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Meerdaal Forest, Belgium (photo Beatrice Flauto)

Climate smart forestry

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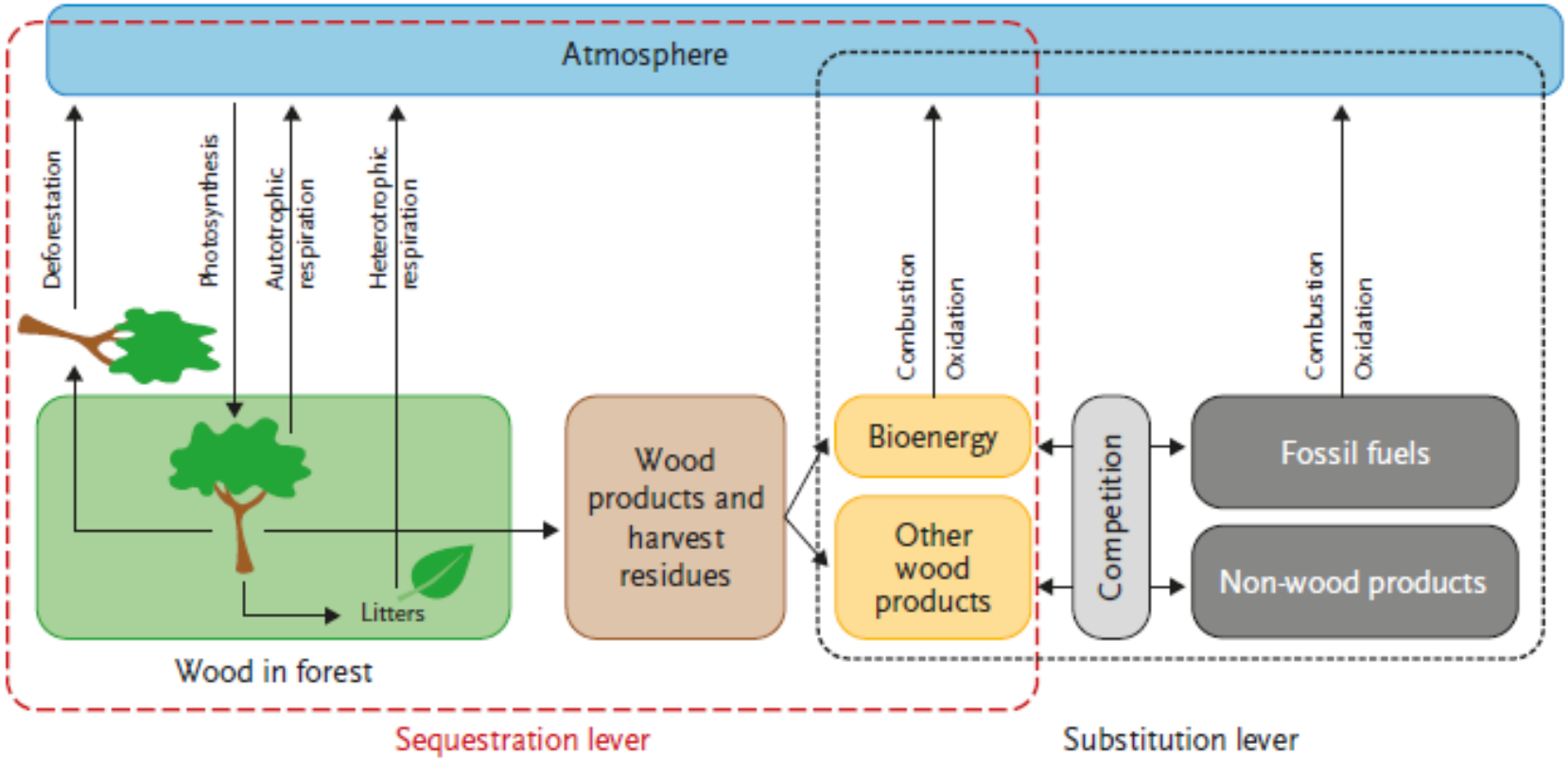
What is climate smart forestry?

- Inspired on Climate Smart Agriculture (Lipper et al 2014 *Nature CC*)
- First mentioned by Nabuurs et al., 2016, EFI FSTP2
- OUR ATTEMPT OF DEFINITION: “an approach to engage forestry in the challenge of climate change ensuring, through climate change **mitigation** and **adaptation**, the continued delivery of **multiple forest ecosystem services**.”

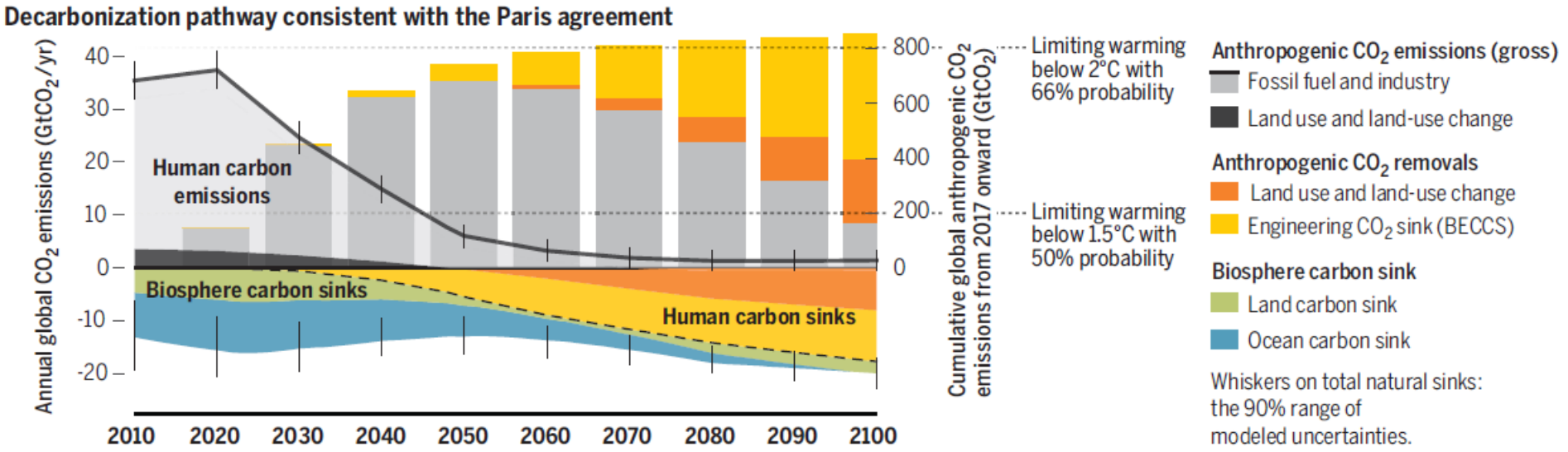
Mitigation options



Nabuurs et al., 2016, EFI FSTP2

Forests play key role in mitigation targets

- PARIS AGREEMENT: ¼ of anticipated global emission reductions by 2030 (INDCs) in LULUCF (Grassi *et al.*, 2017, *Nature CC*)
- LULUCF crucial to stay within 1.5°C



Rockström et al. 2017 “A roadmap for rapid decarbonization”, *Science*

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Forests play key role in mitigation targets

- EUROPE: even if EU has only 4% of world forests, but 10% of global CO_2 emissions, 12% of European GHG emissions are absorbed by forest sector (without substitution) Nabuurs et al. 2017, unpubl.
- Role of EU forest sector as a sink recently increased by overall decrease in EU emission, and could either increase or decrease depending on future forest sector development

The mitigation dilemma: to manage or not to manage

Not to manage	To manage
Europe's forest management did not mitigate climate change (Naudts et al. 2016, *Science*) Trade-off between forest carbon & harvesting; few HWP end up in long life products	Several countries combine large sinks with large harvests (Nabuurs et al., 2016, EFI FSTP2)
All climate forcing mechanisms addressed (carbon, effect of tree species on albedo, ET, products)	Substitution effects overlooked in climate policy
Both strategies may work, but is there a trade-off and where is the optimum? State of the art is inconclusive Need for **integrated, dynamic and consequential** assessment (cf. EU FP7 FORMIT)	

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Time explicit LCA integrating forest and wood

- Breakthrough by FORMIT project (PhD G. Cardellini): New Brightway2Temporalis LCA software

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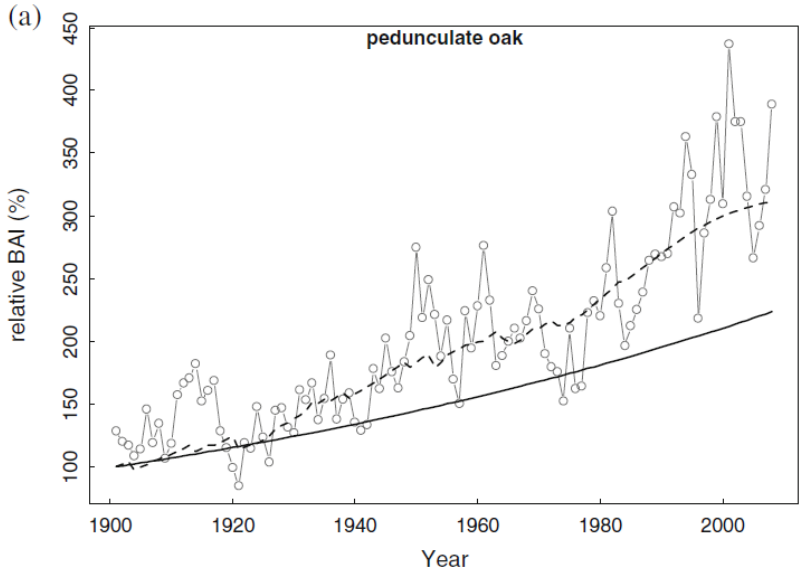
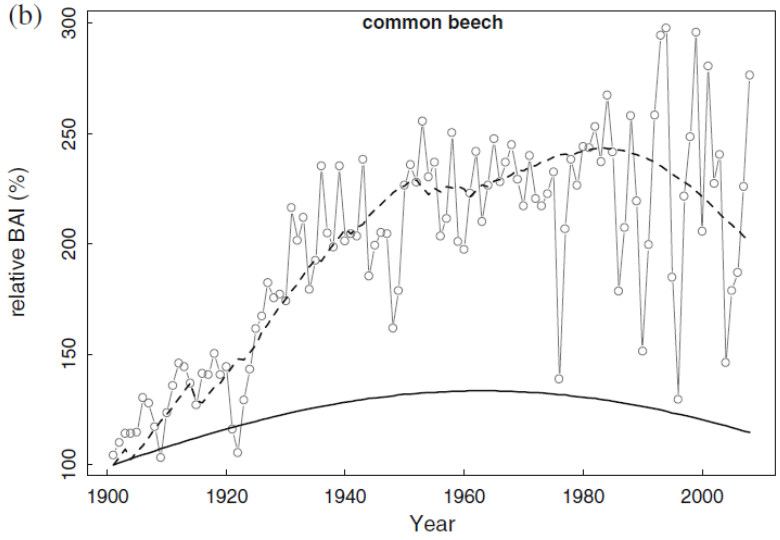
Forest carbon

- EU forests are a huge carbon sink of 450 Mt CO_2 per yr
- 3 early warning signals for sink saturation: slow down in stem volume increment, afforestation/deforestation rate slowing down, increased disturbances (Nabuurs et al. 2013 *Nature Climate Change*)





Kint et al. 2012 *Climatic Change*

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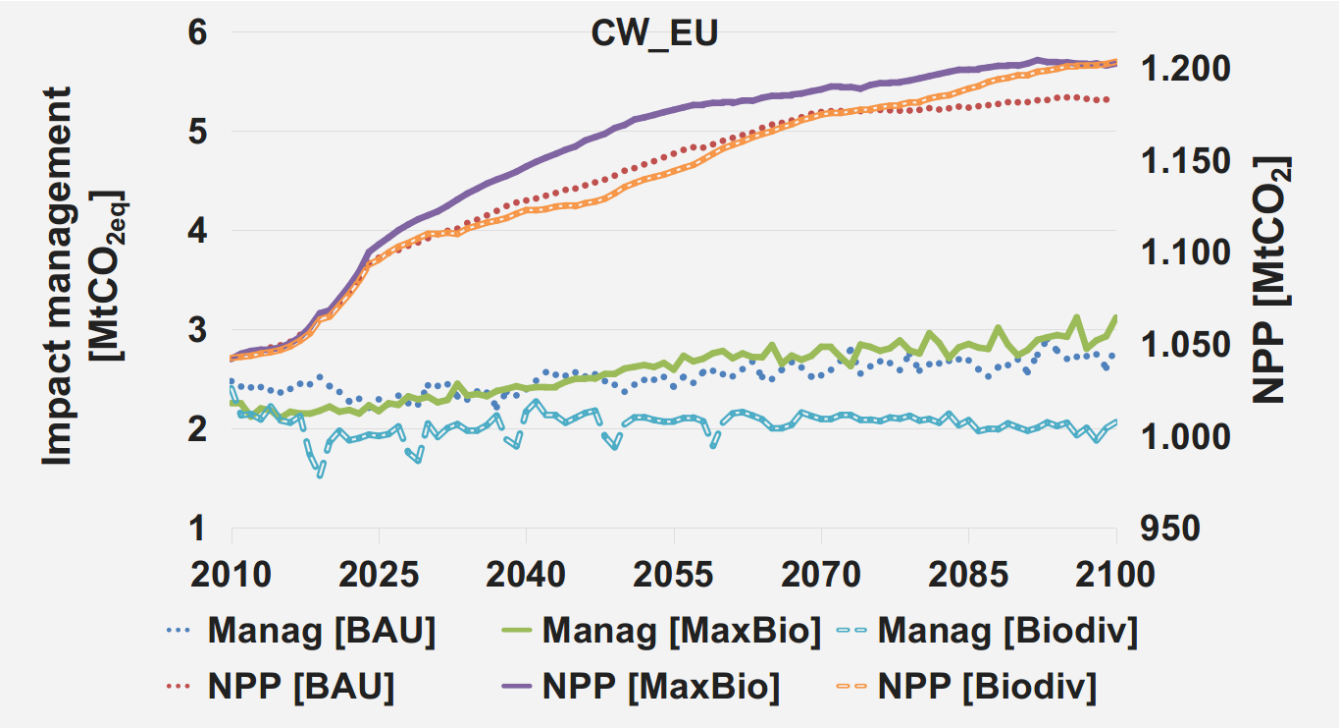
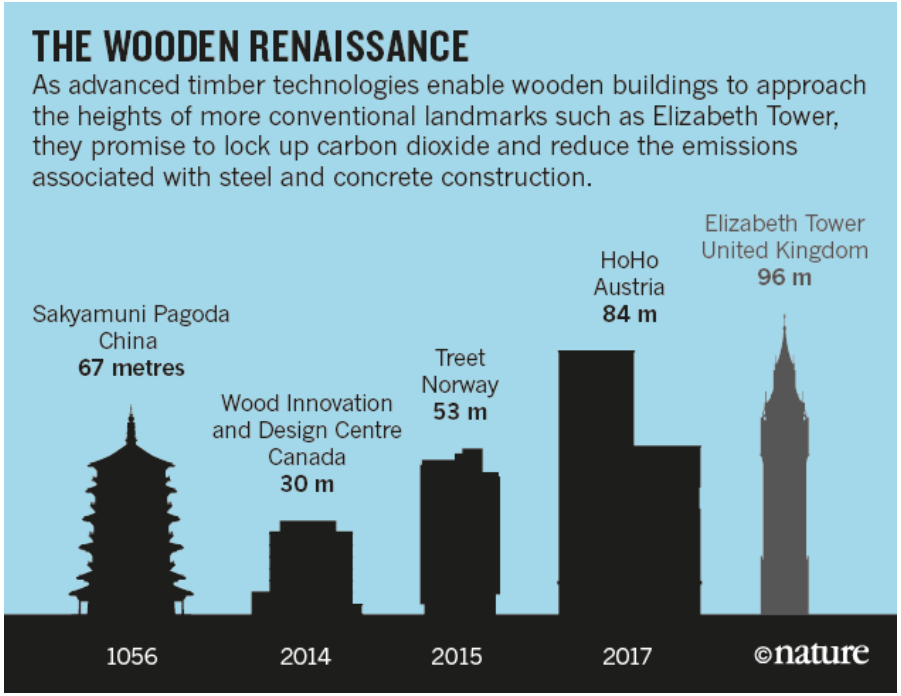
Carbon emissions from forest operations



- For any management scenario, the C emissions from operations are negligeable compared to the forest flux
  (Cardellini et al. 2017b, in prep, EU FP7 FORMIT)

Carbon storage in wood

- EU-POOL: 9t C for every ha of productive forest (Germany 22tC/ha, doubled over the last 20 years) (Brunet Navarro 2017, PhD KU Leuven, CASTLE Marie Curie Training Network)
- CURRENT EU-SINK: about 10% of forest carbon sink
- SHORT TERM: maintaining sink only at the expense of forest C (Pili et al. 2015, *Carbon Balance & Management*)
- LONG TERM: maintaining sink by generalising **CLT** in construction and **cascading**



Tollefson, 2017 "The wooden skyscrapers that could help to cool the planet" *Nature*

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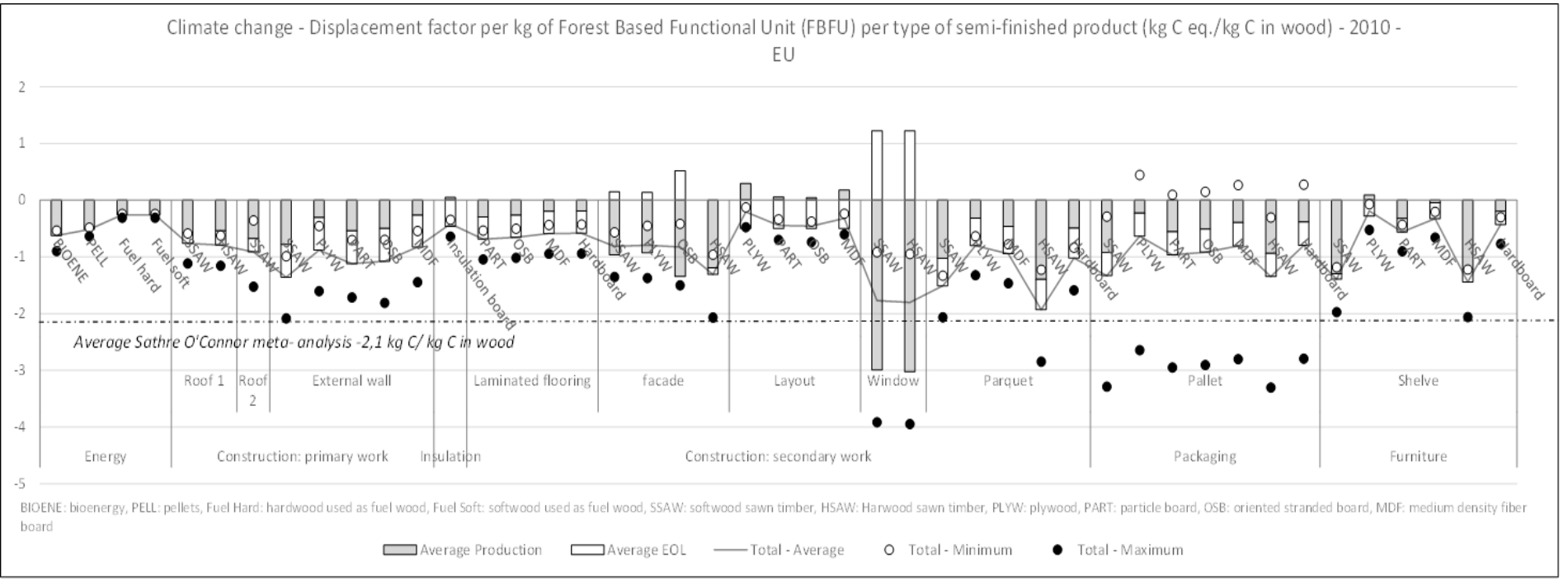
Material and energy substitution



- New data from FORMIT FP7 (from final report)
- Substitution effects (about -1kg Ceq per kg C in the wood) generally half of rough estimations from the past; Material substitution more effective than energy substitution

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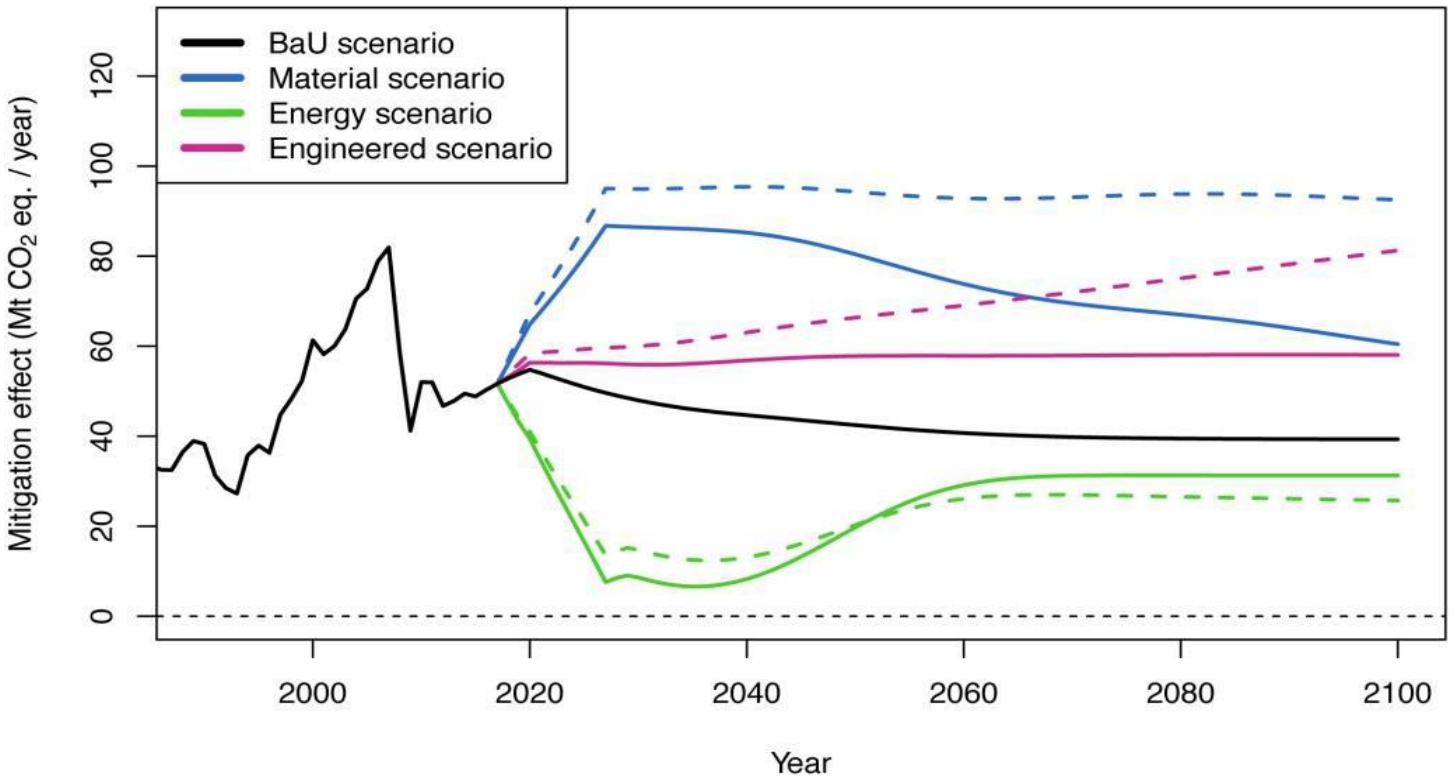
Cascading and substitution



- **Mitigation effect of EU wood sector**: effects of carbon stock change (full lines) and total effect with substitution (dashed lines) for different scenarios (Brunet Navarro, 2017, PhD KU Leuven, CASTLE Marie Curie Training Network)
- Long-term potential of cascading scenarios and substitution is huge; energy scenario always less effective than BAU; need to include substitution in climate policies

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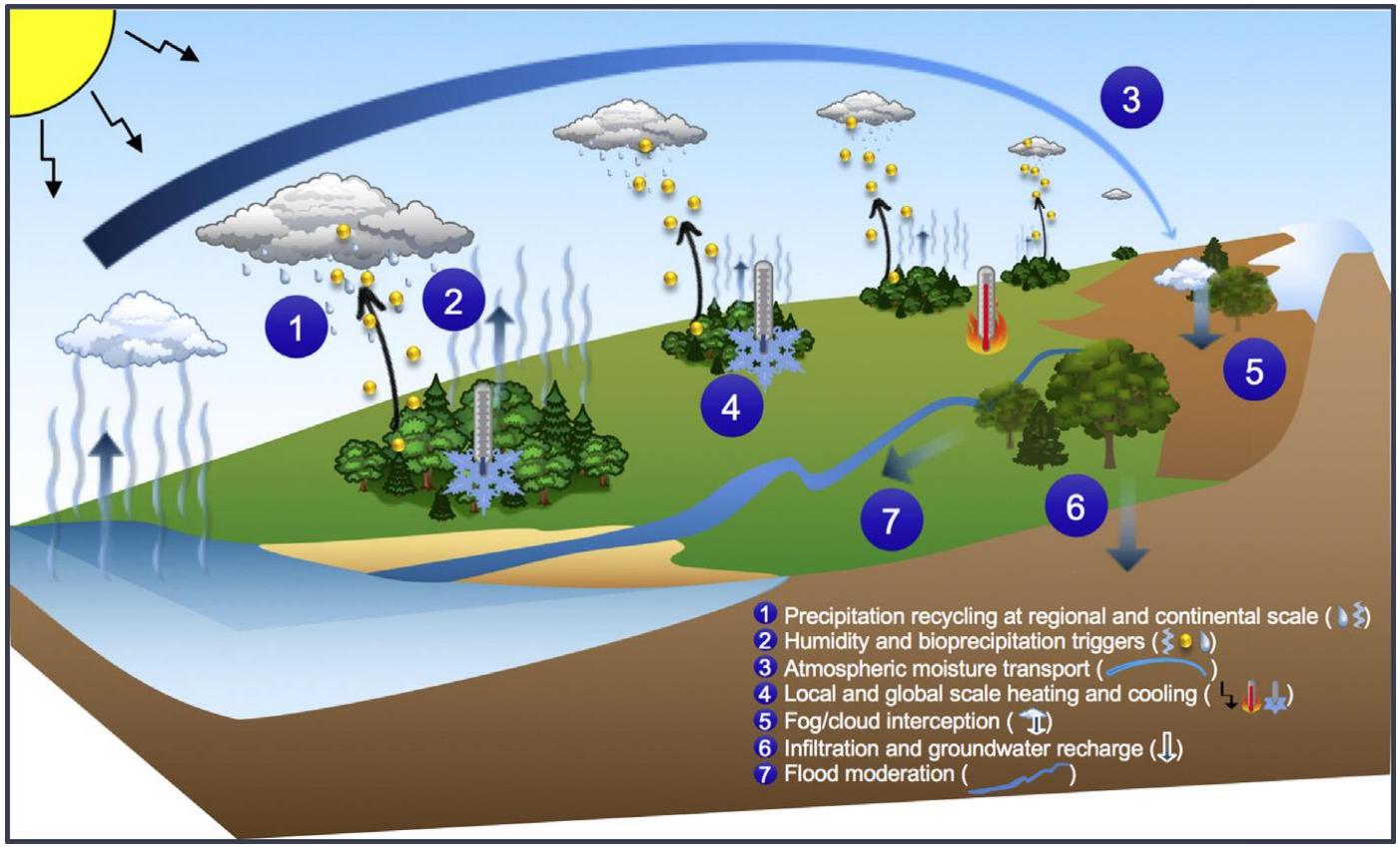
Bioenergy from the forest

Strengths	Weaknesses
Income for forest owners	Price pressure on other wood resources
Large resource potential	Low photosynthetic efficiency – space needs – insufficient potential
Renewable energy source	Dirty fuel, particle emissions
Versatile technology	Better technology for smart grids existing
Cheap alternative energy source	Waste of valuable resource
Potential for lorry and airplane fuel	Higher potential for material and chemical use

Mitigation data gaps

- Forest data harmonization; northern forest dynamics (North State project)
- Urgent need for wood sector data disclosure

Beyond carbon: forests for global ecosystem services



- Trees, forests and water: Cool insights for a hot world
  (Ellison et al. 2017, *Global Environmental Change*)
- Joint efforts between conventions and DGs

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Integrating mitigation with other ecosystem services: from tradeoffs to synergies

- Decision support system development
- Lessons learnt from AFFOREST, INTEGRAL, DIABOLO, ALTERFOR, MANFOR projects

Fig. 3 Harvest schedule for the next twenty years under three different scenarios, a wood production scenario (*WPS*), a biodiversity scenario (*BS*) and an integrated scenario (*IS*). Some stands are only harvested under one scenario, some are harvested under two scenarios (*brown* and *green dots*) and some even under three scenarios (*black dots*). (Color figure online)

Van Gansbeke et al. 2016 Spatially combining wood production and recreation with biodiversity conservation. *Biodiversity & Conservation*

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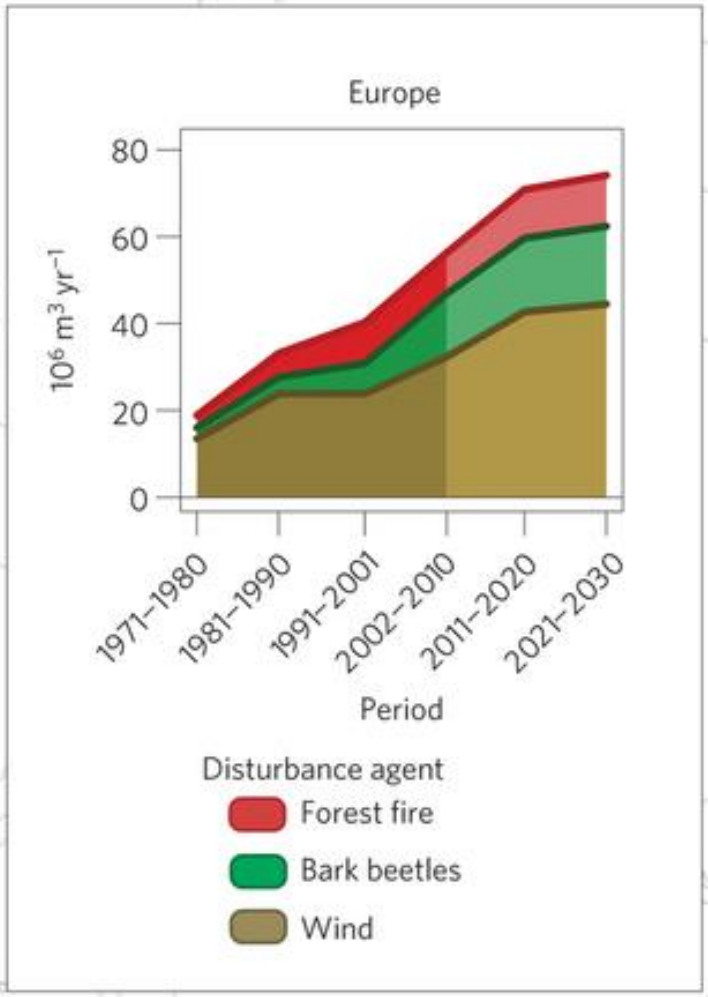
No mitigation without adaptation



- Increasing forest disturbances in Europe have impact on carbon storage
- Mitigation only possible in healthy, stable forests.
- Need for overall increase of forest resilience
- Start now for long-term benefits

Seidl et al. 2014 *Nature Climate Change*

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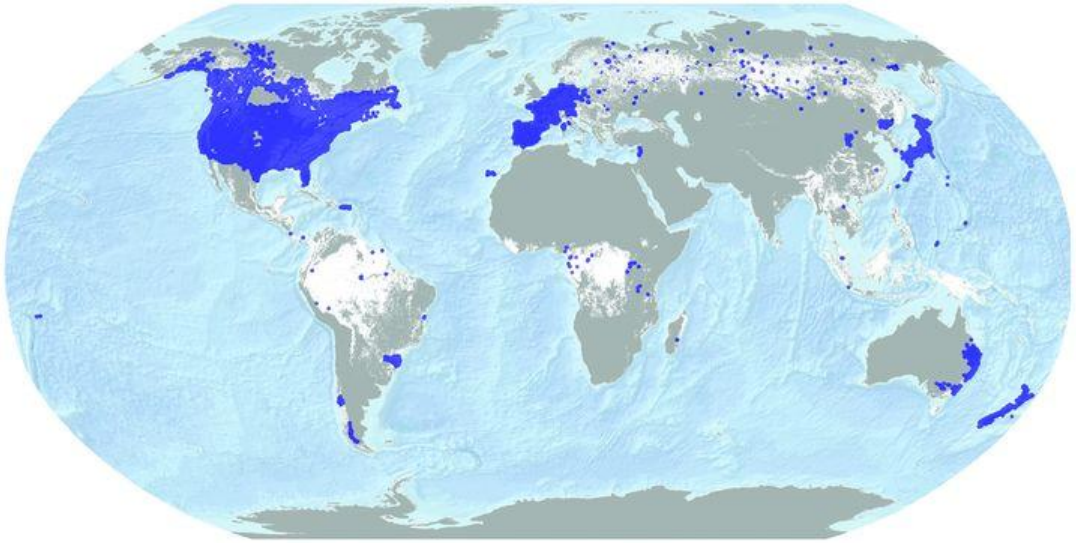
The undervalued role of forest genetics

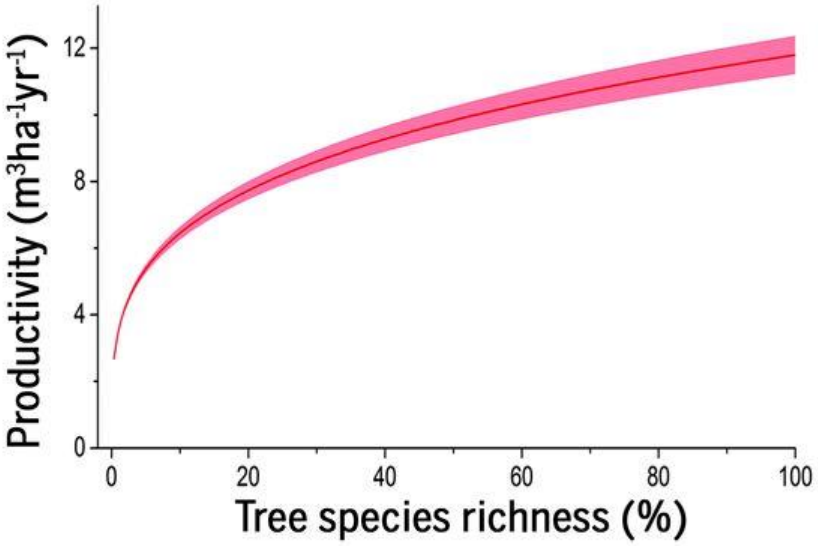
- Forest management can mitigate effects of CC on forest genetic diversity, but today's forest management often contributes to loss of genetic diversity (Fady et al. 2015 *Reg. Env. Change)*
- Table with examples of **Evolution-oriented forestry** practices (Lefèvre et al. 2013 *Annals of Forest Science)*

Forestry practice	Expected benefits
N_e-oriented regulation of the density and spatial distribution to equalize reproductive success between trees in small populations	Reduce the variance in reproductive success to reduce genetic drift Reduce spatial genetic structure in the seedlings and inbreeding in next generation
In heterogeneous environment, dissociate areas of production and areas of evolution (selection patches in harsh areas) and allow gene flow between these entities	Increase the reproductive contribution of the trees that have survived to drastic selection pressure
Save the lone tree, which cumulates long distance dispersal (in allo-pollinated seeds) and can be adapted to marginal conditions; collect seeds for local assisted regeneration	Diversify the mating pairs to favour the emergence of new genotypic combinations Promote adaptation to marginal conditions
Assisted local seed dispersal (e.g. collecting, possibly over several years, mixing and replanting seeds within the stand) or pollen dispersal (e.g. air flow used in seed orchards)	Enhance local gene flow to diversify the mating pairs and favour the emergence of new genotypic combinations Reduce inbreeding
Enhance local migration capacity by favouring seed dispersal and germination at distance from the main stand	Speed-up colonisation of locally favourable habitats in an environmental gradient
Genetic enrichment by introduction of a limited amount of seeds or pollen from presumably pre-adapted allochthonous origins	Introduce pre-adapted genotypes Increase local genetic diversity
Marker-assisted selective thinning (futurist)	Increase selection intensity on target major genes while retaining genetic diversity in the rest of the genome

The power of mixture

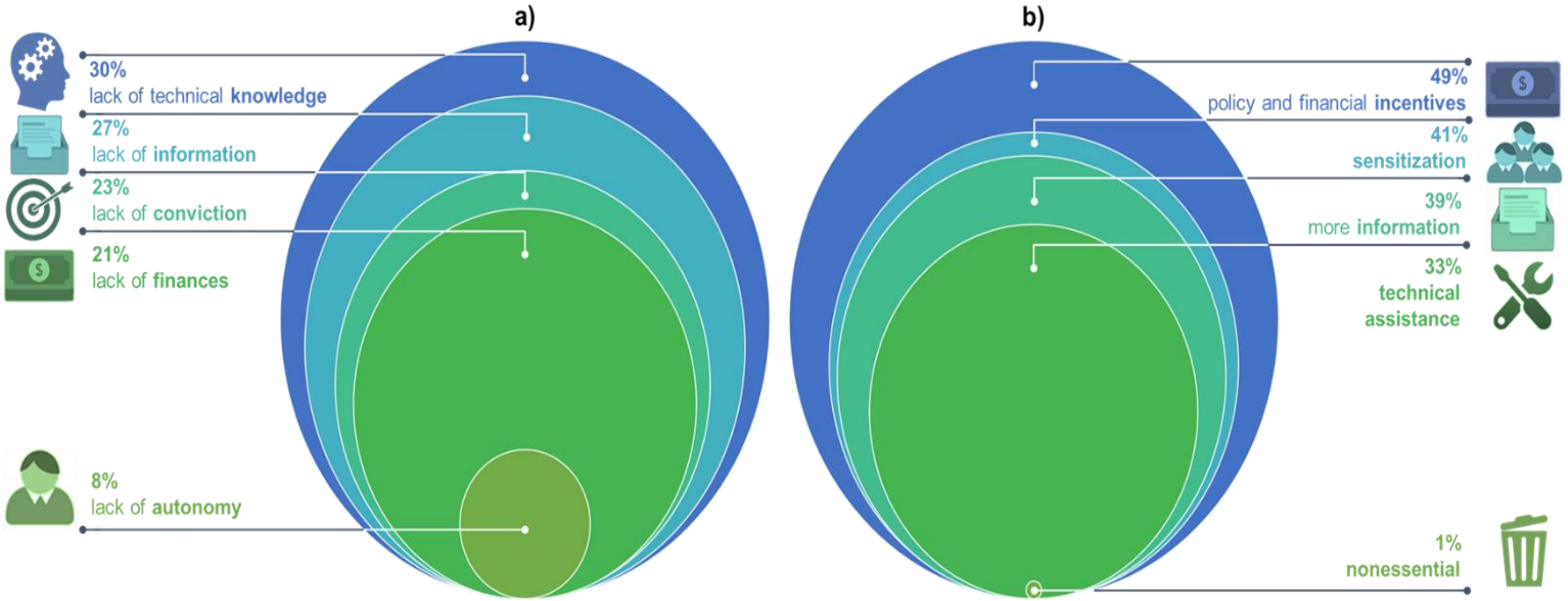
- Growing evidence of positive diversity-productivity and diversity-stability relationships (global inventory data, FunDivEUROPE exploratories, TREEDIVNET experiments





Liang et al. 2016 Positive biodiversity-productivity relationship predominant in global forests, *Science*

The need for information to adapt



- European forest adaptation survey. a) Constraints limiting climate change adaptation and b) assistance required to address those impediments (PhD Rita Silva-Sousa, KU Leuven)
- LIFE projects

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Systemic forestry

Table 1. Comparison between "systemic forestry" and other approaches.

	"Conventional" forestry[1]	Close to nature forestry[2] Ecological forestry[3]	Resilience thinking[4]	"Systemic" forestry
View of the forest	The forest as a sum of trees	Focus on trees expanding to include soil and biodiversity. The forest as an ecosystem	Forests as complex social-ecological adaptive systems	
Multifunctionality	*Wake theory*: if forests are efficiently managed for wood production, then all the other forest utilities will follow	The production function must comply with conservation of other values (*e.g.* biodiversity). Multiple use forestry based on a sound ecological basis	Focus on maintaining options rather than a particular way of using a resource	Multifunctionality is the outcome of complex interactions between various sub-systems
The Future	High predictability	Predict ecological consequences of management practices	Low predictability - Uncertainty is acknowledged	
Management	Approaches based on forecasting	Management based on knowledge of past disturbance regimes and/or "desired future condition"	To maintain a desirable state (identity), or transform into a more desirable state	Approaches based on monitoring and adaptation of silvicultural interventions to reactions of the system
	Maintain an optimal condition of the resource		Maintain the systems' identity - function, structure and feedbacks	Develop an optimal management capacity
	Strictly ruled forest planning	Planning based on multifunctional optimization models	Maintaining options rather than a particular way of using a re-	Adaptive forest planning

Nocentini et al. 2017 *Forest Systems*

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Highlights

- Large mitigation potential in EU forest sector
- Mitigation focus on forest carbon (afforestation, conservation) AND on wood carbon (cascading and substitution)
- Forest bioenergy does not seem to have a high potential to play a key role in the mitigation strategy
- No mitigation without adaptation
- Adaptive forest management needs support

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