

Species mixture vs. age mixture: how to conciliate wood production and carbon sequestration objectives under drought and windstorm risks in forest

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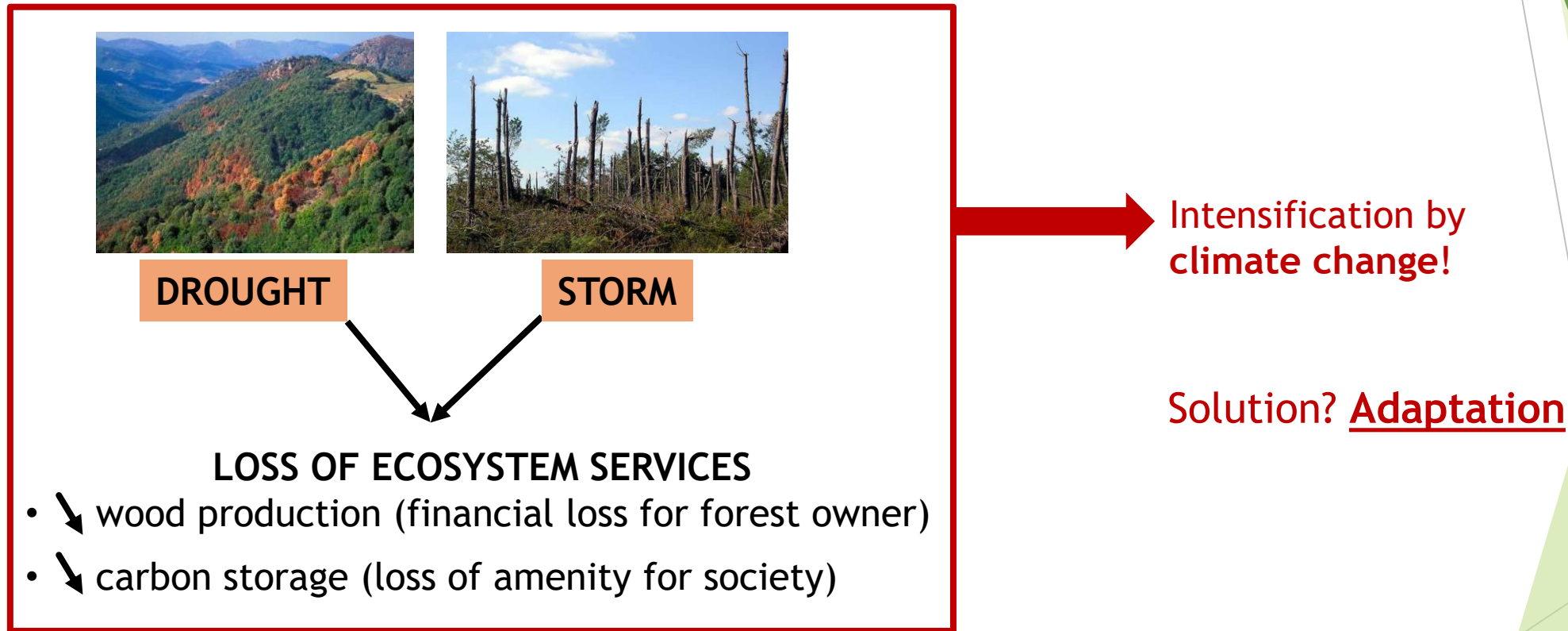
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Context: Drought and storm issues



State of the art

- ▶ Few studies with an **economic approach on forest adaptation** (Hanewinkel *et al.*, 2010 ; Yousefpour *et al.*, 2010 ; Brunette *et al.*, 2014 ; Yousefpour and Hanewinkel, 2014),
and few on drought-induced risk of forest decline
(Bréda and Brunette, 2019 ; Brêteau-Amores *et al.*, 2019).
- ▶ Only one study on **storm-induced risk of forest decline** and **few comparing different strategies of adaptation** (Jönsson *et al.*, 2015 ; Brêteau-Amores *et al.*, 2019).
- ▶ Only Petucco and Andrés-Domenech (2018) combined two risks
but no study combining drought and storm risks.

➤ Objective of the paper:

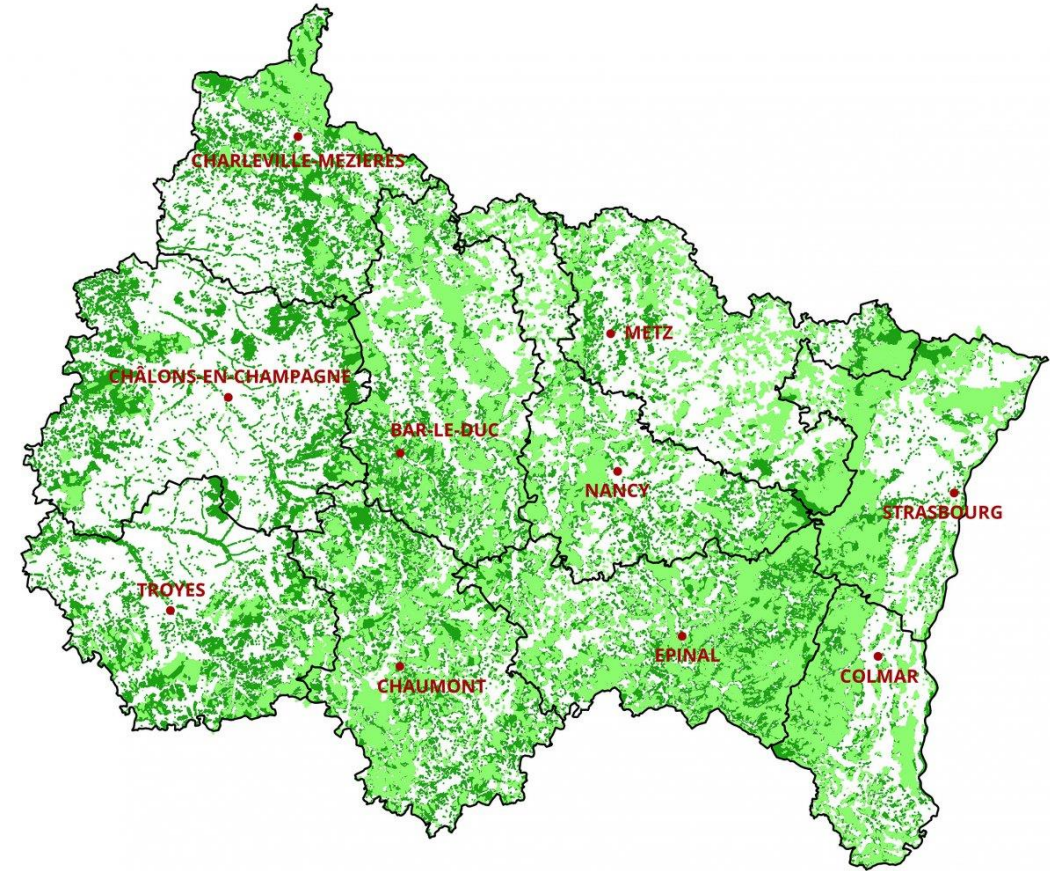
Comparison of different strategies of adaptation in terms of financial balance for the forest owner and carbon balance for the society, under two climate scenarios.

Our case study: Beech stands in Grand-Est

Grand-Est (French region):

- ▶ Forest cover: 33% of the territory.
- ▶ 42% of forests: **private property**.
- ▶ Most important species: **beech** and oak.
- ▶ Main function: **wood production**.

However, predictions of **beech decline, even extinction**, in France (Badeau *et al.*, 2004; Suttmöller *et al.*, 2008; Charru *et al.*, 2010).



Picture source: La Forêt Bouge.

Different strategies of adaptation

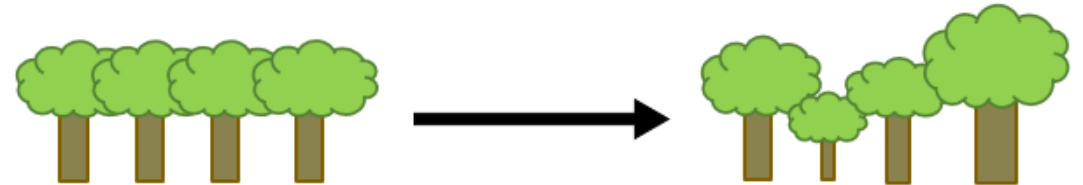
► 1. Species mixture (beech and oak):

Better wood productivity (complementarity) (Pretzsch *et al.*, 2012, 2013 ; Fruleux *et al.*, 2016) and **better resistance** (Lebourgeois *et al.*, 2013 ; Forrester, 2014).

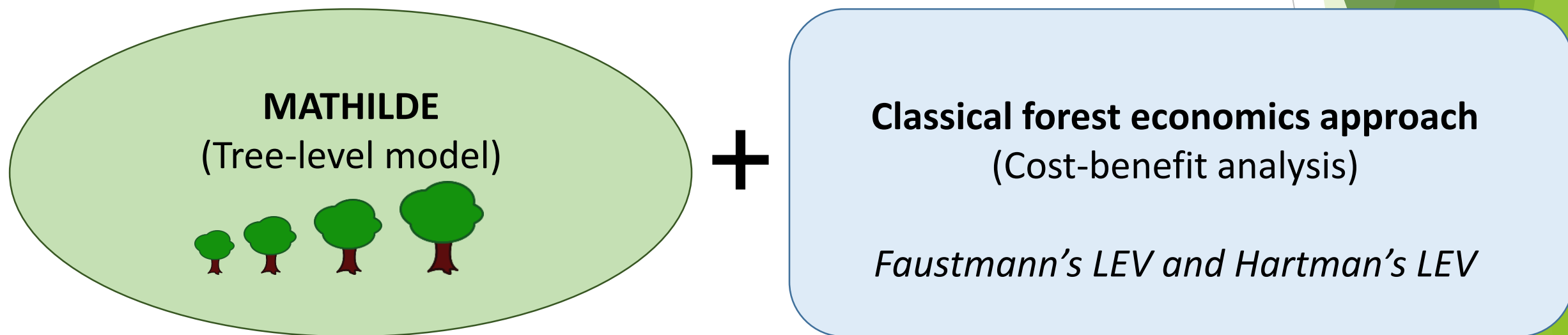


► 2. Age mixture (from even-aged to uneven-aged silviculture):

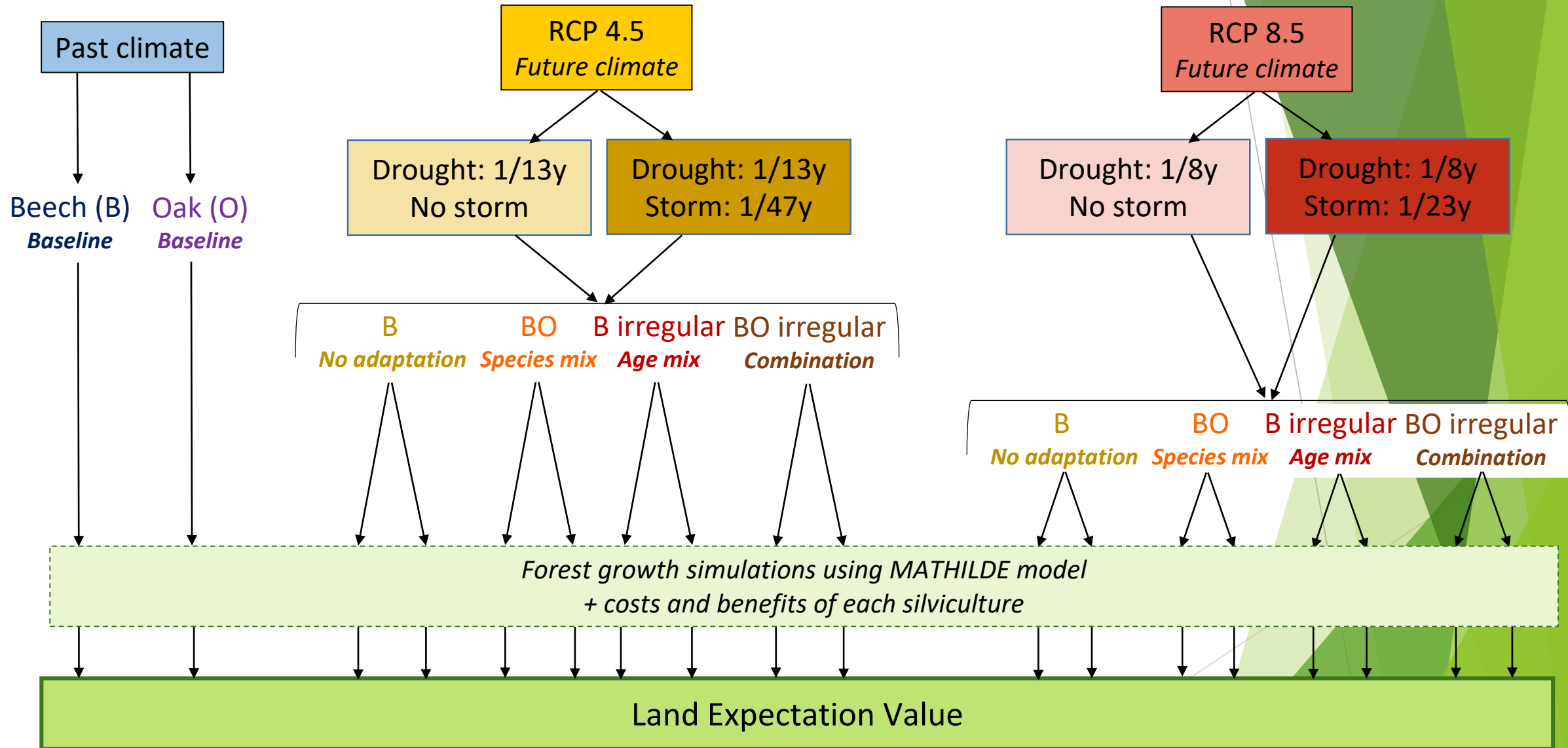
Better wood productivity (Dănescu *et al.*, 2016) and **trade-off between ecological and economic objectives** (PRO SILVA France, 2005).



Material and Methods: Based on a forest growth model and an economic approach



Material and Methods: 18 scenarios



BO= mix 50% beech – 50% oak

Preliminary results: Total productivity (standing wood + deadwood + harvested wood)

SCENARIOS		Productivity
Past (baseline)		Beech
		Oak
RCP 4.5	Drought	Beech
		Oak
		Mix
		Uneven
		Uneven_mix
	Drought + Storm	Beech
		Oak
		Mix
		Uneven
		Uneven_mix
RCP 8.5	Drought	Beech
		Oak
		Mix
		Uneven
		Uneven_mix
	Drought + Storm	Beech
		Oak
		Mix
		Uneven
		Uneven_mix

- ▶ Drought and storm decrease productivity.
- ▶ Beech (baseline/no adaptation scenario) is the best scenario.
- ▶ Adaptation decreases productivity from 4 to 40% (according to the baseline/no adaptation scenario).

Legend

Best scenarios

Worst scenarios

Preliminary results: Mortality

SCENARIOS		Productivity	Mortality
Past (baseline)		Beech	Beech
		Oak	Oak
RCP 4.5	Drought	Beech	Beech
		Oak	Oak
		Mix	Mix
		Uneven	Uneven
		Uneven_mix	Uneven_mix
	Drought + Storm	Beech	Beech
		Oak	Oak
		Mix	Mix
		Uneven	Uneven
		Uneven_mix	Uneven_mix
RCP 8.5	Drought	Beech	Beech
		Oak	Oak
		Mix	Mix
		Uneven	Uneven
		Uneven_mix	Uneven_mix
	Drought + Storm	Beech	Beech
		Oak	Oak
		Mix	Mix
		Uneven	Uneven
		Uneven_mix	Uneven_mix

- Drought and storm increase mortality.
- Uneven-aged beech-oak silviculture (-62% to -70%) and pure oak stand (-47%) are the best scenarios.
- Adaptation decreases mortality (according to the baseline/no adaptation scenario).

Legend

Best scenarios

Worst scenarios

Preliminary results: Economic perspective (LEV)

SCENARIOS		Productivity	Mortality	LEV
Past (baseline)		Beech	Beech	Beech
		Oak	Oak	Oak
RCP 4.5	Drought	Beech	Beech	Beech
		Oak	Oak	Oak
		Mix	Mix	Mix
		Uneven	Uneven	Uneven
		Uneven_mix	Uneven_mix	Uneven_mix
	Drought + Storm	Beech	Beech	Beech
		Oak	Oak	Oak
		Mix	Mix	Mix
		Uneven	Uneven	Uneven
		Uneven_mix	Uneven_mix	Uneven_mix
RCP 8.5	Drought	Beech	Beech	Beech
		Oak	Oak	Oak
		Mix	Mix	Mix
		Uneven	Uneven	Uneven
		Uneven_mix	Uneven_mix	Uneven_mix
	Drought + Storm	Beech	Beech	Beech
		Oak	Oak	Oak
		Mix	Mix	Mix
		Uneven	Uneven	Uneven
		Uneven_mix	Uneven_mix	Uneven_mix

- Drought and storm decrease LEV.
- Uneven-aged beech-oak silviculture and pure oak stand are the best scenarios.
- Adaptation increases LEV from 2 to 20 times (according to the baseline/no adaptation scenario), but it can be the **worst scenario** as well (RCP 8.5 D+S).

Legend

Best scenarios

Worst scenarios

In process

Results in terms of **carbon** (above/belowground pool).

Robust optimisation of the forest management according to 2 objectives :

- ▶ Wood production and carbon sequestration.

Discussion about :

- ▶ Additivity of the two risks.
- ▶ Additivity and/or synergy of the two adaptation strategies.

Thank you for your attention!

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