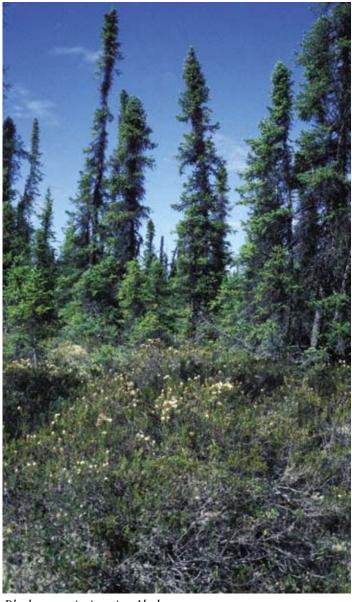# Aboveground Biomass Equations for the Trees of Interior Alaska

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*Black spruce in interior Alaska.*
Photo courtesy of the U.S. Fish & Wildlife Service

## 1.0 Introduction

Calculation of forest biomass requires the use of equations that relate the mass of a tree or its components to physical measurements that are relatively easy to obtain. In the literature individual tree relationships have been reported that estimate aboveground biomass on individual sites (e.g. Barney and Van Cleve 1973) and over large landscape areas where many data sets are combined (Jenkins et al. 2003). The equations presented in this report represent a compilation of aboveground biomass data collected within interior Alaska over the past 40 years. Equations were developed for white and black spruce (*Picea glauca* (Moench) Voss and *P. mariana* (Mill.) B.S.P.), paper birch (*Betula neoalaskana* Sarg.), aspen and balsam poplar (*Populus tremuloides* Michx. and *P. balsamifera* L.). The equations utilize the stem diameter at breast height (1.37m, DBH) and tree height as independent variables to be related to various components of the total aboveground biomass.

## 2.0 Methods

Sample trees were selected from a number of sites throughout interior Alaska. The number of trees per location (plot) and the number of locations varied for each species (Appendix 1). The overall geographic range across interior Alaska included stands in the Porcupine and Black River drainages east of Fort Yukon, stands in the vicinity of the Tanana River drainage near Fairbanks, stands within the Bonanza Creek Experimental Forest located approximately 20 km west of Fairbanks, stands along the Chena Hot Springs Road northwest of Fairbanks, and stands in the vicinity of Delta Junction. Not all species were selected in all locations. For example, balsam poplar was only sampled from four stands along the Tanana River Floodplain in the vicinity of Fairbanks (Appendix 1). Also, the number of tree components measured differed between sites, which resulted in a large number of missing data points in the data spreadsheet presented in Appendix 2.

The specific methods used to collect the field data have been described in a number of papers (Barney and Van Cleve 1973, Barney et al. 1978, Yarie and Van Cleve 1983). In general, for each data set used in this study the methods used to determine the tree biomass followed the same procedures.

Fresh mass of tree components was determined in the field using an autopsy balance (±10 g) or spring balance (± 2.3 kg). To determine moisture content, subsamples of the crown and stem were returned to the lab and dried to a constant weight at 65º C. The specific tree components measured varied among the studies. All individual measurements are listed in Appendix 2. The relationships developed for independent variables in this report include standing biomass of foliage, live branches, stemwood, bark, the combined measurement of stemwood and bark, and total aboveground biomass. The independent variables used were diameter at breast height (DBH), $DBH^2$, total tree height (HT), basal diameter (BDIA) and $BDIA^2$. The diameter at breast height (1.37 m aboveground) and basal diameter (0.35 m aboveground) were measured before felling the tree. Total height (m) was measured after tree felling.

We also developed an equation to estimate current stemwood growth on an annual basis. The annual estimate was based on an average measurement of the last five years of growth. The current growth of foliage and branch tips was also measured and added to the annual stem growth to estimate the total aboveground annual growth. The independent variables used for the biomass equations were used for development of the growth equations.

For each of the biomass components a series of regression equations was developed using the SAS REG procedure (SAS 2005). When two or more independent variables were included in the potential model, a forward stepwise procedure was used. When the potential multiple independent variable equation is not statistically different from the single independent variable equation, only the single independent variable equation is presented.

Four sets of regression models were developed. The first set used a stepwise procedure to develop a model using DBH and $DBH^2$ as potential independent variables. The second set of equations included tree height with the diameter values as potential independent variables. Only those equations that included height as a significant independent term are reported. The third set of equations was developed using only tree height as an independent variable. The last set of equations were developed using BDIA and $BDIA^2$ as the potential independent variables. All equation types were developed with and without an intercept term. The potential regression models used to estimate biomass of the selected components were:

First Set:
1) Mass = a + b*DBH
2) Mass = a + b*DBH + $c*DBH^2$
3) Mass = b*DBH
4) Mass = b*DBH + $c*DBH^2$

Second Set:
5) Mass = a + b*DBH + c* $DBH^2$ + d*HT
6) Mass = b*DBH + c* $DBH^2$ + d*HT

Third Set:
7) Mass = a + b*HT
8) Mass = b*HT

Fourth Set
9) Mass = a + b*BDIA
10) Mass = a + b*BDIA + $c*BDIA^2$
11) Mass = b*BDIA
12) Mass = b*BDIA + $c*BDIA^2$

The equations presented in the following tables 2 through 6 include only the relationships with significant ($\alpha$ = 0.05) independent variables. As a result, there is not a complete set of all twelve equation types for each species and component. In several cases the DBH or $DBH^2$ variable was not significant when the other variable was present. This was also true for equation types that combined DBH, $DBH^2$ and/or HT.

A set of equations relating height to tree DBH were also developed. The regression models used for this relationship were:

1) Height = a + b*DBH
2) Height = b*DBH

The standard error of estimate is also included in the tables for all significant independent variables and the intercept when present. This will allow users to calculate confidence limits around the estimated biomass. The entire raw dataset is available through the Bonanza Creek (BNZ) Long-Term Ecological Research (LTER) website at http://www.lter.uaf.edu/data_detail.cfm?datafile_pkey=230.

# 3.0 Results and Discussion

The total number of sample trees and the average, maximum, and minimum values for DBH, BDIA, height, and total aboveground biomass are presented in Table 1. We caution users of the equations against using them outside the range of the independent variables that are presented.

The equations for each biomass component and the total aboveground biomass are presented in tables 2 through 6. Each table represents a different species. As expected, the range of tree sizes was the greatest for white spruce, which also displayed the largest size for an individual tree (Table 1). Black spruce tree sizes did include individuals that were shorter than 1.37 m. As a result, the minimum value for DBH was 0 and the data set does include trees that would be classified as seedlings in most forest inventories. If biomass estimates are needed for these sizes, then the basal diameter equations could be used to derive biomass estimates.

# 4.0 References

Barney, R. J., and K. Van Cleve. 1973. Black spruce fuel weights and biomass in two interior Alaska stands. *Can. J. For. Res*. 3:304-311.

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Jenkins, J. C., D. C. Chojnacky, L. S. Heath, and R. A. Birdsey. 2003. National-Scale biomass estimators for United States tree species. *Forest Science* 49:12-35.

SAS. 2005. SAS/REG software, Version 9.1 of the SAS System for Windows XP. Copyright 2005 SAS Institute Inc. SAS and all other SAS Institute Inc. product or service names are registered trademarks of SAS Institute Inc., Cary, NC, USA.

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*Yellow warbler nest with eggs.*
Photo courtesy of the US Fish & Wildlife Service

## Table 1. Average, minimum and maximum values for DBH, BDIA, height and total aboveground biomass for sampled trees.

| Item | Balsam Poplar | Aspen | Birch | Black Spruce | White Spruce |
|---|---|---|---|---|---|
| Number of Sample Trees | 17 | 41 | 37 | 126 | 58 |
| Avg DBH (cm) | 19.45 | 7.16 | 12.93 | 5.41 | 20.62 |
| Min DBH (cm) | 4.10 | 0.60 | 3.70 | 0.0* | 3.70 |
| Max DBH (cm) | 46.50 | 19.30 | 32.70 | 12.80 | 50.00 |
| Avg Basal Dia (cm) | 22.35 | 3.97 | 14.82 | 6.71 | 29.01 |
| Min Basal Dia (cm) | 5.50 | 1.30 | 5.30 | 1.00 | 4.60 |
| Max Basal Dia (cm) | 50.0 | 11.30 | 36.00 | 17.5 | 59.40 |
| Avg HT (m) | 17.85 | 14.52 | 13.64 | 3.65 | 15.96 |
| Min HT (m) | 8.00 | 8.40 | 6.00 | 0.10 | 3.00 |
| Max HT (m) | 27.40 | 19.90 | 20.50 | 12.24 | 30.50 |
| Avg Biomass (Kg) | 170.90 | 23.20 | 52.30 | 7.46 | 228.10 |
| Min Biomass (Kg) | 4.10 | 0.10 | 2.10 | 0.05 | 2.10 |
| Max Biomass (Kg) | 624.40 | 139.00 | 367.60 | 63.40 | 1078.20 |

* Trees smaller than 1.37 meters in height were sampled.

**Table 2. Biomass (grams/tree) and annual growth (grams/tree and year) equations for selected components of balsam poplar trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Foliage | $-3123.246 + 484.620 * DBH - 5.997 * DBH^2$ | 17 | 0.807 | I: 1101.84; DBH: 107.71; $DBH^2$: 2.24 |
| | $178.690 * DBH$ | 17 | 0.874 | DBH: 16.99 |
| | $-3440.255 + 438.435 * BDIA - 4.750 * BDIA^2$ | 17 | 0.734 | I: 1242.63; BDIA: 109.77; $BDIA^2$: 2.07 |
| | $157.964 * BDIA$ | 17 | 0.878 | BDIA: 14.72 |
| | $-3934.566 + 404.982 * HT$ | 17 | 0.723 | I: 1213.70; HT: 64.73 |
| | $205.263 * HT$ | 17 | 0.870 | HT: 25.06 |
| Live Branches | $-11505.0 + 1611.775 * DBH$ | 17 | 0.870 | I: 3598.65; DBH: 160.61 |
| | $631.112 * DBH + 17.346 * DBH^2$ | 17 | 0.918 | DBH:274.17; DBH2: 8.38 |
| | $1848.109 * DBH - 849.662 * HT$ | 17 | 0.921 | DBH: 316.66; HT: 378.38 |
| | $-12503.0 + 1447.304 * BDIA$ | 17 | 0.828 | I: 4322.68; BDIA: 170.13 |
| | $450.159 * BDIA + 16.611 * BDIA^2$ | 17 | 0.900 | BDIA: 282.98; $BDIA^2$: 7.91 |
| | $-29743.0 + 2778.629 * HT$ | 17 | 0.692 | I: 8977.04; HT: 478.74 |
| | $1268.856 * HT$ | 17 | 0742 | HT: 187.08 |
| Stemwood | $14561.0 + 199.999 * DBH^2$ | 17 | 0.906 | I: 12206.0; $DBH^2$: 16.66 |
| | $1926.135 * DBH + 158.062 * DBH^2$ | 17 | 0.958 | DBH: 1145.23; $DBH^2$: 35.03 |
| | $-10569.0 * DBH + 333.715 * DBH^2 + 8817.508 * HT$ | 17 | 0.971 | DBH: 4973.89; $DBH^2$: 74.80; HT: 3441.37 |
| | $8671.138 + 164.659 * BDIA^2$ | 17 | 0.882 | I: 14081.0; $BDIA^2$: 15.49 |
| | $171.435 * BDIA^2$ | 17 | 0.941 | $BDIA^2$: 10.69 |
| | $-177309.0 + 16376.0 * HT$ | 17 | 0.706 | I: 51231.0; HT: 2732.16 |
| | $7376.186 * HT$ | 17 | 0.742 | HT: 1088.02 |

**Table 2. Biomass (grams/tree) and annual growth (grams/tree and year) equations for selected components of balsam poplar trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Bark | $-23308.0 + 2869.0 * DBH$ | 17 | 0.896 | I: 5664.03; DBH: 252.79 |
| | $61.936 * DBH^2$ | 17 | 0.939 | $DBH^2$: 3.95 |
| | $922.525 + 48.918 * BDIA^2$ | 17 | 0.862 | I: 4590.99; $BDIA^2$: 5.05 |
| | $49.638 * BDIA^2$ | 17 | 0.928 | $BDIA^2$: 3.45 |
| | $-47071.0 + 4458.507 * HT$ | 17 | 0.579 | I: 18422.0; HT: 982.45 |
| | $2069.165 * HT$ | 17 | 0.687 | HT: 349.50 |
| Stemwood and Bark | $-49753.0 + 6341.804 * DBH + 138.375 * DBH^2$ | 17 | 0.954 | I: 28774.0; DBH: 2812.84; $DBH^2$: 58.62 |
| | $1885.229 * DBH + 220.383 * DBH^2$ | 17 | 0.972 | DBH: 1198.77; $DBH^2$: 36.66 |
| | $244.383 * DBH^2 + 1449.714 * HT$ | 17 | 0.973 | $DBH^2$: 20.81; HT: 813.17 |
| | $1548.478 + 219.241 * BDIA^2$ | 17 | 0.918 | I: 15405.0; $BDIA^2$: 16.95 |
| | $220.451 * BDIA^2$ | 17 | 0.958 | $BDIA^2$: 11.56 |
| | $-237122.0 + 21303.0 * HT$ | 17 | 0.700 | I: 67519.0; HT: 3600.76 |
| | $9266.617 * HT$ | 17 | 0.720 | HT: 1443.35 |
| Current Wood Growth | $-3139.220 + 506.462 * DBH - 5.953 * DBH^2$ | 15 | 0.809 | I: 1265.54; DBH: 120.87; $DBH^2$: 2.47 |
| | $200.136 * DBH$ | 15 | 0.884 | DBH: 19.33 |
| | $-3458.815 + 462.057 * BDIA - 4.825 * BDIA^2$ | 15 | 0.734 | I: 1401.76; BDIA: 121.40; $BDIA^2$: 2.27 |
| | $178.039 * BDIA$ | 15 | 0.886 | BDIA: 17.04 |
| | $-4644.812 + 460.743 * HT$ | 15 | 0.831 | I: 1095.43; HT: 57.61 |
| | $228.308 * HT$ | 15 | 0.843 | HT: 26.33 |

**Table 2. Biomass (grams/tree) and annual growth (grams/tree and year) equations for selected components of balsam poplar trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Total Annual Growth | - 4123.158 + 713.063 * DBH - 7.294 * DBH$^2$ | 15 | 0.873 | I: 1583.53; DBH: 151.24; DBH$^2$: 3.09 |
| | 326.919 * DBH | 15 | 0.928 | DBH: 24.41 |
| | - 4538.907 + 645.879 * BDIA - 5.825 * BDIA$^2$ | 15 | 0.866 | I: 1791.52; BDIA: 155.15; BDIA$^2$: 2.90 |
| | 290.213 * BDIA | 15 | 0.926 | BDIA: 21.97 |
| | - 7220.504 + 732.389 * HT | 15 | 0.894 | I: 1330.62; HT: 69.97 |
| | 371.061 * HT | 15 | 0.875 | HT: 37.44 |
| Total Above-ground Biomass | - 63610.0 + 8393.574 * DBH + 141.872 * DBH$^2$ | 17 | 0.961 | I: 31024.0; DBH: 3032.78; DBH$^2$: 63.20 |
| | 2695.760 * DBH + 246.721 * DBH$^2$ | 17 | 0.974 | DBH: 1337.89; DBH$^2$: 40.92 |
| | 283.987 * DBH$^2$ + 1932.339 * HT | 17 | 0.975 | DBH$^2$: 23.46; HT: 916.44 |
| | 5305.834 + 256.501 * BDIA$^2$ | 17 | 0.922 | I: 17459.0; BDIA$^2$: 19.21 |
| | 260.647 * BDIA$^2$ | 17 | 0.961 | BDIA$^2$: 13.13 |
| | - 273391.0 + 24893.0 * HT | 17 | 0.702 | I: 78547; HT: 4188.90 |
| | 11016.0 * HT | 17 | 0.731 | HT: 1672.35 |
| Height | 3.318 + 1.120 * DBH - 0.015 * DBH$^2$ | 17 | 0.893 | I: 1.73; DBH: 0.17; DBH$^2$: 0.004 |
| | 1.417 * DBH - 0.020 * DBH$^2$ | 17 | 0.987 | DBH: 0.07; DBH$^2$: 0.002 |

**Table 3. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of quaking aspen trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable & Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Foliage | $31.892 + 6.226 * DBH^2$ | 41 | 0.903 | I: 41.27; $DBH^2$: 0.33 |
| | $6.387 * DBH^2$ | 41 | 0.942 | $DBH^2$: 0.25 |
| | $- 121.369 + 79.865 * BDIA$ | 23 | 0.957 | I: 17.73; BDIA: 3.68 |
| | $24.854 * BDIA + 4.555 * BDIA^2$ | 23 | 0.969 | BDIA; 6.52; $BDIA^2$: 0.81 |
| | $- 832.349 + 123.384 * HT$ | 20 | 0.573 | I: 379.05; HT: 25.11 |
| | $70.380 * HT$ | 20 | 0.820 | HT: 7.57 |
| Live Branches | $2102.347 - 722.293 * DBH + 68.792 * DBH^2$ | 23 | 0.770 | I: 1680.90; DBH: 353.52; $DBH^2$: 17.13 |
| | $- 325.581 * DBH + 52.188 * DBH^2$ | 23 | 0.867 | DBH: 158.19; $DBH^2$: 10.98 |
| | $667.691 - 456.253 * BDIA + 83.307 * BDIA^2$ | 5 | 0.999 | I: 57.54; BDIA: 24.79; $BDIA^2$: 1.96 |
| | $- 196.396 * BDIA + 64.323 * BDIA^2$ | 5 | 0.997 | BDIA: 71.72; $BDIA^2$: 7.29 |
| | $- 3980.240 + 572.153 * HT$ | 20 | 0.338 | I: 2848.89; HT: 188.70 |
| | $318.690 * HT$ | 20 | 0.654 | HT: 53.20 |
| Stemwood | $3842.733 - 2388.907 * DBH + 370.644 * DBH^2$ | 39 | 0.975 | I: 1627.52; DBH: 469.52; $DBH^2$: 25.87 |
| | $- 1445.992 * DBH + 325.786 * DBH^2$ | 39 | 0.981 | DBH: 261.73; $DBH^2$:18.62 |
| | $- 3666.282 * DBH + 390.960 * DBH^2 + 1058.378 * HT$ | 20 | 0.988 | DBH: 838.49; $DBH^2$: 29.97; HT: 464.65 |
| | $- 11.476 + 90.912 * BDIA^2$ | 21 | 0.974 | I: 139.0; $BDIA^2$: 3.43 |
| | $90.738 * BDIA^2$ | 21 | 0.983 | $BDIA^2$: 2.63 |
| | $- 41498.0 + 5107.977 * HT$ | 20 | 0.663 | I: 12955.0; HT: 858.05 |
| | $2465.389 * HT$ | 20 | 0.794 | HT: 287.89 |
| Bark | $- 554.585 + 47.289 * DBH^2$ | 21 | 0.945 | I: 458.92; $DBH^2$: 2.61 |
| | $44.621 * DBH^2$ | 21 | 0.980 | $DBH^2$: 1.41 |
| | $- 6149.561 + 889.082 * HT$ | 20 | 0.672 | I: 2209.03; HT: 146.32 |
| | $497.477 * HT$ | 20 | 0.856 | HT: 46.859 |

## Table 3. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of quaking aspen trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.

| Dependent Variable | Equation | # of obs | $r^2$ | Variable & Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Stemwood and Bark | $5128.294 - 2946.520 * DBH + 446.147 * DBH^2$ | 23 | 0.968 | I: 4769; DBH: 1002.99; DBH$^2$: 48.61 |
| | $- 1978.811 * DBH + 405.646 * DBH^2$ | 23 | 0.985 | DBH: 444.54; DBH$^2$: 30.84 |
| | $- 4005.659 * DBH + 447.027 * DBH^2 + 1202.888 * HT$ | 20 | 0.989 | DBH: 960.15; DBH$^2$: 34.32; HT: 532.07 |
| | $- 447.358 + 118.807 * BDIA^2$ | 5 | 0.986 | I: 606.62; BDIA$^2$: 8.20 |
| | $114.186 * BDIA^2$ | 5 | 0.992 | BDIA$^2$: 4.98 |
| | $- 47648.0 + 5997.075 * HT$ | 20 | 0.668 | I: 15043.0; HT: 996.41 |
| | $2962.863 * HT$ | 20 | 0.806 | HT: 332.95 |
| Current Wood Growth | $- 49.991 + 6.504 * DBH^2$ | 23 | 0.842 | I: 103.55; DBH$^2$: 0.62 |
| | $6.264 * DBH^2$ | 23 | 0.934 | DBH$^2$: 0.36 |
| | $- 9.360 + 8.256 * BDIA^2$ | 5 | 0.961 | I: 71.22; BDIA$^2$: 0.96 |
| | $8.160 * BDIA^2$ | 5 | 0.983 | BDIA$^2$: 0.54 |
| | $- 682.938 + 112.702 * HT$ | 20 | 0.480 | I: 417.34; HT: 27.64 |
| | $69.213 * HT$ | 20 | 0.800 | HT: 7.93 |
| Total Growth | $1396.056 - 295.226 * DBH + 25.770 * DBH^2$ | 21 | 0.880 | I: 892.72; DBH: 164.0; DBH$^2$: 6.97 |
| | $12.598 * DBH^2$ | 21 | 0.948 | DBH$^2$: 0.66 |
| | $- 1572.414 + 239.767 * HT$ | 20 | 0.552 | I: 768.83; HT: 50.92 |
| | $139.636 * HT$ | 20 | 0.818 | HT: 15.14 |
| Total Aboveground Biomass | $4768.253 - 3033.186 * DBH + 497.269 * DBH^2$ | 41 | 0.974 | I: 2066.15; DBH: 618.83; DBH$^2$: 34.58 |
| | $- 1834.450 * DBH + 439.664 * DBH^2$ | 41 | 0.980 | DBH: 354.54; DBH$^2$: 25.23 |
| | $- 4445.485 * DBH + 517.053 * DBH^2 + 1235.768 * HT$ | 20 | 0.986 | DBH: 1265.28; DBH$^2$: 45.22; HT: 701.16 |
| | $541.341 - 556.477 * BDIA + 221.590 * BDIA^2$ | 23 | 0.998 | I: 440.03; BDIA: 202.41; BDIA$^2$: 17.70 |
| | $- 326.436 * BDIA + 203.312 * BDIA^2$ | 23 | 0.983 | BDIA: 78.44; BDIA$^2$: 9.74 |
| | $- 53160.0 + 6808.866 * HT$ | 20 | 0.639 | I: 18223; HT: 1207.02 |
| | $3423.638 * HT$ | 20 | 0.800 | HT: 392.22 |
| Height | $4.000 + 0.888 * DBH$ | 20 | 0.670 | I: 1.83; DBH: 0.15 |
| | $1.600 * DBH - 0.029 * DBH^2$ | 20 | 0.975 | DBH: 0.20; DBH$^2$: 0.014 |

## Table 4. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of Alaska birch trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Foliage | $-1494.788 + 331.746 * DBH - 4.784 * DBH^2$ | 19 | 0.776 | I: 612.75; DBH: 81.96; DBH²: 2.39 |
| | $145.892 * DBH$ | 19 | 0.877 | DBH: 12.89 |
| | $-1144.095 + 158.166 * BDIA$ | 25 | 0.784 | I: 283.06; BDIA: 17.33 |
| | $4.267 * BDIA^2$ | 25 | 0.857 | BDIA²: 0.36 |
| | $-2468.470 + 271.472 * HT$ | 36 | 0.518 | I: 630.66; HT: 44.94 |
| | $100.560 * HT$ | 36 | 0.645 | HT: 12.60 |
| Live Branches | $3322.457 - 883.631 * DBH + 92.016 * DBH^2$ | 19 | 0.927 | I: 4050.06; DBH: 541.76; DBH²: 15.83 |
| | $-472.032 * DBH + 81.536 * DBH^2$ | 19 | 0.949 | DBH: 202.38; DBH²:9.25 |
| | $10349.0 - 2135.998 * BDIA + 109.312 * BDIA^2$ | 25 | 0.973 | I: 2325.43; BDIA: 272.68; BDIA²: 7.21 |
| | $-988.733 * BDIA + 82.348 * BDIA^2$ | 25 | 0.960 | BDIA: 119.81; BDIA²: 5.26 |
| | $-25064.0 + 2375.710 * HT$ | 36 | 0.358 | I: 7652.73; HT: 2375.71 |
| | $640.312 * HT$ | 36 | 0.356 | HT: 145.65 |
| Stemwood | $-30966.0 + 5360.216 * DBH + 90.984 * DBH^2$ | 11 | 0.967 | I: 16521.0; DBH: 2054.69; DBH²: 55.98 |
| | $1783.003 * DBH + 177.304 * DBH^2$ | 11 | 0.978 | DBH: 860.95; DBH²: 35.99 |
| | $-10733.0 + 191.269 * BDIA^2$ | 24 | 0.915 | I: 4667.05; BDIA²: 12.46 |
| | $-1370.059 * BDIA + 226.386 * BDIA^2$ | 24 | 0.948 | BDIA: 540.16; BDIA²: 23.48 |
| | $-128016.0 + 12266.0 * HT$ | 28 | 0.622 | I: 26506.0; HT: 1876.42 |
| | $3458.428 * HT$ | 28 | 0.554 | HT: 596.85 |
| Bark | $-1044.436 + 50.747 * DBH^2$ | 10 | 0.989 | I: 753.22; DBH²: 1.86 |
| | $49.010 * DBH^2$ | 10 | 0.992 | DBH²: 1.44 |
| | $4238.779 - 920.698 * BDIA + 63.309 * BDIA^2$ | 24 | 0.938 | I: 2608.50; BDIA: 308.17; BDIA²: 8.12 |
| | $-447.227 * BDIA + 52.174 * BDIA^2$ | 24 | 0.952 | BDIA: 104.03; BDIA²: 4.52 |
| | $-24469.0 + 2307.983 * HT$ | 27 | 0.525 | I: 6144.93; HT: 438.81 |
| | $610.515 * HT$ | 27 | 0.457 | HT: 130.42 |

## Table 4. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of Alaska birch trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Stemwood and Bark | - 17719.0 + 3016.589 * DBH + 201.520 * DBH$^2$ | 19 | 0.968 | I: 11021.0; DBH: 1474.22; DBH$^2$: 43.06 |
| | 292.182 * DBH$^2$ | 19 | 0.978 | DBH$^2$: 10.30 |
| | - 13766.0 + 231.338 * BDIA$^2$ | 25 | 0.918 | I: 5357.40; BDIA$^2$: 14.40 |
| | - 1781.503 * BDIA + 277.650 * BDIA$^2$ | 25 | 0.952 | BDIA: 608.23; BDIA$^2$: 277.65 |
| | - 129847.0 + 12797.0 * HT | 36 | 0.576 | I: 26398.0; HT: 1880.99 |
| | 3806.413 * HT | 36 | 0.558 | HT: 573.091 |
| Current Wood Growth | - 289.470 + 171.374 * DBH | 10 | 0.764 | I: 560.93; DBH: 33.63 |
| | 156.171 * DBH | 10 | 0.918 | DBH: 15.55 |
| | - 114.521 + 142.323 * BDIA | 6 | 0.569 | I: 1488.17; BDIA: 61.94 |
| | 137.712 * BDIA | 6 | 0.951 | BDIA: 13.99 |
| | - 3060.658 + 356.462 * HT | 9 | 0.598 | I: 1743.27; HT: 110.49 |
| | 166.624 * HT | 9 | 0.842 | HT: 25.52 |
| Total Growth | - 2230.978 + 557.754 * DBH - 9.020 * DBH$^2$ | 9 | 0.920 | I: 903.06; DBH: 116.13; DBH$^2$: 3.15 |
| | 231.416 * DBH | 9 | 0.987 | DBH: 20.23 |
| | 2328.166 + 117.602 * BDIA | 5 | 0.770 | I: 932.497; BDIA: 37.09 |
| | 293.951 * BDIA - 3.129 * BDIA$^2$ | 5 | 0.984 | BDIA: 34.93; BDIA$^2$: 1.22 |
| | - 4099.958 + 510.073 * HT | 8 | 0.729 | I: 2007.79; HT: 126.98 |
| | 257.000 * HT | 8 | 0.895 | HT: 33.33 |
| Total Aboveground Biomass | - 16809.0 + 2656.482 * DBH + 284.416 * DBH$^2$ | 19 | 0.980 | I: 10934.0; DBH: 1462.56; DBH$^2$: 42.72 |
| | 361.738 * DBH$^2$ | 19 | 0.987 | DBH$^2$: 9.89 |
| | 14753.0 - 4356.496 * BDIA + 401.390 * BDIA$^2$ | 25 | 0.947 | I: 16895.0; BDIA: 1981.13; BDIA$^2$: 52.36 |
| | - 2721.005 * BDIA + 362.951 * BDIA$^2$ | 25 | 0.964 | BDIA: 642.30; BDIA$^2$: 28.20 |
| | - 157688.0 + 15496.0 * HT | 36 | 0.546 | I: 33985; HT: 2421.63 |
| | 4578.445 * HT | 36 | 0.536 | HT: 720.71 |
| Height | 5.619 + 0.899 * DBH - 0.014 * DBH$^2$ | 18 | 0.786 | I: 1.22; DBH: 0.16; DBH$^2$: 0.004 |
| | 1.577 * DBH - 0.031 * DBH$^2$ | 18 | 0.920 | DBH: 0.08; DBH$^2$: 0.004 |

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Foliage | $27.774 + 157.489 * DBH$ | 56 | 0.433 | I: 131.24; DBH: 24.53 |
| | $161.583 * DBH$ | 56 | 0.680 | DBH: 14.95 |
| | $-299.253 + 168.65 * BDIA$ | 98 | 0.647 | I: 85.54; BDIA: 12.72 |
| | $57.997 * BDIA + 7.167 * BDIA^2$ | 98 | 0.773 | BDIA: 22.13; $BDIA^2$: 2.0 |
| | $-141.961 + 254.873 * HT$ | 104 | 0.642 | I: 74.47; HT: 18.84 |
| | $227.533 * HT$ | 104 | 0.732 | HT: 12.37 |
| Live Branches | $-176.986 + 188.234 * DBH$ | 56 | 0.518 | I: 132.25; DBH: 24.72 |
| | $98.535 * DBH + 7.693 * DBH^2$ | 56 | 0.685 | DBH: 43.83; $DBH^2$:4.98 |
| | $374.988 * DBH - 290.863 * HT$ | 55 | 0.707 | DBH: 86.62; HT: 116.89 |
| | $-53.707 + 19.042 * BDIA^2$ | 98 | 0.631 | I: 110.71; $BDIA^2$: 1.49 |
| | $18.605 * BDIA^2$ | 98 | 0.721 | $BDIA^2$: 1.18 |
| | $-392.742 + 395.689 * HT$ | 104 | 0.539 | I: 143.32; HT: 36.26 |
| | $320.102 * HT$ | 104 | 0.629 | HT: 24.25 |
| Stemwood | $-726.276 + 142.399 * DBH^2$ | 9 | 0.994 | I: 417.39; $DBH^2$: 4.16 |
| | $-267.688 * DBH + 159.822 * DBH^2$ | 9 | 0.998 | DBH: 128.39; $DBH^2$: 11.34 |
| | $-1310.347 * DBH + 178.427 * DBH^2 + 1012.287 * HT$ | 9 | 0.999 | DBH: 603.02; $DBH^2$: 14.81; HT: 582.88 |
| | $-9269.001 + 2918.578 * HT$ | 8 | 0.925 | I: 2616.36; HT: 338.61 |
| | $1805.016 * HT$ | 8 | 0.917 | HT: 205.0 |
| Bark | $62.498 + 25.647 * DBH^2$ | 9 | 0.996 | I: 65.28; $DBH^2$: 0.65 |
| | $26.134 * DBH^2$ | 9 | 0.998 | $DBH^2$: 0.40 |
| | $-1420.234 + 519.656 * HT$ | 8 | 0.926 | I: 464.45; HT: 60.11 |
| | $349.032 * HT$ | 8 | 0.941 | HT: 33.10 |

Table 5. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of black spruce trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.

**Table 5. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of black spruce trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Stemwood and Bark | $617.979 - 660.530 * DBH + 199.813 * DBH^2$ | 78 | 0.959 | I: 340.41; DBH: 135.03; $DBH^2$: 11.59 |
| | $- 463.567 * DBH + 186.396 * DBH^2$ | 78 | 0.976 | DBH: 81.59; $DBH^2$: 9.06 |
| | $- 1355.881 * DBH + 193.610 * DBH^2 + 1091.024 * HT$ | 77 | 0.986 | DBH: 135.15; $DBH^2$: 7.04; HT: 147.26 |
| | $996.400 - 690.927 * BDIA + 123.782 * BDIA^2$ | 119 | 0.694 | I: 1021.75; BDIA: 329.29; $BDIA^2$: 20.67 |
| | $- 411.382 * BDIA + 108.421 * BDIA^2$ | 119 | 0.780 | BDIA: 162.02; $BDIA^2$: 13.39 |
| | $- 3671.573 + 2335.872 * HT$ | 125 | 0.738 | I: 578.35; HT: 125.53 |
| | $1700.525 * HT$ | 125 | 0.755 | HT: 86.97 |
| Current Wood Growth | $- 12.702 + 22.144 * DBH$ | 56 | 0.551 | I: 14.55; DBH: 2.72 |
| | $20.271 * DBH$ | 56 | 0.728 | DBH: 1.67 |
| | $37.644 * DBH - 23.717 * HT$ | 55 | 0.746 | DBH: 9.67; HT: 13.06 |
| | $5.479 + 1.353 * BDIA^2$ | 98 | 0.682 | I: 7.03; $BDIA^2$: 0.09 |
| | $1.399 * BDIA^2$ | 98 | 0.783 | $BDIA^2$: 0.07 |
| | $- 16.596 + 28.030 * HT$ | 104 | 0.568 | I: 9.56; HT: 2.42 |
| | $24.833 * HT$ | 104 | 0.705 | HT: 1.58 |
| Total Growth | $22.018 + 2.125 * DBH^2$ | 7 | 0.991 | I: 7.83; $DBH^2$: 0.09 |
| | $7.859 * DBH + 1.621 * DBH^2$ | 7 | 0.990 | DBH: 2.28; $DBH^2$: 0.21 |
| | $42.771 * DBH + 0.991 * DBH^2 - 34.818 * HT$ | 6 | 0.999 | DBH: 15.02; $DBH^2$: 0.30; HT: 15.11 |
| | $- 104.532 + 45.042 * HT$ | 6 | 0.940 | I: 39.26; HT: 5.71 |
| | $31.146 * HT$ | 6 | 0.942 | HT: 3.46 |
| Total Aboveground Biomass | $493.254 + 190.364 * DBH^2$ | 78 | 0.810 | I: 613.26; $DBH^2$: 10.59 |
| | $358.352 * DBH + 158.166 * DBH^2$ | 78 | 0.905 | DBH: 240.81; $DBH^2$: 26.75 |
| | $- 385.958 + 113.196 * BDIA^2$ | 119 | 0.702 | I: 673.93; $BDIA^2$: 6.817 |
| | $110.564 * BDIA^2$ | 119 | 0.804 | $BDIA^2$: 5.02 |
| | $- 4125.345 + 3168.099 * HT$ | 125 | 0.755 | I: 749.46; HT: 162.67 |
| | $2454.230 * HT$ | 125 | 0.803 | HT:109.19 |
| Height | $0.441 + 0.703 * DBH$ | 77 | 0.920 | I: 0.15; DBH: 0.02 |
| | $0.760 * DBH$ | 77 | 0.977 | DBH: 0.01 |

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Foliage | $79.278 + 36.393 * DBH^2$ | 49 | 0.668 | I: 2861.21; $DBH^2$: 3.74 |
| | $36.463 * DBH^2$ | 49 | 0.787 | $DBH^2$: 2.74 |
| | $751.011 + 26.488 * BDIA^2$ | 29 | 0.574 | I: 5642.59; $BDIA^2$: 4.39 |
| | $25.928 * BDIA^2$ | 29 | 0.763 | $BDIA^2$: 2.84 |
| | $- 14056.0 + 2178.105 * HT$ | 49 | 0.481 | I: 5638.08; HT: 329.87 |
| | $1451.640 * HT$ | 49 | 0.624 | HT: 162.81 |
| Live Branches | $10742.0 - 1912.837 * DBH + 99.280 * DBH^2$ | 49 | 0.760 | I 8709.42; DBH: 877.16; $DBH^2$: 18.49 |
| | $- 945.336 * DBH + 81.567 * DBH^2$ | 49 | 0.822 | DBH: 394.72; $DBH^2$: 11.72 |
| | $74.670 * DBH^2 - 986.031 * HT$ | 49 | 0.826 | $DBH^2$: 8.27; HT: 369.89 |
| | $- 9995.967 + 47.476 * BDIA^2$ | 29 | 0.702 | I: 7659.52; $BDIA^2$: 5.96 |
| | $- 897.286 * BDIA + 62.328 * BDIA^2$ | 29 | 0.817 | BDIA: 526.18; $BDIA^2$: 12.74 |
| | $- 23485.0 + 3206.828 * HT$ | 49 | 0.415 | I: 9487.41; HT: 555.09 |
| | $1993.094 * HT$ | 49 | 0.525 | HT: 273.74 |
| Stemwood | $- 19410.0 + 285.858 * DBH^2$ | 58 | 0.936 | I: 8492.25; $DBH^2$: 9.98 |
| | $- 2091.578 * DBH + 326.759 * DBH^2$ | 58 | 0.962 | DBH: 828.62; $DBH^2$: 23.53 |
| | $- 10633.0 * DBH + 391.999 * DBH^2 + 8733.396 * HT$ | 58 | 0.975 | DBH: 1753.91; $DBH^2$: 22.94; HT: 1652.67 |
| | $- 29693.0 + 212.109 * BDIA^2$ | 37 | 0.899 | I: 16382.0; $BDIA^2$: 12.0 |
| | $- 2210.639 * BDIA + 245.663 * BDIA^2$ | 37 | 0.948 | BDIA: 1164.45; $BDIA^2$: 27.52 |
| | $- 166591.0 + 19682.0 * HT$ | 58 | 0.781 | I: 24974.0; HT: 1391.74 |
| | $11427.0 * HT$ | 58 | 0.762 | HT: 845.66 |
| Bark | $17.756 + 37.661 * DBH^2$ | 58 | 0.894 | I: 1475.40; $DBH^2$: 1.73 |
| | $37.675 * DBH^2$ | 58 | 0.941 | $DBH^2$: 1.25 |
| | $- 394.918 + 27.406 * BDIA^2$ | 37 | 0.873 | I: 2409.70; $BDIA^2$: 1.77 |
| | $27.185 * BDIA^2$ | 37 | 0.942 | $BDIA^2$: 1.13 |
| | $- 18897.0 + 2563.204 * HT$ | 58 | 0.729 | I: 3748.13; HT: 208.87 |
| | $1626.867 * HT$ | 58 | 0.781 | HT: 114.24 |

Table 6. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of white spruce trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.

*continued*

**Table 6. Biomass (grams/tree) and annual production (grams/tree year) equations for selected components of white spruce trees in interior Alaska. The diameter variables are measured in centimeters and height in meters.**

| Dependent Variable | Equation | # of obs | $r^2$ | Variable and Standard Error (I = Equation intercept) |
|---|---|---|---|---|
| Stemwood and Bark | $-20471.0 + 324.288 * DBH^2$ | 58 | 0.940 | I: 9336.87; $DBH^2$: 10.98 |
| | $-2197.092 * DBH + 367.185 * DBH^2$ | 58 | 0.964 | DBH: 912.10; $DBH^2$: 25.90 |
| | $-11266.0 * DBH + 436.452 * DBH^2 + 9272.356 * HT$ | 58 | 0.976 | DBH: 1964.44; $DBH^2$: 25.70; HT: 1851.05 |
| | $-32204.0 + 240.599 * BDIA^2$ | 37 | 0.907 | I: 17734.0; $BDIA^2$: 13.0 |
| | $-2412.519 * BDIA + 277.329 + BDIA^2$ | 37 | 0.953 | BDIA: 1259.72; $BDIA^2$: 29.77 |
| | $-186477.0 + 22268.0 * HT$ | 58 | 0.780 | I: 28353; HT: 1580.03 |
| | $13028.0 * HT$ | 58 | 0.766 | HT: 954.14 |
| Current Wood Growth | $-583.614 + 119.487 * DBH$ | 47 | 0.500 | I: 409.09; DBH: 17.80 |
| | $97.805 * DBH$ | 47 | 0.704 | DBH: 9.36 |
| | $-552.576 + 101.539 * BDIA$ | 28 | 0.374 | I: 807.80; BDIA: 25.78 |
| | $85.696 * BDIA$ | 28 | 0.684 | BDIA: 11.20 |
| | $-931.459 + 176.109 * HT$ | 47 | 0.492 | I: 460.70; HT: 26.66 |
| | $128.416 * HT$ | 47 | 0.686 | HT: 12.82 |
| Total Growth | $-1615.401 + 278.838 * DBH$ | 47 | 0.735 | I: 573.82; DBH: 24.96 |
| | $106.843 * DBH + 3.490 * DBH^2$ | 47 | 0.848 | DBH: 40.31; $DBH^2$: 1.19 |
| | $3.863 * DBH^2 + 131.931 * HT$ | 47 | 0.882 | $DBH^2$: 0.80; HT: 36.01 |
| | $-1970.257 + 245.071 * BDIA$ | 28 | 0.610 | I: 1203.64; BDIA: 38.41 |
| | $105.892 * BDIA + 2.082 * BDIA^2$ | 28 | 0.829 | BDIA: 56.99; $BDIA^2$: 1.37 |
| | $-2472.711 + 413.952 * HT$ | 47 | 0.734 | I: 642.62; HT: 37.18 |
| | $287.343 * HT$ | 47 | 0.822 | HT: 19.74 |
| Total Aboveground Biomass | $-23209.0 + 430.621 * DBH^2$ | 58 | 0.966 | I: 3107.51; $DBH^2$: 10.71 |
| | $-2446.278 * DBH + 478.048 * DBH^2$ | 58 | 0.981 | DBH: 889.35; $DBH^2$: 25.26 |
| | $-8628.215 * DBH + 525.267 * DBH^2 + 6320.941 * HT$ | 58 | 0.984 | DBH: 2127.12; $DBH^2$: 27.82; HT: 2004.34 |
| | $-36076.0 + 321.991 * BDIA^2$ | 37 | 0.938 | I: 19088.0; $BDIA^2$: 13.99 |
| | $-2566.012 * BDIA + 360.040 * BDIA^2$ | 37 | 0.967 | BDIA: 1362.91; $BDIA^2$: 32.21 |
| | $-231877.0 + 28831.0 * HT$ | 58 | 0.763 | I: 38554; HT: 2148.50 |
| | $17342.0 * HT$ | 58 | 0.771 | HT: 1250.26 |
| Height | $1.470 + 0.848 * DBH - 0.005 * DBH^2$ | 58 | 0.866 | I: 1.28; DBH: 0.13; $DBH^2$: 0.003 |
| | $0.978 * DBH - 0.007 * DBH^2$ | 58 | 0.971 | DBH: 0.06; $DBH^2$: 0.002 |

# Appendix 1. General Location of Sample Plots

| Species | Plot Number | General Location | Study Principal Investigator |
|---|---|---|---|
| Balsam Poplar | 25, 36, 131 | Tanana River | Van Cleve |
| | 13 | Porcupine River | Yarie |
| Aspen | 1, 1A, 15, | Bonanza Creek Exp Forest | Van Cleve |
| Birch | 1, 2, 3, 10 13, B1, B2 | Bonanza Creek Exp Forest | Van Cleve |
| | 28 | Porcupine River | Yarie |
| White Spruce | 17, 21, 23, 24, 27, 30, 10, 12, 14, 15, 26, 100, 367 | Porcupine River | Yarie |
| | 12 | Tanana River | Van Cleve |
| Black Spruce | 12, 21, 29 | Porcupine River | Yarie |
| | WC, Upper1, Upper2, Upper3, Lower1, Lower2, Lower3 | Bonanza Creek Exp Forest and Washington Creek | Van Cleve |
| | DF57, DFCC, DFTC | Delta | Mack |
| | H, pl, ml, | Bonanza Creek Exp Forest | Kane |

# Appendix 2. Raw data used in development of the biomass equations

The following variables are presented in the raw data files, which are available on the UAF Long Term Ecological Research website at: http://www.lter.uaf.edu/data_detail.cfm?datafile_pkey=230.

1) Sp: sample species
2) Plot: sample plot number supplied by collector of the sample
3) Tree No: tree number within the sample plot
4) dbh (cm): diameter at breast height (1.37 m)
5) height (m): total tree height
6) height to first limb (m): height from ground to first limb
7) BDIA (cm): basal diameter at 0.3 meters above ground
8) Total age (years) was determined at 0.3 meters above ground.
9) breast height age (years)

10) total wood green weight (g): wood only no bark in this estimate
11) total wood dry weight (g): wood only no bark
12) stem to 4 inch top green weight (g): green weight of wood to a 4 inch top diameter
13) bark dry weight (g)
14) stemwood plus bark (g): weight of the main tree stem
15) foliage dry weight (g)
16) live branches (g)
17) dead branches (g)
18) cones (g)
19) live crown (g): total of items 15, 16 and 18
20) total crown (g): total of items 17 and 19
21) aboveground total (g)
22) crown current growth (g): new foliage and branch tips
23) wood 5-year growth (g): stemwood growth over the five years prior to sampling
24) total tree annual aboveground production (g): crown growth plus (wood 5-year growth) divided by 5
25) year of sample: year in which sample was collected
26) site index
27) sample author

# Agricultural and Forestry Experiment Station

*Fairbanks Experiment Farm, Agricultural & Forestry Experiment Station*

**UAF** UNIVERSITY OF ALASKA **FAIRBANKS**