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Recent progress on forest monitoring in the UK and potential applications to carbon reporting

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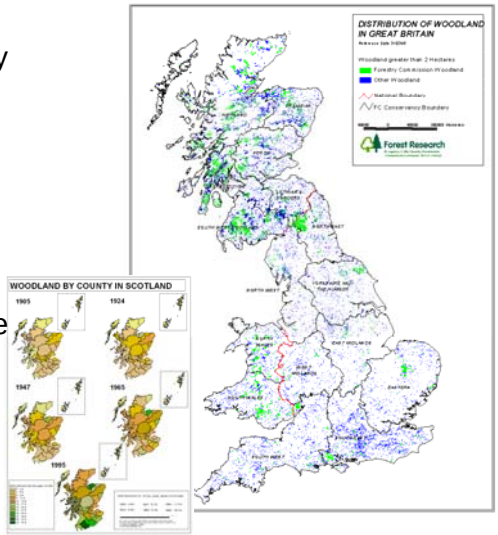
Forest areas in Great Britain

- Forest areas in UK are relatively 'small' (~2.8 Mha), 10% of land and fragmented
- Area has doubled in less than 100 years
- Composition is diverse (10 *major*, many minor tree species)
- Active forest management is the norm and is evolving radically
- Administration in GB and NI separate - England, Wales & Scotland diverging.



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Forest carbon accounting in the UK: Current status

- The UK has a sophisticated and well-respected methodology for estimating, reporting and projecting forest carbon stocks and stock changes.
- This involves the extensive application of purpose-designed forest carbon accounting models such as CFLOW and CARBINE.

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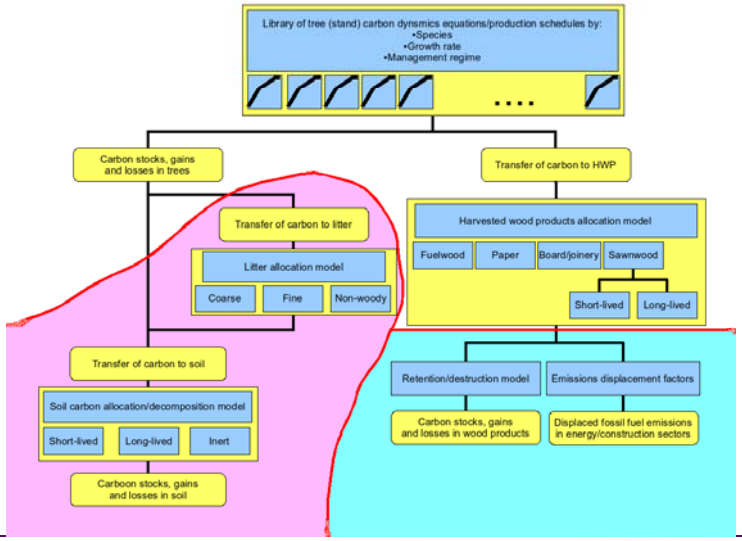
CARBINE/CFLOW modelling approach



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CFLOW/CARBINE methodology & use of yield tables

- Species
- Growth rate
- Management regime

→ Outputs from forest yield table (standing stem volume over time)

CFLOW/CARBINE

Carbon content factors
- Foliage
- Branches
- Roots

‘Expansion factors’
- Foliage
- Branches
- Roots

→ Tree carbon stocks over time

→ Other forest sector carbon pools and processes (deadwood, litter, soil, harvested wood products)

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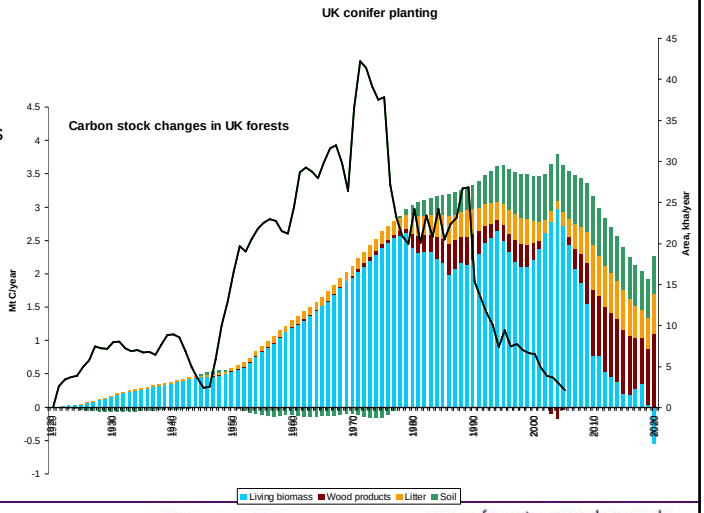
Model-based methods: CARBINE and CFLOW

- 2.8 million ha in the UK
- Significant new plantings since 1950 (mostly conifers)
- Plantation species, productivity and management (state/private) vary throughout the country.



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Exploring sensitivity of carbon calculations

- Simple assumptions in current model
  - All conifers are Sitka spruce (Yield class 12 or 14)
  - All broadleaves are beech (yield class 6)
  - Forest planted before 1920 is in carbon balance
- Questions:
  - How do the species planted and their productivity vary over space and time?
  - Are there differences between public and private forest management?
  - How do we model older forests?
  - ***What effect does this all have on forest carbon stocks and fluxes?***

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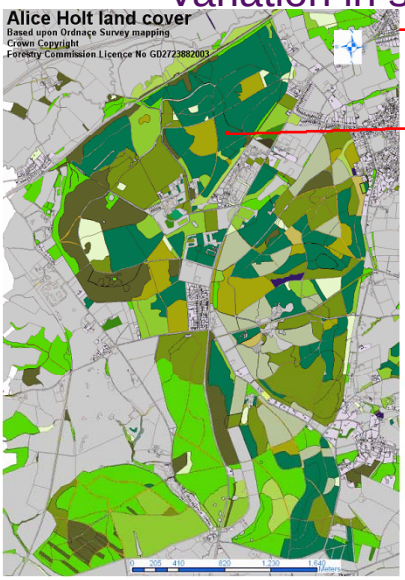
Variation in space and time

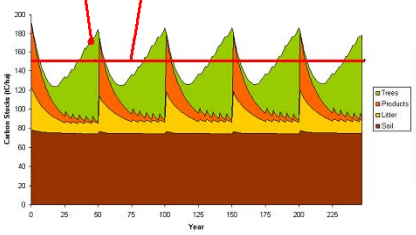


Define area of land in terms of current/intended forest cover

Characterisation of homogenous units (stands) forming forest area - for example:

Characteristic	Value
Species composition	Sitka spruce
Age	42
Yield class	12
Management regime	'Standard thinning' Clearfell rotation 50 years

Assignment of standard carbon model result to stand based on characteristics and 'reading off' of carbon stock, either for specific age or long-term average



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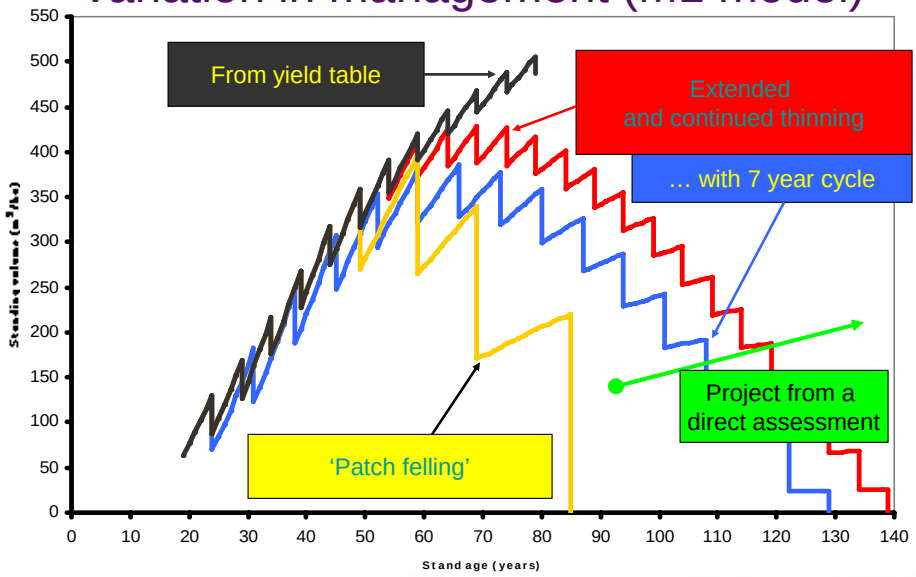
Variation in management (M1 model)



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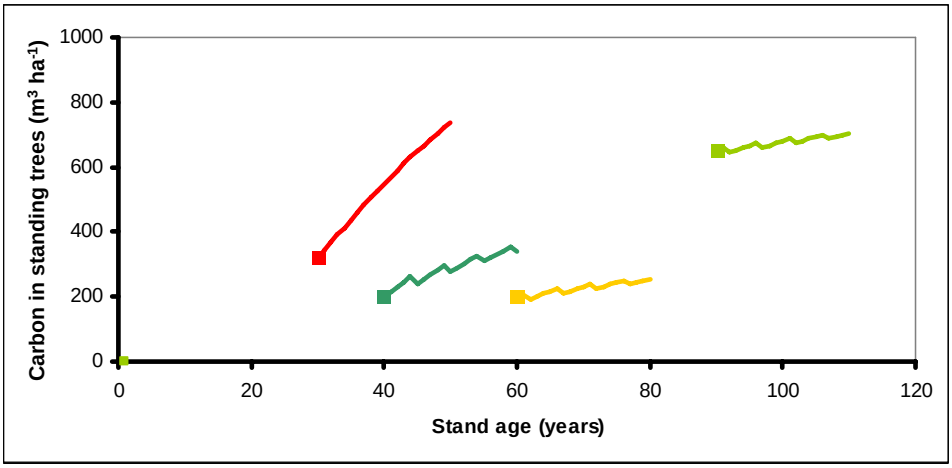
Linking carbon stock estimates and projections directly to inventory data



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Forest carbon accounting in the UK: Requirement for data in support of models

- We understand the critical importance of ‘hard data’ to underpin the model-based methodology
- There is no substitute for a programme of direct assessment of forests
- The details of the actual assessment methodology are open to discussion, depending on specific objectives and goals
- Can we build on existing knowledge and data?

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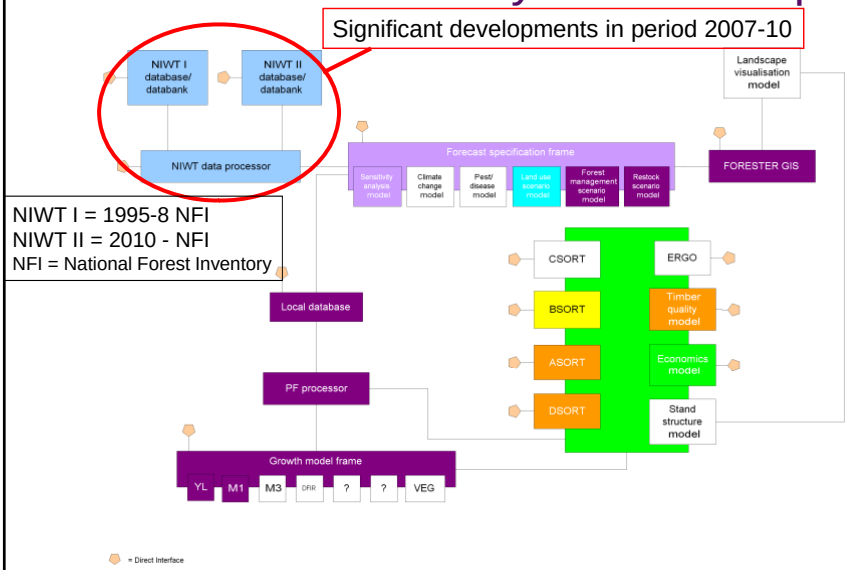
Incremental forecast system development



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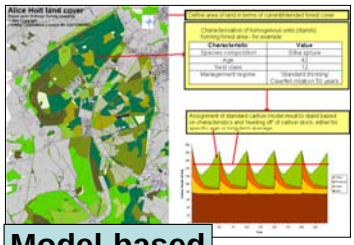
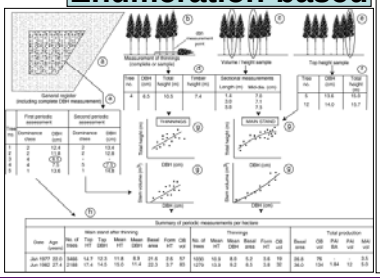
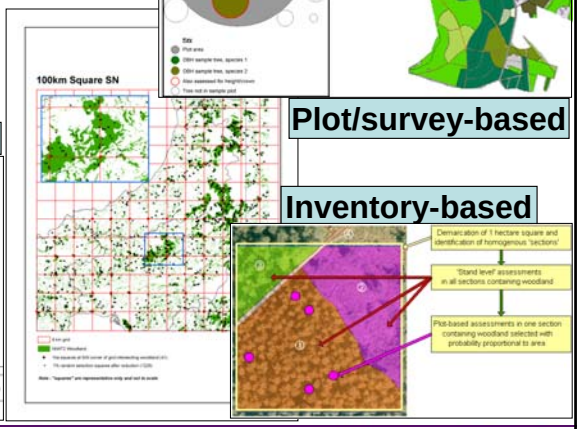
Forest carbon monitoring framework



Model-based

Enumeration-based





Plot/survey-based

Inventory-based

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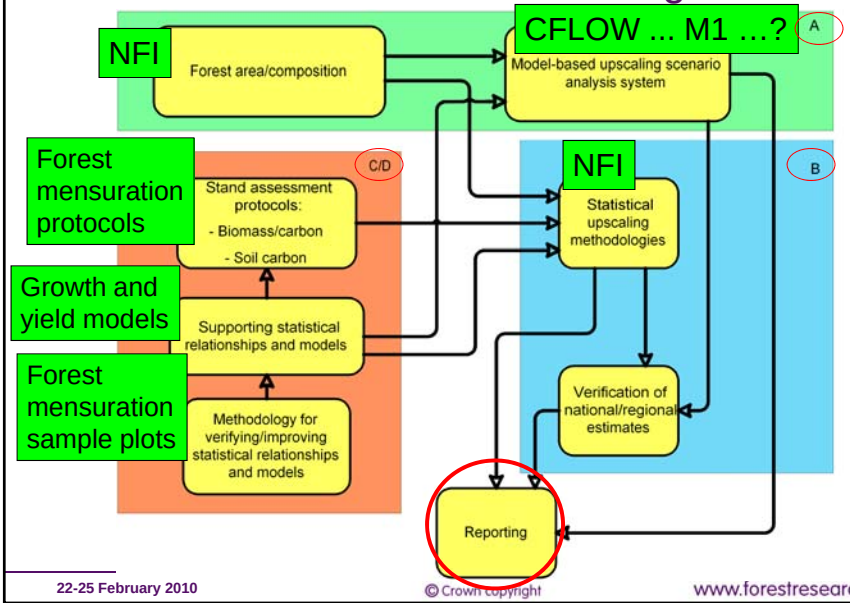
Possible forest carbon monitoring framework



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‘A/B’ - Forest carbon accounting in the UK: Recent development of NFI

- The Forestry Commission is developing an approached aimed at linking direct forest assessments as part of a National Forest Inventory to the Forest carbon inventory (and projection) methodology
- Good progress has been made but is still early days.

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Forestry Commission NFI

One of the primary objectives of the NFI
is to produce a new map of woodland in Great Britain

- Using Orthorectified Aerial Imagery
- OS Mastermap
- External woodland boundaries are captured and the areas are divided into Interpreted Forest Types (IFTs)
- Use of OS Mastermap should ensure a better fit with other rural land datasets

The map is used to determine a programme
of field assessments based on a stratified sample

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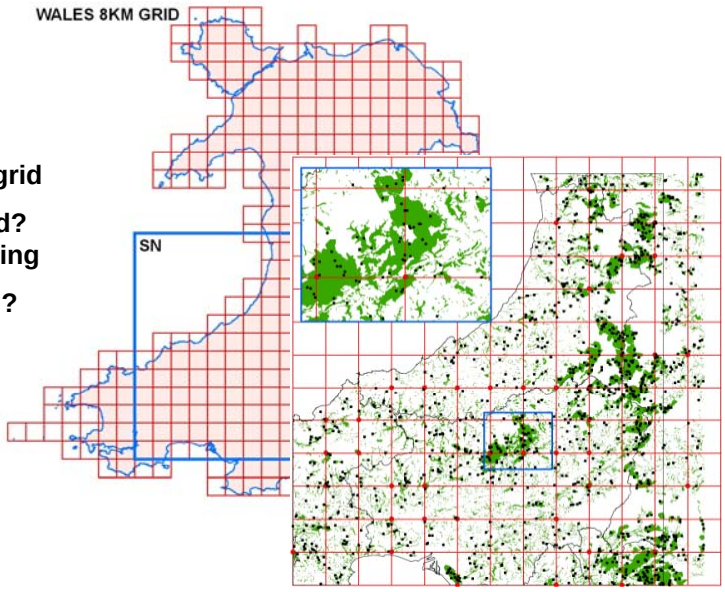
Field Sampling

- 8 km x 8 km grid
- Plus stratified? random sampling
- Plus 'top ups'?



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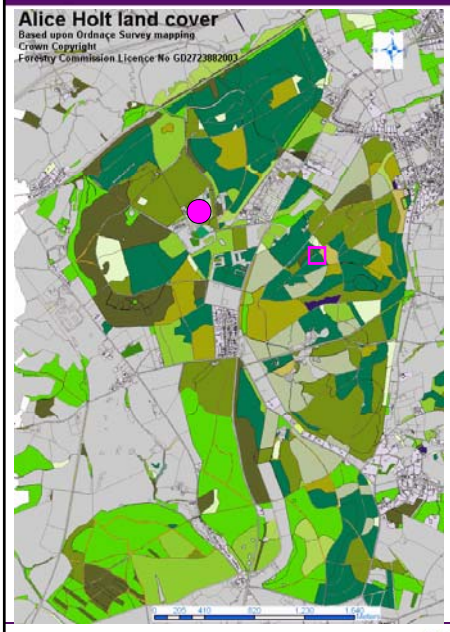

Trial sample square at Alice Holt

Coniferous trees
Coniferous trees & scrub
Rough grassland
Broadleaf trees
Broadleaf trees & scrub
Grassland & scrub

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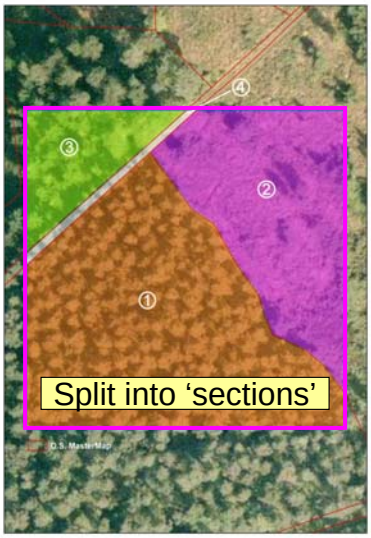
‘Mensuration’ assessments in sample squares



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‘Hard’ mensuration assessments: previous investigations and trials

- No assessments (pre 2005)
- Circular plots (2005)
- Transects (2005)
- Nearest neighbour methods (2006)
- Mixed methods (2006)
- No progress (2007)
- Circular plots (2008).

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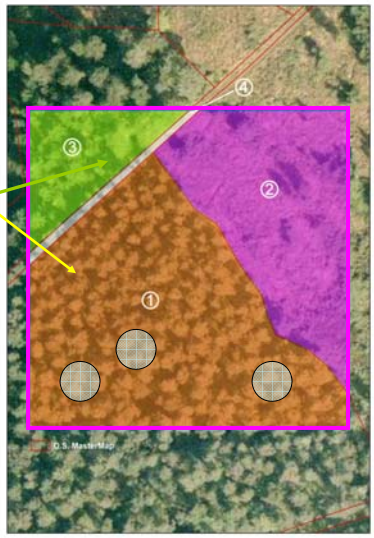
Mensuration assessments in sample plots

Plot-based assessments in each section

- Sampling scheme:
  - 2-3 plots per section at random locations.
  - Plot area 0.01 hectare.
  - Plot shape circular.
  - Exception: where section is small or low number of trees make 100% assessment (i.e. census).
- Plot assessments:
  - Count of trees
  - DBH assessment down to 3-4 cm.
  - Sample height and crown assessments by storey/species.



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NFI: Long term monitoring of UK/GB forests

Data collection:

- 5 year cycle
- 15,000 - 20,000 plots
- Permanent %?

Reporting:

- PF2011
- Annual (map) with 5 yearly data report?

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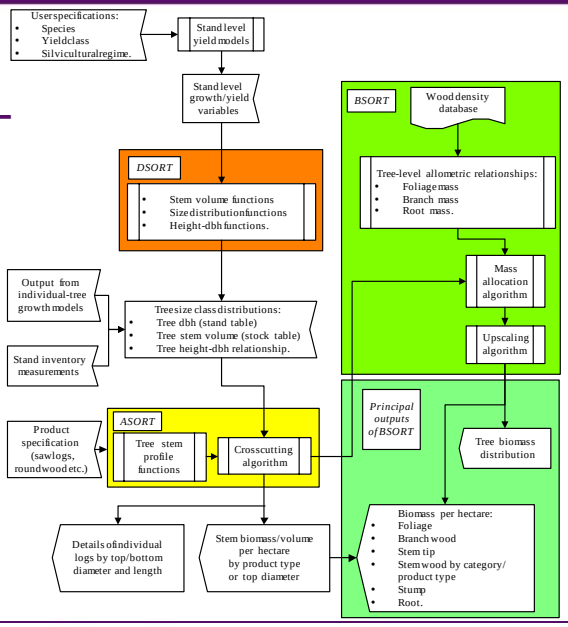
‘C/D’ (example) - BSORT biomass model



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Forest carbon accounting in the UK: A role for remote sensing?

- Although many remote sensing technologies are now at an advanced stage of development …
- Only certain specific examples have reached the point where practical application as part of the UK NFI has been considered
- Where remote sensing techniques have been demonstrated to work in an operational context, these are being applied within the NFI methodology
- Main example is use of aerial photography in construction of national forest area map
- Other techniques are being considered for certain aspects of the NFI, e.g. satellite imagery (change detection), LIDAR (gross forest composition).

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Creation of GB woodland map

All woodland (both urban and rural, regardless of ownership) which is 0.5 ha or greater in size.

Canopy – the land must have > 20% tree canopy cover, or potential to achieve >20%.

Width – minimum width of woodland is 20m

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Forest carbon accounting in the UK: There are not always clear and easy solutions

- Some aspects of forest carbon monitoring and reporting remain technically difficult and potentially costly
- One example is soil carbon
- The issues surrounding carbon in harvested wood products also remain.

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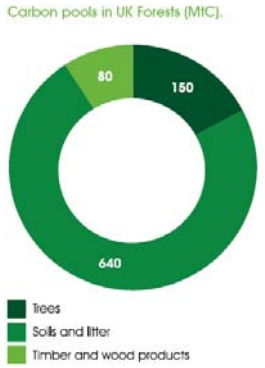
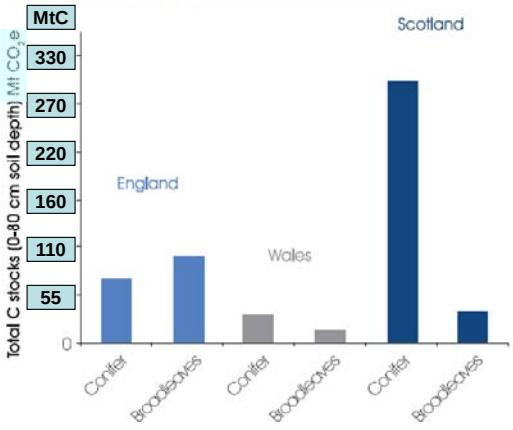
The challenge of soil carbon

- In UK are largest forest carbon pool
- Quite large uncertainty in estimates
- Costly to measure
- Detecting change is even more difficult and costly.



Total carbon stocks (in CO_2 equivalents) in forest soils in England, Wales and Scotland for the two main forest types, estimated by up-scaling UK BioSoil results.



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Conclusions

- In the UK there are tried and tested approaches that can be applied to monitoring and projecting forest carbon
- Some aspects are more difficult than others
- Remote sensing technologies offer opportunities for development and modernisation of methods but …
- At the moment, moving rapidly towards an operational methodology which is very reliant on remote sensing would incur very high risks
- Experience suggests an incremental approach to such developments.

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Implications

- Continue strategic development of FC NFI and forecast systems
- Recognise that these are medium-term developments
- Meanwhile, make continuous, consistent improvements to existing modelling approaches
- Prioritise areas where there are potentially significant uncertainties, lack of supporting data and potential for tractable solutions
- This will ensure that reported estimates have the strongest possible ‘audit trail’ and precision, while minimising risk associated with longer-term development of more complex methods and tools
- Integrate remote sensing technologies as they become proven operationally.

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