

APPENDIX A

Additional information on sample forests and trees

Table A.1: Main site characteristics.

| Tree species | Forest | ID | Thinning modality | Number of sampled trees | Initial stand density (tree.ha ⁻¹) | Last measurement | | |
|------------------------------|-------------------|-----|-------------------|-------------------------|--|--|--|---------------------|
| | | | | | | Stand density (tree.ha ⁻¹) | Basal area (m ² .ha ⁻¹) | Dominant height (m) |
| <i>Abies alba</i> | Saint-Prix | Aa1 | Without | 4 | 13794 | 7986 | 39.5 | 16.5 |
| | | | Heavy | 4 | 13649 | 649 | 17.2 | 17.4 |
| | Saint-Prix | Aa2 | Without | 6 | 13794 | 4148 | 39.5 | 16.5 |
| | | | Moderate | 4 | 11857 | 611 | 24.0 | 18.3 |
| | Mont-Sainte-Marie | Aa3 | Heavy | 4 | 13649 | 350 | 17.2 | 17.4 |
| | | | Without | 6 | 9400 | 1584 | 33.8 | 14.3* |
| | | | Moderate | 5 | 6800 | 518 | 31.5 | 14.7* |
| | | | Heavy | 4 | 5600 | 266 | 22.7 | 15.7* |
| <i>Pseudotsuga menziesii</i> | Mélagues | Pm1 | Without | 4 | 1300 | 835 | 66.4 | ≈ 29 |
| | | | Heavy | 4 | 1300 | 141 | 29.7 | ≈ 29 |
| | Grison | Pm2 | Without | 5 | 1600 | 948 | 72.5 | 33.0 |
| | | | Moderate | 5** | 1300 | 349 | 44.3 | 30.2 |
| | Quartier | Pm3 | Heavy | 5 | 1300 | 167 | 36.1 | 30.8 |
| | | | Without | 5 | 2500 | 2125 | 31.9 | ≈ 15 |
| | | | Moderate | 5 | 1100 | 506 | 15.0 | ≈ 15 |
| | | | Heavy | 5** | 350 | 341 | 17.2 | ≈ 15 |

* Dominant height in 2008, 6 years before sampling.

** One tree from each of these modalities was not included in the analyses due to lack of information on *BD* at breast height.

The *Abies alba* stands are mixed forests of *Abies alba*, *Picea abies* and various hardwood species with 40-50% (Aa1 and Aa2) or 80% (Aa3) of *Abies alba*.

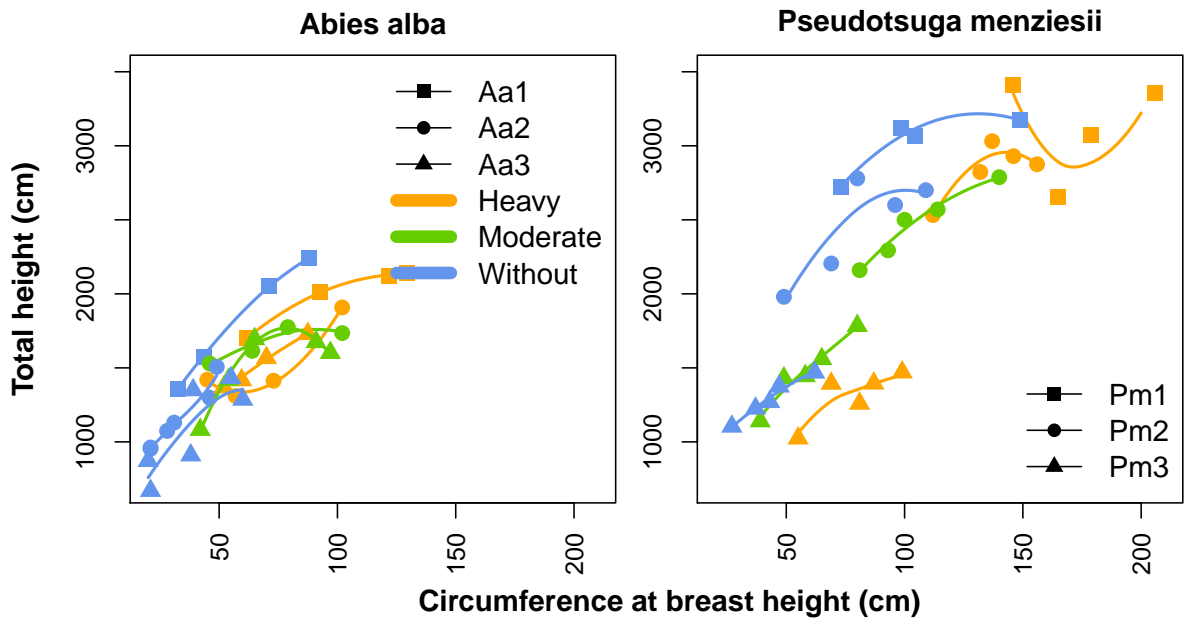


Figure A.1: Total height of the tree as a function of circumference at breast height of the tree and corresponding smoothed curve for each forest and each species. Orange is for the trees from “heavy thinned” forests, green for “moderate thinned” forests and blue for “unthinned” forests.

Table A.2: Tree characteristics. $C130$ is the circumference at breast height, H is the total tree height, hLC is the height of the base of the living crown and $hLLB$ is the height of the lowest living branch.

| Tree species | Forest | ID | Thinning modality | Tree Age | $C130$ (cm) | H (m) | hLC (m) | $hLLB$ (m) | | |
|-------------------|-------------------|-----|-------------------|----------|----------------|------------|--------------|---------------|-------|------|
| <i>Abies alba</i> | Saint-Prix | Aa1 | Without | S1 | 50 | 88 | 22.40 | 13.55 | 11.23 | |
| | | | | S2 | 44 | 43.5 | 15.75 | 13.47 | 11.35 | |
| | | | | S3 | 51 | 71 | 20.50 | 10.95 | 9.45 | |
| | | | | S4 | 57 | 32.5 | 13.60 | 9.48 | 9.48 | |
| | | | Heavy | S5 | 48 | 61.6 | 16.99 | 7.80 | 7.20 | |
| | | | | S6 | 43 | 129.5 | 21.40 | 7.95 | 4.90 | |
| | | | | S7 | 43 | 92.7 | 20.10 | 7.60 | 5.10 | |
| | | | | S8 | 44 | 122 | 21.20 | 8.90 | 7.03 | |
| | Saint-Prix | Aa2 | Without | PT1 | 43 | 49 | 15.07 | 9.65 | 8.32 | |
| | | | | PT2 | 41 | 31 | 11.30 | 7.70 | 7.16 | |
| | | | | PT3 | 38 | 21 | 9.62 | 7.89 | 7.44 | |
| | | | | PT4 | 39 | 21 | 9.54 | 6.83 | 6.01 | |
| | | | | PT5 | 43 | 28 | 10.74 | 6.23 | 6.23 | |
| | | | | PT6 | 36 | 46 | 12.98 | 8.38 | 7.25 | |
| | | | Moderate | PW1 | 41 | 79 | 17.75 | 9.18 | 9.14 | |
| | | | | PW2 | 38 | 46 | 15.30 | 9.11 | 7.40 | |
| | Heavy | PW3 | 44 | 64 | 16.15 | 8.98 | 8.54 | | | |
| | | PW4 | 46 | 102 | 17.35 | 8.15 | 8.49 | | | |
| | | PS1 | 41 | 45 | 14.20 | 6.73 | 5.67 | | | |
| | | PS2 | 36 | 73 | 14.13 | 2.62 | 1.08 | | | |
| | | | | | PS3 | 38 | 57 | 13.10 | 3.13 | 1.83 |
| | | | | | PS4 | 40 | 102 | 19.08 | 6.81 | 3.78 |
| | | | | | MT1 | 51 | 38 | 9.10 | 4.55 | 3.64 |
| | | | | | MT2 | 55 | 39 | 13.50 | 8.22 | 7.65 |
| | Mont-Sainte-Marie | Aa3 | Without | MT3 | 60 | 21 | 6.70 | 3.17 | 2.84 | |
| | | | | MT4 | 54 | 60 | 12.86 | 3.59 | 3.20 | |
| | | | | MT5 | 72 | 55 | 14.32 | 6.40 | 3.48 | |
| | | | | MT6 | 62 | 20 | 8.72 | 5.18 | 4.40 | |
| Moderate | | | | MM1 | 49 | 97 | 16.02 | 3.90 | 3.86 | |
| | | | | MM2 | 74 | 65 | 16.95 | 7.88 | 4.90 | |
| Heavy | | | MM3 | 48 | 54 | 14.20 | 5.54 | 4.98 | | |
| | | | MM4 | 40 | 42 | 10.82 | 5.37 | 3.85 | | |
| | | | | MM5 | 45 | 91 | 16.75 | 4.90 | 3.29 | |
| | | | | MF1 | 79 | 87.5 | 17.30 | 5.50 | 3.48 | |
| | | | | MF2 | 80 | 70 | 15.67 | 5.77 | 4.76 | |
| | | | | MF3 | 50 | 59.5 | 14.17 | 6.10 | 5.02 | |
| | | | | MF4 | 48 | 52 | 13.70 | 8.39 | 8.34 | |

| Tree species | Forest | ID | Thinning modality | Tree | Age | $C130$ (cm) | H (m) | hLC (m) | $hLLB$ (m) | | |
|------------------------------|----------|----------|-------------------|-------|---------|----------------|------------|--------------|---------------|-------|-------|
| <i>Pseudotsuga menziesii</i> | Mélagues | Pm1 | Without | D5 | 48 | 73 | 27.19 | 24.10 | 17.80 | | |
| | | | | D6 | 48 | 149 | 31.75 | 20.60 | 18.90 | | |
| | | | | D7 | 48 | 104.5 | 30.65 | 20.35 | 18.15 | | |
| | | | | D8 | 48 | 98.5 | 31.20 | 19.10 | 17.62 | | |
| | | | | D1 | 48 | 179 | 30.72 | 13.90 | 11.10 | | |
| | | Heavy | D2 | 48 | 146 | 34.13 | 14.00 | 10.45 | | | |
| | | | D3 | 48 | 165 | 26.55 | 10.50 | 8.15 | | | |
| | | | D4 | 48 | 206 | 33.60 | 12.15 | 8.90 | | | |
| | | | Grison | Pm2 | Without | GT1 | 43 | 49 | 19.80 | 17.25 | 15.25 |
| | | | | | | GT2 | 43 | 69 | 22.05 | 17.85 | 17.60 |
| | GT3 | 43 | | | | 80 | 27.80 | 19.46 | 18.85 | | |
| | GT4 | 43 | | | | 96 | 26.00 | 20.59 | 16.53 | | |
| | GT5 | 43 | | | | 109 | 27.00 | 18.30 | 17.65 | | |
| | Moderate | GI1 | 43 | 81 | 21.60 | 16.55 | 15.20 | | | | |
| | | GI2 | 43 | 93 | 22.94 | 15.00 | 11.04 | | | | |
| | | GI3 | 43 | 100 | 25.00 | 10.45 | 10.45 | | | | |
| | | GI4 | 43 | 114 | 25.70 | 13.20 | 13.00 | | | | |
| | | GI5 | 43 | 140 | 27.88 | 12.96 | 11.88 | | | | |
| | Heavy | GD1 | 43 | 112 | 25.32 | 15.58 | 4.27 | | | | |
| | | GD2 | 43 | 132 | 28.23 | 18.20 | 16.56 | | | | |
| | | GD3 | 43 | 137 | 30.31 | 14.25 | 10.96 | | | | |
| | | GD4 | 43 | 146 | 29.30 | 12.89 | 12.74 | | | | |
| | | GD5 | 43 | 156 | 28.75 | 14.67 | 12.72 | | | | |
| | Quartier | Pm3 | Without | QT1 | 20 | 27 | 11.04 | 5.32 | 4.46 | | |
| | | | | QT2 | 20 | 37 | 12.26 | 5.34 | 4.46 | | |
| | | | | QT3 | 20 | 43 | 12.70 | 8.57 | 4.74 | | |
| | | | | QT4 | 20 | 47 | 13.75 | 7.18 | 6.23 | | |
| | | | | QT5 | 20 | 62 | 14.69 | 6.24 | 5.33 | | |
| | | Moderate | QI1 | 20 | 39 | 11.40 | 3.70 | 2.25 | | | |
| | | | QI2 | 20 | 49 | 14.30 | 4.10 | 3.32 | | | |
| QI3 | | | 20 | 58 | 14.45 | 4.68 | 2.96 | | | | |
| QI4 | | | 20 | 65 | 15.60 | 4.32 | 2.60 | | | | |
| QI5 | | | 20 | 80 | 17.84 | 4.64 | 3.33 | | | | |
| Heavy | QD1 | 20 | 55 | 10.24 | 1.95 | 1.15 | | | | | |
| | QD2 | 20 | 69 | 13.94 | 3.94 | 1.65 | | | | | |
| | QD3 | 20 | 81 | 12.59 | 2.83 | 1.86 | | | | | |
| | QD4 | 20 | 87 | 13.95 | 2.71 | 0.97 | | | | | |
| | QD5 | 20 | 99 | 14.70 | 4.40 | 2.27 | | | | | |

APPENDIX B

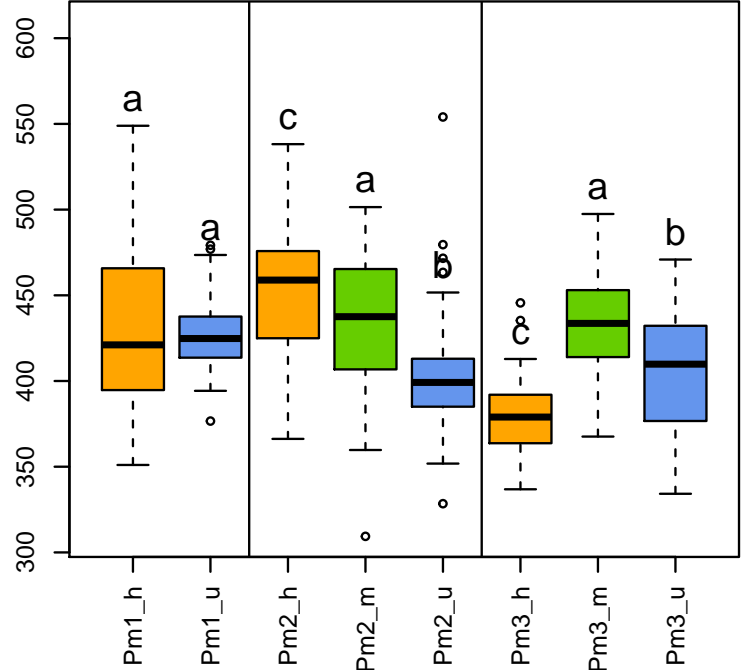
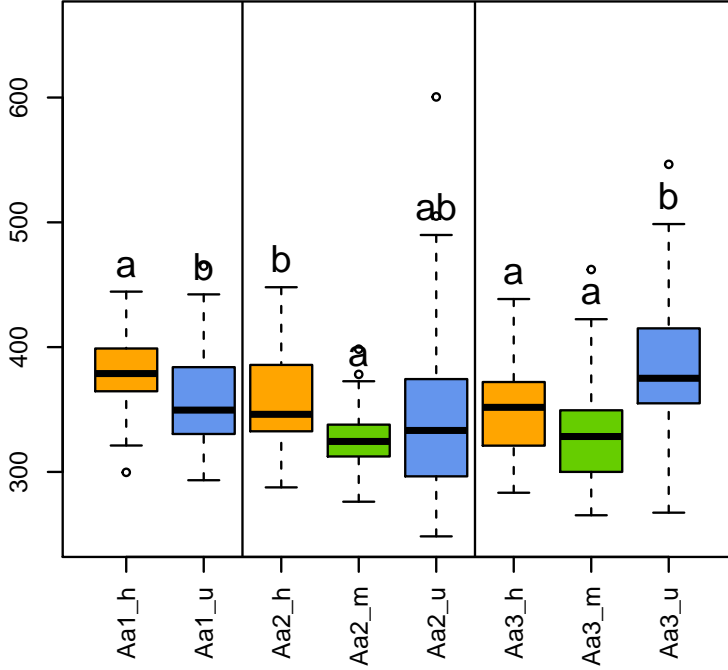
Thinning modality effect on dendrometric variables

The following boxplots show the dendrometric variables as well as the *BD* variables according to the thinning modality. “u” means unthinned modality, “m” means moderate thinning and “h” means heavy thinning. The letters located above the boxplots allow to statistically compare the means of the dendrometric variables between the different thinning modalities. Anova and Tukey Honest Significant Difference methods were used for this purpose.

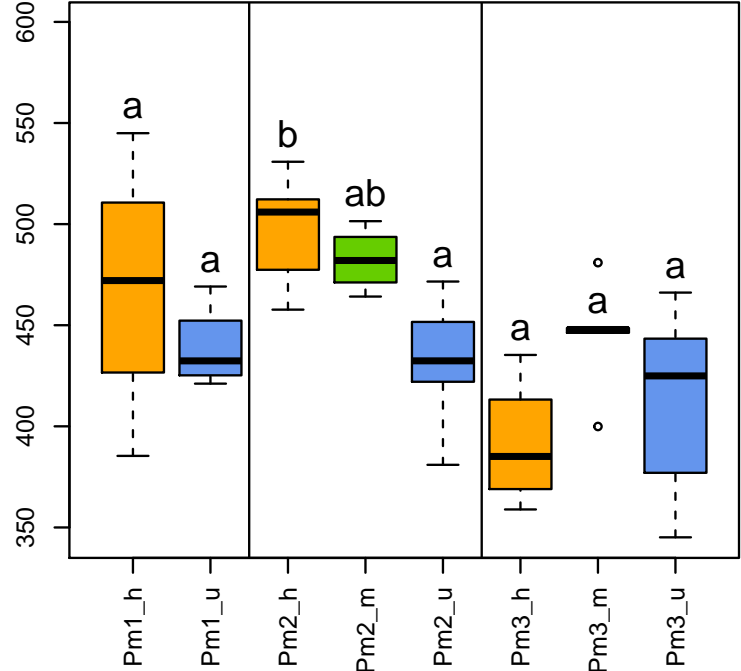
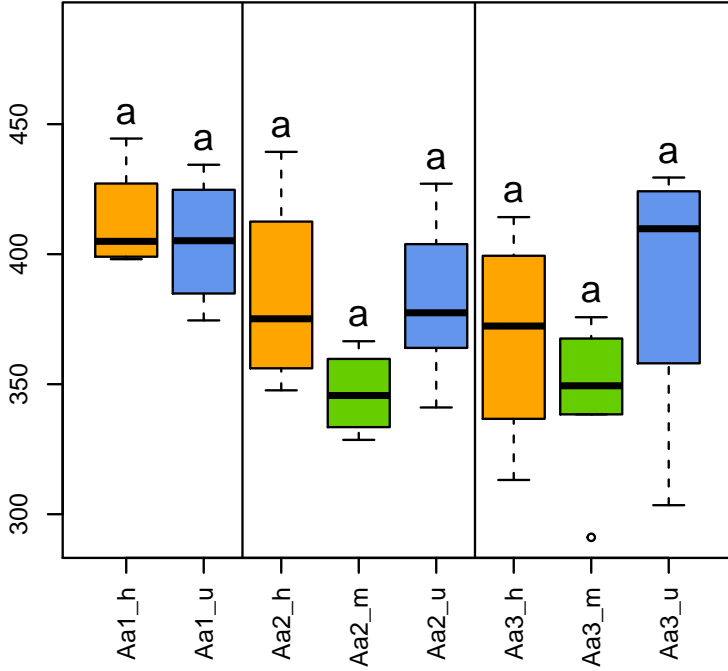
Abies alba

Pseudotsuga menziesii

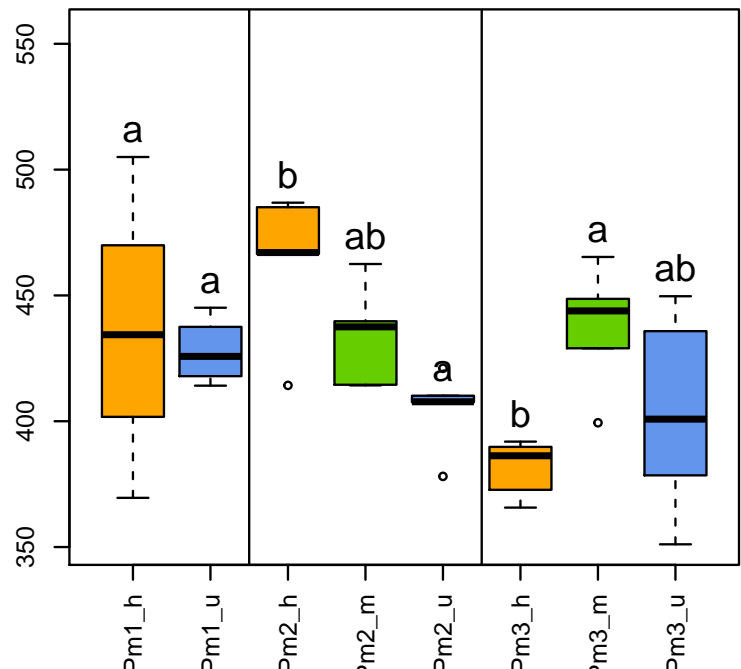
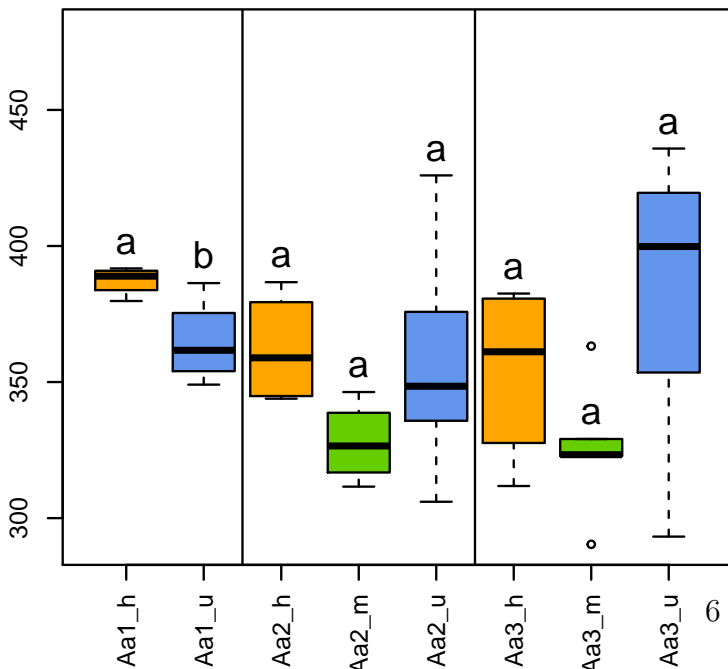
Basic density of the discs (kg/m³)



Basic density at breast height (kg/m³)



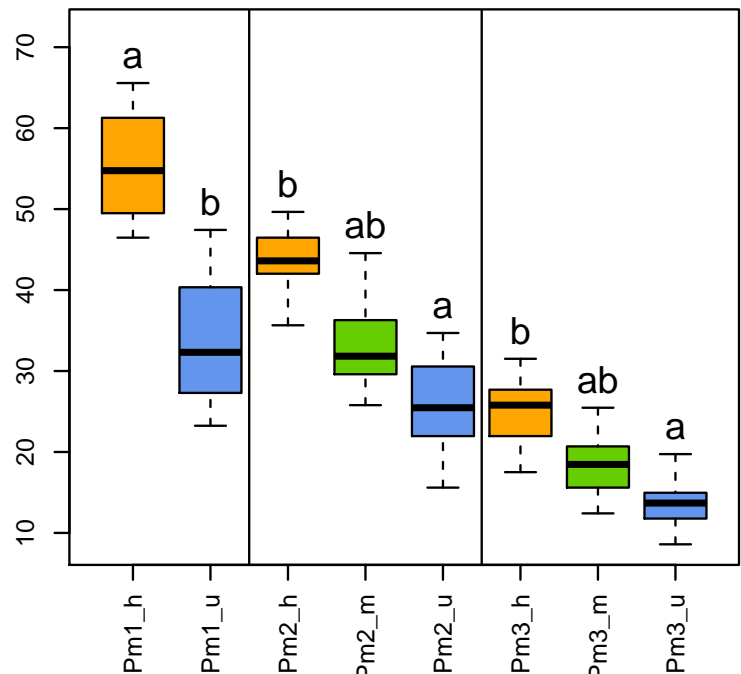
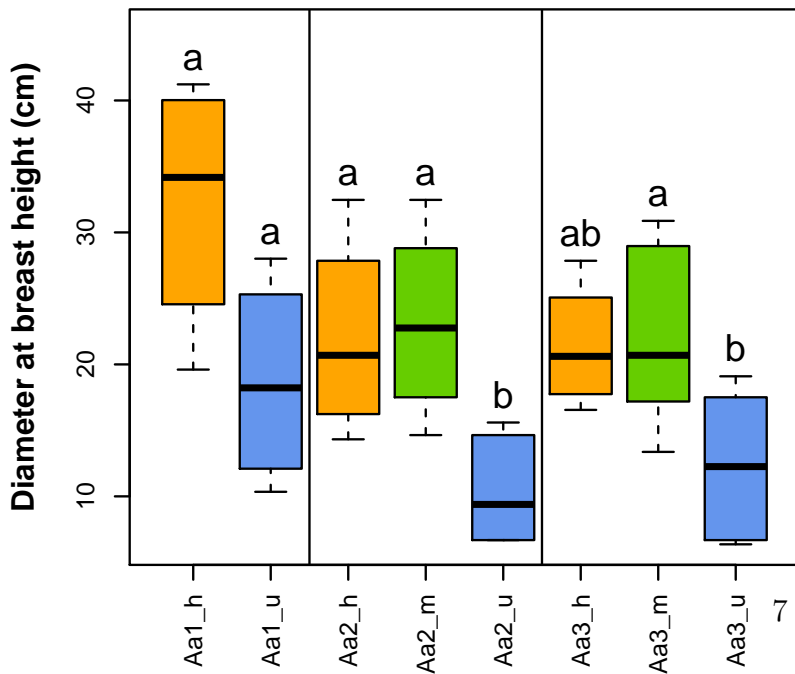
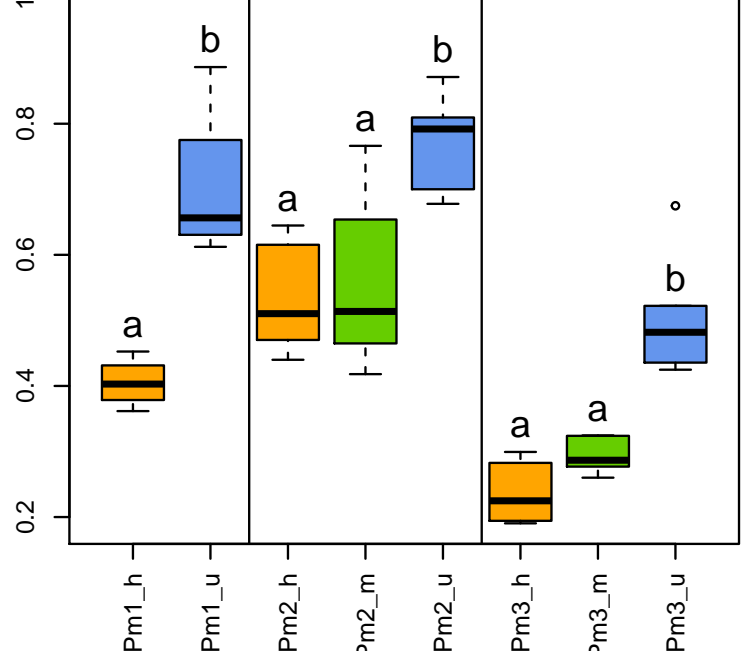
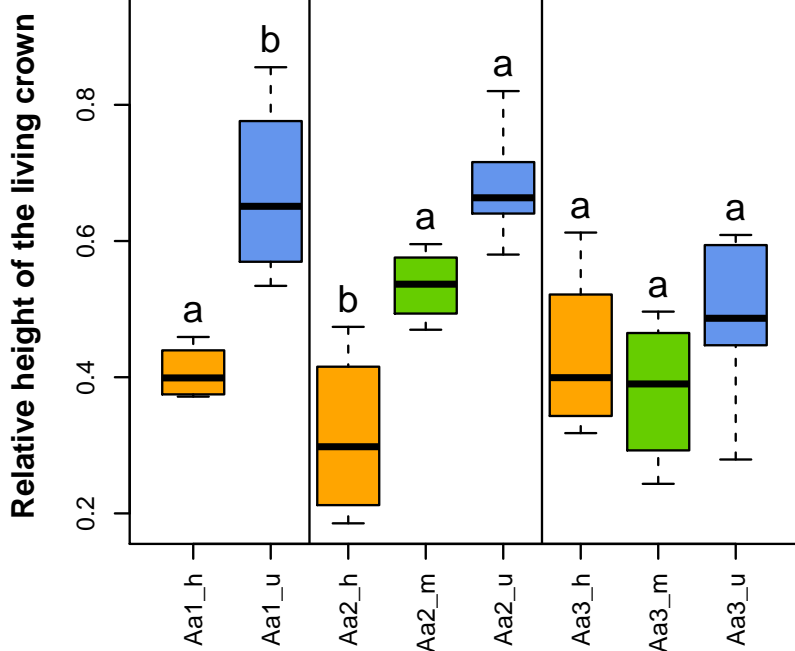
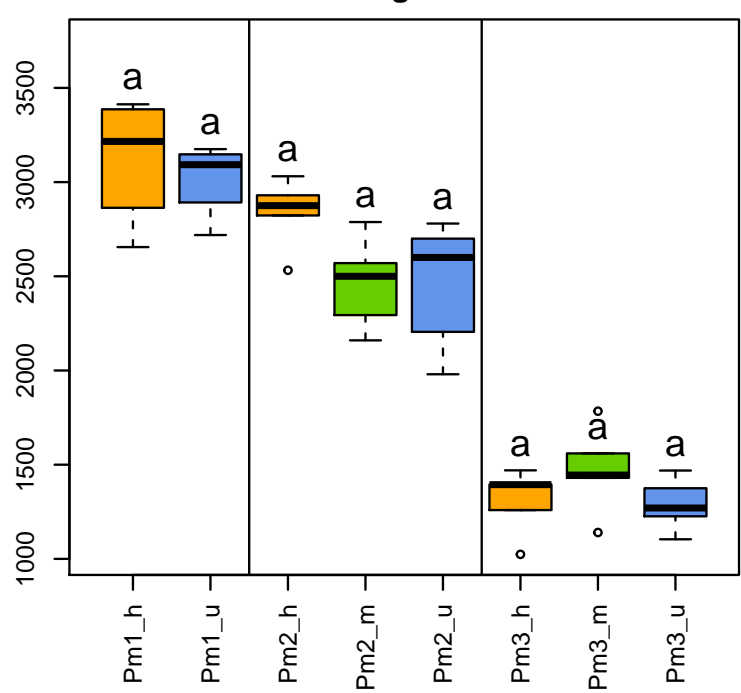
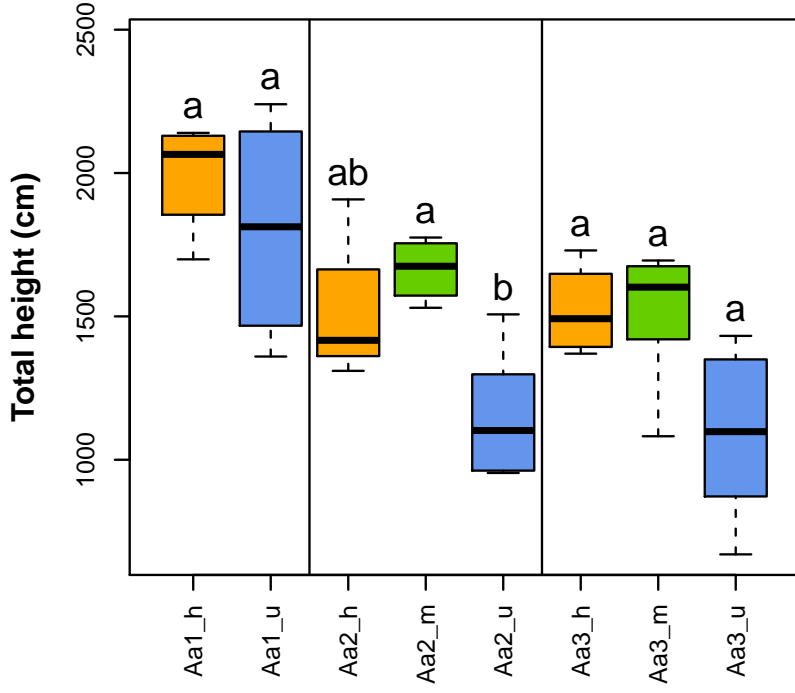
Mean basic density of the stem (kg/m³)



Thinning modality

Abies alba

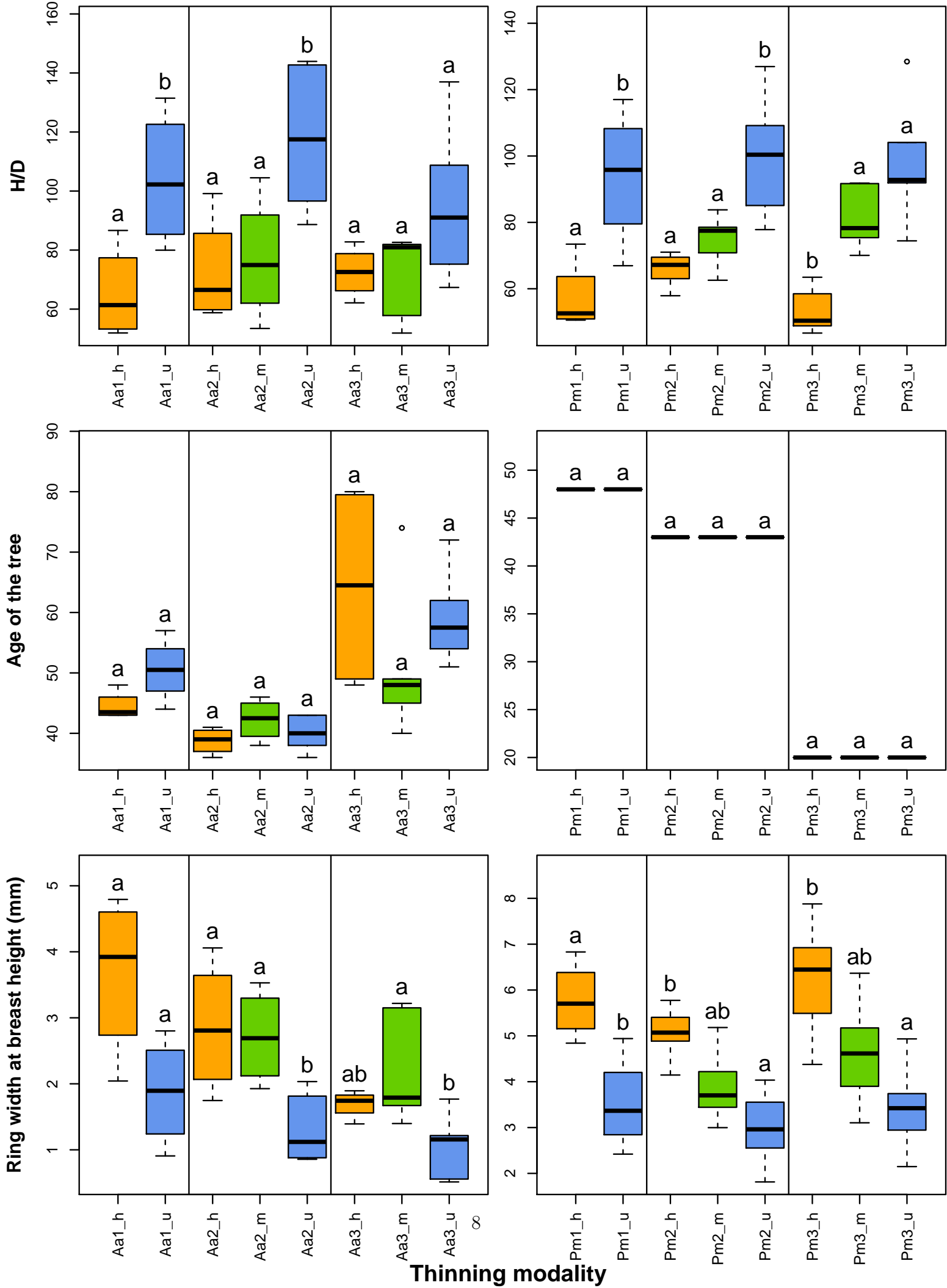
Pseudotsuga menziesii



Thinning modality

Abies alba

Pseudotsuga menziesii



APPENDIX C

Variation in basic density with weighted ring width, weighted cambial age and proportion of corewood

The following graphics show basic density according to weighted ring width, weighted cambial age and proportion of corewood. In Figure C.4 trend curves have been drawn for each thinning modality where the type of line represents the stand: Solid lines are for stand #1 (Saint-Prix or Mélagues), dotted dashed lines are for stand #2 (Saint-Prix or Grison) and dashed lines are for stand #3 (Mont-Sainte-Marie or Quartier). The colors represent the thinning modality: Blue points and dark blue lines are for unthinned modality, green points and dark green lines are for moderate thinning and orange points and dark orange lines are for heavy thinning.

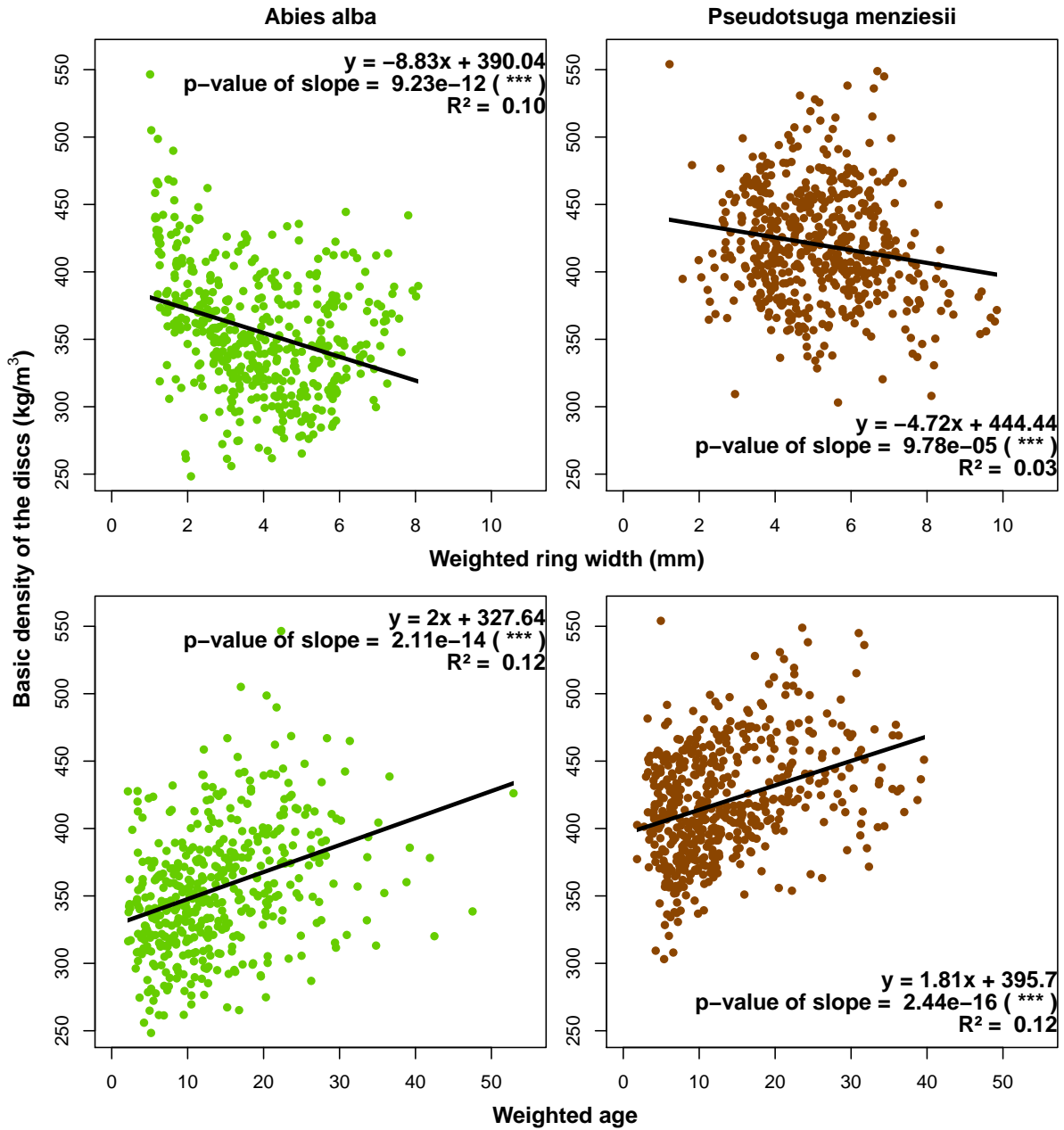


Figure C.1: Basic density of discs as a function of weighted ring width and weighted cambial age. The black lines correspond to the regression lines. The regression equations and the significance of the slope parameters (p-value) are given on each figure: NS: $p \geq 0.05$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

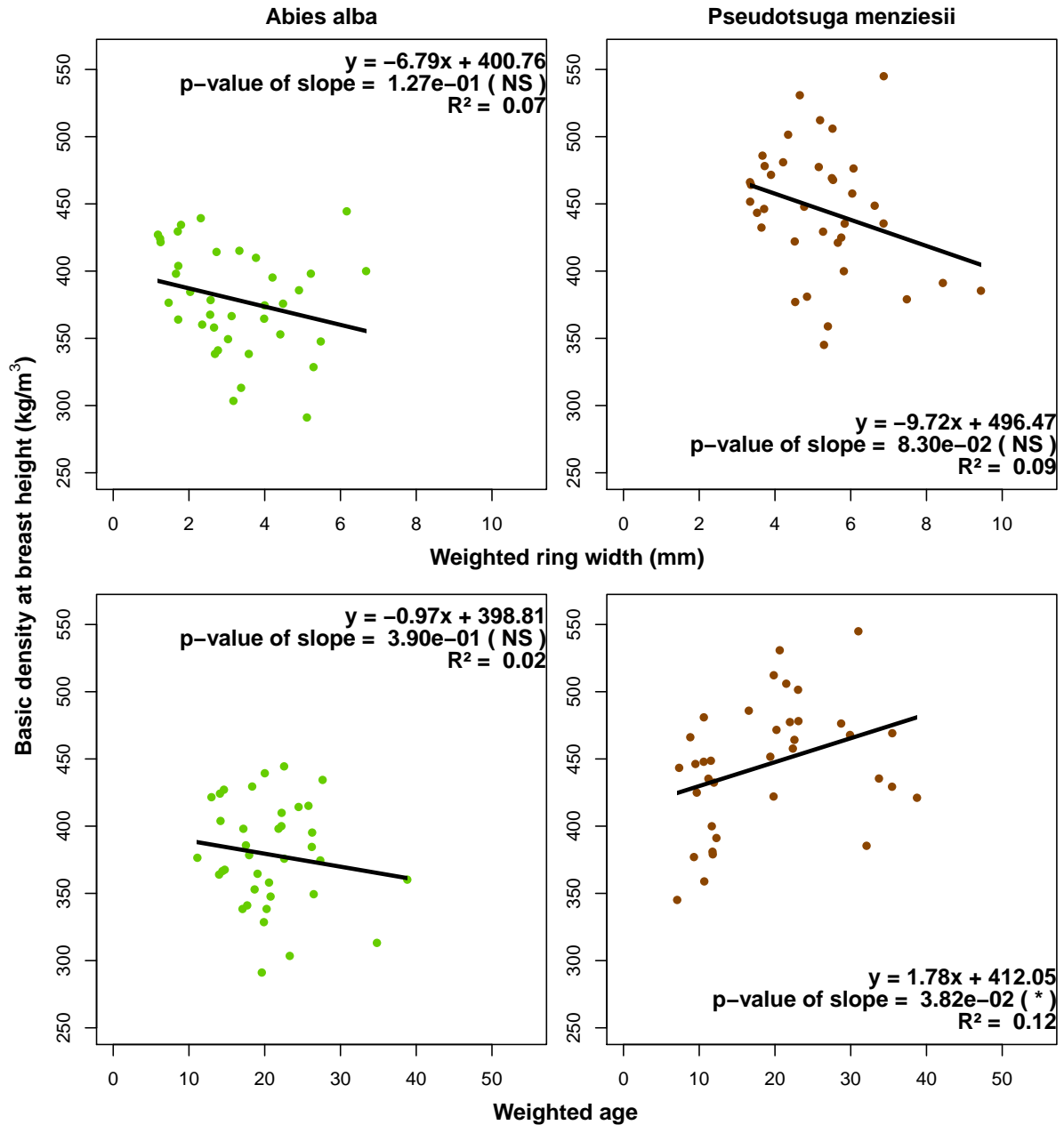


Figure C.2: Basic density at breast height as a function of weighted ring width and weighted cambial age. The black lines correspond to the regression lines. The regression equations and the significance of the slope parameters (p-value) are given on each figure: NS: $p \geq 0.05$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

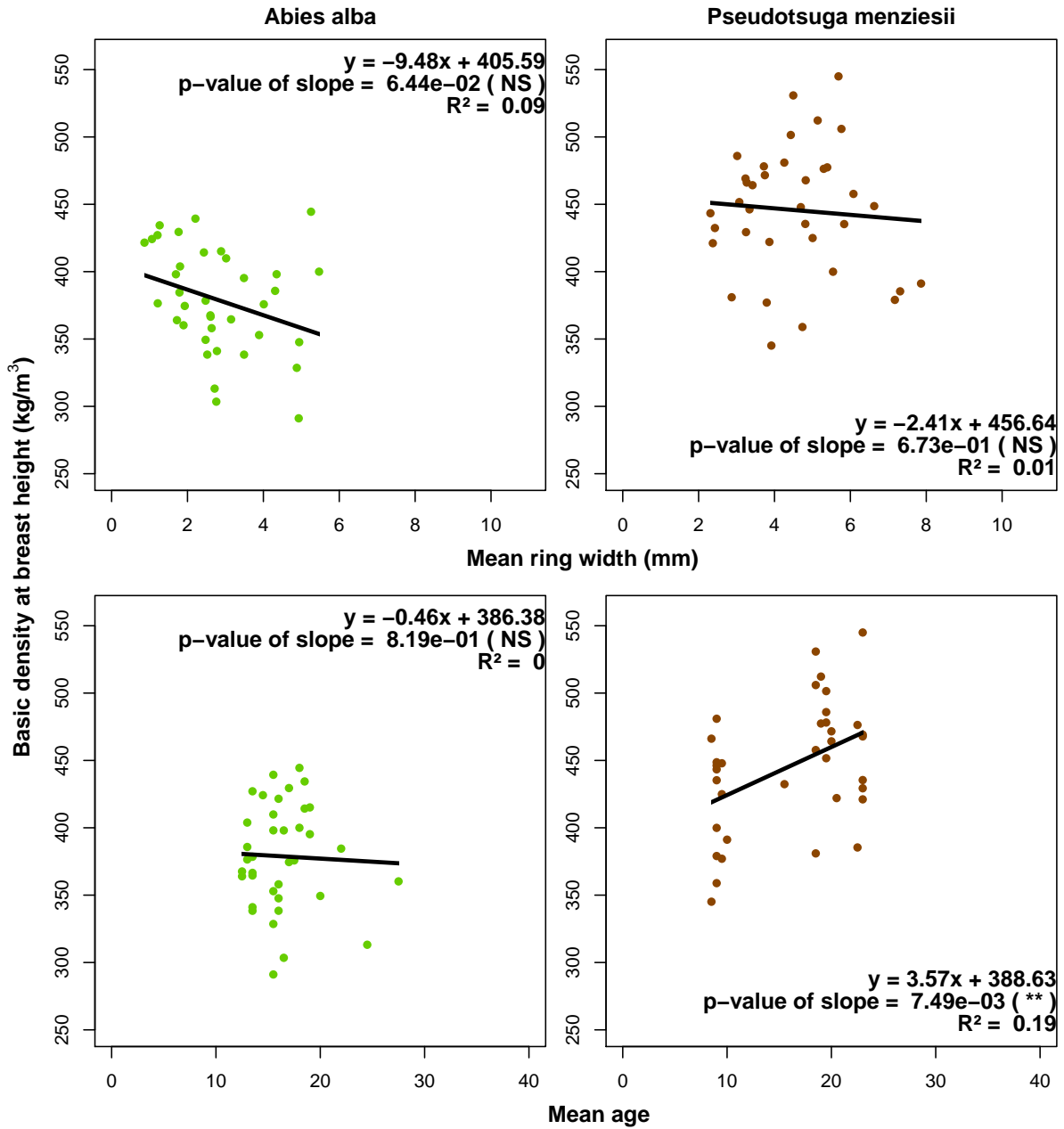


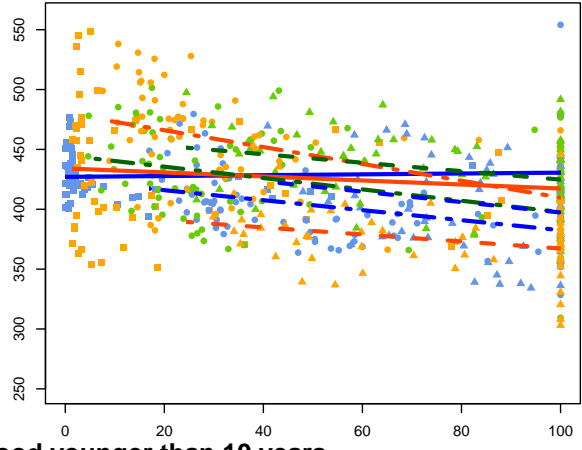
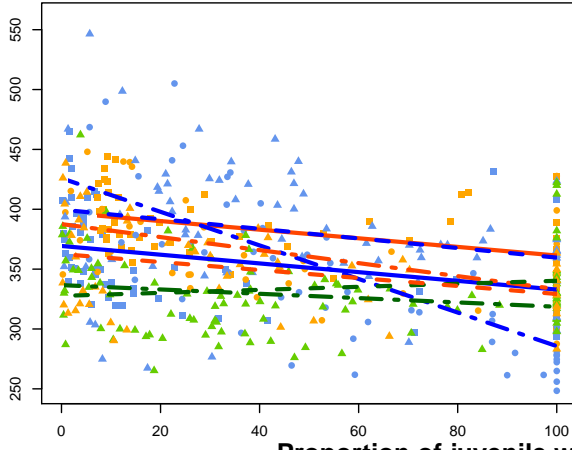
Figure C.3: Mean basic density at breast height as a function of ring width and cambial age at the disc level. The black lines correspond to the regression lines. The regression equations and the significance of the slope parameters (p-value) are given on each figure: NS: $p \geq 0.05$, *: $p < 0.05$, **: $p < 0.01$, ***: $p < 0.001$.

- Heavy
- Medium
- Without
- Aa1
- Aa1-h
- Aa1-u
- Aa2
- Aa2-h
- Aa2-m
- Aa2-u
- Aa3
- Aa3-h
- Aa3-m
- Aa3-u

- Heavy
- Medium
- Without
- Pm1
- Pm1-h
- Pm1-u
- Pm2
- Pm2-h
- Pm2-m
- Pm2-u
- Pm3
- Pm3-h
- Pm3-m
- Pm3-u

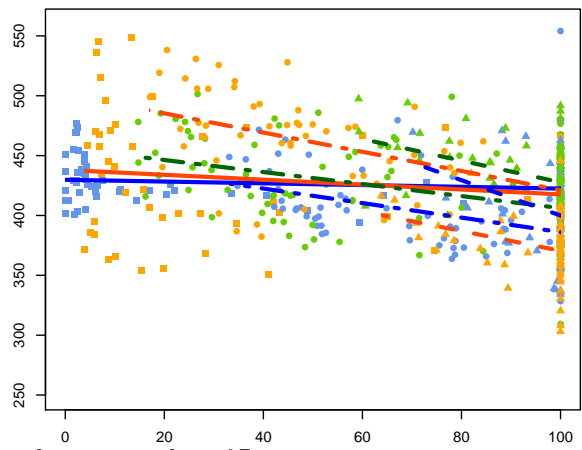
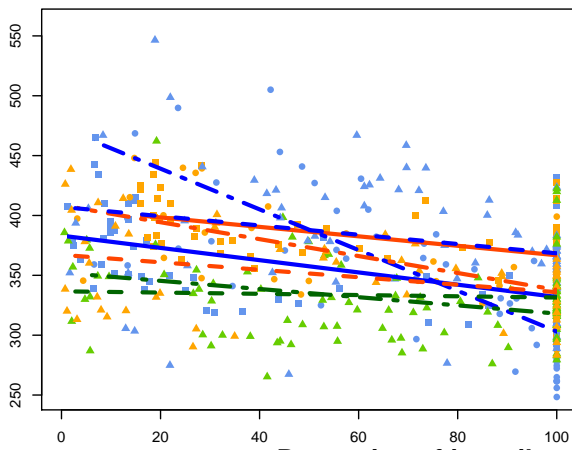
Abies alba

Pseudotsuga menziesii

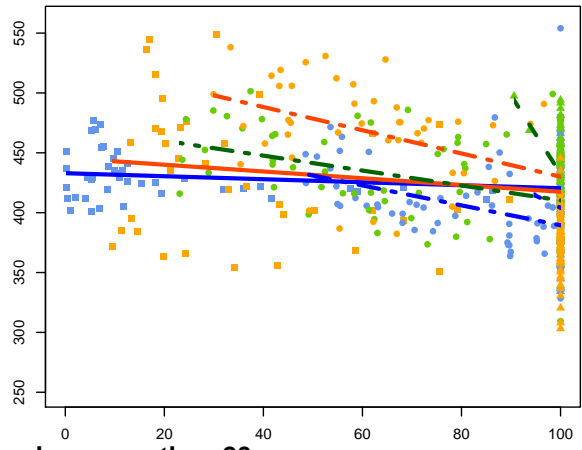
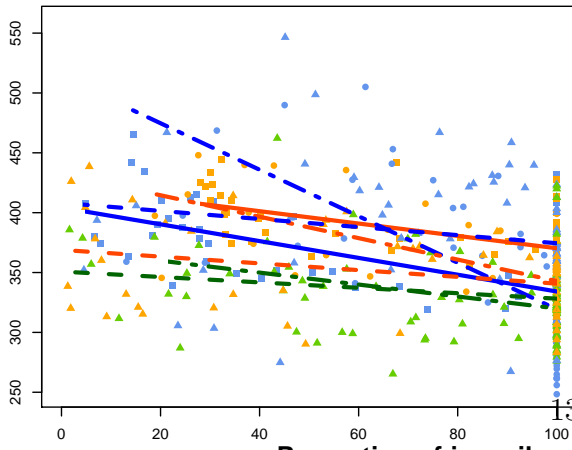


Proportion of juvenile wood younger than 10 years

Basic density of the discs (kg/m³)



Proportion of juvenile wood younger than 15 years



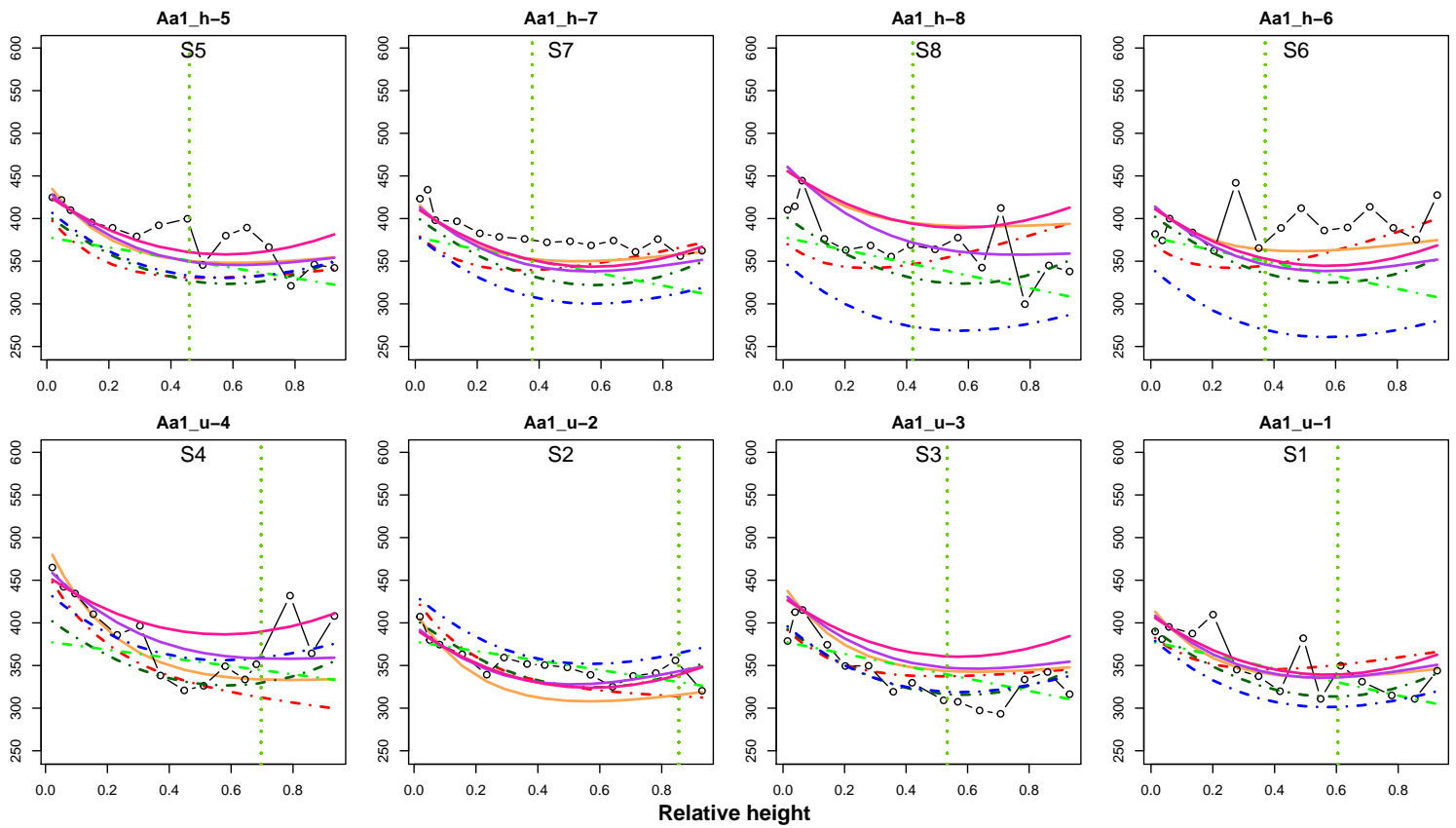
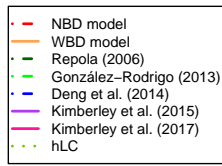
Proportion of juvenile wood younger than 20 years

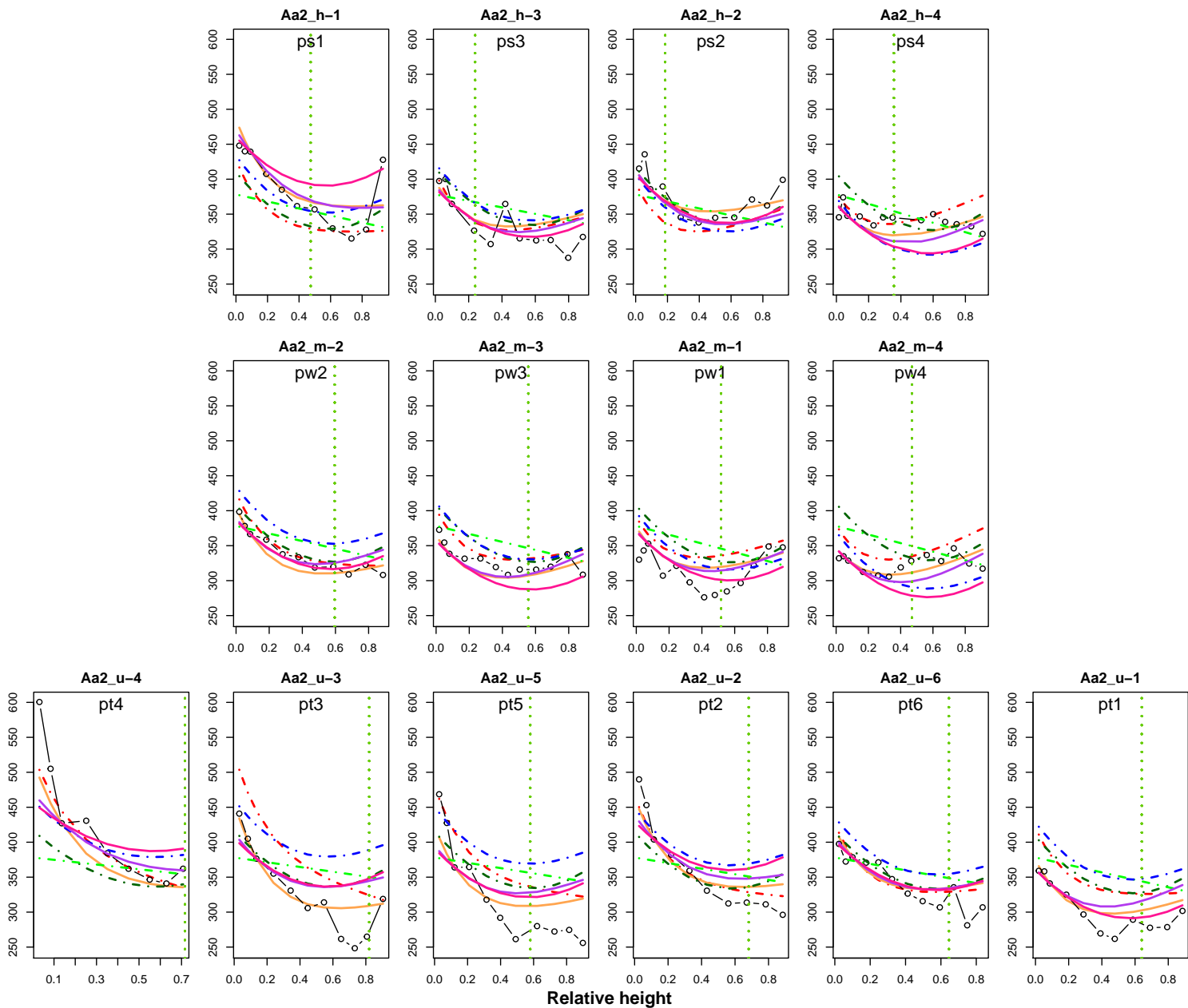
APPENDIX D

Model representations for *A. alba*

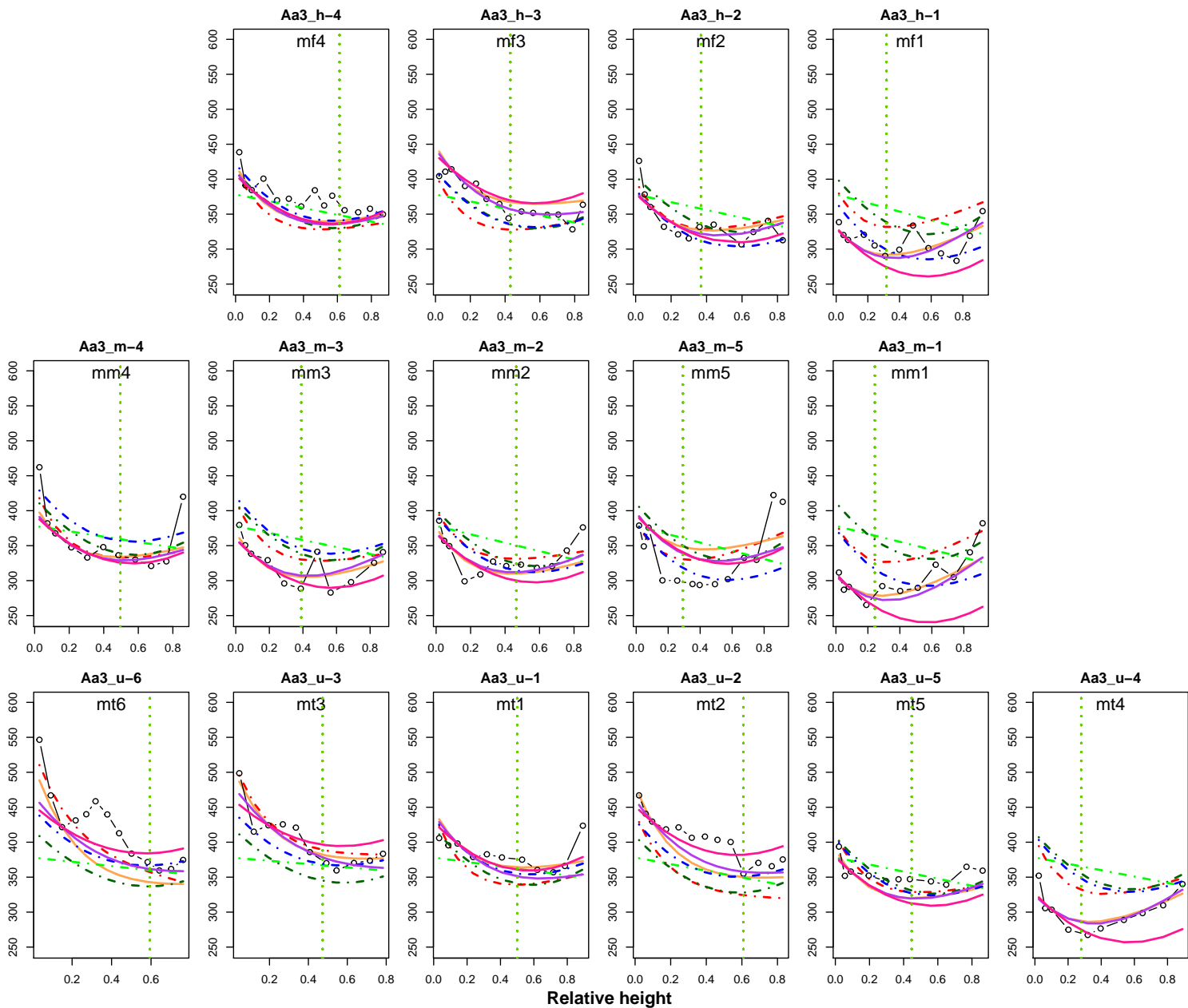
In the following figures the dash-dotted lines represent the models without using BD at breast height as an input: The red dash-dotted line represents our NBD model, the dark green dash-dotted line represents the model of Repola (2006), the light green dash-dotted line represents the model of González-Rodrigo (2013) and the blue dash-dotted line represents the model of Deng et al. (2014). The solid lines represent the models with using BD at breast height as an input: The orange line represents our WBD model, the purple line represents the model of Kimberley et al. (2015), the pink line represents the model of Kimberley et al. (2017). The vertical green dotted line represents the relative height of the living crown ($hrLC$). The ID of the tree is given below the graphic title. Only fixed-effect parameters were used to plot these models. The trees were classified according to their diameter at breast height (from the smallest to the largest). “u” means unthinned modality, “m” means moderate thinning and “h” means heavy thinning.

Basic density of the stem wood (kg/m^3)





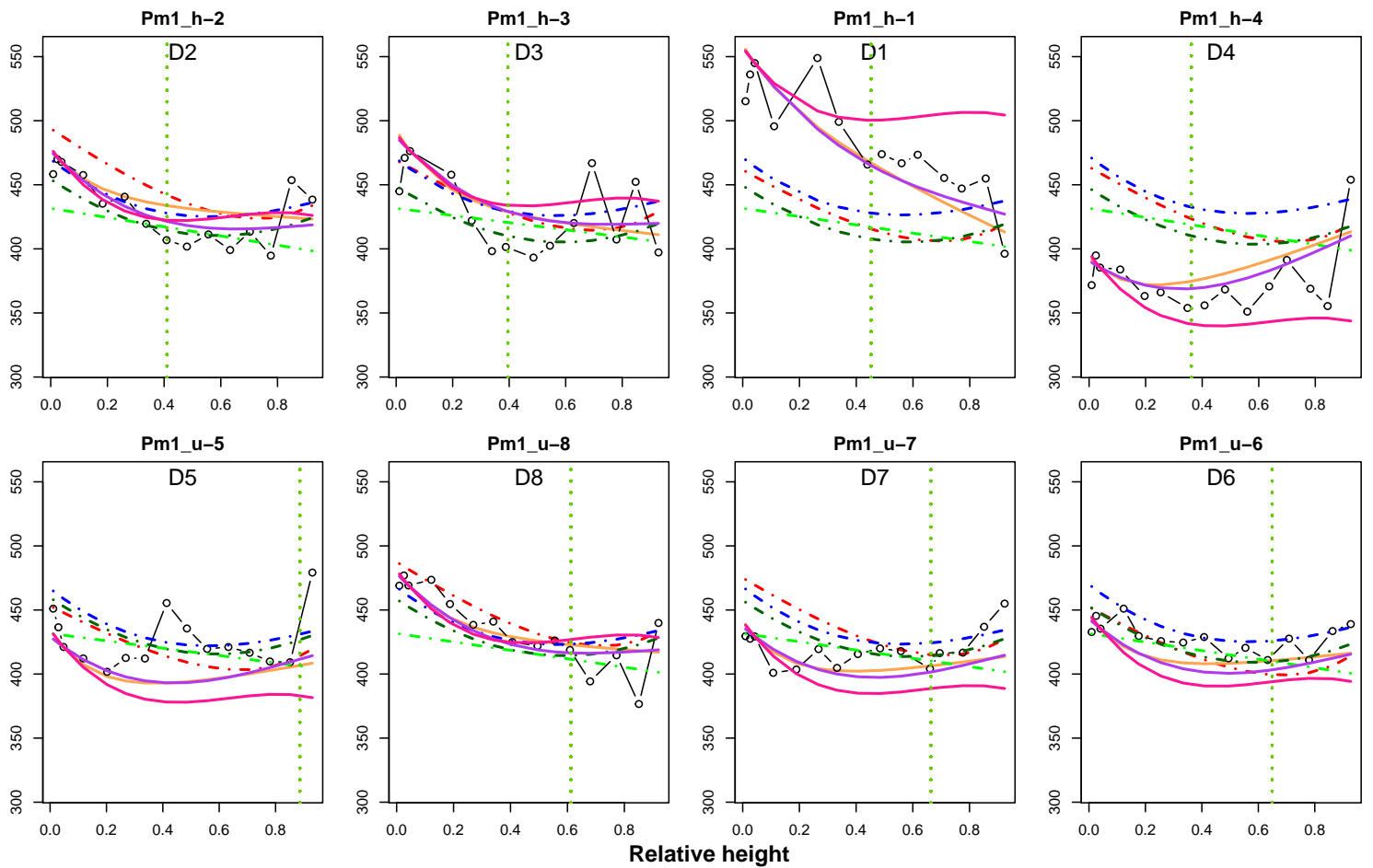
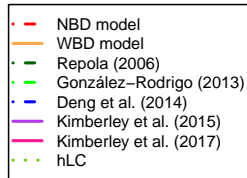
Basic density of the stem wood (kg/m^3)



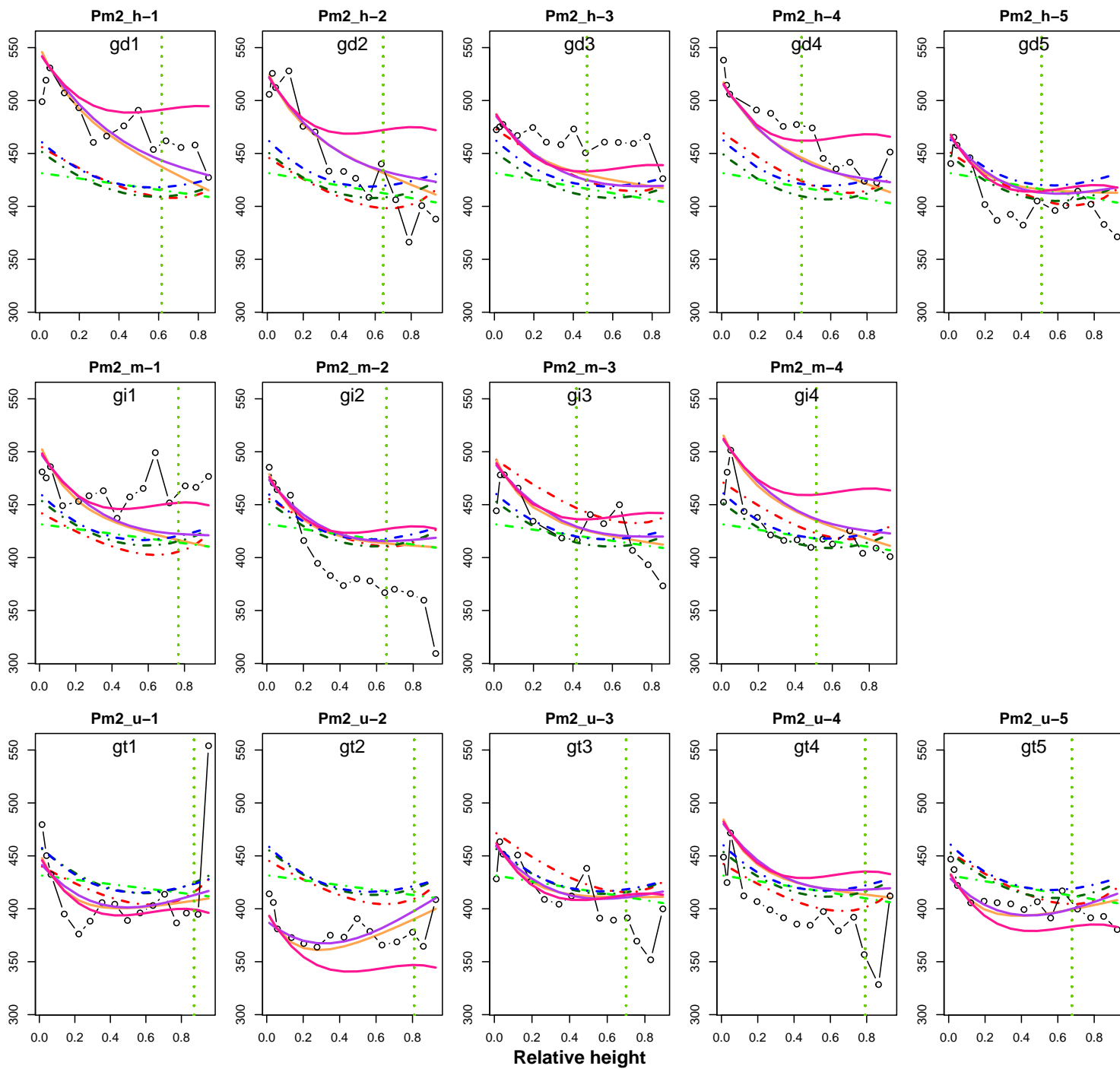
Model representations for *Ps. menziesii*

In the following figures the dash-dotted lines represent the models without using BD at breast height as an input: The red dash-dotted line represents our NBD model, the dark green dash-dotted line represents the model of Repola (2006), the light green dash-dotted line represents the model of González-Rodrigo (2013) and the blue dash-dotted line represents the model of Deng et al. (2014). The solid lines represent the models with using BD at breast height as an input: The orange line represents our WBD model, the purple line represents the model of Kimberley et al. (2015), the pink line represents the model of Kimberley et al. (2017). The vertical green dotted line represents the relative height of the living crown ($hrLC$). The ID of the tree is given below the graphic title. Only fixed-effect parameters were used to plot these models. The trees were classified according to their diameter at breast height (from the smallest to the largest). “u” means unthinned modality, “m” means moderate thinning and “h” means heavy thinning.

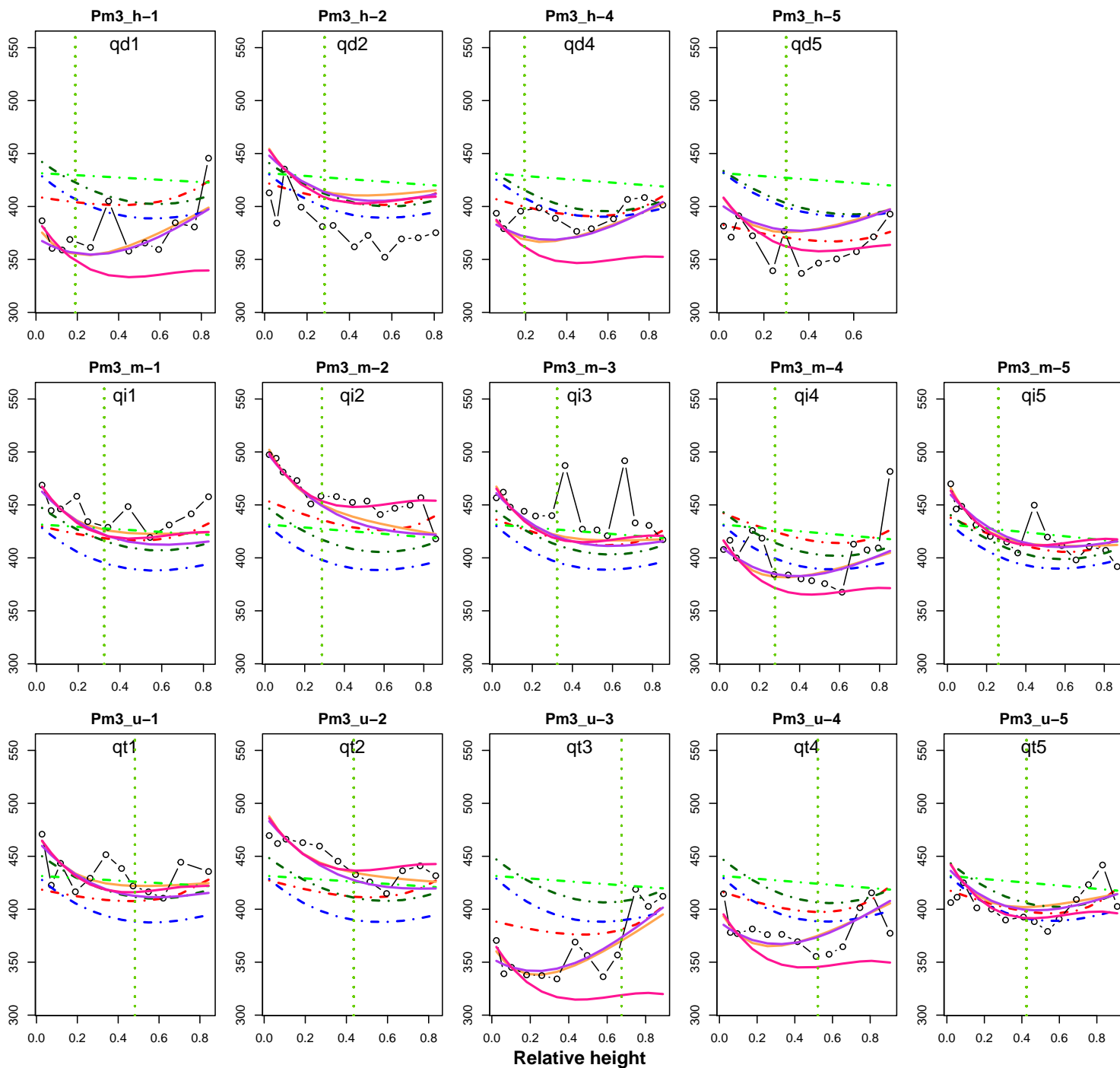
Basic density of the stem wood (kg/m^3)



Basic density of the stem wood (kg/m^3)



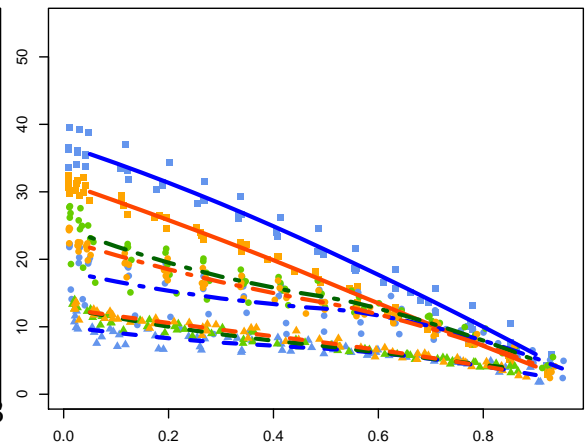
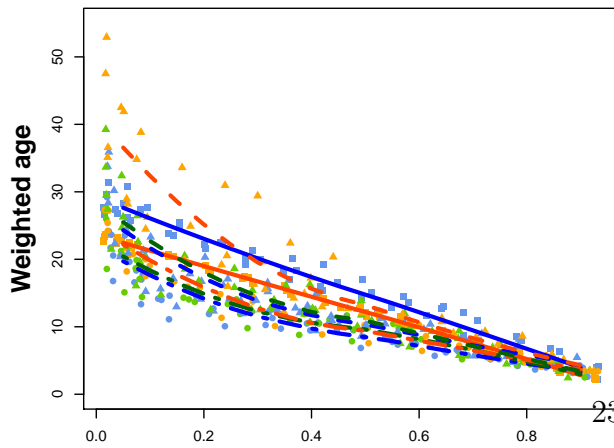
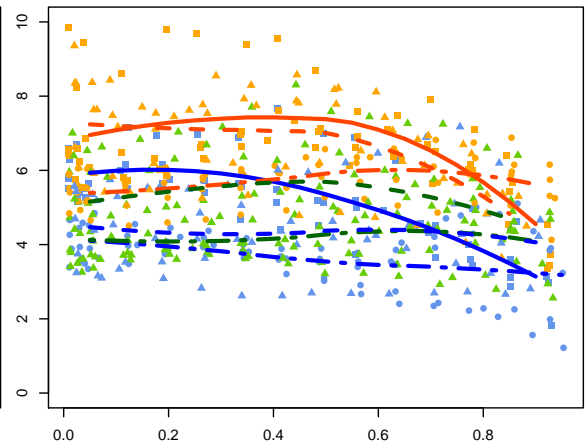
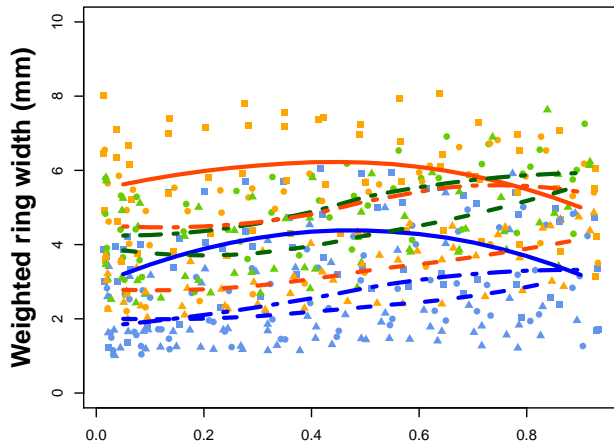
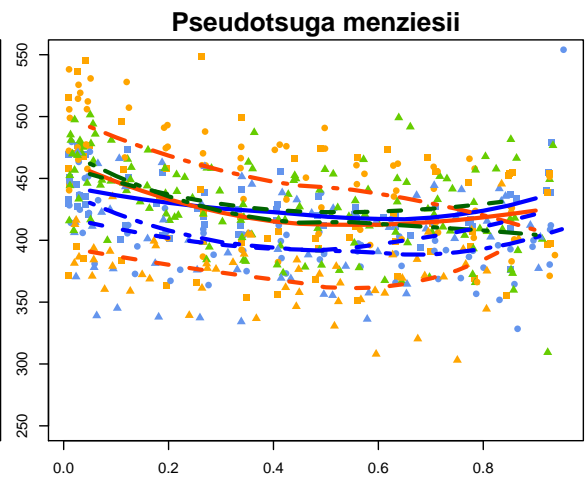
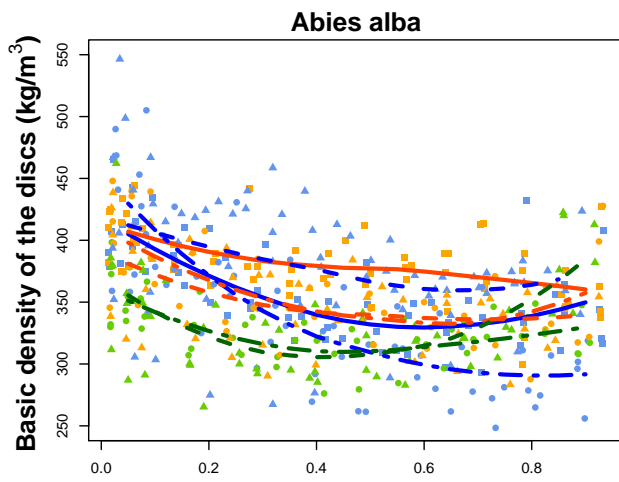
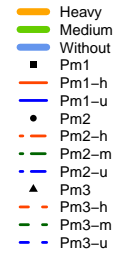
Basic density of the stem wood (kg/m^3)

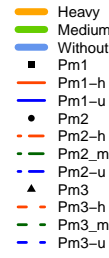


Variation in weighted ring width, weighted cambial age, proportion of corewood and surface of corewood with relative height

The figures F.1 to F.3 show weighted ring width, weighted cambial age, proportion of corewood and surface of corewood as a function of the relative height in the tree. Trend curves have been drawn for each thinning modality where the type of line represents the stand: Solid lines are for stand #1 (Saint-Prix, Mas-Dorier or Mélagues depending on the species), dotted dashed lines are for stand #2 (Saint-Prix or Grison) and dashed lines are for stand #3 (Mont-Sainte-Marie or Quartier). The colors represent the thinning modality: Blue points and dark blue lines are for unthinned modality, green points and dark green lines are for moderate thinning and orange points and dark orange lines are for heavy thinning.

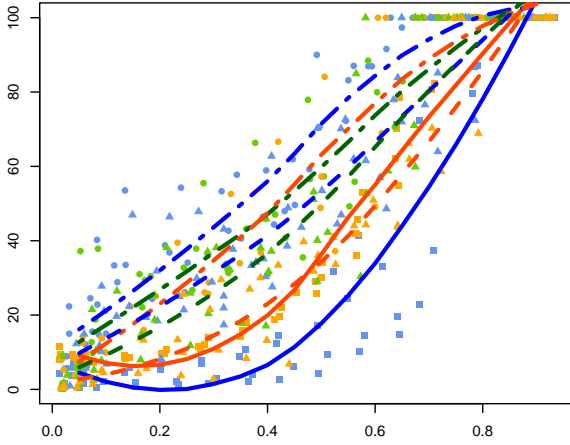
The proportion of corewood and surface of corewood were calculated for three hypotheses: the corewood represents the 10 first rings, the 15 first rings or the 20 first rings. These three hypotheses were made in relation to Lachenbruch et al. (2011) assertions that the number of rings is more important in determining the amount of corewood than the diameter of the trees. Moreover, the transition between corewood and mature wood does not seem influenced by the thinning intensity or the height in the living crown (Gartner et al., 2002). The ring width and cambial age were weighted by the surface of the rings to compute consistent variables at the disc level.



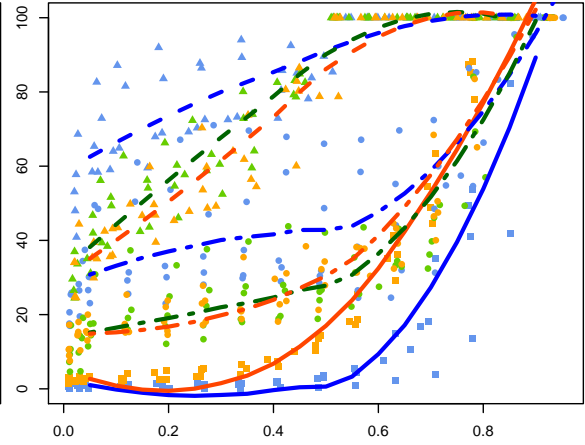


Proportion of juvenile wood younger than 10 years

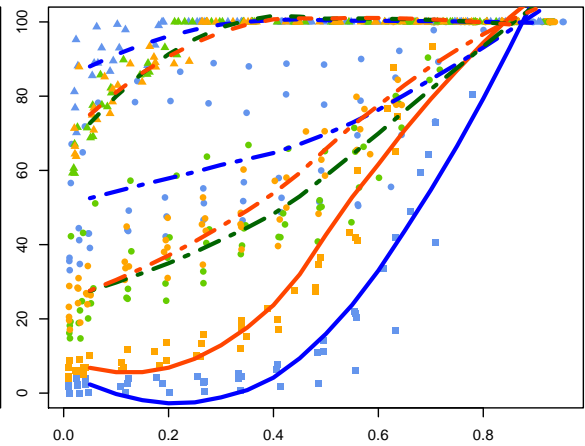
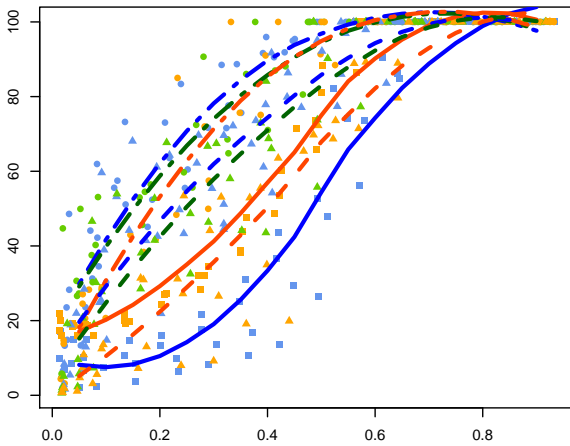
Abies alba



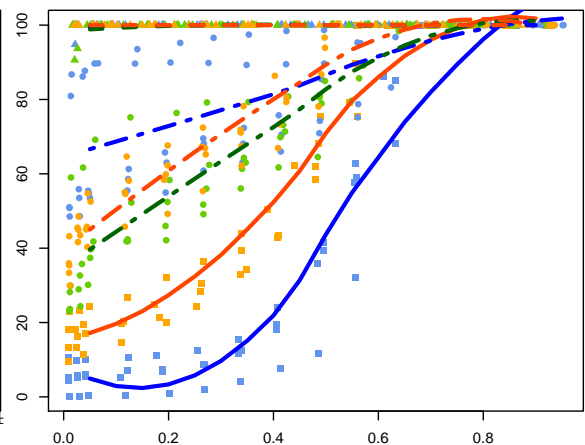
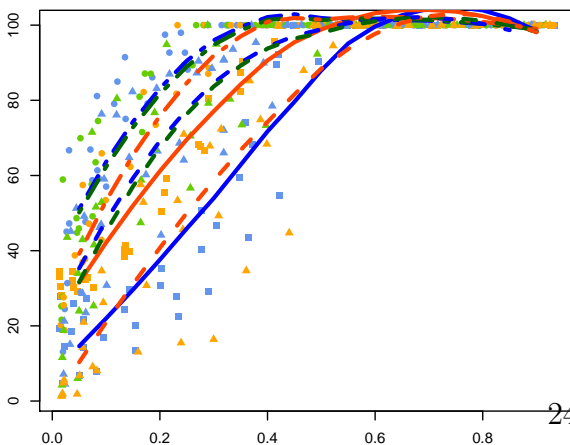
Pseudotsuga menziesii



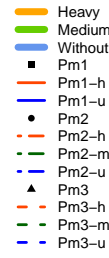
Proportion of juvenile wood younger than 15 years



Proportion of juvenile wood younger than 20 years

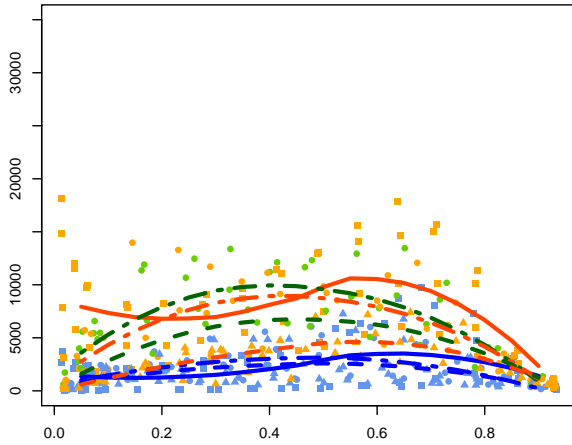


Relative height

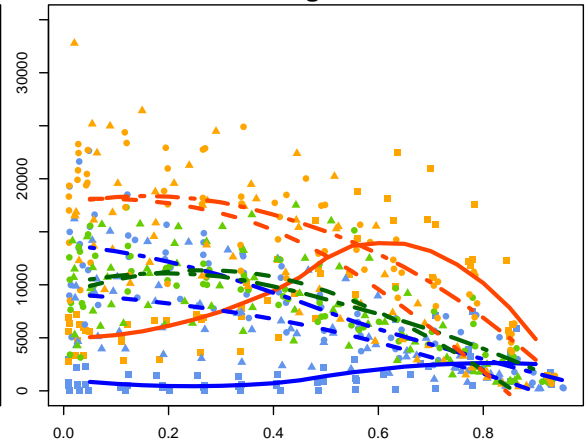


Surface of juvenile wood younger than 10 years

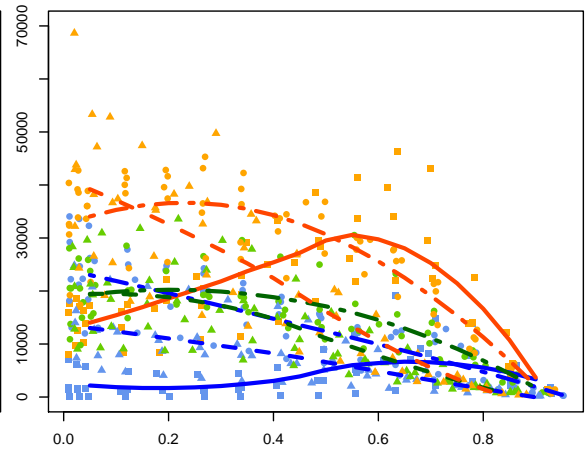
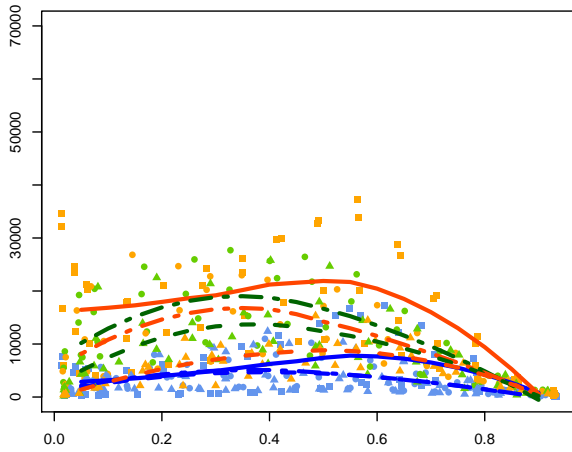
Abies alba



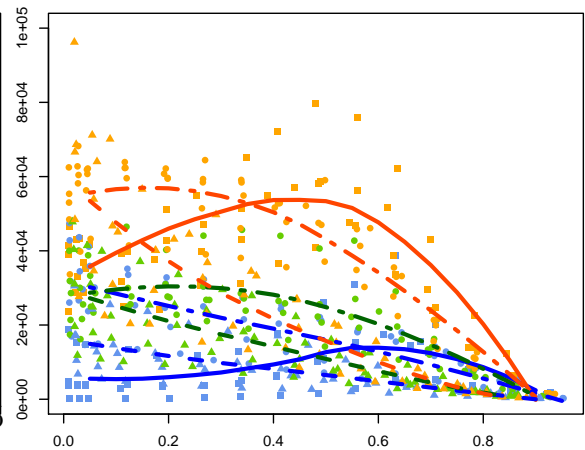
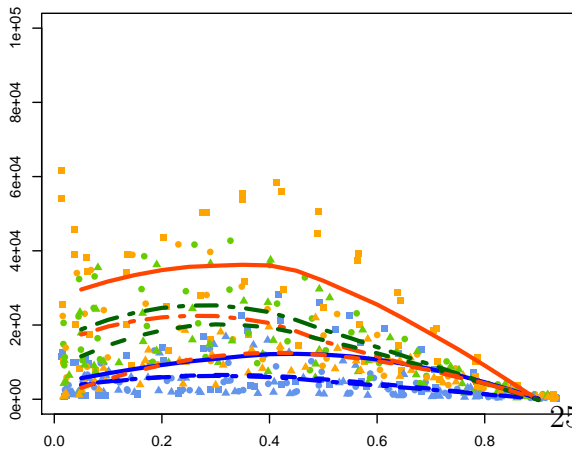
Pseudotsuga menziesii



Surface of juvenile wood younger than 15 years



Surface of juvenile wood younger than 20 years



Relative height