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# Biomass Equations for European Trees: Addendum*

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A review of stem volume and biomass equations for tree species growing in Europe (Zianis et al. 2005) resulted in suggestions for additional equations. The numbers of original equations, compiled from scientific articles were 607 for biomass and 230 for stem volume. On the basis of the suggestions and an updated literature search, some new equations were published after our review, but more equations were also available from earlier literature. In this addendum, an additional 188 biomass equations and 8 volume equations are presented. One new tree species (*Pinus cembra*) is included in the list of volume equations. Biomass equations for twelve new tree species are presented: *Abies alba, Carbinus betulus, Larix decidua, P. cembra, P. nigra, Quercus robur, Salix caprea, S. 'Aquatica', S. dasyclados, S. phylicifolias, S. triandra* and *S. accuparia*.

The tree-level equations predict stem volume, whole tree biomass or biomass of certain components (e.g., foliage, roots, total above-ground) as a function of diameter or diameter and height of a tree. Biomass and volume equations with other independent variables have also been widely developed but they are excluded from this addendum because the variables selected may reflect locally valid dependencies that cannot be generalized to other geographical regions.

Most of the equations presented here are developed for Sweden, Finland and Norway in northern Europe, for Austria in central Europe and for Italy in southern Europe. There are also few equations from Poland and Belgium. Most of the equations deal with above-ground components such as stem, branches and foliage, but some new equations are also available for root biomass. Zianis et al. (2005) and this addendum can be used together as guides to the original publications of these equations. Our updated database of the biomass and volume equations is available also from the website *www.metla.fi/hanke/3306/tietokanta.htm*.

**Keywords** aboveground biomass, allometry, belowground biomass, biomass functions, dbh, tree diameter, tree height
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*Zianis, D., Muukkonen, P., Mäkipää, R. & Mencuccini, M. 2005. Biomass and stem volume equations for tree species in Europe. Silva Fennica Monographs 4. 63 p.

**Appendix A.** Biomass equations for different biomass components by tree species. In addition to scientific names of the tree species, common names are shown as they are reported in the original publications. The format of the biomass equation is given in the column labelled Equation, and a, b, c, d, and e are parameter values. The "ln" is the natural logarithm and the "log" is the 10-based logarithm. Number of sampled trees (*n*), coefficients of determination ($r^2$), and range of diameter (*D*) and height (*H*) of sampled trees are reported when available in the original article. References (Ref.) to the original papers according to author as well as the contact (Cont.) person who submitted the equation to this database are given at

| | | Unit of | | | Range of | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biom. | *D* | *H* | *D* (cm) | *H* (m) | Ref. | Cont. | Comm. | *n* | $r^2$ |
| ***Abies alb***a (Silver fir) | | | | | | | | | | | |
| 608 Italy | AB | kg | cm | m | 8.9–55.5 | 8.9–55.6 | 2 | 2 | 1 | 40 | 0.978 |
| 609 Italy | ABW | kg | cm | m | 8.9–55.5 | 8.9–55.6 | 2 | 2 | 2 | 40 | 0.982 |
| 610 Austria | CR | kg | cm | m | 14.7–67.2 | 14.7–39.3 | 7 | 5 | – | 199 | 0.73 |
| 611 Italy | CR | kg | cm | m | 8.9–55.5 | 8.9–55.6 | 2 | 2 | 3 | 40 | 0.883 |
| 612 Italy | DB | kg | cm | m | 8.9–55.5 | 8.9–55.6 | 2 | 2 | – | 40 | 0.521 |
| 613 Italy | SU | kg | cm | m | 8.9–55.5 | 8.9–55.6 | 2 | 2 | – | 40 | 0.627 |
| ***Alnus glutinosa*** (Common alder, Black alder, Klibbal) | | | | | | | | | | | |
| 614 Norway | ln(BR) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 133 | 0.862 |
| 615 Norway | ln(FL) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 130 | 0.769 |
| 616 Norway | ln(ST) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 137 | 0.981 |
| ***Alnus incana*** (Grey alder, Gråal, Harmaaleppä) | | | | | | | | | | | |
| 617 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.917 |
| 618 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.856 |
| 619 Finland | log(BR) | g | – | cm | – | – | 10 | 4 | 5 | – | 0.74 |
| 620 Finland | BR | g | mm | cm | – | – | 10 | 4 | 5 | – | 0.86 |
| 621 Finland | BR | g | mm | dm | 0.2–3.7 | 1.4–5.3 | 12 | 4 | 5 | 178 | 0.86 |
| 622 Finland | BR | g | mm | – | 0.8–6.3 | 2.4–8.1 | 12 | 4 | 5 | 179 | 0.82 |
| 623 Finland | BR | g | cm | – | 5.9–16.2 | 9.9–14 | 12 | 4 | 5 | 45 | 0.92 |
| 624 Norway | ln(BR) | kg | cm | – | 1–15 | 1.5–15 | 6 | 3 | – | 54 | 0.892 |
| 625 Finland | ln(BR) | g | mm | dm | 0.3–5 | 1.4–5.3 | 13 | 4 | 6 | 87 | 0.66 |
| 626 Finland | ln(BR) | g | mm | dm | 2.4–9.9 | 4.3–9.7 | 13 | 4 | 7 | 59 | 0.88 |
| 627 Finland | log(DB) | kg | cm | – | 1.2–20.1 | 2.2–13.1 | 11 | 4 | – | 42 | 0.547 |
| 628 Finland | log(DB) | kg | cm | – | 1–21.9 | 2.8–15.6 | 11 | 4 | – | 65 | 0.358 |
| 629 Finland | log(DB) | kg | cm | – | 1–21.9 | 2.2–15.6 | 11 | 4 | – | 107 | 0.414 |
| 630 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.913 |
| 631 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.635 |
| 632 Finland | log(FL) | g | – | cm | – | – | 10 | 4 | 5 | – | 0.78 |
| 633 Finland | FL | g | mm | – | – | – | 10 | 4 | 5 | – | 0.86 |
| 634 Finland | FL | g | mm | – | 0.2–3.7 | 1.4–5.3 | 12 | 4 | 5 | 178 | 0.86 |
| 635 Finland | FL | g | mm | – | 0.8–6.3 | 2.4–8.1 | 12 | 4 | 5 | 179 | 0.85 |
| 636 Finland | FL | g | cm | – | 5.9–16.2 | 9.9–14 | 12 | 4 | 5 | 45 | 0.48 |
| 637 Finland | ln(FL) | g | mm | dm | 0.3–5 | 1.4–5.3 | 13 | 4 | 6 | 87 | 0.64 |
| 638 Finland | ln(FL) | g | mm | dm | 2.4–9.9 | 4.3–9.7 | 13 | 4 | 7 | 59 | 0.88 |
| 639 Norway | ln(FL) | kg | cm | – | 1–15 | 1.5–15 | 6 | 3 | – | 48 | 0.838 |
| 640 Finland | log(SB) | g | – | cm | – | – | 10 | 4 | 5 | – | 0.83 |
| 641 Finland | SB | g | mm | cm | – | – | 10 | 4 | 5 | – | 0.95 |
| 642 Finland | SB | g | cm | – | 5.9–16.2 | 9.9–14 | 12 | 4 | 5 | – | 0.75 |
| 643 Finland | log(SB) | kg | cm | m | 1.2–20.1 | 2.2–13.1 | 11 | 4 | – | 42 | 0.988 |
| 644 Finland | log(SB) | kg | cm | m | 1–21.9 | 2.8–15.6 | 11 | 4 | – | 65 | 0.988 |
| 645 Finland | log(SB) | kg | cm | m | 1–21.9 | 2.2–15.6 | 11 | 4 | – | 107 | 0.984 |
| 646 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.985 |
| 647 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.916 |
| 648 Finland | ST | g | mm | – | 0.2–3.7 | 1.4–5.3 | 10 | 4 | 5 | – | 0.96 |
| 649 Finland | ST | g | mm | – | 0.8–6.3 | 2.4–8.1 | 12 | 4 | 5 | – | 0.97 |
| 650 Finland | ln(ST) | g | mm | dm | 0.3–5 | 1.4–5.3 | 13 | 4 | 6 | 87 | 0.88 |
| 651 Finland | ln(ST) | g | mm | dm | 2.4–9.9 | 4.3–9.7 | 13 | 4 | 7 | 60 | 0.98 |
| 652 Norway | ln(ST) | kg | cm | – | 1–15 | 1.5–15 | 6 | 3 | – | 54 | 0.988 |

the end of the table. In the comments column (Comm.) occur some comments about the particular equation. Abbreviations for dependent variables (tree biomass components) are AB = Total aboveground biomass, ABW = Total aboveground woody biomass, BR = Branch biomass, CR = Crown biomass (BR+FL), DB = Biomass of dead branches, FL = Total foliage biomass, RC = Biomass of coarse roots[a] , RF = Biomass of fine roots[a] , RS = Biomass of small roots[a] , RT = Biomass of roots (RC+RF+RS), SB = Biomass of stem bark, SR = Biomass of the stump-root system[a] , ST = Total stem biomass (SW+SB), SU = Stump biomass[a] , SW = Stem wood biomass, TW = Total woody biomass ([a] defined differently in each study).

| | | Parameters | | | | |
|---|---|---|---|---|---|---|
| | Equation | a | b | c | d | e |
| 608 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 3.3424 | 0.016487 | 8.1355 | – | – |
| 609 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 0.98961 | 0.01398 | 0.01895 | – | – |
| 610 | $\exp(a+b\cdot \ln(D)+\ln(c))$ | –3.99741 | 2.31769 | 1.082 | – | – |
| 611 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 1.6305 | $1.7321\cdot10^{-3}$ | 0.068361 | – | – |
| 612 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 0.8453 | $4.6052\cdot10^{-4}$ | $-3.1032\cdot10^{-3}$ | – | – |
| 613 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –0.12302 | 0.031463 | 0.01202 | – | – |
| 614 | $a+b\cdot \ln(D)+c\cdot(\ln(D))^2$ | 3.0924 | 2.5837 | –0.2296 | – | – |
| 615 | $a+b\cdot \ln(D)+c\cdot(\ln(D))^2$ | 3.2181 | 2.3556 | –0.2912 | – | – |
| 616 | $a+b\cdot \ln(D)+c\cdot(\ln(D))^2$ | 4.5879 | 1.7177 | 0.2904 | – | – |
| 617 | $a\cdot(D^2\cdot H)^b$ | 0.0001 | 1.115 | – | – | – |
| 618 | $a\cdot(D^2\cdot H)^b$ | 0.0001 | 1.1328 | – | – | – |
| 619 | $a+b\cdot H^2$ | –3.43 | 0.81 | – | – | – |
| 620 | $a\cdot H+b\cdot H^2+c\cdot D^2$ | 0.38 | –0.0011 | 0.0005 | – | – |
| 621 | $a+b\cdot D^2+c\cdot H^2$ | 35.5 | 0.45 | –0.097 | – | – |
| 622 | $a+b\cdot D+c\cdot D^2$ | 89.7 | –10.5 | 0.39 | – | – |
| 623 | $a+b\cdot D+c\cdot D^2$ | 6926 | –1597 | 129 | – | – |
| 624 | $a+b\cdot \ln(D)$ | 2.4591 | 2.1996 | – | – | – |
| 625 | $a+b\cdot D+c\cdot H^2$ | 4.722 | 0.0834 | –0.00062 | – | – |
| 626 | $a+b\cdot D+c\cdot D^2+d\cdot H^2$ | 2.806 | 0.112 | –0.00036 | –0.00023 | – |
| 627 | $a+b\cdot \log(D)$ | –6.6914 | 1.969 | – | – | – |
| 628 | $a+b\cdot \log(D)$ | –7.8693 | 1.8433 | – | – | – |
| 629 | $a+b\cdot \log(D)$ | –7.6679 | 2.0291 | – | – | – |
| 630 | $a\cdot(D^2\cdot H)^b$ | 0.0009 | 0.9305 | – | – | – |
| 631 | $a\cdot(D^2\cdot H)^b$ | 0.0015 | 0.8807 | – | – | – |
| 632 | $a+b\cdot H^2$ | –4.48 | 0.92 | – | – | – |
| 633 | $a+b\cdot D^2$ | 0.0001 | 0.0719 | – | – | – |
| 634 | $a+b\cdot D^2$ | –4.56 | 0.16 | – | – | – |
| 635 | $a+b\cdot D+c\cdot D^2$ | 28.4 | –4.15 | 0.22 | – | – |
| 636 | $a+b\cdot D+c\cdot D^2$ | –516.7 | 57.4 | 3.38 | – | – |
| 637 | $a+b\cdot D+c\cdot H^2$ | 4.835 | 0.0782 | –0.00069 | – | – |
| 638 | $a+b\cdot D+c\cdot H+d\cdot D^2$ | 2.507 | 0.124 | –0.0316 | –0.00047 | – |
| 639 | $a+b\cdot \ln(D)+c\cdot(\ln(D))^2$ | 2.8932 | 1.00001 | 0.3156 | | – |
| 640 | $a+b\cdot H^2$ | –1.41 | 0.5 | – | – | – |
| 641 | $a\cdot H+b\cdot D^2$ | 0.08 | 0.2027 | – | – | – |
| 642 | $a+b\cdot D+c\cdot D^2$ | 1.79 | 0.79 | 0.17 | – | – |
| 643 | $a+b\cdot \log(D)+c\cdot \log(H)$ | –4.4906 | 1.7215 | 0.6056 | – | – |
| 644 | $a+b\cdot \log(D)+c\cdot \log(H)$ | –4.2898 | 1.818 | 0.3039 | – | – |
| 645 | $a+b\cdot \log(D)+c\cdot \log(H)$ | –4.9747 | 1.524 | 0.9554 | – | – |
| 646 | $a\cdot(D^2\cdot H)^b$ | 0.0033 | 0.9139 | – | – | – |
| 647 | $a\cdot(D^2\cdot H)^b$ | 0.0041 | 0.9011 | – | – | – |
| 648 | $a+b\cdot D^2$ | 12.5 | 0.92 | – | – | – |
| 649 | $a+b\cdot D+c\cdot D^2$ | 144.5 | –19.1 | 1.42 | – | – |
| 650 | $a+b\cdot D+c\cdot D^2+d\cdot \ln(H)$ | 6.262 | 0.1087 | –0.00076 | –0.5562 | – |
| 651 | $a+b\cdot H^2+c\cdot \ln(D)$ | –0.30015 | 0.000057 | 2.023 | – | – |
| 652 | $a+b\cdot \ln(D)+c\cdot(\ln(D))^2$ | 4.317 | 2.0521 | 0.187 | – | – |

| **Appendix A** | | Unit of | | | Range of | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biom. | *D* | *H* | *D* (cm) | *H* (m) | Ref. | Cont. | Comm. | *n* | $r^2$ |
| 653 Finland | SU | g | mm | – | 0.8–6.3 | 2.4–8.1 | 12 | 4 | 5 | – | 0.58 |
| 654 Finland | log(SW) | g | – | cm | – | – | 10 | 4 | 5 | – | 0.9 |
| 655 Finland | SW | g | mm | – | – | – | 10 | 4 | 5 | – | 0.99 |
| 656 Finland | SW | g | cm | – | 5.9–16.2 | 9.9–14 | 12 | 4 | 5 | – | 0.92 |
| 657 Finland | log(SW) | kg | cm | m | 1.2–20.1 | 2.2–13.1 | 11 | 4 | – | – | 0.994 |
| 658 Finland | log(SW) | kg | cm | m | 1–21.9 | 2.8–15.6 | 11 | 4 | – | – | 0.994 |
| 659 Finland | log(SW) | kg | cm | m | 1–21.9 | 2.2–15.6 | 11 | 4 | – | – | 0.994 |
| ***Betula pendula*** (Silver birch, Pendula birch, White birch, Rauduskoivu, Vårtbjörk) | | | | | | | | | | | |
| 660 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.896 |
| 661 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.782 |
| 662 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.954 |
| 663 Finland | ln(BR) | g | mm | dm | 0.1–3.6 | 1.3–4.5 | 13 | 4 | 6 | 88 | 0.77 |
| 664 Finland | ln(BR) | g | mm | dm | 1.6–7.1 | 2.9–8.2 | 13 | 4 | 7 | 30 | 0.96 |
| 665 Norway | ln(BR) | kg | cm | – | 1–13 | 1.5–16 | 6 | 3 | – | 41 | 0.922 |
| 666 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.725 |
| 667 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.674 |
| 668 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.789 |
| 669 Finland | ln(FL) | g | mm | dm | 0.1–3.6 | 1.3–4.5 | 13 | 4 | 6 | 88 | 0.84 |
| 670 Finland | ln(FL) | g | mm | dm | 1.6–7.1 | 2.9–8.2 | 13 | 4 | 7 | 30 | 0.91 |
| 671 Norway | ln(FL) | kg | cm | – | 1–13 | 1.5–16 | 6 | 3 | – | 34 | 0.746 |
| 672 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.941 |
| 673 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.991 |
| 674 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.988 |
| 675 Finland | ln(ST) | g | mm | dm | 0.1–3.6 | 1.3–4.5 | 13 | 4 | 6 | 88 | 0.88 |
| 676 Finland | ln(ST) | g | mm | dm | 1.6–7.1 | 2.9–8.2 | 13 | 4 | 7 | 30 | 0.99 |
| 677 Norway | ln(ST) | kg | cm | – | 1–13 | 1.5–16 | 6 | 3 | – | 88 | 0.985 |
| ***Betula pubescens*** (White birch, Pubescent birch, Hieskoivu, Glasbjörk, Björk) | | | | | | | | | | | |
| 678 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.69 |
| 679 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.947 |
| 680 Finland | BR | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.836 |
| 681 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.401 |
| 682 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.887 |
| 683 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.791 |
| 684 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.932 |
| 685 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.991 |
| 686 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.966 |
| ***Betula*** spp. (Birch, Koivu, Björk) | | | | | | | | | | | |
| 687 Sweden | ln(RF) | g | mm | – | 0.5–26.7 | 1.7–20.8 | 8 | 3 | 8 | 13 | 0.955 |
| 688 Sweden | ln(RS) | g | mm | – | 0.5–26.7 | 1.7–20.8 | 8 | 3 | 9 | 13 | 0.952 |
| ***Carpinus betulus*** (Hornbeam) | | | | | | | | | | | |
| 689 Austria | ln(BR) | kg | cm | – | 11.9–47.4 | 11.1–24.8 | 3 | 5 | – | 50 | 0.801 |
| 690 Austria | BR | kg | cm | – | 6–29.9 | 8.8–25.1 | 7 | 5 | – | 483 | 0.669 |
| ***Fagus sylvatica*** (Beech, European beech, Hêtres, Rotbuche) | | | | | | | | | | | |
| 691 Italy | AB | kg | cm | m | 9.5–56.5 | 9.3–22.3 | 2 | 2 | 1 | 30 | 0.956 |
| 692 Italy | ABW | kg | cm | m | 9.5–56.5 | 9.3–22.3 | 2 | 2 | 2 | 30 | 0.955 |
| 693 Austria | ln(BR) | kg | cm | – | 12.8–68.7 | 11.9–38.6 | 3 | 5 | – | 606 | 0.656 |
| 694 Austria | ln(BR) | kg | cm | – | 6.6–52 | 9–40.1 | 4 | 5 | – | 36 | 0.89 |
| 695 Austria | ln(BR) | kg | cm | m | 6.6–52 | 9–40.1 | 4 | 5 | – | 36 | 0.912 |
| 696 Austria | BR | kg | cm | – | 2–67.1 | 3.6–39 | 7 | 5 | – | 4213 | 0.891 |
| 697 Italy | CR | kg | cm | m | 9.5–56.5 | 9.3–22.3 | 2 | 2 | 3 | 30 | 0.881 |
| 698 Italy | DB | kg | cm | m | 9.5–56.5 | 9.3–22.3 | 2 | 2 | – | 30 | 0.217 |
| 699 Austria | RT | kg | cm | – | 4–53 | 7–28 | 1 | 5 | – | 27 | 0.93 |
| 700 Austria | SR | kg | cm | – | 4–53 | 7–28 | 1 | 5 | – | 27 | 0.94 |
| 701 Italy | SU | kg | cm | m | 9.5–56.5 | 9.3–22.3 | 2 | 2 | – | 30 | 0.78 |
| ***Fraxinus excelsior*** (European ash) | | | | | | | | | | | |
| 702 Austria | ln(BR) | kg | cm | – | 12.5–55.4 | 12.3–32.7 | 3 | 5 | – | 162 | 0.736 |
| 703 Norway | ln(BR) | kg | cm | – | 1–11 | 1.5–14 | 6 | 3 | – | 18 | 0.926 |
| 704 Norway | ln(FL) | kg | cm | – | 1–11 | 1.5–14 | 6 | 3 | – | 19 | 0.961 |
| 705 Norway | ln(ST) | kg | cm | – | 1–11 | 1.5–14 | 6 | 3 | – | 32 | 0.987 |

| | Equation | Parameters a | b | c | d | e |
|---|---|---|---|---|---|---|
| 653 | a+b·D+c·D$^2$ | 13.9 | 0.17 | 0.39 | – | – |
| 654 | a+b·H$^2$ | –2.83 | 0.78 | – | – | – |
| 655 | a+b·D$^2$ | 38 | 0.0014 | – | – | – |
| 656 | a+b·D+c·D$^2$ | 24.2 | –2.92 | 1.99 | – | – |
| 657 | a+b·log(D)+c·log(H) | –3.4033 | 1.9521 | 0.6485 | – | – |
| 658 | a+b·log(D)+c·log(H) | –4.0313 | 1.9828 | 1.1717 | – | – |
| 659 | a+b·log(D)+c·log(H) | –3.8363 | 1.7576 | 1.0098 | – | – |
| 660 | a·(D$^2$·H)$^b$ | 0.0032 | 0.8756 | – | – | – |
| 661 | a·(D$^2$·H)$^b$ | 0.0353 | 0.6961 | – | – | – |
| 662 | a·(D$^2$·H)$^b$ | 0.0007 | 1.0163 | – | – | – |
| 663 | a+b·D+c·H$^2$+d·ln(D)+e·ln(H) | 10.39 | 0.0604 | 0.00047 | 1.074 | –2.804 |
| 664 | a+b·ln(D)+c·ln(H) | 2.694 | 3.15 | –1.914 | – | – |
| 665 | a+b·ln(D)+c·(ln(D))$^2$ | 3.5489 | 1.286 | 0.2959 | – | – |
| 666 | a·(D$^2$·H)$^b$ | 0.1119 | 0.7255 | – | – | – |
| 667 | a·(D$^2$·H)$^b$ | 0.0033 | 0.7925 | – | – | – |
| 668 | a·(D$^2$·H)$^b$ | 0.0068 | 0.748 | – | – | – |
| 669 | a+b·H+c·D+d·D$^2$ | 3.746 | –0.0228 | 0.1661 | –0.002 | – |
| 670 | a+b·ln(D)+c·ln(H) | 0.649 | 3.323 | –1.731 | – | – |
| 671 | a+b·ln(D)+c·(ln(D))$^2$ | 2.8272 | 0.8999 | 0.3934 | – | – |
| 672 | a·(D$^2$·H)$^b$ | 0.0122 | 0.8203 | – | – | – |
| 673 | a·(D$^2$·H)$^b$ | 0.0091 | 0.851 | – | – | – |
| 674 | a·(D$^2$·H)$^b$ | 0.0072 | 0.8579 | – | – | – |
| 675 | a+b·D+c·ln(D)+d·ln(H) | 6.552 | 0.0699 | 0.6334 | –1.0098 | – |
| 676 | a+b·D$^2$+c·ln(D) | –1.844 | –0.00011 | 2.638 | – | – |
| 677 | a+b·ln(D)+c·(ln(D))$^2$ | 5.0003 | 1.5713 | 0.3271 | – | – |
| 678 | a·(D$^2$·H)$^b$ | 0.0068 | 0.8248 | – | – | – |
| 679 | a·(D$^2$·H)$^b$ | 0.0003 | 1.0628 | – | – | – |
| 680 | a·(D$^2$·H)$^b$ | 0.0018 | 0.9231 | – | – | – |
| 681 | a·(D$^2$·H)$^b$ | 0.2521 | 0.4843 | – | – | – |
| 682 | a·(D$^2$·H)$^b$ | 0.0001 | 1.0242 | – | – | – |
| 683 | a·(D$^2$·H)$^b$ | 0.0003 | 0.9583 | – | – | – |
| 684 | a·(D$^2$·H)$^b$ | 0.0231 | 0.7748 | – | – | – |
| 685 | a·(D$^2$·H)$^b$ | 0.0031 | 0.9355 | – | – | – |
| 686 | a·(D$^2$·H)$^b$ | 0.0143 | 0.8066 | – | – | – |
| 687 | a+b·[D/(D+138)] | 4.90864 | 9.91194 | – | – | – |
| 688 | a+b·[D/(D+225)] | 6.1708 | 10.01111 | – | – | – |
| 689 | ln(a)+b·ln(D) | –8.37005 | 3.78168 | | – | – |
| 690 | exp(a+b·ln(D)+ln(c)) | –5.52257 | 3.11695 | 1.166 | – | – |
| 691 | a+b·D$^2$·H+c·D$^2$ | –1.0798 | 0.018017 | 0.25888 | – | – |
| 692 | a+b·D$^2$·H+c·D$^2$ | –3.7197 | 0.019559 | 0.088089 | – | – |
| 693 | ln(a)+b·ln(D) | –10.02932 | 3.98035 | – | – | – |
| 694 | a+b·ln(D) | –4.82606 | 2.69521 | – | – | – |
| 695 | a+b·ln(D)+c·ln(H) | –3.54015 | 3.93514 | – | – | – |
| 696 | exp(a+b·ln(D)+ln(c)) | –4.21566 | 2.57726 | 1.162 | – | – |
| 697 | a+b·D$^2$·H+c·D$^2$ | –5.587 | $-1.9468\cdot10^{-4}$ | 0.15641 | – | – |
| 698 | a+b·D$^2$·H+c·D$^2$ | –0.3231 | $5.0689\cdot10^{-4}$ | $-3.5765\cdot10^{-3}$ | – | – |
| 699 | a·exp(b+c·ln(D)) | 1.09 | –4.04 | 2.27 | – | – |
| 700 | a·exp(b+c·ln(D)) | 1.08 | –4 | 2.32 | – | – |
| 701 | a+b·D$^2$·H+c·D$^2$ | –1.1678 | $-1.0182\cdot10^{-4}$ | 0.017957 | – | – |
| 702 | ln(a)+b·ln(D) | –9.56889 | 3.92535 | – | – | – |
| 703 | a+b·(ln(D))$^2$ | 4.0215 | 0.9332 | – | – | – |
| 704 | a+b·ln(D)+c·(ln(D))$^2$ | 0.411 | 4.1947 | – | – | – |
| 705 | a+b·ln(D) | 4.375 | 2.618 | – | – | – |

## Appendix A

| | | Unit of | | | Range of | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biom. | *D* | *H* | *D* (cm) | *H* (m) | Ref. | Cont. | Comm. | *n* | $r^2$ |
| ***Larix decidua*** | | | | | | | | | | | |
| 706 Italy | AB | kg | cm | m | 7.7–53.9 | 5.6–24.9 | 2 | 2 | 1 | 33 | 0.964 |
| 707 Italy | ABW | kg | cm | m | 7.7–53.9 | 5.6–24.9 | 2 | 2 | 2 | 33 | 0.965 |
| 708 Austria | ln(BR) | kg | cm | – | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.89 |
| 709 Austria | ln(BR) | kg | cm | m | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.896 |
| 710 Austria | ln(CR) | kg | cm | – | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.886 |
| 711 Austria | ln(CR) | kg | cm | m | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.894 |
| 712 Italy | CR | kg | cm | m | 7.7–53.9 | 5.6–24.9 | 2 | 2 | 3 | 33 | 0.816 |
| 713 Italy | DB | kg | cm | m | 7.7–53.9 | 5.6–24.9 | 2 | 2 | – | 33 | 0.564 |
| 714 Austria | ln(FL) | kg | cm | – | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.848 |
| 715 Austria | ln(FL) | kg | cm | m | 4–90 | 4.6–30 | 9 | 5 | – | 28 | 0.855 |
| 716 Italy | SU | kg | cm | m | 7.7–53.9 | 5.6–24.9 | 2 | 2 | – | 33 | 0.807 |
| ***Picea abies*** (Norway spruce, Kuusi, Gran, Fichte, Rødgran, Epicéa) | | | | | | | | | | | |
| 717 Italy | AB | kg | cm | m | 7.9–31.2 | 2.8–35.8 | 2 | 2 | 1 | 82 | 0.965 |
| 718 Italy | ABW | kg | cm | m | 7.9–31.2 | 2.8–35.8 | 2 | 2 | 2 | 82 | 0.972 |
| 719 Austria | ln(BR) | kg | cm | – | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 82 | 0.935 |
| 720 Austria | ln(BR) | kg | cm | m | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 82 | 0.934 |
| 721 Austria | ln(CR) | kg | cm | – | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 82 | 0.945 |
| 722 Austria | ln(CR) | kg | cm | m | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 82 | 0.946 |
| 723 Austria | CR | kg | cm | – | 2.4–65.9 | 2.8–42.6 | 7 | 5 | – | 3753 | 0.785 |
| 724 Italy | CR | kg | cm | m | 7.9–31.2 | 2.8–35.8 | 2 | 2 | 3 | 82 | 0.702 |
| 725 Italy | DB | kg | cm | m | 7.9–31.2 | 2.8–35.8 | 2 | 2 | – | 82 | 0.692 |
| 726 Austria | ln(FL) | kg | cm | – | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 89 | 0.838 |
| 727 Austria | ln(FL) | kg | cm | m | 9.2–43.2 | 12.2–31.2 | 4 | 5 | – | 89 | 0.837 |
| 728 Sweden | ln(RF) | g | mm | – | 4.2–37.7 | 3.5–27.8 | 8 | 3 | 8 | 339 | 0.971 |
| 729 Sweden | ln(RS) | g | mm | – | 4.2–37.7 | 3.5–27.8 | 8 | 3 | 9 | 339 | 0.973 |
| 730 Austria | RT | kg | cm | – | 16–74 | 16–37 | 1 | 5 | – | 42 | 0.92 |
| 731 Austria | SR | kg | cm | – | 16–74 | 16–37 | 1 | 5 | – | 42 | 0.92 |
| 732 Italy | SU | kg | cm | m | 7.9–31.2 | 2.8–35.8 | 2 | 2 | – | 82 | 0.794 |
| ***Pinus cembra*** | | | | | | | | | | | |
| 733 Italy | AB | kg | cm | m | 7.7–56.3 | 4.4–22.2 | 2 | 2 | 1 | 30 | 0.99 |
| 734 Italy | ABW | kg | cm | m | 7.7–56.3 | 4.4–22.2 | 2 | 2 | 2 | 30 | 0.991 |
| 735 Italy | CR | kg | cm | m | 7.7–56.3 | 4.4–22.2 | 2 | 2 | 3 | 30 | 0.901 |
| 736 Italy | DB | kg | cm | m | 7.7–56.3 | 4.4–22.2 | 2 | 2 | – | 30 | 0.782 |
| 737 Italy | SU | kg | cm | m | 7.7–56.3 | 4.4–22.2 | 2 | 2 | – | 30 | 0.681 |
| ***Pinus nigra*** | | | | | | | | | | | |
| 738 Italy | AB | kg | cm | m | 8.9–35.9 | 5.6–20.9 | 2 | 2 | 1 | 30 | 0.974 |
| 739 Italy | ABW | kg | cm | m | 8.9–35.9 | 5.6–20.9 | 2 | 2 | 2 | 30 | 0.984 |
| 740 Italy | CR | kg | cm | m | 8.9–35.9 | 5.6–20.9 | 2 | 2 | 3 | 30 | 0.845 |
| 741 Italy | DB | kg | cm | m | 8.9–35.9 | 5.6–20.9 | 2 | 2 | – | 30 | 0.758 |
| 742 Italy | SU | kg | cm | m | 8.9–35.9 | 5.6–20.9 | 2 | 2 | – | 30 | 0.894 |
| ***Pinus sylvestris*** (Scots pine, Mänty, Tall) | | | | | | | | | | | |
| 743 Italy | AB | kg | cm | m | 8.4–40.6 | 6.4–20.8 | 2 | 2 | 1 | 30 | 0.961 |
| 744 Italy | ABW | kg | cm | m | 8.4–40.6 | 6.4–20.8 | 2 | 2 | 2 | 30 | 0.952 |
| 745 Austria | ln(BR) | kg | cm | | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.936 |
| 746 Austria | ln(BR) | kg | cm | m | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.939 |
| 747 Austria | ln(CR) | kg | cm | | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.939 |
| 748 Austria | ln(CR) | kg | cm | m | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.936 |
| 749 Italy | CR | kg | cm | m | 8.4–40.6 | 6.4–20.8 | 2 | 2 | 3 | 30 | 0.746 |
| 750 Italy | DB | kg | cm | m | 8.4–40.6 | 6.4–20.8 | 2 | 2 | – | 30 | 0.671 |
| 751 Austria | ln(FL) | kg | cm | | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.915 |
| 752 Austria | ln(FL) | kg | cm | m | 5.3–34.8 | 3.9–25.3 | 4 | 5 | – | 23 | 0.912 |
| 753 Poland | FL | kg | cm | m | 6–48 | 6–34 | 14 | 3 | – | 113 | 0.678 |
| 754 Poland | FL | kg | cm | m | 6–48 | 6–34 | 14 | 3 | – | 113 | 0.723 |
| 755 Sweden | ln(RF) | g | mm | – | 8.5–37.7 | 6.6–25.5 | 8 | 3 | 8 | 328 | 0.958 |
| 756 Sweden | ln(RS) | g | mm | – | 8.5–37.7 | 6.6–25.5 | 8 | 3 | 9 | 328 | 0.958 |
| 757 Italy | SU | kg | cm | m | 8.4–40.6 | 6.4–20.8 | 2 | 2 | – | 30 | 0.813 |
| ***Populus tremula*** (European aspen, Asp) | | | | | | | | | | | |
| 758 Norway | ln(BR) | kg | cm | – | 1–15 | 1.5–12 | 6 | 3 | – | 106 | 0.922 |
| 759 Norway | ln(FL) | kg | cm | – | 1–15 | 1.5–12 | 6 | 3 | – | 70 | 0.935 |

| | Equation | Parameters a | b | c | d | e |
|---|---|---|---|---|---|---|
| 706 | $a+b\cdot D^2\cdot H+c\cdot D$ | | | | | |
| 707 | $a+b\cdot D^2\cdot H+c\cdot D$ | | | | | |
| 708 | $a+b\cdot \ln(D)$ | –3.003 | 2.093 | – | – | – |
| 709 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –2.62 | 2.613 | –0.726 | – | – |
| 710 | $a+b\cdot \ln(D)$ | –2.614 | 2.019 | – | – | – |
| 711 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –2.219 | 2.555 | –0.748 | – | – |
| 712 | $a+b\cdot D^2\cdot H+c\cdot D$ | –6.1618 | $-9.446\cdot10^{-4}$ | 2.1432 | – | – |
| 713 | $a+b\cdot D^2\cdot H+c\cdot D$ | 2.243 | $4.5782\cdot10^{-4}$ | –0.15684 | – | – |
| 714 | $a+b\cdot \ln(D)$ | –3.201 | 1.578 | – | – | – |
| 715 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –2.874 | 2.021 | –0.618 | – | – |
| 716 | $a+b\cdot D^2\cdot H+c\cdot D$ | –0.43937 | $1.109\cdot10^{-4}$ | 0.15787 | – | – |
| 717 | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 8.8297 | 0.01876 | $-8.5316\cdot10^{-5}$ | – | – |
| 718 | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 2.5338 | $9.5351\cdot10^{-3}$ | $6.2893\cdot10^{-3}$ | – | – |
| 719 | $a+b\cdot \ln(D)$ | –5.1689 | 2.69049 | – | – | – |
| 720 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –5.04936 | 2.73927 | –0.0886 | – | – |
| 721 | $a+b\cdot \ln(D)$ | –4.75446 | 2.7063 | – | – | – |
| 722 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –4.63873 | 2.75352 | –0.08578 | – | – |
| 723 | $\exp(a+b\cdot \ln(D)+\ln(c))$ | –2.47383 | 1.8578 | 1.143 | – | – |
| 724 | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 5.4653 | $8.1739\cdot10^{-3}$ | $-5.8838\cdot10^{-3}$ | – | – |
| 725 | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 0.6473 | $4.2878\cdot10^{-4}$ | $-1.0435\cdot10^{-4}$ | – | – |
| 726 | $a+b\cdot \ln(D)$ | –6.17165 | 2.83519 | | – | – |
| 727 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –6.68745 | 2.62911 | 0.7713 | – | – |
| 728 | $a+b\cdot [D/(D+138)]$ | 4.58761 | 10.44035 | | – | – |
| 729 | $a+b\cdot [D/(D+142)]$ | 4.52965 | 10.57571 | | – | – |
| 730 | $a\cdot \exp(b+c\cdot \ln(D))$ | 1.04 | –5.9 | 2.85 | – | – |
| 731 | $a\cdot \exp(b+c\cdot \ln(D))$ | 1.04 | –5.59 | 2.79 | – | – |
| 732 | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 0.18324 | $6.2237\cdot10^{-4}$ | $-3.8640\cdot10^{-4}$ | – | – |
| 733 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –3.4268 | 0.010256 | 0.14144 | – | – |
| 734 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –2.9695 | 0.010066 | 0.084233 | – | – |
| 735 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 0.64194 | $-1.5615\cdot10^{-4}$ | 0.039256 | – | – |
| 736 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –1.0563 | $-9.7619\cdot10^{-4}$ | 0.01648 | – | – |
| 737 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –0.042908 | $3.3702\cdot10^{-4}$ | $1.4672\cdot10^{-3}$ | – | – |
| 738 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | | | | – | – |
| 739 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –3.5712 | 0.014429 | 0.068047 | – | – |
| 740 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –8.7135 | $6.7203\cdot10^{-4}$ | 0.11893 | – | – |
| 741 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –0.67033 | $4.0558\cdot10^{-5}$ | 0.010169 | – | – |
| 742 | $a+b\cdot D^2\cdot H+c\cdot D^2$ | $-3.0325\cdot10^{-3}$ | $9.5\cdot10^{-6}$ | $4.9177\cdot10^{-3}$ | – | – |
| 743 | $a+b\cdot D^2\cdot H$ | –0.73626 | 0.018465 | | – | – |
| 744 | $a+b\cdot D^2\cdot H$ | 2.7081 | 0.023724 | | – | – |
| 745 | $a+b\cdot \ln(D)$ | –3.34766 | 2.04663 | | – | – |
| 746 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –3.28558 | 2.16843 | –0.14726 | – | – |
| 747 | $a+b\cdot \ln(D)$ | –2.90582 | 1.98705 | | – | – |
| 748 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –2.8762 | 2.04516 | –0.07025 | – | – |
| 749 | $a+b\cdot D^2\cdot H$ | 2.5406 | $4.2895\cdot10^{-3}$ | | – | – |
| 750 | $a+b\cdot D^2\cdot H$ | 0.14696 | $6.8895\cdot10^{-4}$ | | – | – |
| 751 | $a+b\cdot \ln(D)$ | –3.78862 | 1.78458 | | – | – |
| 752 | $a+b\cdot \ln(D)+c\cdot \ln(H)$ | –3.88761 | 1.59036 | 0.23481 | – | – |
| 753 | $a\cdot D^b$ | 0.523 | 1.21105 | | – | – |
| 754 | $a\cdot D^b$ | 0.1722 | 1.28785 | | – | – |
| 755 | $a+b\cdot (D/(D+113))$ | 3.44275 | 11.06537 | | – | – |
| 756 | $a+b\cdot (D/(D+113))$ | 3.39014 | 11.06822 | | – | – |
| 757 | $a+b\cdot D^2\cdot H$ | 0.094123 | $2.8144\cdot10^{-4}$ | | – | – |
| 758 | $a+b\cdot \ln(D)+c\cdot (\ln(D))^2$ | 3.2121 | 1.7161 | 0.1982 | – | – |
| 759 | $a+b\cdot \ln(D)+c\cdot (\ln(D))^2$ | 3.1422 | 1.2007 | 0.2414 | – | – |

## Appendix A

| | | Unit of | | | Range of | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Biom. | D | H | D (cm) | H (m) | Ref. | Cont. | Comm. | n | $r^2$ |
| 760 Norway | ln(ST) | kg | cm | – | 1–15 | 1.5–12 | 6 | 3 | – | 132 | 0.988 |
| ***Populus*** **spp. (Poplar)** | | | | | | | | | | | |
| 761 Austria | ln(BR) | kg | cm | – | 11.7–92 | 12.2–38 | 3 | 5 | – | 347 | 0.713 |
| ***Quercus robur*** **(Pedunculate oak)** | | | | | | | | | | | |
| 762 Belgium | BR | kg | cm | – | – | – | 15 | 1 | – | 9 | 0.942 |
| 763 Belgium | FL | kg | cm | – | – | – | 15 | 1 | – | 9 | 0.91 |
| 764 Belgium | RC | kg | cm | – | – | – | 15 | 1 | – | 9 | 0.959 |
| 765 Belgium | ST | kg | cm | – | – | – | 15 | 1 | – | 9 | 0.994 |
| 766 Belgium | SU | kg | cm | – | – | – | 15 | 1 | – | 9 | 0.958 |
| ***Quercus*** **spp. (Oak, Eiche)** | | | | | | | | | | | |
| 767 Austria | ln(BR) | kg | cm | – | 20.3–75.9 | 12.4–26.3 | 3 | 5 | – | 186 | 0.813 |
| 768 Austria | ln(BR) | kg | cm | – | 6.5–61 | – | 4 | 5 | – | 30 | 0.972 |
| 769 Austria | ln(BR) | kg | cm | m | 6.5–61 | 9.5–19 | 4 | 5 | – | 30 | 0.972 |
| 770 Austria | BR | kg | cm | – | 3.6–26.3 | 6.6–22.4 | 7 | 5 | – | 96 | 0.668 |
| ***Salix caprea*** | | | | | | | | | | | |
| 771 Norway | ln(BR) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 35 | 0.878 |
| 772 Norway | ln(FL) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 34 | 0.877 |
| 773 Norway | ln(ST) | kg | cm | – | 1–14 | 1.5–14 | 6 | 3 | – | 39 | 0.985 |
| ***Salix 'Aquatica'*** | | | | | | | | | | | |
| 774 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.856 |
| 775 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.917 |
| 776 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.908 |
| 777 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.969 |
| ***Salix dasyclados*** | | | | | | | | | | | |
| 778 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.893 |
| 779 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.621 |
| 780 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.863 |
| 781 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.975 |
| 782 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.985 |
| 783 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.989 |
| ***Salix phylicifolias*** | | | | | | | | | | | |
| 784 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.887 |
| 785 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.87 |
| 786 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.943 |
| 787 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.971 |
| 788 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.977 |
| ***Salix triandra*** | | | | | | | | | | | |
| 789 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.812 |
| 790 Finland | FL | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.757 |
| 791 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.98 |
| 792 Finland | ST | g | mm | cm | – | – | 5 | 4 | 4 | – | 0.762 |
| ***Sorbus aucuparia*** | | | | | | | | | | | |
| 793 Norway | ln(BR) | kg | cm | – | 1–10 | 1.5–12 | 6 | 3 | – | 42 | 0.897 |
| 794 Norway | ln(FL) | kg | cm | – | 1–10 | 1.5–12 | 6 | 3 | – | 42 | 0.813 |
| 795 Norway | ln(ST) | kg | cm | – | 1–10 | 1.5–12 | 6 | 3 | – | 43 | 0.991 |

## References – Appendix A


1 Bolte, A., Rahmann, T., Kuhr, M., Pogoda, P., Murach, D. & Gadow, K.v. 2004. Relationship between tree dimension and coarse root biomass in mixed stands of European beech (Fagus sylvatica L.) and Norway spruce (Picea abies [L.] Karst.). Plant and Soil 264: 1–11.

2 Gasparini, P., Nocetti M., Tabacchi, G. & Tosi, V. Biomass equations and data for forst stands and shrublands of the Eastern Alps. Submitted manuscript.

3 Gschwantner, T. & Schadauer, K. 2006. Branch biomass functions for broadleaved tree species in Austria. Austrian Journal of Forest Science 123: 17–34.

4 Hochbichler, E., Bellos, P. & Lick, E. 2006. Biomass functions for estimating needle and branch

| | Equation | a | b | Parameters c | d | e |
|---|---|---|---|---|---|---|
| 760 | $a+b\cdot\ln(D)+c\cdot(\ln(D))^2$ | 4.7356 | 1.9414 | 0.1559 | – | – |
| 761 | $\ln(a)+b\cdot\ln(D)$ | –10.44819 | 3.81917 | | – | – |
| 762 | $a\cdot D^b$ | 0.0021 | 3.3064 | – | – | – |
| 763 | $a\cdot D^b$ | 0.0024 | 2.6081 | – | – | – |
| 764 | $a\cdot\ln(b\cdot D)$ | 1.8984 | 0.0856 | – | – | – |
| 765 | $a\cdot D^b$ | 0.0654 | 2.5753 | – | – | – |
| 766 | $a\cdot D^b$ | 0.0103 | 2.5443 | – | – | – |
| 767 | $\ln(a)+b\cdot\ln(D)$ | –9.8231 | 3.99492 | | – | – |
| 768 | $a+b\cdot\ln(D)$ | –5.33002 | 3.04628 | | – | – |
| 769 | $a+b\cdot\ln(D)+c\cdot\ln(H)$ | –3.85999 | 3.1926 | –0.754 | – | – |
| 770 | $\exp(a+b\cdot\ln(D)+\ln(c))$ | –2.60326 | 1.91283 | 1.199 | – | – |
| 771 | $a+b\cdot\ln(D)$ | 2.4721 | 2.4987 | | – | – |
| 772 | $a+b\cdot\ln(D)$ | 1.4718 | 2.3117 | | – | – |
| 773 | $a+b\cdot\ln(D)+c\cdot(\ln(D))^2$ | 4.5086 | 1.9234 | 0.2613 | – | – |
| 774 | $a\cdot(D^2\cdot H)^b$ | 0.0008 | 1.0213 | | – | – |
| 775 | $a\cdot(D^2\cdot H)^b$ | 0.0107 | 0.7313 | | – | – |
| 776 | $a\cdot(D^2\cdot H)^b$ | 0.0025 | 0.9549 | | – | – |
| 777 | $a\cdot(D^2\cdot H)^b$ | 0.002 | 1.0049 | | – | – |
| 778 | $a\cdot(D^2\cdot H)^b$ | 0.006 | 0.7708 | | – | – |
| 779 | $a\cdot(D^2\cdot H)^b$ | 0.0594 | 0.5096 | | – | – |
| 780 | $a\cdot(D^2\cdot H)^b$ | 0.0049 | 0.8003 | | – | – |
| 781 | $a\cdot(D^2\cdot H)^b$ | 0.0023 | 0.9673 | | – | – |
| 782 | $a\cdot(D^2\cdot H)^b$ | 0.015 | 1.032 | | – | – |
| 783 | $a\cdot(D^2\cdot H)^b$ | 0.0006 | 1.091 | | – | – |
| 784 | $a\cdot(D^2\cdot H)^b$ | 0.0002 | 1.0014 | | – | – |
| 785 | $a\cdot(D^2\cdot H)^b$ | 0.0015 | 0.8657 | | – | – |
| 786 | $a\cdot(D^2\cdot H)^b$ | 0.0013 | 1.0238 | | – | – |
| 787 | $a\cdot(D^2\cdot H)^b$ | 0.003 | 0.9608 | | – | – |
| 788 | $a\cdot(D^2\cdot H)^b$ | 0.0006 | 1.0928 | | – | – |
| 789 | $a\cdot(D^2\cdot H)^b$ | 0.0017 | 0.8448 | | – | – |
| 790 | $a\cdot(D^2\cdot H)^b$ | 0.0007 | 0.944 | | – | – |
| 791 | $a\cdot(D^2\cdot H)^b$ | 0.0023 | 0.9671 | | – | – |
| 792 | $a\cdot(D^2\cdot H)^b$ | 0.01 | 0.8469 | | – | – |
| 793 | $a+b\cdot\ln(D)+c\cdot(\ln(D))^2$ | 2.7241 | 1.4068 | 0.4646 | – | – |
| 794 | $a+b\cdot\ln(D)+c\cdot(\ln(D))^2$ | 2.2305 | 0.607 | 0.7941 | – | – |
| 795 | $a+b\cdot\ln(D)+c\cdot(\ln(D))^2$ | 4.9569 | 1.5396 | 0.4408 | – | – |

biomass of sprice (Picea abies) and Scots pine (Pinus sylvestris) and branch biomass of beech (Fagus sylvatica) and oak (Quercus robur and petrea). Austrian Journal of Forest Science 123: 35–46.

5 Hytönen, J., Saarsalmi, A. & Rossi, P. 1995. Biomass production and nutrient uptake of short-rotation plantations. Silva Fennica 29(2): 117–139.

6 Korsmo, H. 1995. Weight equations for determining biomass fractions of young hardwoods from natural regenerated stand. Scandinavian Journal of Forest Research 10: 333–346.

7 Ledermann, T. & Neumann, M. 2006. Biomass equations from data of old long-term experimental plots. Austrian Journal of Forest Science 123: 47–64.

8 Petersson, H. & Ståhl, G. 2006. Functions for below-ground biomass of Pinus sylvestris, Picea

abies, Betula pendula and Betula pubescens in Sweden. Scandinavian Journal of Forest Research 21(7): 84–93.
9 Rubatscher, D., Munk, K., Stöhr, D., Bahn, M., Mader-Oberhammer, M. & Cernusca, A. 2006. Biomass expansion functions for Larix decidua: a contribution to the estimation of forest carbon stocks. Austrian Journal of Forest Science 123: 87–101.
10 Saarsalmi, A., Palmgren, K. & Levula, T. 1985. Biomass production and nutrient and water consumption in an Alnus incana plantation. Folia Forestalia 628. 24 p.
11 Saarsalmi, A. & Mälkönen, E. 1989. Biomass production and nutrient consumption in Alnus incana stands. Folia Forestalia 728. 16 p.
12 Saarsalmi, A., Palmgren, K. & Levula, T. 1991. Biomass production and nutrient consumption of the sprouts of Alnus incana. Folia Forestalia 768. 25 p.
13 Saarsalmi, A., Palmgren, K. & Levula, T. 1992. Biomass production and nutrient consumption of Alnus incana and Betula pendula in energy forestry. Folia Forestalia 797. 29 p.
14 Socha, J. & Wezyk, P. 2006. Allometric equations for estimating the foliage biomass of Scots pine. European Journal of Forest Research (in press).
15 Yuste, J.C., Konopka, B., Janssens, I.A., Coenen, K., Xiao, C.W. & Ceulemans, R. 2005. Contrasting net primary productivity and carbon distribution between neighboring stands of Quercus robur and Pinus sylvestris. Tree Physiology 25: 701–712.

## Contact persons – Appendix A

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## Comments – Appendix A

1 Includes stump
2 Stem and branches more than 5 cm in diameter, excludes stump
3 Foliage and branches less than 5 cm in diameter
4 Short-rotation plantations, young trees, diameter at the tree base
5 Young trees
6 5-year-old stand
7 9-year-old stand
8 Roots down to 2 mm are included
9 Roots down to 5 mm are included

**Appendix B.** General descriptions of volume equations. Both scientific and common names of the tree species are shown. Number of sampled trees ($n$), coefficients of determination ($r^2$), and range of diameter ($D$) and height ($H$) of sampled trees are reported. References (Ref.) to the original paper as well as the contact (Cont.) person who submitted the equation to this database are given. Format and parameter values of these equations are shown in Appendix C.

| | Unit of | | | Range of | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | Vol. | *D* | *H* | *D* (cm) | *H* (m) | Ref. | Cont. | Comm. | *n* | $r^2$ |
| ***Abies alba*** (Silver fir) | | | | | | | | | | |
| 231 Italy | $dm^3$ | cm | m | 8.9–55.5 | 7.5–26.8 | 1 | 1 | 1 | 40 | 0.987 |
| ***Fagus sylvatica*** (Beech, Rotbuche, Beuk) | | | | | | | | | | |
| 232 Italy | $dm^3$ | cm | m | 9.5–56.5 | 9.3–22.3 | 1 | 1 | 1 | 30 | 0.96 |
| ***Larix decidua*** (Larch, Mélèzes) | | | | | | | | | | |
| 233 Italy | $dm^3$ | cm | m | 7.7–53.9 | 5.6–24.9 | 1 | 1 | 1 | 33 | 0.991 |
| ***Picea abies*** (Norway spruce, Kuusi, Gran, Epicéa, Fijnspar) | | | | | | | | | | |
| 234 Italy | $dm^3$ | cm | m | 7.9–61 | 2.8–35.8 | 1 | 1 | 1 | 82 | 0.991 |
| ***Pinus cembra*** | | | | | | | | | | |
| 235 Italy | $dm^3$ | cm | m | 7.7–56.3 | 4.5–22.2 | 1 | 1 | 1 | 30 | 0.991 |
| ***Pinus nigra*** var ***nigra*** (Black pine, Pin negru) | | | | | | | | | | |
| 236 Italy | $dm^3$ | cm | m | 8.9–35.9 | 5.9–20.9 | 1 | 1 | 1 | 30 | 0.992 |
| ***Pinus sylvestris*** (Scots pine, Mänty, Tall, Furu, Grove den, Pin silvestri) | | | | | | | | | | |
| 237 Italy | $dm^3$ | cm | m | 8.4–40.6 | 6.4–20.8 | 1 | 1 | 1 | 30 | 0.972 |

**Appendix C.** Volume equations for different tree species. The format of the stem volume equation (where D is diameter and H is height) is given in the column labelled Equation, and a–c are parameter values.

| | Equation | Parameters | | |
|---|---|---|---|---|
| | | a | b | c |
| ***Abies alba*** (Silver fir) | | | | |
| 231 Italy | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –2.7916 | 0.034492 | 0.08354 |
| ***Fagus sylvatica*** (Beech, Rotbuche, Beuk) | | | | |
| 232 Italy | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –8.015 | 0.03108 | 0.018083 |
| ***Larix decidua*** (Larch, Mélèzes) | | | | |
| 233 Italy | $a+b\cdot D^2\cdot H+c\cdot D^2$ | 8.8267 | 0.03426 | 0.27518 |
| ***Picea abies*** (Norway spruce, Kuusi, Gran, Epicéa, Fijnspar) | | | | |
| 234 Italy | $a+b\cdot D^2\cdot H+c\cdot D\cdot H^2$ | 4.37664 | 0.02848 | 0.01165 |
| ***Pinus cembra*** | | | | |
| 235 Italy | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –5.5632 | 0.03008 | 0.1546 |
| ***Pinus nigra*** var ***nigra*** (Black pine, Pin negru) | | | | |
| 236 Italy | $a+b\cdot D^2\cdot H+c\cdot D^2$ | –5.6704 | 0.031896 | 0.1271 |
| ***Pinus sylvestris*** (Scots pine, Mänty, Tall, Furu, Grove den, Pin silvestri) | | | | |
| 237 Italy | $a+b\cdot D^2\cdot H$ | 2.6374 | 0.04102 | – |

## References

1 Gasparini, P., Nocetti, M., Tabacchi, G. & Tosi, V. Biomass equations and data for forst stands and shrublands of the Eastern Alps. Submitted manuscript.

## Contact persons

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## Comments

1 Stem and branches more than 5 cm in diameter, excludes stump