BIOMASS COMPONENT EQUATIONS FOR *Castanea sativa* MILL HIGH FOREST IN THE NORTHWEST OF PORTUGAL

M.S. Patrício 1, M. Tomé 2 and M.L. Monteiro1

1 Department of forestry, Bragança Polytechnic Institute, ESAB, Quinta Sta. Apolónia Apartado 172, 5301-855 Bragança Portugal
2 Department of forestry, ISA, Tapada da Ajuda, 1349-017 Lisboa, Portugal

Introduction

The biomass and nutrients relationship are in the base of the studies of ecosystems dynamics and is functionality. The knowledge of the contents of mineral elements in the several components of the trees is essential to understand its state and flow in the globality of the system, as well as to evaluate the site sustainability. The biomass equations can be used to predict the growth of young forest stands (Wagner and Ter-Mikaelian, 1999) and can be integrated in yield production models, to model the growth at both tree and stand levels (Korzukhin, 1996) with view to the analysis of the long term productivity and site sustainability as well as to foresee the potential carbon sequestering in the stands (Reed et al, 1995).

Thus, the purpose of the present work was to develop biomass prediction equations as a function of biometric variables by components. This work is part of a broader investigation with view to the determination of the biomass content in the several aboveground tree components and soil, essential to understand its state and flow in the globality of the system, as well as to evaluate the site sustainability.

Data

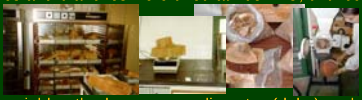
This study is based on information gathered in 34 felled trees, distributed by the diameter classes present in three old chestnut high forest stands located in the North of Portugal: Bornes (41º 29' 37'' N, 6º 55'' 12''W), Marão (41º 14' 24'' N, 7º 55' 38'' W) and Padrela (41º 30' 34'' N, 7º 36' 54''W). The following trees were randomly selected in each stand: 18 trees in Padrela, 7 trees in Bornes and 9 trees in Marão, distributed by the diameter classes, according to its frequency. The study was carried out in the vegetative period, when the leaves already presented its maximum dimension.

The trees were felled and the total length of the tree and the base of the living crown were measured, the last corresponding to the first living branch considered significant (Liu and Burkhart, 1993) (in this case diameter superior to 2.5 cm). The main stem was sectioned with the first cut at the breast height level previously marked in the tree. Starting from this level the stems were sectioned in 2,25 m logs until the diameter of 7 cm. In the inferior section of each log a disk with 5 cm of thickness was kept for biomass determination. The fresh weight for the tree following components [leaves, flowers, branches, logs 1 to n (W1…..Wn) with bark, disks (1 to n) with bark and bark of the disks 1 to n] was obtained *in loco*:

Ransom samples with 1kg, approximately, of each component were obtained for laboratory determ

Treatment of the samples in laboratory

After the determination of the fresh weight the samples of the leaves, flowers and barks were dried in stove at 70 ±2ºC, while the logs samples and branches were dried at 103±2ºC, until constant weight.



Methods

The following candidate allometric models were tested:

$y = \beta_1 d^2 h$

$y = \beta_1 (d^2 h)^{\beta 2}$

$y = d^2/(\beta_1+\beta_2 h^{-1})$

$y = \beta_0+\beta_1 d^{\beta 2} h^{\beta 3}$

$y = \beta_1 d^{\beta 2} h^{\beta 3}$

$y = \beta 1 d^{\beta 2}$

$y = \beta 1 d^{\beta 2}\ e\ (\beta 3\ d)$

$y = \beta 0 + \beta 1 d2h$

$y = d(\beta 0+\beta 1\ hc)$

Due to the low correlation initially found among the biomass of some of the components considered and the tree variables[(d; h; diameter base crown (dbc), height to the live crown base (hbc) and length of the crown (hc)], the dry weights of some components considered separately during the phase of data collection were pooled. Thus, both the flowers and the leaves were joint together in the same category designated by (W_Ltot). The live branches biomass were also pooled in the same category (W_Bliv). Beyond these two classes the following categories were also considered: bark biomass (W_Bark); main stem biomass under bark (W_Wood), main stem biomass over bark (W_Bole) and the total aboveground biomass (W_Tot).

The biomass equations were fitted by the ordinary least squares method (OLS) associated with both the PROC REG (linear equations) and PROC NLIN (non linear equations) procedures of SAS/STAT. The modified Gauss-Newton iterative method was applied in the non linear model fitting.

The models were evaluated in terms of measures of fit and prediction ability: modelling efficiency (EM), mean square error (MSE), models parameter significance, R^2 of prediction (R2pred), mean of PRESS residuals (m_PRESS) and mean absolute PRESS residuals (ma_PRESS) as well as the percentiles 95% (P95) and 5% (P5) of the PRESS residuals. The normality of the studentaized residuals was analysed using normal QQ plots. The presence of heteroscedasticity associated with the error term of the models was checked by ploting the studentaized residuals against the predicted values.

The regression assumptions departure was solved with non linear iteratively rewheighted least squares (IRWLS) using the Huber function with the maximum value of r = 1 and weighting factors.

Results and discussion

Among the considered independent variables the base crown diameter (d_bc) and respective height (h_bc) did not present, in the generality, a superior contribution for the model error explanation relatively to the diameter at breast height (d) and total height (h). This fact associated to the largest easiness of variables mensuration, important for the future use of the mode,l was taken into account in the selection of (d) and (h) as final regressor variables.

The analysis accomplished, based in the criteria mentioned behind, lead to the selection of the following models for each biomass component:

(2) $W\_Barc = 0{,}0141(d^2\ h)^{0{,}7892}$

(3) $W\_Ltot = d^2/(187{,}7-1791{,}6\ h^{-1})$

(1) $W\_Bliv = 0{,}00451\ d^2 h$

(5) $W\_Wood = 0{,}0160\ d\_ub^{1{,}7308}\ h^{1{,}3088}$

(5) $W\_Bole = 0{,}0142\ d^{1{,}7243}\ h^{1{,}3582}$

(6) $W\_tot = 0{,}1236\ d^{2{,}3929}$

These equations predicted the biomass of the different components in (kg), with base in diameter (d) with bark (with the exception of the wood) in centimetres and in the total height (h) in meter. The selected equations were used to predict the total and component biomass of the individual trees in the three stands.

Models fitting and prediction statistics with better performance to de biomasss estimation

Mod.	Comp.	MSE	EM	mPRESS	maPRESS	R^2_{pred}	P95	P5
(2)	W_Barc	0,0271	0,9655	0,2605	5,5818	0,9518	15,4379	-15,2183
(3)	W_Ltot	0,8062	0,7887	-0,0180	3,8283	0,7299	10,3780	-5,7564
(1)	W_Bliv	4,1846	0,7724	5,5598	77,8096	0,5483	340,4550	-152,2570
(5)	W_Wood	26,8100	0,9882	-0,9964	42,4307	0,9642	127,1610	-65,4566
(5)	W_Bole	33,6004	0,9869	-2,0055	49,0936	0,9599	138,3160	-72,2298
(6)	W_Tot	2,9359	0,9883	1,2531	60,4847	0,9827	124,1600	-149,8300

Total and by components aboveground biomass of the stands

Component	Predicted aboveground biomass per stand					
	Bornes (N=1227 tre/ha)		Marão (N=485 tre/ha)		Padrela (N=259 tre/ha)	
	Mg/ha	%	Mg/ha	%	Mg/ha	%
Wood	294.1	72.5	328.0	71.7	152.4	71.3
Barck	30.8	7.6	31.7	6.9	15.6	7.3
Branches	75.2	18.5	90.9	19.9	42.5	19.9
Lives+Flowers	5.7	1.4	6.9	1.5	3.2	1.5
Total of tree	405.8	100	457.5	100	213.7	100

Final considerations

The biomass of the wood prevails both at the level of the stem as well as to the total biomass, contributing with more than 70% of the aboveground biomass. The branches are responsible for around 20%, followed closely by the bark, with approximately 7% of the total and the leaves and flowers with just 1.5% approximately. Thus, 78.5% to 80% of the chestnut high forest aboveground total biomass is coming of the main stem, while 20 to 21.5% results from the crown.

The information obtained with these biomass individual trees equations can be applied to the large scale biomass inventories and to a great variety of ecological and forest problems, allowing to relate, for example, the amount of fuel with the fires propagation conditions. It is also important to evaluate the residues resulting of the forest activities either in economical terms or as loss for the ecosystem.

References

Liu J., Burkhart E. H. 1993. Dynamics of size-variable distribution parameters in juvenile loblolly pine (Pinus taeda L.) stands. For. Ecol. Man., nº 58, pp. 321-347.

Ter-Mikaelian M. T., Korzukhin M.D. 1997. Biomass equations for sixty-five North American tree species. For. Ecol. Manage. 97, 1-24.

Reed D. D., Mroz G.D., Liechty H.O., Jones E. A., Cattelino P. J., Balster N. J., Zhang Y. 1995. Above and below-ground biomass of precompetitive red pine in Northern Michigan. Can. J. For. Res. 25, pp. 1064-1069.