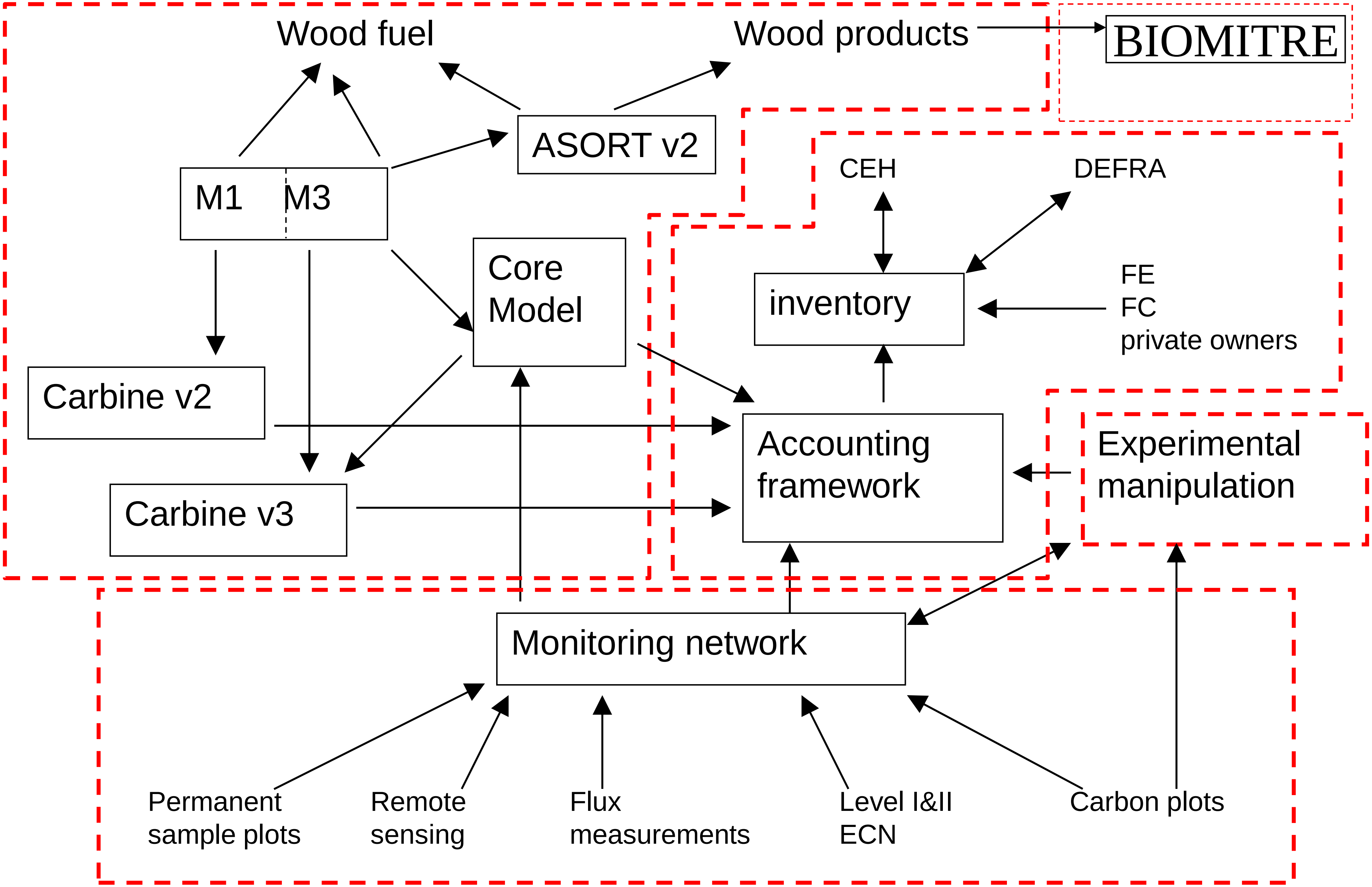
Tools for evaluating project-level and national-level measures for GHG mitigation

based on carbon sinks and bioenergy

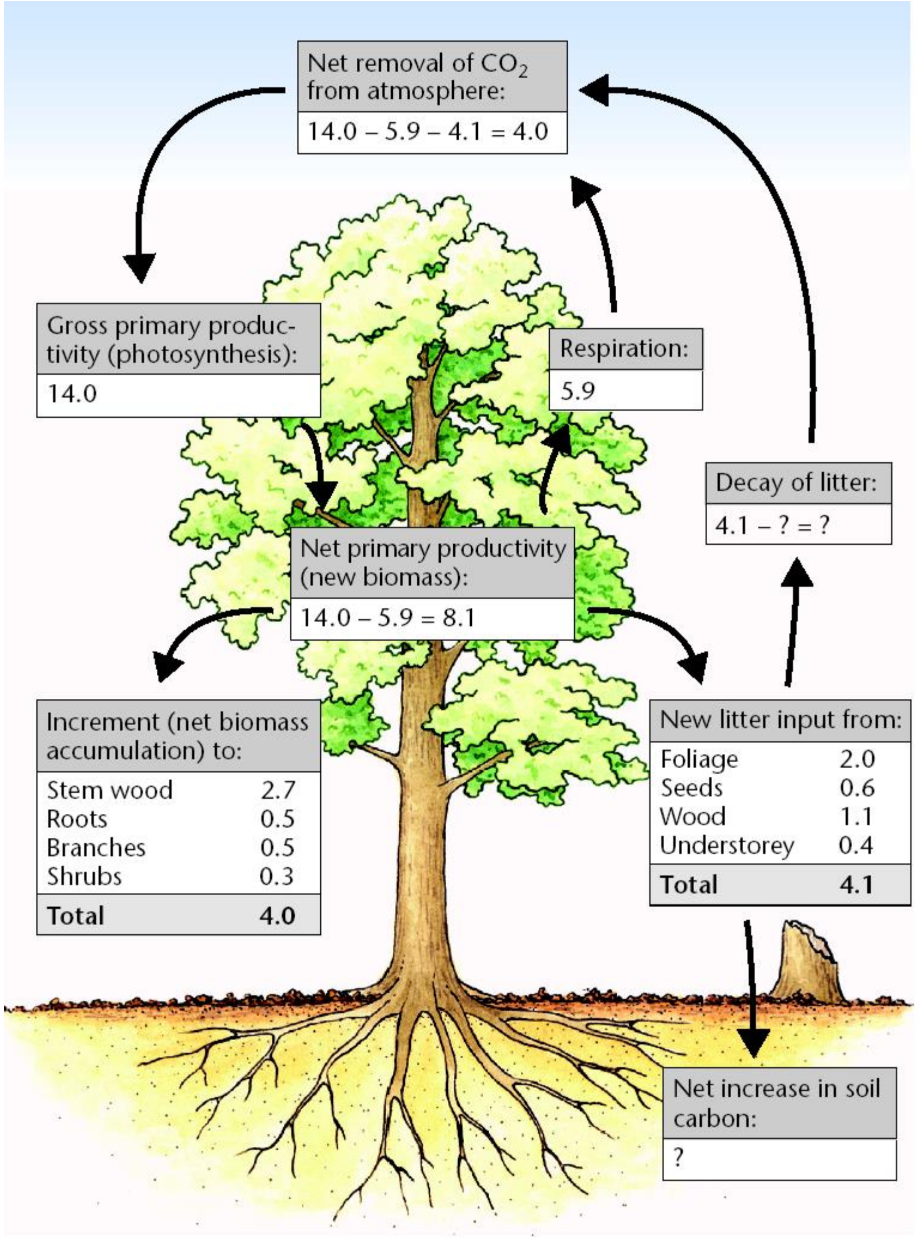
Robert Matthews

UK Forest Research

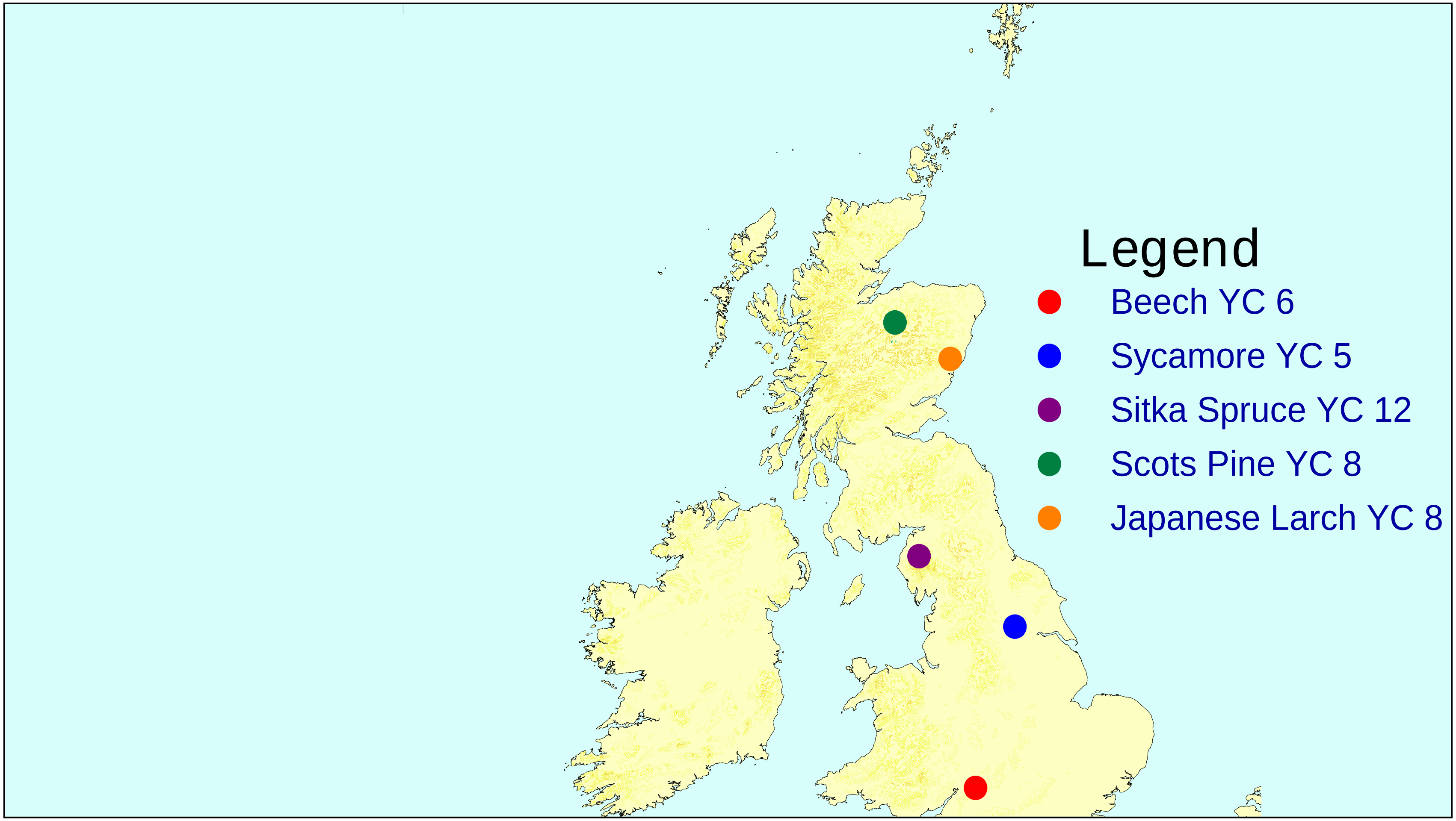


Forest Research model suite

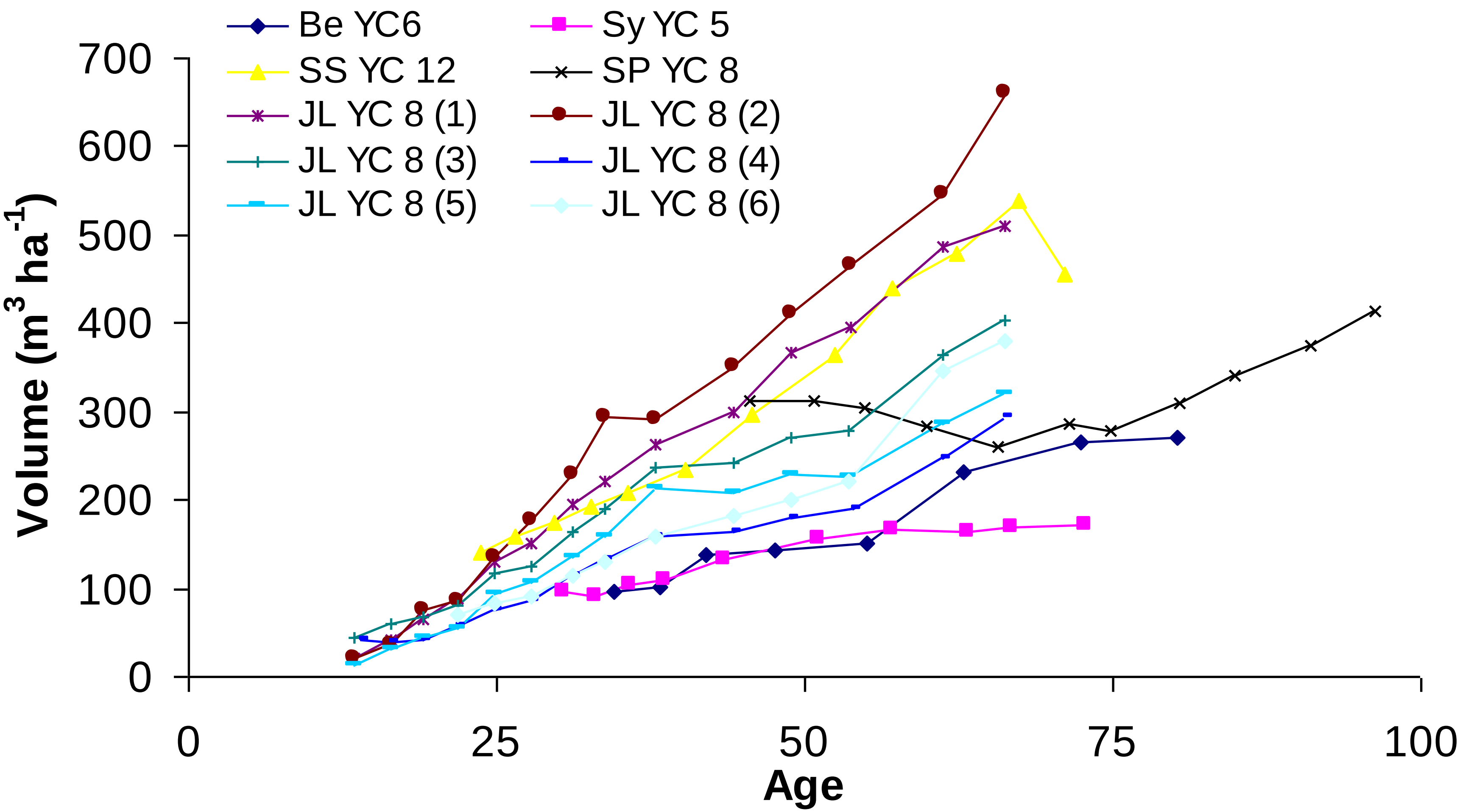
Straits carbon budget

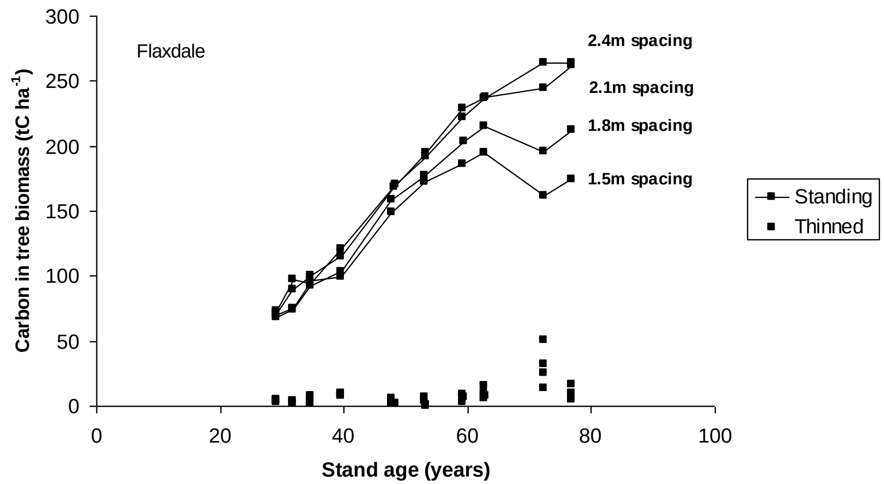


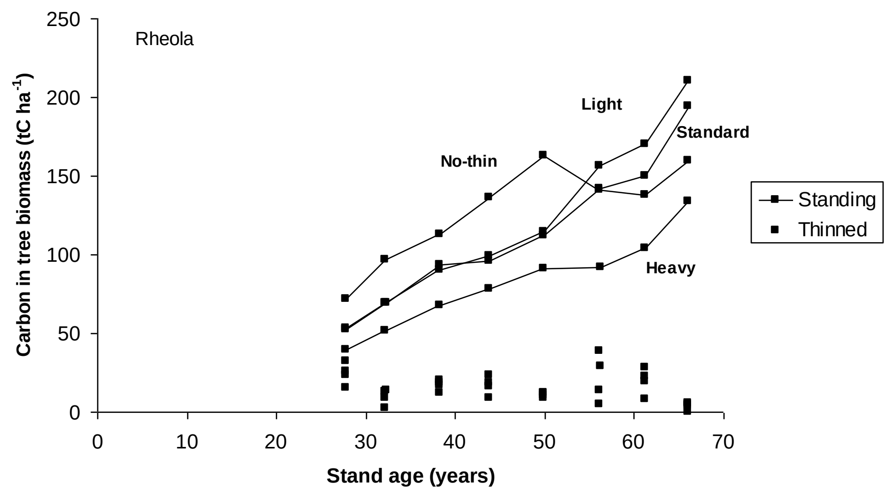
Biomass estimates from sample plots



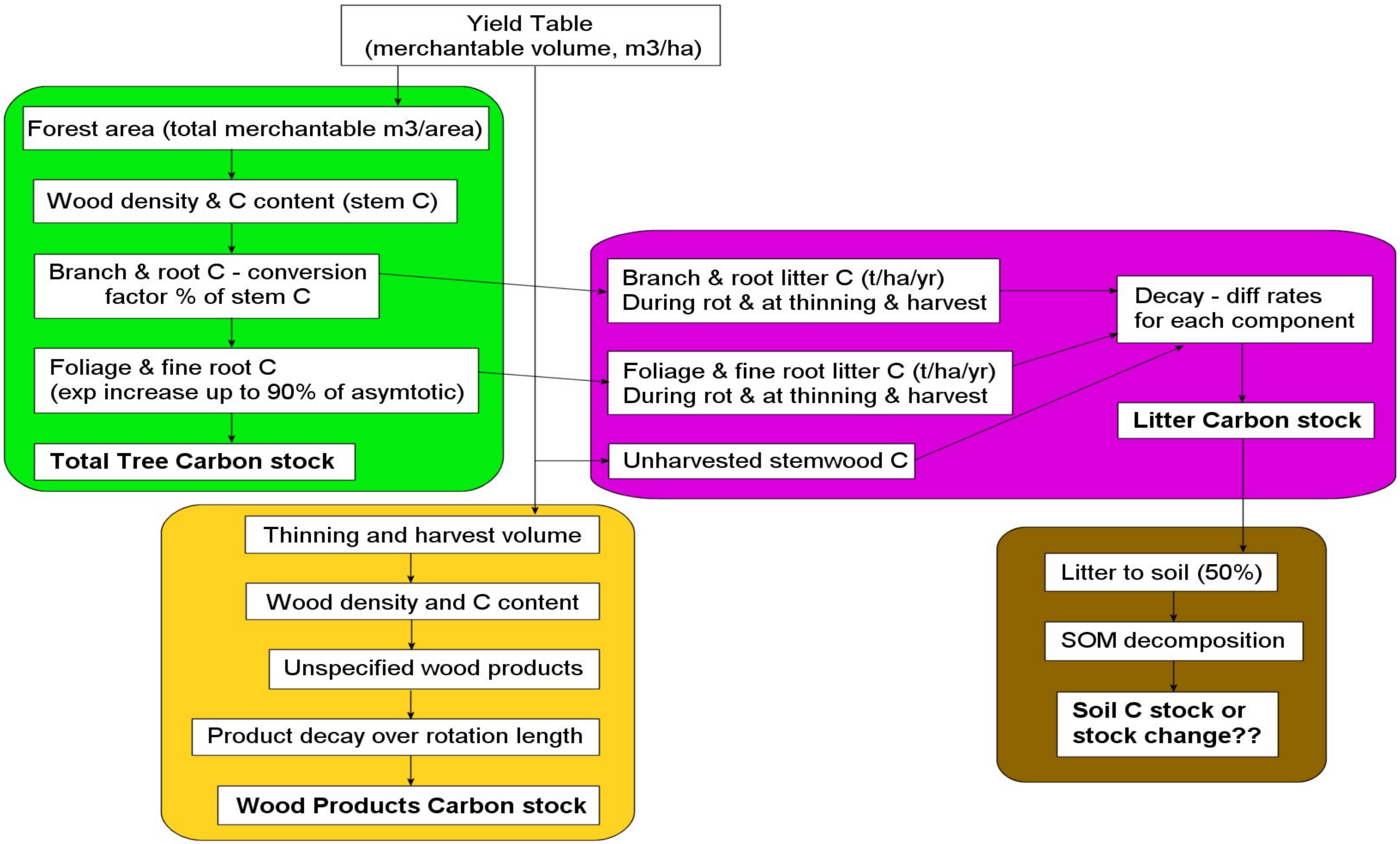
Biomass estimates from sample plots



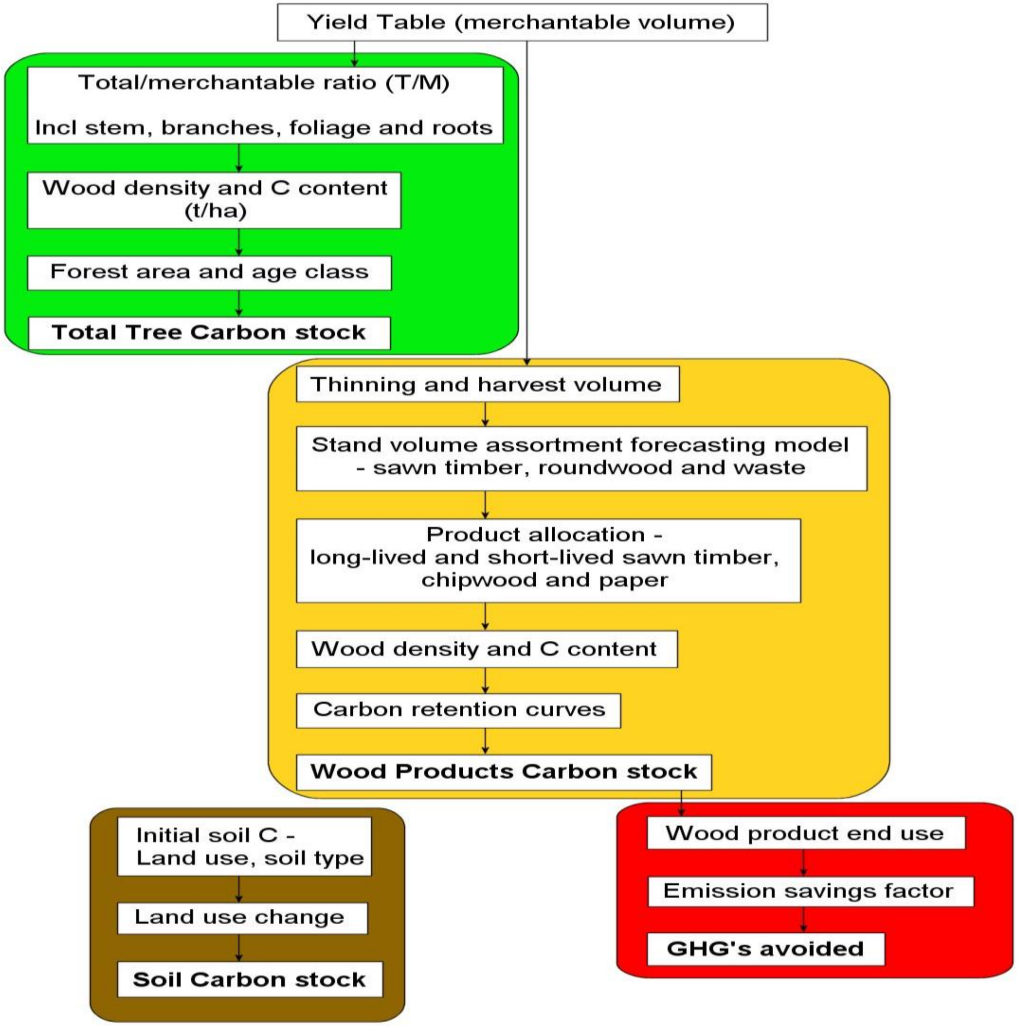

Flaxdale
2.4m spacing
2.1m spacing
1.8m spacing
1.5m spacing
Standing
Thinned
Carbon in tree biomass (tC ha-1)
Stand age (years)

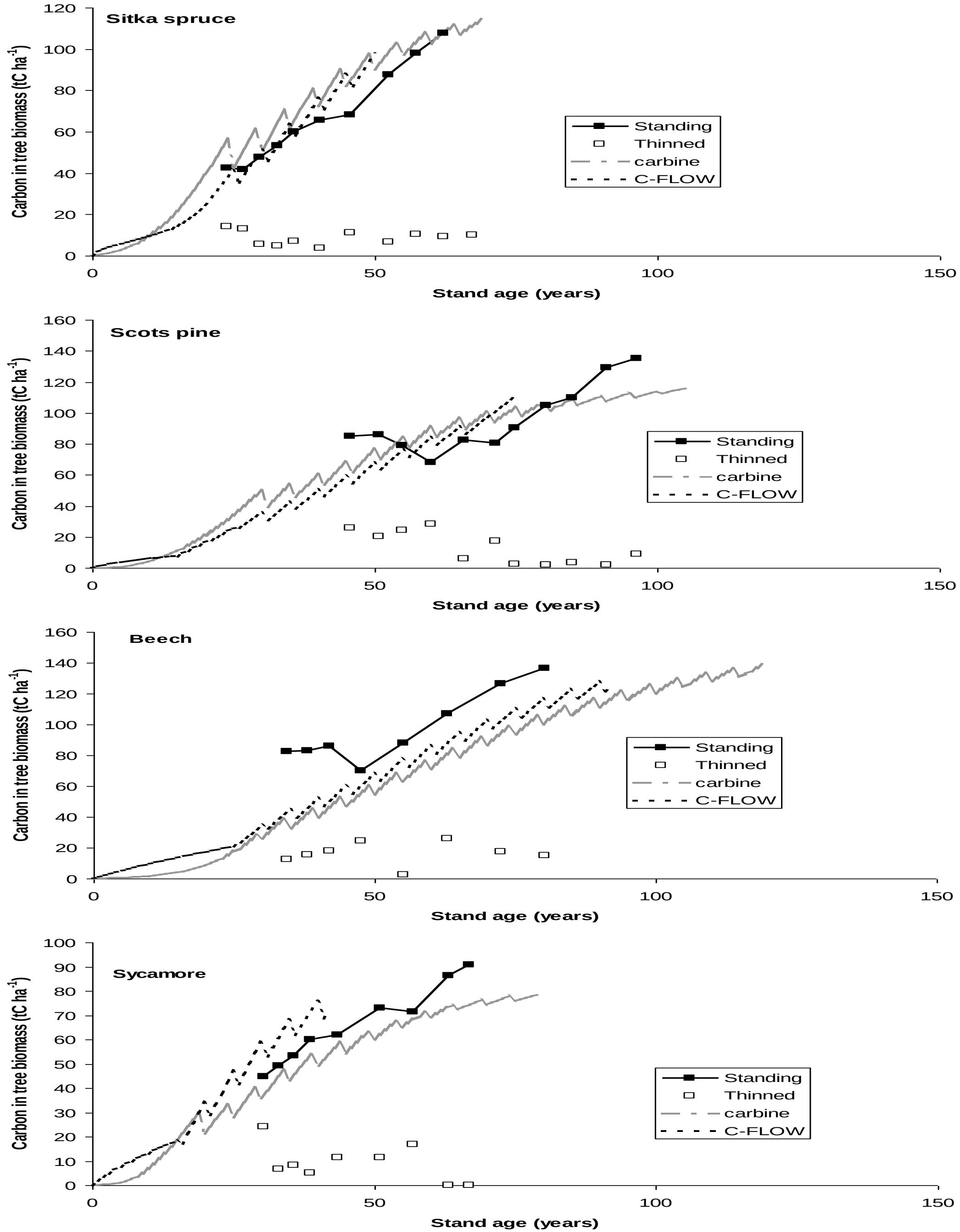

Rheola
Light
Standard
No-thin
Heavy
Standing
Thinned
Carbon in tree biomass (tC ha-1)
Stand age (years)

Model structure: CFLOW

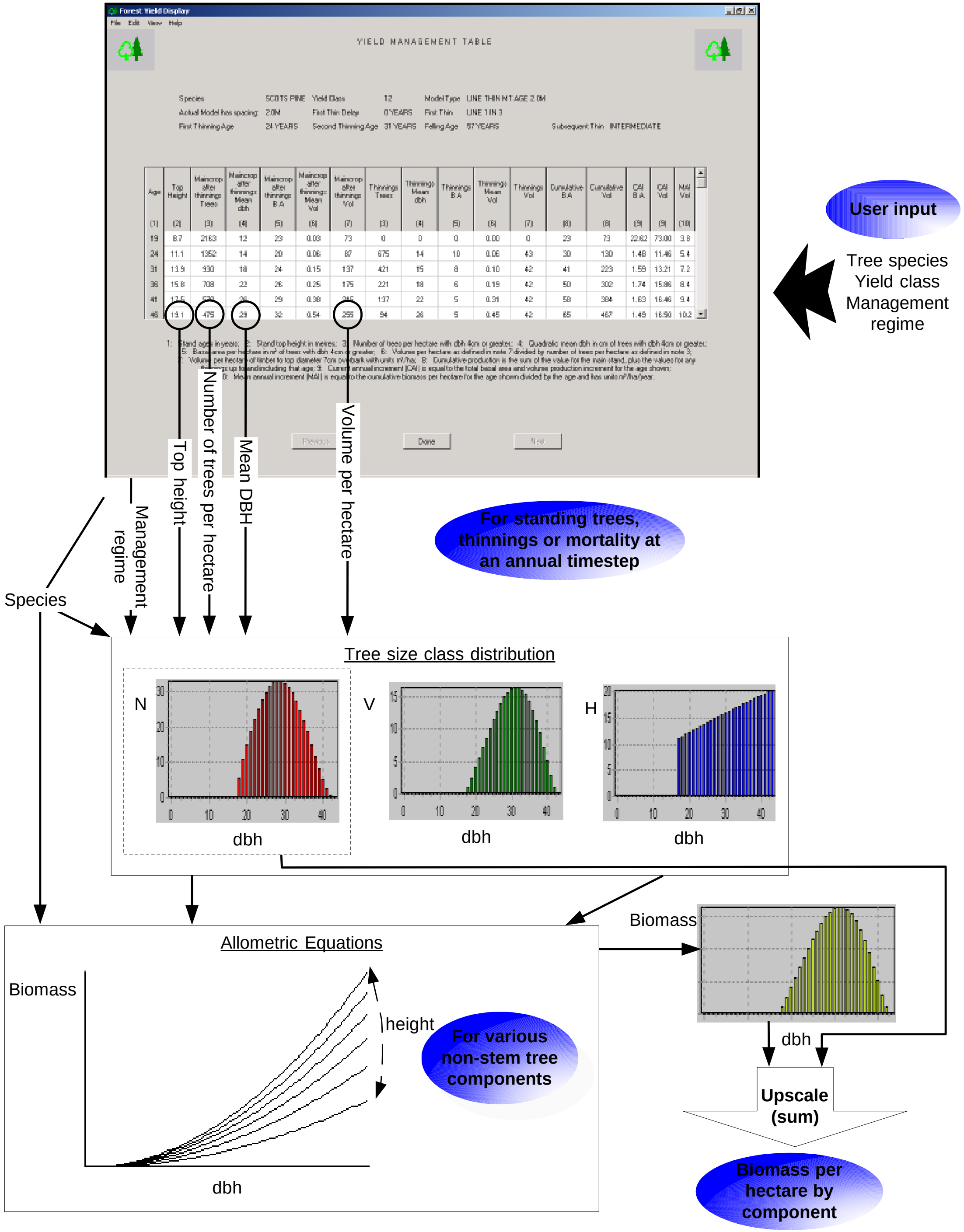


Model structure: CARBINE

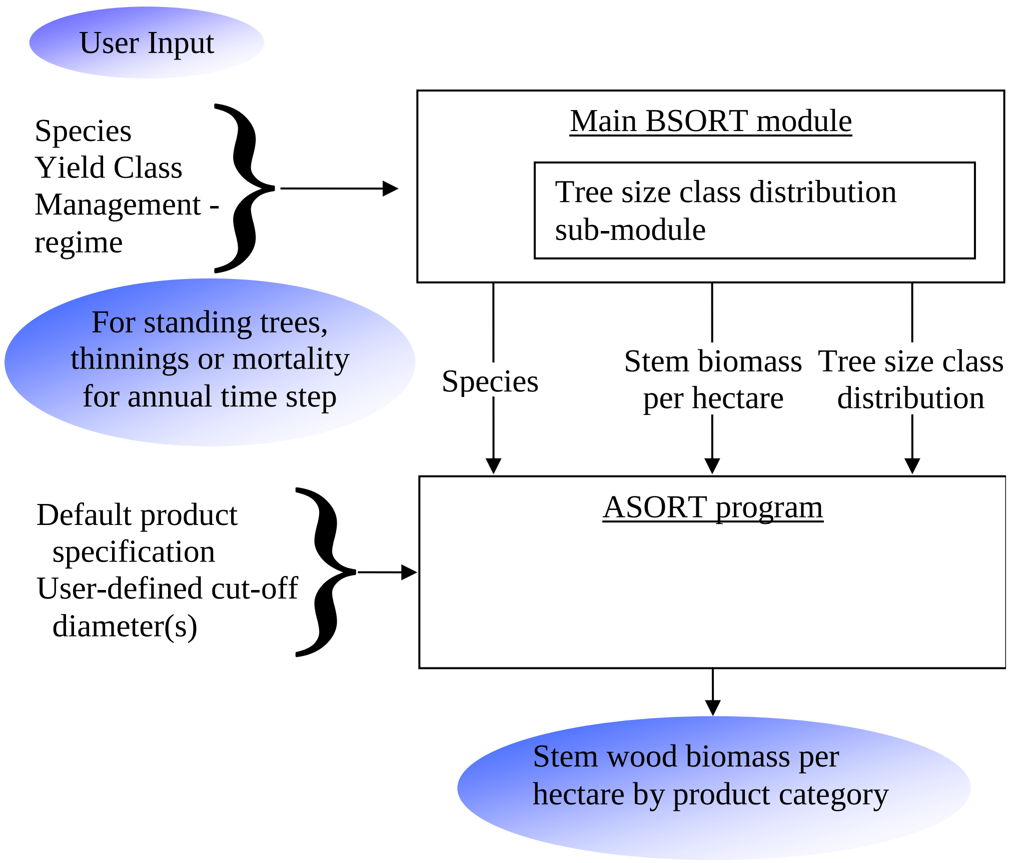


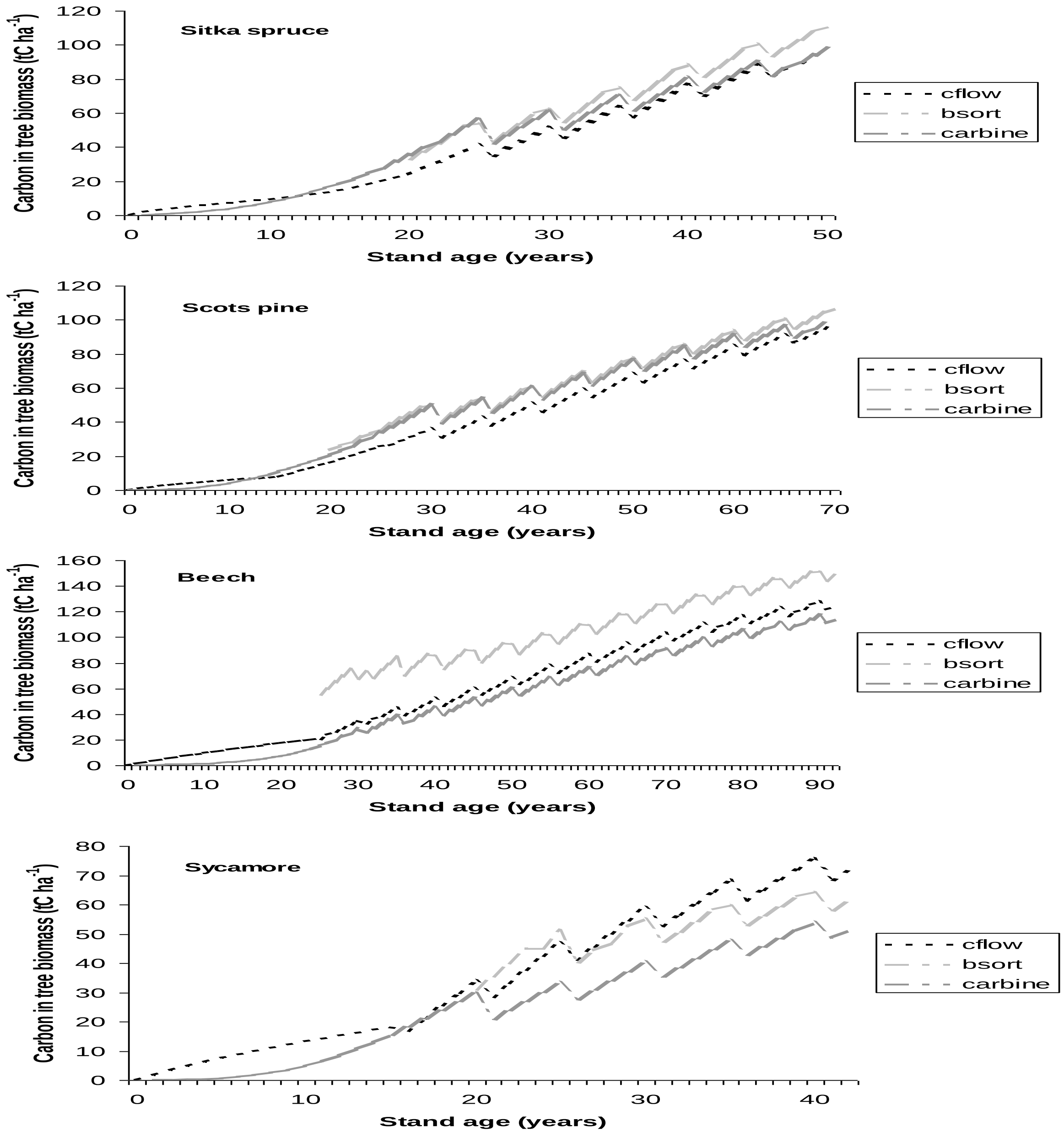


Sitka spruce
Carbon in tree biomass (tC ha-1)
Stand age (years)
Standing
Thinned
carbine
C-FLOW
0
20
40
60
80
100
120
0
50
100
150
Scots pine
Carbon in tree biomass (tC ha-1)
Stand age (years)
Standing
Thinned
carbine
C-FLOW
0
20
40
60
80
100
120
140
160
0
50
100
150
Beech
Carbon in tree biomass (tC ha-1)
Stand age (years)
Standing
Thinned
carbine
C-FLOW
0
20
40
60
80
100
120
140
160
0
50
100
150
Sycamore
Carbon in tree biomass (tC ha-1)
Stand age (years)
Standing
Thinned
carbine
C-FLOW
0
10
20
30
40
50
60
70
80
90
100
0
50
100
150



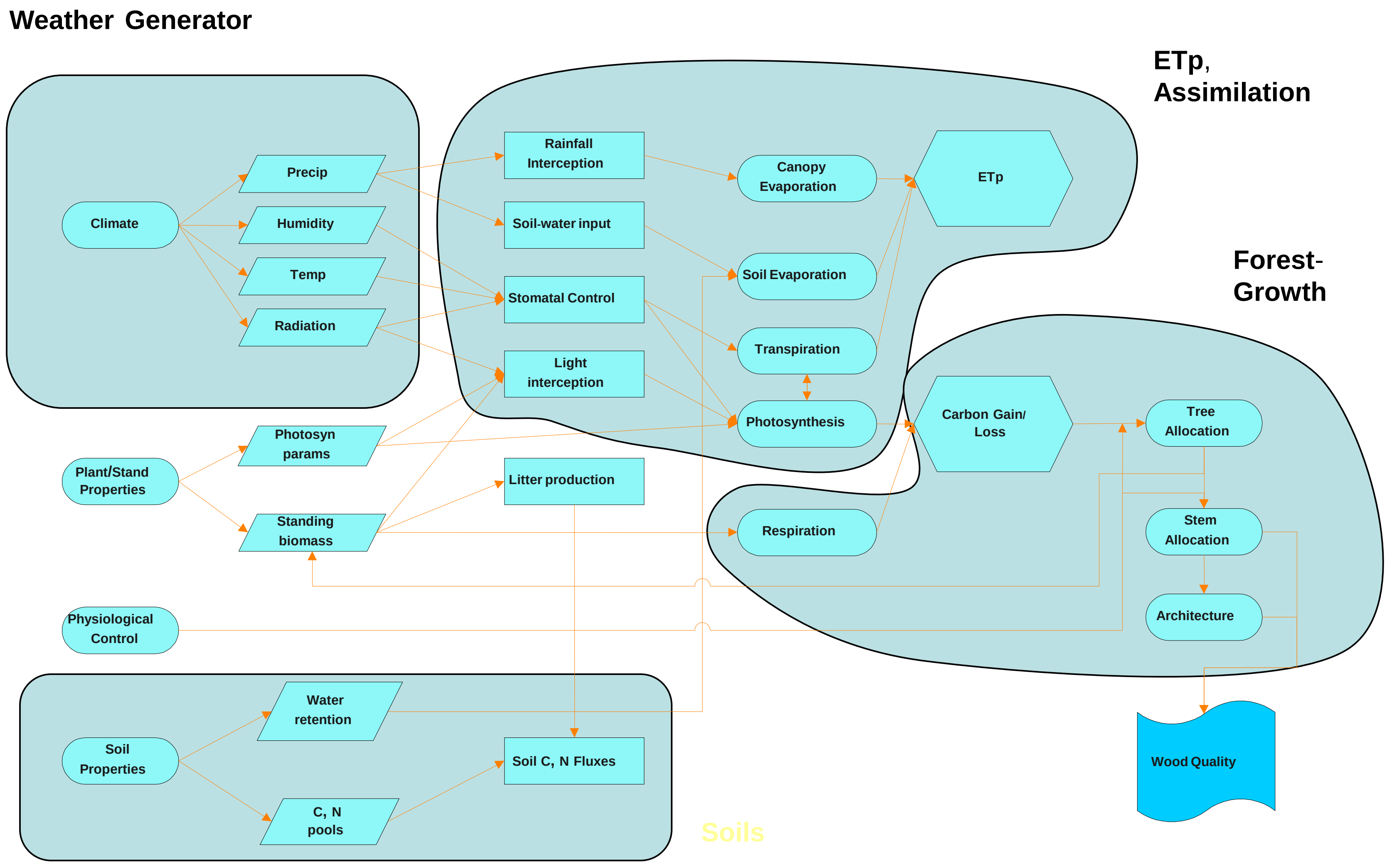
Forest Yield Display
YIELD MANAGEMENT TABLE
User input
Tree species
Yield class
Management
regime
Species
Management
regime
Top height
Number of trees per hectare
Mean DBH
Volume per hectare
For standing trees,
thinnings or mortality at
an annual timestep
Tree size class distribution
N
V
H
dbh
dbh
dbh
Allometric Equations
Biomass
height
dbh
For various
non-stem tree
components
Biomass
dbh
Upscale
(sum)
Biomass per
hectare by
component


User Input
Species
Yield Class
Management - regime
For standing trees, thinnings or mortality for annual time step
Main BSORT module
Tree size class distribution sub-module
Species
Stem biomass per hectare
Tree size class distribution
Default product specification
User-defined cut-off diameter(s)
ASORT program
Stem wood biomass per hectare by product category

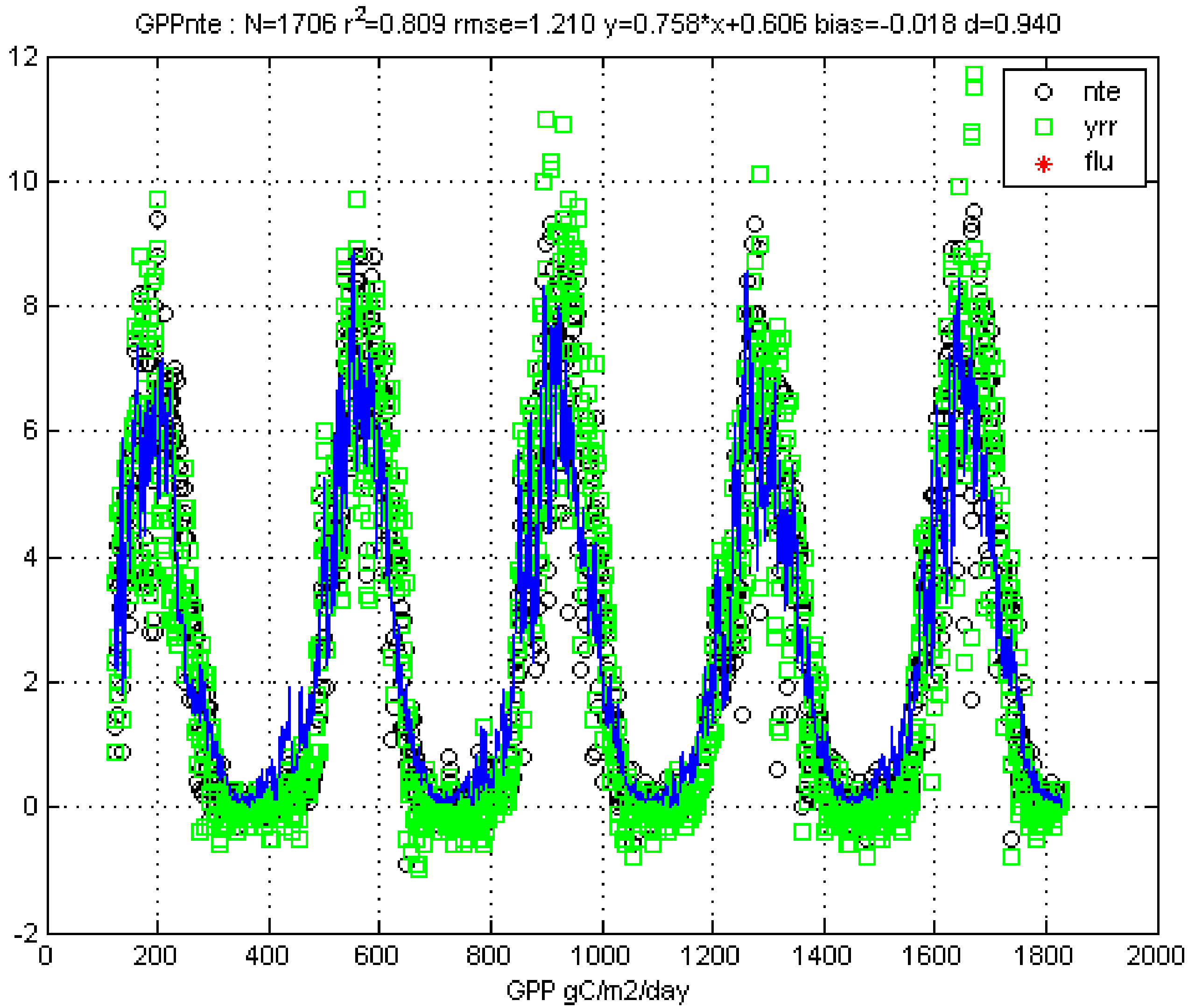


Sitka spruce
Scots pine
Beech
Sycamore
Carbon in tree biomass (tC ha-1)
Stand age (years)
cflow
bsort
carbine

EtP Model Structure



GPP (g C m-2 day-1) from flux

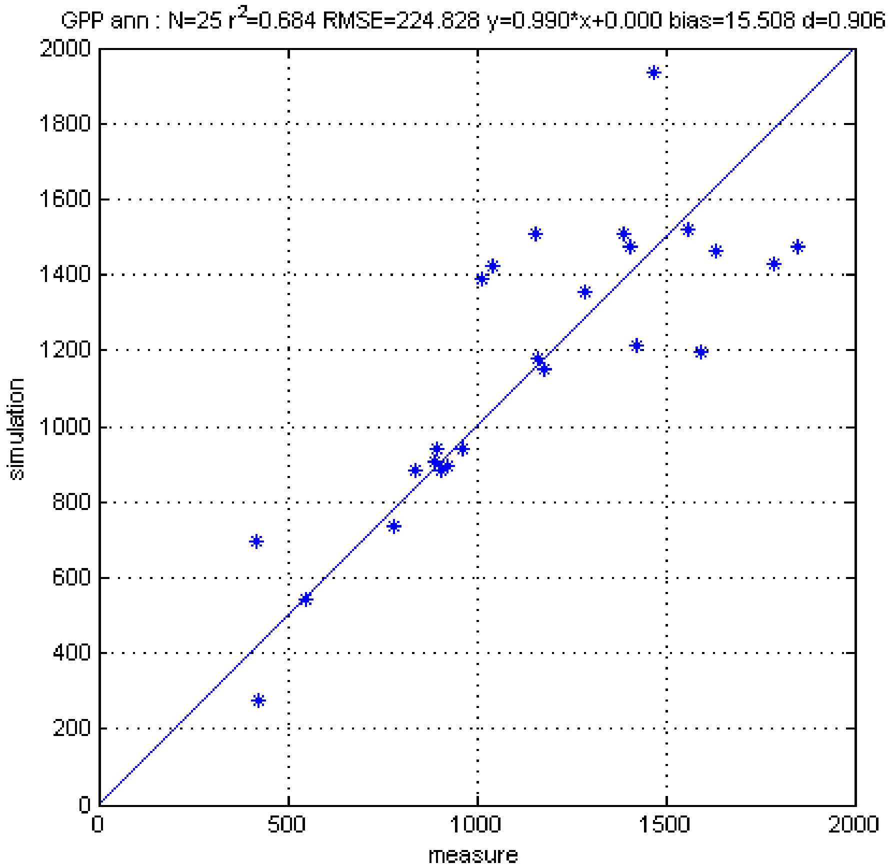


$R^2 = 0.81$

Site : Hyytiala (Finland)

Validation - ForestETp
GPP and ETp from flux sites at the annual timestep

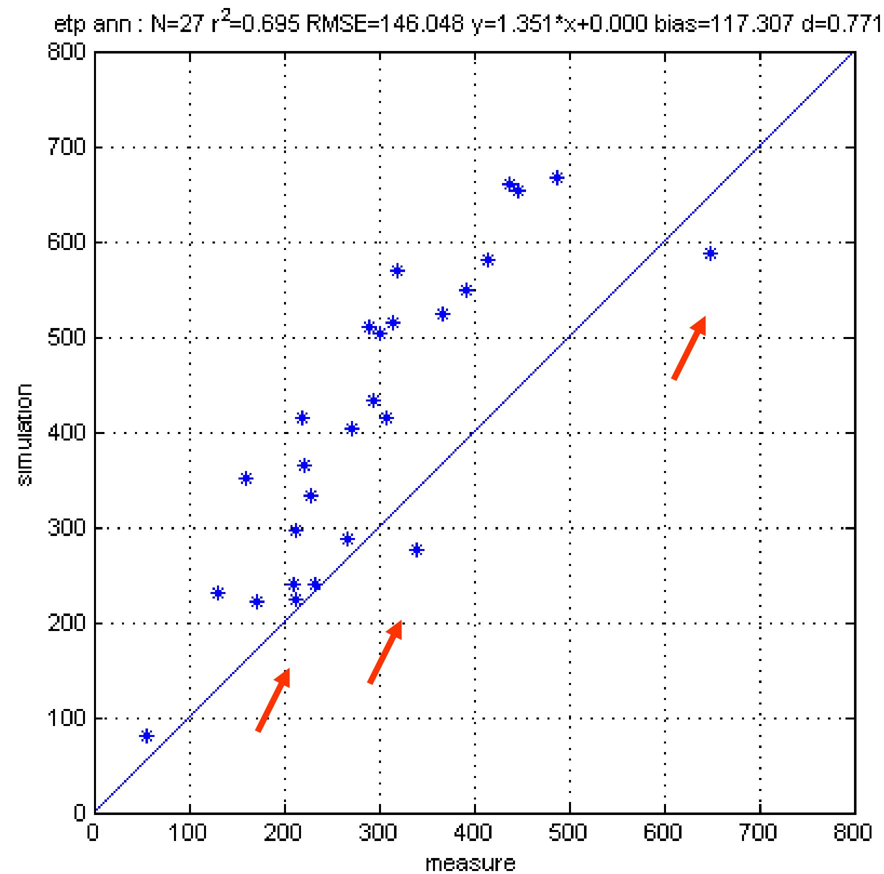
GPP (g C m^{-2} year^{-1})



r^2=0.68

model = 0.99*measured

ETP (mm year^{-1})

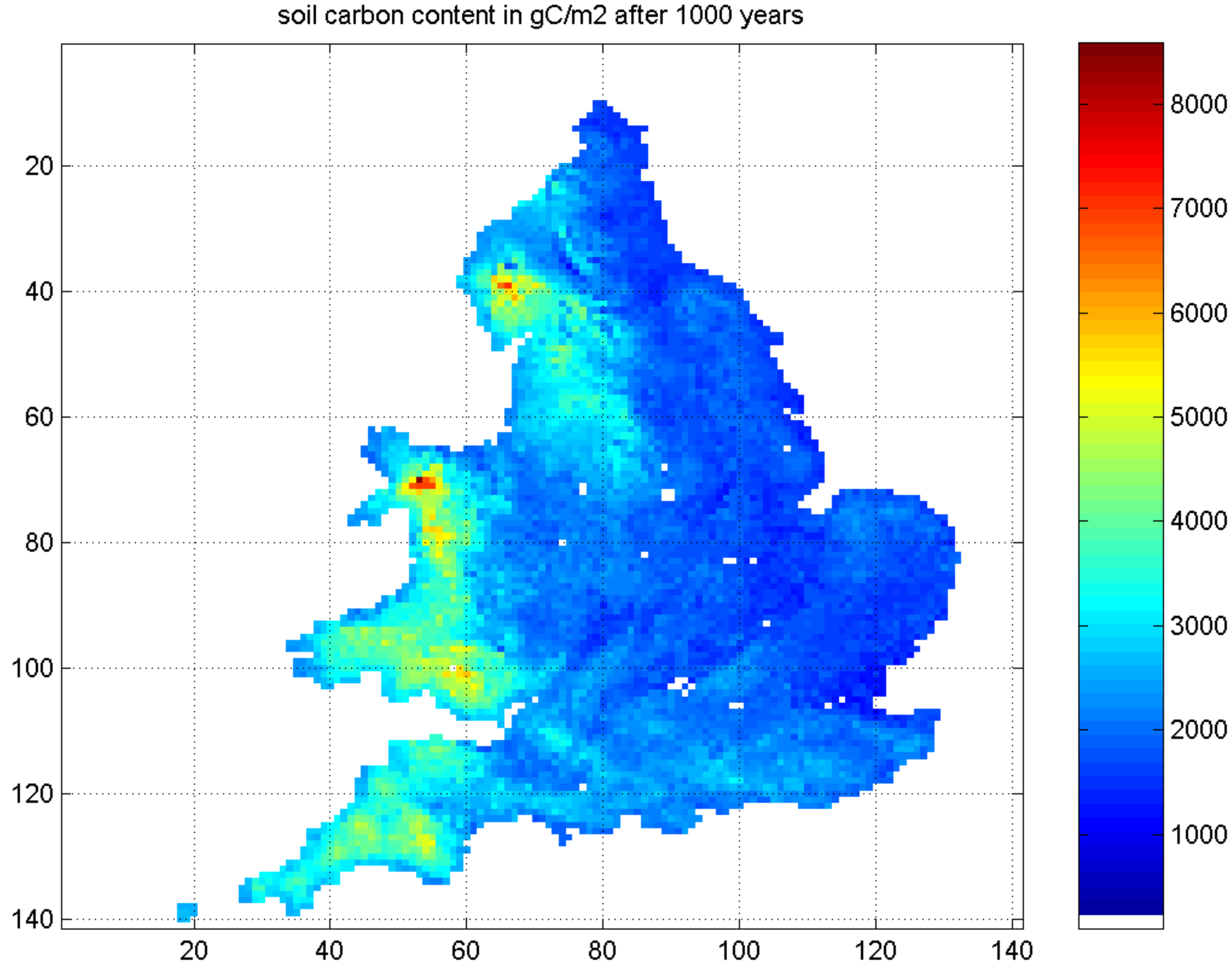


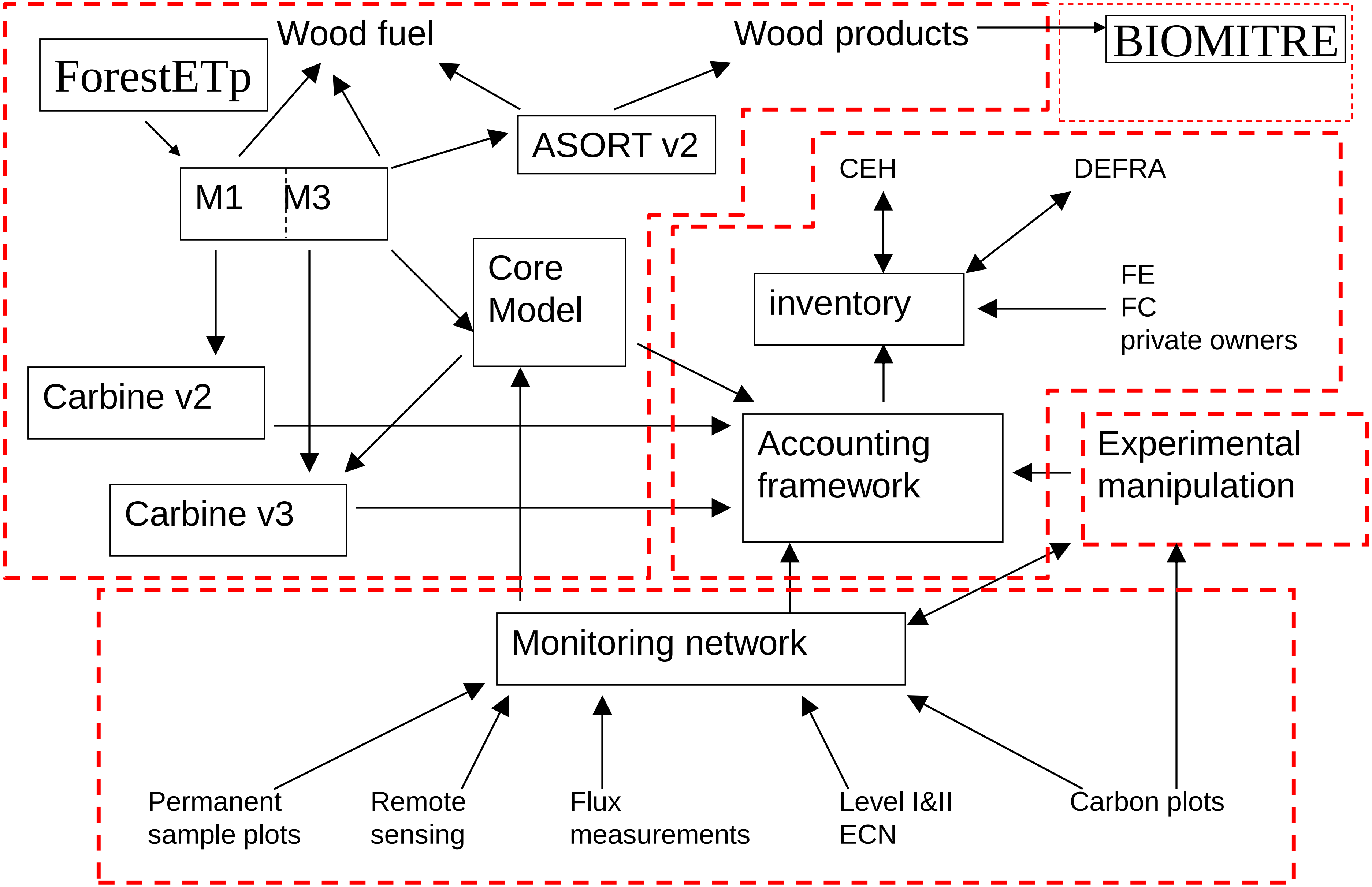
r^2=0.69

model = 1.35*measured

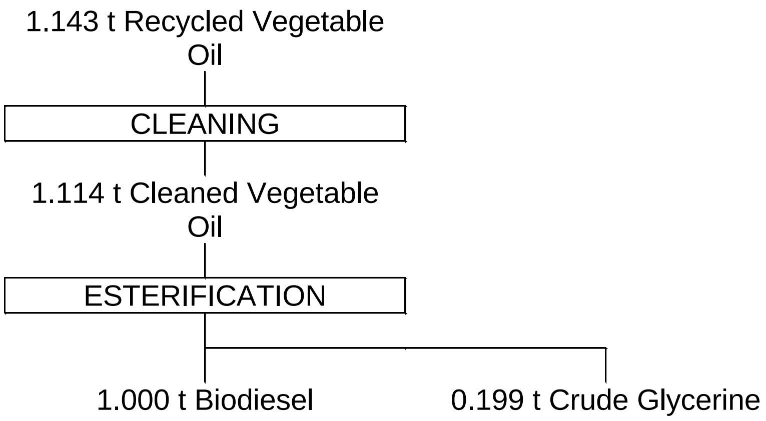
CTCD
Centre *for* Terrestrial Carbon Dynamics

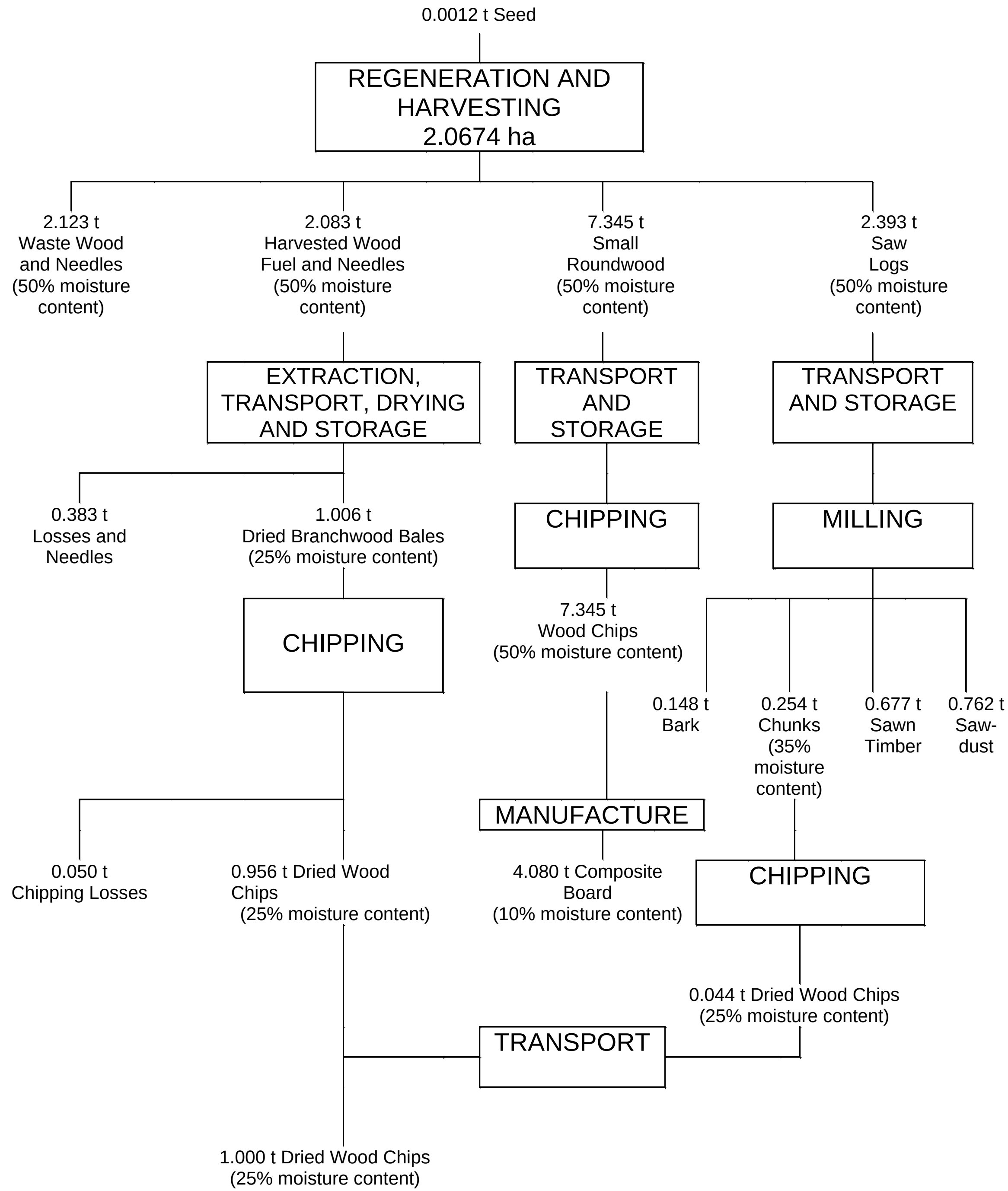
NATURAL ENVIRONMENT RESEARCH COUNCIL


soil carbon content in gC/m2 after 1000 years
20
40
60
80
100
120
140
20
40
60
80
100
120
140
8000
7000
6000
5000
4000
3000
2000
1000



Forest Research model suite


1.143 t Recycled Vegetable Oil
CLEANING
1.114 t Cleaned Vegetable Oil
ESTERIFICATION
1.000 t Biodiesel
0.199 t Crude Glycerine


0.0012 t Seed
REGENERATION AND HARVESTING 2.0674 ha
2.123 t Waste Wood and Needles (50% moisture content)
2.083 t Harvested Wood Fuel and Needles (50% moisture content)
7.345 t Small Roundwood (50% moisture content)
2.393 t Saw Logs (50% moisture content)
EXTRACTION, TRANSPORT, DRYING AND STORAGE
TRANSPORT AND STORAGE
TRANSPORT AND STORAGE
0.383 t Losses and Needles
1.006 t Dried Branchwood Bales (25% moisture content)
CHIPPING
MILLING
CHIPPING
7.345 t Wood Chips (50% moisture content)
0.148 t Bark
0.254 t Chunks (35% moisture content)
0.677 t Sawn Timber
0.762 t Saw-dust
MANUFACTURE
0.050 t Chipping Losses
0.956 t Dried Wood Chips (25% moisture content)
4.080 t Composite Board (10% moisture content)
CHIPPING
0.044 t Dried Wood Chips (25% moisture content)
TRANSPORT
1.000 t Dried Wood Chips (25% moisture content)

Functional Unit:	Biodiesel at point of distribution derived from recycled vegetable oil							
Final Unit of Measurement:	1 tonne of biodiesel							
Relevant Location:	United Kingdom							
Relevant Period:	2002							
Allocation Procedures:	Based on average market prices, assuming 0.199 tonnes of glycerine at £388/t (UK 1997 - 2000 average; Ref. 1) and 1.000 tonnes of biodiesel at £268/t (UK 1997 - 2000 average; Ref. 1), giving a 78% allocation to biodiesel.							
Contribution	Per Unit	Total Greenhouse Gas Output (kg eq CO_2)						
		Direct		Indirect		Total		Notes
		Value	Range	Value	Range	Value	Range	
Cleaning:								
- Natural Gas	*t rvo*	-	-	-	-	-	-	(a)
	t bd	**-**	**-**	**-**	**-**	**-**	**-**	(b)
Esterification:								
- Methanol	*t bd*	-	-	*576*	*±85*	*576*	*±85*	(a)
- Pot. Hydroxide	*t bd*	-	-	*18*	-	*18*	-	(a)
Sub-Totals	*t bd*	-	-	*594*	*±85*	*594*	*±85*	
	t bd			**463**	**±66**	**463**	**±66**	(c)
Plant Construction								
	t bd	-	-	*1*	-	*1*	-	(a)
	t bd	**-**	**-**	**1**	**-**	**1**	**-**	(c)
Plant Maintenance								
	t bd	-	-	*1*	-	-	-	(a)
	t bd	**-**	**-**	**1**	**-**	**1**	**-**	(c)
Distribution:								
- Diesel Fuel	**t bd**	**25**	**±1**	**7**	**±1**	**32**	**±1**	(a)
Totals	**t bd**	**25**	**±1**	**472**	**±66**	**497**	**±66**	

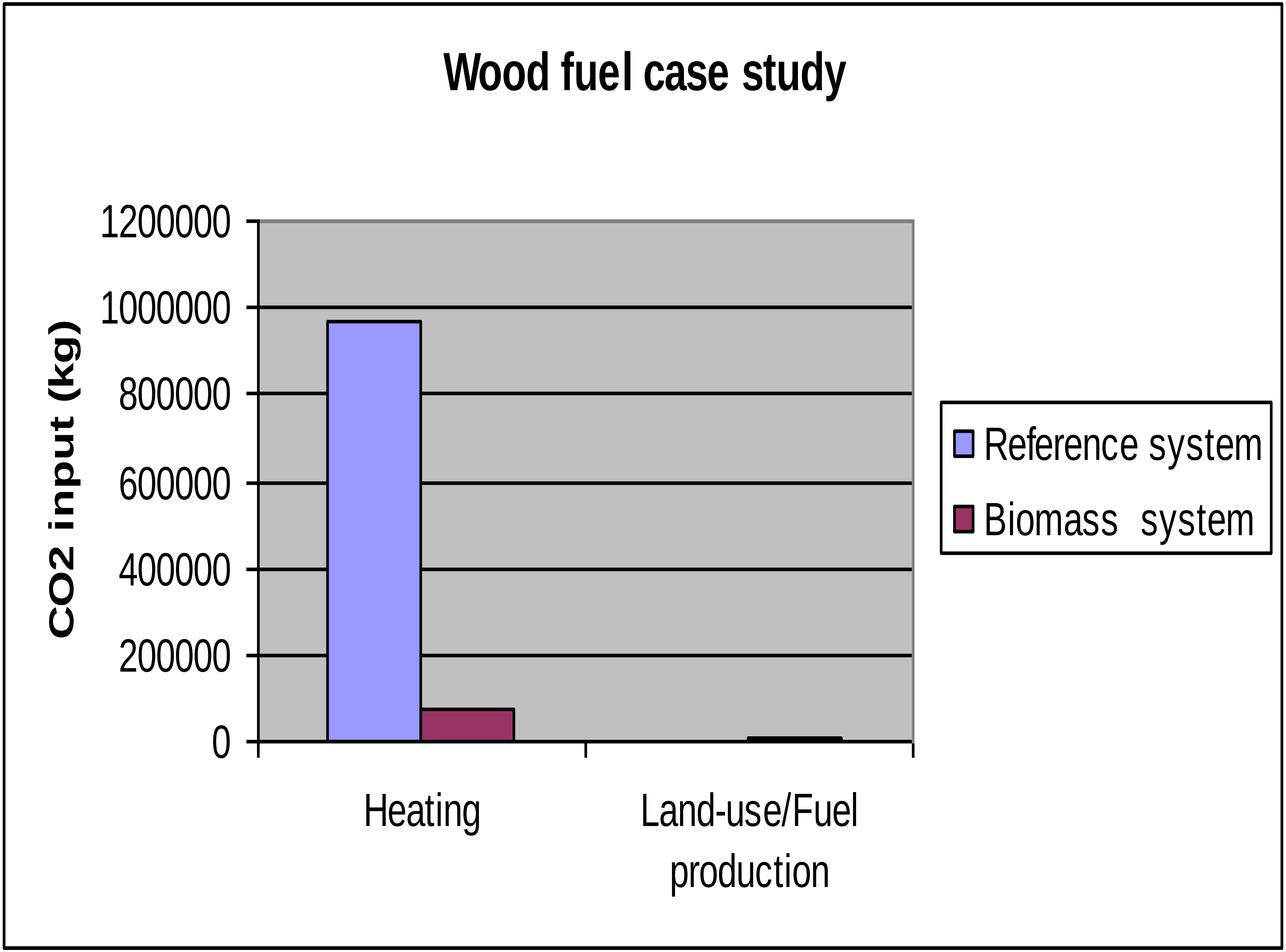
Selected Biofuel Technology	Total Greenhouse Gas Requirement (kg eq CO_2/MJ)
Biodiesel from oilseed rape	0.041 ± 0.002[(a)]
Biodiesel from recycled vegetable oil	0.013 ± 0.002[(a)]
Combined Heat and Power (large scale with industrial load) by combustion of wood chip from forestry residues	0.008 ± 0.002[(b)]
Combined Heat and Power (small scale) by gasification of wood chip from short rotation coppice (Option A)	0.005 ± 0.001[(b)]
Combined Heat and Power (small scale) by gasification of wood chip from short rotation coppice (Option B)	0.004 ± 0.001[(b)]
Electricity (large scale) by combustion of miscanthus	0.026 ± 0.001
Electricity (large scale) by combustion of straw	0.066 ± 0.004
Electricity by combustion of wood chip from forestry residues (large scale)	0.022 ± 0.001
Electricity by combustion of wood chip from short rotation coppice (Option A)	0.025 ± 0.003
Electricity by combustion of wood chip from short rotation coppice (Option B)	0.023 ± 0.003
Electricity by gasification of wood chip from forestry residues (large scale)	0.007
Electricity by gasification of wood chip from short rotation coppice (Option A)	0.008 ± 0.001
Electricity by gasification of wood chip from short rotation coppice (Option B)	0.007 ± 0.001
Electricity by pyrolysis of wood chip from forestry residues (large scale)	0.014 ± 0.001
Electricity by pyrolysis of wood chip from short rotation coppice (Option A)	0.016 ± 0.002
Electricity by pyrolysis of wood chip from short rotation coppice (Option B)	0.015 ± 0.002
Ethanol from lignocellulosics (wheat straw)	0.016 ± 0.002[(a)]
Ethanol from sugar beet	0.040 ± 0.003[(a)]
Ethanol from wheat	0.029 ± 0.002[(a)]
Heat (small scale) by combustion of wood chip from forestry residues (large scale)	0.007
Heat (small scale) by combustion of wood chip from woodland management (Option A)	0.007
Heat (small scale) by combustion of wood chip from woodland management (Option B)	0.007
Rapeseed Oil from oilseed rape	0.031 ± 0.002[(a)]

Location of the two systems

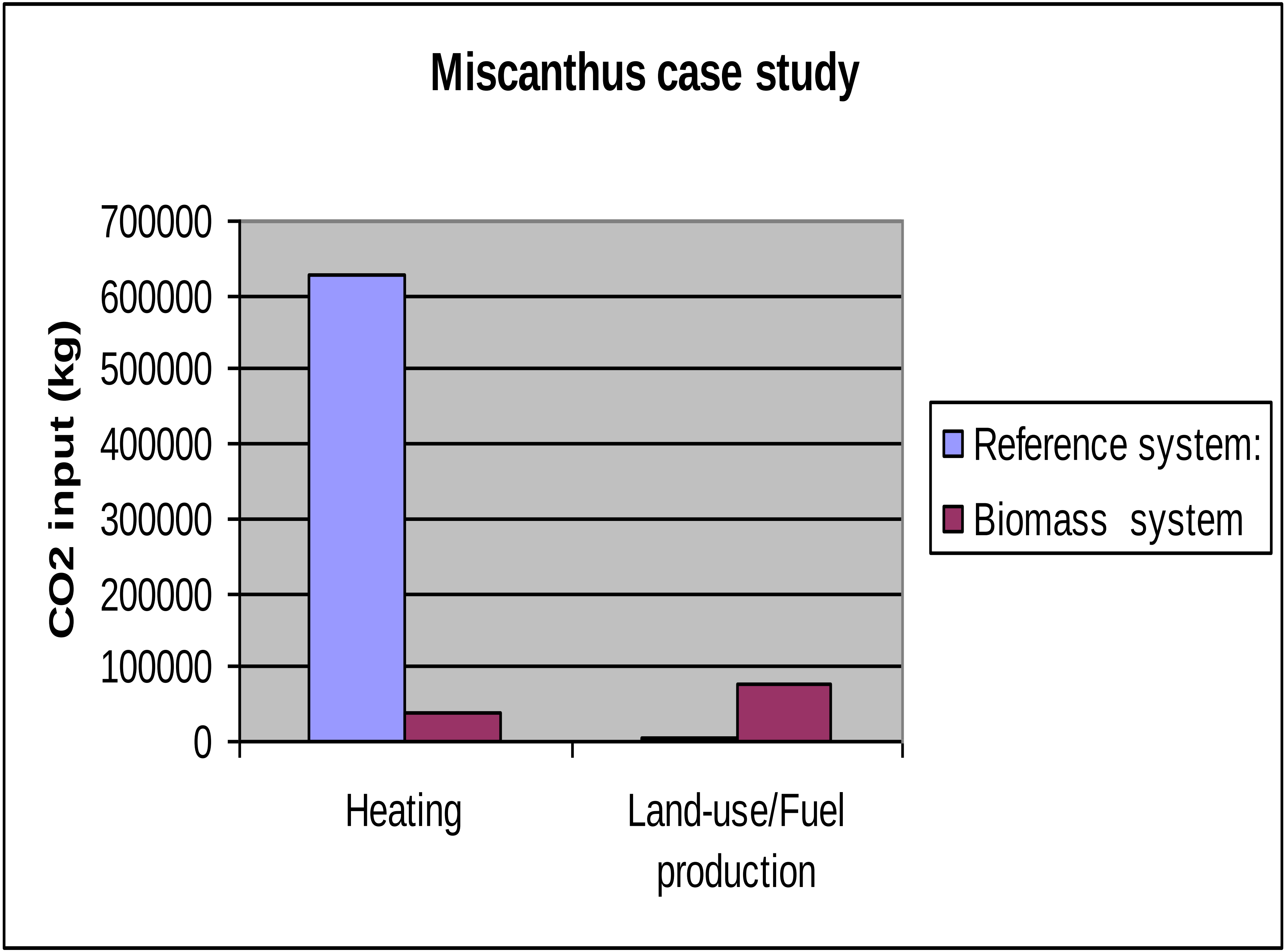
Grascott Farm
150 kWth wood fuel system

Kings Langley
70 kWth Miscanthus system

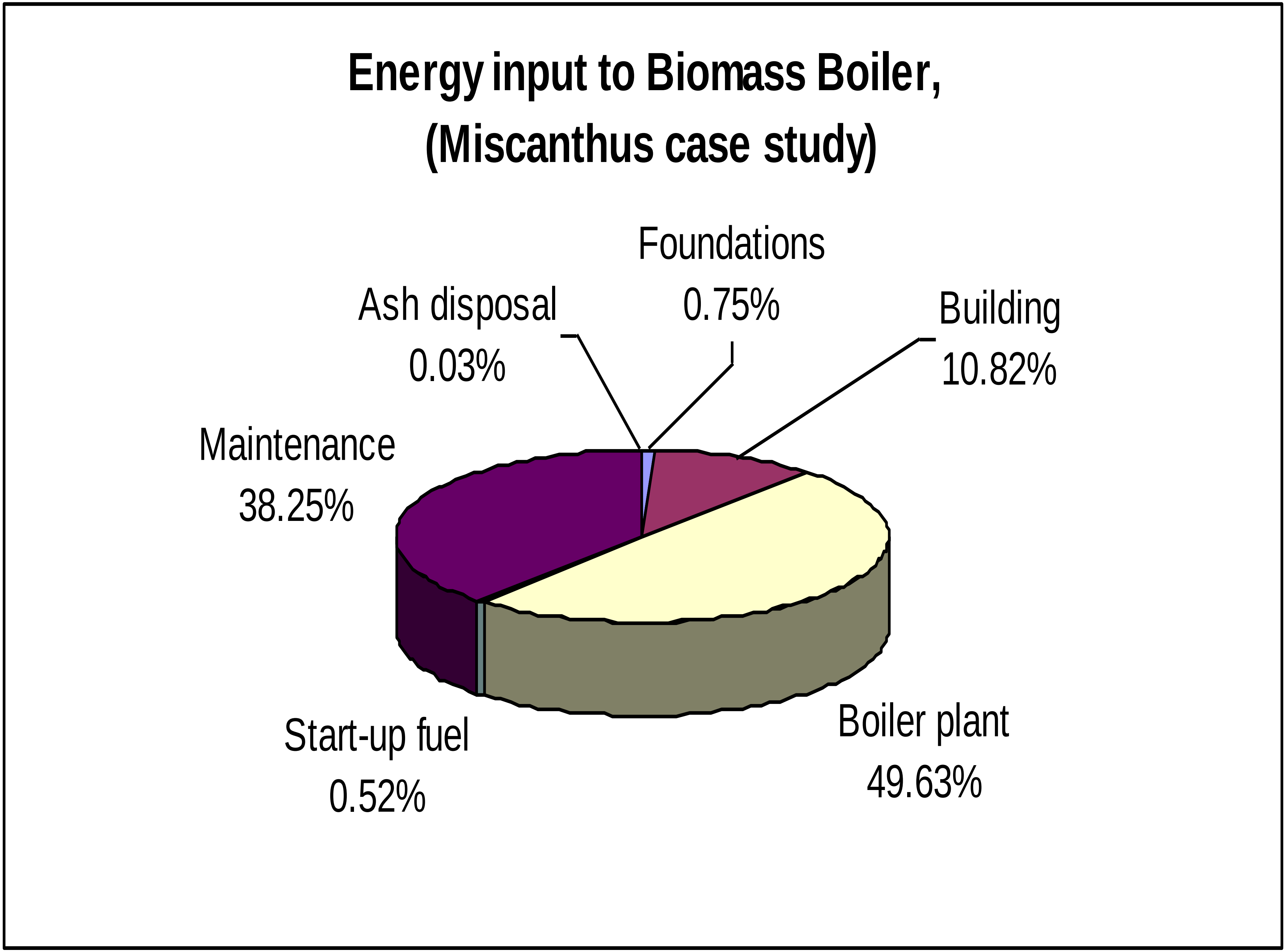
GRASCOTT FOREST
To Exmoor
Ford
bridge
Beech wood
Golden Larch
Swimming pond
Pheasant
Badger Sett
Larch & Douglas fir
Spring flower meadows
mixed woodland
Track
conifers
Kingfisher
Grascott Farm
Blackberry Lane
Otter
Barn Owl
orchids
Red Kite
Badger Sett
Roe Deer
To the Coast
To Dartmoor
bridleway
1 mile to road
Grascott Forest
212 acres
·Key · Field names
15 Lamb Park
16 Barn meadow
17 Scotch moor
7 Cow field
11 Pond field
Map not to scale – By

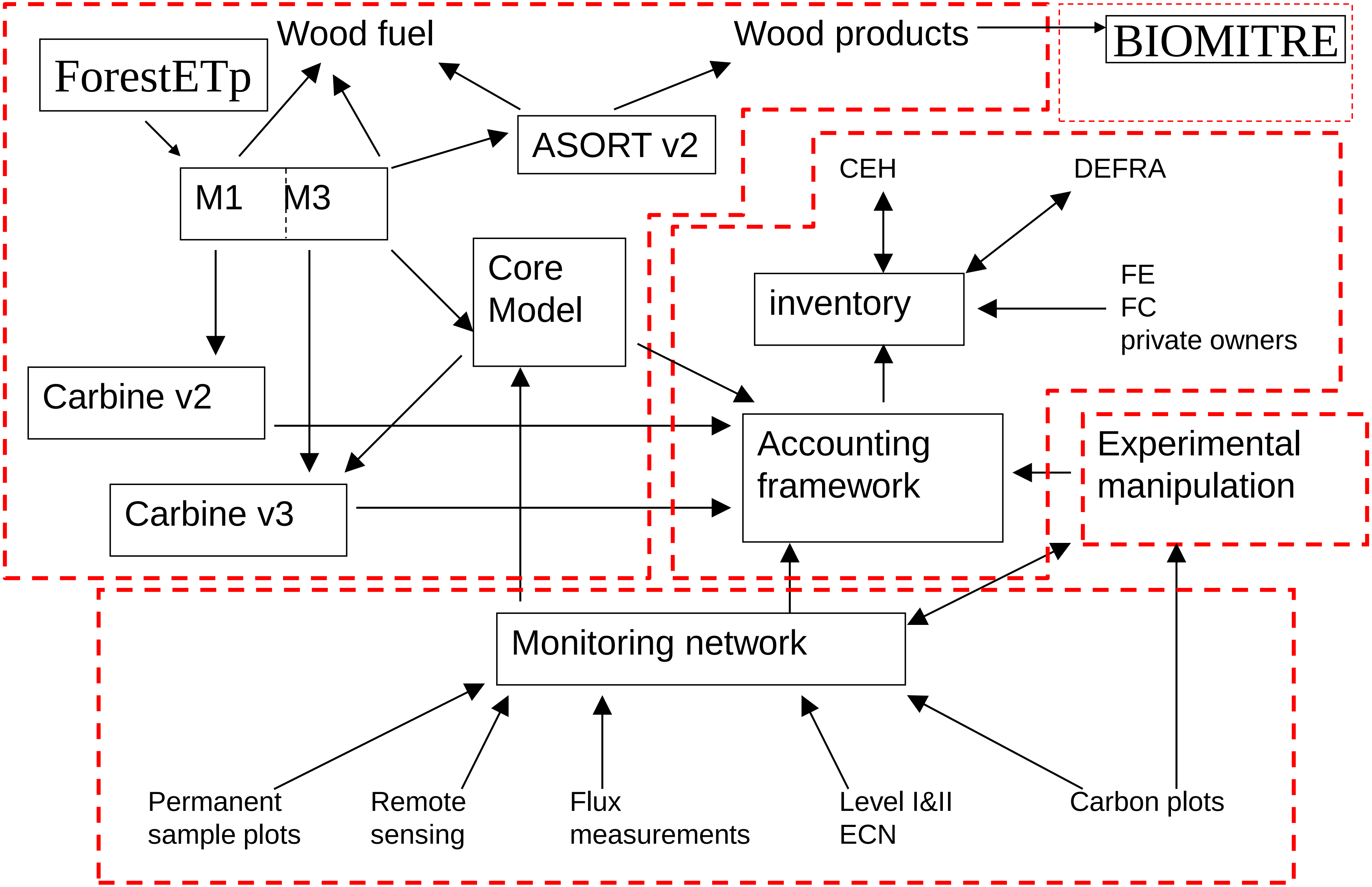


Wood fuel case study
CO2 input (kg)
1200000
1000000
800000
600000
400000
200000
0
Heating
Land-use/Fuel production
Reference system
Biomass system



Miscanthus case study
CO2 input (kg)
700000
600000
500000
400000
300000
200000
100000
0
Heating
Land-use/Fuel production
Reference system:
Biomass system

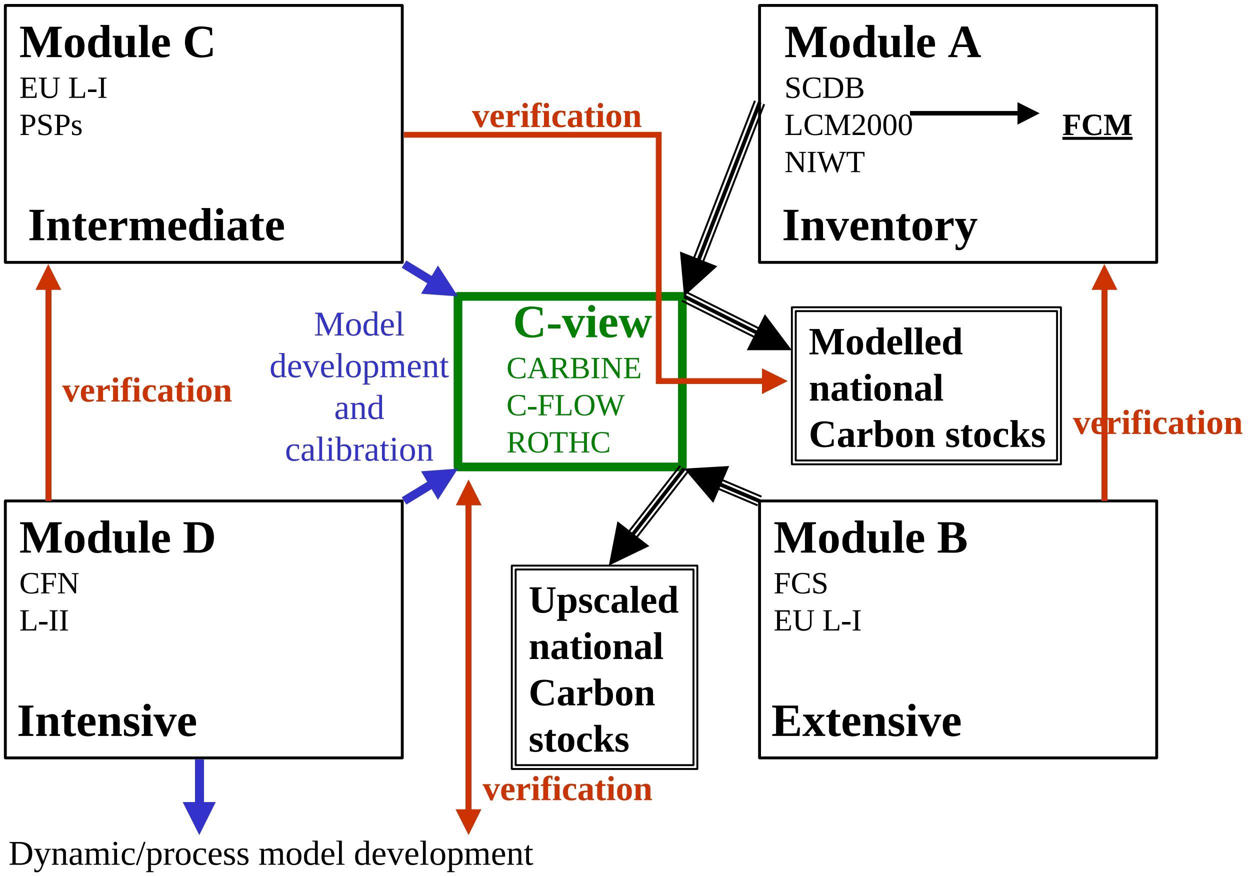

Energy input to Biomass Boiler,
(Miscanthus case study)
Foundations
0.75%
Ash disposal
0.03%
Building
10.82%
Maintenance
38.25%
Start-up fuel
0.52%
Boiler plant
49.63%



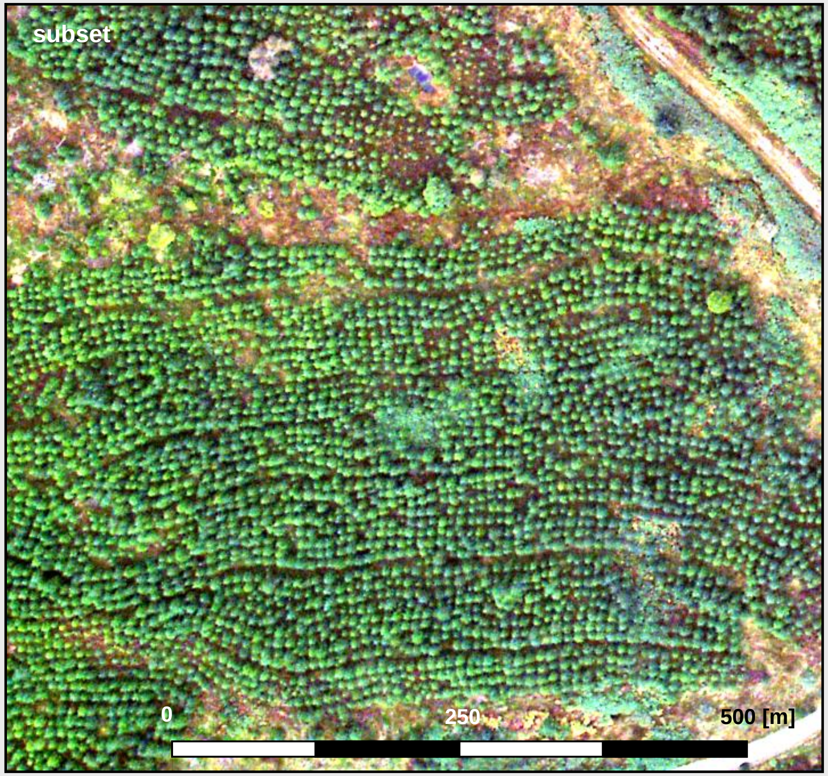
Forest Research model suite

UK Carbon inventory

- Pilot study to be run in two areas -
- objective to roll out for 2008 and 2012 (Kyoto)
- opportunity to ground truth remote sensing estimates



Automatic production of GIS information with eCognition using high resolution aerial ortho-photos.



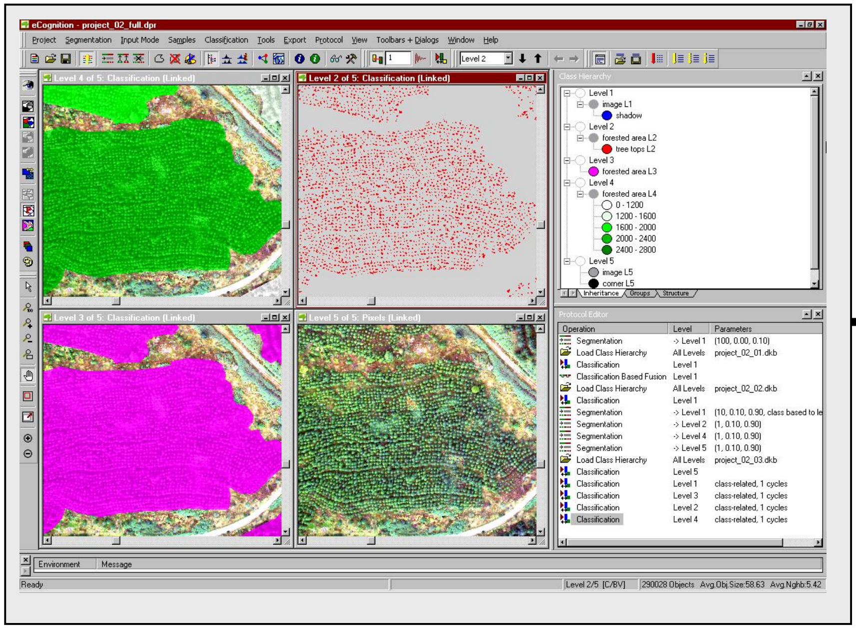
High resolution ortho-photo (RGB)

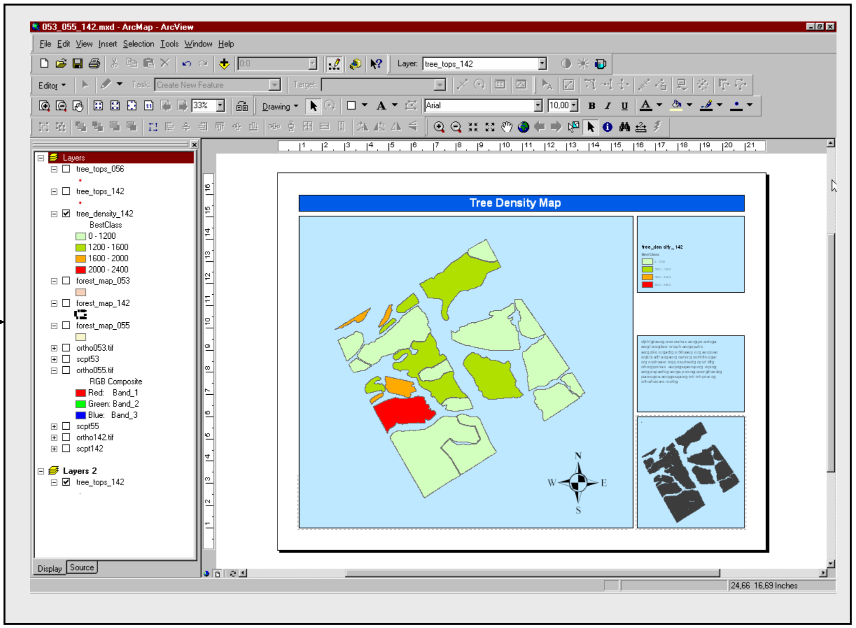
Exportable classification results: ● tree tops

Processing time: 19 sec/ha

precision: + - 5% (compared with visual count)

Data Transfer





eCognition:

- Automatic, protocol operated data analysis
- export of classification results as vector data (point-shapes)

Geoinformation system (e.g. ArcGIS):

- import of vector data
- design of thematic maps