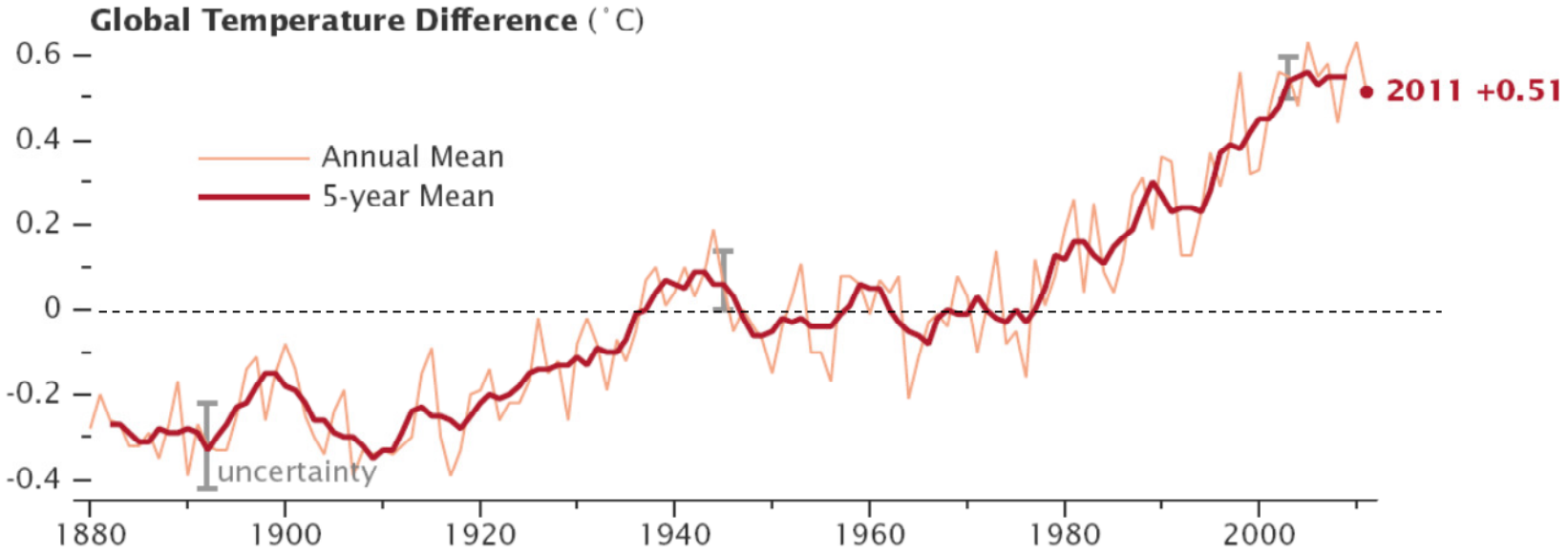
Forest Research
The Research Agency of the Forestry Commission

The possible contribution of trees, woods and forests to the UK GHG balance

James Morison
Centre for Forestry
& Climate Change

CARBiFOR II Stakeholder meeting,
4th September, Dublin

Global climate change



10 of the 12 warmest years in the 350 year Central England Temperature record have occurred in the last 20 years

UK forests & 'mitigation'

Introduction & Outline

- Climate change is occurring because of anthropogenic emissions of GHG (CO_2, CH_4, N_2O, halocarbons etc.)
- UK Government and the Devolved Administrations have set challenging targets to reduce net GHG emissions

- *What part can woodlands, forests, trees and forestry play ?*
- *What are uncertainties ?*

UK Climate Change Committee

3rd Progress Report to UK Parliament, June '11

- **On forestry** the report:
- urges Government to set out a strategy for raising woodland creation in the UK to 21,000 ha a year by 2015.
- action now to realise C benefits in the coming decades….
- specific measures to increase woodland creation be in place by 2014….
- important role of timber in construction…

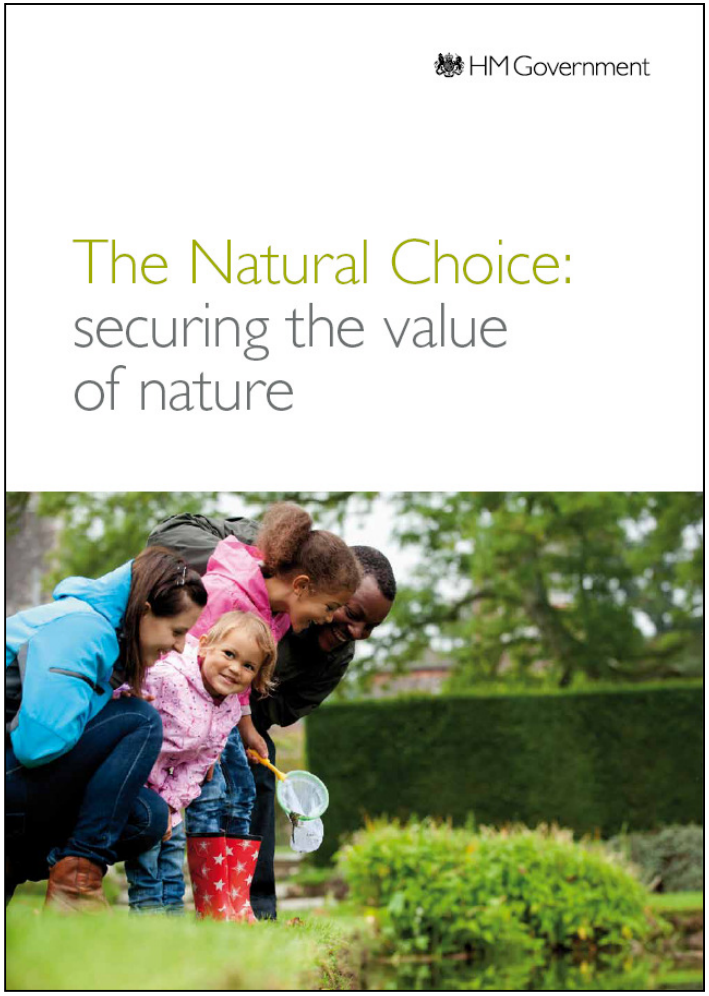
UK Natural Environment White Paper, 2011

Ambitions for:

- a major increase in the area of woodland in England, e.g. increase in woodland area by 1/3 of current levels by 2060;
- better management of existing woodlands with much more woodland in active management;

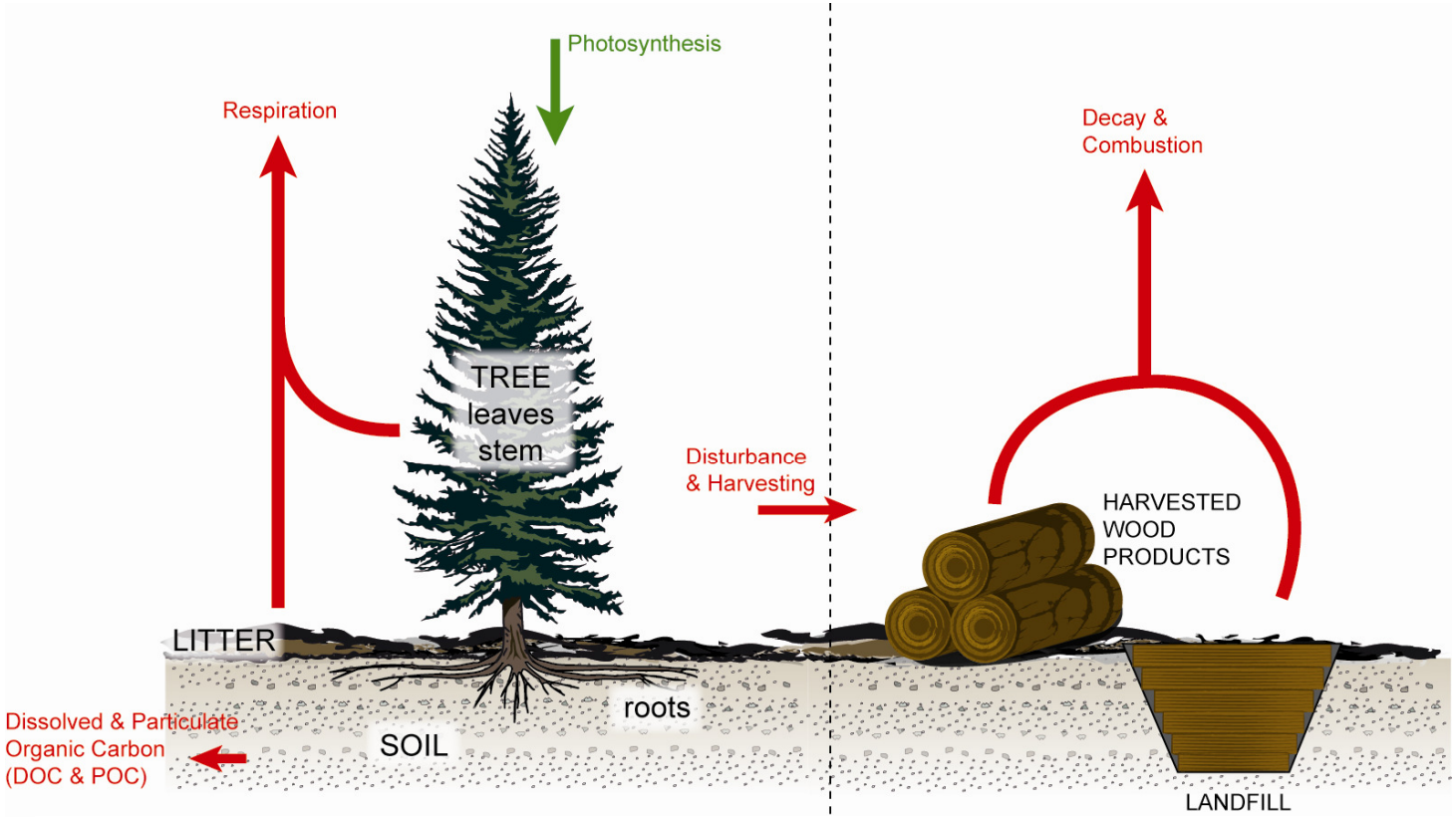
Linkages to:

- multiple benefits including renewable energy and timber, reducing GHG emissions;



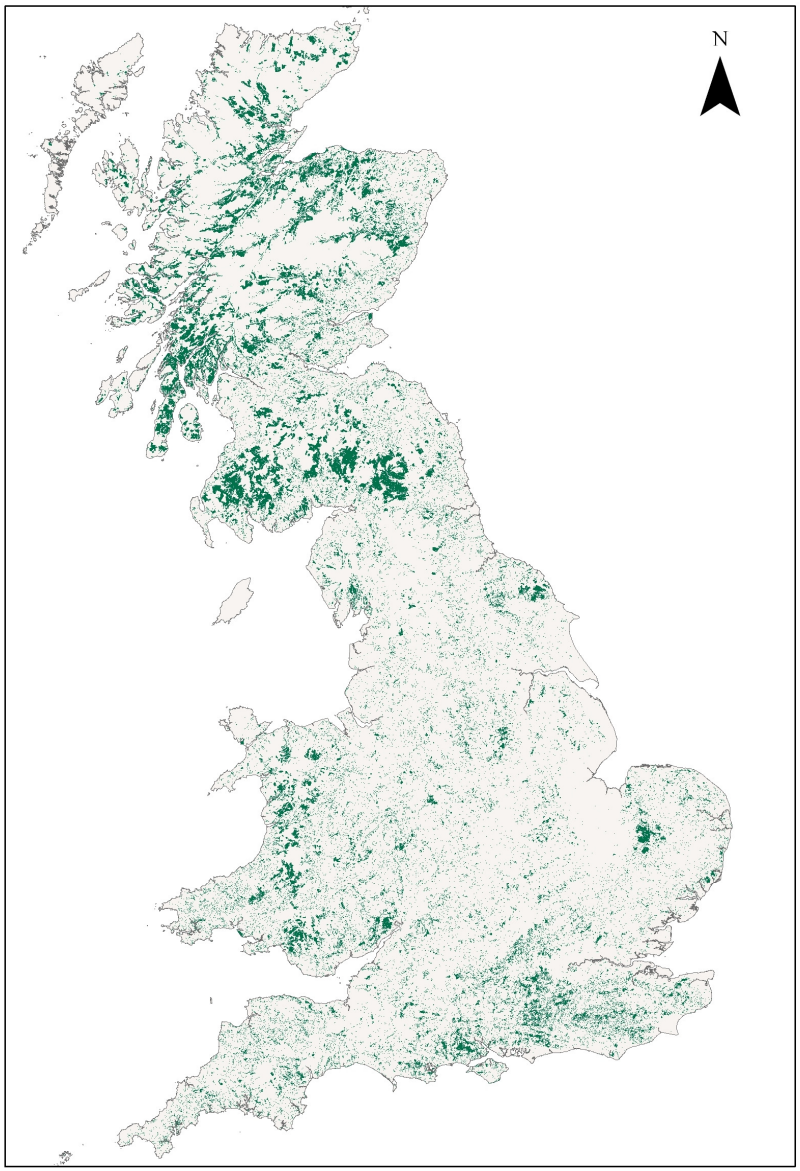
UK forests & 'mitigation'

Forestry GHG components and balance



Also need to consider: fossil fuel use in forestry and substitution benefits of woodfuel and HWP

Information sources

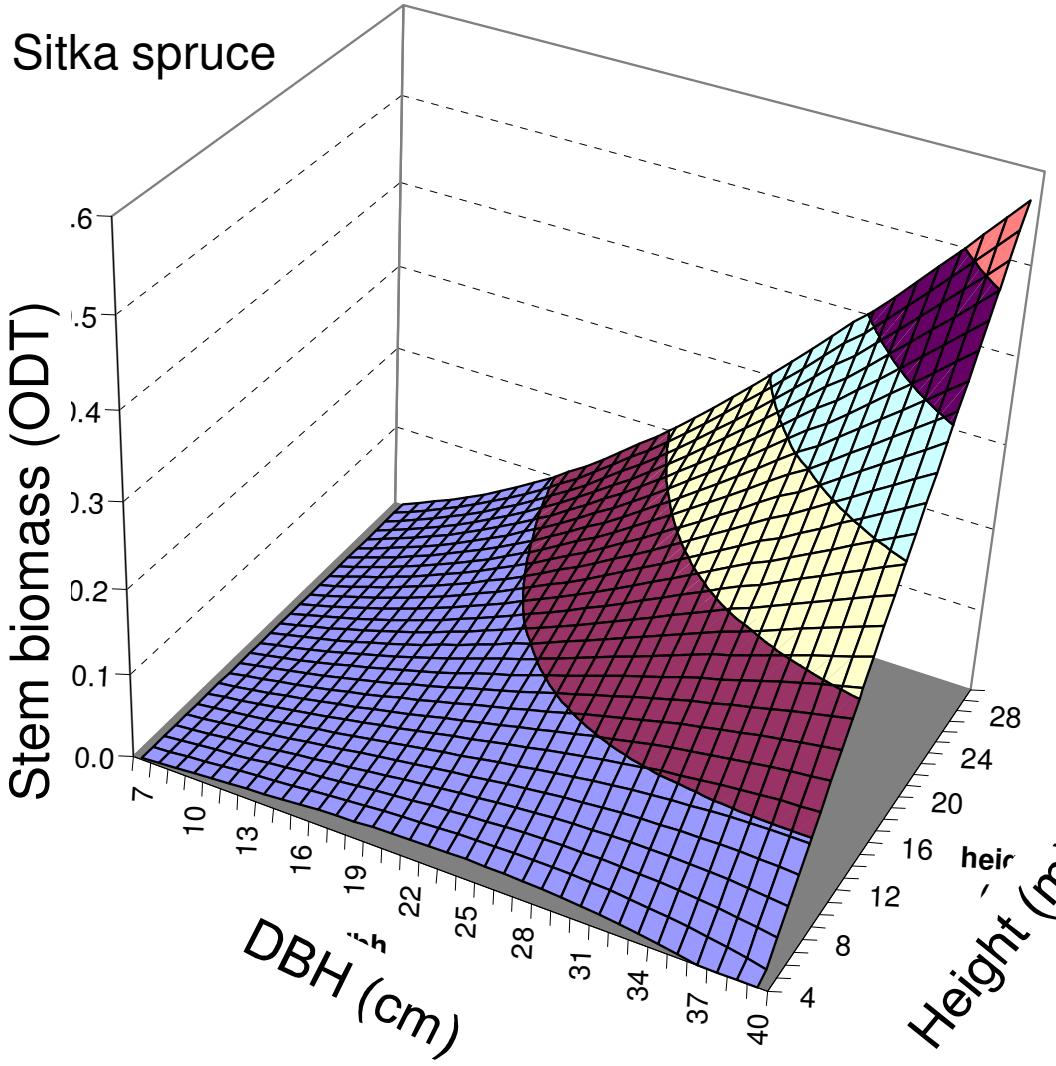


National Forest Inventory (NFI)

- 3.0 million hectares under woodland or forest (13% of GB land)
- 0.8 Mha public forest
- 1 Mha conifer plantation
- 0.6 Mha semi-natural woodland
- 9.4 Mt softwood, 0.5 Mt hardwood per year
- Important ecosystem services

(NFI gives slight increase over previous NIWT)

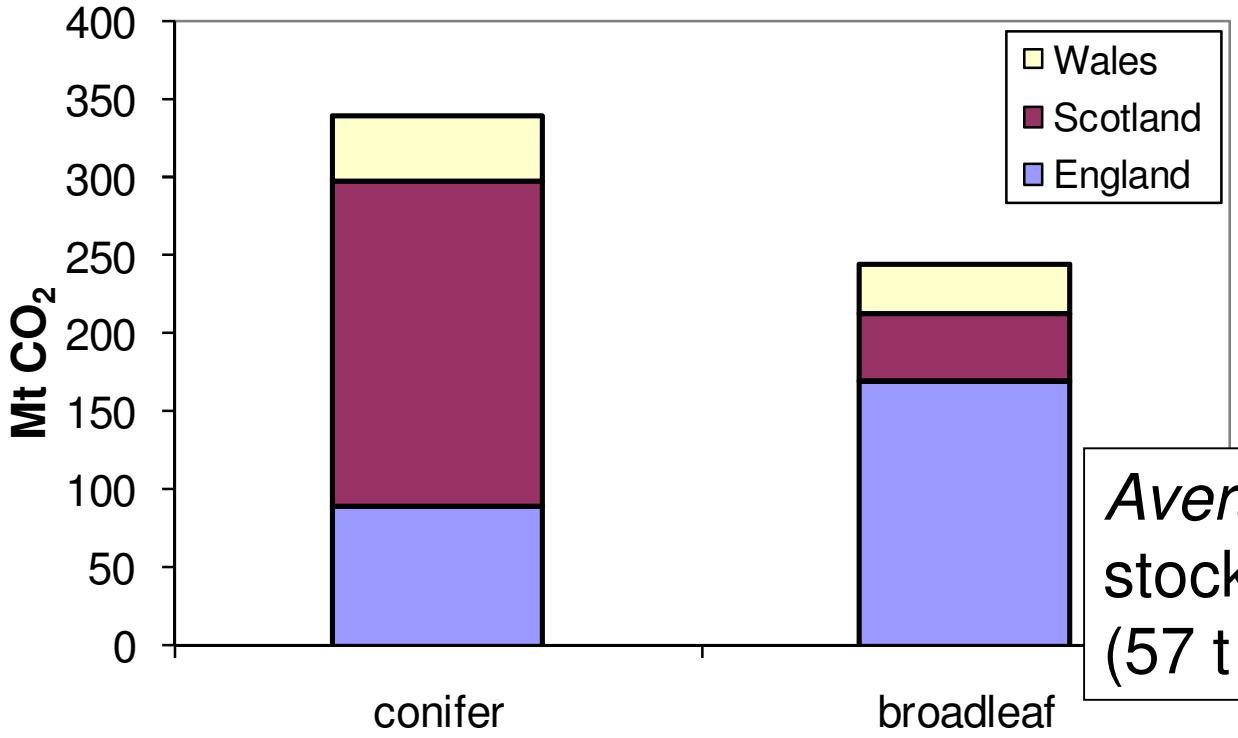
C Stocks in trees - stems



- Tree stems - well characterised by forest mensuration and permanent sample plots
- Well-described relationships between stem size, height, volume and mass, and time
- Biomass Expansion Factor and Root:Shoot ratio

But only for major timber species

C Stocks in GB trees - national



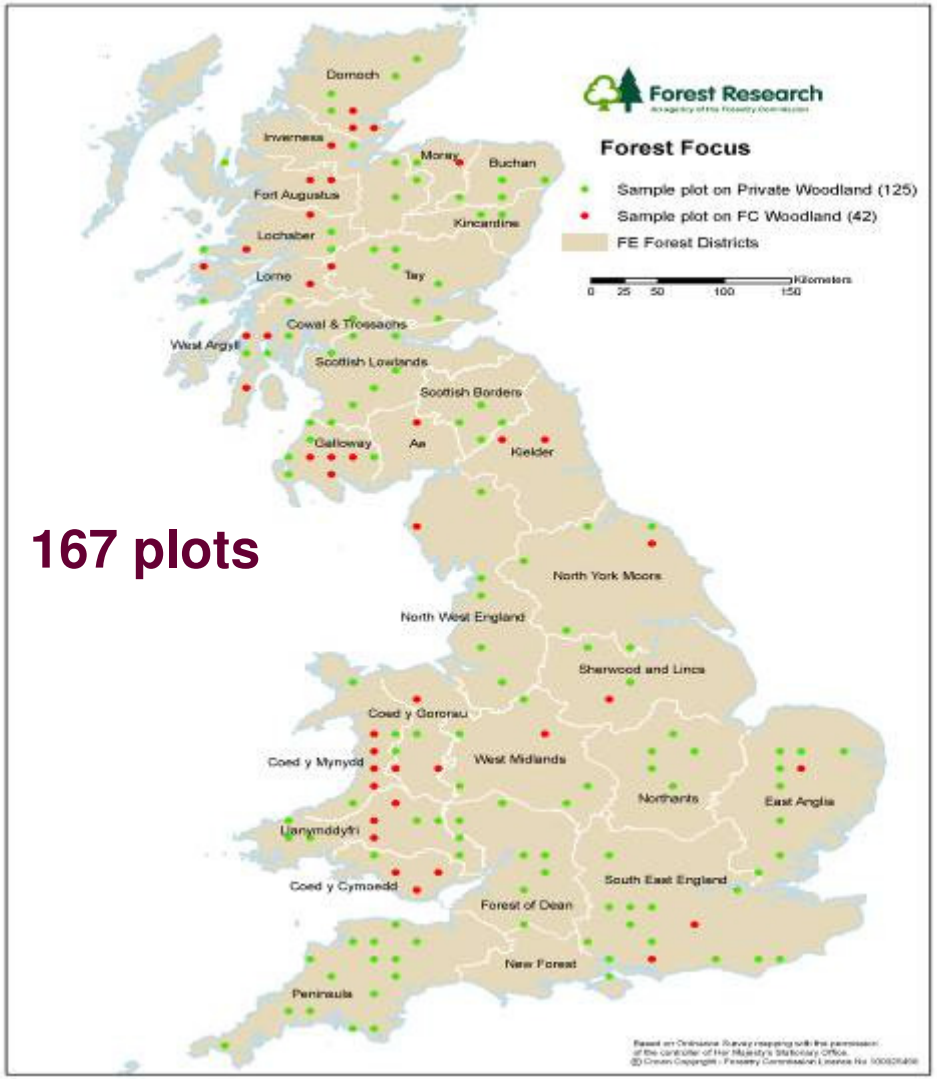
Average GB tree C stock = 209 t CO_2 ha^{-1} (57 t C ha^{-1})

Total C stock in GB = 595 Mt CO_2 (162 Mt C)
71% in private ownership, 29% in broadleaves in England
32% in Scottish spruce & pine forests

(Woodfuel Resource in Britain, McKay et al., 2003)

C Stocks in woodland soils

UK BioSoil survey, 2007



167 plots

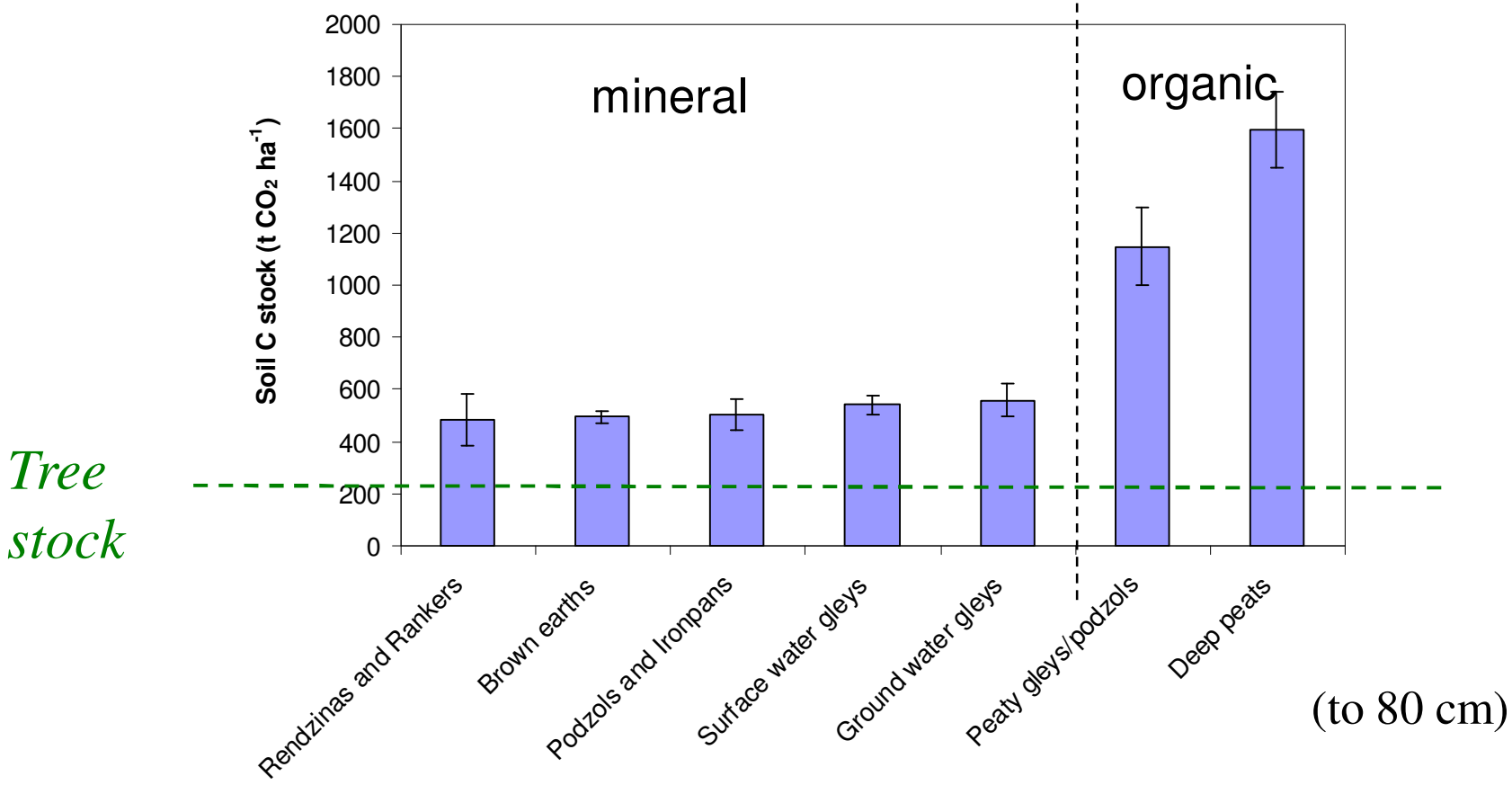
Podzol

Gleysol

Histosol

(Elena Vanguelova)

C Stocks in UK woodland soils

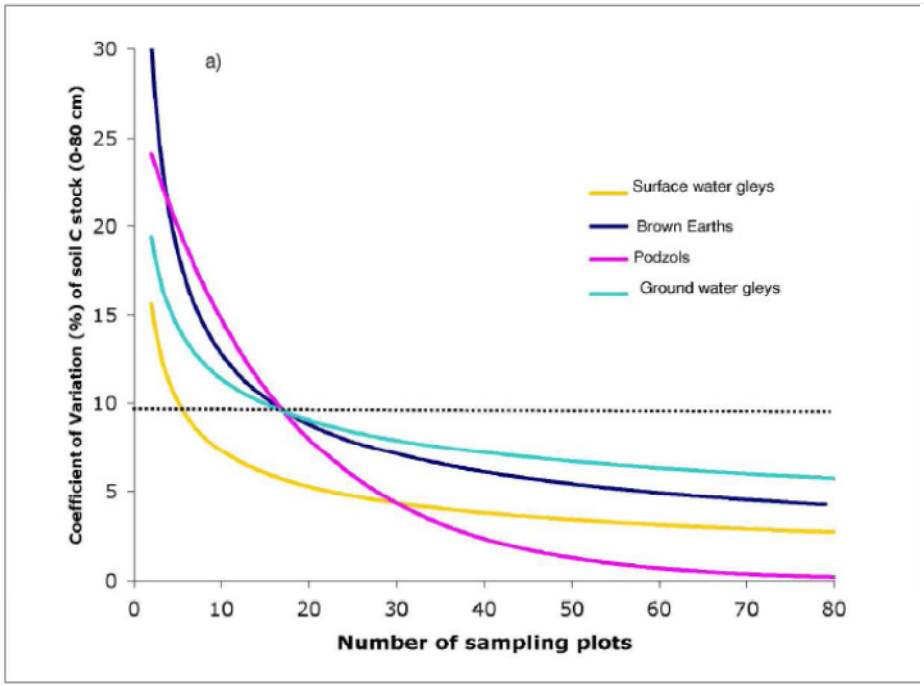


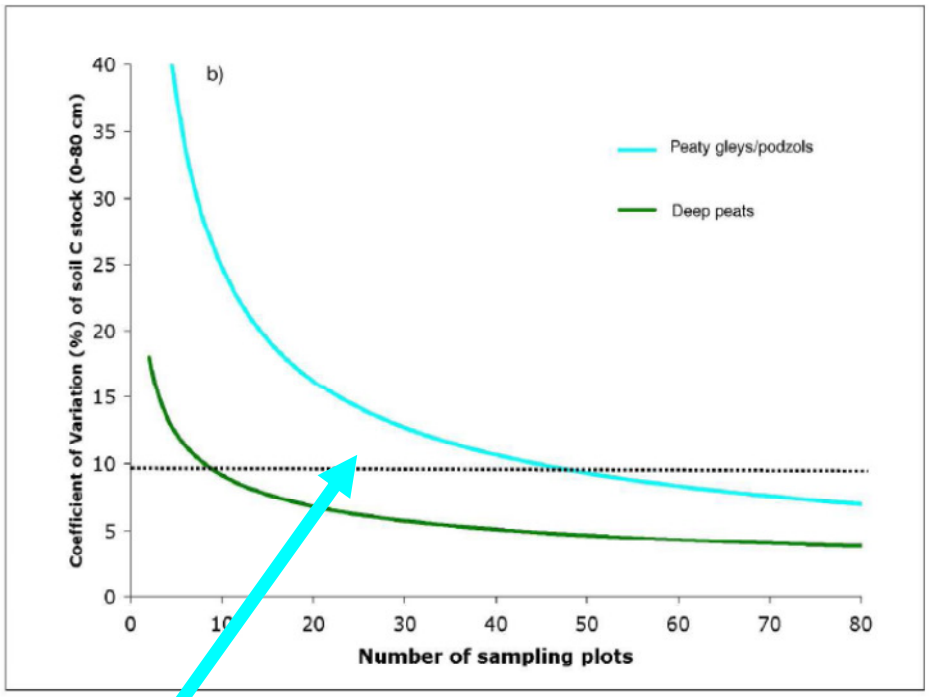
(to 80 cm)

In most woodlands, more C in soil than in trees, particularly the organic soils

(BioSoil Survey, 2007, Vanguelova et al. in press, Soil Use & Management)

Soil C Stock uncertainties





Considerable uncertainty over peaty gleys

(BioSoil Survey, 2007, Vanguelova et al., in press, Soil Use & Management)

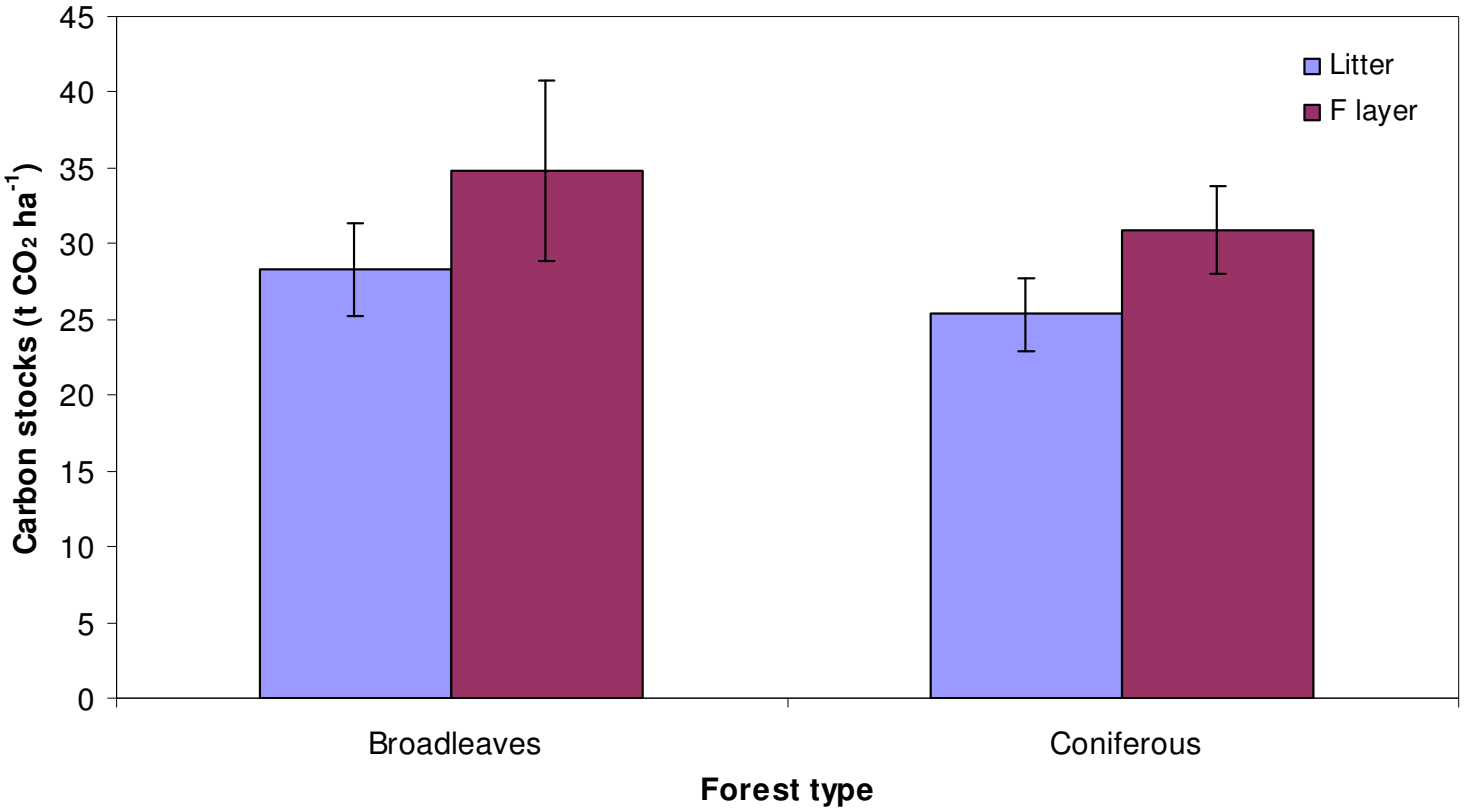
C Stocks in UK woodland soils

All soils (0-80 cm)	England	Wales	Scotland	Total GB
Total forest area (Mha)	1.1	0.3	1.3	2.7
Total soil carbon stock (Mt C)	162.9	45.7	337.0	545.6
Standard Error of Mean (Mt C)	14.6	4.6	28.8	32.6
Coefficient of Variation (%)	9.0	10.1	8.5	6.0

Scaling up estimates for regional or national stocks depends on soil map(s) accuracy & resolution.

(BioSoil Survey, 2007, Vanguelova et al., in press, Soil Use & Management)

C Stocks in UK woodlands litter



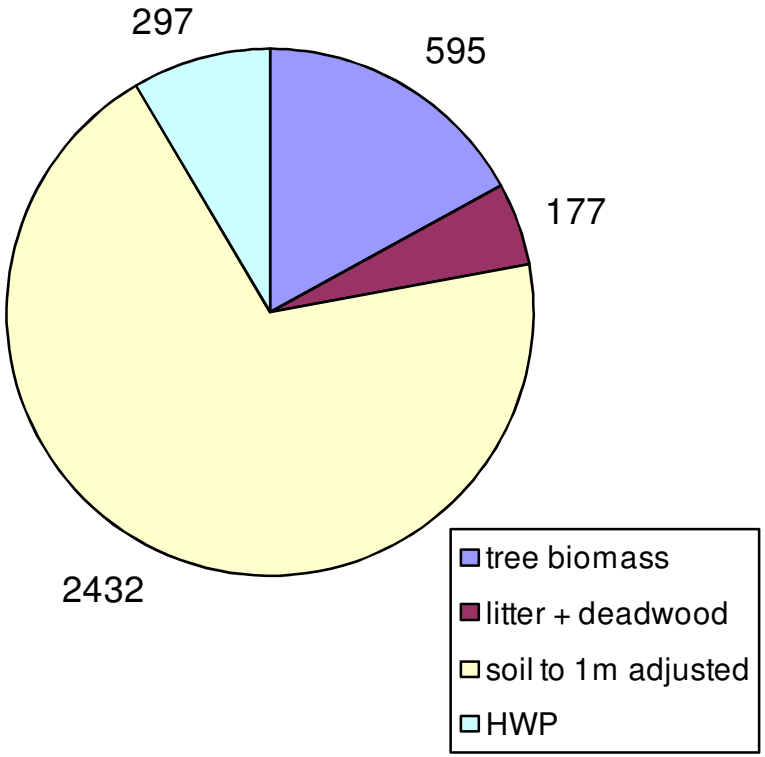
Litter and F layer adds another 20-35%
Key difference from other land uses

(BioSoil Survey, 2007, Vanguelova et al.)

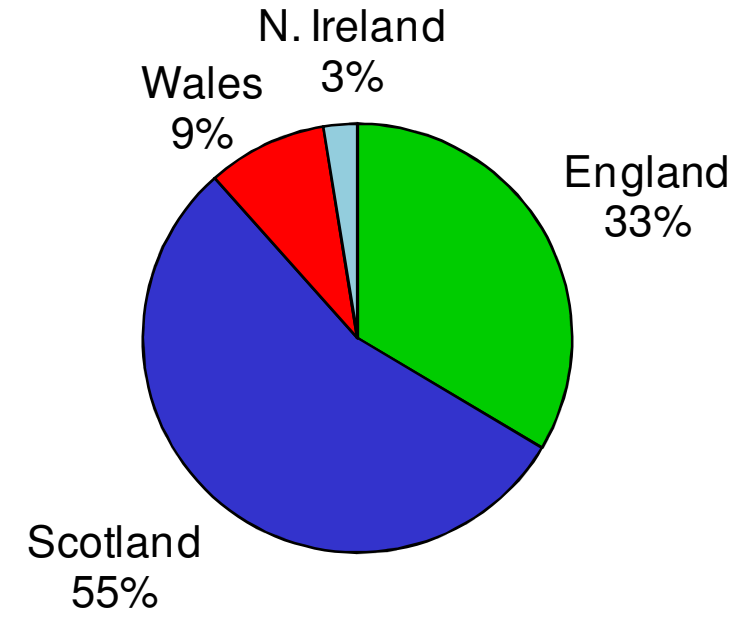
C Stocks in UK forestry

UK Forestry C stocks

(Mt CO_2)



UK total trees, litter and soils



Total UK: 3500 Mt CO_2

955 Mt C

(HWP does not include amount in landfill)

Uncertainties in C stocks

- Soils:
  - C deeper than 1m, depth of peats, organo-mineral soils
- Deadwood stocks
  - Decay rates
  - Need information on 2nd and 3rd rotation
- HWP products
  - Pool is dominated by imported timber
  - Lifetimes, end products
  - Landfill stocks and changes
- Missing components ?

***Trees*, woodland & forests**

- "Urban greening" frequently promoted for climate change impacts benefits:
  - cooling, shelter, recreation, health, air pollution etc
- UK is heavily urbanised
- How much C is there in urban trees ?

Journal of Applied Ecology

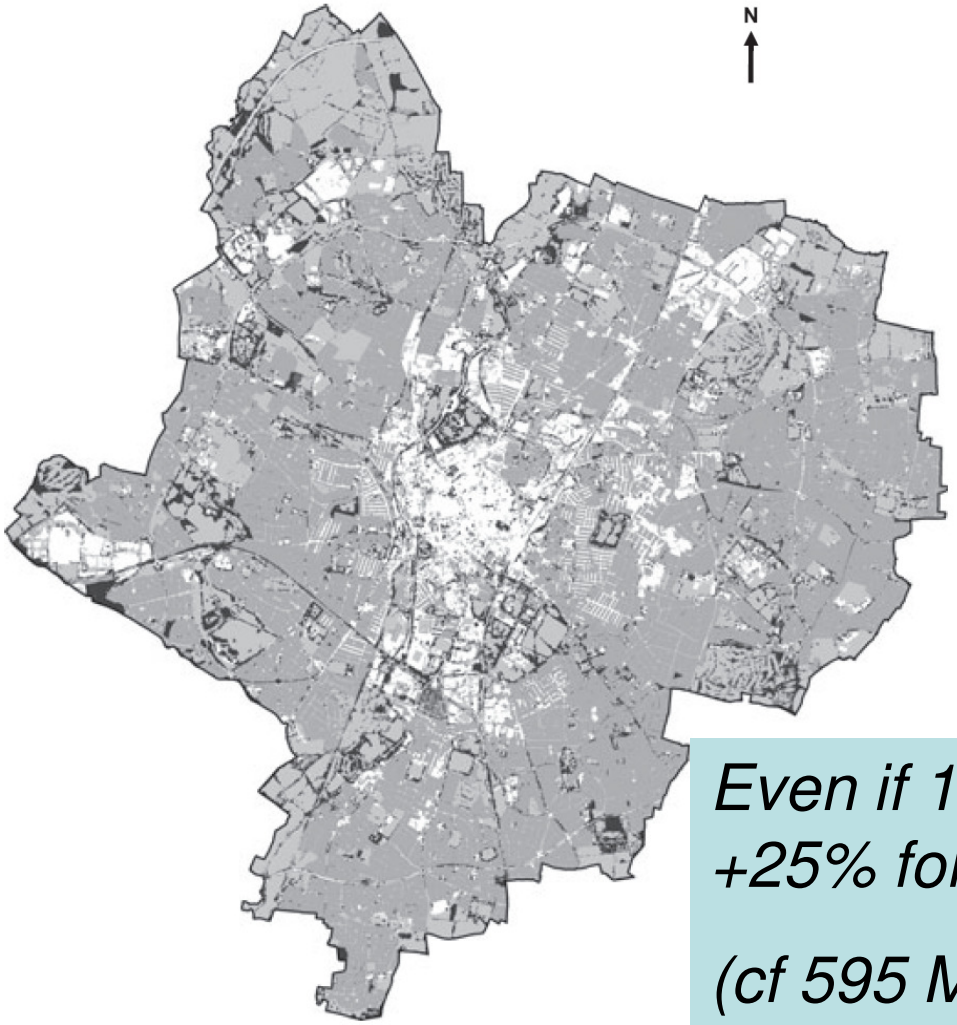
British Ecological Society

Journal of Applied Ecology doi: 10.1111/j.1365-2664.2011.02021.x

Mapping an urban ecosystem service: quantifying above-ground carbon storage at a city-wide scale

Zoe G. Davies[1,2*], Jill L. Edmondson[1], Andreas Heinemeyer[3], Jonathan R. Leake[1] and Kevin J. Gaston[1,†]

Leicester: C stocks in vegetation



Davies et al. J Appl Ecol, 2011

300k people

Above ground carbon

Scale: 0-290 tC/ ha

Mean = 32 tC/ ha

Total: 0.232 Mt C

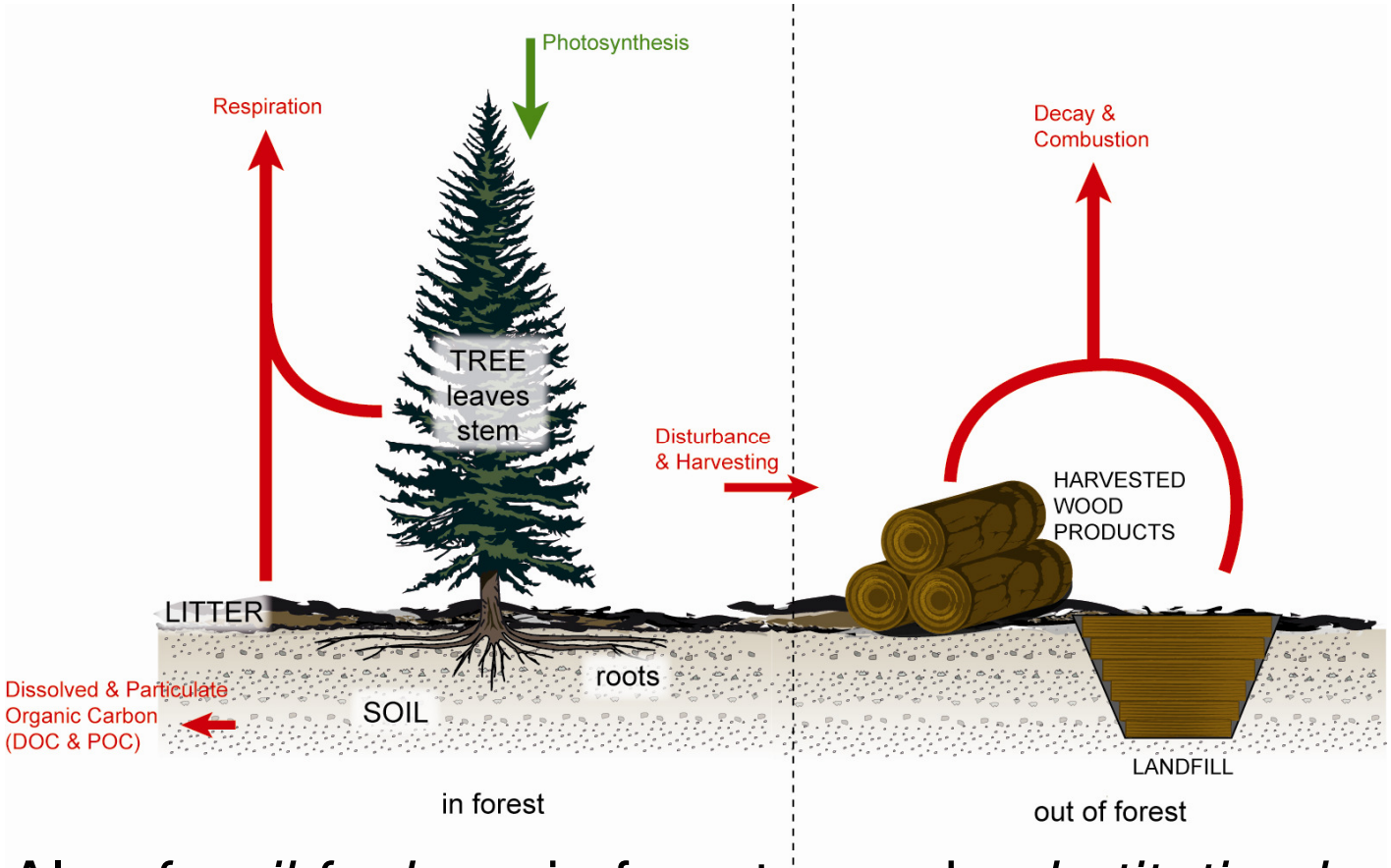
97% in trees

Average garden tree 60 kg C

Even if 100x for all urban areas, and +25% for below ground = 29 Mt C

(cf 595 Mt C in woodland trees)

Fluxes matter more than stocks



Also *fossil fuel use* in forestry, and *substitution benefits* of woodfuel and harvested wood products.

C fluxes in forestry

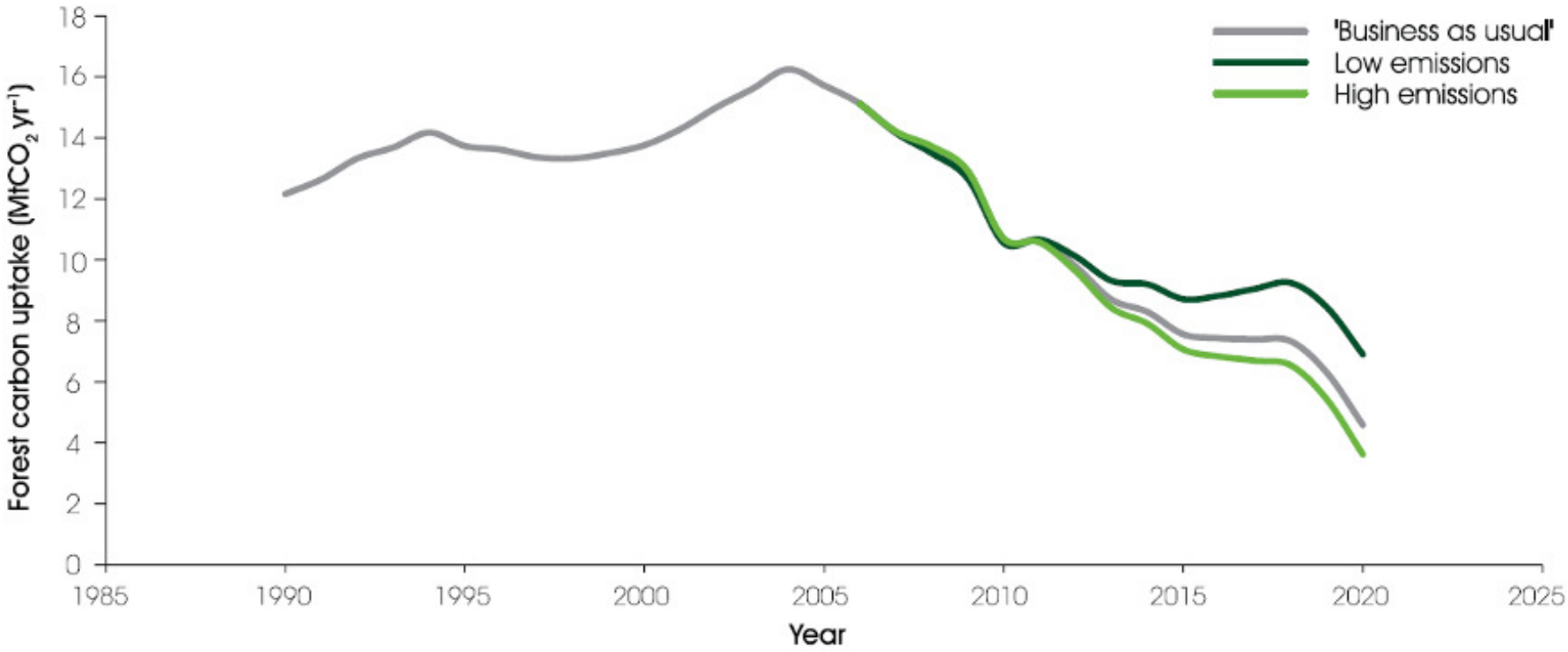
Approximate calculations

	$MtCO_2\ y^{-1}$
Total UK CO_2 flux *into* woody biomass	**+26**
Flux *out* of forest from UK wood production	**-6.5**
Approximate annual net uptake CO_2 by UK forests	**+19**

	$MtCO_2e\ y^{-1}$
GHG emissions from forest management activities	**0.26**
GHG emissions from timber haulage	**0.10**
Total fossil-fuel derived emissions in forestry	**0.36**

Total UK CO_2 emissions (2009) = 481 Mt $CO_2\ y^{-1}$
UK forests absorb approx 4% of current emissions
But will be much larger % if emissions reduction occur

Modelling future C sinks



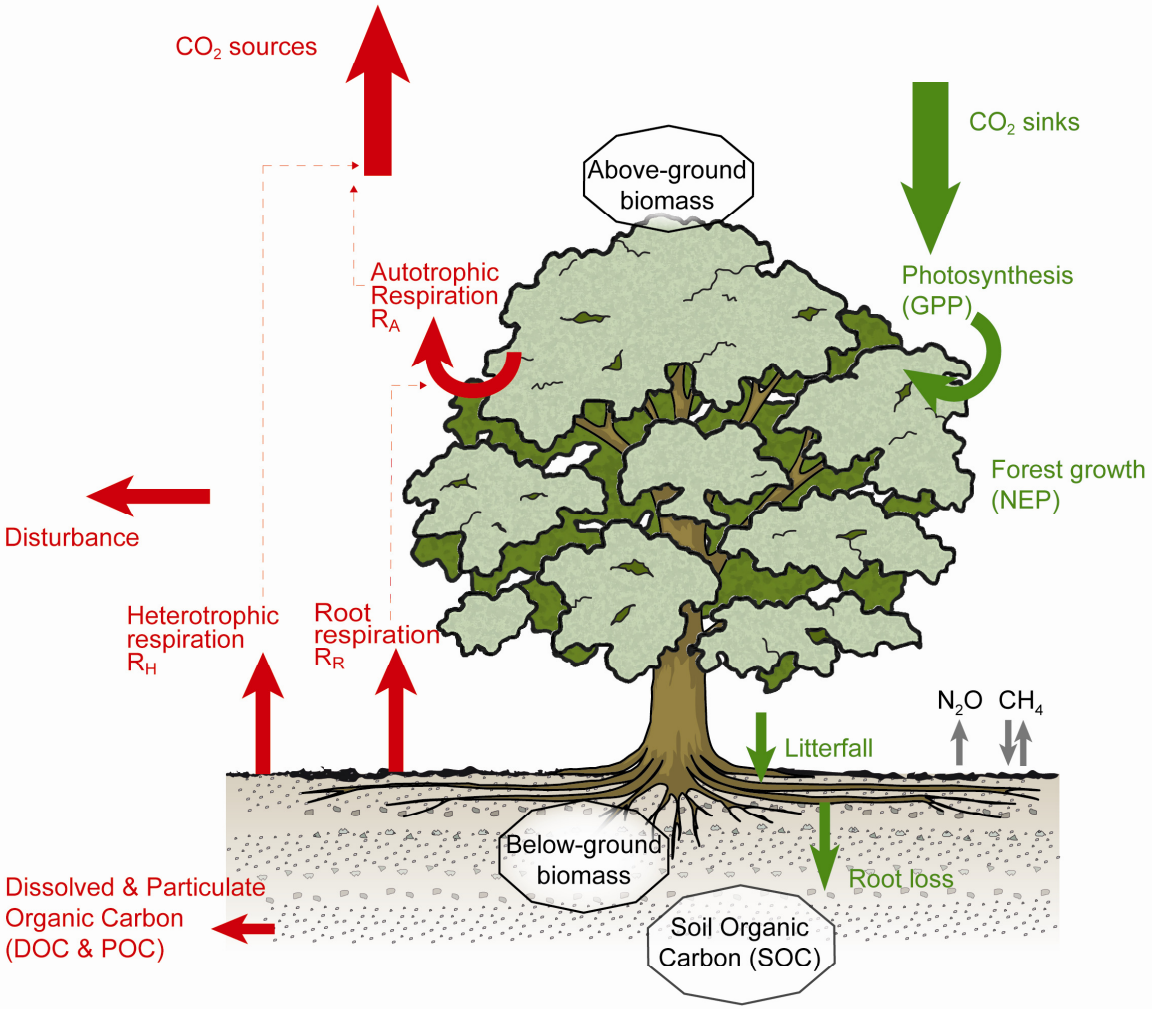
(based on CARBINE calculations, Robert Matthews, FR)

(From: *Combating Climate Change*, "Read Report", FC, 2009)

Modelling C fluxes in forestry

- Depends on afforestation, deforestation, harvesting and restocking rates
- Growth rates; species & age profile
- Fossil fuel use
- Need to include all GHGs, (CH_4 and N_2O)
- Soil C accumulation/loss
- 'Substitution' value calculation
- Policy and management influences
  - (e.g. re-managing, woodfuel, habitat recreation, deer, squirrel control)
- Direct and indirect climate effects
  - Pests and pathogens

Woodland C balance & GHG fluxes



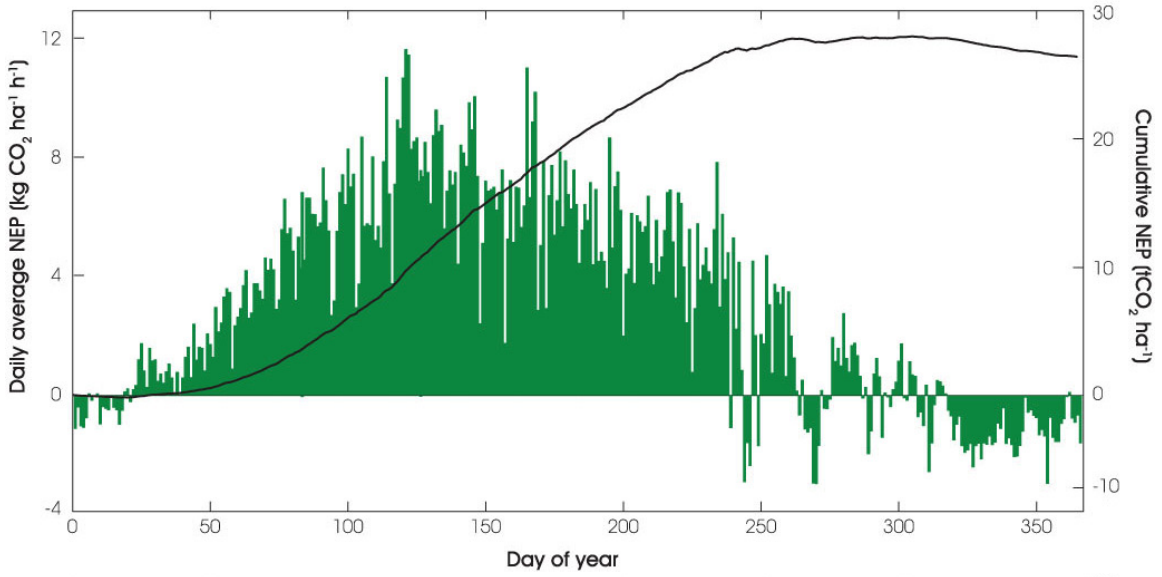
Carbon stocks

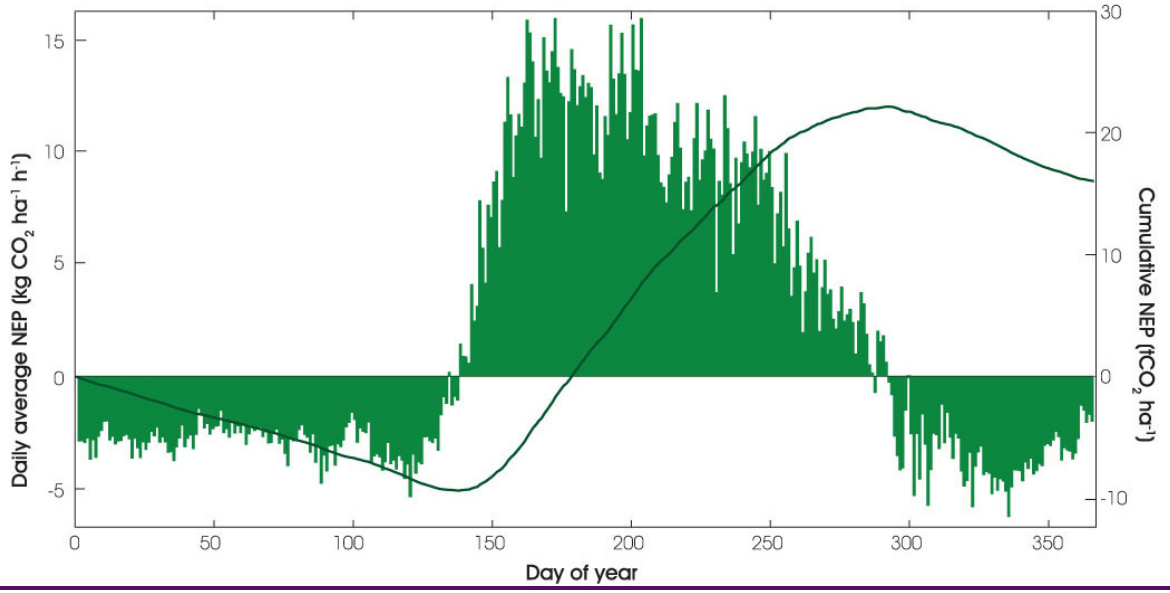
- Above-ground biomass
  - stemwood
  - branchwood
  - bark
  - foliage
  - seeds
- Below-ground biomass
  - coarse roots
  - fine roots
  - stumps
- Litter
- Coarse woody debris
- Soil organic carbon

17–21 year old Sitka spruce evergreen. Annual removal of 26 t CO_2 per hectare per year.

Griffin
&
Alice Holt Forests

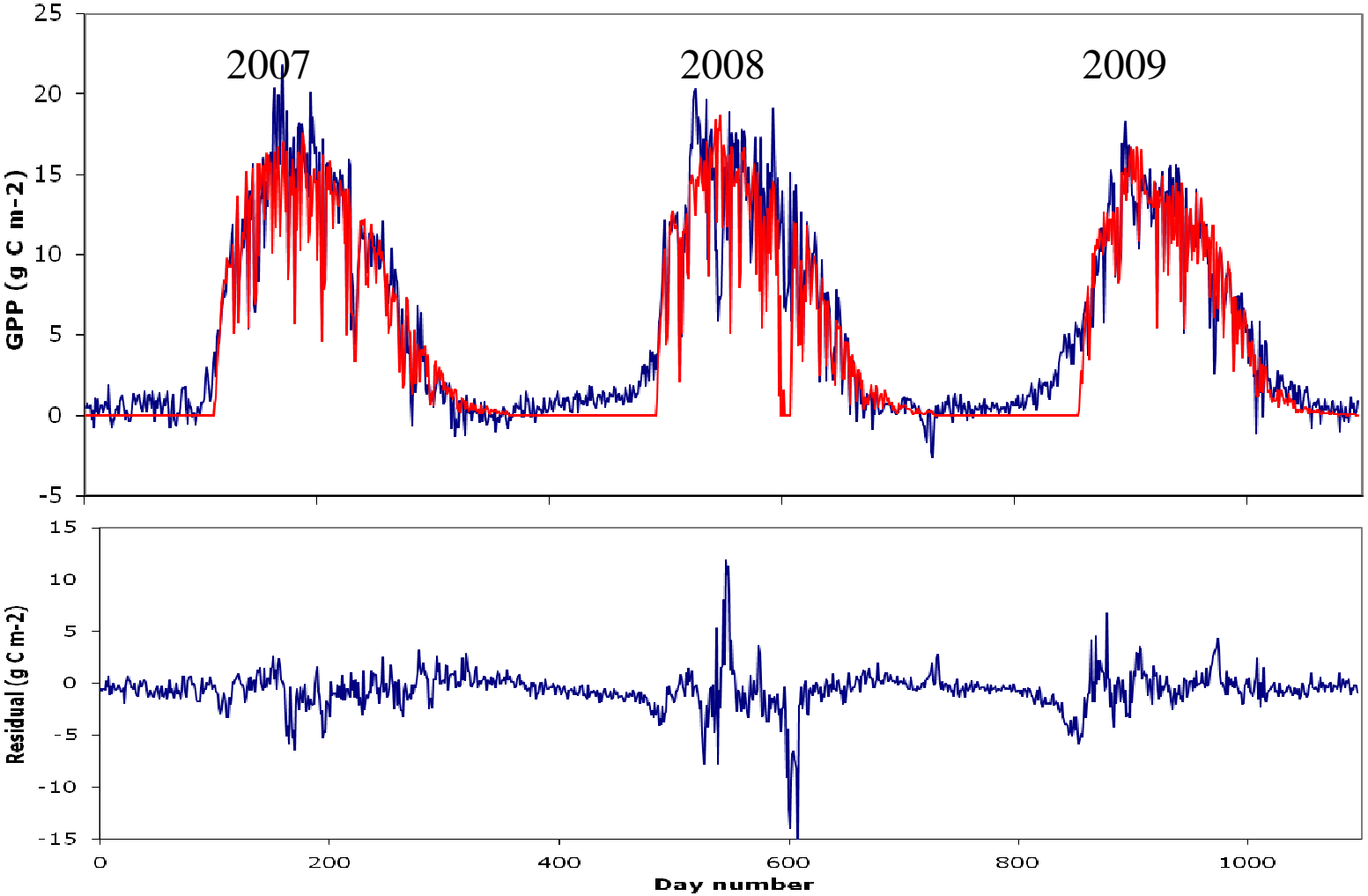
72–80 year old oak & mixed deciduous. Annual removal of 18 t CO_2 per hectare per year.





Stand scale

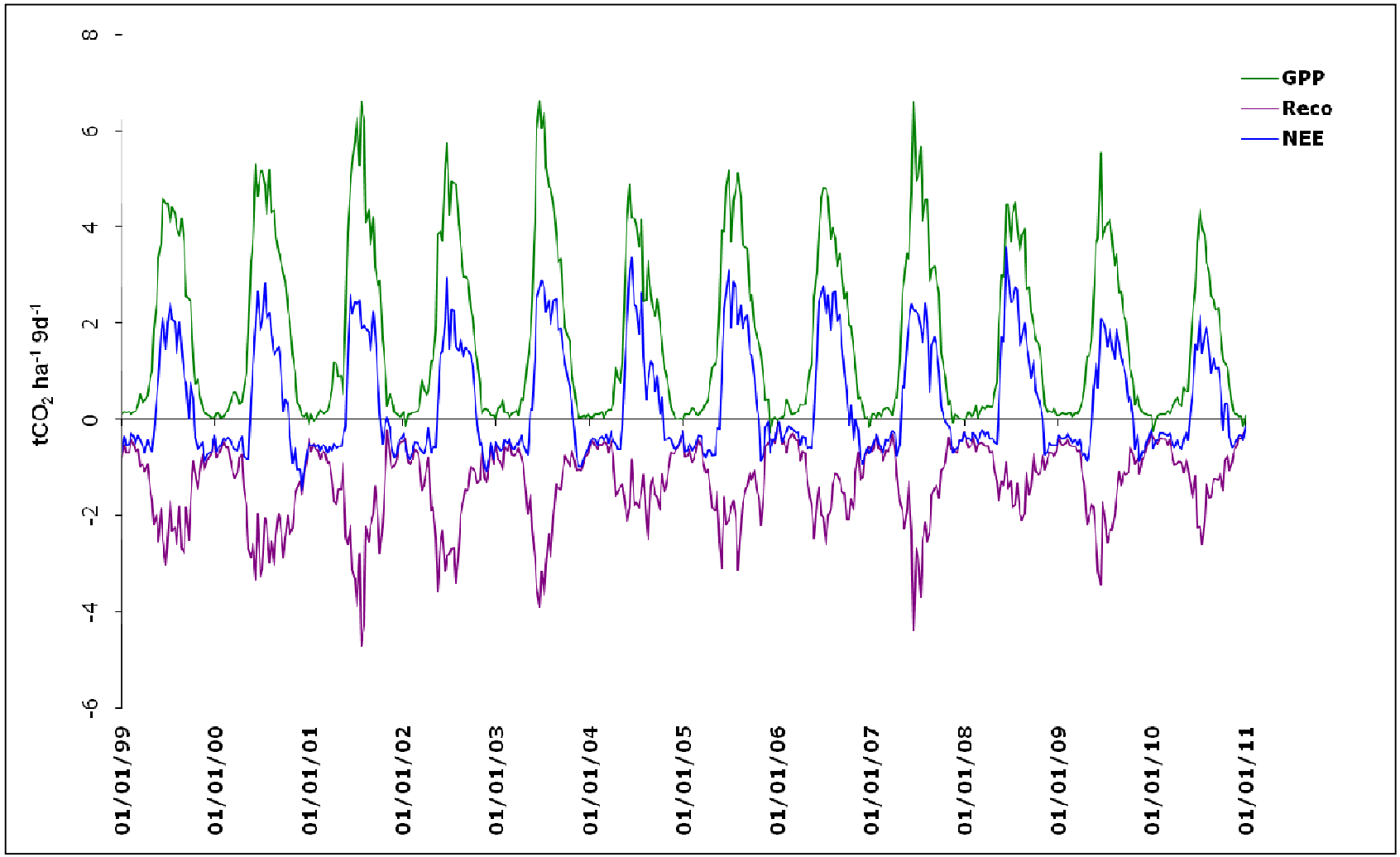
Modelling woodland CO_2 fluxes



SPA Data Assimilation model: Mat Williams (Univ. Edinburgh), Eric Casella, FR

Stand scale

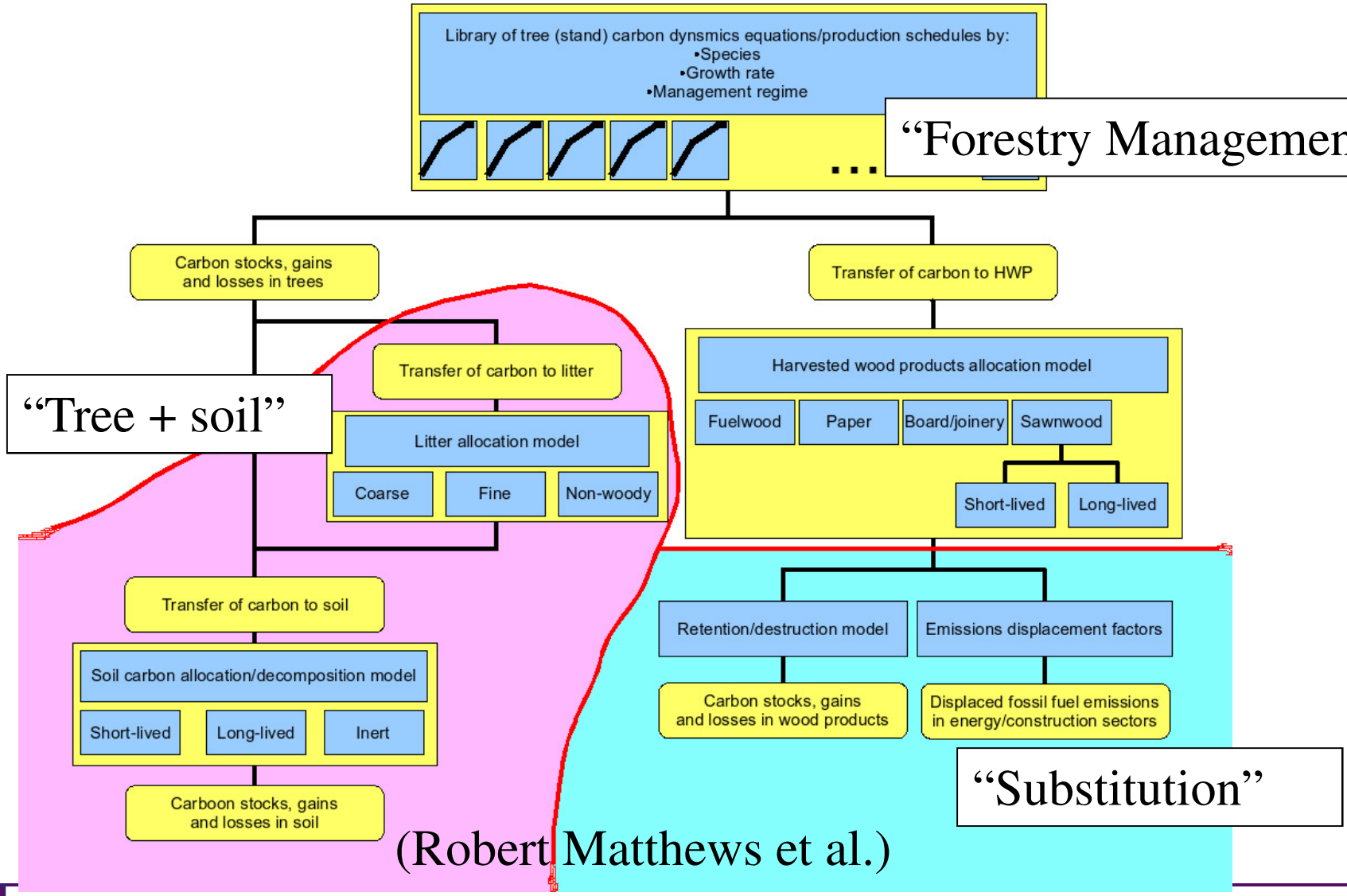
Straits Inclosure CO_2 flux site, Alice Holt



(Matt Wilkinson, Mark Broadmeadow, Ed Eaton et al. , FR, Biogeosciences Discuss)

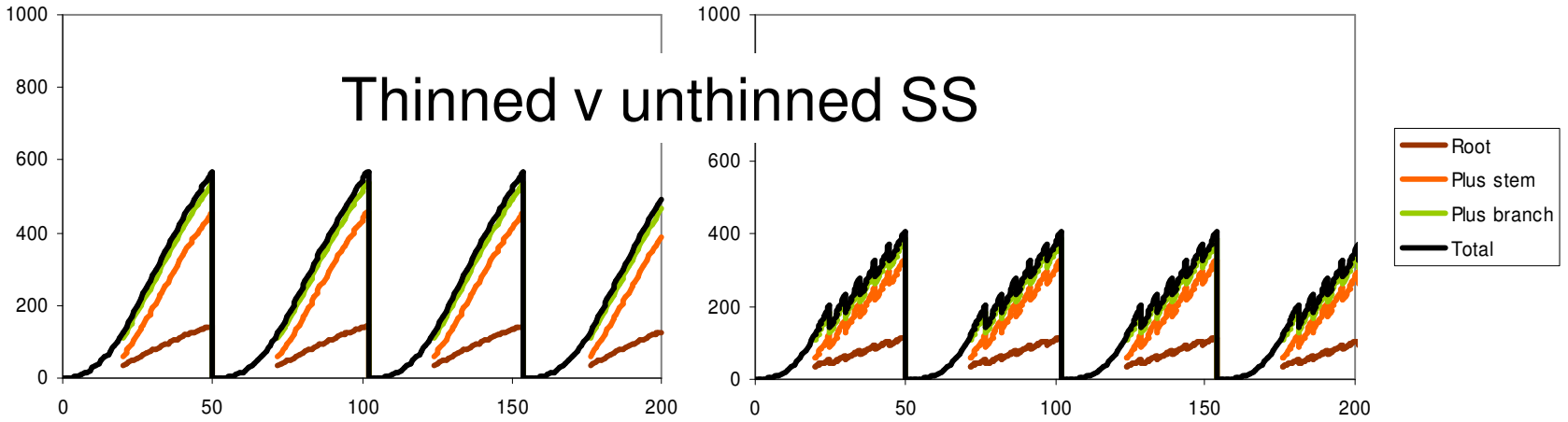
Country scale

Forest C accounting models: CSORT, CARBINE

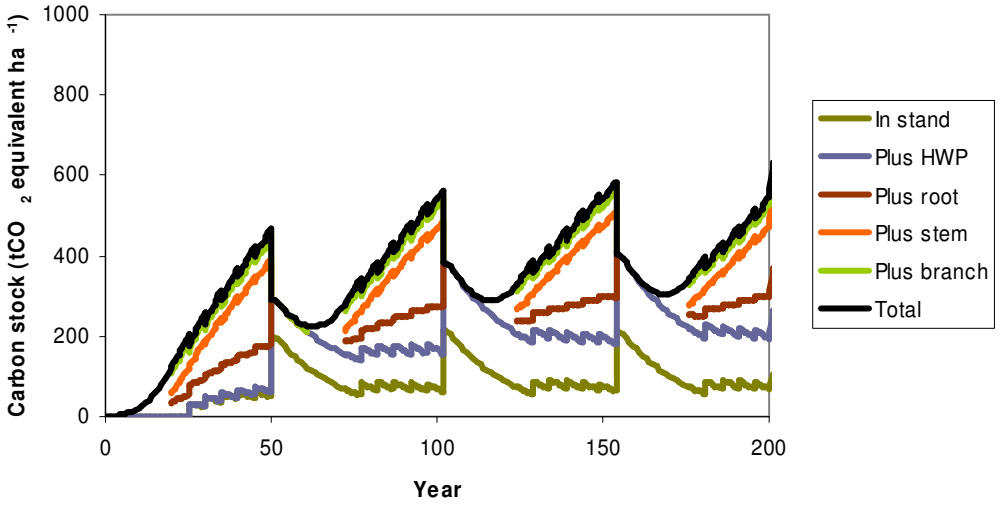


(Robert Matthews et al.)

Modelled stand C uptake – management & substitution



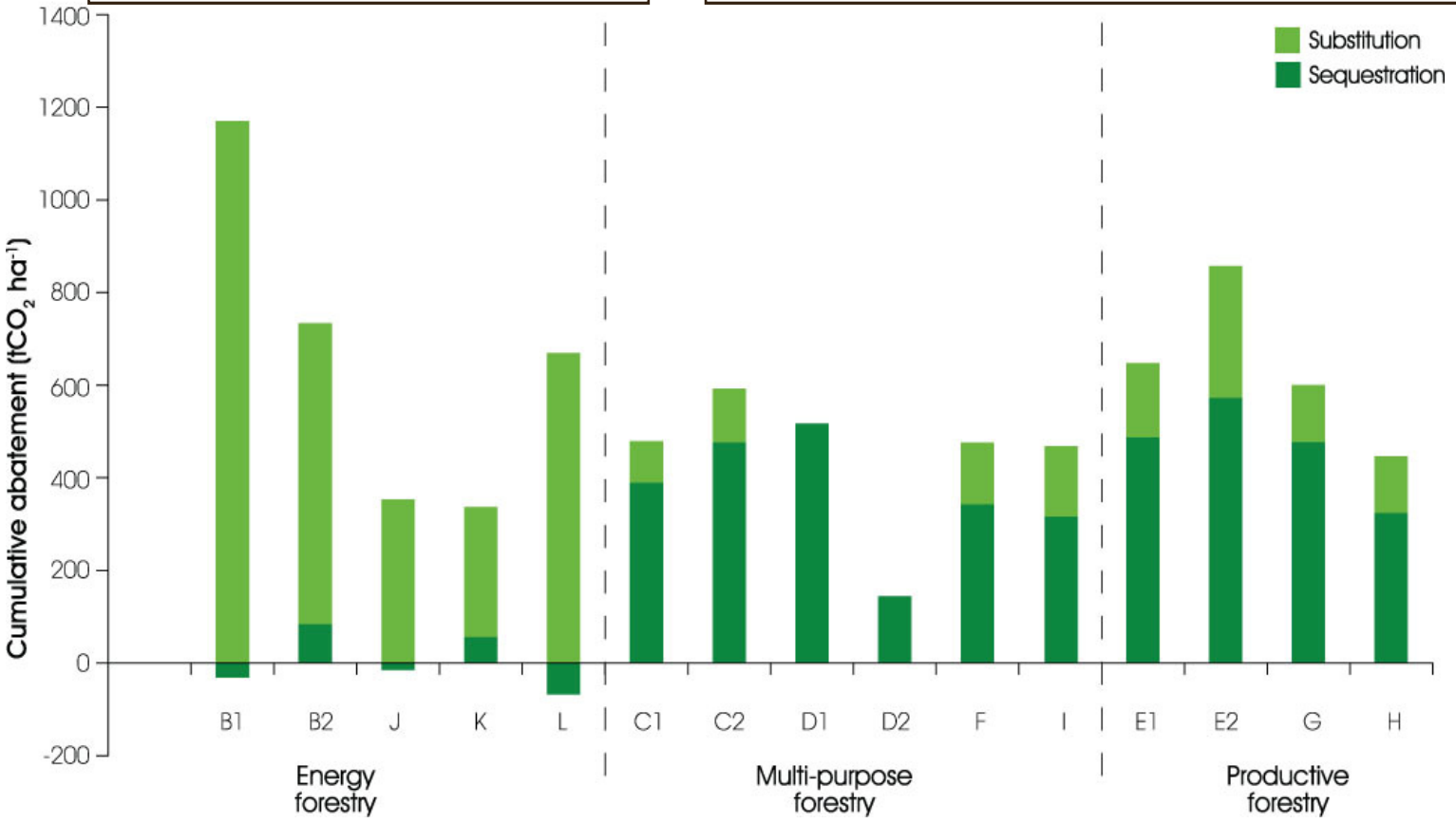
Different contributions to emissions abatement



(Robert Matthews et al.)

Biomass: replacing fossil fuels

Different objectives and strategies: all positive



Matthews & Broadmeadow, Ch 8, Read et al. *Combating Climate Change*

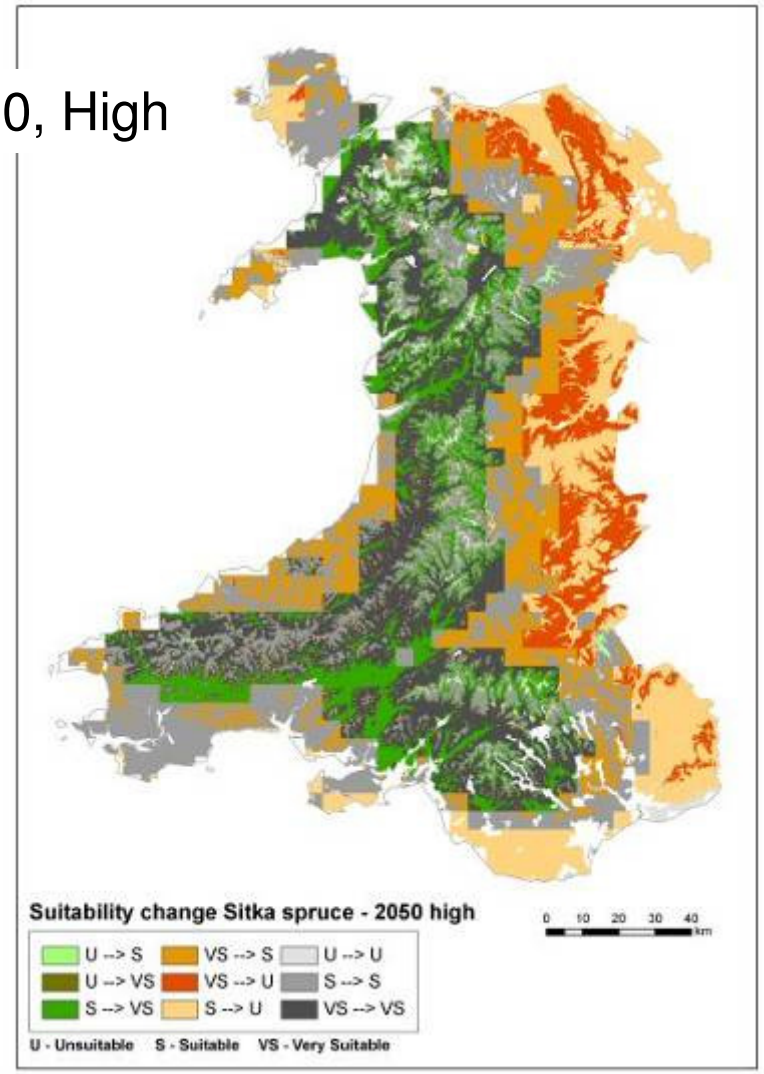
Forest Management

- What species, provenance/genotype ?
  - "right tree, right place"
- What silvicultural system ?
  - Ground prep, spacing, thinning, clearfell or LISS ?
- Rotation length?
  - E.g. SRF
- Products ?
  - Woodfuel: chips, brash, stumps ?
  - Timber: round wood, sawlogs, timber ?
  - Recreation ?
  - Catchment protection ?
  - Biodiversity ?
- Product chain & LCA ? (Leave, burn or build ?)

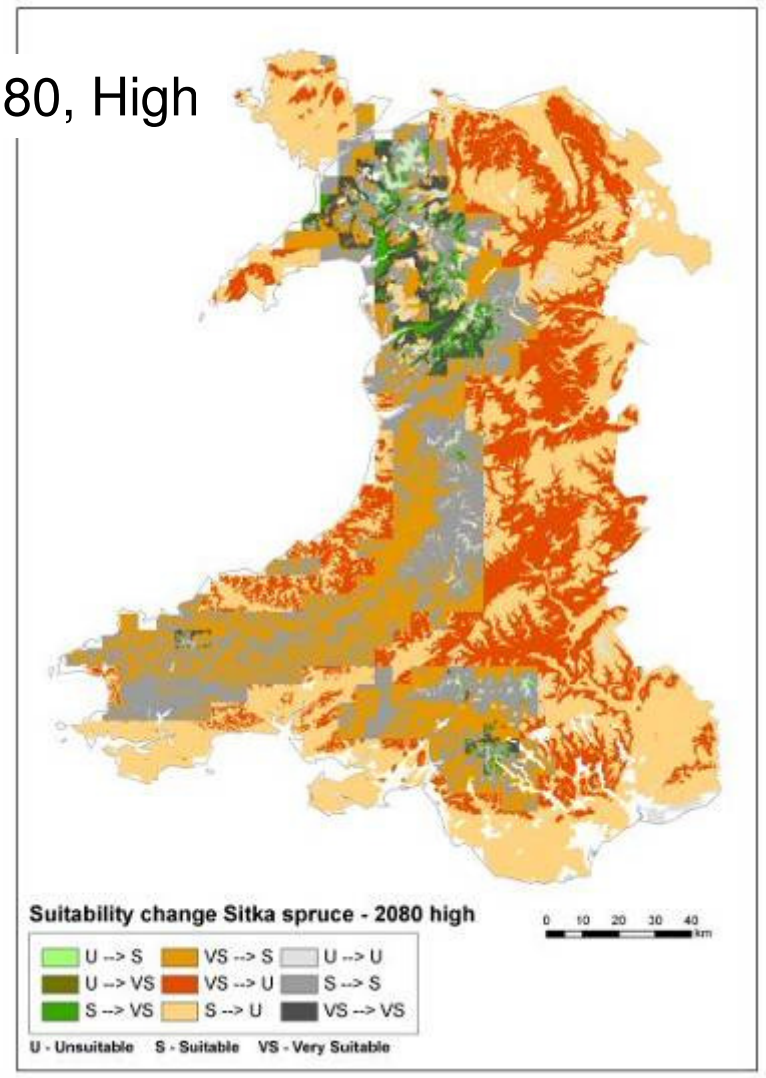
ESC projections

Sitka spruce

2050, High



2080, High



Brash removal

Stump harvesting

Short Rotation Forestry

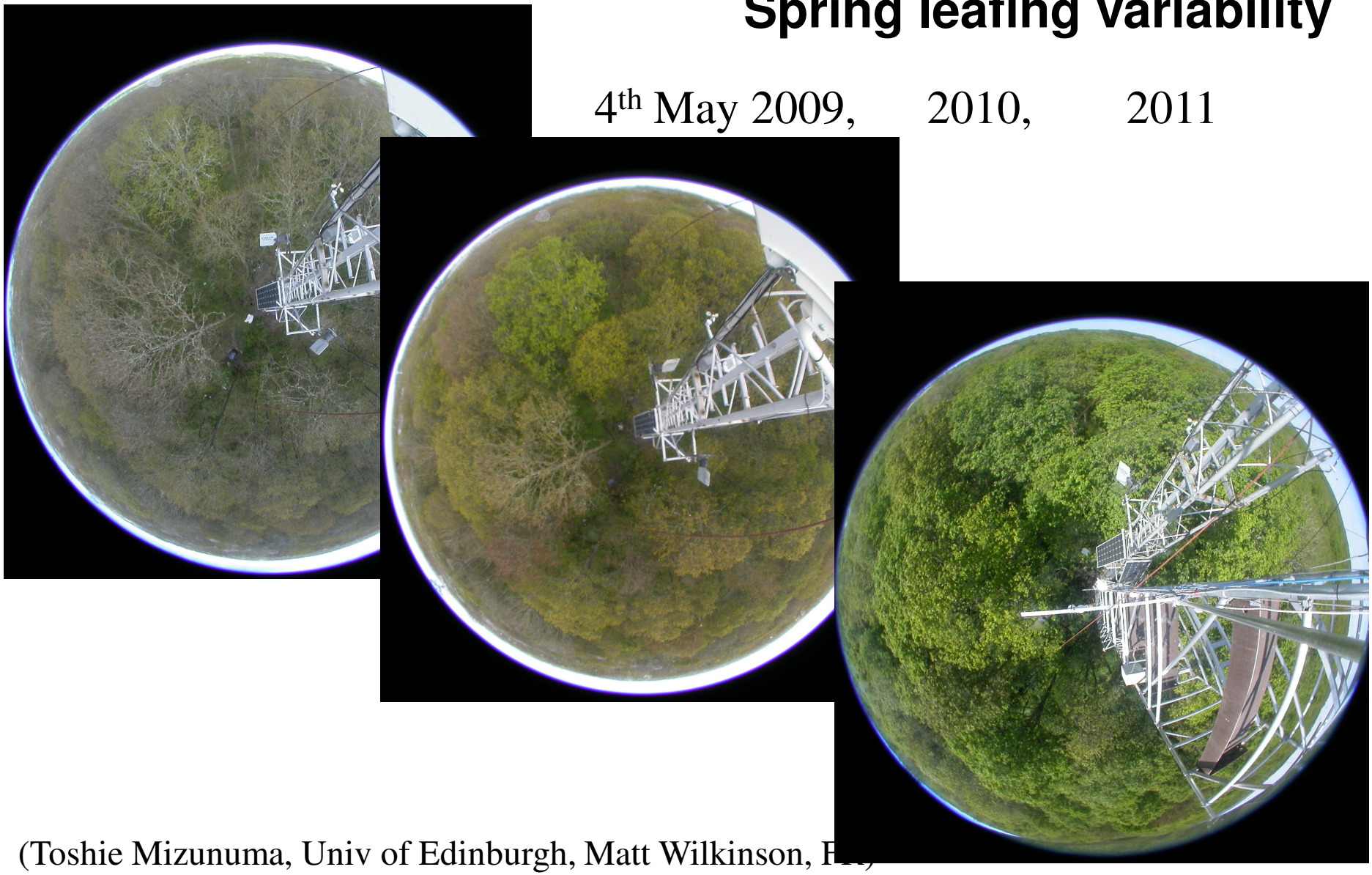
New woodland creation?

Other uncertainties

- Weather variation and extremes
- Pests & pathogens
- Soil C changes
- Other biophysical effects of changing forest area
- New understanding & new questions
  - Methane from trees (soil derived, stem derived)
  - Albedo change, biophysical effects of LUC
  - Unknown unknowns…

Spring leafing variability

4th May 2009, 2010, 2011



(Toshie Mizunuma, Univ of Edinburgh, Matt Wilkinson, F

Forest Research
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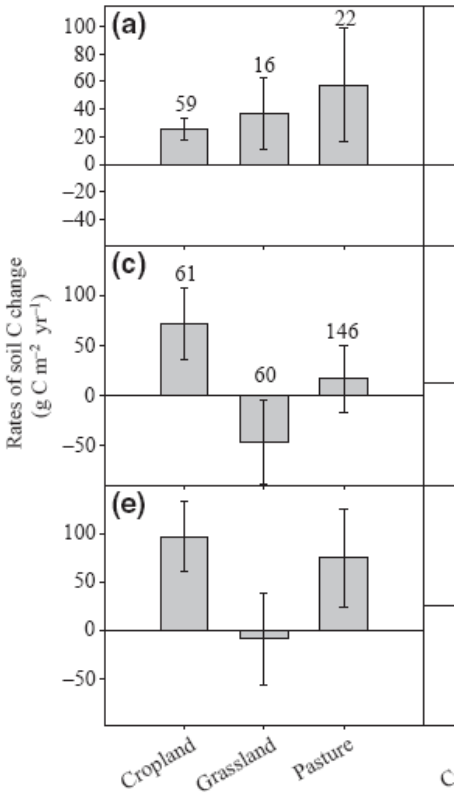
Tree pests and diseases

Afforestation and soil C change

- Recent Meta-analyses of afforestation data

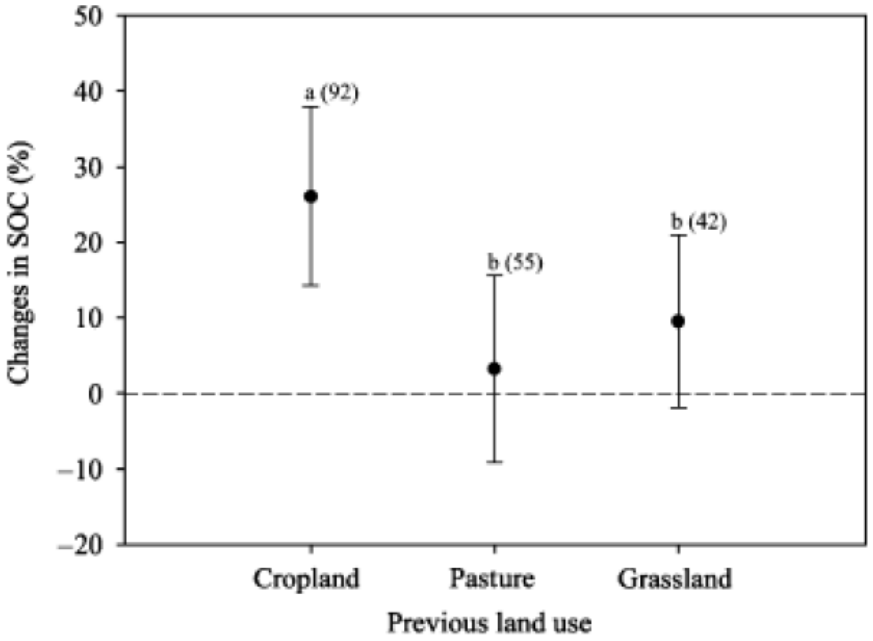
• soil C stock increased on cropland and pasture, and in tropical, subtropical and boreal zones.
• soil C stock increased with hardwoods, but did not change with softwoods.
•C sequestration through afforestation depends on prior land use, climate and the tree species planted.

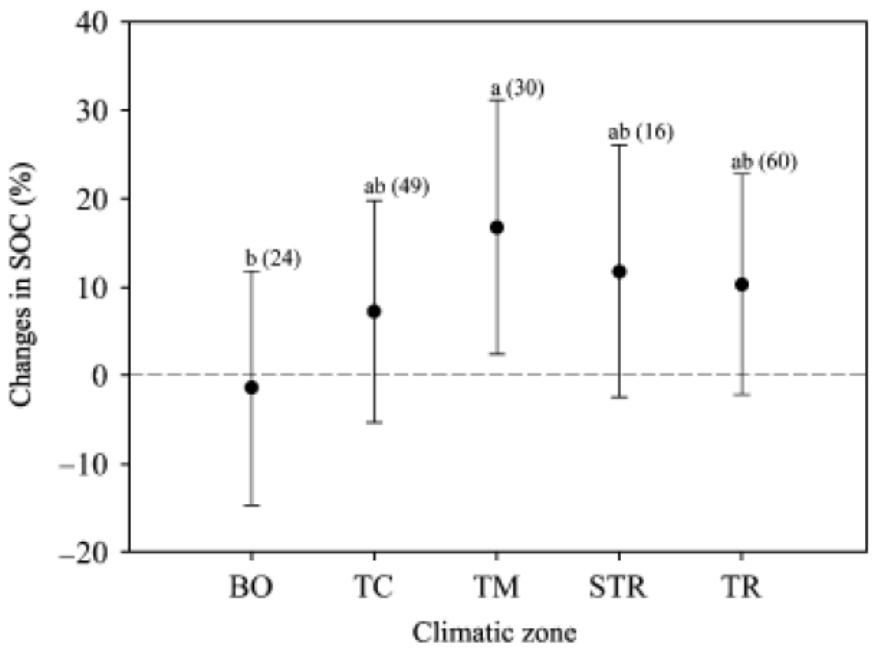


Li, Niu & Luo, New Phytol 195, 2012

SOC & LUC

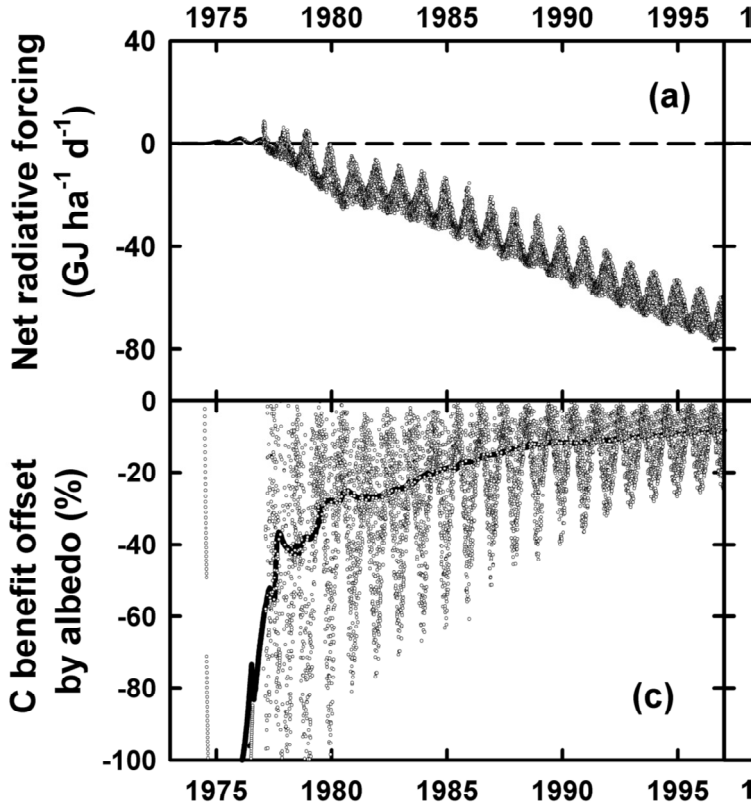
- the positive impact of afforestation on SOC stocks is more pronounced in cropland soils than in pastures or natural grasslands
- broadleaf have a greater capacity to accumulate SOC than conifers species
- clay-rich soils have a greater capacity to accumulate SOC than soils with a lower clay content





Laganiere et al. GCB 16, 2010.

Albedo effect of LUC

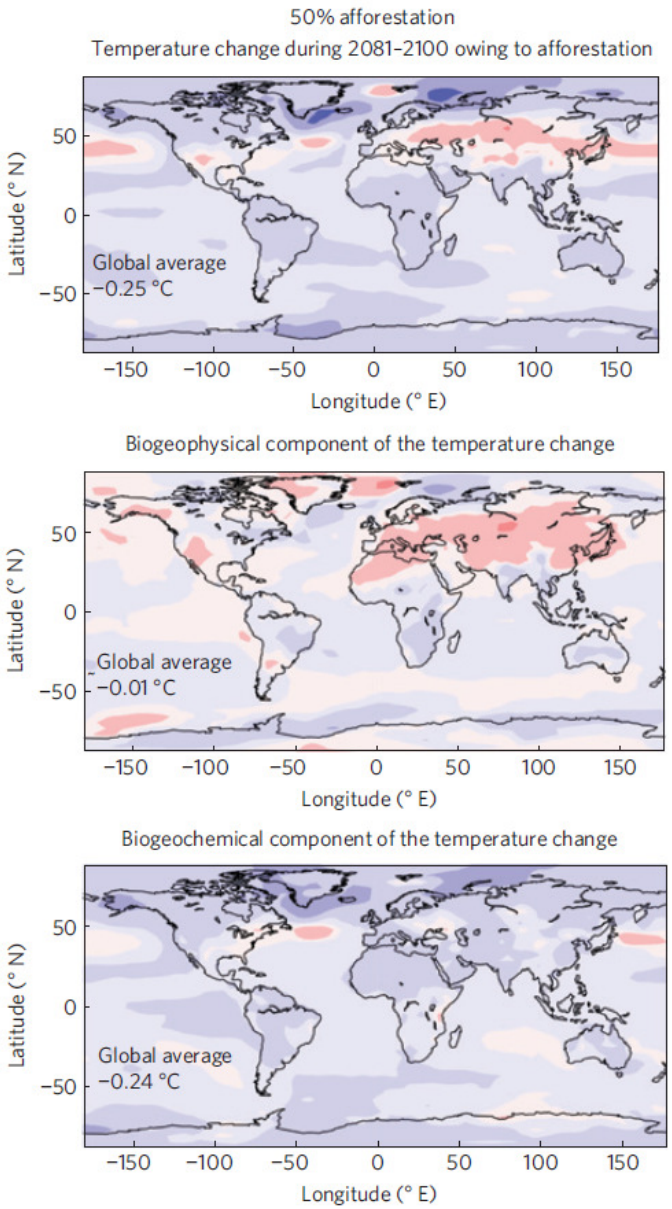


- Albedo change pasture 20% to *P. radiata* 13%
- Averaged over the whole length of the rotation, the changes in albedo negated the benefits from increased carbon storage by 17% (–24) %.
- Effect depends on climate, growth rate and albedo change

No soil C change included
Applicability for British conditions ?

Kirschbaum et al. Biogeosciences, 8, 2011

Biophysical effects of afforestation



Modelled effect of 50% afforestation of cropland

warming reductions per unit afforested area are around 3X higher in the tropics than in the boreal and northern temperate regions,.

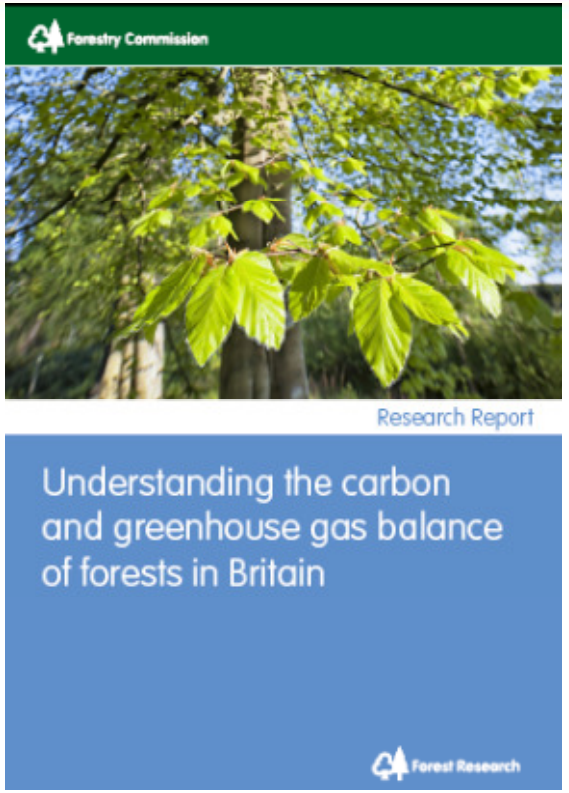
Arora & Montenegro 2011, Nature Geoscience

Summary

- Building good quantitative understanding of C stocks and GHG processes in forests
- Good evidence that forestry does contribute to reduce country scale GHG emissions,
- Possible increased contribution in future – with afforestation and 're-management'
  - New questions and challenges to quantify
- Major uncertainties in contribution
  - abiotic risk: wind, fire, climate change
  - biotic risk: pest & pathogen

Thank you !

james.morison@forestry.gsi.gov.uk



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