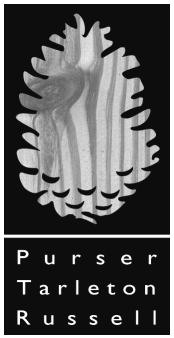
Scaling up forest GHG estimates to the national level



Overview

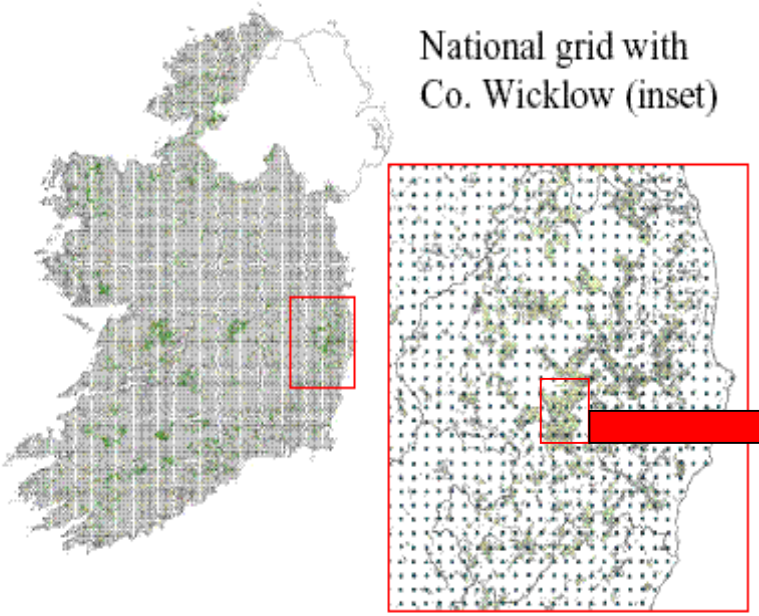
- National requirements
- National inventory design
- Model choice and description
- Software design and function
- Validation
  - NFI (growth and mortality models)
  - Carbifor flux data (total C balance)
- National estimates and projections
- Future research needs and opportunities

National requirements

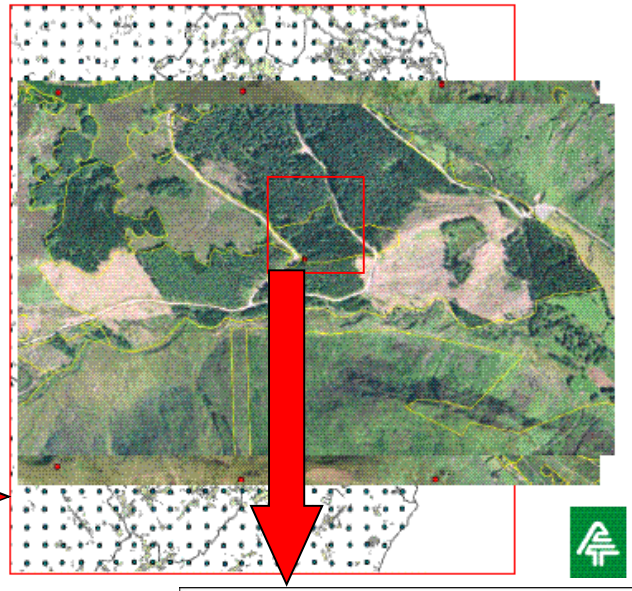
- CLIMIT (2007-2012) strong focus on national GHG reporting and CC adaptation requirements
- UNFCCC obligations and negotiations
  - KP LULUCF reporting
  - Projections and baselines for post 2012
- National strategy and EPA MoU
- CARBiFOR II designed to meet reporting requirements (CARBWARE)
  - Biomass functions, soils, non CO_2 GHGs and validation

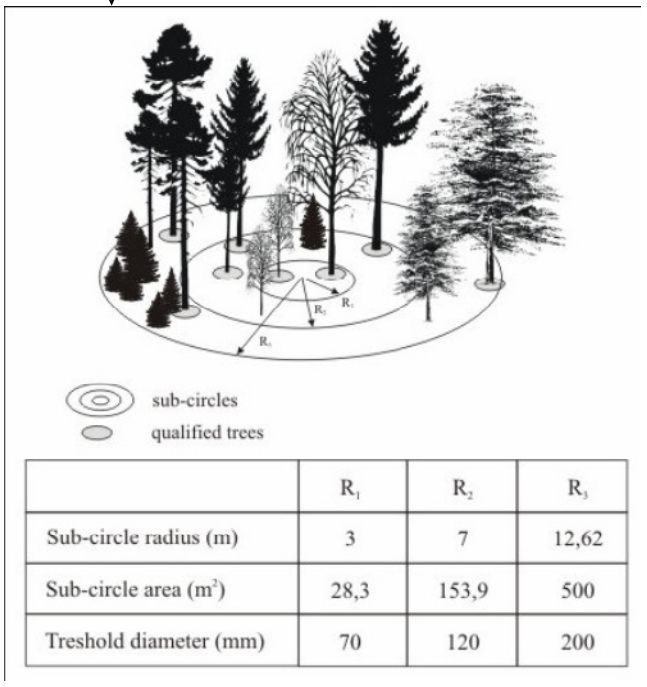
National forest inventory

PHASE 1- SAMPLE GRID – 2 x 2 km



Forest Identification





	R_1	R_2	R_3
Sub-circle radius (m)	3	7	12,62
Sub-circle area (m^2)	28,3	153,9	500
Treshold diameter (mm)	70	120	200

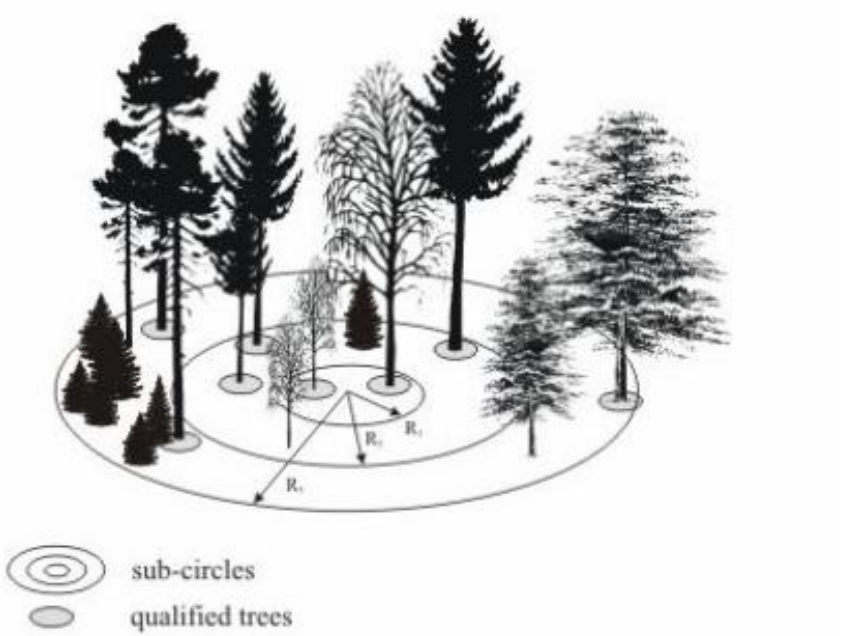
Ist inventory completed in 2006, next due in 2012

- No stock change for Art 3.3 reporting
- Require modelling approach
- Partial tree sample presented difficulties in using

Conventional stand based models

NFI PSP design

- Model needs to facilitate NFI design
- Does NFI partial plot sampling introduce bias?
- In growth of trees
- Problem in deriving top height (limited application of stand based models)



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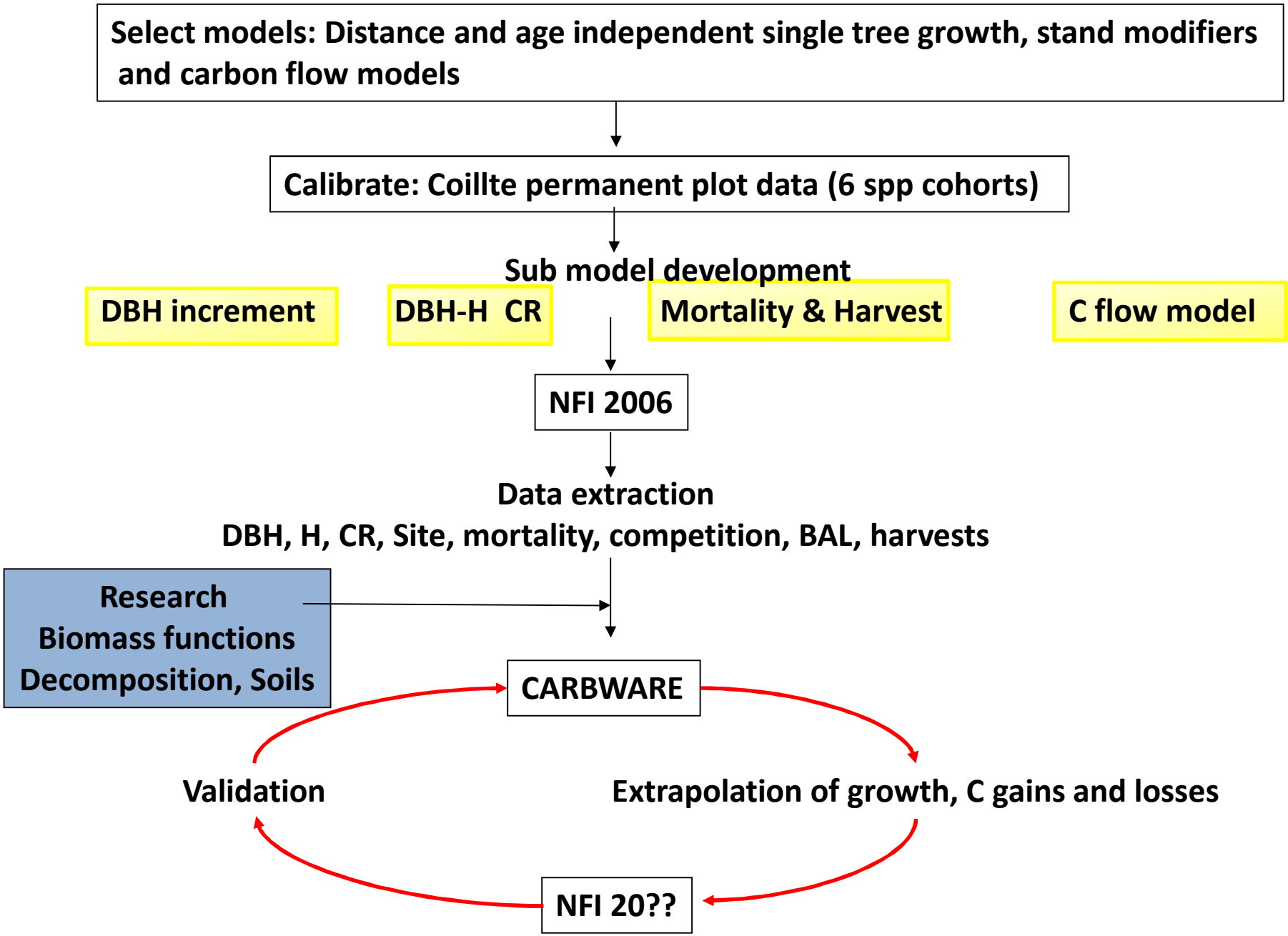
Model choice and description



Growth model description

The total coefficient of determination (R^2 in %) with the partial variation explained by the three major variable groupings SIZE (tree size variables), COMP (competition measures) and SITE (site factors) by species

Species	No. trees	R^2 (%)			
		Total	SIZE	COMP	SITE
Spruce	25427	41.4	16.7	17.0	7.7
Fir	1814	27.4	9.5	11.2	6.7
Larch	2940	48.8	18.6	20.8	9.4
Scots pine	3989	34.1	9.5	17.6	7.0
Black pine	558	34.4	1.6	24.7	8.1
Stone pine	251	22.7	11.2	11.5	–
Beech	4332	23.9	14.5	9.1	0.3

For example (spruce cohort):

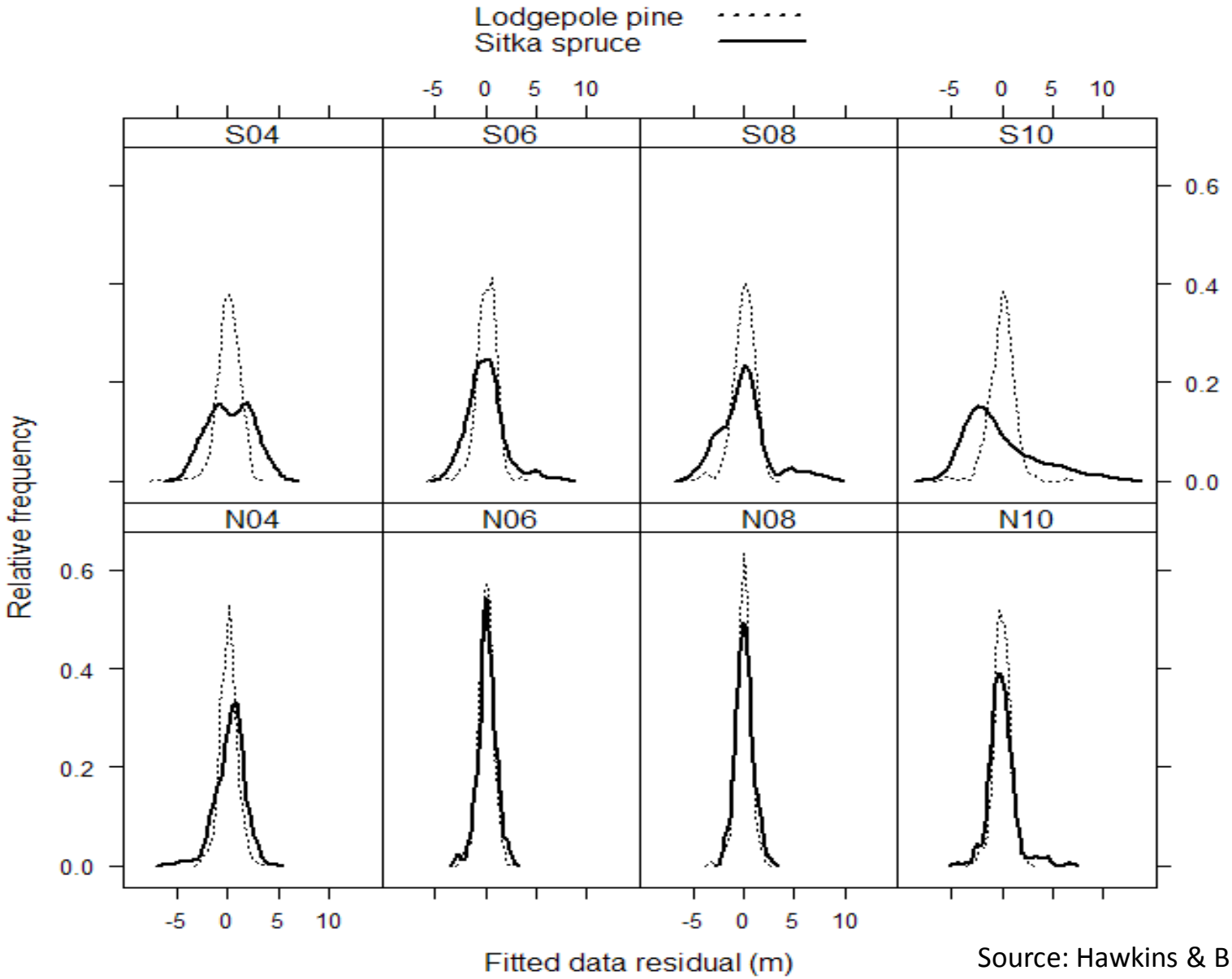
DBHinc(cm) = f(a_site + a1lnDBH + a2DBH2 + a3.lnCR + a4.lnCCF + a5.BAL)

1. SIZE

2.. COMP :Crown ratio, Crown competition factor, Basal area in larger trees

Application across a wide range of site types (Coillte PSP experiments)

Example, Sitka spruce and Lodgepole pine planted at 4, 6, 8 and 10 foot spacing's, selective (S) and no thin (N) scenarios



Source: Hawkins & Black 2012

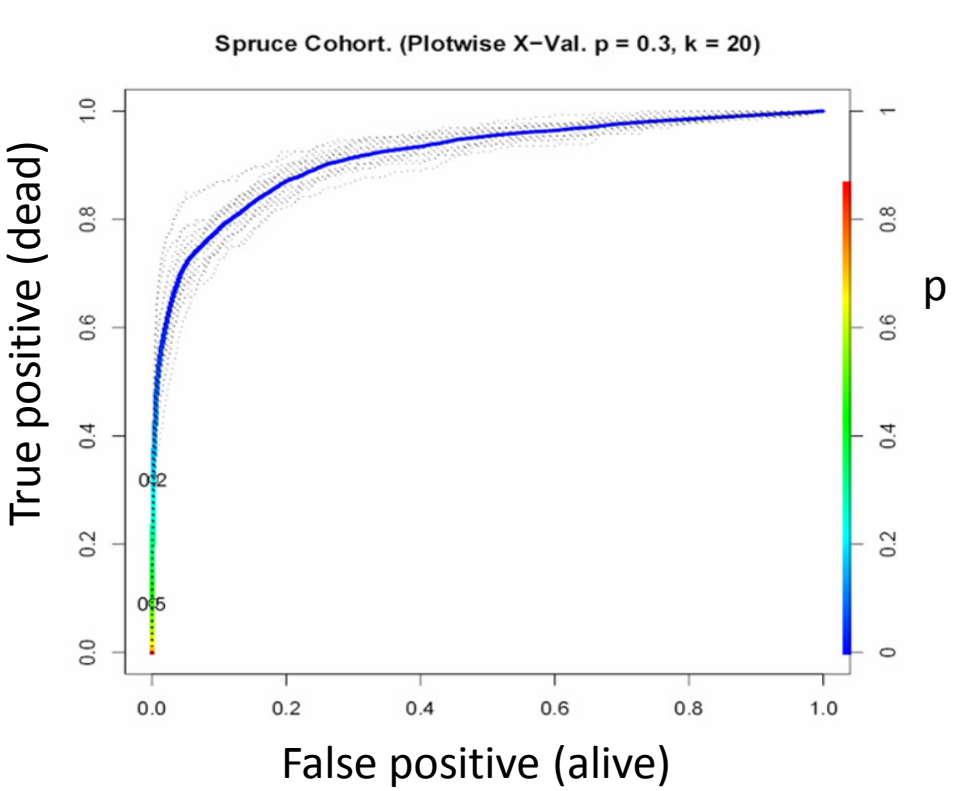
Mortality models

$$Pmort = IL(a1 + a2 \times BAL - a3 \times CR - a4 \times DBH - b1 \times \frac{1}{DBH} + c \times DBH^2$$

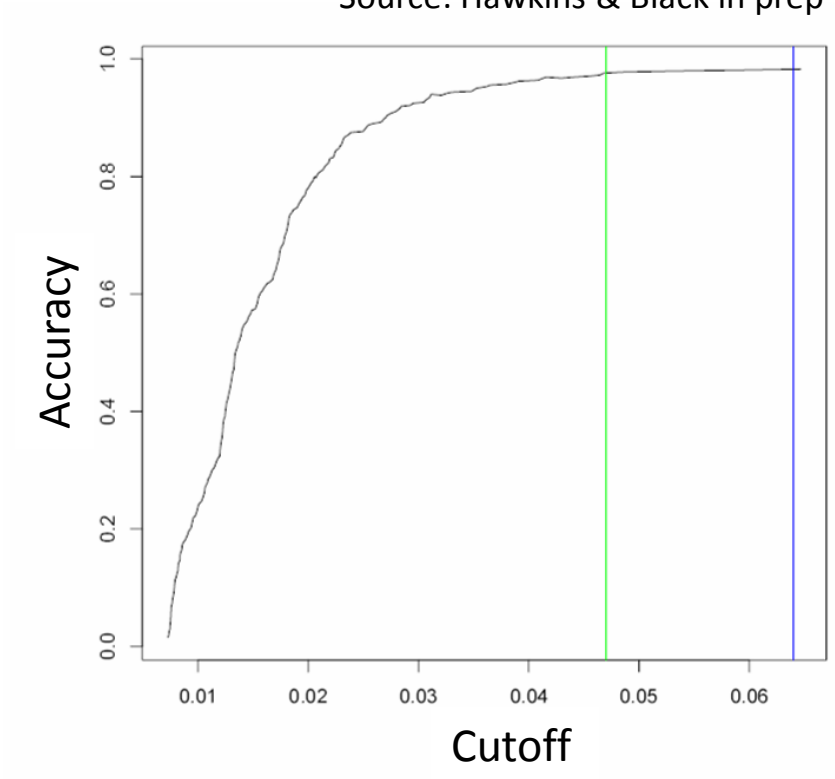
where (0 < P < 1) is the probability the tree is dead. IL(.) is the inverse logit, e.g. IL(x) = exp(x)/(1+exp(x)).

Used receiver operating characteristic curve (ROC) for performance of binary classifier
Derived probability cut off based on Bayesian statistics using NFI data as validation data set

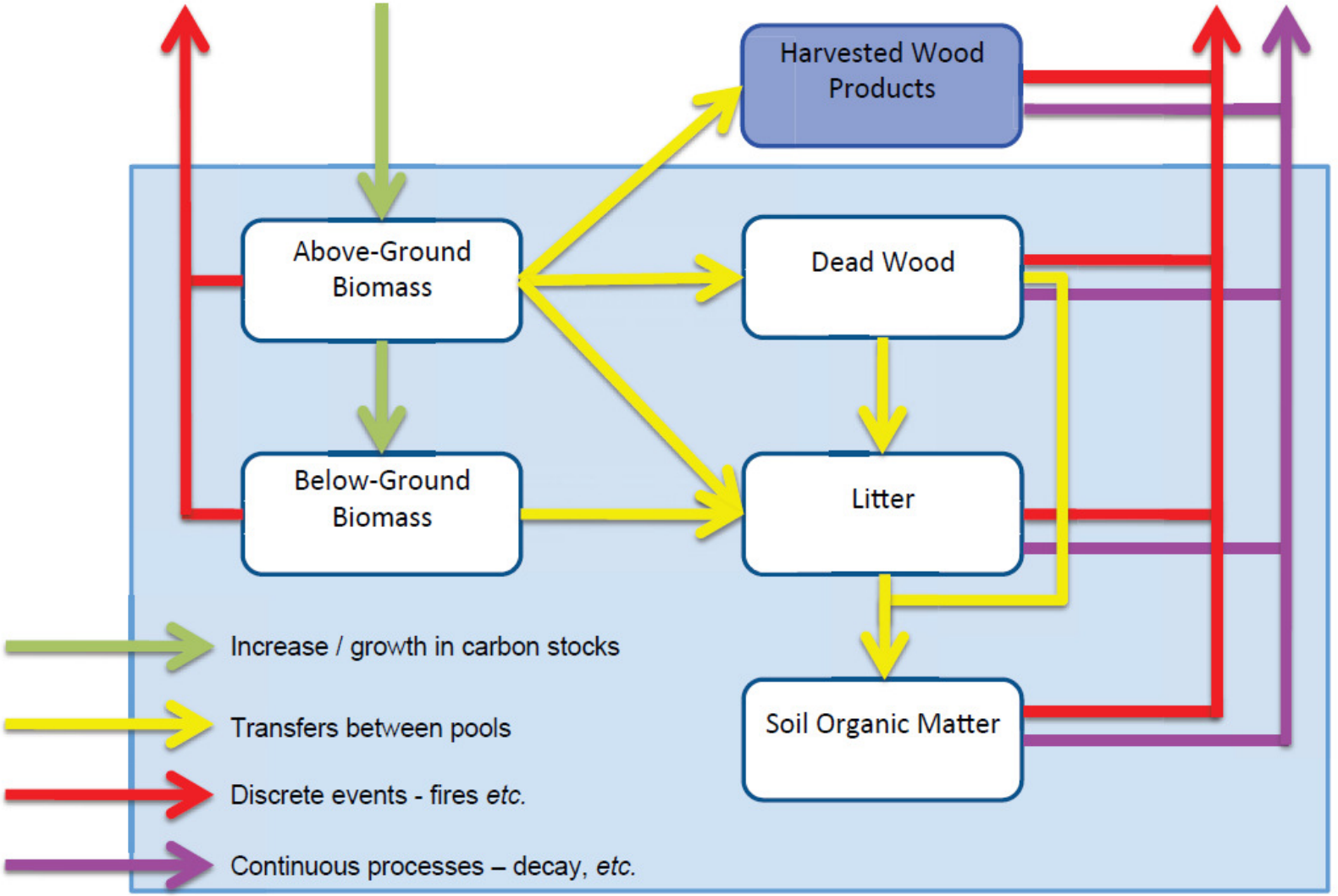
Post test probability



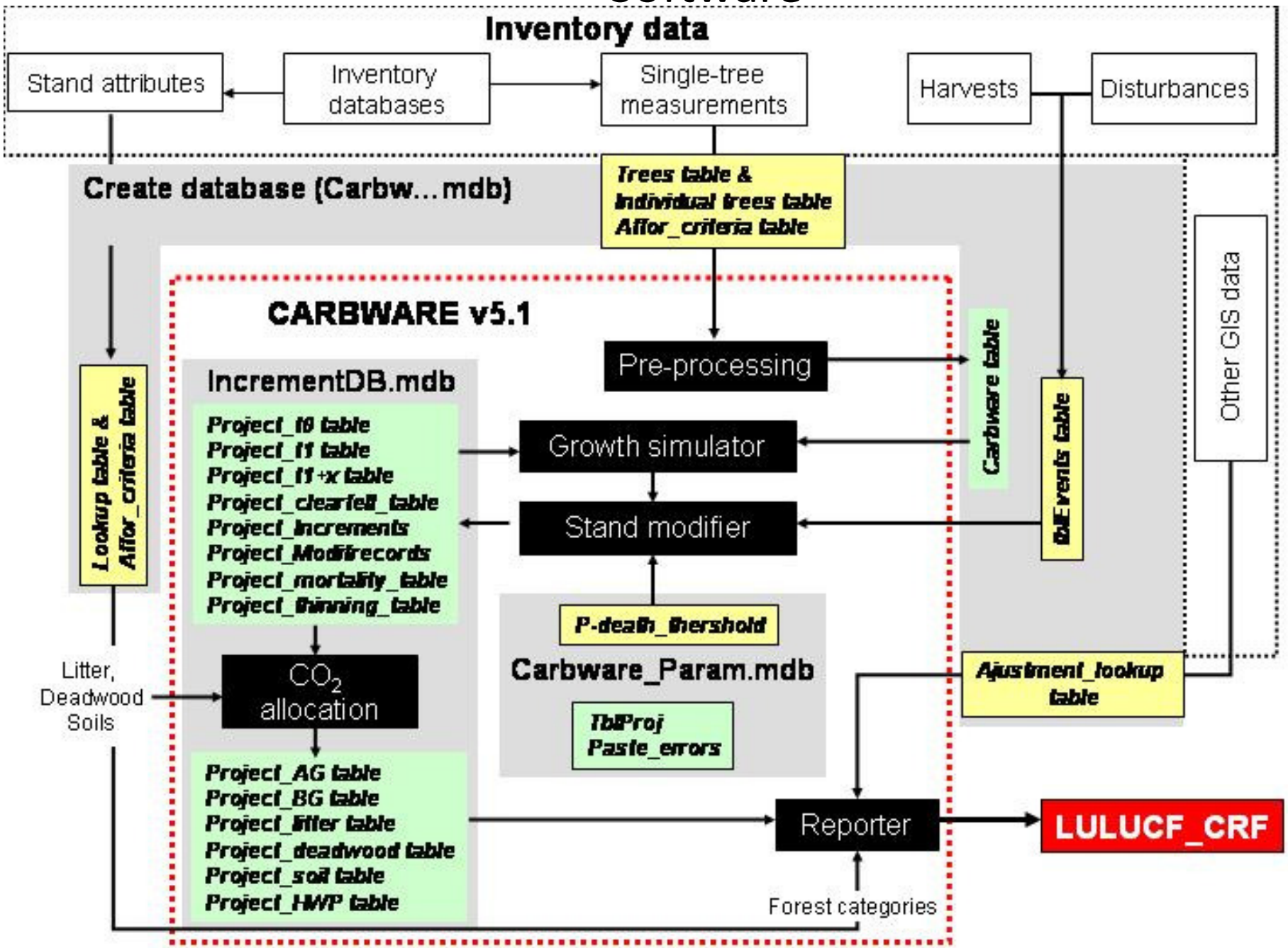
Source: Hawkins & Black in prep



C flow model


Harvested Wood Products
Above-Ground Biomass
Dead Wood
Below-Ground Biomass
Litter
Soil Organic Matter
Increase / growth in carbon stocks
Transfers between pools
Discrete events - fires *etc.*
Continuous processes – decay, *etc.*

Software


Inventory data
Stand attributes
Inventory databases
Single-tree measurements
Harvests
Disturbances
Create database (Carbw…mdb)
Trees table & Individual trees table Affor_criteria table
Other GIS data
CARBWARE v5.1
Pre-processing
Carbware table
IncrementDB.mdb
Lookup table & Affor_criteria table
Project_f0 table
Project_f1 table
Project_f1+x table
Project_clearfell_table
Project_increments
Project_Modifrecords
Project_mortality_table
Project_thinning_table
Growth simulator
Stand modifier
tblEvents table
P-death_thershold
Carbware_Param.mdb
TblProj
Paste_errors
Litter, Deadwood Soils
CO2 allocation
Ajustment_lookup table
Project_AG table
Project_BG table
Project_litter table
Project_deadwood table
Project_soil table
Project_HWP table
Reporter
LULUCF_CRF
Forest categories

NFI validation DBH increment: NFI 2006 and partially completed NFI in 2011 (70 % of plots)

Accuracy and precision for all species and size classes

Cohort	<12 cm	12-20 cm	20-30 cm	30-40 cm	>40 cm	All classes
Spruce						
Accuracy	- 0.42	0.09	0.28	0.09	-0.73	0.17 (4.8%)
Precision	1.94	1.90	1.86	1.91	2.09	2.04
P-value	<0.01	0.37	0.14	0.55	0.03	0.36
N	204	1234	1092	226	48	2804
FGB						
Accuracy	<0.001	1.44	3.06	4.19	ND	2.0 (128.1 %)
Precision	1.49	1.85	1.87	2.47	ND	2.28
P-value	0.20	<0.001	<0.0001	<0.0001	ND	<0.0001
N	64	194	183	35	19	495

Source: Black in prep

Accuracy and precision for all species across different management and in semi-natural stands

Cohort	Thinned	No thinned	Mixed Conifer	Mixed Broadleaf	Semi-natural	All classes
All						
Accuracy	0.04	0.14	0.36	1.42	-1.56	0.21 (5.9%)
Precision	1.51	1.32	1.86	2.01	2.11	1.52
P-value	0.21	0.37	0.14	0.003	<0.001	0.19
N	3204	4234	2041	2511	1148	134380

Source: Black in prep

DBH growth model validation

- Broad and Lynch (2006) reported Growfor over estimation of volume increment using Coillte PSP, experimental site bias (not evident in this study)
- Within 10% accuracy and 95 % confidence for all classes, but……
- Smaller DBH
  - Introduce error in NFI PSP sub-sample
  - Calibration-less data for smaller trees
- Broadleaf cohorts
  - Calibration- limited data
  - No calibration set for semi natural stands
- Good performance across a range of silviculural treatments
- Overall all measurement error
- Validation only tests one model component

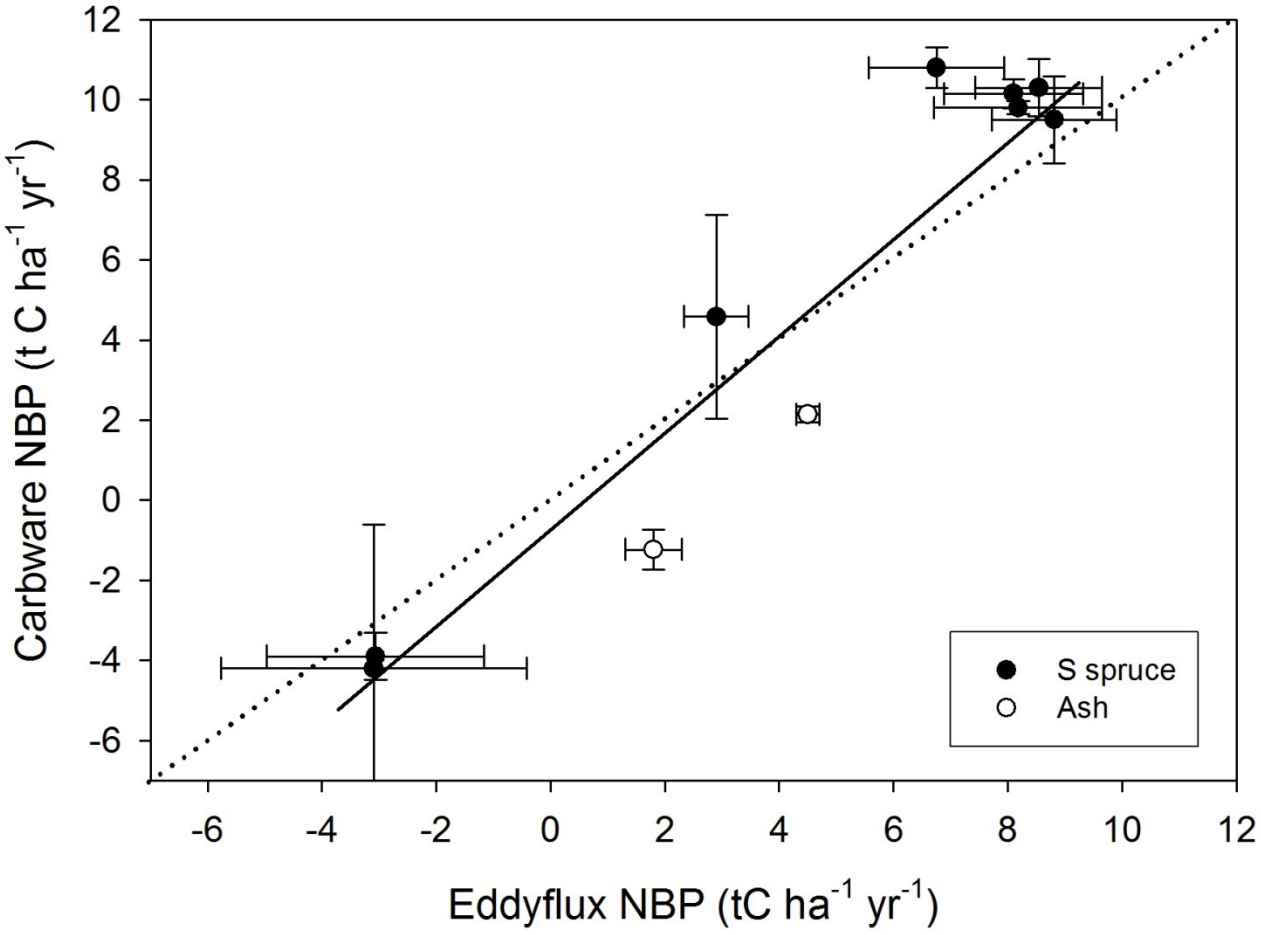
Validation of all model components

—Carbifor data- thinning experiments

Comparison of CARBWARE with flux data (thinning) tC ha^{-1}. yr^{-1}

Source: Black in prep					Source: Saunders et al., 2011	
	NBP (Carbware)	SD	NBP (NEE-harvest)	SD	NEE	SD
2006	9.63	1.09	8.81	1.09	8.81	1.09
2007	-4.42	3.64	-3.09	2.67	10.33	1.41
2008	10.82	0.48	6.75	1.19	6.75	1.19
2009	-3.49	0.59	-3.06	1.90	8.14	1.94
2010	9.82	0.16	8.18	1.40	8.18	1.47
2011	10.34	0.72	8.54	1.10	8.54	1.11

Chronosequence validation

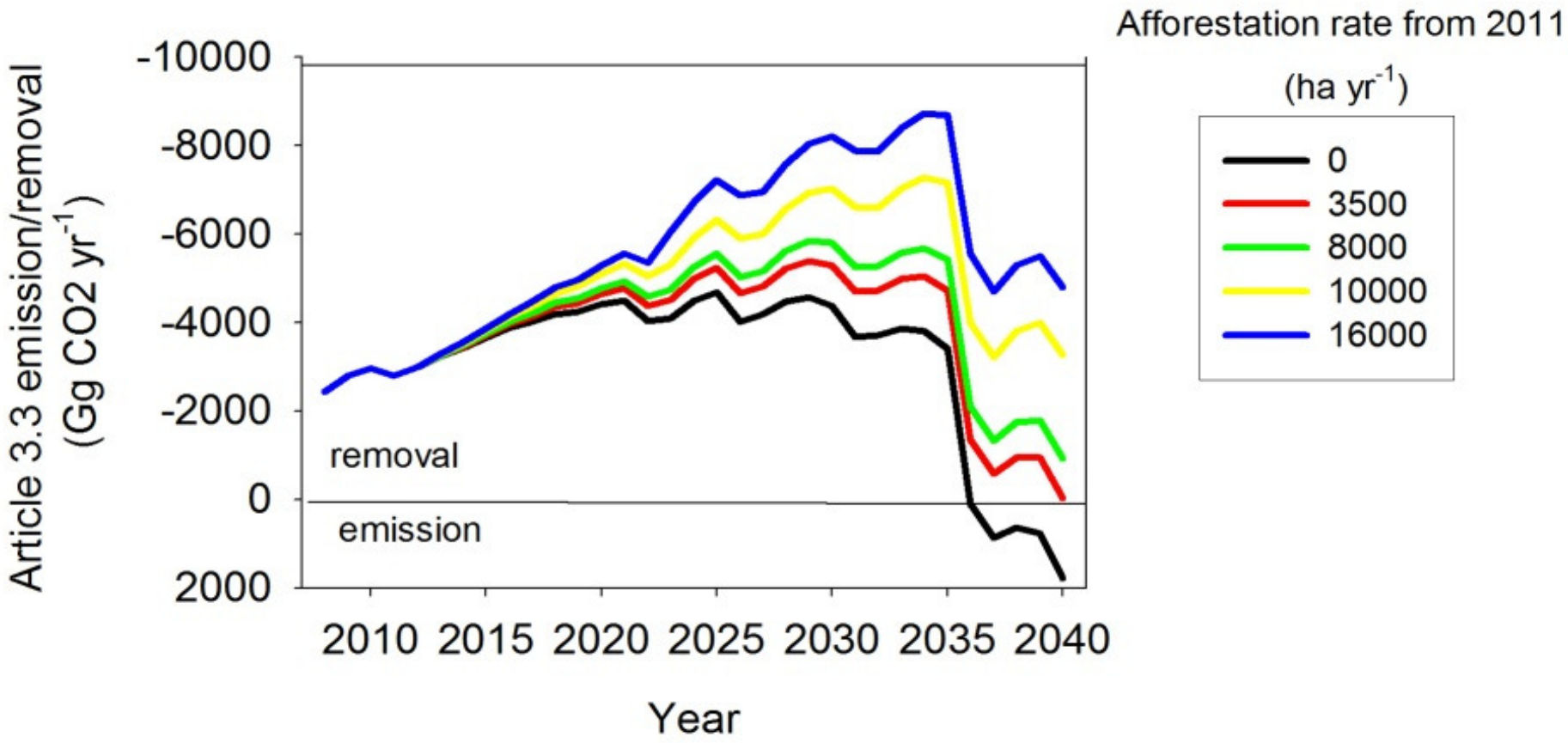


All model components

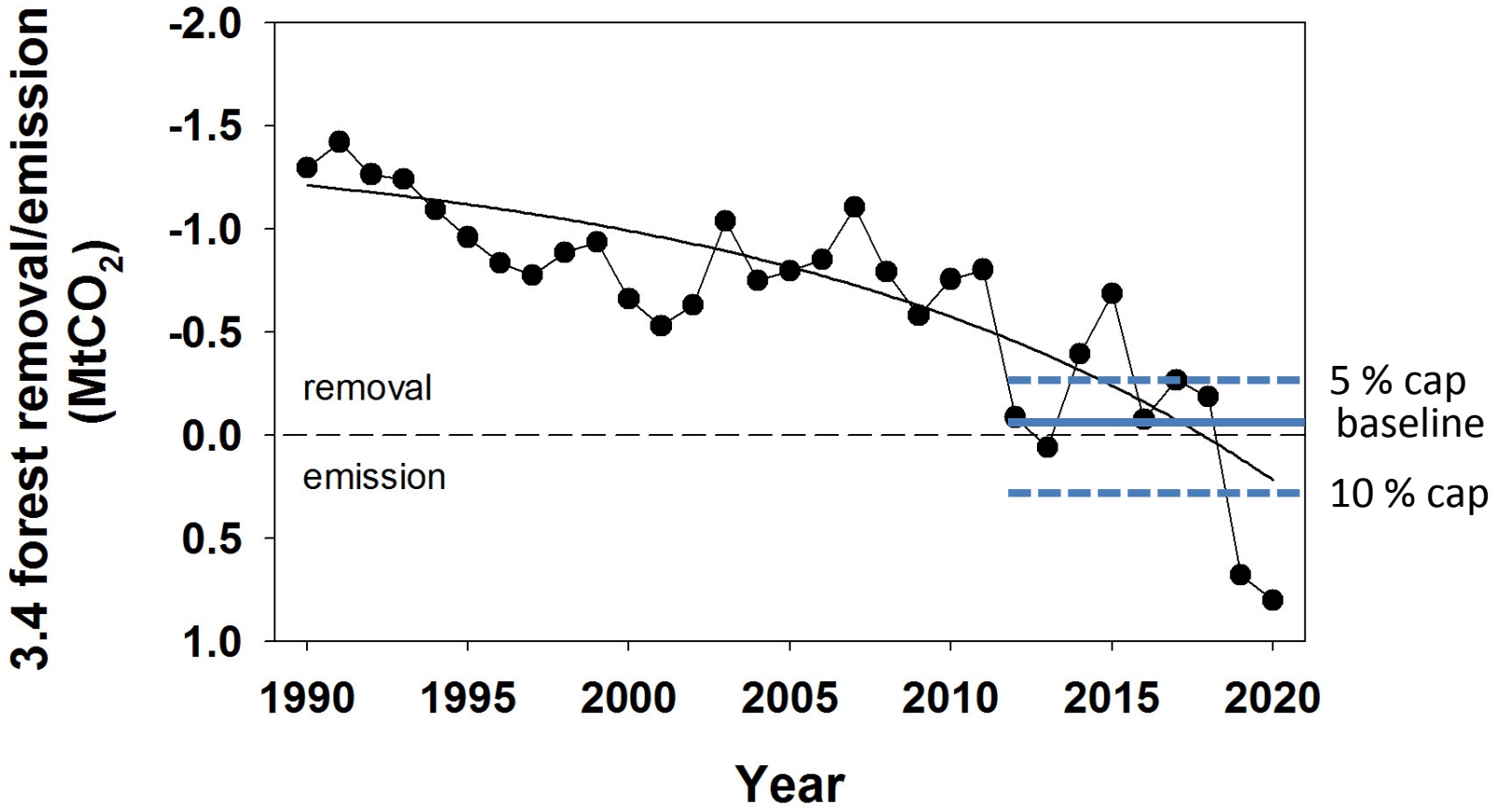
- Within 21% accuracy and 90 % confidence
  - Carbware slight overestimation in Spruce sites but under estimation in Ash site
- Inter-annual variability not captured
- Broadleaf cohorts
  - Growth model
  - C flow- transfer functions e.g. litter fall
  - Biomass algorithms
- Discrete processes e.g. thinnings compared well with eddyflux data
- Non forest biomass at pre canopy closure

National projections

Post 1990 forests (art 3.3)

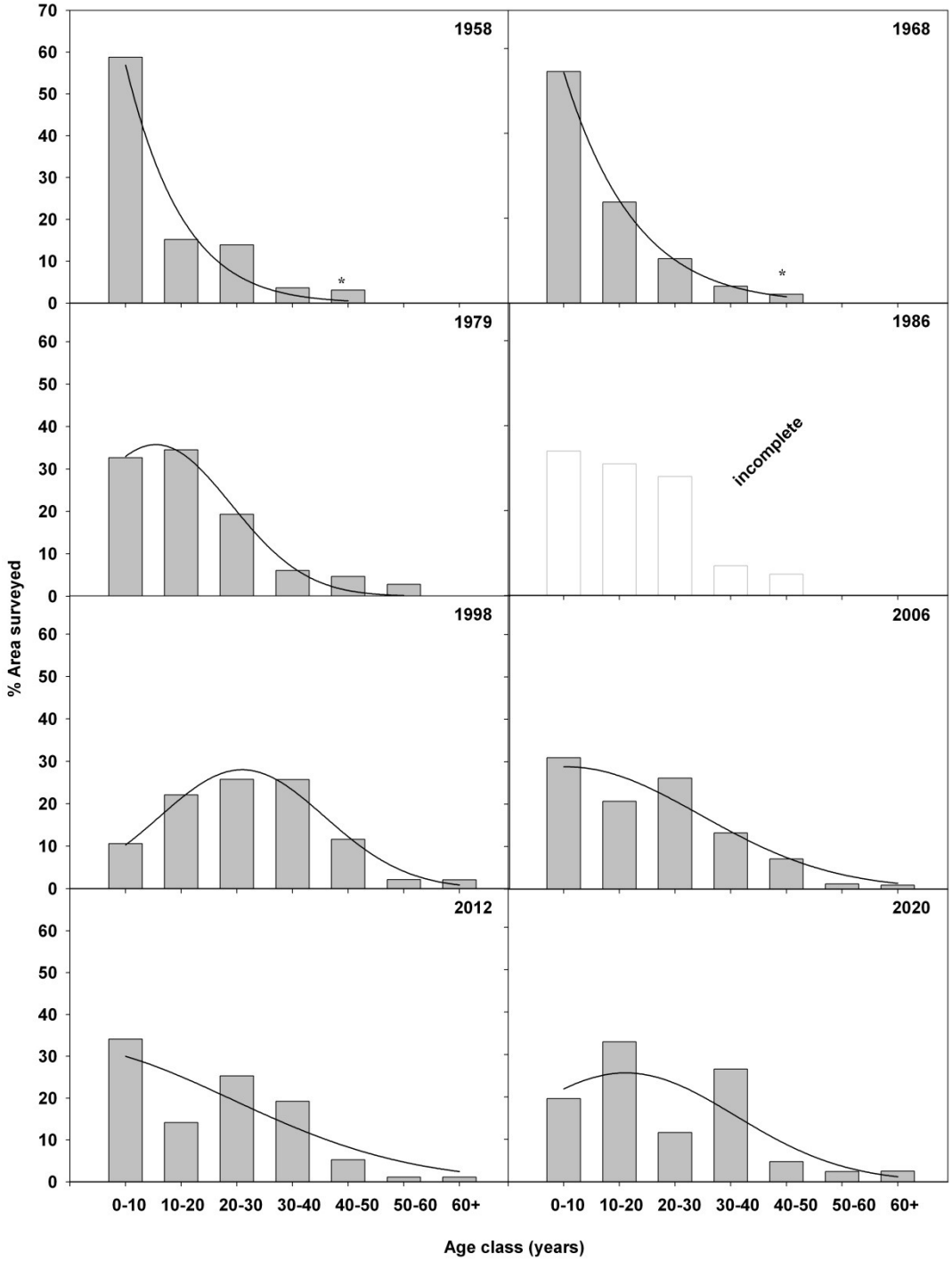


Pre-1990 forest (art 3.4 FM)



BAU scenario based on Coillte forecast

Source: Black et al., 2012



Source: Black et al., 2012

Future improvements

- Models performs well but need more growth data for FGB, SGB and trees less than 12 cm DBH
- Models do not account for inter-annual variability and non forest biomass
- NFI sampling design increases uncertainty
- Continuous validation and refinement as more NFI cycles are completed: Site effects in growth model
- Soils, fires and deforestation???

Other applications

- Designed for Irish NFI, but can be used with other data
- Single tree growth forecasting
  - Timber assortment and taper, better performance than assortment classes (based in individual tree data)
  - Timber and biomass resource optimisation