The role of Forests in Mitigating Climate Change – An Irish Perspective

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Irish Meteorological Society, 22nd November 2023, Customs House, Dublin 1.

Content of presentation

- Terminology
- The global carbon cycle
- Forestry in Ireland
- Carbon in Irish forests
    - Examples of scientific methods, current knowledge and knowledge gaps
- Conclusions

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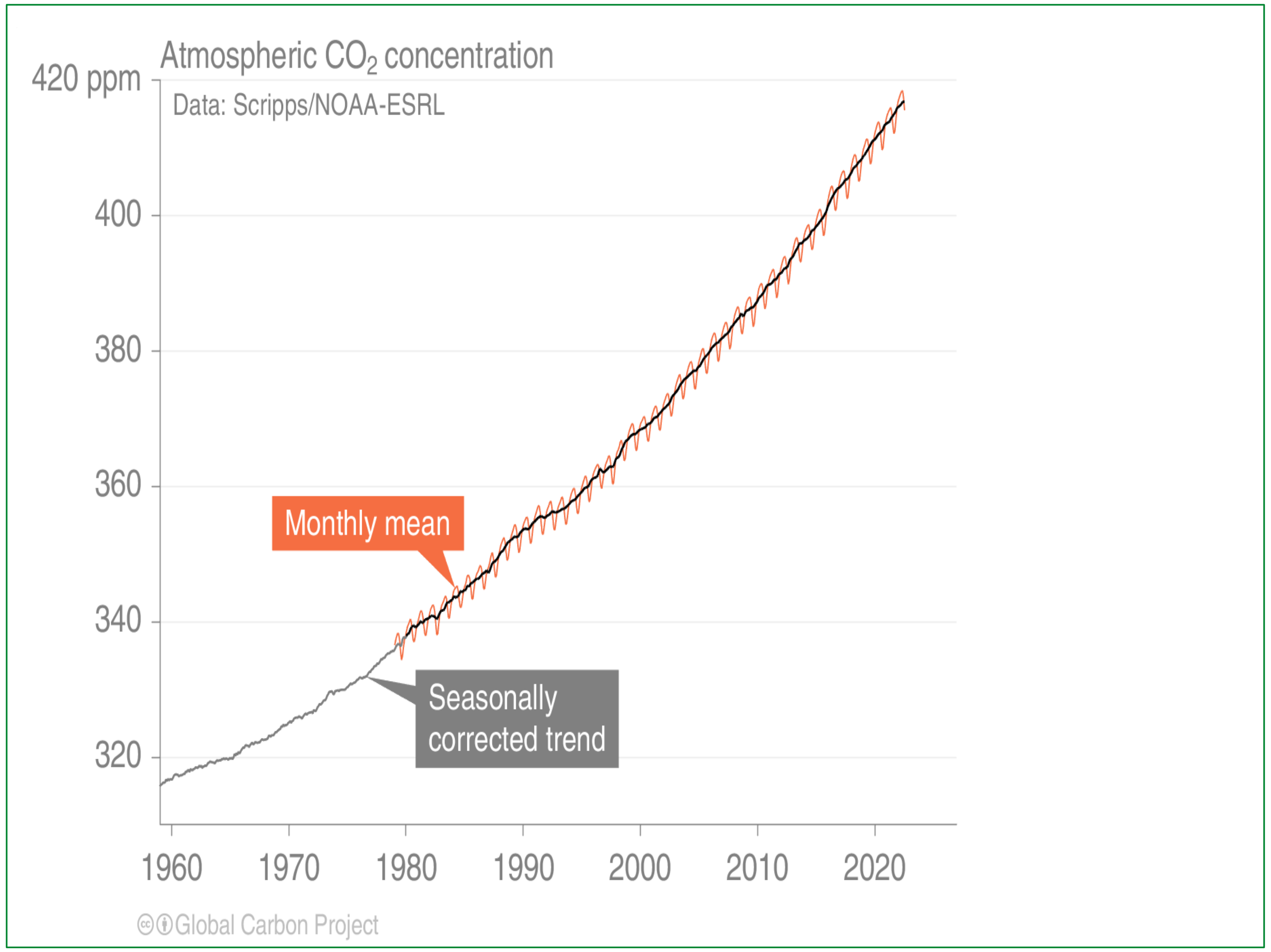
Terminology

- Carbon sequestration
  - Carbon sequestration is the process in which carbon is removed from the atmosphere and stored in the carbon pools of specific habitats, such as above-ground biomass, roots and soil. **The absolute quantity of carbon held in a habitat pool at any specified time is the carbon stock or store.**
- Carbon source
  - A process that releases carbon into the atmosphere
- Carbon sink
  - A process that absorbs carbon from the atmosphere
- Carbon flux
  - The amount of carbon exchanged between carbon stocks over a specified time.

Atmospheric CO_2 concentration

The global CO_2 concentration increased from ~277 ppm in 1750 to 417.2 ppm in 2022 (up 51%)



Globally averaged surface atmospheric CO_2 concentration. Data from: NOAA-ESRL after 1980; the Scripps Institution of Oceanography before 1980

Source: NOAA-ESRL; Scripps Institution of Oceanography; Friedlingstein et al 2022; Global Carbon Project 2022

https://www.globalcarbonproject.org/carbonbudget/22/presentation.htm

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Fate of anthropogenic CO_2 emissions (2012–2021)

Sources = Sinks

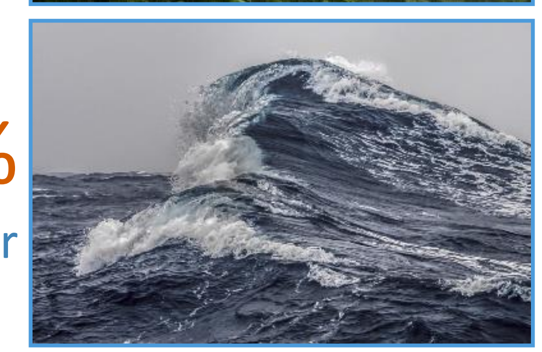
35.2 $GtCO_2/yr$
89%

11%
4.5 $GtCO_2/yr$

19.1 $GtCO_2/yr$
48%

29%
11.4 $GtCO_2/yr$

26%
10.5 $GtCO_2/yr$



Budget Imbalance:
(the difference between estimated sources & sinks)

3%
-1.2 $GtCO_2/yr$

Source: Friedlingstein et al 2022; Global Carbon Project 2022

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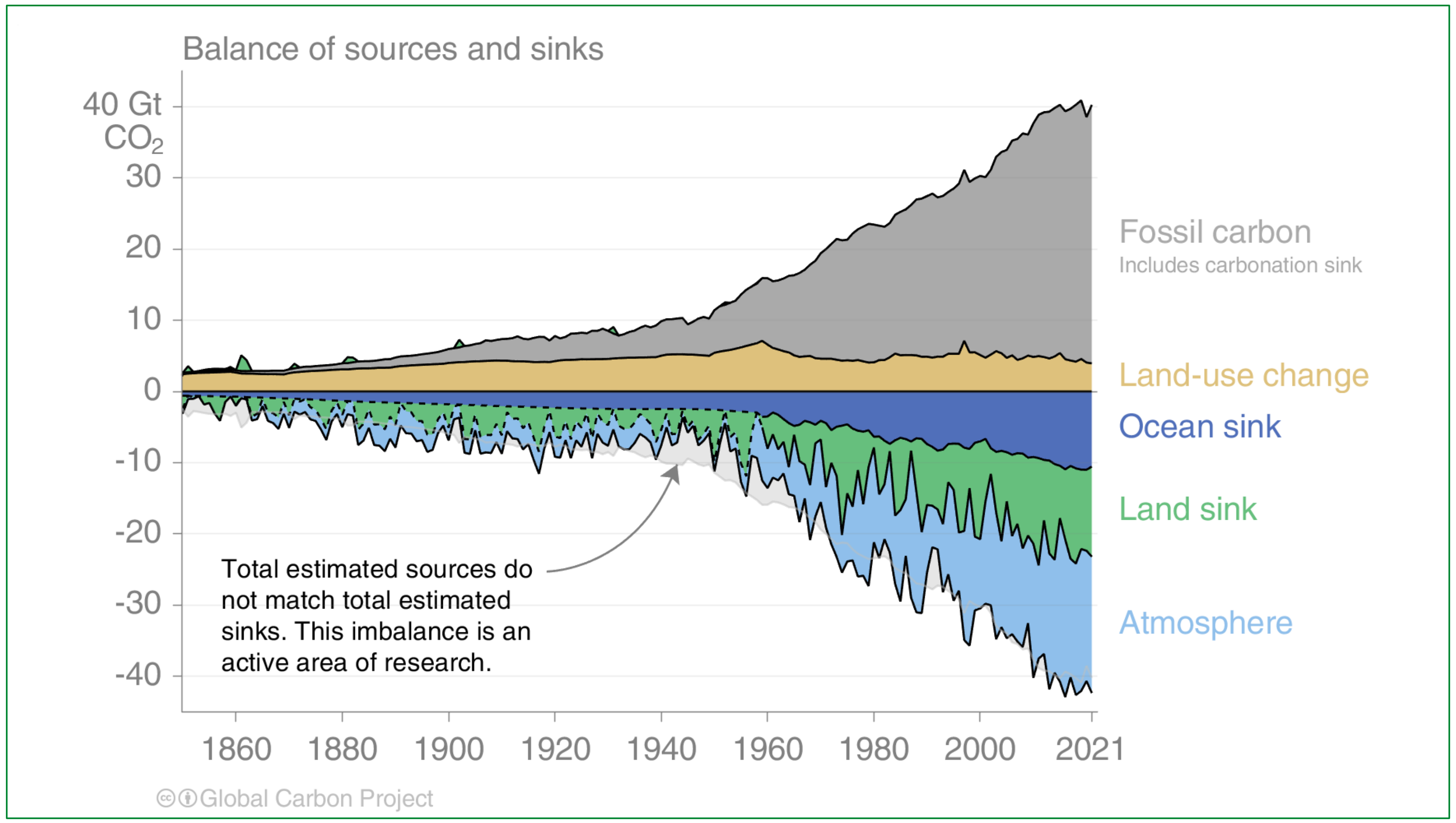
https://www.globalcarbonproject.org/carbonbudget/22/presentation.htm

Global carbon budget

Carbon emissions are partitioned among the atmosphere and carbon sinks on land and in the ocean
The “imbalance” between total emissions and total sinks is an active area of research



Source: [Friedlingstein et al 2022](); [Global Carbon Project 2022]()

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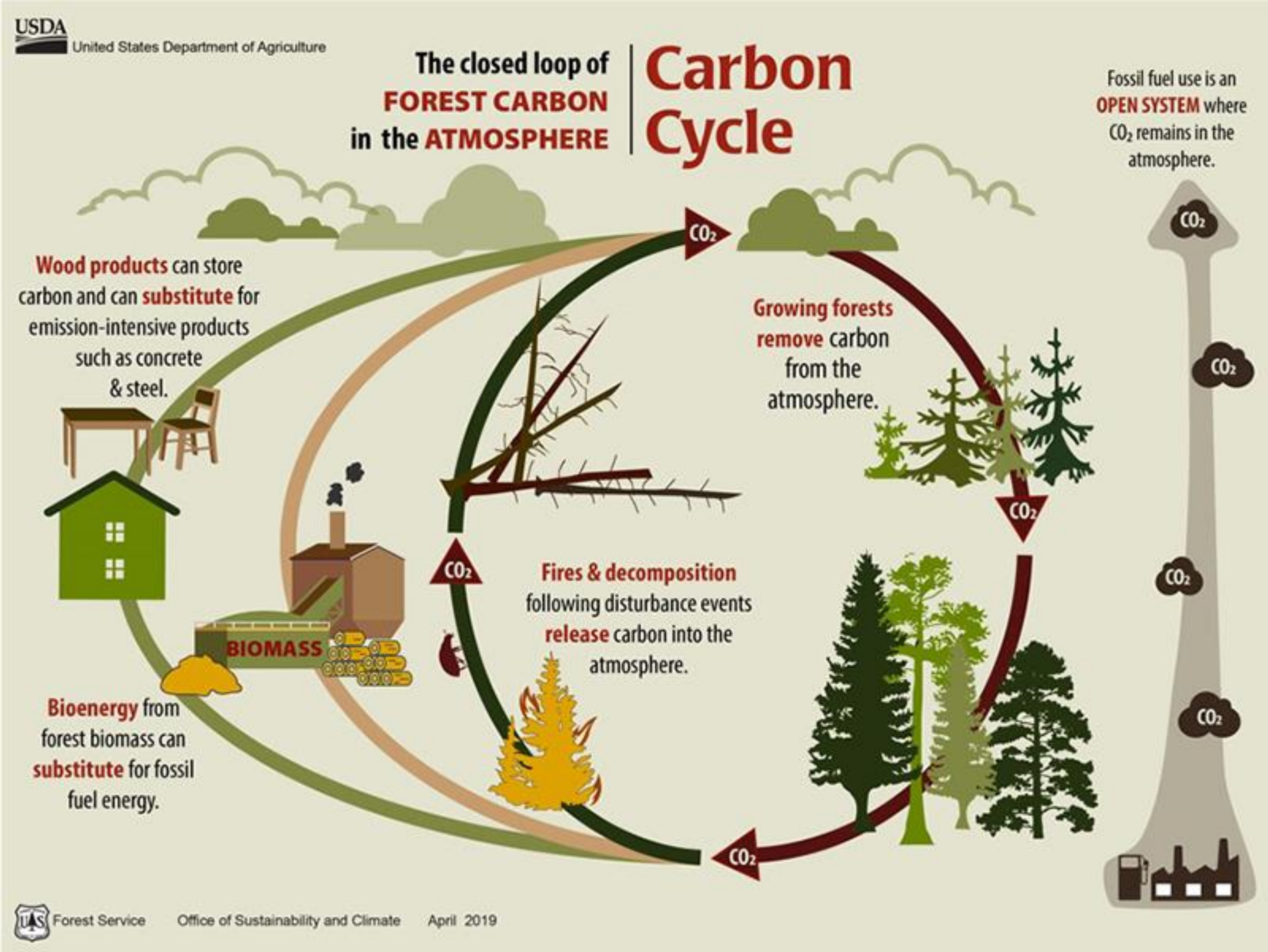
The Forest Carbon Cycle



- Carbon dynamics within the forest vary in space (e.g. soil type, species, management) and time (e.g. forest growth, species, management events)
- How we manage our forests, from site to national scale, influences
  - the carbon balance of the total forest area
  - the post-harvest climate impact
- Assessment of the climate impact of our forests need to consider all of these drivers of the carbon cycle

Ecosystem carbon balance

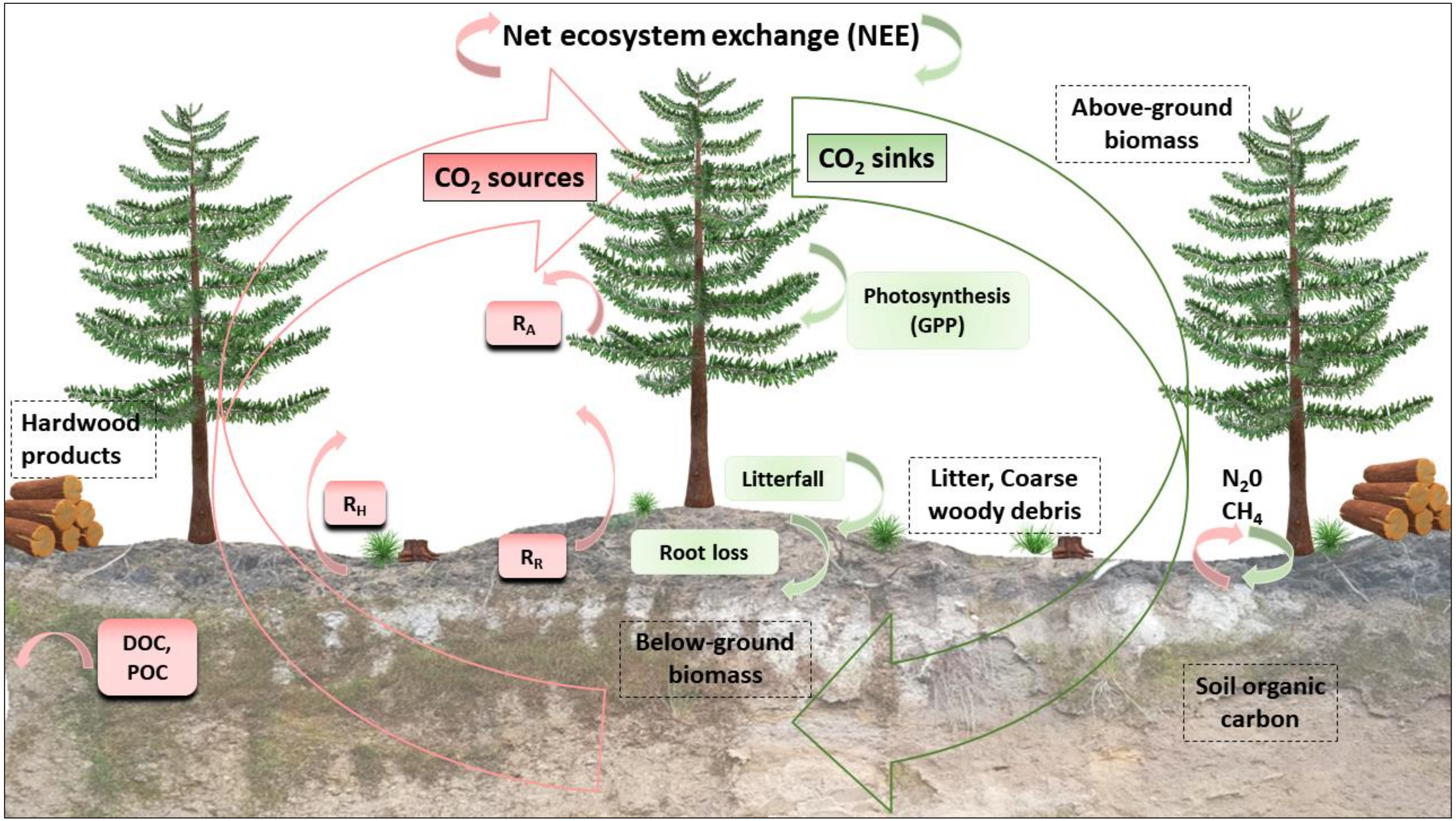


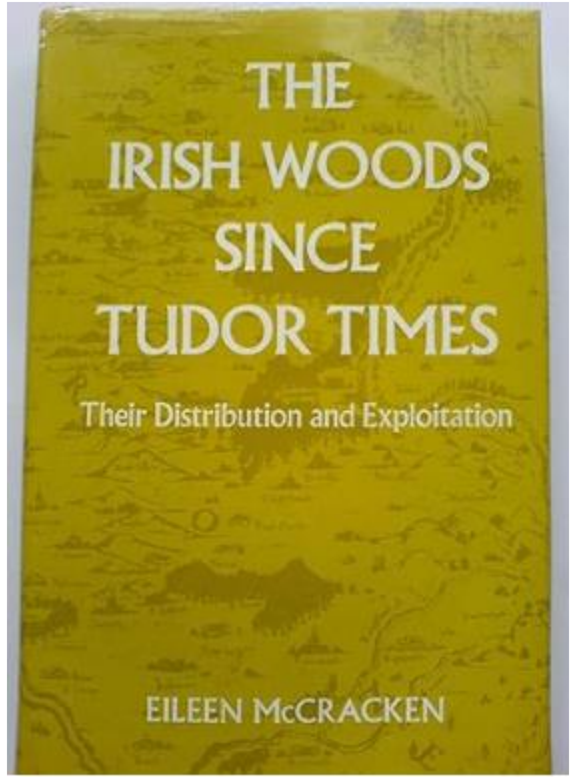
Diagram courtesy of Dr. Caren Jarmain, UL

Centuries of exploitation

Cill Chais

Cad a dhéanfaimid feasta gan adhmad?
Tá deireadh na gcoillte ar lár ....

[Now what will we do for timber,
with the last of the woods laid low?]



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Estate Woodlands

Coppice Wood Management in the Eighteenth Century: an Example from County Wicklow

Melvyn Jones

Department of Recreational and Environmental Studies, Sheffield City Polytechnic.

ABSTRACT

The extent and commercial significance of semi-natural coppice woods in Ireland in the past are far from clear and relatively little detailed analysis of coppice management using primary sources has been undertaken. Employing a collection of documents relating to the Watson-Wentworth estate in Co. Wicklow, coppice wood management in the first half of the eighteenth century is analysed. Evidence is presented which shows that during that period coppice woods covering more than 800 hectares were managed in a fairly sophisticated way, resulting not only in the preservation of important semi-natural woods but also in the production of a wide range of commercial products. The woods made an important contribution to the income of the estate, generated local employment, developed trading links over a surprisingly wide area and provided a renewable supply of raw materials for a number of important manufacturing industries.

INTRODUCTION

The extent and commercial significance of semi-natural coppice woods in Ireland during the three centuries before the First World War remain unclear despite a longstanding interest in the exploitation and preservation of native woods. Arthur Young in the late eighteenth century appeared to suggest a fairly widespread distribution, being of the opinion that the surviving woods in Ireland were 'what in England would be called copses' (Young, 1892 edn., vol.2, p. 90), but he is often better remembered for his view that woods had been 'destroyed for a century past, with the most thoughtless prodigality' (Young, 1892 edn., vol. 2, p. 85). Durand (1980), for example, in a review of the history of forestry in Ireland stresses wasteful exploitation and clearance for agriculture in the seventeenth and eighteenth centuries and planting during the nineteenth century; no mention is made of coppicing in his account. Others, though acknowledging the role of landowners in planting and preserving woods during the eighteenth century, are equally silent about coppice management (e.g., Freeman, 1969). Those

Jones (1986)

'The most striking thing on a first sight of the Irish landscape is the total absence of trees of any kind. They are only seen in private parks' – Pascha; Grousset, *Ireland's Disease*, 1887.

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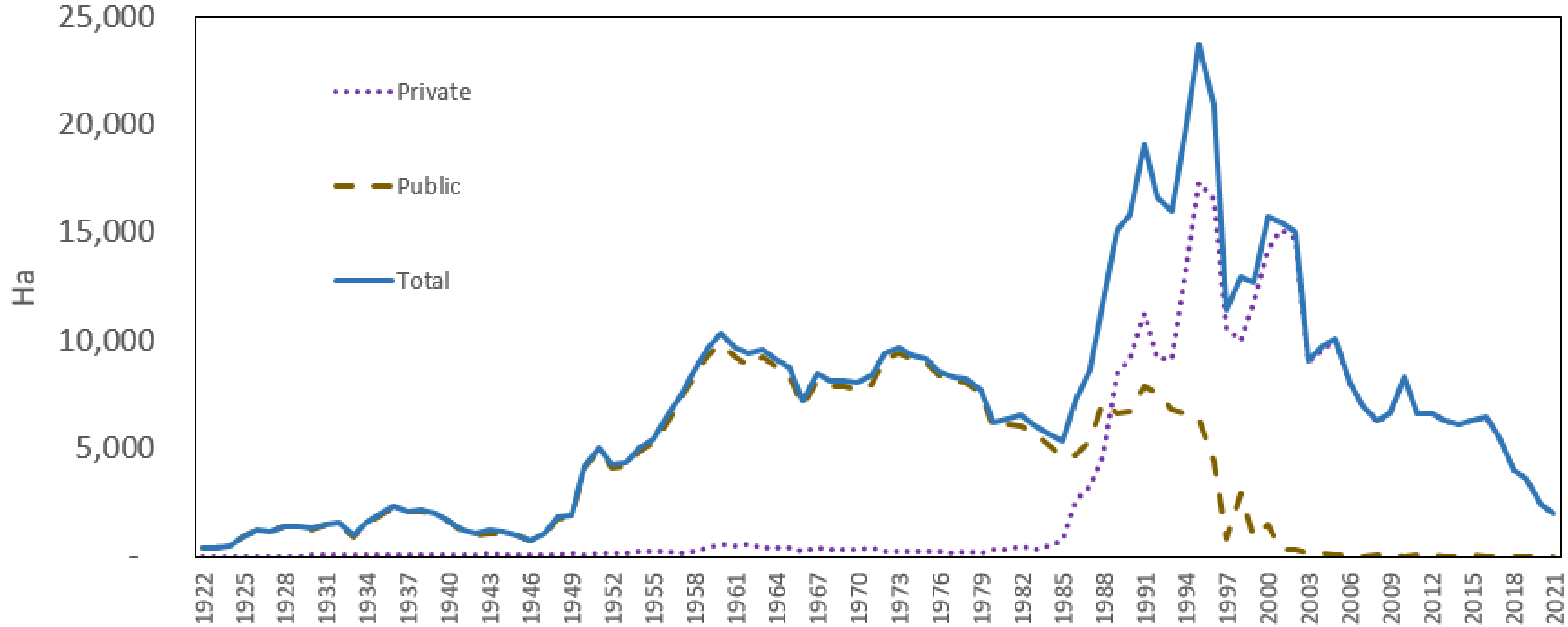
Annual Report of the Minister for Agriculture 1925-26

‘The department do not desire to acquire for afforestation land fit for agricultural purposes which might be capable of being used to form new holdings or enlarge existing ones. With a view, therefore, to prevent such land being acquired for afforestation they have fixed a maximum price at such a figure as to render its sale to the Department for this purpose an uneconomic transaction.’

Annual area of state and private sector afforestation (ha/year) during 1922-2021



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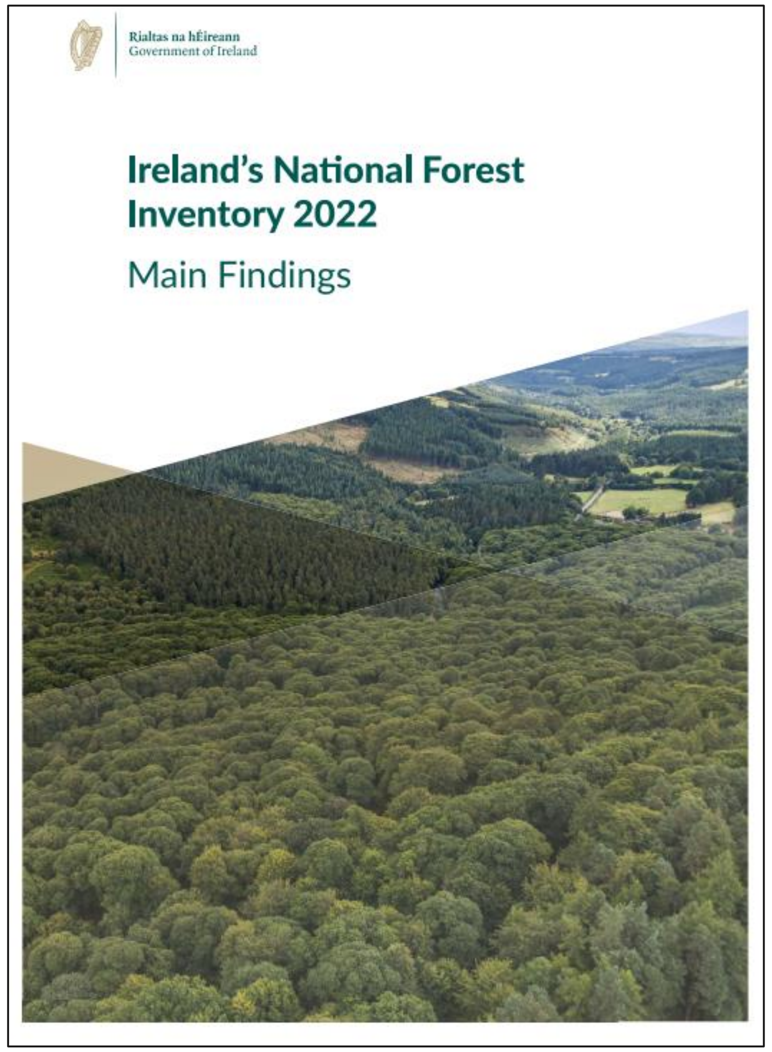
Where are we now?

- 808,848 ha (11.6% on total land area) in 2022
  - Stocked forest (713,152 ha); Temporarily unstocked (7,597 ha); forest open areas (88,100 ha)
- 89.3% under forest (remainder in open areas)
- 50.9% in private ownership, remainder public
- Coniferous species cover 69.4% of the stocked forest area and broadleaves the remaining 30.6%.
- 5,472 ha cleafelled/year during 2017-2022.
- Total roundwood harvest in during 2017-2022: 4.1 million m^3/year
- Legacy issues:
  - Uneven afforestation rate
  - Consequent uneven age class distribution
  - Large proportion of forests are on peat soils (38.4%)



Press release

European Commission approves afforestation measures in Forestry Programme 2023 - 2027

From Department of Agriculture, Food and the Marine
Published on 2 August 2023
Last updated on 25 August 2023

Afforestation Scheme 2023-2027: Grant and premium rates

	Forest type	Grant/ha	Annual premium/ha	Duration of premiums for farmers
FT1	Native Forests	€6,744	€1,103	20
FT2	Forests for water*	€6,744	€1,142	20
FT3	Forests on Public Lands**	€10,544	n/a	n/a
FT4	NeighbourWoods***	€10,200	€1,142	20
FT5	Emergent Forest	€2,500	€350	20
FT6	Broadleaf, mainly oak and beech	€6,744	€1,037	20
FT7	Diverse Broadleaf	€4,314	€973	20
FT8	Agroforestry	€8,555	€975	10
FT9	Seed Orchards	€10,000	€1,142	20
FT10	Continuous Cover Forestry	€5,421	€912	20
FT11	Mixed high forests: Conifer, 20% broadleaves	€4,452	€863	20
FT12	Mixed high forests with mainly spruce, 20% broadleaves	€3,858	€746	20

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Legacy issues

Uneven age class distribution

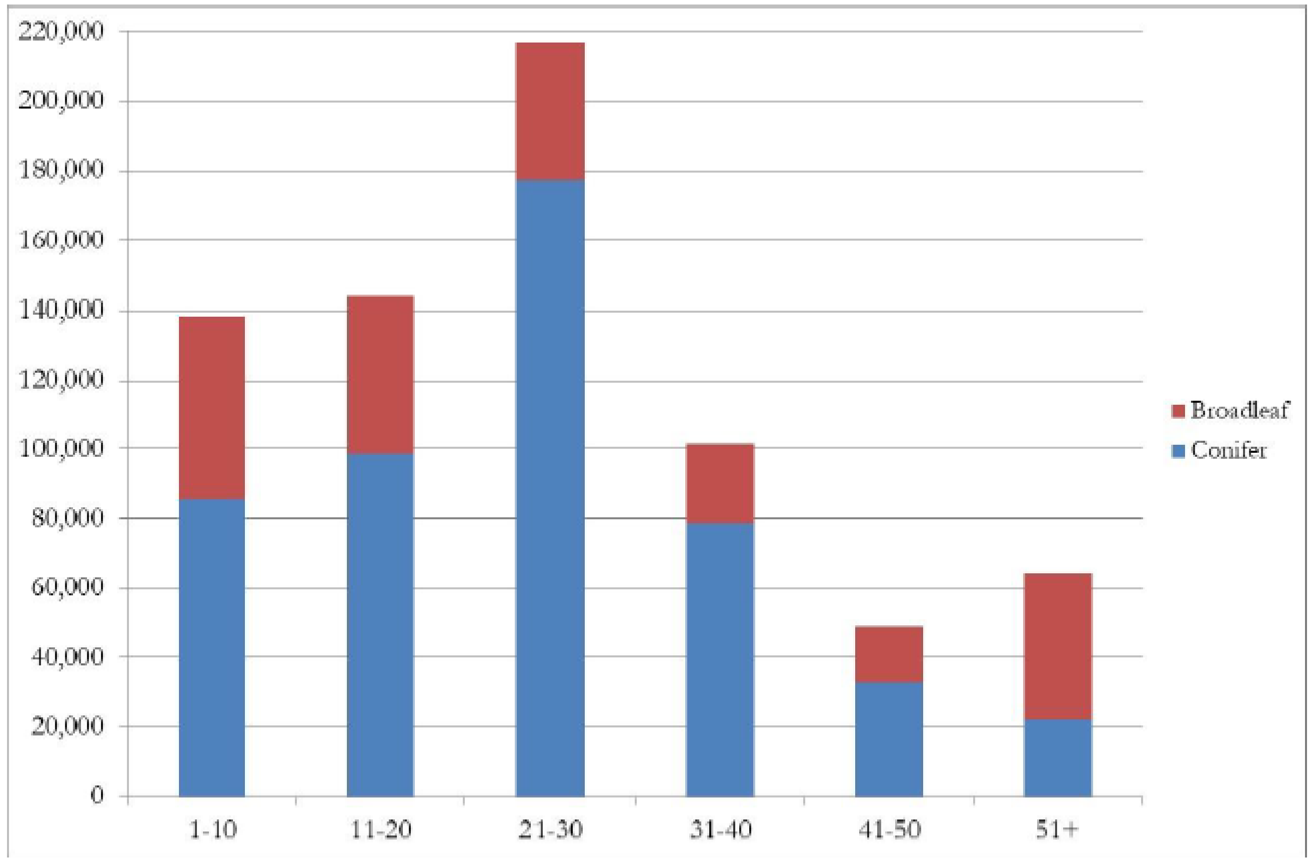


Figure 20. Total stocked forest area by age class and species group.

High proportion of peat soils

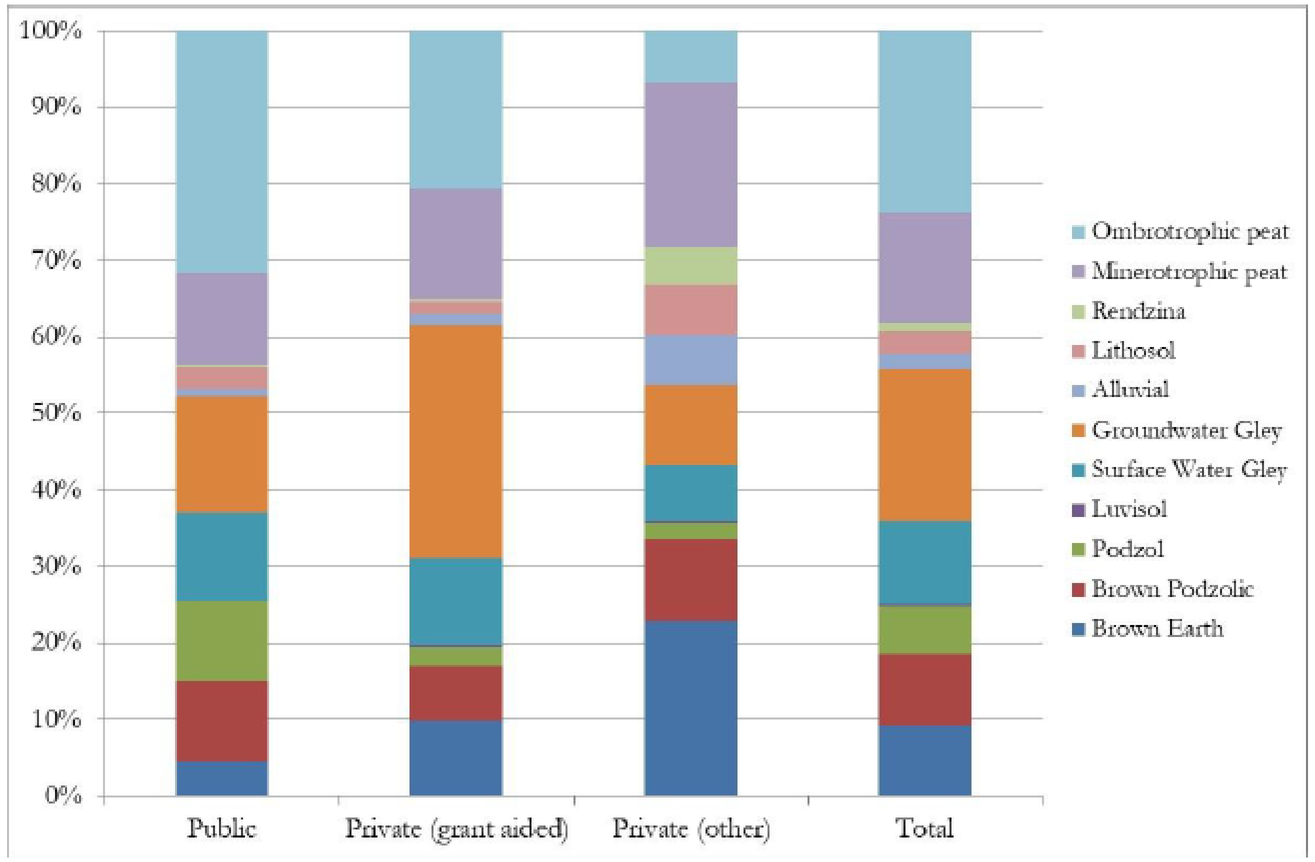
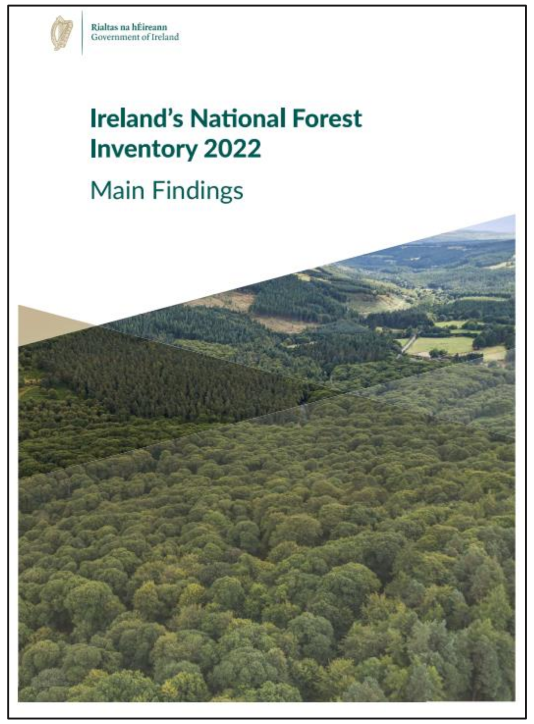


Figure 26. Proportion of the stocked forest by soil group by ownership.



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How do we measure forest carbon stock and stock changes?

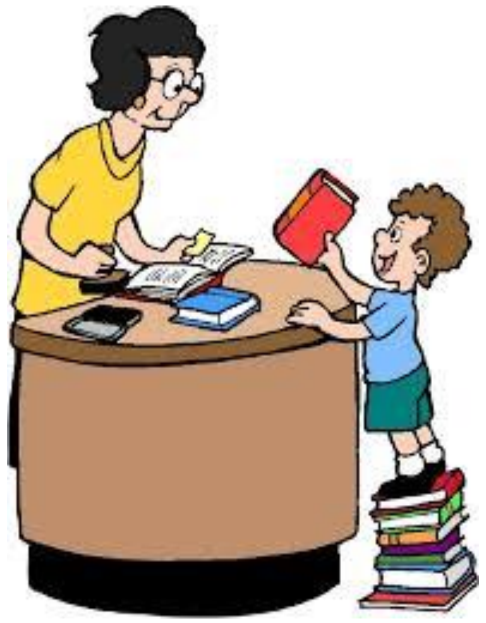
Library analogy

Stock Method
Measure C stock at regular intervals and estimate C stock change

OR

Flux Method
Measure C inputs and outputs and estimate C stock change by difference

Best to do both !



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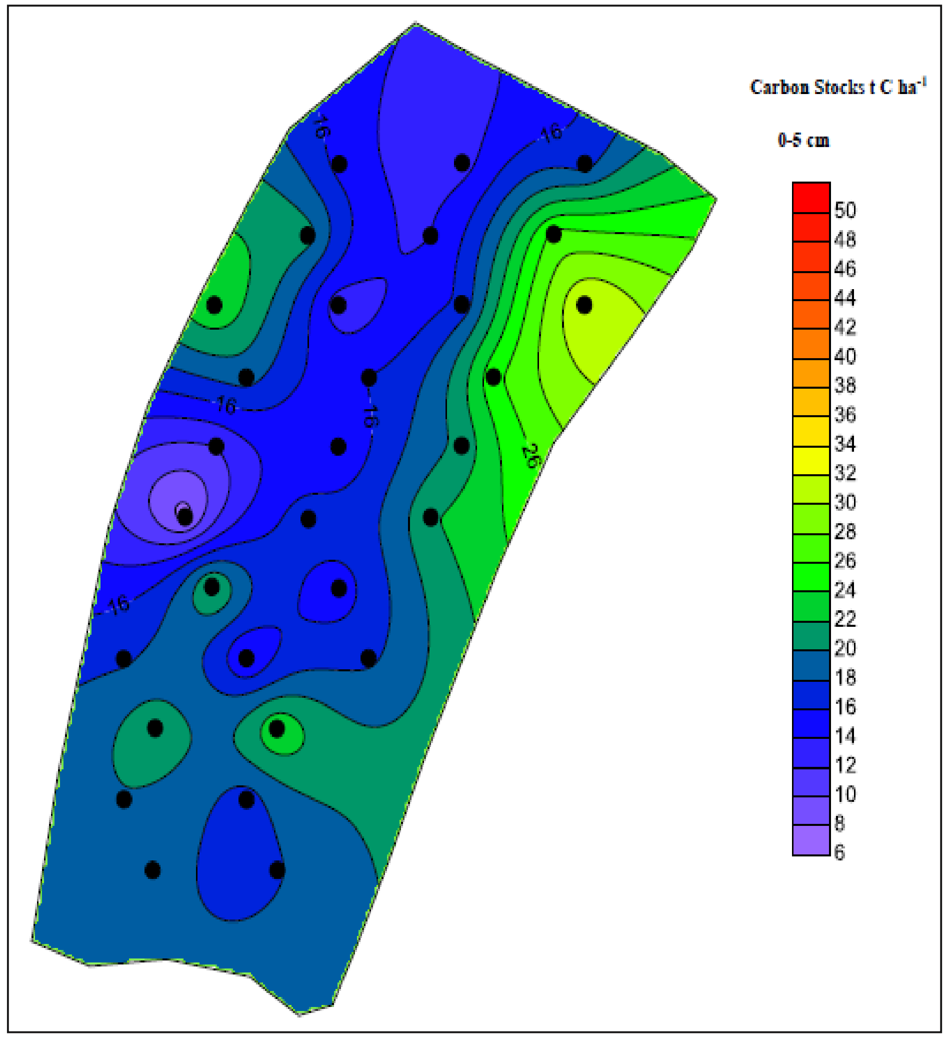
Stock change method for soil carbon

Repeated Sampling (Hayes 2010)



Hayes (2010)

Chronosequence approach

(Reidy & Bolger 2013)

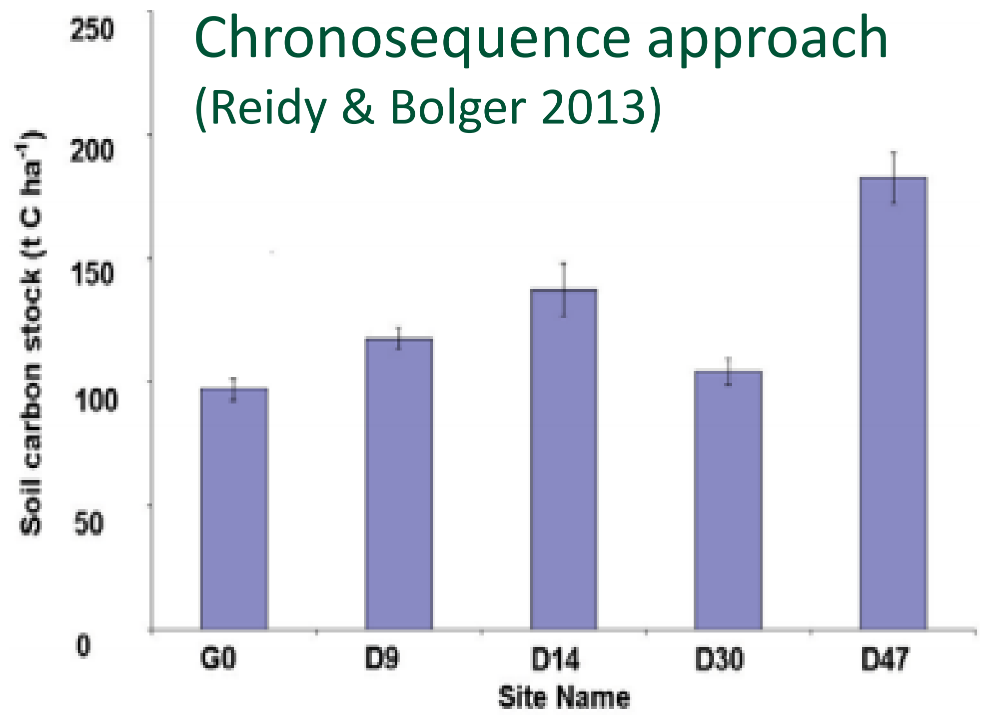


Figure 1: *Total soil C (t C ha^{-1}, ± S.E.) in the combined mineral and organic layers at each site in the chronosequence.*

Paired plot approach

(Wellock et al. 2010)

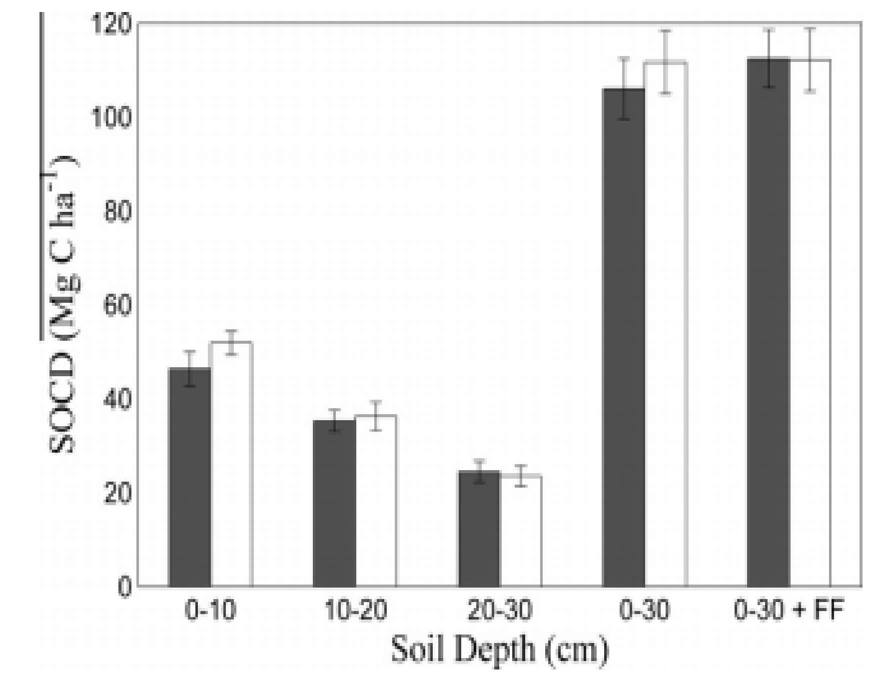


Fig. 4. The mean ± standard error carbon density (Mg C ha^{-1}) of the forest sites (filled bars) and non-forest sites (unfilled bars) for each soil layer and 0–30 cm + forest floor (FF).

Flux method for soil carbon

Site description

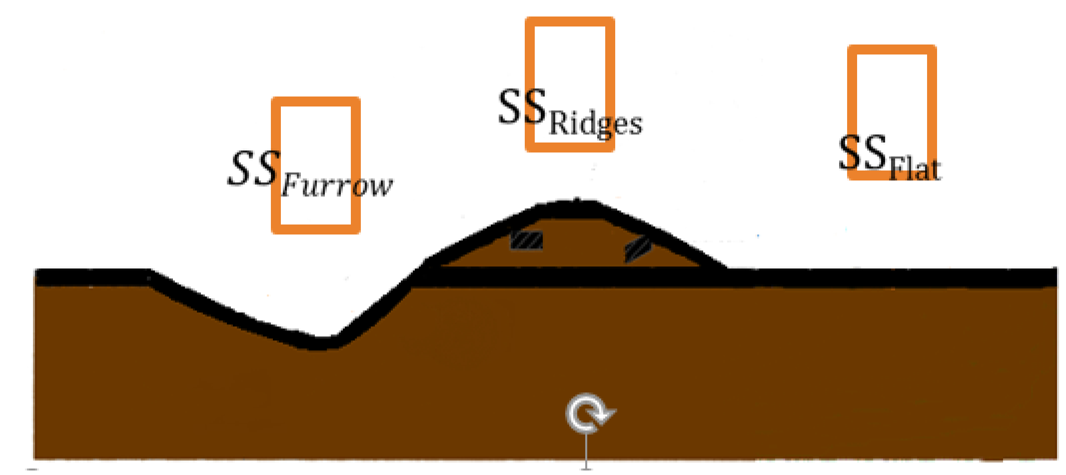
- South-west Ireland
- 8 sites
  - 18-44 years old
  - Afforestation (except 1 site)
    - 7 Sitka spruce
    - 1 lodgepole pine
- Ombrotrophic peat
  - Peat depth: 60-150 cm
  - Drained at time of planting
- Mean annual precipitation 1600 mm

Jovani Sancho et al. (2021)

We need to separate or tease apart the different components of the soil CO_2 fluxes to assess the change in soil carbon stock.

Flux method for soil carbon

- In each site:
  - 7 subsites
  - 3 microtopographies
  - Fresh litter removed
- Soil respiration
  - Measured fortnightly
  - Infra red gas analyser (EGM-4) with a modified chamber
  - From February 2014 to February 2016



- Environmental variables
  - Soil temperature at 10 cm depth
  - Water table depth
- Peat sampling
  - BD, ash content, pH, SOC and N content
- Belowground inputs

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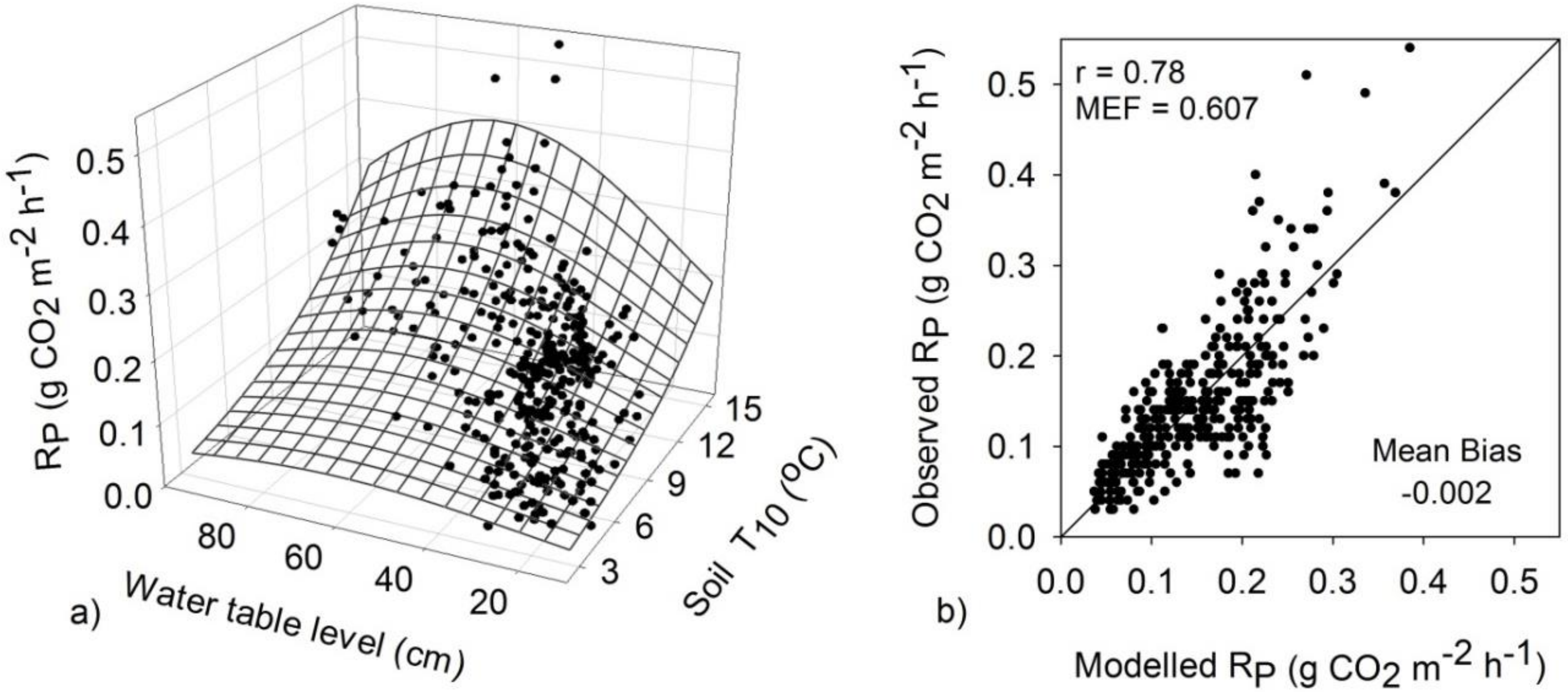
Flux method for soil carbon

- Pooled data from all sites were fed into a single nonlinear model following the same approach
- Multiplicative combined model of T exponential function and the WT Gaussian equation



Our best estimate is that these soils emit 1.68 ± 0.33 t CO_2-C ha/year

But the trees are storing more carbon than the soil is losing …………….

National picture

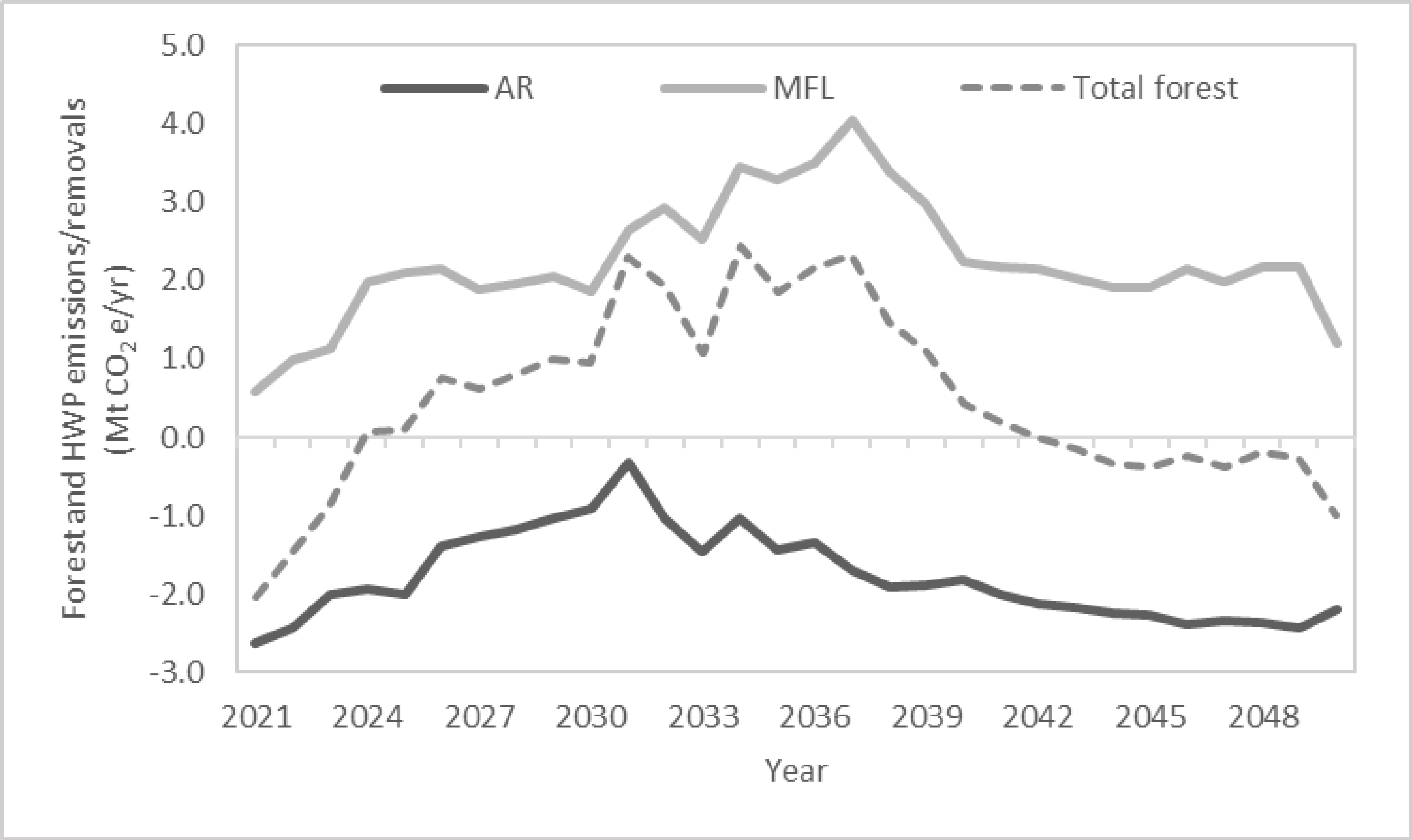
Table 11. Forest Carbon stock 2006 - 2022.

Carbon Stock	2006		2012		2017		2022	
	Million tonnes	% Total	Million tonnes	% Total	Million tonnes	% Total	Million tonnes	% Total
Aboveground	30.6	8.9	39.7	10.4	45.6	14.6	52.6	16.3
Belowground	6.7	1.9	8.8	2.3	10.3	3.3	12.3	3.8
Deadwood	1.2	0.4	2.5	0.6	2.1	0.7	3.0	0.9
Litter	2.5	0.7	6.3	1.6	7.1	2.3	3.6	1.1
Soil	304.9	88.1	323.7	85.1	246.6	79.1	252.1	77.9
Total	345.9	100	381.0	100	311.7	100	323.5	100

- Ireland’s forests removed an average of 3.8 million tonnes of carbon dioxide equivalent per year from the atmosphere over the period 2007 to 2016.
- Forests > 30 years old (60% of the total area) will be a small net source of approximately 0.1 million tonnes of CO_2 per year, when harvested wood products are included, over the period 2021-2025 but return to a sink over the period 2036-2050
- Forests < 30 years old (40% of the total area) will remain a carbon sink.

The carbon cliff…….

Figure 3 Annual projected CO_2e emission (positive) and removal (negative) for afforested land less than 30 years old (AR), managed forest land (MFL) and the total forest, all including HWP. Data is for the period 2021–2050 and units are Mt CO_2e/yr. Data is following adjustments to EFs. Jarmain et al. (in press)



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Continuous cover forest (CCF) management

- Few stands under CCF management in Ireland
- Most of these are transforming to CCF
- International studies offer insight but long term studies in Ireland are needed.
- Challenges:
  - Robust growth models need to be developed for CCF. To date there are a limited number of single tree models that can do this and these are confined to continental Europe. These models have not been calibrated for UK or Irish conditions.
  - The is limited CCF data to calibrate the required models. One cannot evaluate carbon flows without a reliable growth model.
  - The effect of CCF vs conventional rotation forestry of carbon balance is unclear and this varies depending on the system boundary used for the evaluation (see Table 1 in full paper).

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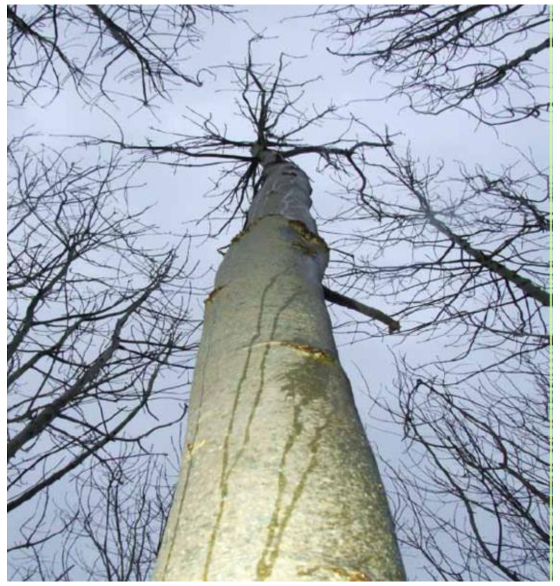
Species selection

- Two important considerations:
  - The annual (short term) rate of sequestration
  - The long term equilibrium carbon storage (over several rotations)
- Conclusion: The following generalisations can be made:
  - Shorter rotation, more productive conifer species, and intensively harvested productive crops have higher average sequestration rates (7-11 tCO_2 ha^{-1} yr^{-1}) but lower long-term equilibrium storage values (147-400 tCO_2 ha^{-1}) when compared to long rotation less intensively managed stands.
  - Broadleaf stands have higher long-term equilibrium storage (>500 tCO_2 ha^{-1}) but lower average annual sequestration rates (3-6 tCO_2 ha^{-1}), when compared to conifer stands.
  - Slower growing, less intensively managed, stands capture carbon slowly but have a higher equilibrium sequestration values, when compared to fast growing intensively managed species.



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Landscape level forest management (1/2)

- Stand level studies are vital not only to understand the carbon balance in forests, but also to evaluate different management systems.
- However, carbon dynamics in forests are also driven by large regional and national factors such as age class structure, soil type, climate and proximity to timber processing facilities.
- Therefore, consideration of how to maximise the carbon benefits of forests should not just be focused on stand level management but should include the impact of stand level decisions on regional and national carbon balance.

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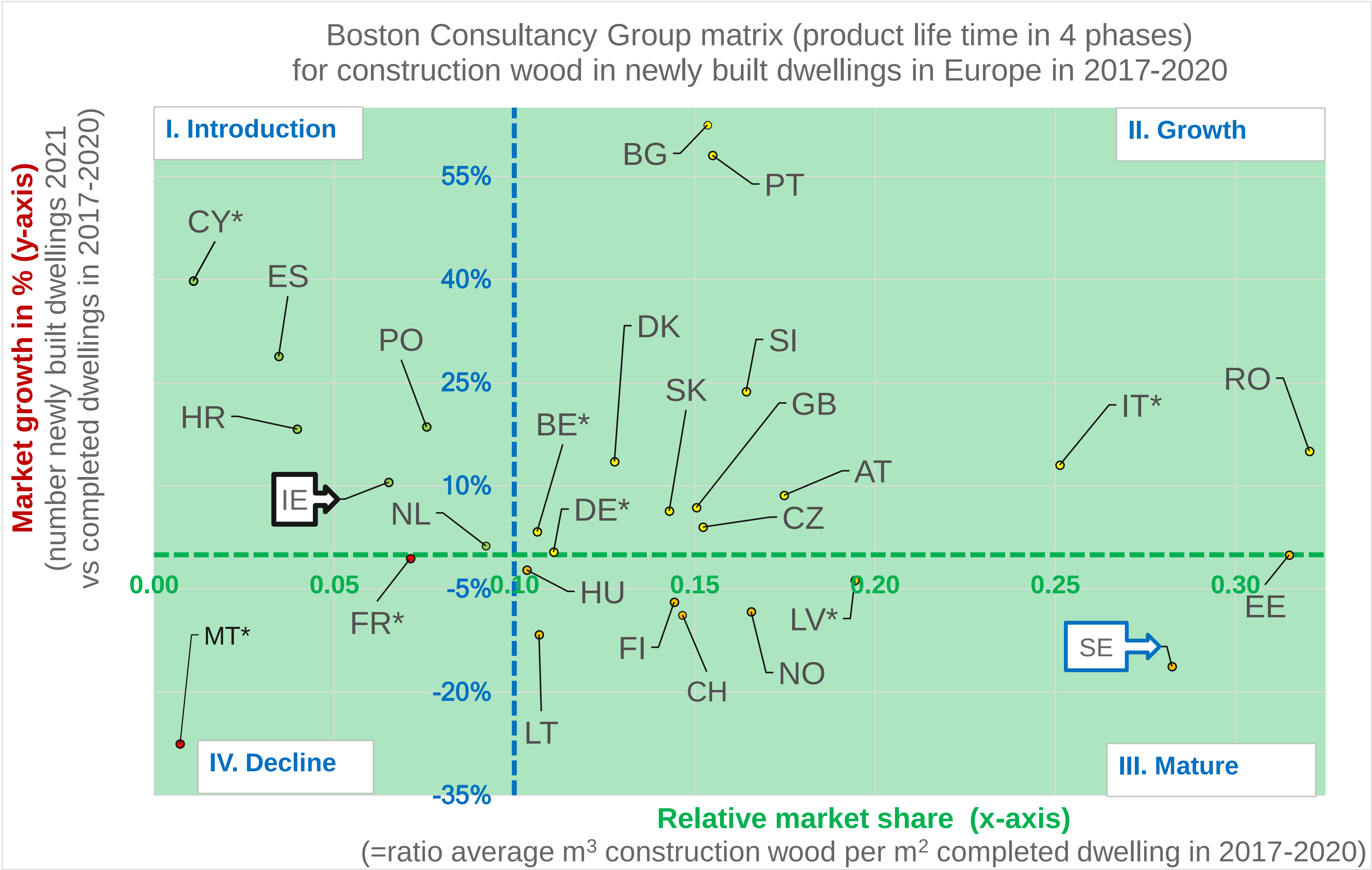
Landscape level forest management (2/2)

- Conclusions:
  - There is a need for coherence in both land use and forest policy that takes accounts of the impact of current and alternative forest management practice on the forest carbon balance at the regional and national scale.
  - We need to focus on management of existing forests as well as afforestation.
  - Various legacy factors influence carbon balance of existing forests, such as age class structure shifts and a silvicultural practice of shorter commercial rotations.
  - Storing carbon in the forest is not enough, we need to harvest it and do things with it, energy, construction etc.
  - Management for carbon needs to be balanced against economic factors, the need for sustainable timber supplies and other ecosystem services provided by forests.

BCG matrix for construction wood in newly built dwellings in Europe in 2017-2020.*



Sikkema et al. 2023

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Overall conclusions

- Management practices greatly influence stand level carbon storage in forest ecosystems.
- Any consideration of changes in stand level management to reduce carbon losses or enhance carbon sequestration must also consider the landscape, regional and national implications of such practices,
  - not only for carbon sequestration in the national forest estate but also for carbon storage in harvested wood products and the potential for such products to displace fossil based products.
- We should not disregard the other ecosystem services that forests provide.

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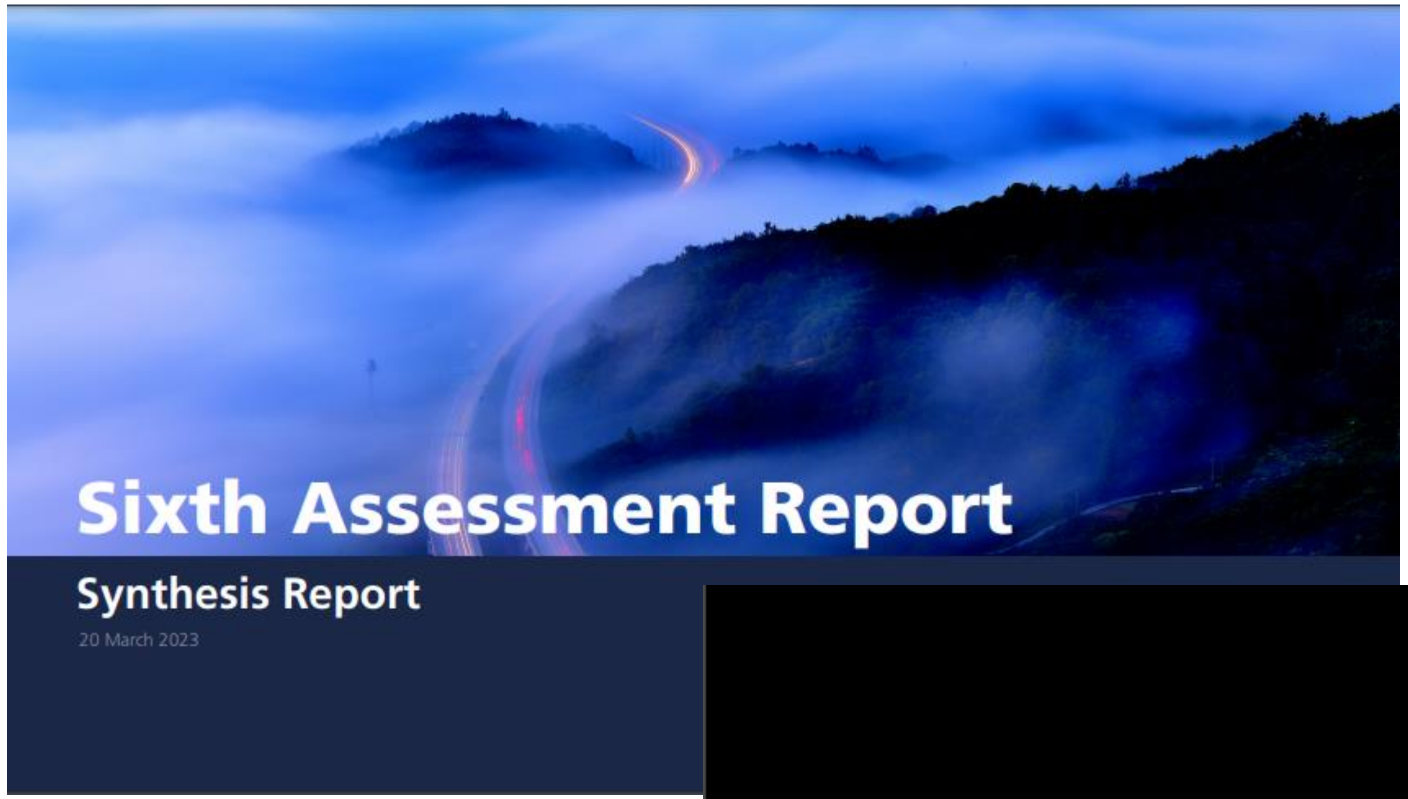

https://www.ipcc.ch/

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- Dr Brian Tobin, UCD

Terrain-AI

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An Roinn Talmhaíochta, Bia agus Mara
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Recent publications

- Black, K., Byrne, K., McInerney, D. and Landy, J. 2022. Forests for Climate. Report on Carbon Modelling of the Coillte Estate. Coillte.
- Byrne, K.A., McInerney, D. and Black, K. 2022. Review of the impact of management practices on stand-level carbon balance in Irish forests. Report to the Climate Change Advisory Council, Ireland.
- Clancy, M., Ruffing, B., Jarmain, C. & Byrne, K.A. 2023. A novel method incorporating large rock fragments for improved soil bulk density and carbon stock estimation. Soil Science Society of America Journal, 87:1029-1041. DOI: 10.1002/saj2.20562
- Jarmain, C., Black, K., McInerney, D., Fazlollahi Mohammadi, M., Saunders, M., Sikkema, R., Styles, D. Tobin, B. and Byrne, K.A. In press. Creating and managing forests for carbon from an Irish perspective. Irish Forestry.
- Jarmain, C., Cummins, T., Jovani-Sancho, A.J., Nairn, T., Premrov, A., Renou-Wilson, F., Tobin, B., Walz, K., Wilson, D. and Byrne K.A. 2023. Soil organic carbon stocks by soil group for afforested soils in Ireland. Geoderma Regional. 32: e00615. doi.org/10.1016/j.geodrs.2023.e00615
- Jovani Sancho, A.J., Cummins, T. and Byrne K.A. 2021. Soil carbon balance of afforested peatlands in the maritime temperate climatic zone. Global Change Biology. 27(15): 3681-3698. doi.org/10.1111/gcb.15654
- Sikema, R., Styles, D., Jonsson, R. and Byrne, K.A. 2023. Corrigendum to `A market inventory of construction wood for residential building in Europe ¿in the light of the Green Deal & new circular economy ambitions: Sustainable Cities and Society 90, 104370, doi.org/10.1016/j.scs.2023.104588

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Abstracts must be submitted to sessions associated with congress Commissions – full details of the sessions per Commission are available here.

Summary of Minimum Requirements

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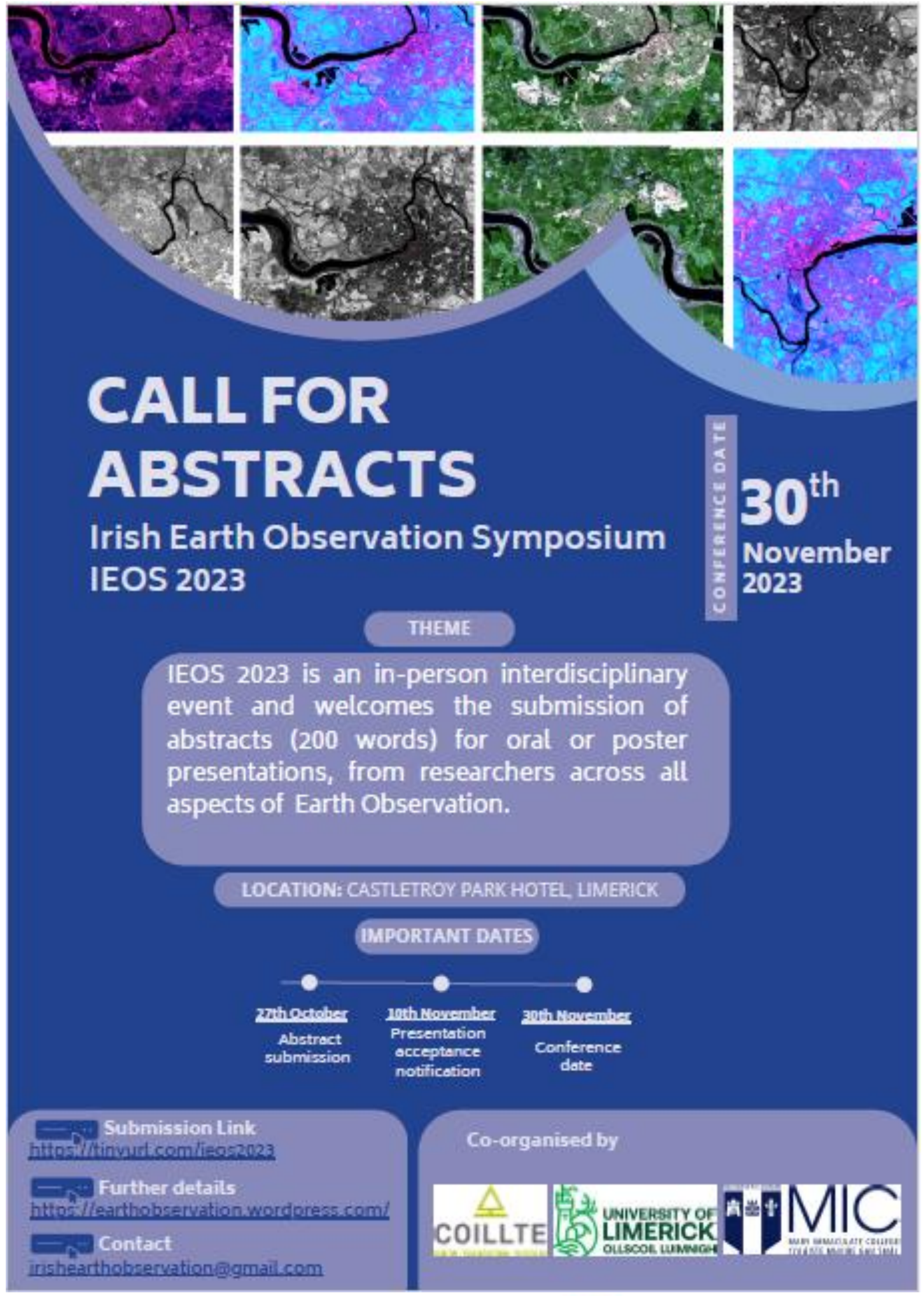
Peatland degradation: Current status and sustainable solutions

Dr John Connolly[1], Prof. Ken Byrne[2]

[1]Trinity College Dublin, Dublin, Ireland. [2]University of Limerick, Limerick, Ireland



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