Climate Mitigation Options through Afforestation:
An introduction to the Forest Carbon Tool

Tom Houlihan, Teagasc
Dr Kevin Black, Forest Environmental and Research Services (FERS)

Teagasc
Agriculture and Food Development Authority

An Roinn Talmhaíochta, Bia agus Mara
Department of Agriculture, Food and the Marine

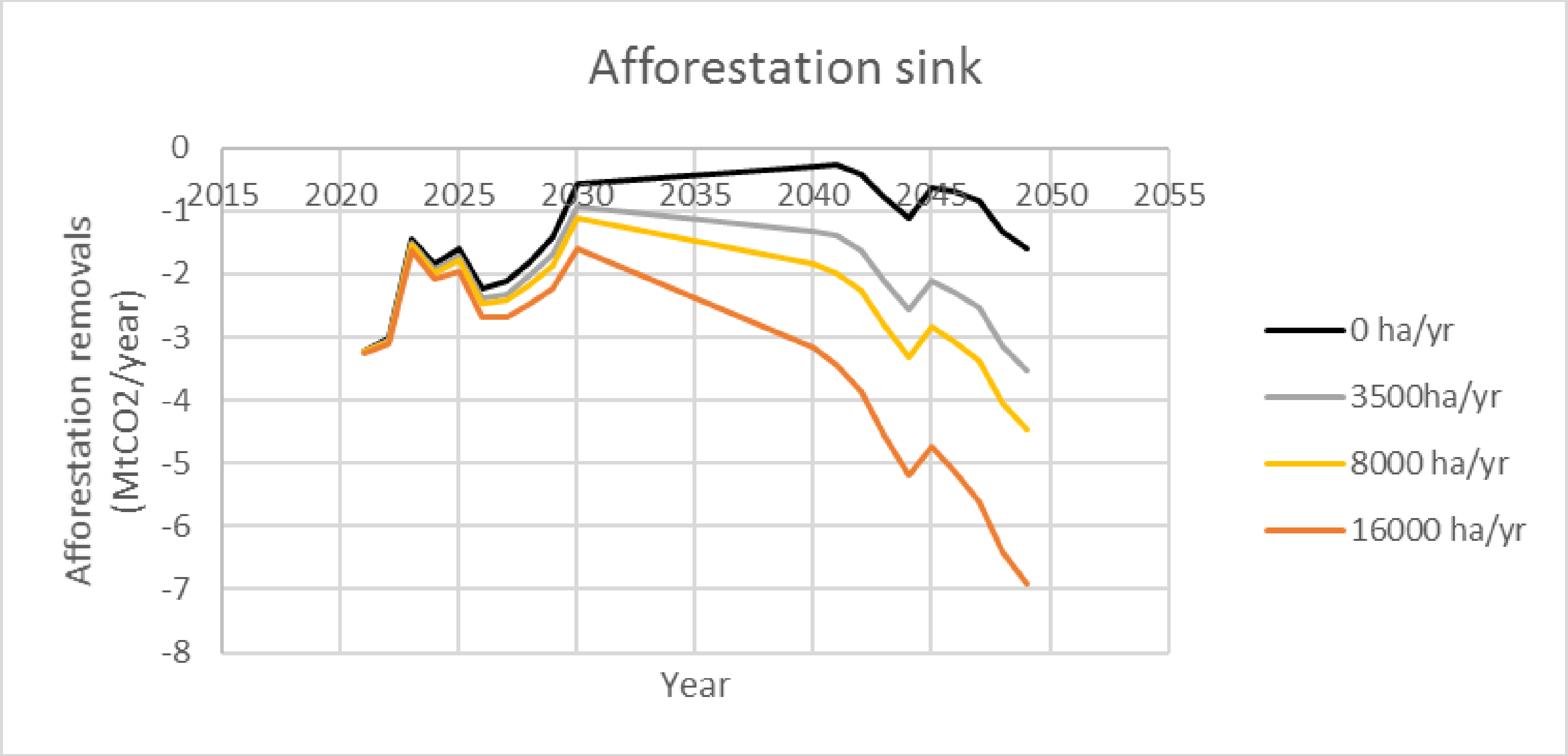
fers

Afforestation scenarios to mid-century

- Net removals from afforestation is the largest land based mitigation option
  - Main contributor to 26.8 $MtCO_2$ EU effort sharing target 2021-2030

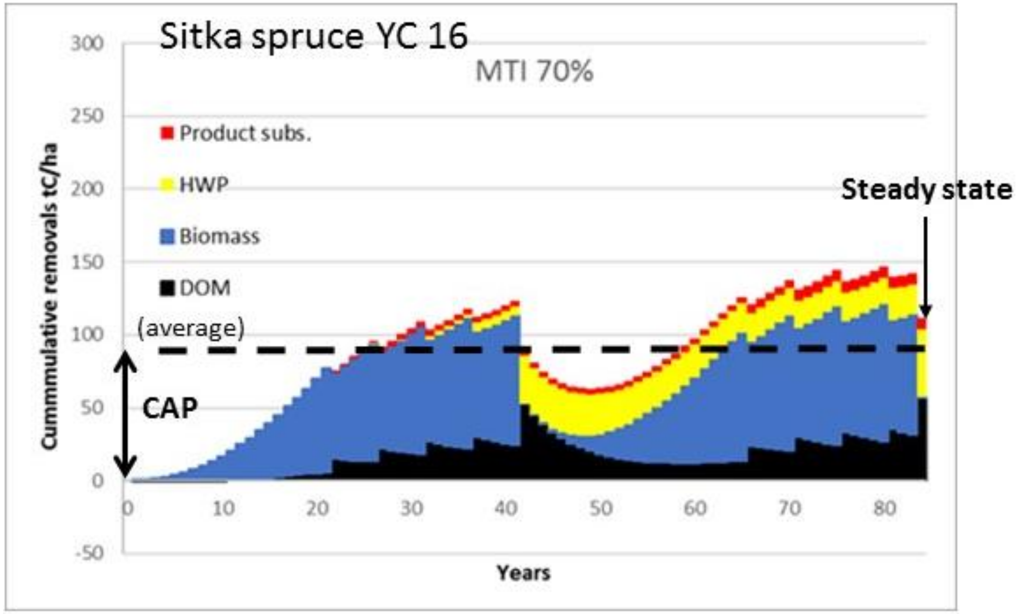
Extent of sink to 2050 dependent on a range of factors including :

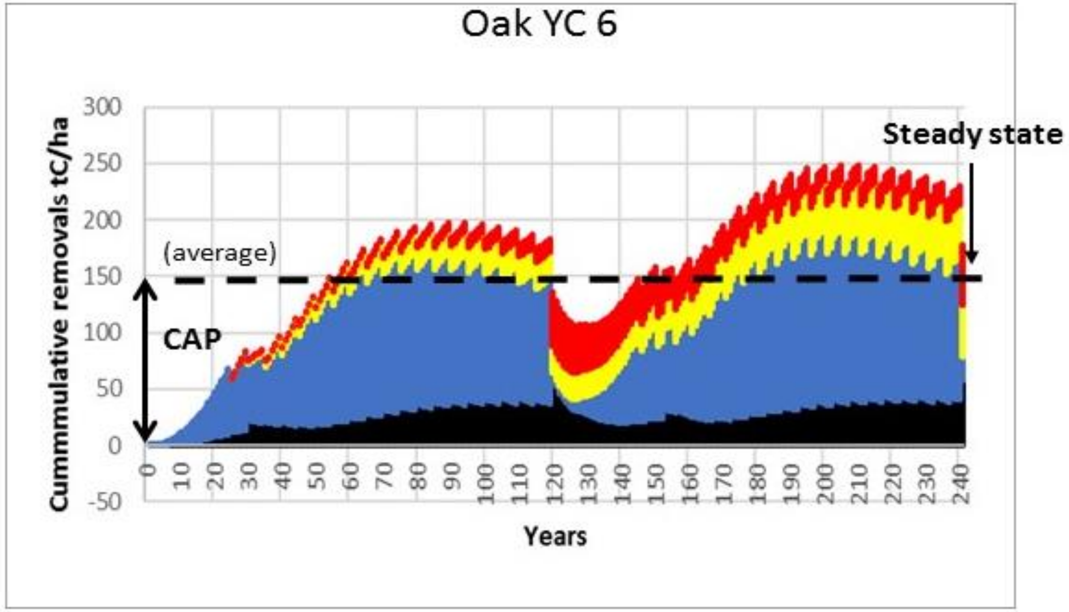
- **Afforestation rate**
- **Species / productivity**
- **Avoiding deforestation**
- **Sustainable forest management**



Concepts

- Afforestation is a once off mitigation (cyclical) and is not permanent unless managed sustainably

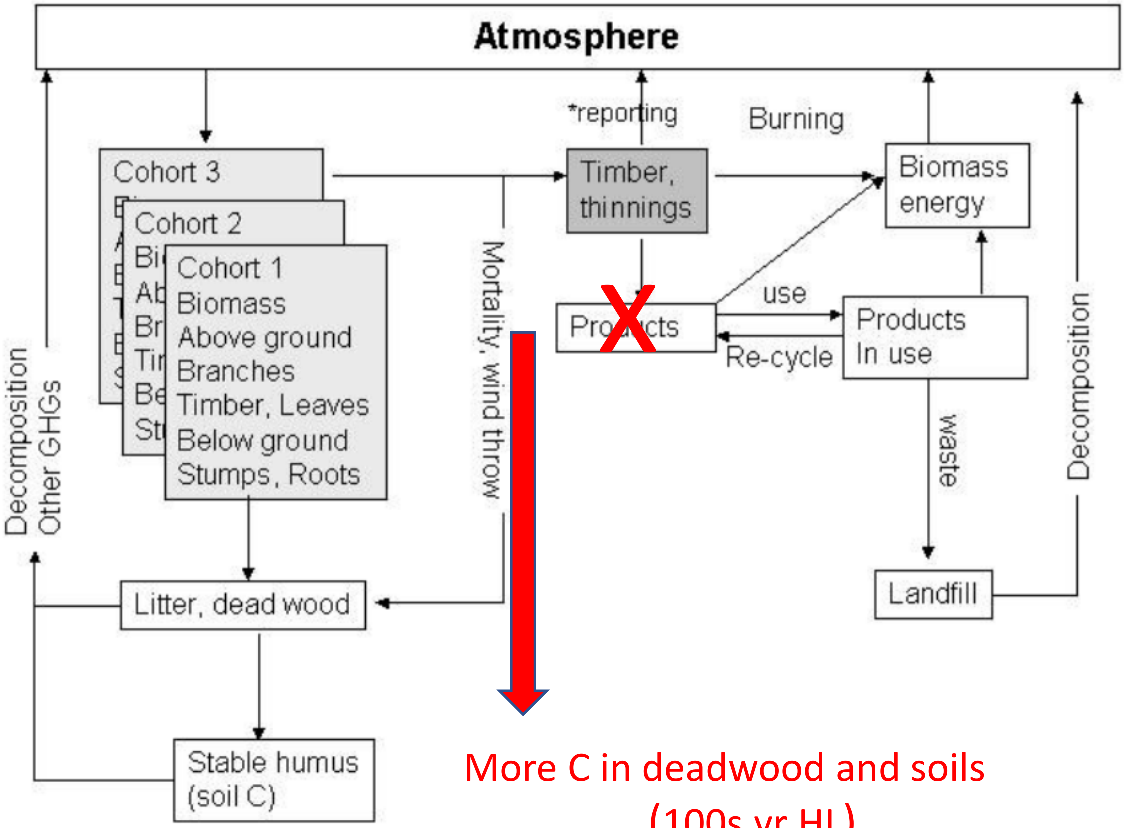




- **CAP sequestration value** (average cumulate value) is a measure of the once-off sequestration potential
- **Mean annual sequestration rate** until steady state reached
- The mean and CAP are normalised measures of sequestration, which allows comparisons over different rotation ages
- Longer rotations **generally** have a higher CAP values but a lower average annual sequestration rate

Concepts: Forest – HWP trade-offs

Forest retention

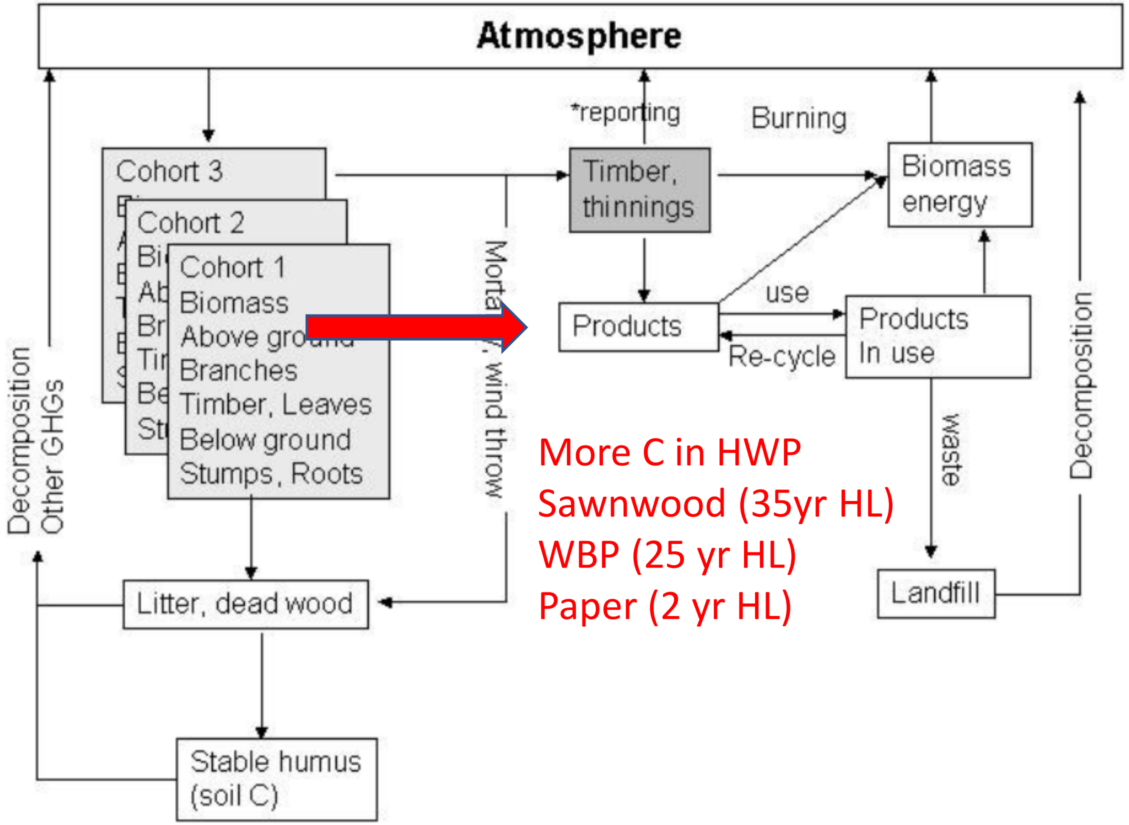


More C in deadwood and soils
(100s yr HL)

Higher C stocks and longer retention of C in system

Higher decomposition losses

Harvest and replant



More C in HWP
Sawnwood (35yr HL)
WBP (25 yr HL)
Paper (2 yr HL)

Lower forest C stocks and retention

Forest Carbon Tool - assumptions and caveats

- Based on fixed management assumptions and timber flows for different species (see table below)
- Higher uncertainties for some GPC categories (e.g. Agroforestry, Native Woodland Scheme)
- Afforestation is assumed to be permanent (no deforestation and same management in perpetuity)
- Afforestation is assumed not to lead to leakage (displacement or intensification leading to emissions elsewhere)

Table 2: Species, yield class, forest management and wood use assumptions applied to the species/species group options in the Forest Carbon Tool

Species groups	CODE	YC range	Management	Rotation length	Wood use
Spruce	SS	12#, 14#, 16, 18, 20, 24	Thinned	MMAI*** - 20%	Energy wood*, WBP**, palletwood and sawlog
Pine	LP	8,12	Unthinned	MMAI	WBP, palletwood
Other Conifers	OC	16	Thinned	MMAI	Energy wood, WBP*, palletwood and sawlog
Fast growing broadleaves (Sycamore, alder, birch)	FGB	6##, 8	Thinned	Grow to diameter of 40-50cm###	Energy wood (early thinnings) and sawlog
Slow growing broadleaves (Oak)	SGB	4, 6	Thinned	Grow to diameter of 50cm (120-150 years)	Energy wood (early thinnings) and sawlog

YC 12 & 14 SS are unthinned

##Maximum diameter (DBH) for YC 6 is 35cm

###Huss et al., 2016

* Wood fuel options e.g. wood chips and firewood

** Wood-based panels

*** MMAI is the age of maximum mean annual increment

Assumptions - GPC categories

Table 1: Grant and premium category (GPC) description, yield class, forest management and wood use assumptions applied to GPC options in the Forest Carbon Tool

GPC Category	Description	Species/Species Group	Mix	% Open area	Yield Class (YC)	Wood Use
GPC 1	Unenclosed	SS	100	15.0	YC 16 and YC 18	Energy wood*, WBP**, palletwood and sawlog
GPC 2	Sitka spruce/Lodgepole pine	SS/LP	50:50	15.0	SS YC 12/LP YC 8	WBP for LP, WBP, palletwood and sawlog for SS, no thinning
GPC 3	10% Diverse Conifer/Broadleaf	SS/FGB^	90:10	15.0	Conifer YC 20/BL YC 6	Energy wood, WBP, palletwood and sawlog /FGB retention
GPC 3	10% Diverse Conifer/Broadleaf	SS/FGB	90:10	15.0	Conifer YC 24/BL YC 8	Energy wood, WBP, palletwood and sawlog / FGB retention
GPC 4	Diverse Conifer	Other conifers	100	15.0	YC 16	Energy wood, WBP, palletwood and sawlog
GPC 5	Broadleaf	FGB	100	15.0	YC 6	Energy wood (early thinnings) and sawlog
GPC 5	Broadleaf	FGB	100	15.0	YC 8	Energy wood (early thinnings) and sawlog
GPC 6	Oak	SGB^^	100	15.0	YC 4	Energy wood (early thinnings) and sawlog
GPC 6	Oak	SGB	100	15.0	YC 6	Energy wood (early thinnings) and sawlog
GPC 7	Beech	SGB	100	15.0	YC 4	Energy wood (early thinnings) and sawlog
GPC 7	Beech	SGB	100	15.0	YC 6	Energy wood (early thinnings) and sawlog
GPC 8	Alder/Birch	FGB	100	15.0	YC 6	Energy wood (early thinnings) and sawlog
GPC 8	Alder/Birch	FGB	100	15.0	YC 8	Energy wood (early thinnings) and sawlog
GPC 9	Native Woodland Est. Scenario 1^^^	SGB	100	15.0	YC 4	Long term retention (some timber removal e.g. sawlog, energy wood)
GPC 10	Native Woodland Est. Scenario 5^^^	SGB/FGB	50:50	15.0	YC 4	Long term retention (some timber removal e.g. sawlog, energy wood)
GPC 11	Agroforestry (5m spacing)	SGB/FGB	100	0		Initial stocking of 400 reduced to 70 stems over the rotation (all sawn to HWP)
GPC 12	Forestry for Fibre	*Eucalyptus nitens*	100	15.0	YC 30	Energy wood

^ Fast growing broadleaves (e.g. Sycamore, alder, birch)

^^ Slow growing broadleaves (e.g. oak)

^^^ Values will be available subject to further data analysis and validation

* Wood fuel options e.g. firewood and wood chips

**Wood-based panels (WBP) from pulpwood

Forest Carbon Tool - system boundaries

Included

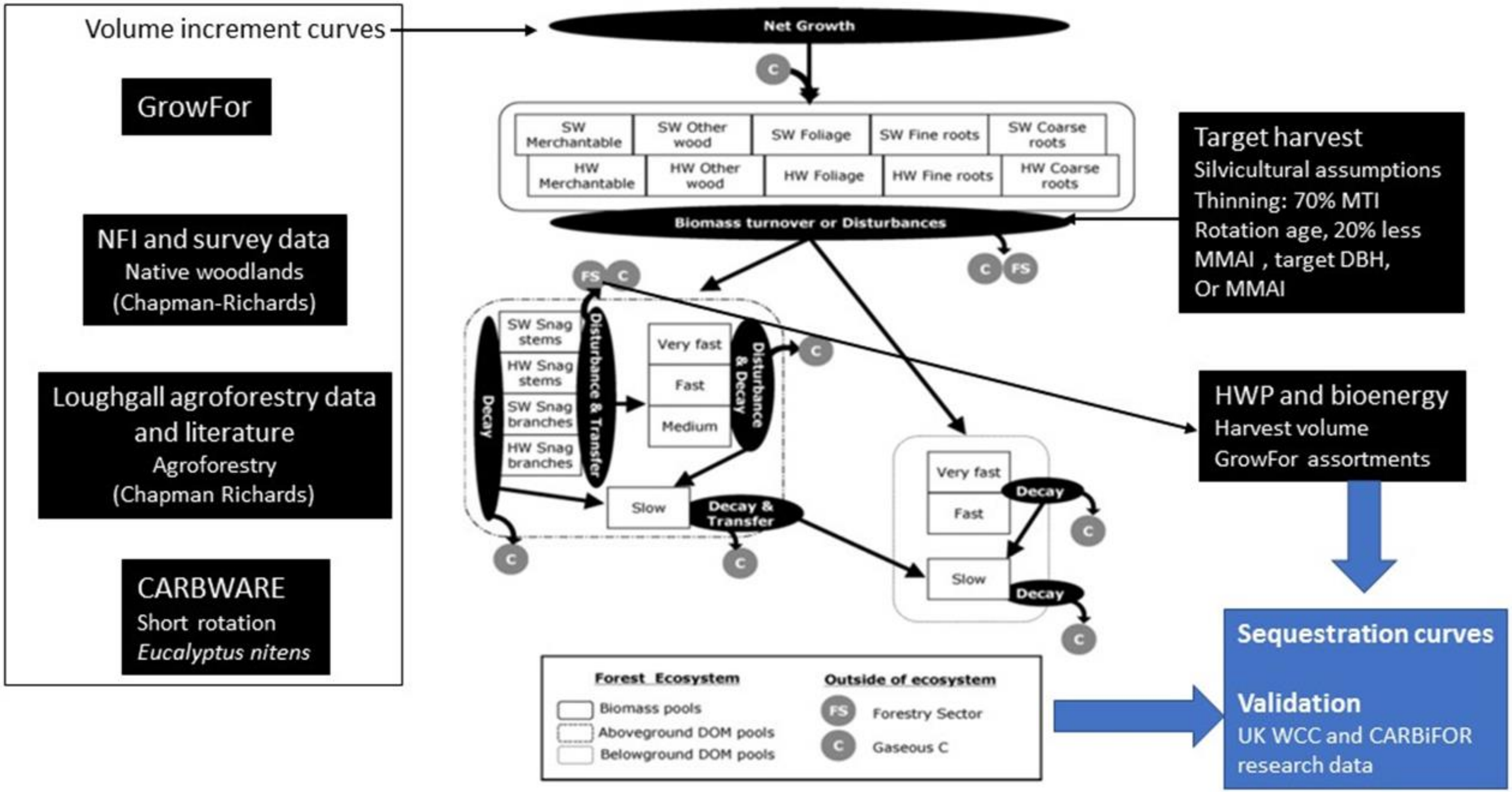
- Forest pools and organic soils
- HWP
- Fossil fuel replacement (thinnings)
- Livestock emissions (agroforestry)

Excluded

- Fossil fuel emissions from forestry operations
- Emissions from forest fires
- Emissions for loss of N_2O due to C mineralisation in soil
- N_2O emissions associated with application of urea
- Additional emissions from the milling sector
- Product substitution of wood for energy intensive materials such as concrete or steel
- Biomass(silage) and soil stock charges for Agroforestry are assumed to have a zero-carbon stock change (Duffy *et al.*, 2019; Fornara *et al.*, 2017).

Methods

CBM-CFS Model framework



Methods

- Methods are fully in line with IPCC guidelines and identical to those used in the national GHG inventory

- Forest growth is based on published and validated models (some exceptions)
  - Forest C model validated and compared to other estimates

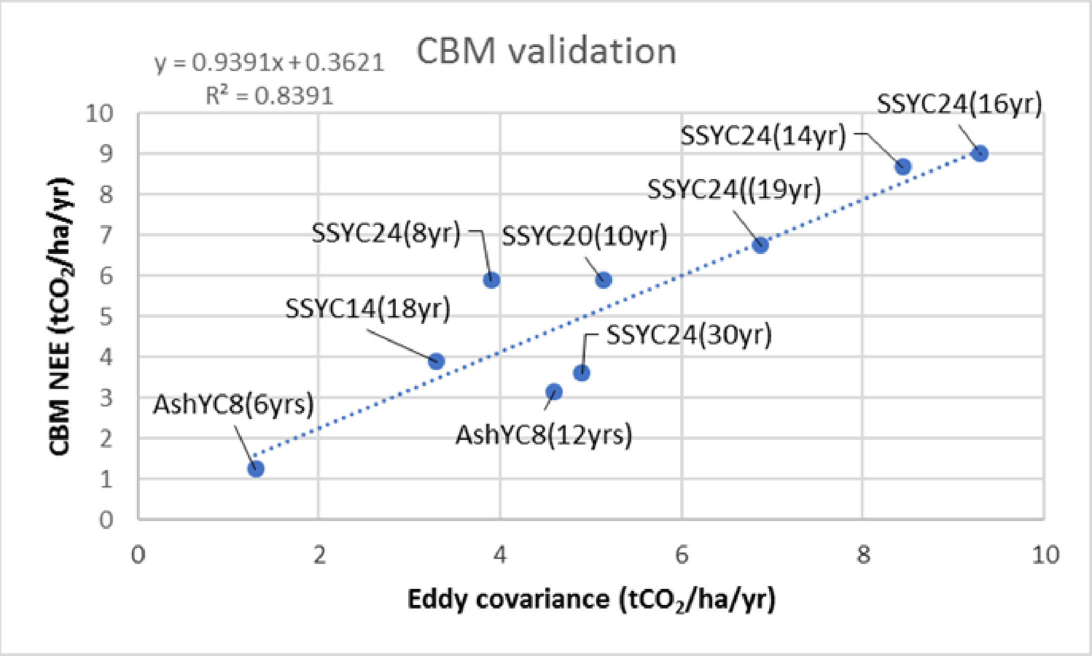
- Mortality, biomass turnover and decomposition based on COFORD research since 2002

- **HWP assumption based on current timber flows**
  - Sawlog is allocated to sawn wood assuming 43% processing loss (FAO/EUROSTAT)
  - Pulp and pallet is allocated to WBO assuming a 49% processing losses (FAO/EUROSTAT)
  - Decomposition of HWP based on IPCC default approach

- **Fossil fuel displacement:**
  - Sitka spruce 15% of 1st and 2nd thinnings (Woodflow, Knaggs and O Driscoll, 2016)
  - Broadleaves - all non-sawlog assumed to be used for bioenergy
  - GPC 12 - all timber used for bioenergy
  - Fossil fuel emission avoidance for energy substitution is based on a displacement factor for oil (0.26 tC/tC wood; Sathre and O'Connor, 2010, Smyth *et al.*, 2016)

Validation - Eddy Covariance

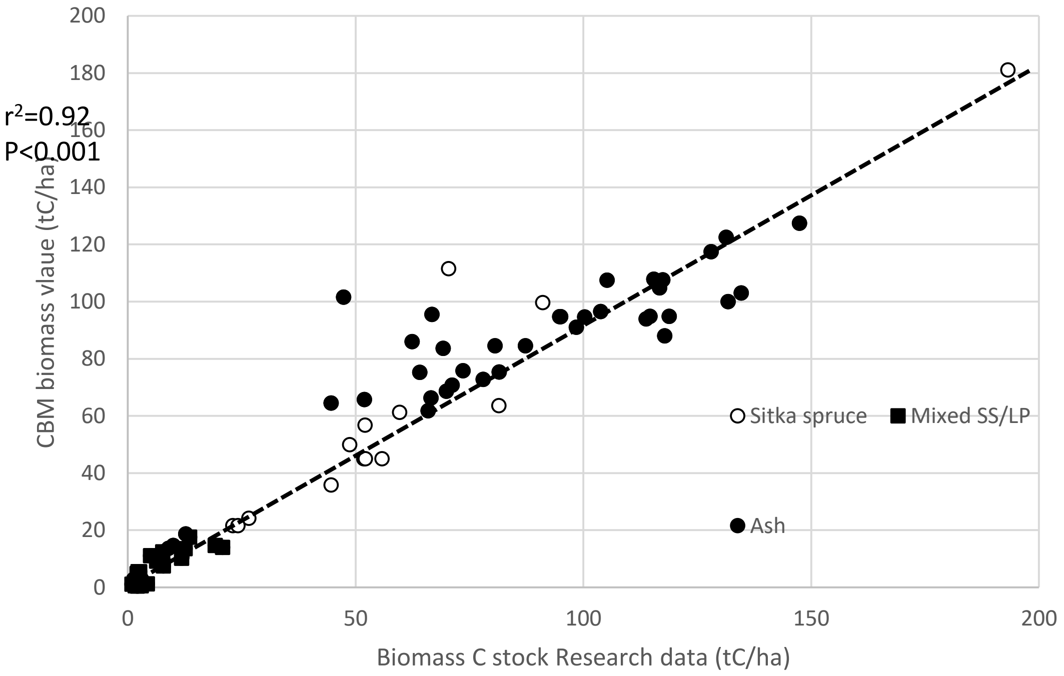
- Eddy covariance measured 30min exchange of CO_2 between forests and the atmosphere
- Annual eddy covariance flux (NEE) should be the same as CBM modelled NEE
  (i.e. biomass, litter, deadwood and soils fluxes)



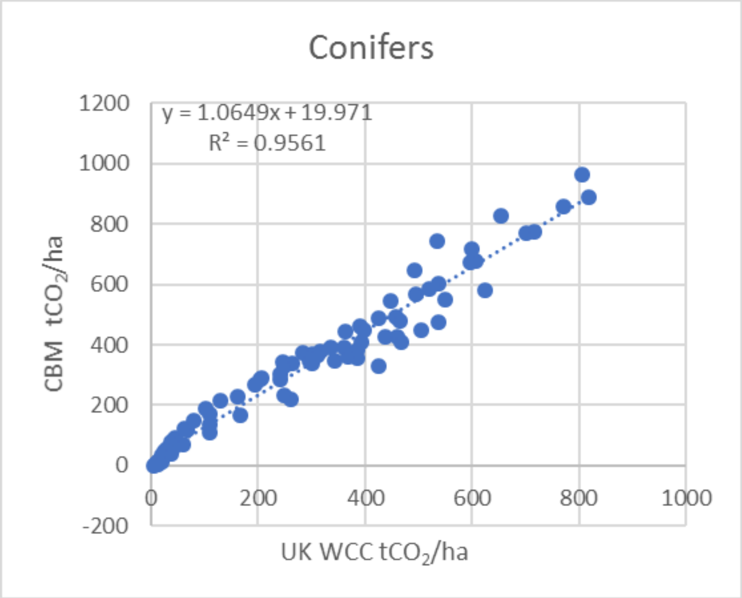
Black et al., 2007, Saunders et al in press

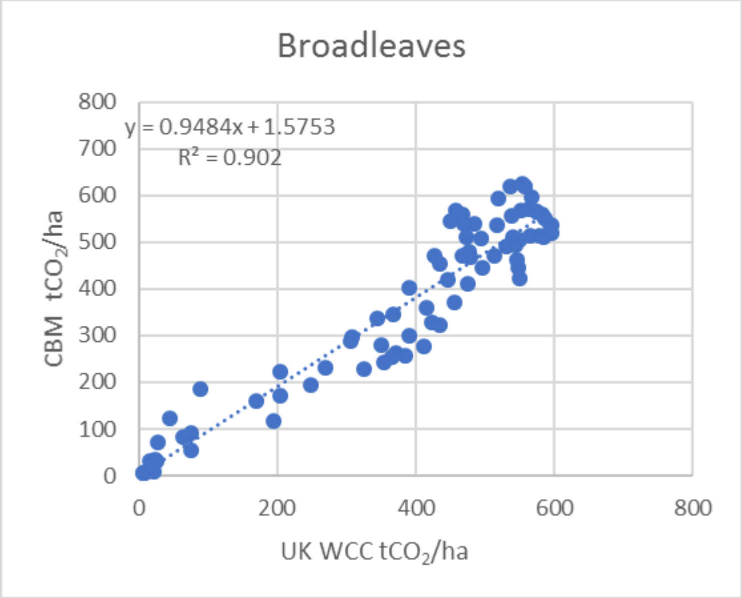
Validation - biomass stocks

- COFORD research data on measured biomass stocks for different forest types and ages

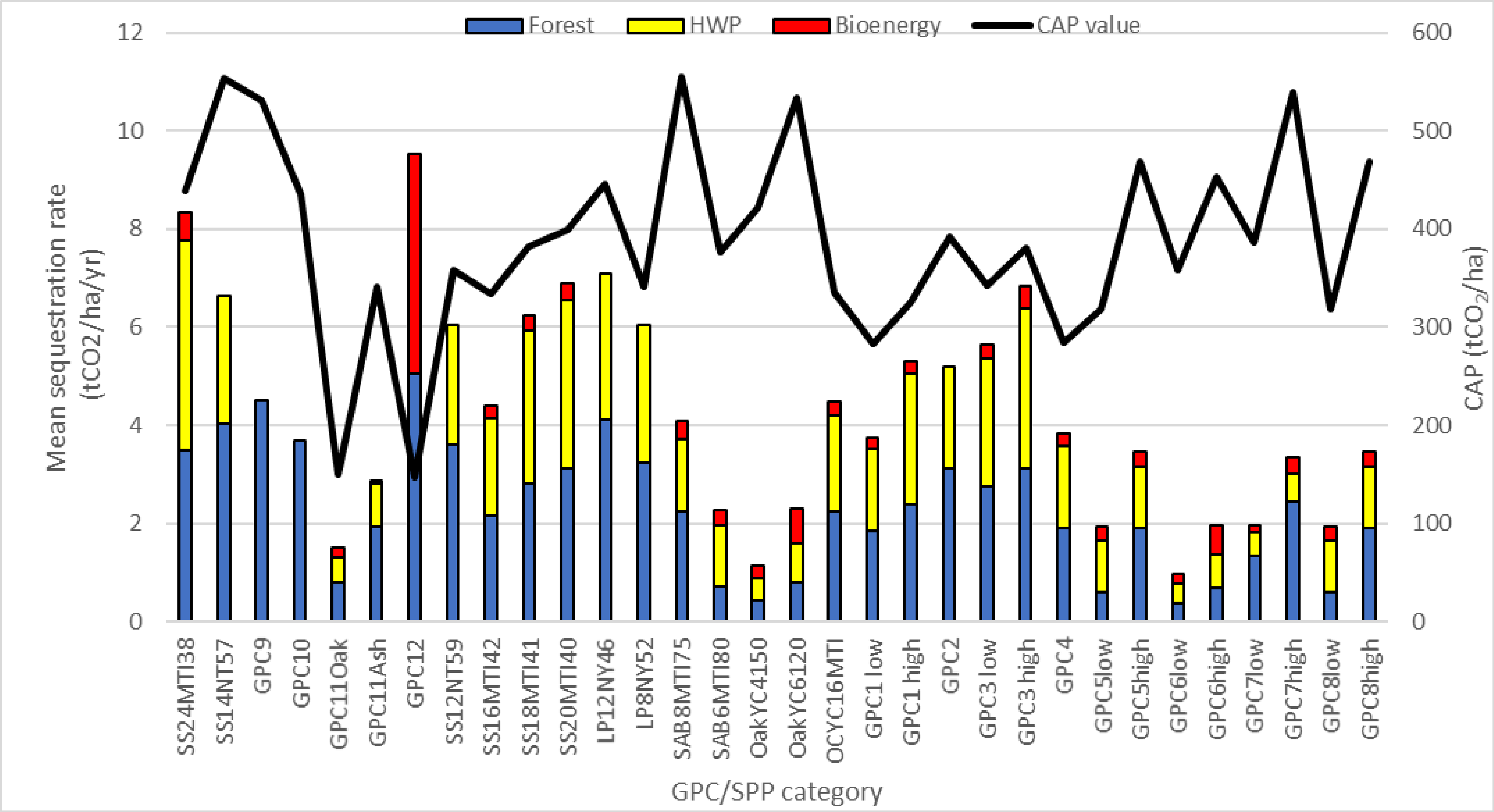


- UK Woodland carbon code estimates





Understanding the results



Summary

- Forests have many ecosystem services-carbon is just one small component
- Mean sequestration rates range from 1 to 9 tCO_2/ha
- Afforestation offers a once off removal but HWPs continue to contribute after steady state
    - Need additional forest policy to increase mitigation potential (e.g. forest management).
    - Product substitution
- Species with high CAP values effect for long term C captures (e.g. NWS, long rotation slow growing BL crops)
- Highly productive species are effective for quicker C capture and flows to HWP and bioenergy (e.g. S. spruce thinned and GPC12)
- No thin appears to provide a higher sequestration potential than thinned crops
    - (i.e. the HWP trade off) C is more resilient in the forest compared to HWPs
    - Product substitution