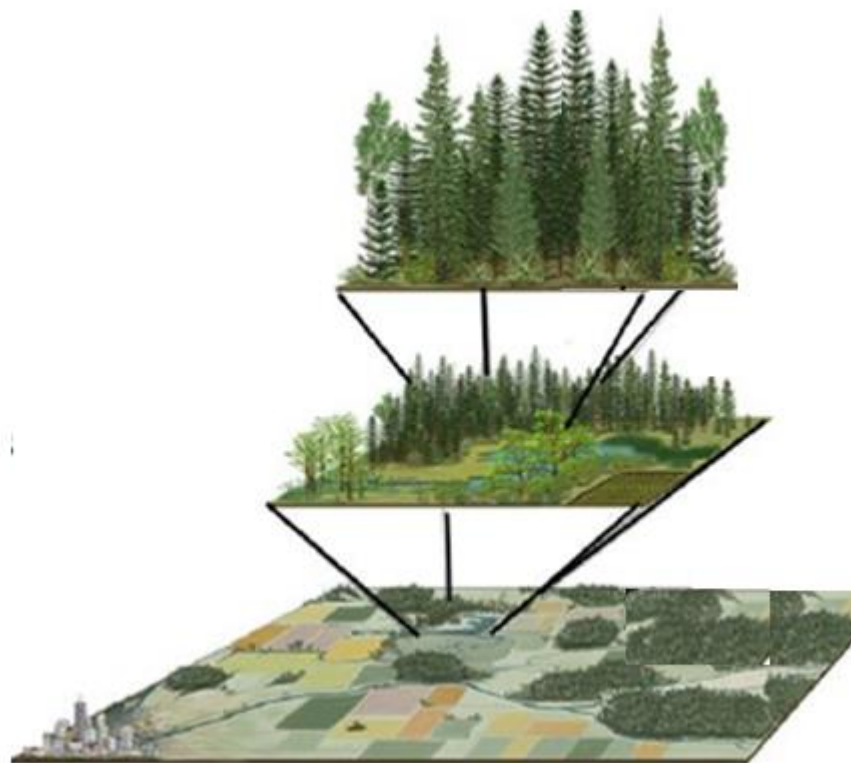
State of the art

“Assessing the impact of structural and compositional complexity across scales on forest and ES resilience : An overview of the literature”

Compositional complexity

Structural complexity

Management complexity



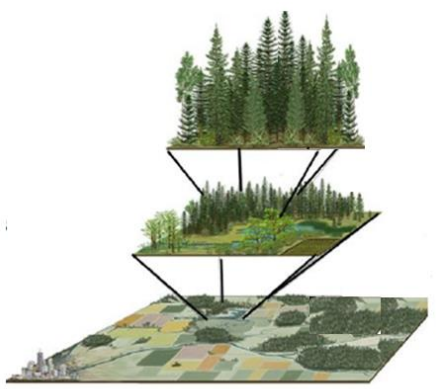
Stand scale

Forest scale

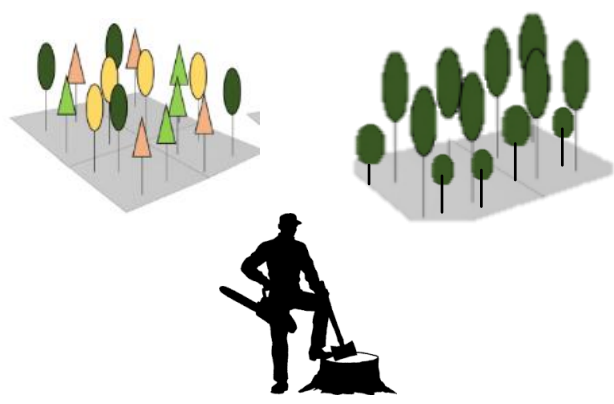
Landscape scale

How is studied the impact of structural and compositional complexity across scales on forest resilience and ecosystem services supply in the littérature ?

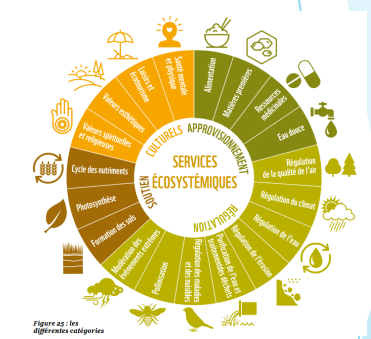
➤ On what scale ?



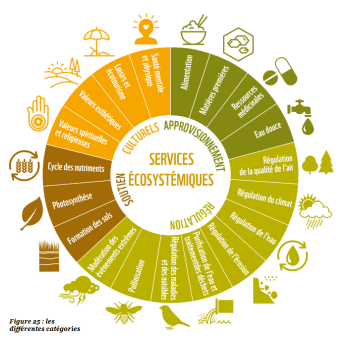
➤ What kind of complexity ?



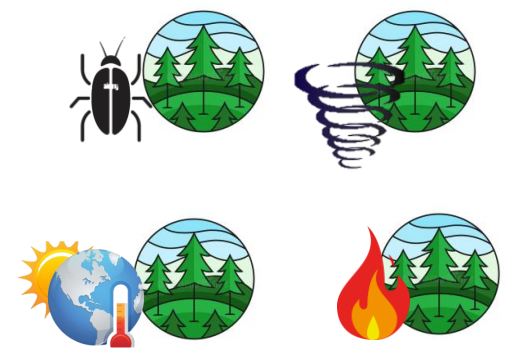
➤ What kind of resilience ?
➤ What component of resilience ?



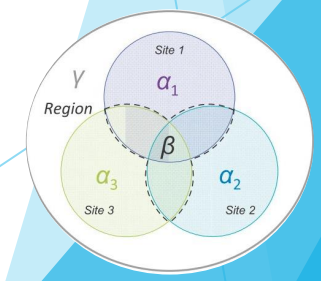
➤ What ecosystem service ?



➤ What type of risk ?



➤ What kind of indicator ?



How is studied the impact of structural and compositional complexity across scales on forest resilience and ecosystem services supply in the littérature ?

Through forests attributes

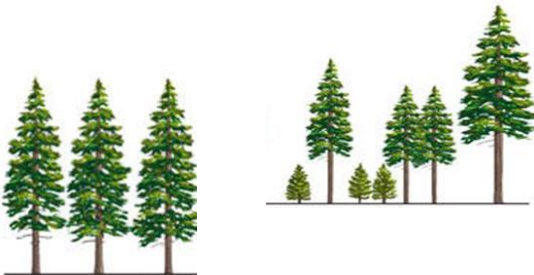
- What type of species mix ?

hardwood/softwood
species diversity
functionnal traits diversity

...



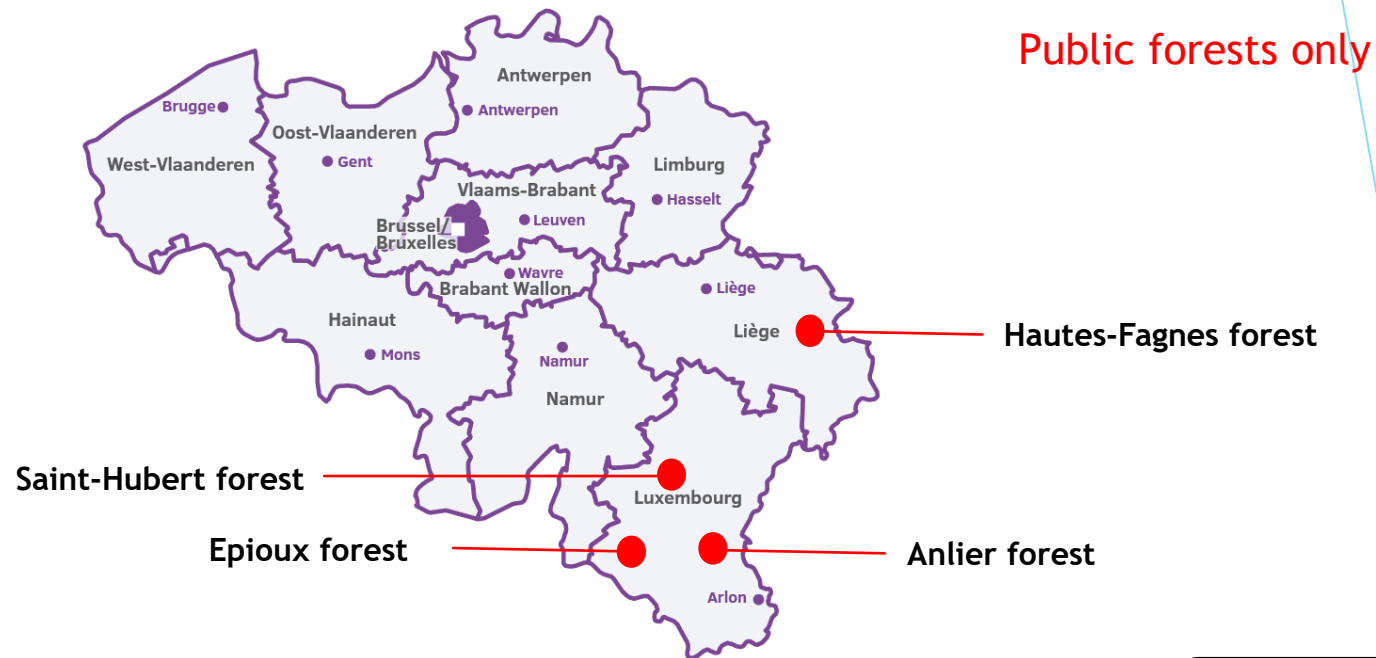
- What kind of structure ?



Through management types

- How is studied the complexity through management ?
- ...

Managing the forest at multiple scales as a way to enhance forest resilience to drought and multifunctionality : Are intensification, extensification and complexification strategies equal ?



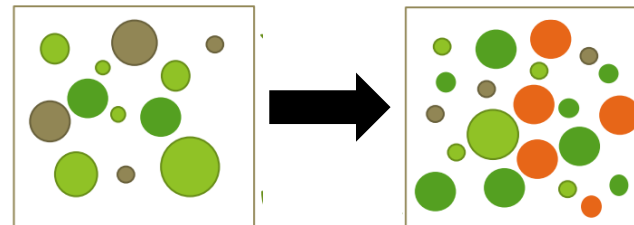
Management scenarios

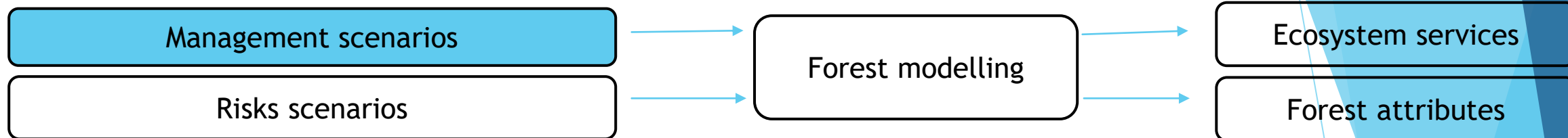
Risks scenarios

Forest modelling

Ecosystem services

Forest attributes





Work in Progress

Scale



Intensification

Reduce minimum cutting diameter
Increase thinning intensity

Extensification

Increase minimum cutting diameter
Decrease thinning intensity

Complexification

Increase compositional/functional diversity ?
Favour secondary species ?

Intensification

Increase proportion of managed area

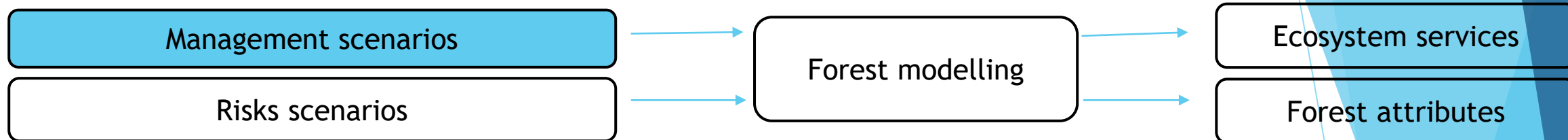
Extensification

Decrease the proportion of managed area

Complexification

Increase balance in even-aged / uneven aged management ?
Hardwood/softwood ratio ?
Increase beta-diversity ?





Scenario type	Stand scale	Forest scale	Enhance Complexity
Baseline	S-Baseline	F-Baseline	No
Intensification	SI	FI	No
Extensification	SE	FE	No
Trade-off 1	SE	FI	No
Trade-off 2	SI	FE	No
Baseline	S-Baseline	F-Baseline	Yes
Intensification	SI	FI	Yes
Extensification	SE	FE	Yes
Trade-off 1	SE	FI	Yes
Trade-off 2	SI	FE	Yes

Work in Progress

Legend

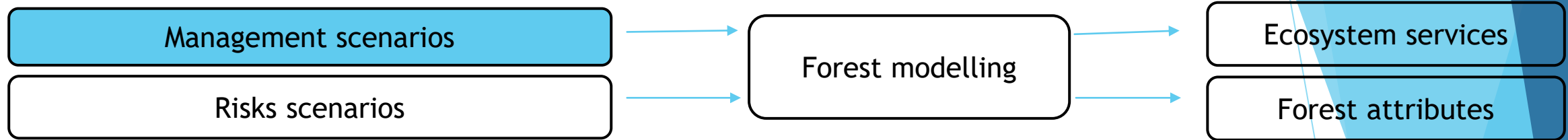
S : « stand »

F : “forest”

I :”intensification”

E : “extensification”





Scenario type	Stand scale	Forest scale	Enhance Complexity
Baseline	S-Baseline	L-Baseline	No
Intensification	SI	LI	No Land sparing based strategy
Extensification	SE	LE	No Land sharing based strategy
Trade-off 1	SE	LI	No
Trade-off 2	SI	LE	No
Baseline	S-Baseline	L-Baseline	Yes
Intensification	SI	LI	Yes Land sparing based strategy
Extensification	SE	LE	Yes Land sharing based strategy
Trade-off 1	SE	LI	Yes
Trade-off 2	SI	LE	Yes

Work in Progress

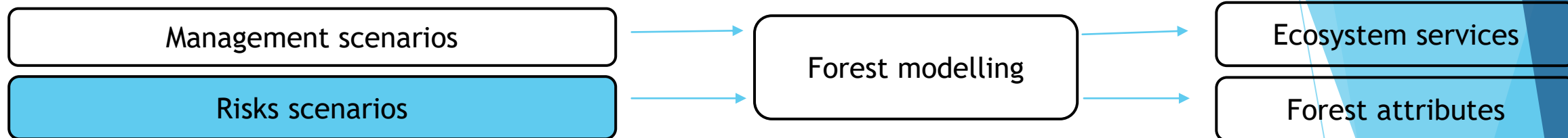
Legend

S : « stand »

F : “forest”

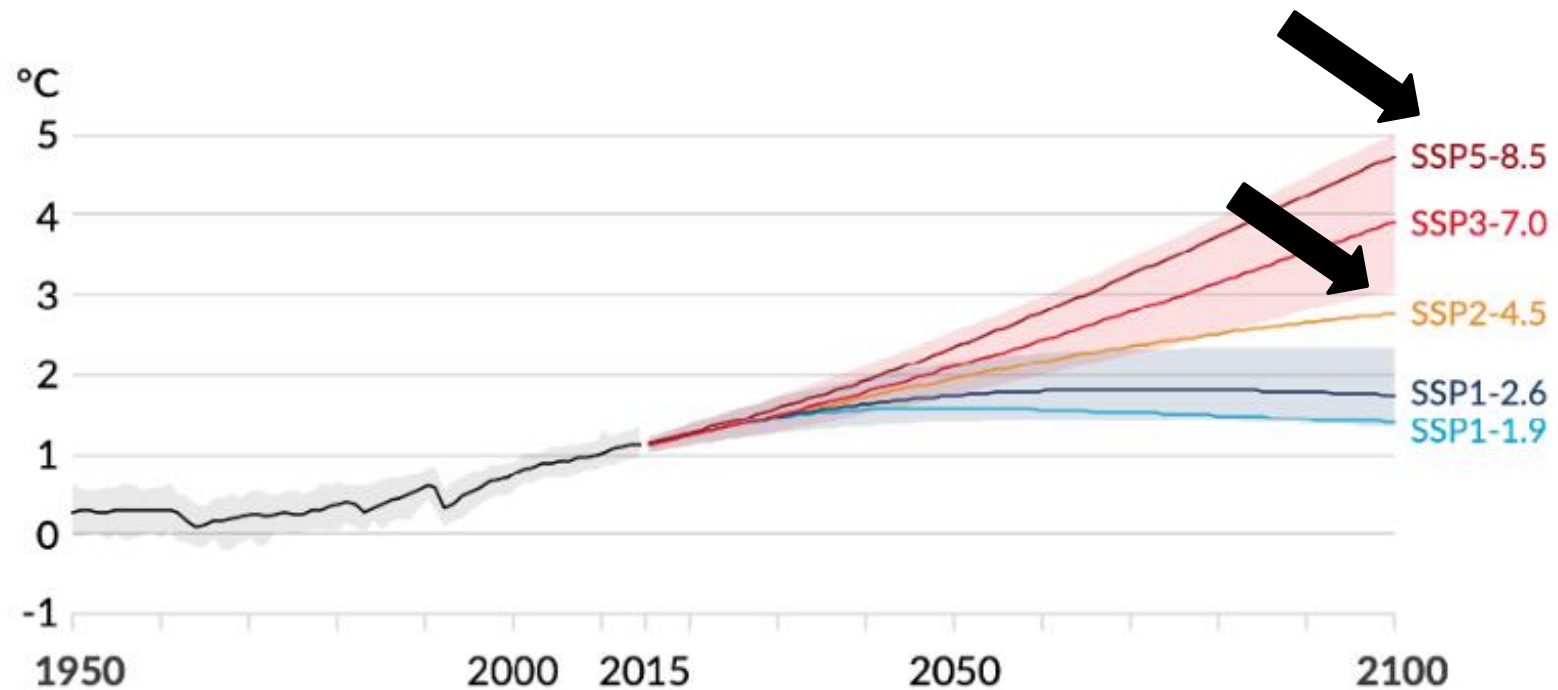
I :”intensification”

E : “extensification”

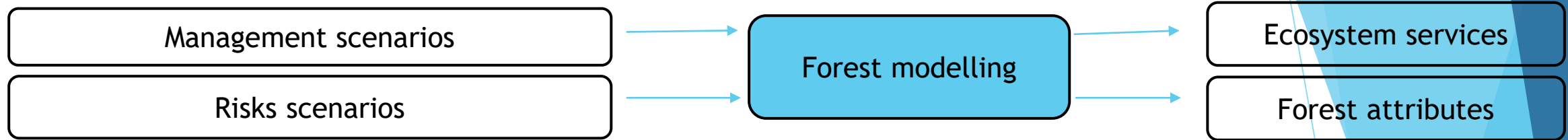


- Two climate scenario will be explore : the SSP2-4.5 and the SSP5-8.5

Focus on drought



IPCC 2021



- We are creating our own simulators on Capsis platform

WaFfleS



Wallonia Forest Simulator

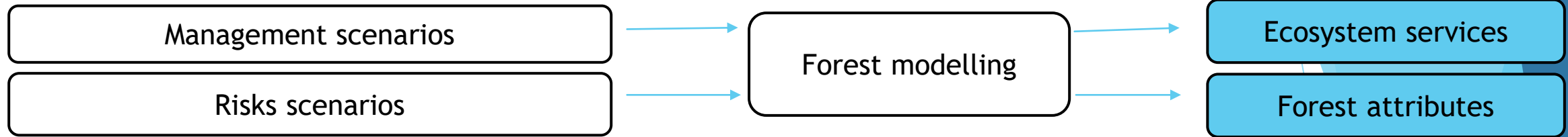
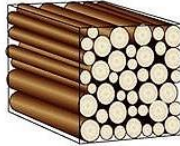
A tree-individual and distance-independent model

Based on empirical growth and regeneration sub-model

Based on semi-empirical mortality sub-model


Calibrated for 17 Belgian species

Designed for mixed, pure, even-aged and uneven-aged stand





Harvested timber [$\text{m}^3/\text{ha}/\text{year}$]
 Harvested timber per species [$\text{m}^3/\text{ha}/\text{year}$]
 Harvested timber per species and girth class [$\text{m}^3/\text{ha}/\text{year}$]

Basal area [$\text{m}^2/\text{ha}/\text{year}$]
 Basal area per species [$\text{m}^2/\text{ha}/\text{year}$]
 Basal area per species and girth class [$\text{m}^2/\text{ha}/\text{year}$]

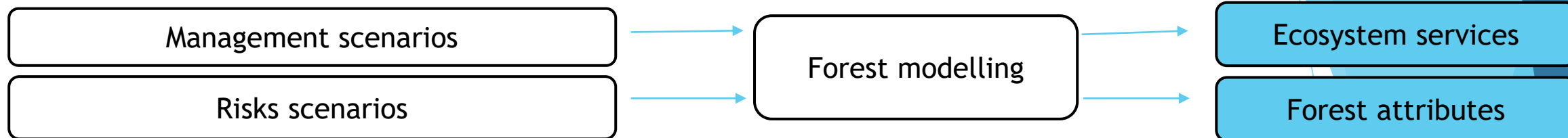


Carbon stock (dead wood, above and below-ground trees biomass) [T/ha]
 Harvested carbon stock [T/ha] (via C.A.T.)



Dead wood volume [m^2/ha]
 Number of living large wood [n/ha]
 Number of dendromicrohabitat tree [n/Ha]

Multifunctionality indicator



Resilience indicators



Niimmo et al. 2017

Species diversity indices

- Species richness
- Shannon index
- Simpson's dominance index

Structural diversity :

- Shannon index
- Gini index

Landscape diversity index :

- To be define in literature






Managers added value :

- New decision support system (WaFfleS)
- New communication tool (WaFfleS)
- Potential guidelines to manage their forest resilience and multifunctionality at large scale considering drought risks



Research added value

- Littérature review on the impact of structural and compositional complexity across scales on forest resilience and ecosystem services supply:
- Potential new knowledges about how to manage forest resilience and multifunctionality at large scale considering drought risks
- New simulator for Belgian forests



Thank you for your attention

Contact : v.vankeymeulen@uliege.be

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Supplementary material : Hypothesis

Ho : increasing structural and compositional complexity at the stand scale increase ES resilience by favouring process linked to growth reactivity

Ho : increasing structural and compositional complexity at the forest scale will decrease disturbances effect by diversifying stand response paths and diversifying their sensitivity

Ho : intensification at forest and stand scale will decrease tree density and reduce competition for water resources

Ho : extensification will reduce pressure on biodiversity, intensification will increase timber production, hypothesis for carbon stocks ?