Modelling the volume of bark from thickness measurements obtained by Swedish bark gauge and from X-ray CT images. Application to the quantification of extractives.

Rodolphe Bauer

In collaboration with Alain Bouvet (FCBA)

Method presentation

Introduction

INRA thesis :
Rodolphe Bauer

LERMAB postdoc
: Maree Brennan

$$M_{extractible\ compartiment} = Volume_{compartiment} * \rho_{b\ compartiment} * C_{exctractible\ du\ compartiment}$$

Ressource évaluation :
Jean-Baptiste
Pichancourt and IGN

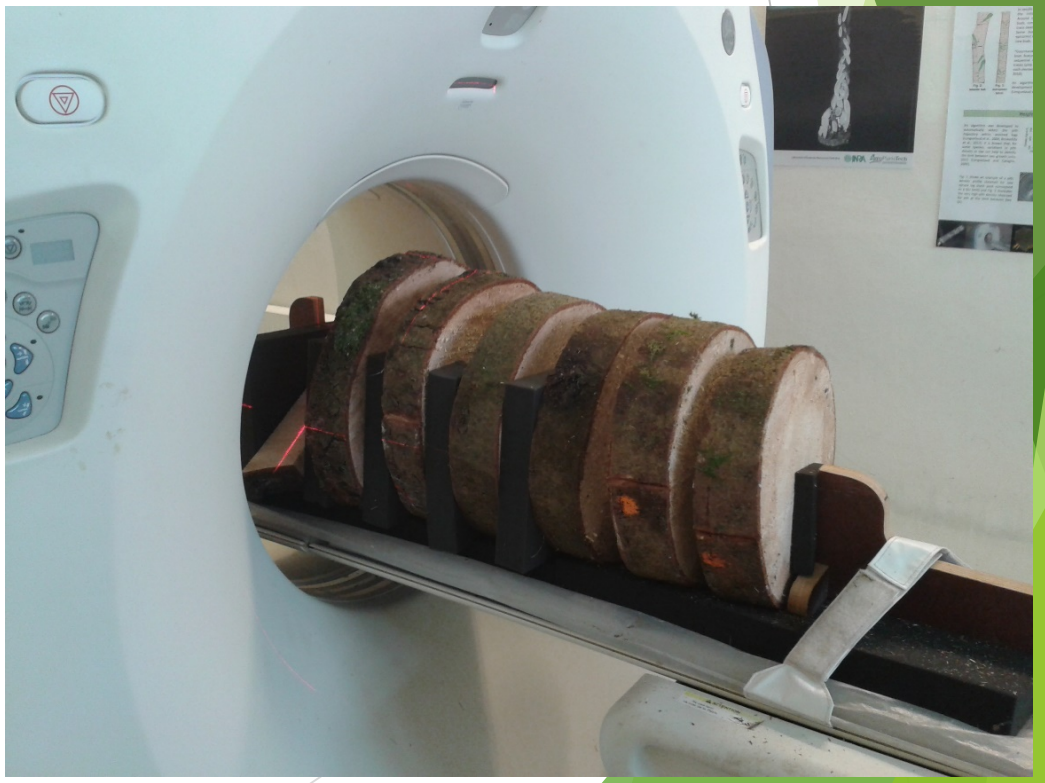
INRA thesis :
Antoine Billard

Method presentation : Data origin

Data origin	Measurement type	Measurement method	Number of data	Species	Number of Trees
FCBA	Bark thickness and stem circumference at different heights	Bark gauge	21221	Fir	924
Extraforest	Bark area and stem area at different heights	Scanner RX trimming	120	Fir	8
Modelfor	Bark area and stem area at different heights	Scanner RX trimming	344	Fir	29
FCBA	Bark thickness and stem circumference at different heights	Bark gauge	22658	Spruce	1032
Extraforest	Bark area and stem area at different height	Scanner RX trimming	120	Spruce	8
FCBA	Bark thickness and stem circumference at different heights	Bark gauge	4931	Douglas fir	335
Extraforest	Bark area and stem area at different heights	Scanner RX trimming	120	Douglas fir	8
Modelfor	Bark area and stem area at different heights	Scanner trimming	404	Douglas fir	29

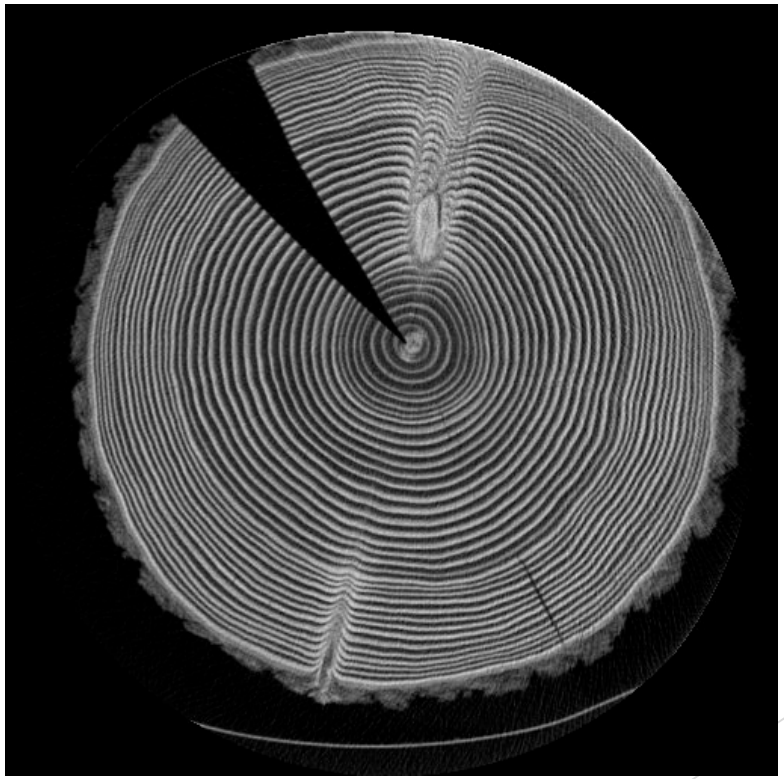
Method presentation : Scanner measurement

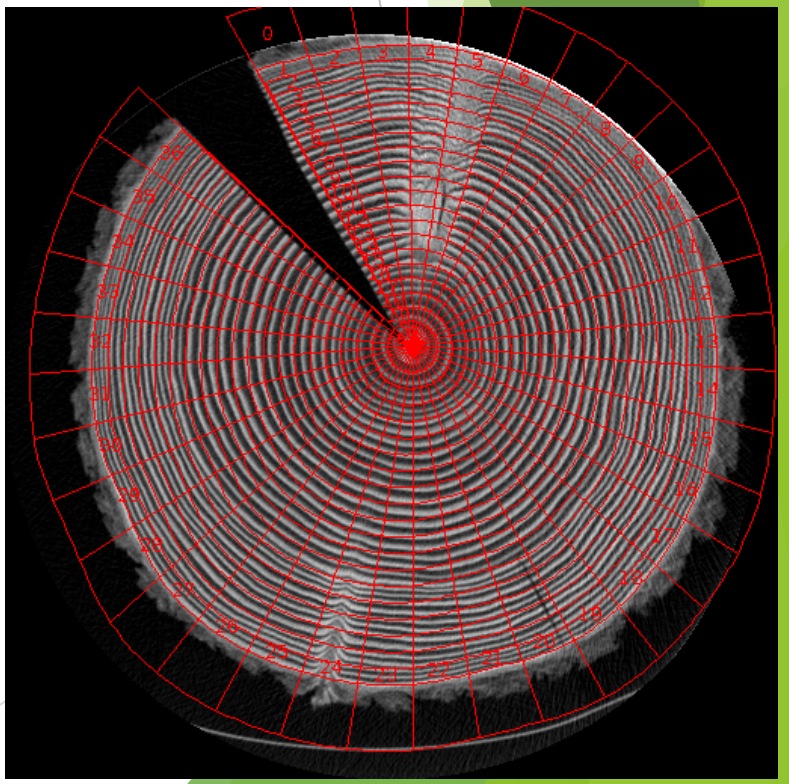
- Harvesting of samples on the field
- Passage of sample in X-ray Scanner



Method presentation : Scanner RX measurement

- First scanner image
- Use of “Calden QB” plugin
- Trimming with “Gourmand” plugin
- Stem and bark area calculation with “Gourmand”





Method presentation : Bark gauge measurement

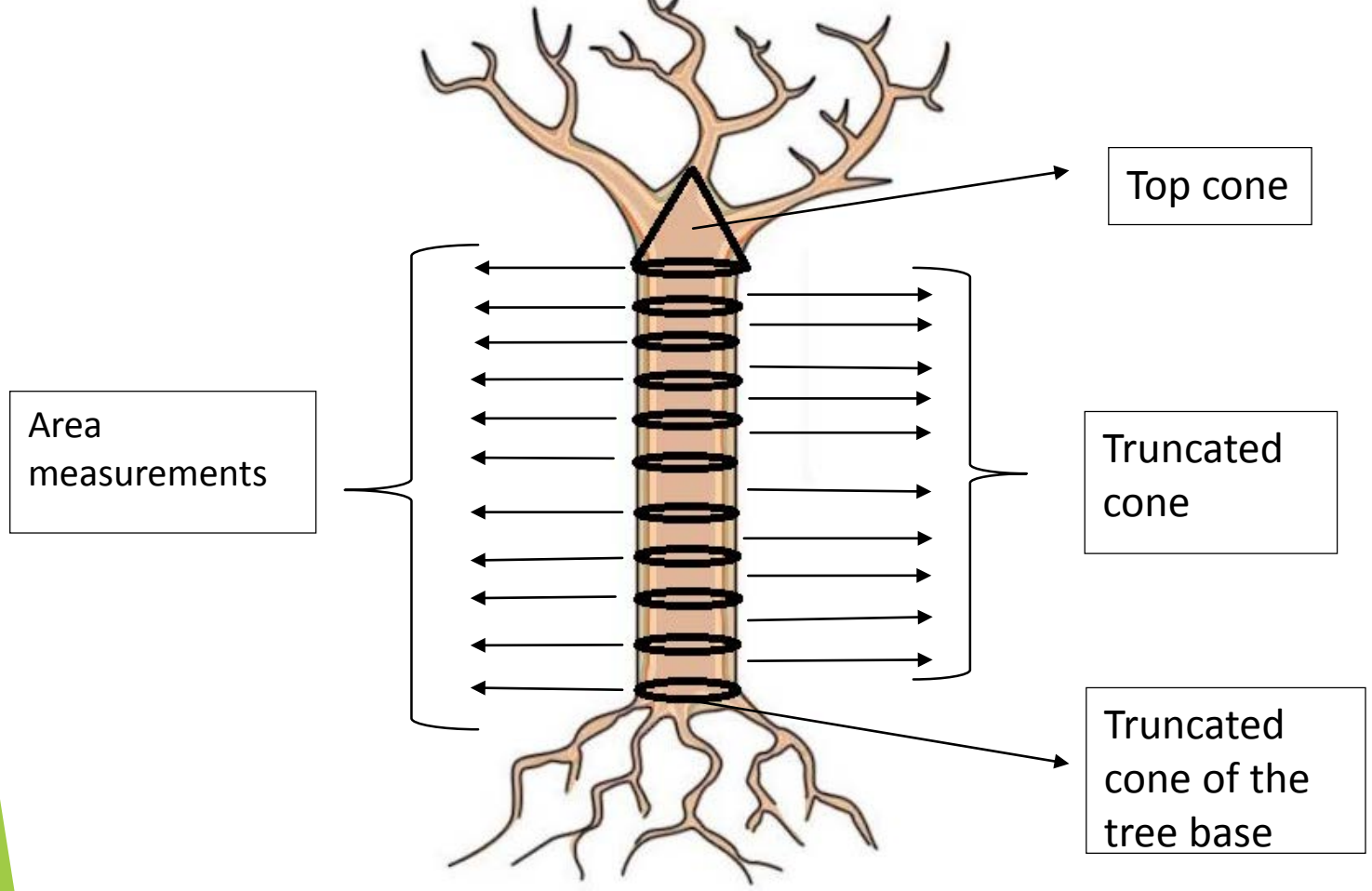
- Measurement at different height of bark thickness
- No need to cut down a tree
- Use of a meter for stem circumference

Method presentation : Bark gauge measurement

- Drawback : weak accuracy
- Measurement error : +0,52+-1,59 mm (Stängle et al 2016)

Method presentation : Bark volume determination

- Calculation of bark and stem area for FCBA measurement



$$V = \frac{h}{3} * S1$$

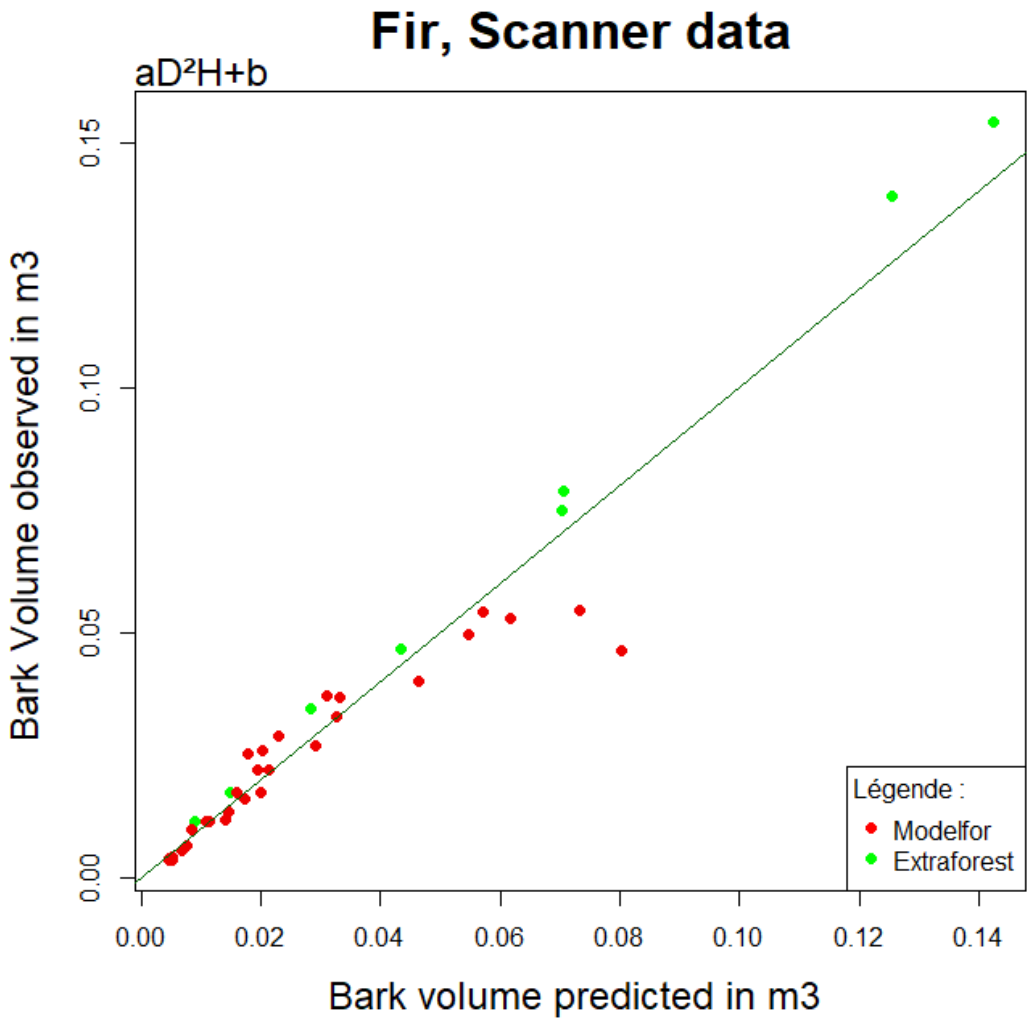
$$V = \frac{h}{3} * (S1 + \sqrt{S1 * S2} + S2)$$

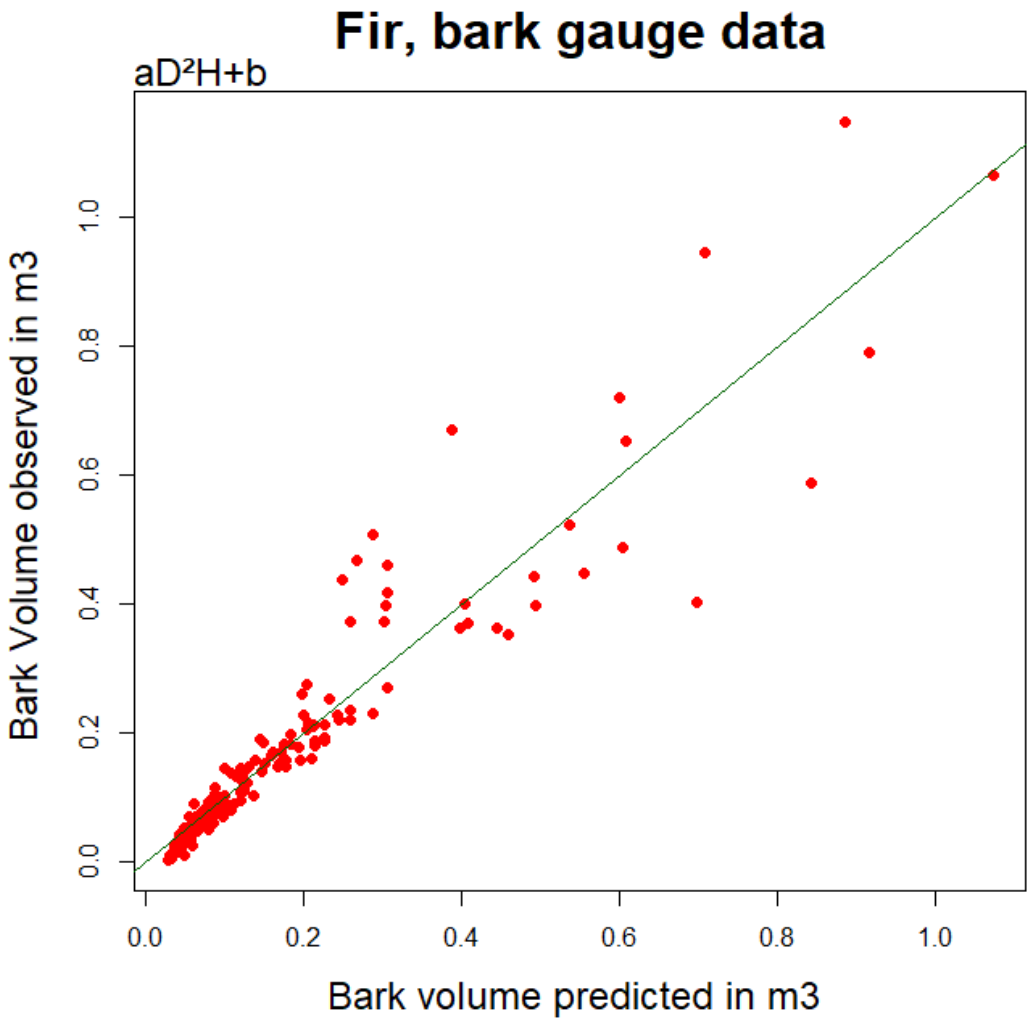
$$V = \frac{h}{3} * \left(S1 + \sqrt{S1 * S2} + S2\right)$$

With S2 estimated from the two first measurements

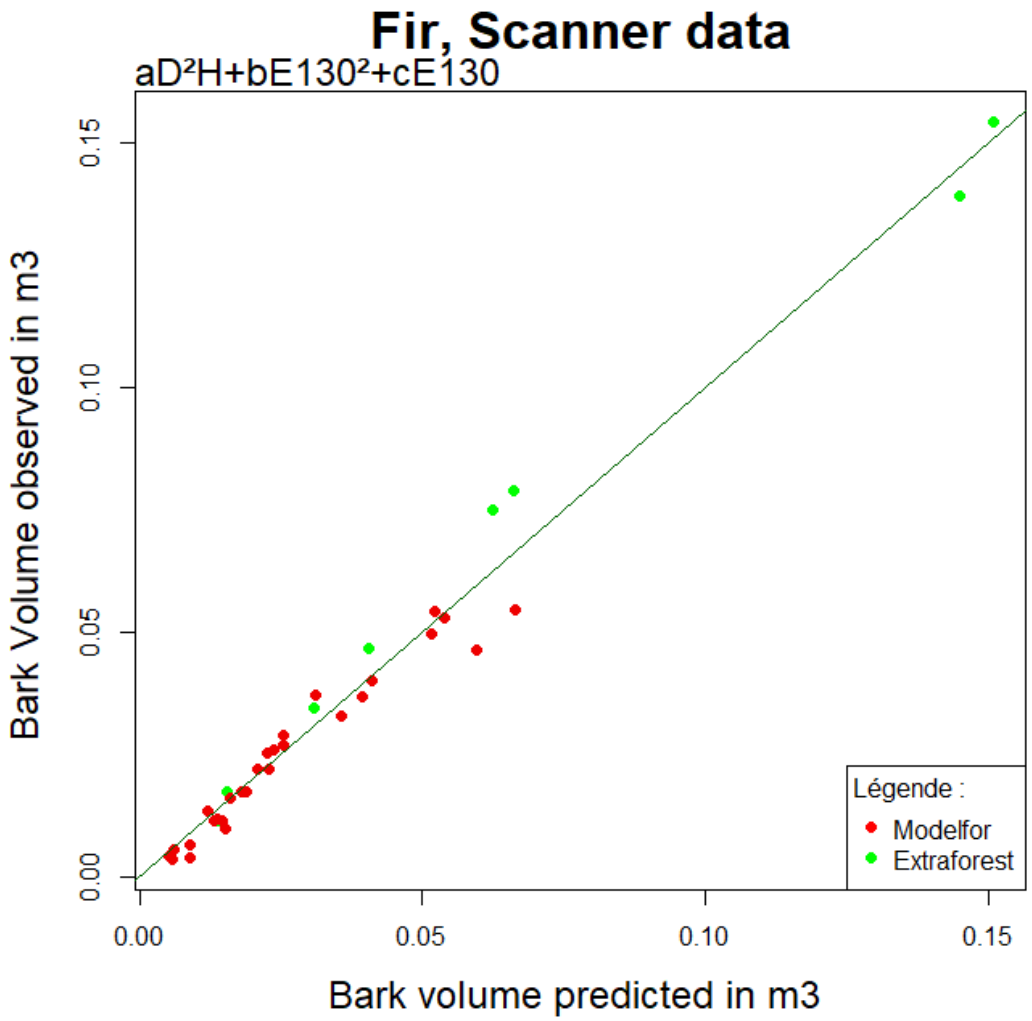
Results

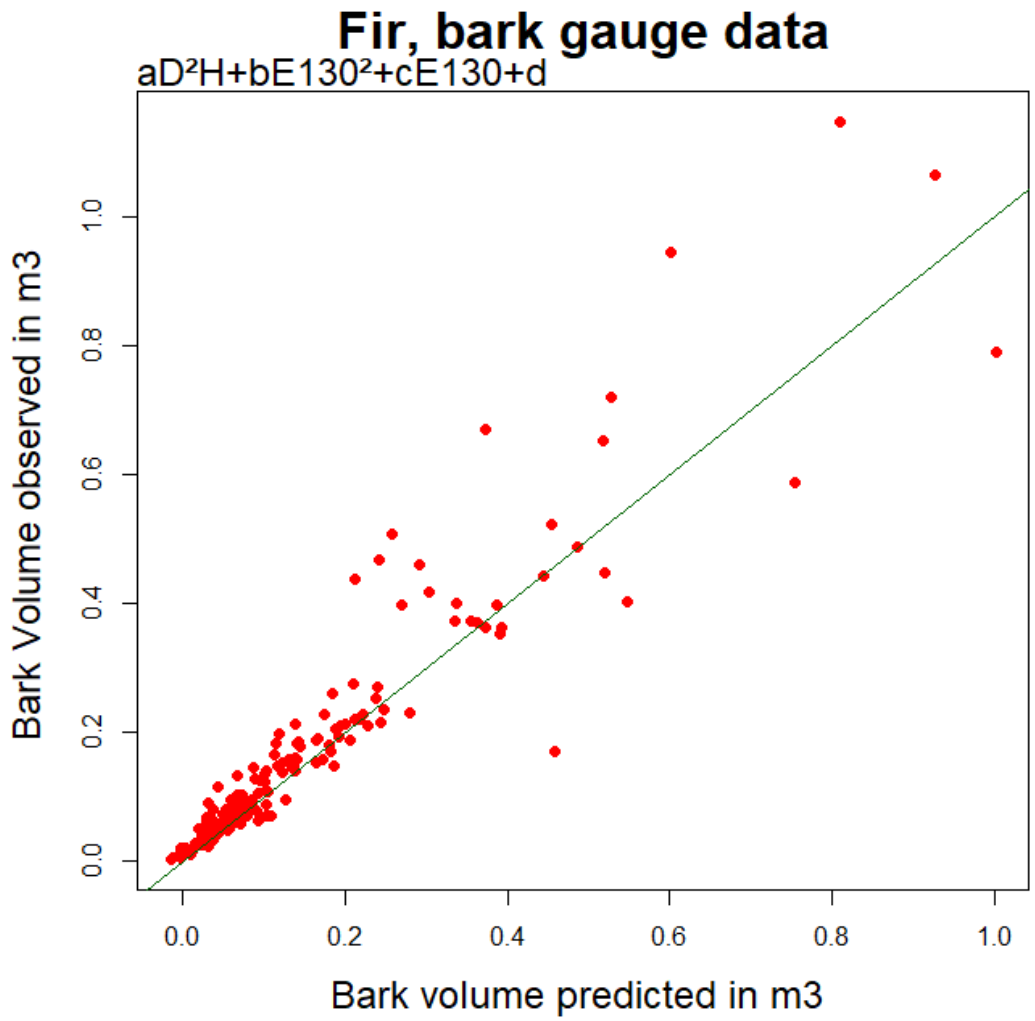
Results: Fir


Fir, Scanner data
aD²H+b
Bark Volume observed in m3
Bark volume predicted in m3
0.00
0.05
0.10
0.15
0.00
0.02
0.04
0.06
0.08
0.10
0.12
0.14
Légende :
Modelfor
Extraforest


Fir, bark gauge data
aD²H+b
Bark Volume observed in m3
Bark volume predicted in m3
0.0
0.2
0.4
0.6
0.8
1.0
0.0
0.2
0.4
0.6
0.8
1.0

Results: Fir

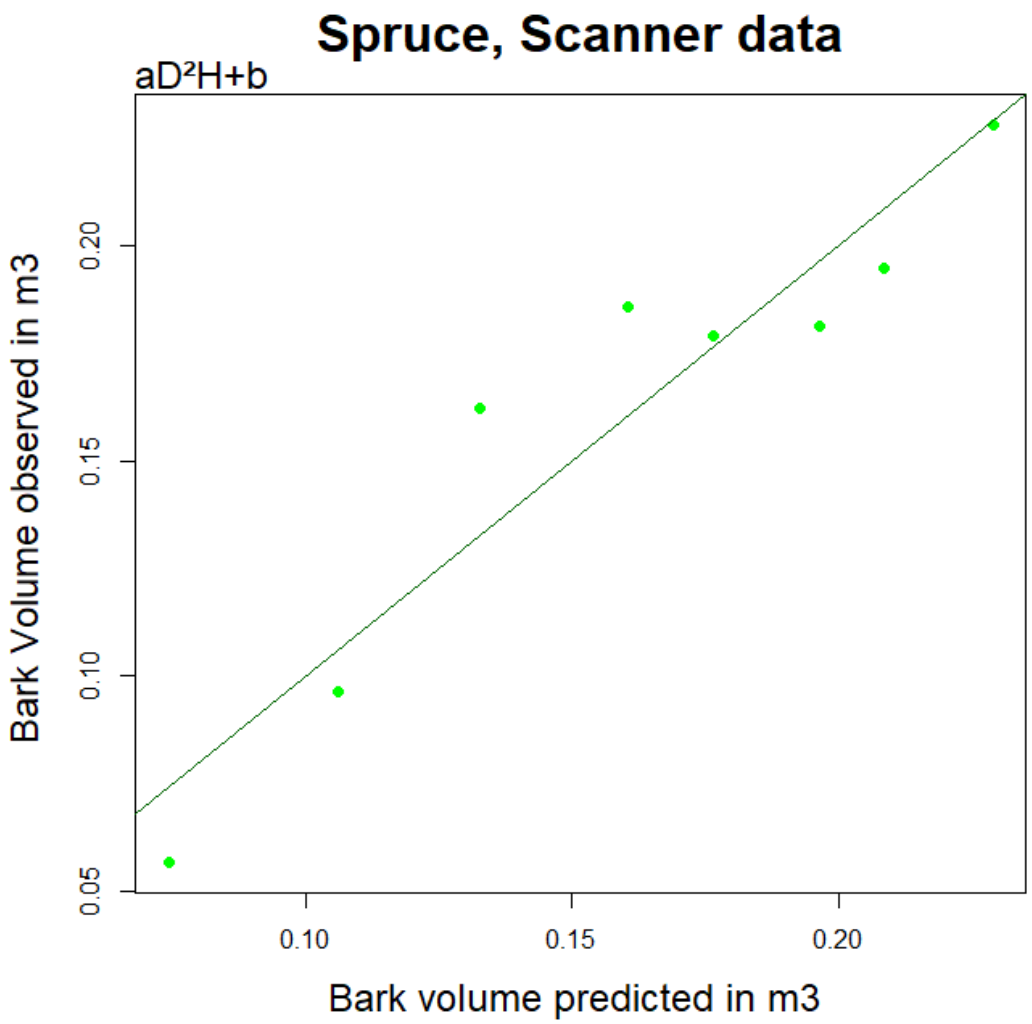

Fir, Scanner data
aD²H+bE130²+cE130
Bark Volume observed in m3
Bark volume predicted in m3
0.00
0.05
0.10
0.15
Légende :
Modelfor
Extraforest

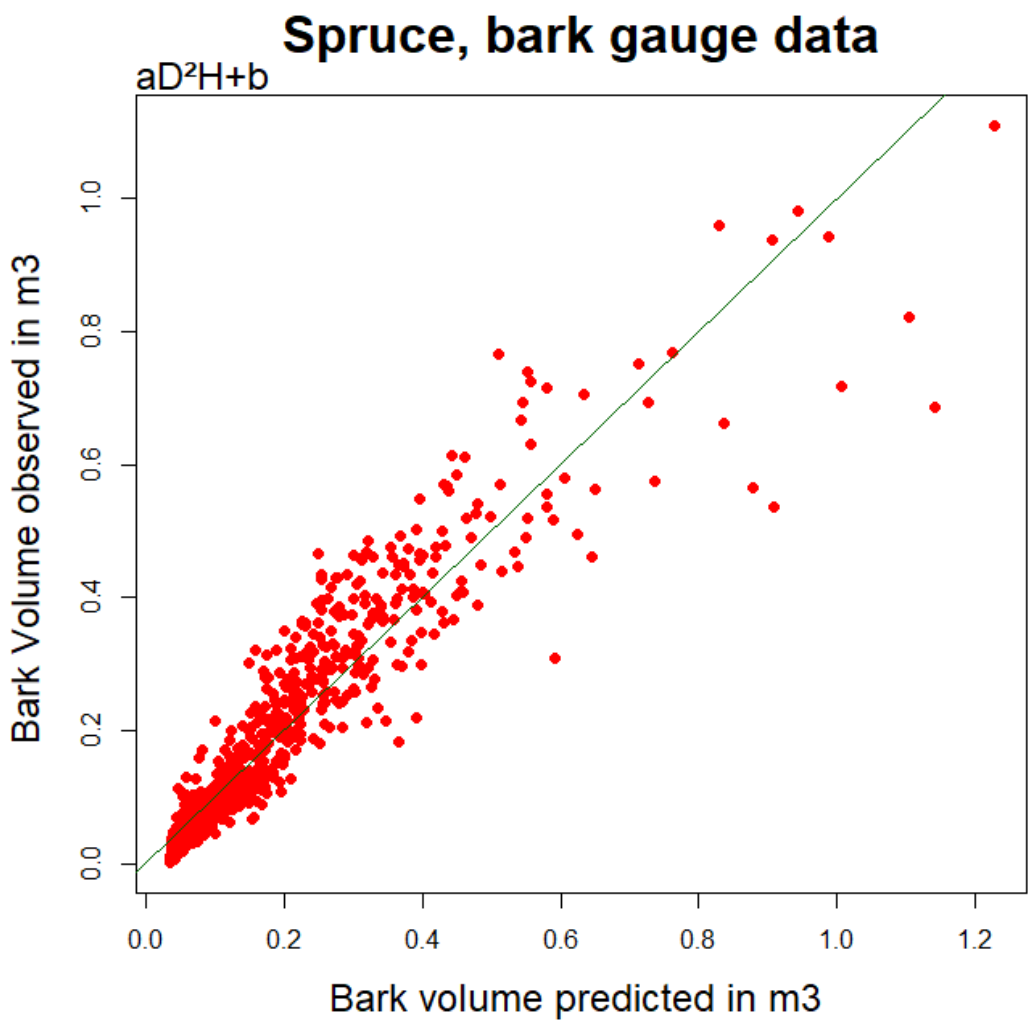

Fir, bark gauge data
aD²H+bE130²+cE130+d
Bark Volume observed in m3
Bark volume predicted in m3
0.0
0.2
0.4
0.6
0.8
1.0

Result: Fir

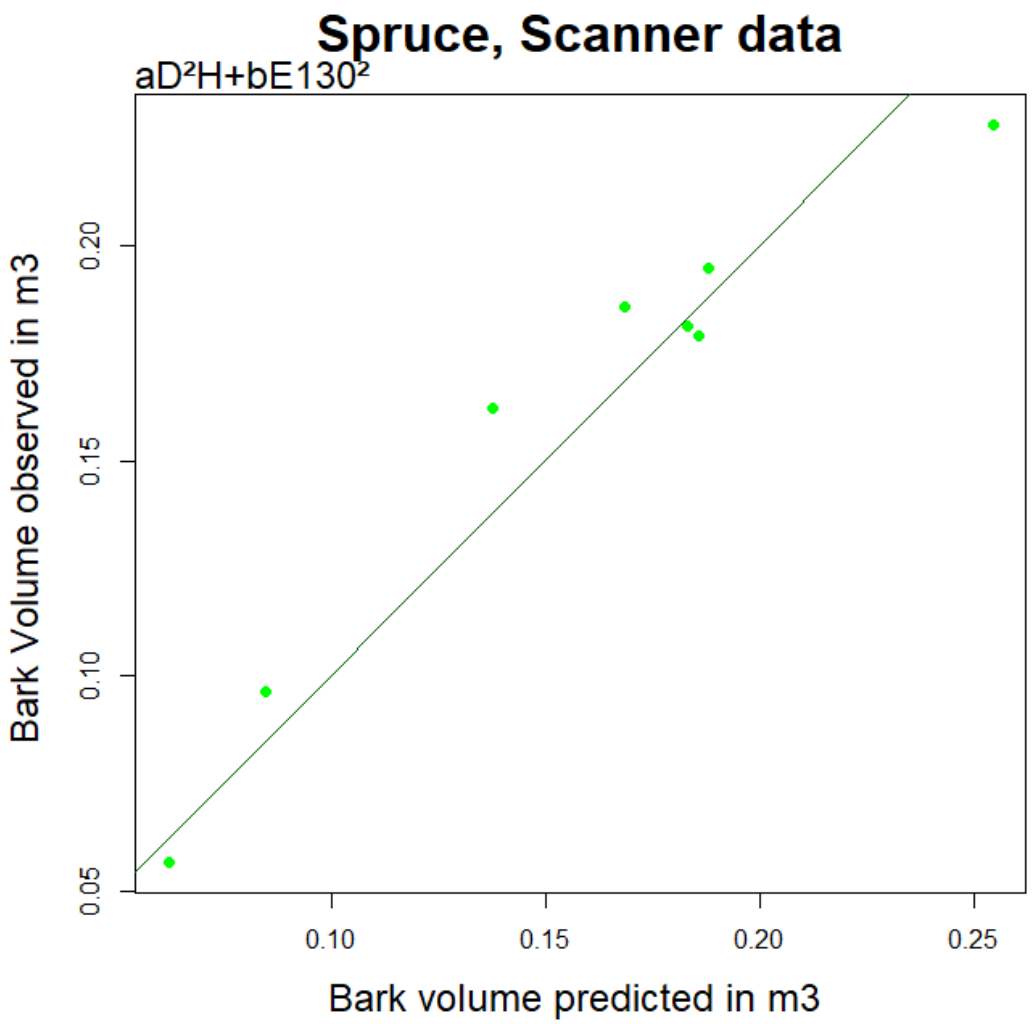
	Scanner RX : $aD^2H+bE130^2+cE130$	Scanner RX : aD^2H	Scanner RX : aD^2H+b	Jauge : $aD^2H+bE130^2+cE130+d$	Jauge : aD^2H	Jauge : aD^2H+b
RMSE	4,96E-03	8,35E-03	7,96E-03	7,25E-02	9,87E-02	9,35E-02
AIC	-2,80E+02	-2,45E+02	-2,47E+02	-2,80E+02	-2,45E+02	-2,47E+02
Paramètre a	2,19E-02	4,02E-02	3,82E-02	3,10E-02	4,17E-02	3,85E-02
Paramètre b	2,76E-04	/	3,45E-03	3,61E-04	/	4,00E-02
Paramètre c	1,55E-03	/	/	4,07E-03	/	/
Paramètre d	/	/	/	-2,37E-02	/	/
Significativité a	1,60E-10	9,16E-29	2,60E-23	0,00E+00	9,16E-29	0,00E+00
Significativité b	3,54E-06	/	7,03E-02	3,06E-10	/	4,00E-23
Significativité c	3,89E-04	/	/	1,35E-02	/	/
Significativité d	/	/	/	1,63E-02	/	/
R^2	0,98	0,94	0,94	0,92	0,86	0,86

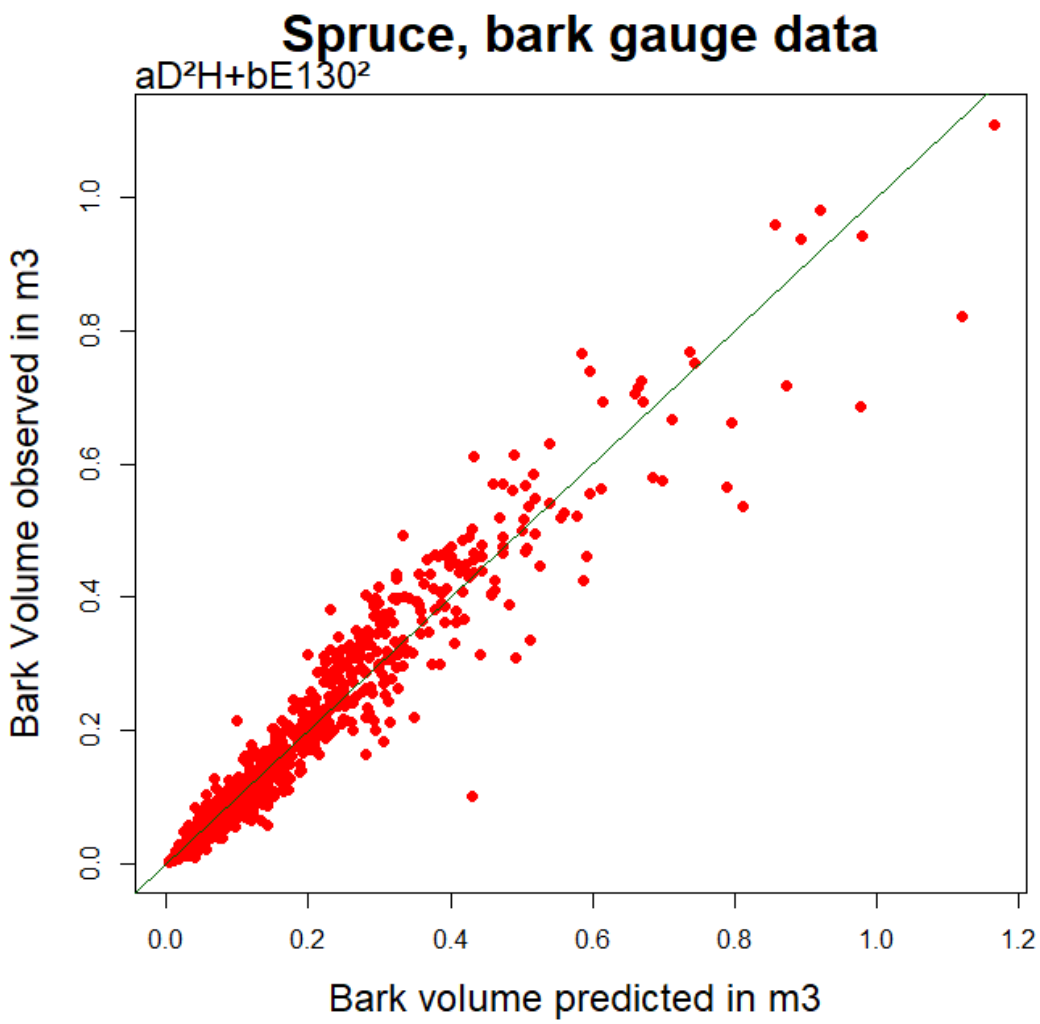
Result: Spruce





Results: Spruce

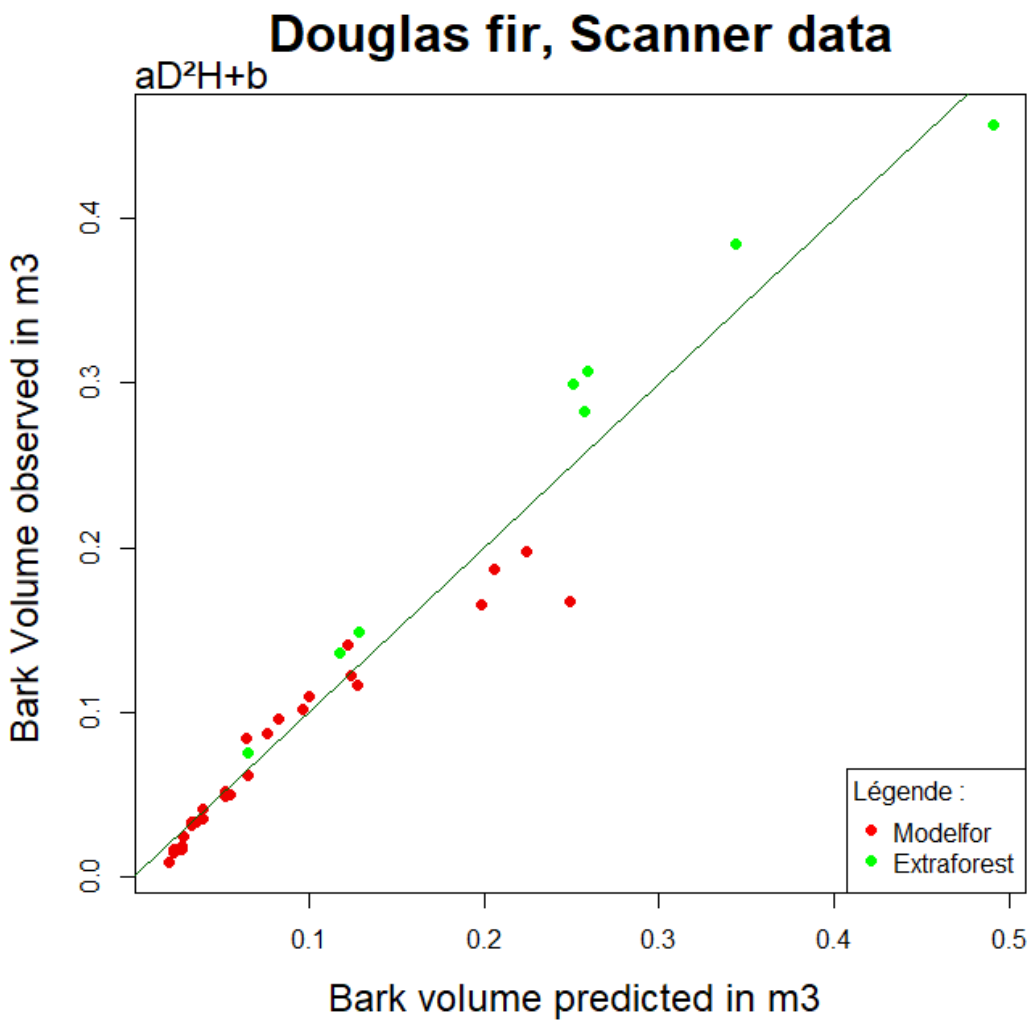


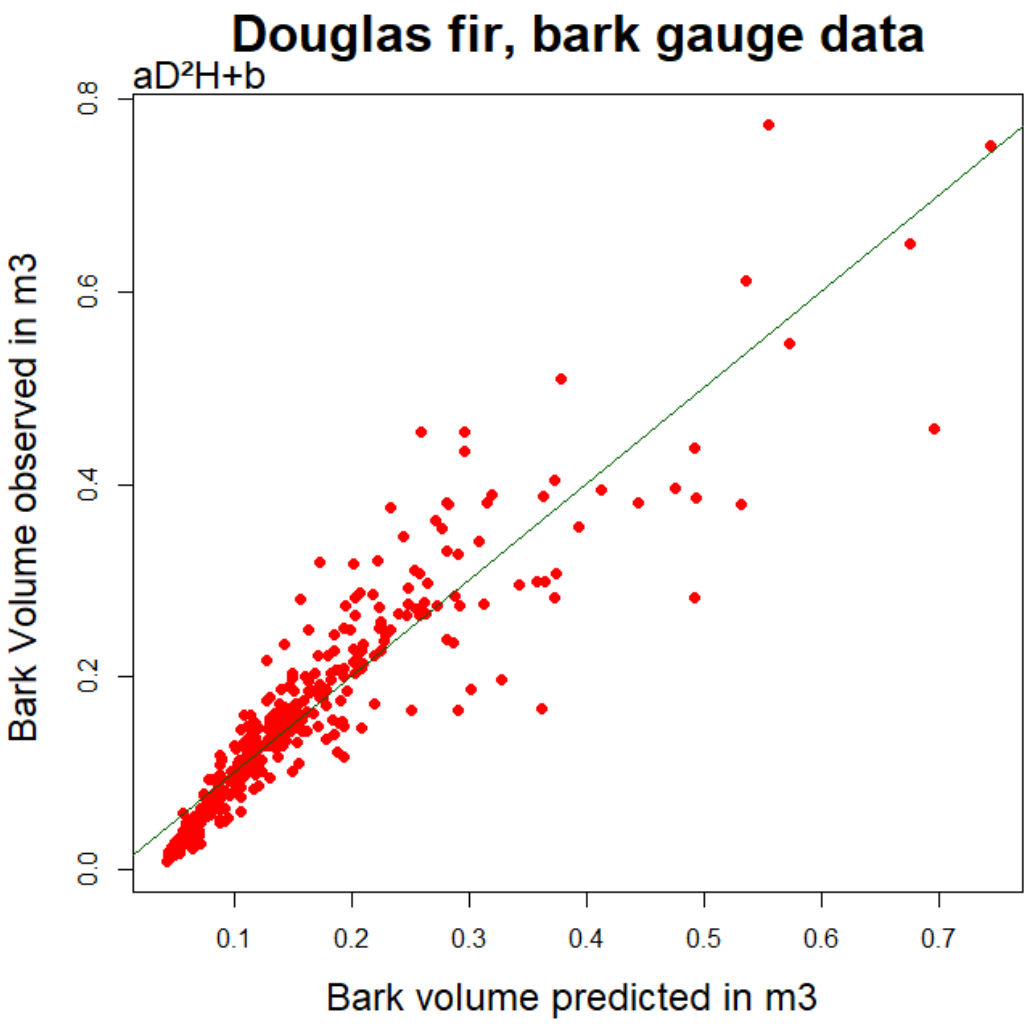


Result: Spruce

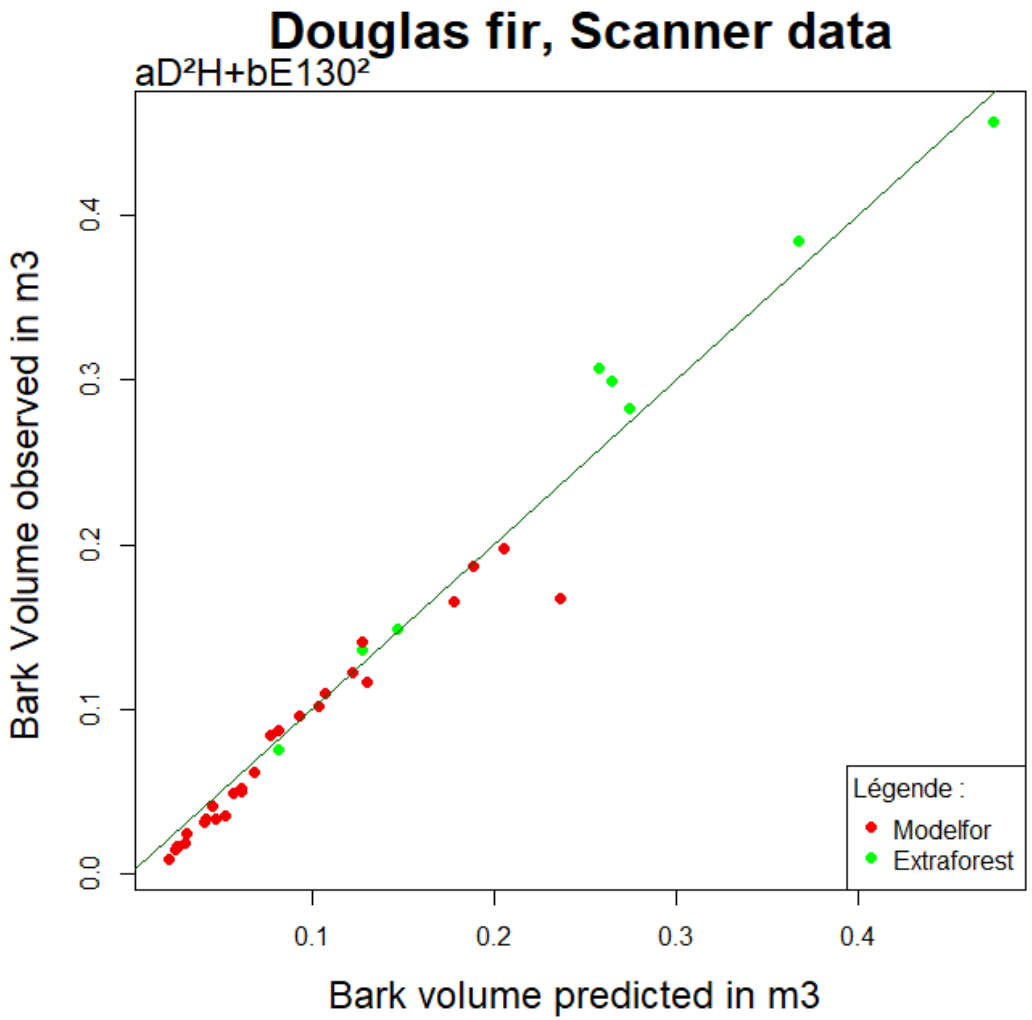
	Scanner RX : $aD^2H+bE130^2$	Scanner RX : aD^2H	Scanner RX : aD^2H+b	Jauge : $aD^2H+bE130^2$	Jauge : aD^2H	Jauge : aD^2H+b
RMSE	1,51E-02	2,22E-02	1,71E-02	4,30E-02	6,25E-02	5,63E-02
AIC	-3,84E+01	-3,42E+01	-3,64E+01	-3,84E+01	-3,42E+01	-3,64E+01
Parameter a	2,70E-02	4,22E-02	3,33E-02	2,32E-02	3,33E-02	3,00E-02
Parameter b	6,83E-04	/	3,78E-02	5,98E-04	/	3,46E-02
Signifiance a	3,89E-03	2,00E-07	3,87E-04	0,00E+00	2,00E-07	0,00E+00
Signifiance b	3,82E-02	/	8,81E-02	9,92E-170	/	1,01E-48
R^2	0,94	0,89	0,89	0,93	0,88	0,88

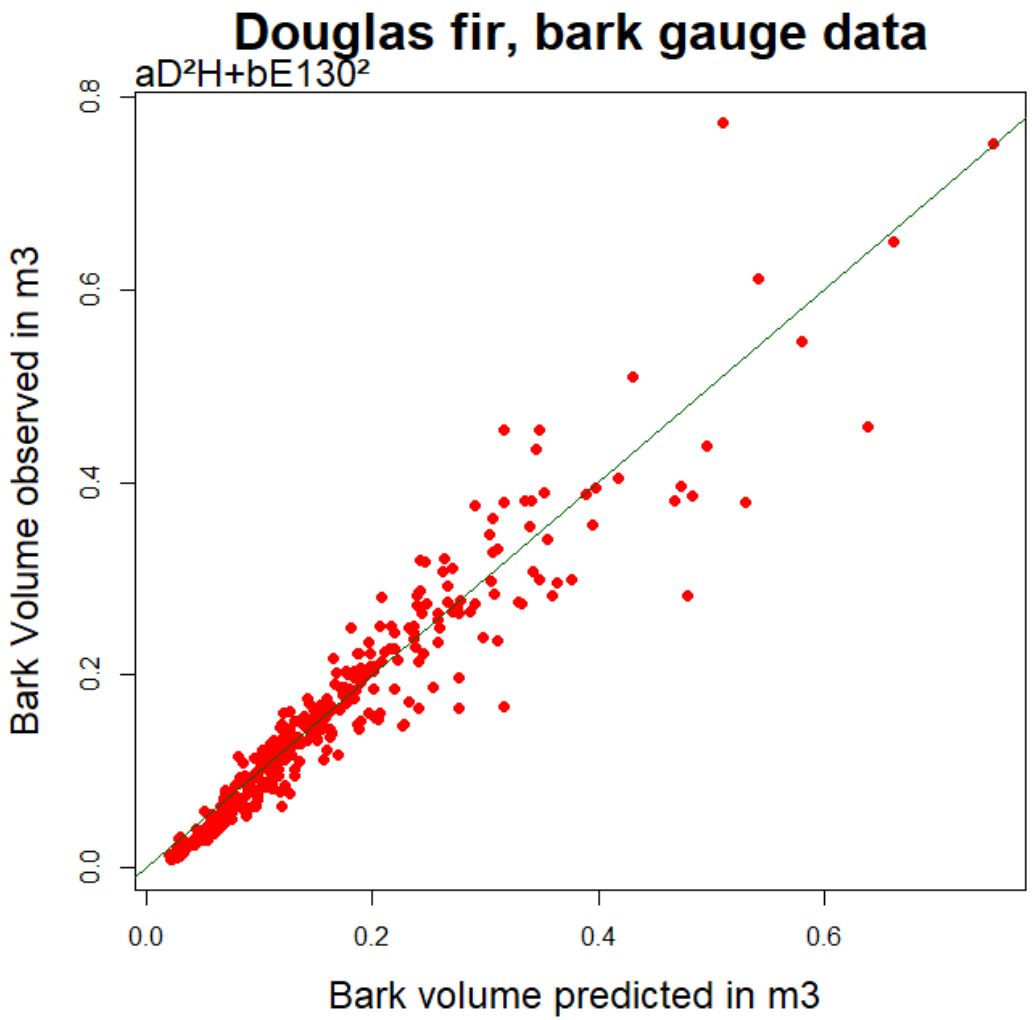
Results: Douglas fir





Results: Douglas fir





Results: Douglas fir

	Scanner RX : $aD^2H+bE130$	Scanner RX : aD^2H	Scanner RX : aD^2H+b	Jauge : $aD^2H+bE130$	Jauge : aD^2H	Jauge : aD^2H+b
RMSE	1,78E-02	2,66E-02	2,34E-02	3,48E-02	4,80E-02	4,10E-02
AIC	-1,82E+02	-1,55E+02	-1,62E+02	-1,82E+02	-1,55E+02	-1,62E+02
Parameter a	2,78E-02	3,54E-02	3,28E-02	3,91E-02	5,72E-02	4,89E-02
Parameter b	4,00E-03	/	1,72E-02	4,12E-03	/	3,75E-02
Signifiance a	1,34E-20	9,04E-29	2,65E-24	9,01E-106	9,04E-29	9,47E-154
Signifiance b	2,18E-07	/	3,48E-03	5,07E-48	/	1,46E-24
R^2	0,98	0,95	0,95	0,91	0,88	0,88

Application of the results

Comparison with FCBA memento

Bark volume proportion (%)	FCBA	Scanner RX	Bark gauge
Fir	11.0	13.4	11.9
Spruce	11.0	12.4	11.3
Douglas Fir	14.5	14.2	16.2

Comparison of results / available information

(from Antoine Billard)

Basic specific gravity (kg.m-3)	Carbofor (IGN)	Stem	Bark
Fir	380	394	533
Spruce	370	373	495
Douglas Fir	430	455	466

Bark biomass proportion (%)	FCBA	Scanner RX	Bark gauge
Fir	7	15.7	13.6
Spruce	7	14.2	13.0
Douglas Fir	7	16.7	20.5

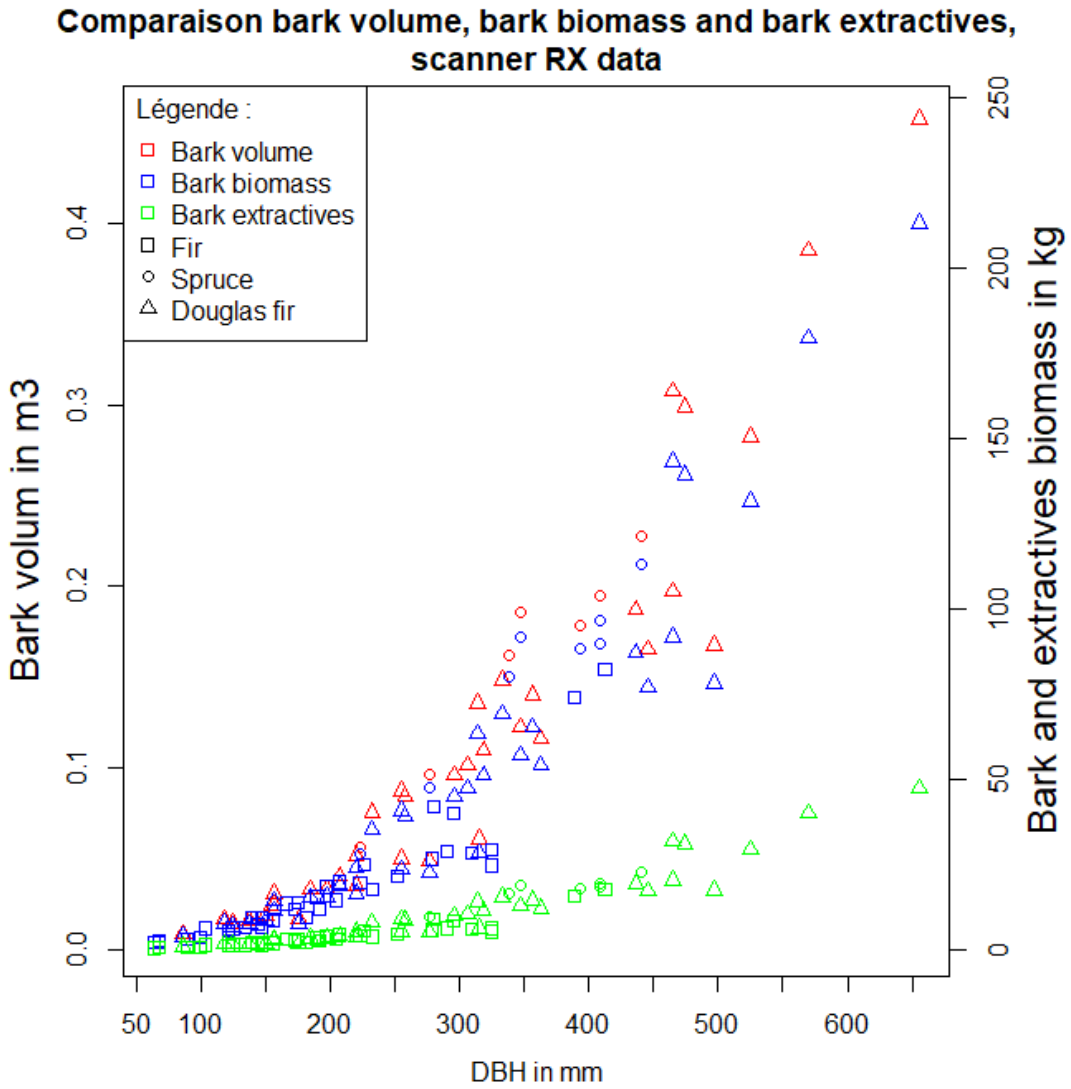
Estimates of biomass & extractives quantities in bark

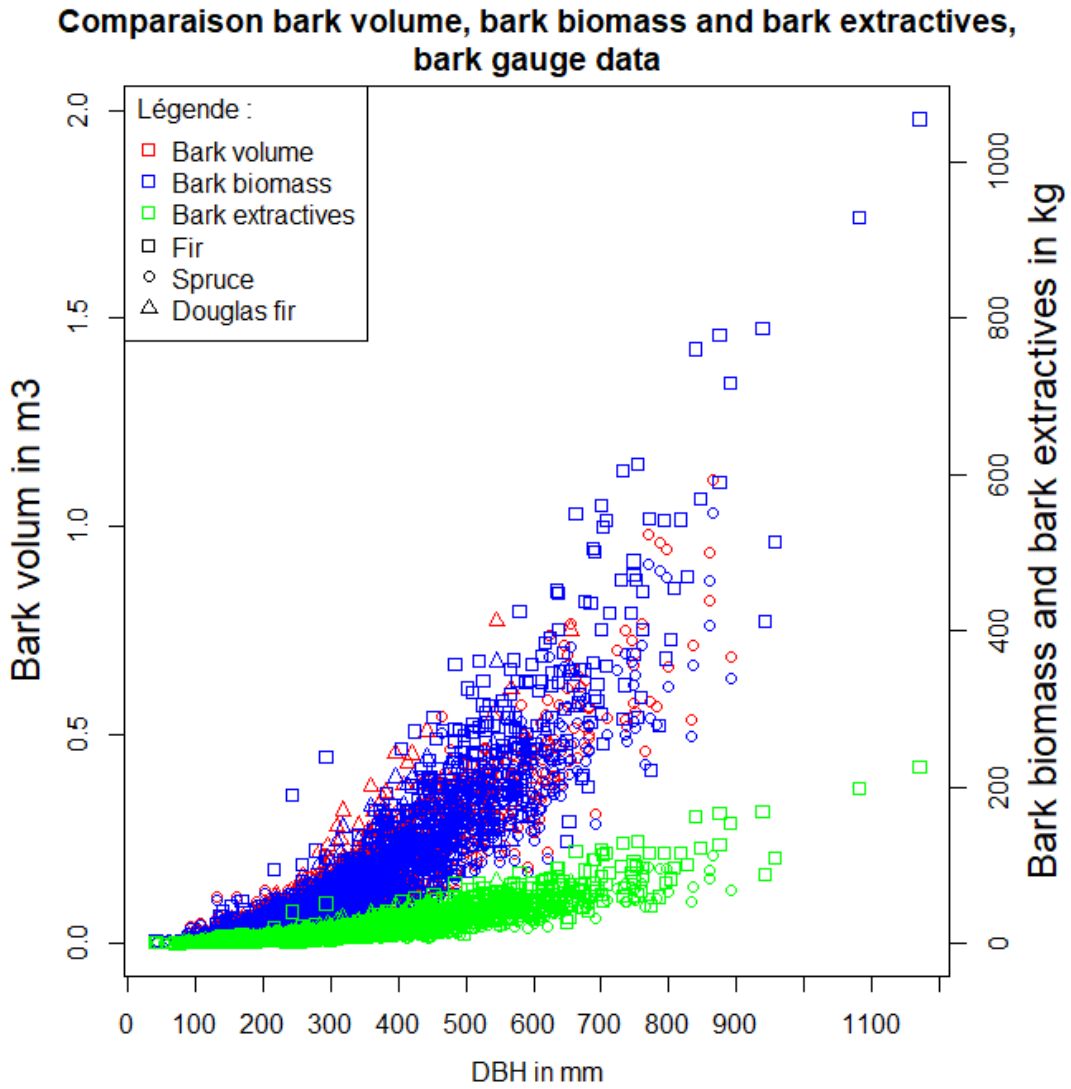
Extractives : average values used

(from Maree Brennan)

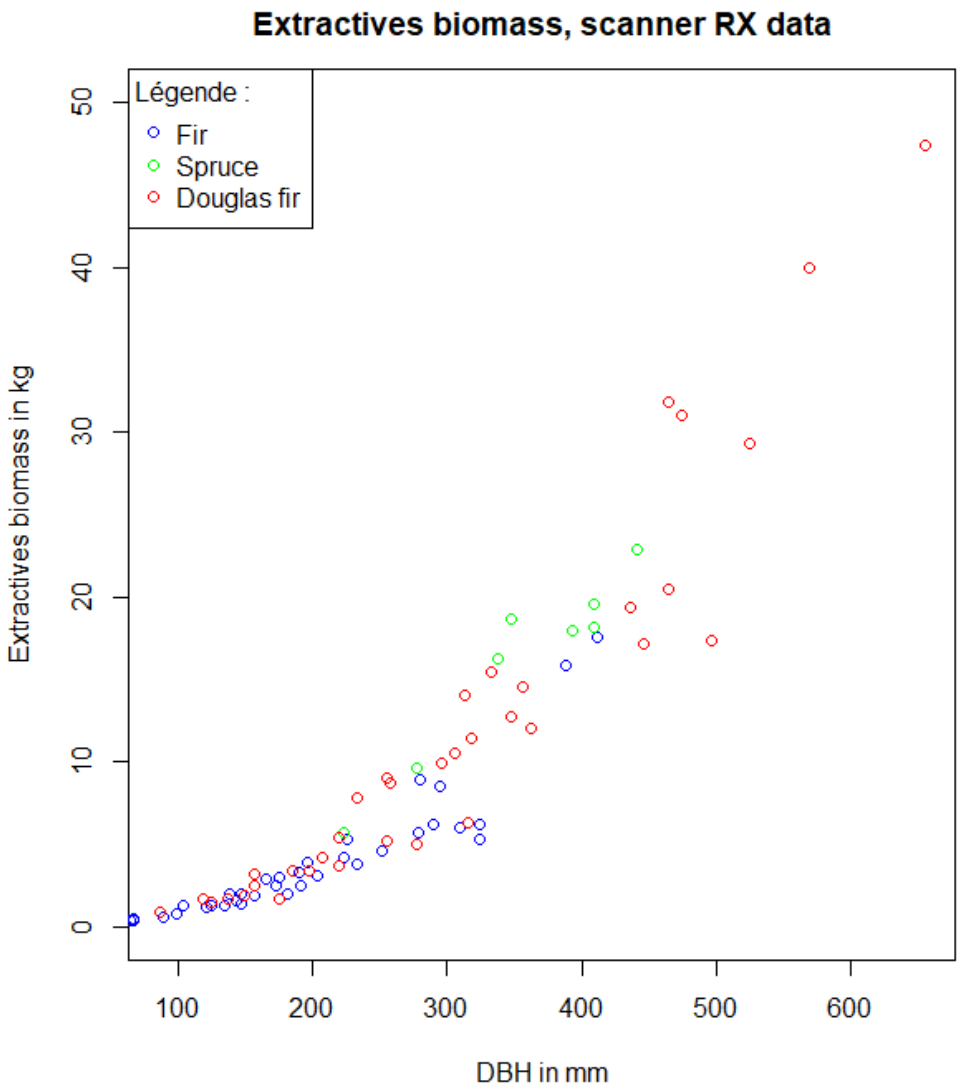
Extractives concentration ($kg.kg_{dry\ mass}^{-1}$)	Bark
Fir	0.22
Spruce	0.21
Douglas Fir	0.20

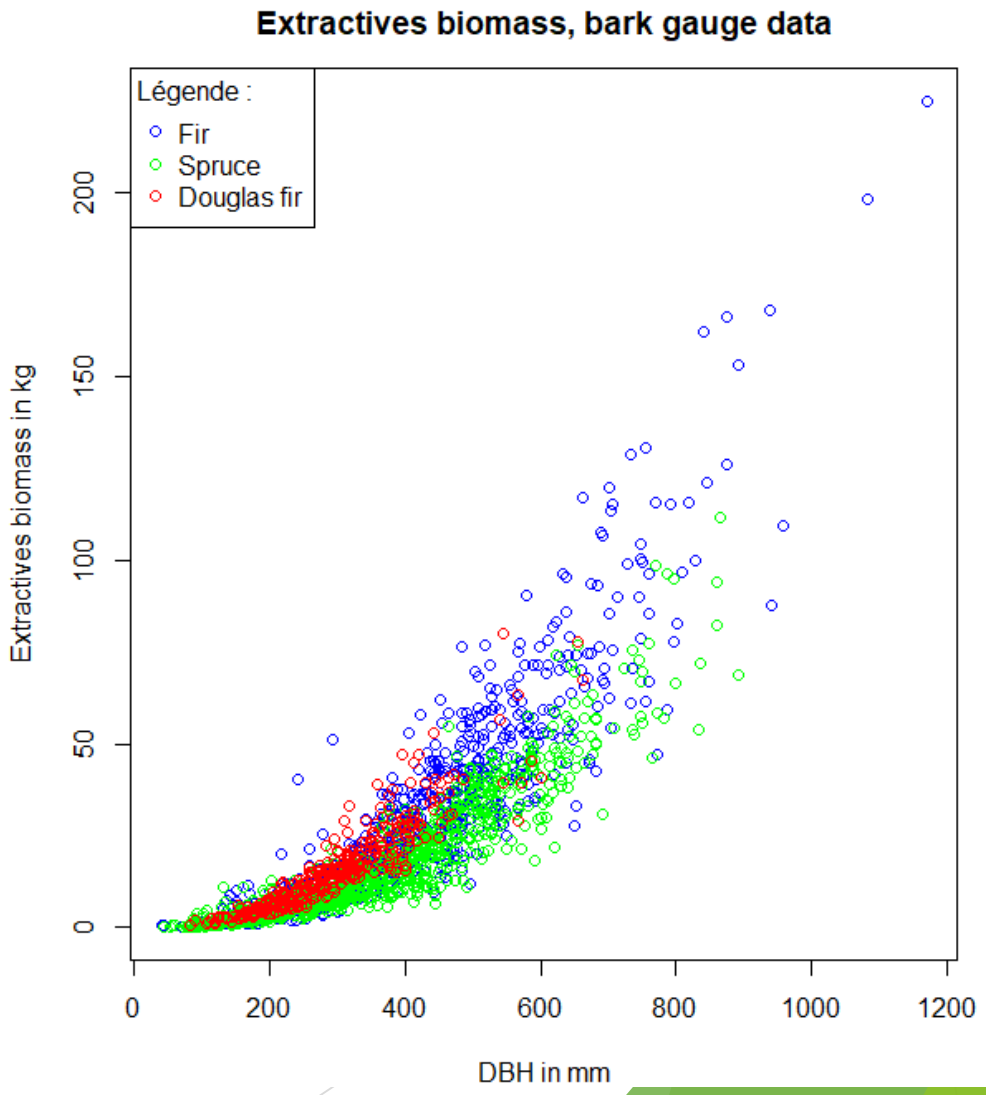
Volume/biomass/extractives





Comparisons extractives / species





Thank you for your attention !

Any questions ?

Comparisons volume/biomass/extractives