



**Circular Economy
Summer School**
Circular Bioeconomy
29 JUNE 2024 - 2 JULY 2024



UNIVERSITÀ DI PADOVA
Dipartimento
di Territorio e Sistemi
agro-forestali

Between opportunities and constraints: the development of a forest-based bioeconomy

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Outline

- Forest resources, climate change and bioeconomy: setting the ground
- Bioeconomy and the ecosystem service framework
- Provisioning services
- Other benefits and ecosystem services
- Final considerations

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NATIONAL GEOGRAPHIC
SAVE THE FORESTS

Forest resources have moved to center stage: increasingly affected by climate change and other global challenges, yet also central to addressing them
(different perspectives, roles, emphasis, voices...)



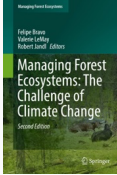
nature
FOREST FORECAST



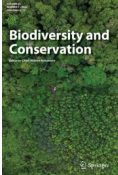
TIME
How to Win the War on Global Warming



TIME
Banking on Trees



Managing Forest Ecosystems: The Challenge of Climate Change



Biodiversity and Conservation



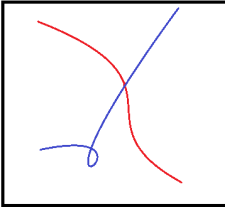
Forest Bioeconomy and Climate Change

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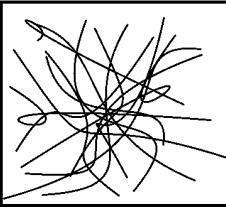
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Forest resources and climate-change: a wicked rather than a linear issue



Traditional Problem



Wicked Problem

Forest resources:

- (possible) Climate change **driver**
- **Affected by** climate-change
- Climate change **mitigation**
- Climate change **adaptation**

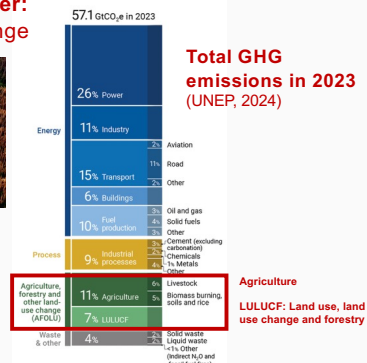
Possible trade-offs (& synergies)

- **Spatial scales** (e.g., EU vs. non-EU)
- Across **different forest benefits** (commercial vs. non-commercial)

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Forest resources as a **climate-change driver**: agriculture, forestry and other land use change



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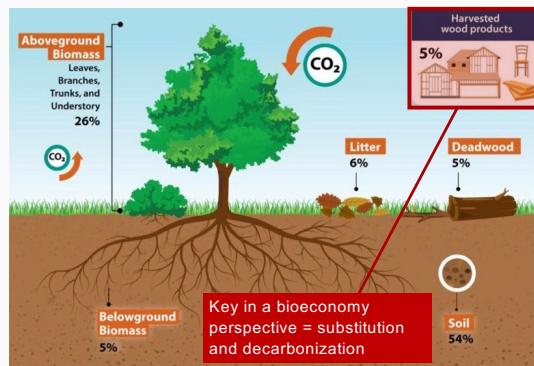
Forest resources as **possible contributors** in addressing the climate-change crisis

Mitigation = decreasing CO₂ concentration in the atmosphere
(removals and substitution of more C-intensive materials)



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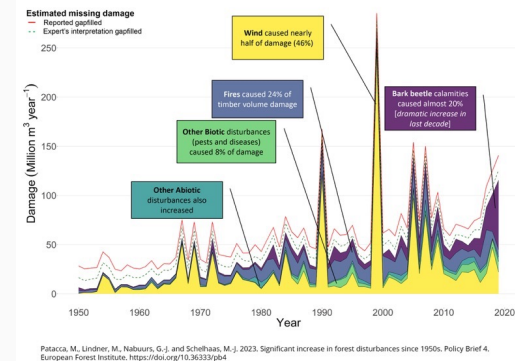
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Source: FAO FRA (2025) and FOCCE (2025)

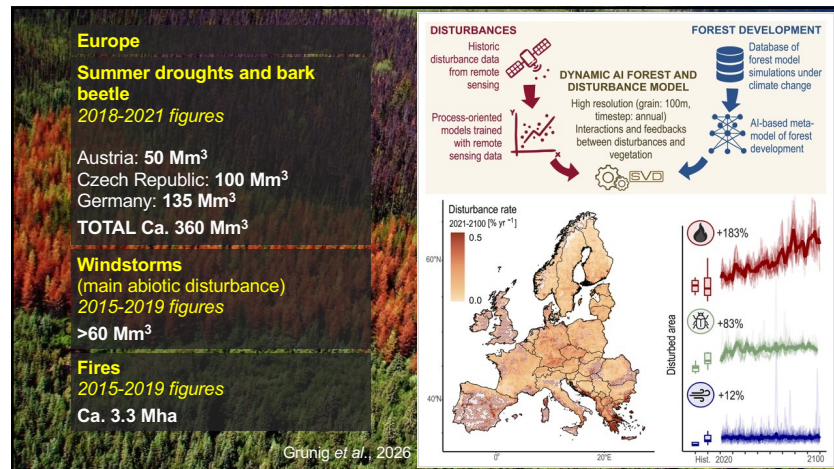
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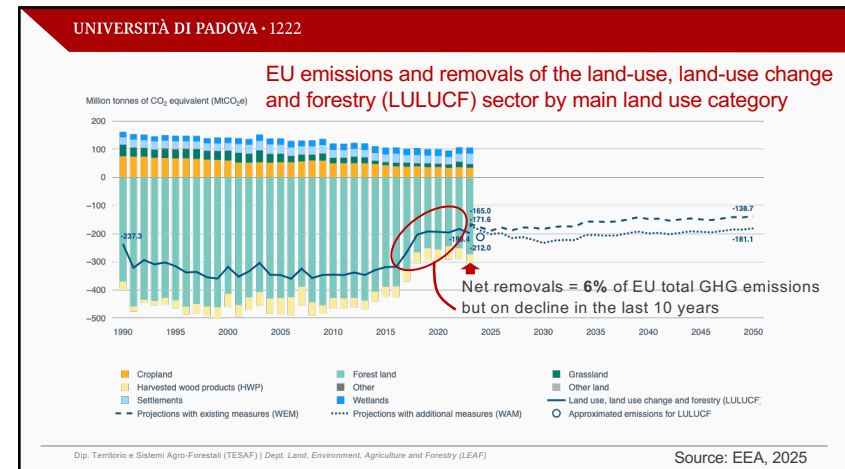
Patacca, M., Lindner, M., Nabuurs, G. J., and Schelhaas, M. J. 2023. Significant increase in forest disturbances since 1950s. Policy Brief 4, European Forest Institute. <https://doi.org/10.36333/pb4>

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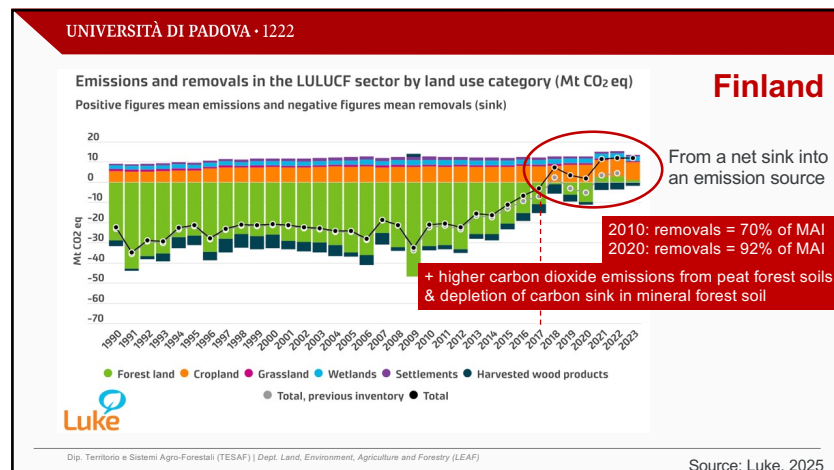
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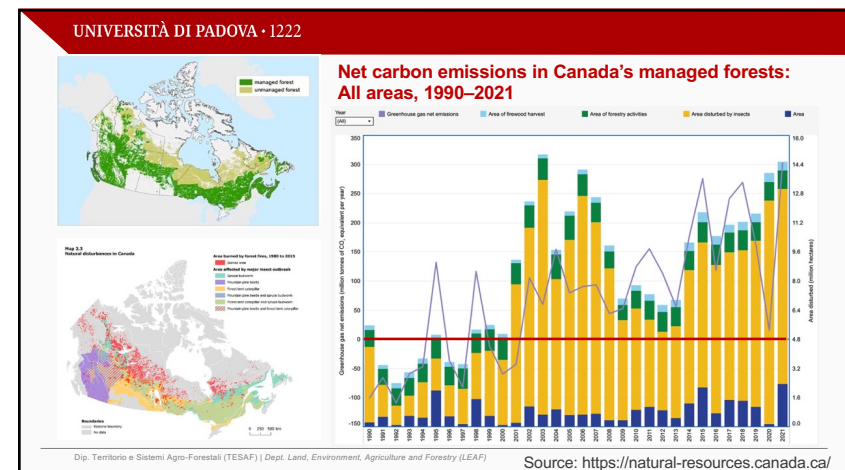
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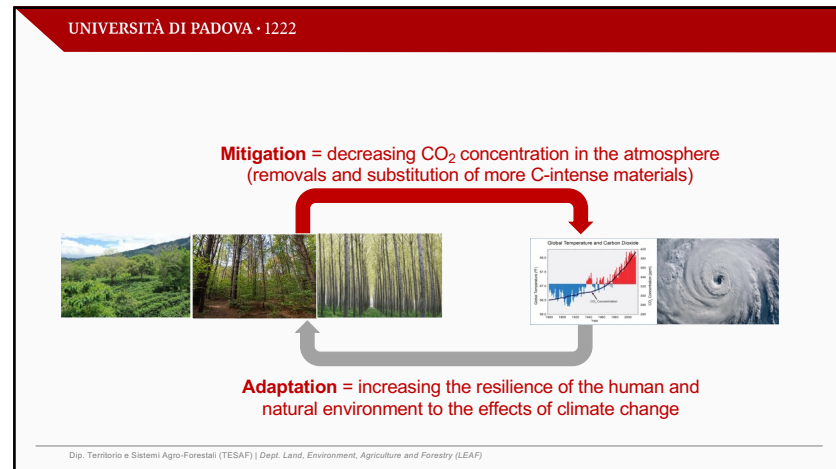
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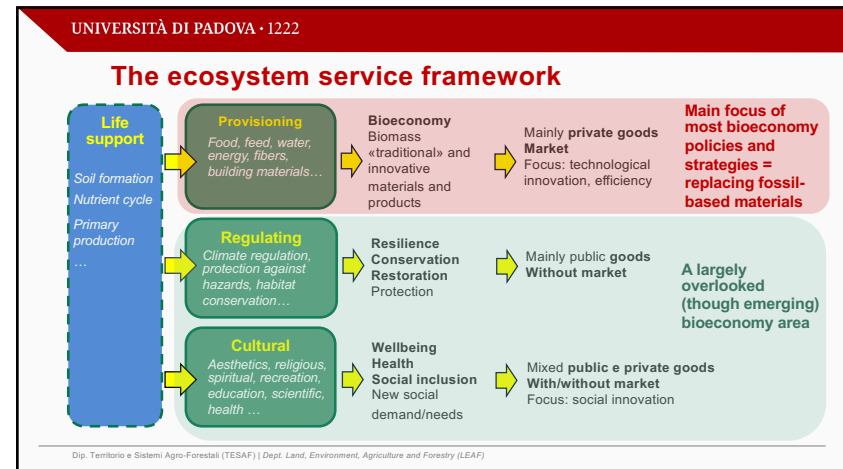
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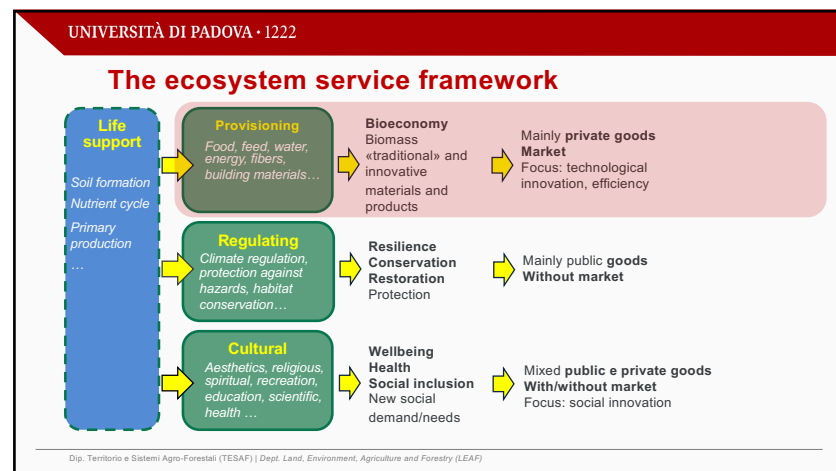
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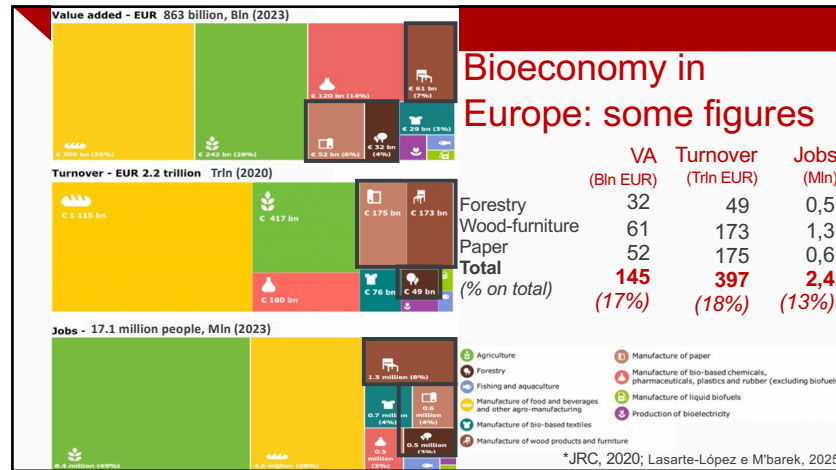
Strategic Framework for a Competitive and Sustainable EU Bioeconomy

Vision: The European Bioeconomy in 2040

"By 2040, sustainable bio-based materials and products such as construction materials, biochemicals, textiles, fertilisers and plant protection products and plastics are widely deployed in the EU. They provide fossil-free alternatives and create new, stable income streams in rural, coastal and industrial regions across Europe."

EUROPEAN COMMISSION
Brussels, 27.11.2025
COM(2025) 960 final
COMMUNICATION FROM THE COMMISSION TO THE EUROPEAN PARLIAMENT, THE COUNCIL, THE EUROPEAN ECONOMIC AND SOCIAL COMMITTEE AND THE COMMITTEE OF THE REGIONS
A Strategic Framework for a Competitive and Sustainable EU Bioeconomy
(SWD(2025) 895 final)
<https://eur-lex.europa.eu/legal-content/EN/TXT/?uri=CELEX:52025DC0960>
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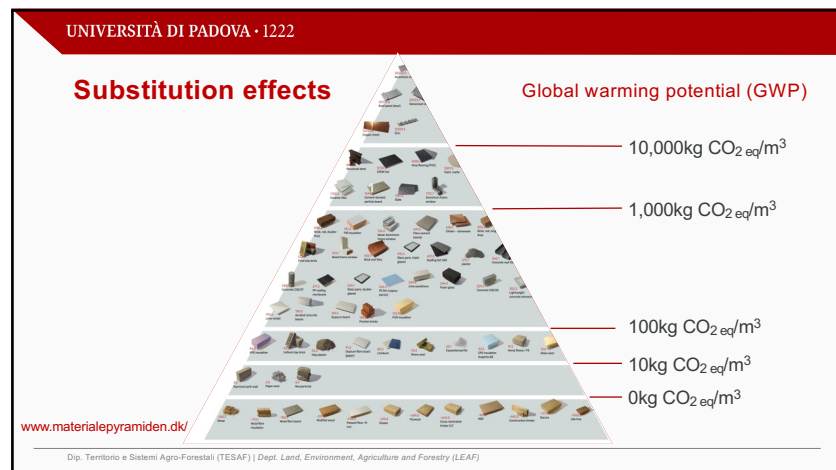
EU Forest Strategy to 2030

Promoting sustainable forest bioeconomy for long-lived wood products → New Bauhaus initiative

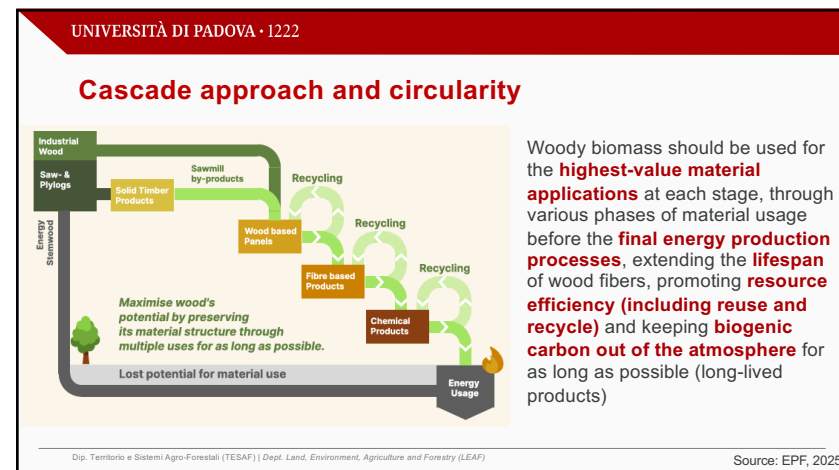
(...) the most important role of wood products is to help **turn the construction sector from a source of greenhouse gas emissions into a carbon sink** (...) There is considerable room for improvement. With less than 3% of market share, wood products are still only a tiny fraction of building materials in Europe



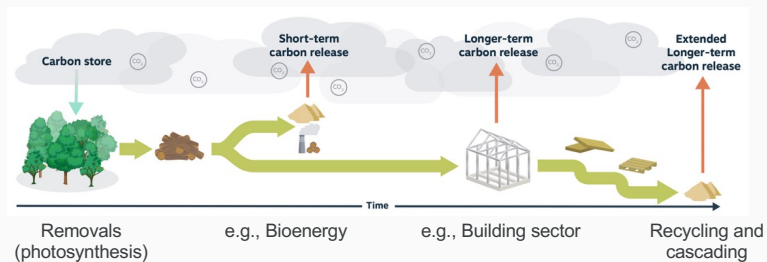
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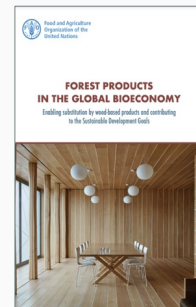


Source: modified from Metabolic Institute and Probos, 2026

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Innovative wood-based products (FAO, 2021)



Product	Main uses and applications
Engineered wood products (CLT, LVL)	Building elements

Mostarinet, 18 floors (Norway) - Credits: Molven

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CLT or X-LAM
Cross-laminated timber

At least three layers of wood planks glued together (or otherwise joined), where the direction of the grain in adjacent layers is perpendicular to each other



Source: Verkerk et al., 2021

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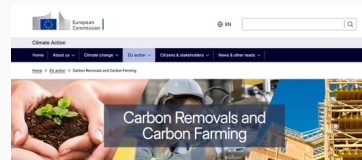
LVL

Laminated veneer lumber

Peeled spruce or pine veneers (up to 6 mm thick) glued together in a continuous process, using a phenolic resin



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Carbon Removals and Carbon Farming (CRCF) Regulation (EU) 2024/3012



Carbon farming

Examples:
Afforestation/Reforestation
Wetland restoration
Agroforestry
Farming practices (e.g. no-tillage)



Long-lasting products

Bio-based construction products:
Timber and wood-based
Crop-based



Permanent removals via industrial technologies (after 2030)

Direct air carbon capture with storage (DACCS)
Bioenergy with carbon capture and storage (BECCS) and other methods (BioCCS)

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Innovative wood-based products (FAO, 2021)

Product	Main uses and applications
Wood foam	Insulation (thermal and acoustic), packaging
Bioplastics	Packaging
Wood-based composites	Packaging, disposable products
Wood-based textile fibres	Textiles



Wood foams



Bioplastics



Wood-based composites



Wood-based textile fibers

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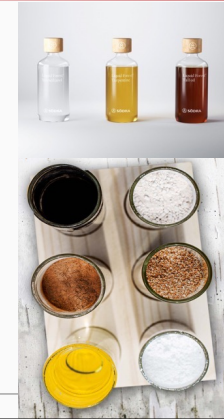
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Other innovative wood-based products

Bio-fuels (2nd generation biofuel from woody material), bio-pharmaceutics and bio-cosmetics (cellulose, hemicellulose, barks), ...

www.sodra.com/en/global/Bioproducts/

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EU Forest Strategy to 2030

2.2 Ensuring sustainable use of wood-based resources for bioenergy

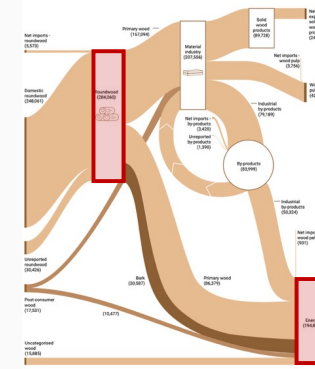
Wood based bioenergy is currently the **main source of renewable energy**, supplying **60% of EU's renewable energy use**. To meet the at least **55% emission reduction target by 2030 (...)** Bioenergy will continue to have a notable role to play in [the energy] mix



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Woody biomass flows in the forest-based sector in the EU, 2017

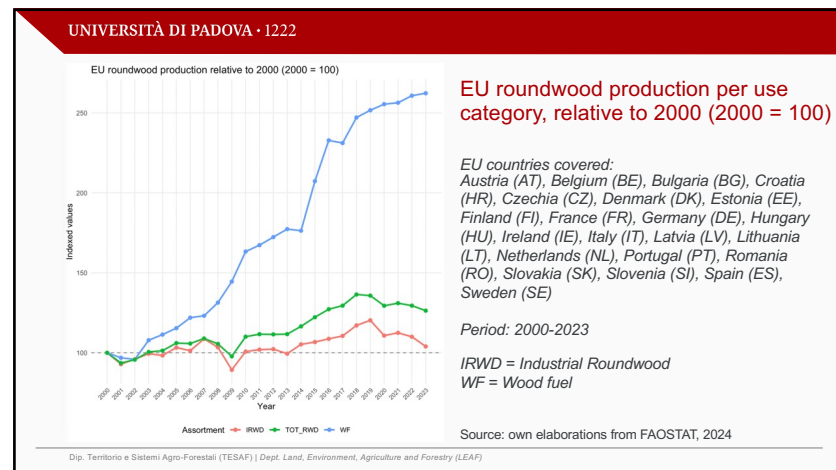


Direct and indirect energy uses accounted for **almost 70%** of the total roundwood production in 2017

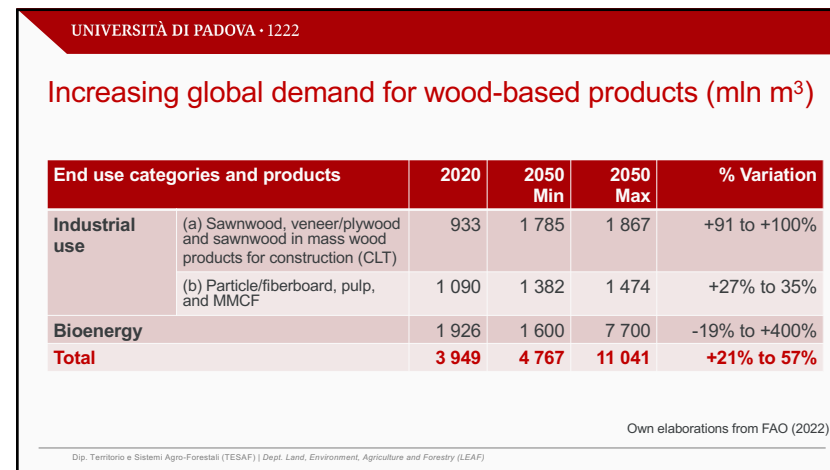
kilo tonnes of dry matter including net trade.
Gurria et al. (2022)

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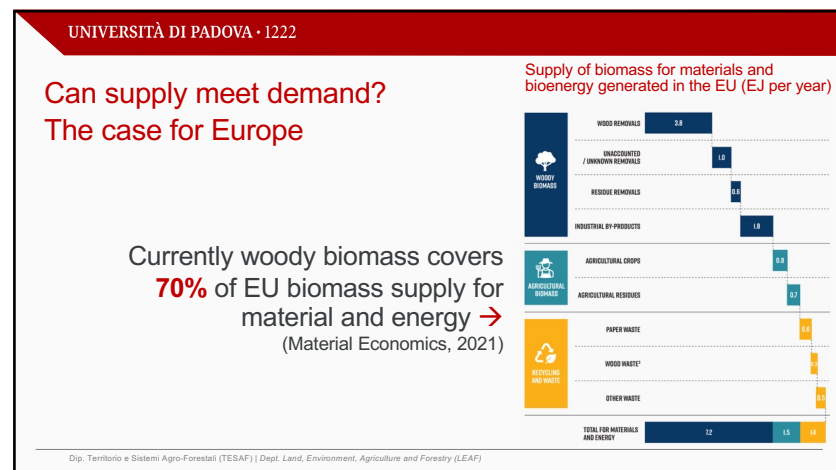
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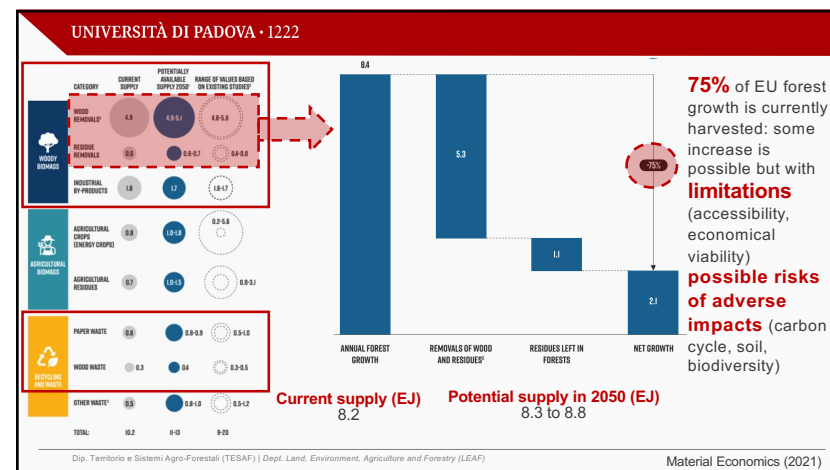
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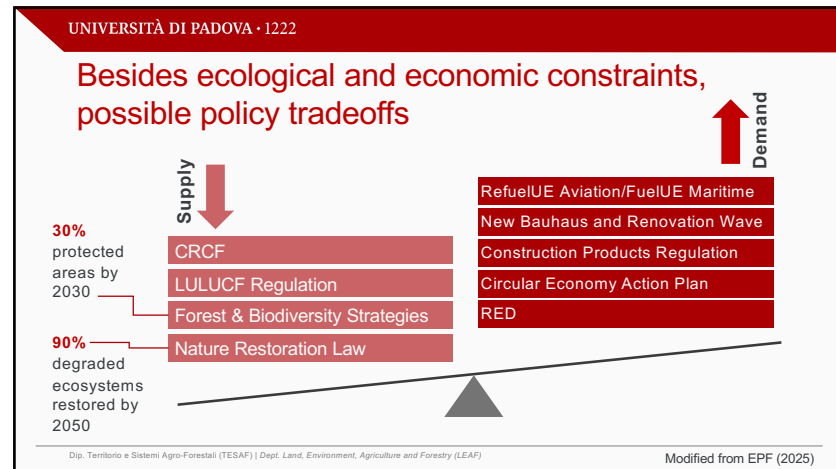
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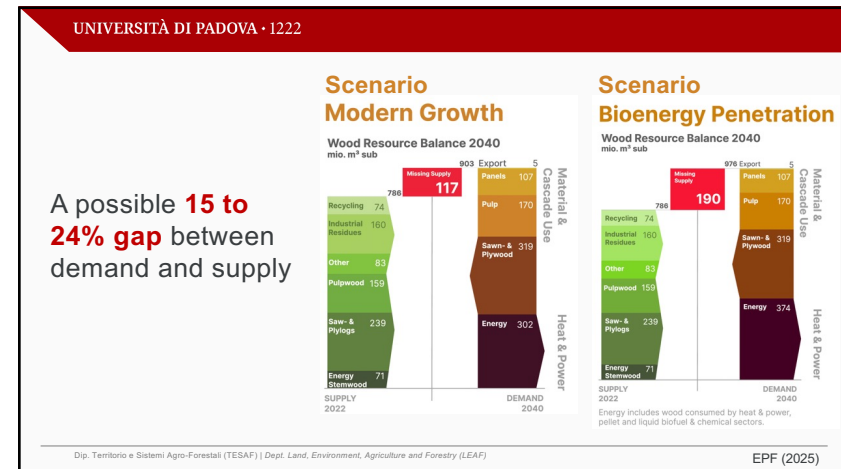
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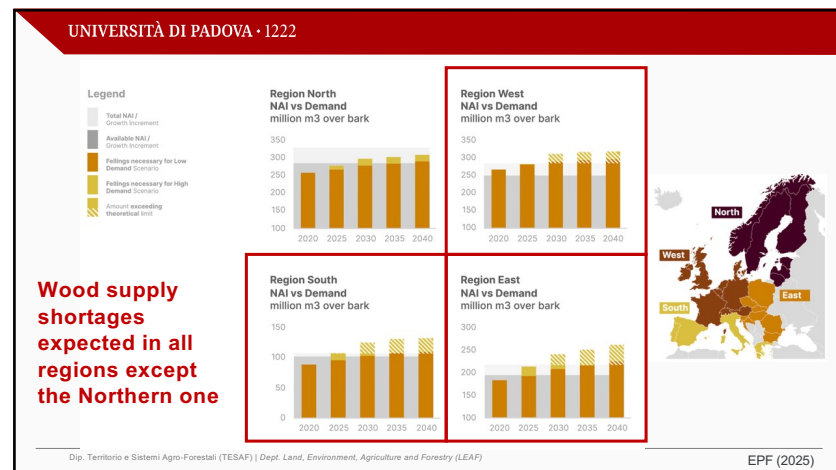
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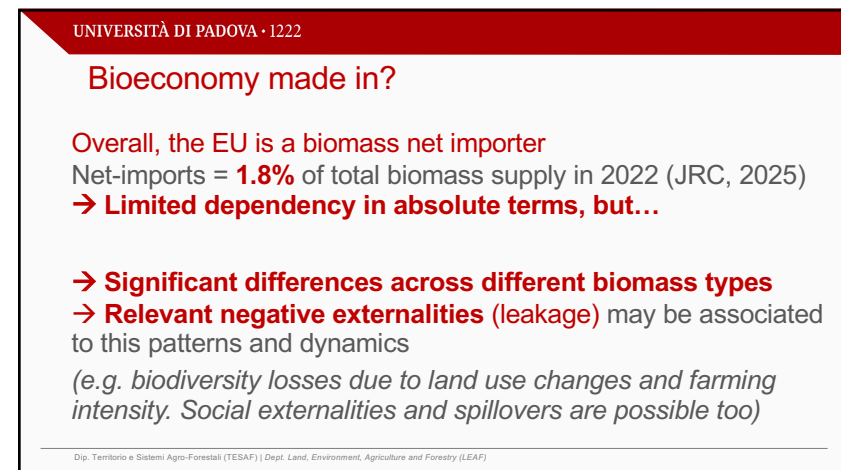
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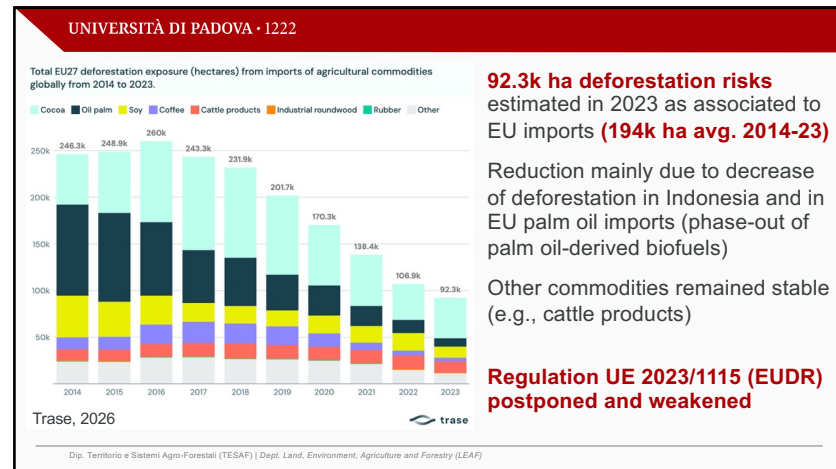
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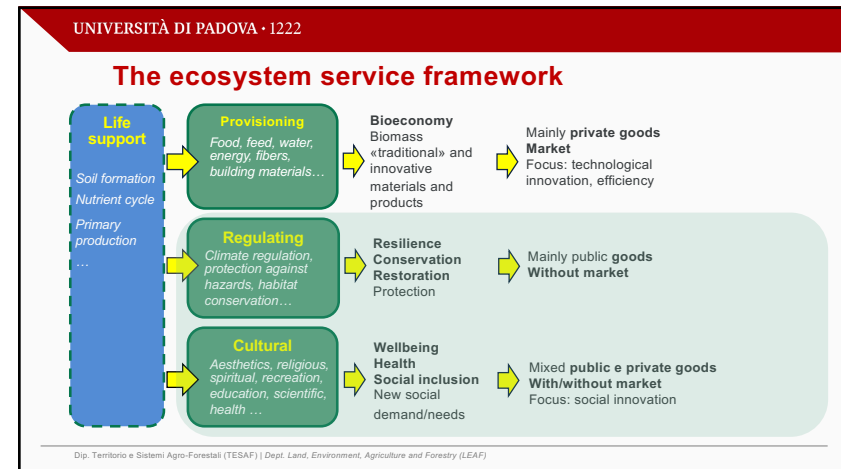
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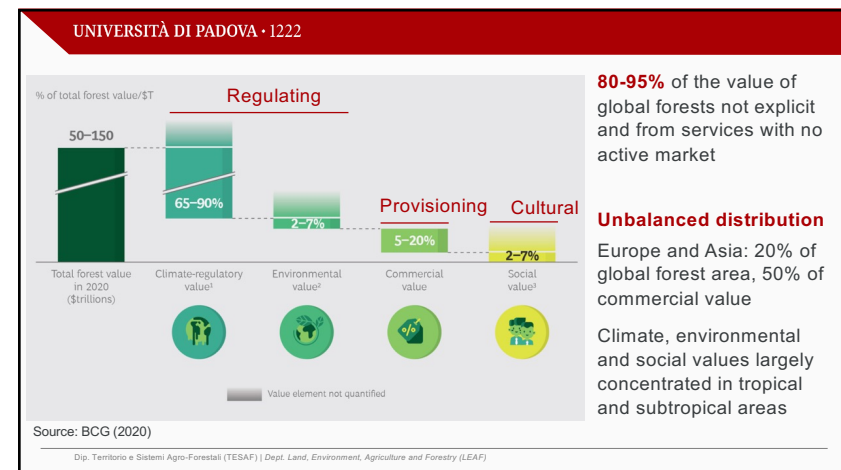
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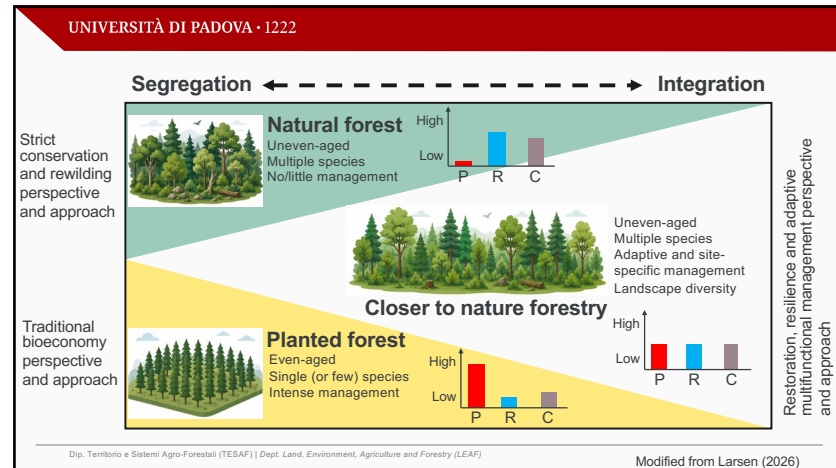
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Some final considerations

- Forests: a possible **climate change (cc) driver** (land-use changes) and resources for **mitigation and adaptation**
- **Affected by cc too**: changed C-stock, growing stock, wood removals and other benefits → ecological, market supply and other socioeconomic impacts
- Different bioeconomy **views and paradigms**

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Some final considerations

- Traditional and prevalent one: **provisioning services and technology** → high potential, but with ecological constraints, policy trade-offs and possible spill-over effects too (externalities)
- **Multifunctional role of forests**: market and non-market benefits (less provisioning services, more public benefits → landscape integration)

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Some final considerations

- Combine **different management objectives** and address **multiple societal needs**
- Take into account **ecological and socioeconomic differences** across regions and countries
- Consider **changes in the short- and long-term** both ecologically (e.g. species shifts) and socioeconomically/geopolitically
- EU Bioeconomy: **Growth and innovation** (2012) → **Sustainability and circularity** (2018) → **Resilience and strategic autonomy** (2025) ...

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Thanks

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