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Models Determination to Estimate the Volume, in the Volume Revising and Extraction Operations (Case Study: District 3, 46 Watershed, IRAN)

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ABSTRACT

Tree volume estimation to calculate forest fee is time consuming and costly. furthermore, long term stock cut logs under warm and humidity condition results in decay.The current study was done to develop regression model to estimate comercial volume of logs using independent variable such as diameter at breast height , the trunk and etc, in the compartments 313 and 314 in the Research and Educational Forest of Tarbiat Modares University. For this purpose, diameter at breast height (DBH), diameter at end of trunk (DET), the height of the tree trunk and total height of 101 trees were measured using the VERTEX and the Image Tools software. Volume of renewing and extraction operations using as dependent variables in volume estimation model designing. Results showed that in preparing model for the renewal volume operation, diameter at breast height and total tree height and in preparation model for extraction operation, diameter at breast height, diameter at the end of the trunk and trunk height are the most important variables.

KeyWords: Industrial bole volume, Regression, Image Tools, harvesting costs, Trees rot

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INTRODUCTION

Accurate forest structural information is crucial to a number of applications including forest management [11], fire behavior analysis [4], and global warming and carbon management [16]. Forest management requires timber valuation that is one of most widely used characteristics in the forest that can be to things such as, fertility, and process improvement or degradation of habitat, allowable harvest rates, growth rates and the basis of purchase and sale and forest management, noted [2,3]. Whenever the production of forest products has to be measured or predicted, then mensurational techniques have to be developed and adapted to suit the particular circumstances [15] as a result, volume will be calculated more accurately and the results of its application would be more accurate and reliable. All forest inventories involve measurement of sample trees, which is a costly process. According to the law Forests and Rangelands Organization (FRO) of Iran, the exploitation of the forests of northern Iran to the prepare and implementation of forestry projects, are focused. In contrast, executives, must paid the proprietorial profit to FRO, in exchange the assignment the projects to the them. To calculate proprietorial profit, to the characteristics such as, volume of industrial trunks and firewood and the percentage of them, is required. On the other hand, inventory in the mountain forests of northern Iran, the work is time consuming and costly, therefore data collection was conducted with long intervals and not available up to date information for forest managers [17].

According, note 1, article 15 and 16, rule protection and exploitation, after cut operation, the trees marked re-measured by the experts, and volume of industrial trunks and firewood, to separation of species, in each licenses of cut, estimated to be. So to calculate the amount of proprietorial interest, renewing the volume of marked trees is necessary. Renewing volume operation of cut trees also required to time and expense, and by increasing staying time wood products in the forest, their value reduced, and on their decay will be added. Also in case that wood products

through traditional methods (for reasons such as: being impassable parcels cutting, high slope, the lack of skid roads), to be withdrawn, wood products become pieces with different dimensions, and to calculate volume of pieces, extraction operation is performed. Using sampling methods, which require fewer diameter measurements along the bole, can reduce the cost but this is only acceptable if the reliability of estimates does not suffer [10]. In many instances, regression models which pass through the origin are well suited to describe relationships between dependent and independent variables. Stem volume formula is function of a tree's height, basal area, shape, etc. Also volume is one of the most difficult parameters to measure, due to the complex behaviour of the tree bole growth and its dimensions and also an error in the measure or assumptions for any one of the above factors will propagate to the volume estimate. Therefore, several mathematical relationships such as Newton, Huber, Pressler and Smalian, to estimate the volume of the trees are used that, from this relationship, using a number of independent variables such as diameter at different heights, volumes are estimated. In principle tree-bole volume estimation is based on measurements of the diameter at certain heights of the tree bole and height measurements [9,12]. Calculations of merchantable volume may also be based on true cubic volume. Direct and indirect methods for estimating volume are available [7]. The method more usual to estimate volume in forest is the tree volume tables or tree volume equations. Besides existing available volume tables and equations with fixed merchantability limits are no longer sufficient for estimating volume in currently changing product and market conditions. Consequently multiple linear and non-linear regressions are the most common ways to estimate tree volume [5,14]. Finally, our goal was to construct models that could accurately estimate the bole volume in renewing and extraction operations using a minimum set of variables that could easily be measured on standing trees.

MATERIALS AND METHODS

2.1 STUDY AREA

The study was in the Research and Educational Forest of Tarbiat Modares University in area about 2000 hectares and 20 kilometers from southwest of the city Noor, (Latitude: 36°29'-36°32' N, Longitude: 51°43'-51°47' E) and in the elevation range of 750 to 1100 m altitude and in the parcel 313 and 314 Series 3 of the watershed 46 Kojur in north of Iran was conducted. Forest inventory is about 400 cubic meters per hectare, and the amount of the annual harvest is about 1,800 cubic meters. Industrial trees of this uneven-age forest, is beech, oak,maple, linden and alder.

2.2 DATA COLLECTION

To perform this study, before cutting operations, entering in the cutting parcels, and the 101 trees of trees that to cutting were marked, were measured. Diameter at breast height (DBH), diameter at end of trunk (DET), trunk height and total height of trees were measured using a 6Mp camera that was placed on a stick, Vertex Laser 400 (Fig. 1) and Image Tool 3.00 software. The distance to tree was measured using laser meter. 2 pictures of each tree, one to calculate the diameter at breast height (DBH), and another to calculate the diameter of end of the trunk (DET), were taken.

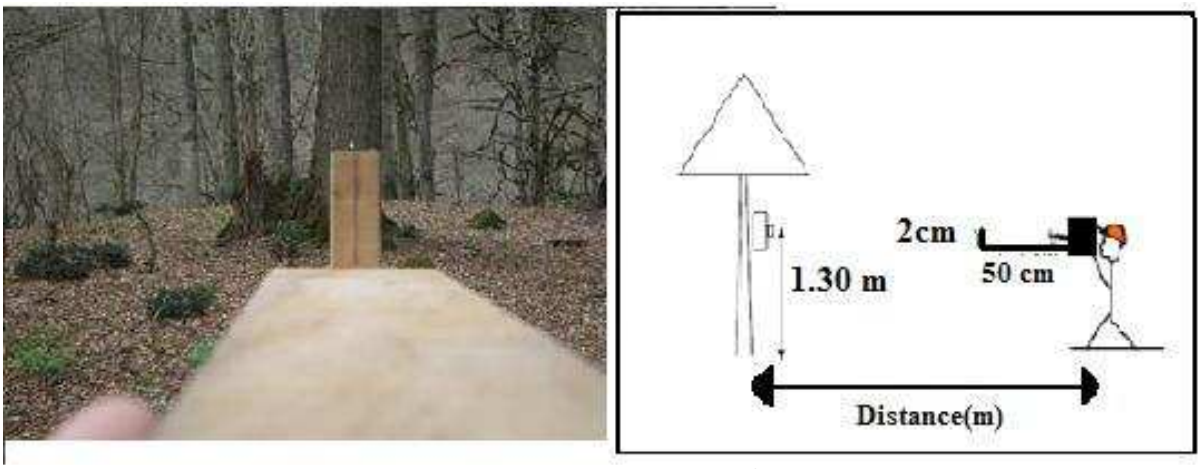

Fig 1- Index and Laser 400 with T3 transponder used for measuring Vertex

The captured tree pictures were entered in Image Tool software where DBH, DSH and DET were calculated by the software using following formula (Eq.1):

$$D = \left(\frac{X_i - L}{50}\right) * 100 \quad (1)$$

Where D is diameter (cm) at each height, X_i is length that measured in software for each trees diameter (cm) and L is distance to trees (m). Tree height and trunk height by using the Vertex laser altimeter tool , and the distance to the tree in the horizon surface using a laser meter and for more accurate with the sound detector system of Vertex, carefully were measured to hundredths of meters. In this method, using the index and the camera, the possibility of measuring diameter of end of the trunk, indirectly, high speed and to millimeter precision were possible. To designing models that could accurately estimate the bole volume in renewing and extraction operations using a minimum set of variables that could easily be measured on standing trees, bole volumes of each operations used as dependent variable and other variables, total tree height, trunk heigh, DBH and DET used as independent variables.
In order to use regression analysis, Lilliefor's statistical test [6] and normal-probability plots [13] were used to examine the normality of the dependent variable. In this study, the total data sets were used for the regression model building. Multiple linear regression (MLR) technique in the SPSS statistical package [13] were used to develop estimation equations for the same output as the dependent variable (v). Four different criteria [1] were used to evaluate the effectiveness of regression models and their ability to make precise predictions. The correlation coefficient (R), the average absolute error (AVABE), the root-mean-square error (RMSE) and the standard error of prediction (RMSE%) as a percentage of the mean tree volume. The principal advantage of the RMSE% is its non-dimensionality, allowing predictions made by different models to be compared on the same basis [8]. 70% of the data to determine the relationship, and 30% were used to validate the relationship. Data analysis using the softwares EXCEL 2007, SPSS 19 and Image Tools 3, was carried.

RESULTS

Figures 2 & 3, respectively shows the relationship between volumes of renewing and extraction operations and other variables.

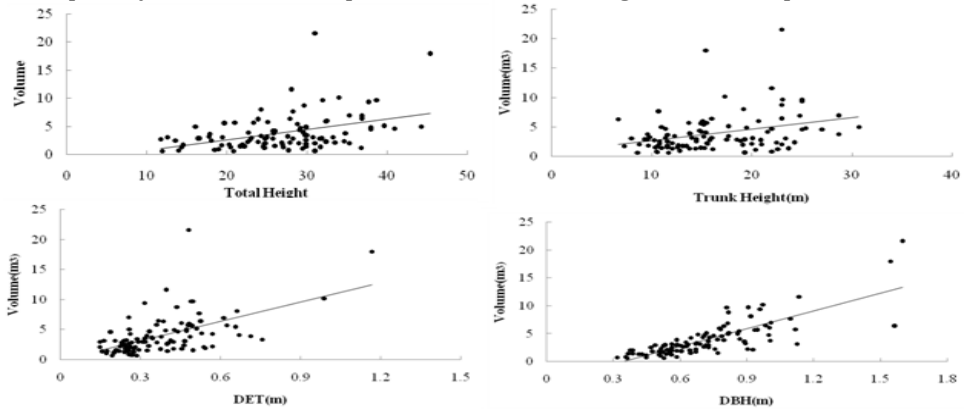

Fig 2- Relationship between volume of renewing operations and other variables

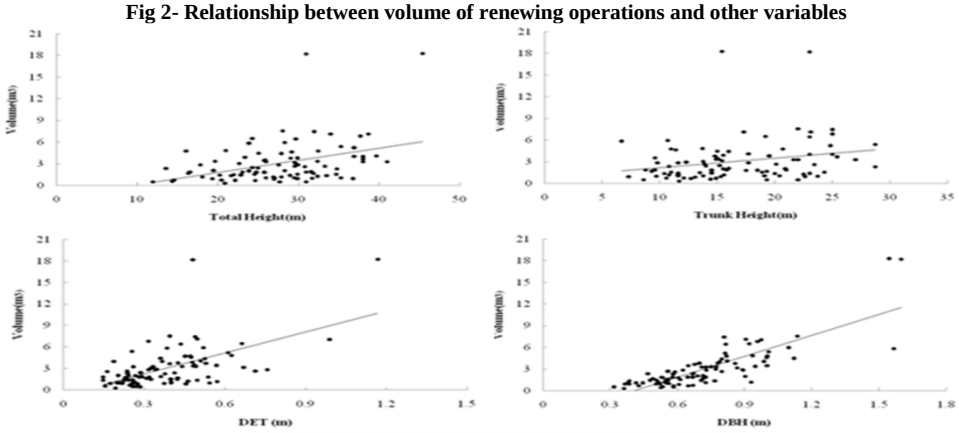

Fig 3- Relationship between volume of extraction operations and other variables

Table 1, shows the results of the correlation analysis between volumes of renewing and extraction operations and other variables.

Table 1- Correlation between renewing and extraction volumes and other variables

Variable	Total H	Trunk H	DBH	DET
Renewing Volume	.40**	.31**	.82**	.56**
Extraction Volume	.33**	.16*	.86**	.53**

***Correlation is significant at the 0.01 level*
** Correlation is significant at the 0.05 level*

With using regression analysis and stepwise method, in renewing and extraction operations, relationship between variables was determined and is shown separately in the tables 2 & 3.

Table 2- Designed models for renewing volume prediction

Models	Functions	R^2	RMSE	%RMSE	AVABE
1	V= -5.367+13.705DBH	0.79	2.76	0.70	2.03
2	V= -7.866+13.125DBH+0.098 Total H	0.82	2.41	0.61	1.80

Table 3- Designed models for extraction volume prediction

Models	Functions	R^2	RMSE	%RMSE	AVABE
1	V= -7.631+14.035DBH	0.77	1.28	0.41	1.12
2	V= -10.089+14.28DBH+0.132Trunk H	0.81	1.22	0.39	0.95
3	V= -10.711+13.316DBH+0.147Trunk H+2.714DET	0.82	1.27	0.40	1.00

In all of renewing and extraction operations designed models, DBH is common variable, but the variable total H is exclusive to renewing operation, and the variables trunk H and DET are exclusive to extraction operation.

Table 4 and 5, respectively shows the results of regression variance analysis and according to significant column demonstrated a significant linear relationship between independents and dependent (both volume of renewing and extraction operations) variables.

Table 4- Regression ANOVA variance analysis in renewing operation

Model		Sum of Squares	df	Mean square	F	Sig.
1	Regression	729.06	1	729.06	259.530	.000[a]
	Residual	193.832	69	2.809		
	Total	922.892	70			
2	Regression	753.616	2	376.808	151.368	.000[b]
	Residual	169.276	68	2.489		
	Total	922.892	70			

a. Predictors: (Constant), DBH- b. Predictors: (Constant), DBH, H total- - d. Dependent Variable: Renewing volume

Table 5- Regression ANOVA variance analysis in extraction operation

Model		Sum of Squares	df	Mean square	F	Sig.
1	Regression	592.752	1	592.752	200.702	.000[a]
	Residual	180.157	61	2.953		
	Total	772.909	62			
2	Regression	624.237	2	312.118	125.962	.000[b]
	Residual	148.672	60	2.478		
	Total	772.909	62			
3	Regression	635.569	3	211.856	91.012	.000[c]
	Residual	137.339	59	2.328		
	Total	727.909	62			

a. Predictors: (Constant), DBH; b. Predictors: (Constant), DBH, Trunk H; c. predictions :(constant), DBH, Trunk H, DET; d. Dependent Variable: Extraction volume

As result of table 1 show, volume (renewing and extraction) has significant possitive correlation with independent variables. Also has maximum correlation with DBH, and minimum correlation with trunk height in both renewing and extraction operations.

DISCUSSION

The aim of this study is designing models for estimation volume in renewing and extraction operations. In practice, accuracy, convenience and economics play the most important role when deciding which methods to utilize for forest inventory. Results of correlation between stem volume and other variables showed that stem volume has highest correlation with DBH, and lowest correlation with the trunk height. Since the aim of creating models to estimate the volume, is reducing measurement time and subsequently, reduce costs. Among relationships prepared for the operation renewing volume, relationship 2, by having two variables that measuring them in forest, requires less expertise and facilities (just by having a caliper and sunto, that are simple and basic devices for forest inventory), and also by having appropriate R^2 and less RMSE than relationship 1, which has low precision and more error, in order to estimate the volume of the trunk in renewing operation, is recommended. But for extraction operation, 3 models designed that among this models, model 3 and model 1, respectively, has the maximum and minimum R^2 and number of variables. On the other hand, relationship 2, by having the variables DBH and Trunk H that like to relationship 2 in renewing operation, requires simple and basic tools (such as sunto and caliper), and with having appropriate R^2 and less error than other models and also compared to relationship 3, that in addition to these variables, have the variable DET, that to calculate this variable in forest, adequate training, expertise and more possibilities is required, in order to estimate the volume of the trunk in extraction operation, is recommended.

CONCLUSION

Selection the model to volume estimation, depending on the purpose of forest manager, so that if the goal is to estimate the volume with high precision, the model should be used which has the maximum variable (model 3 in renewing operation and model 2 in extraction operation), but if the purpose is estimation with less cost, from the variables that require time, resources and less expertise to be calculated, will be used (model 1 for both renewing and extraction operations). The advantage of this method was using software, that in increasing the speed and accuracy has a very large role in the calculation of different diameters, noted; so that, making possible the calculation the diameter of the tree, and indirectly to millimeter accuracy, even at the end of the trunk. However, with the notice that this method with spending less cost to collecting data, so that the measurements action done by one person in the along renewing group and also has appropriate accuracy, it is suggested that with conduct similar studies in other forests in the north of IRAN and with more samples, attempted to produced models to estimate the volume.

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