

# **Remote Sensing Applications for yield Estimation of *Pinus brutia* Stands in North of Iraq**

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## **ABSTRACT**

The study was performed for three areas in the northern of Iraq ; Acra, Atroosh and Zaweeta aimed at estimating LAI, live volume, and mass of Bruti pine stands which are located between latitude line ( $^{\circ}36\ 43^{\circ}-^{\circ}36\ 54^{\circ}$ ) and longitude line ( $^{\circ}43\ 02^{\circ}-^{\circ}44\ 00^{\circ}$ ) and height from sea level (681–1014)m.

Research method for data collection is depended on Mult-phase sampling space data (space survey) it is first phase and field data ( ground survey) it is second phase . Ground survey has been done in summer 2007 where the basic data of the study was collected including tree and stand variables from (30) samples or locations. Space data applied in the study were taken from landsat 7 by Enhanced thematic mapper plus ETM+ using channels (1,2,3,4,5,7). The study has sought to find a set of equations to estimate LAI equations for estimating stand and tree weight as well as stand and tree volume through a number of equations of linear regression and non-linear regression methods which are available in computer as statcraft software. To make a comparison among the equations employed for each group of various axes of the study and choose the best one that represents data; the researcher has used accuracy measurements such as the Coefficient of Determination, standard error, Bias, and Othomo test. Results were as follows :

## 1 – Equations of LAI Estimation :

A. LAI estimation equation from the ground survey where two equations were chosen. The first by using the area occupied by sample's trees as an independent variable by applying non-linear regression method. The second by using quadratic diameter mean and density as independent variables through the non-linear regression method and based on accuracy measurement used in the study :

$$LAI = -1.16417 + 0.1351ScL^{-0.4068}$$

$$R^2_{adj.} = 0.9996 \quad S.E = 0.007 \quad n = 0.0004 \quad m = 09999 \quad Bais = 0.0012$$

$$LAI = 0.6865 + 0.0000015DG^{0.3897}N^{2.205}$$

$$R^2_{adj.} = 0.9342 \quad S.E = 0.001 \quad n = 0.0001 \quad m = 1.0004 \quad Bais = 0.0047$$

B. LAI estimation equation from space data by the denotation of channels (3 , 4) the equation was derived by means of non-linear regression method :

$$LAI = 0.0079B_3^{0.3131}B_4^{0.6955}$$

$$R^2_{adj.} = 0.9992 \quad S.E = 0.001 \quad n = 0.0001 \quad m = 1.0001 \quad Bais = -0.0001$$

C. LAI estimation equation by integrating ground data with space data by the denotation of the area occupied by sample's trees and SR :

$$LAI = -1.1662 + 0.13449SCL^{0.4089}SR^{0.0029}$$

$$R^2_{adj.} = 0.9993 \quad S.E = 0.0003 \quad n = -0.0019 \quad m = 1.0025 \quad Bais = 0.0012$$

2 . Equations of estimating the weight of stand's stem by the denotation of its variables and space data :

A. Estimation equation of stem wet weight by the denotation of diameters quadratic mean, height and density mean :

$$WGS = 65.4143 + 0.0297DG^2Hm^{0.8242}N$$

$$R^2_{adj} = 0.9815 \quad S.E = 454.97 \quad n = 0.0099 \quad m = 0.9999 \quad Bais = -0.0311$$

B. Estimation equation of stem wet weight by denotation of diameter quadratic mean, height mean and channel 4 ( $B_4$ ):

$$WGS = -27198.5 + 406.063DG + 720.443Hm + 156.414B_4$$

$$R^2_{adj} = 0.9257 \quad S.E = 929.93 \quad n = -0.0008 \quad m = 1.0 \quad Bais = 0.05$$

3 - Estimation equation of stand branches' wet weight by denotation its variables and data :

A. Estimation equation of branches' wet weight by denotation of diameter quadratic, height and density mean :

$$WGB = -848.933 + 2.2529DG^2 + 0.5940Hm^{0.3626}N$$

$$R^2_{adj} = 0.9621 \quad S.E = 141.51 \quad n = 0.0238 \quad m = 1.0001 \quad Bais = 4.1933$$

B. Estimation equation of branches' wet weight by denotation of diameter quadratic mean , height mean and  $B_4$ :

$$WGB = -3291.88 + 2.1554DG^2 + 12.3424Hm^{0.4232}B_4$$

$$R^2_{adj} = 0.9255 \quad S.E = 198.44 \quad n = 0.032 \quad m = 1.0002 \quad Bais = 1.5900$$

4 - Estimation equations of leaves' wet weight by denotation of stand variables and space data :

A. Estimation equation of leaves wet weight by denotation of diameter quadratic mean, height and density mean :

$$WGL = -166.504 + 0.03654DG^2Hm^{1.10986} + 3.25036N$$

$$R^2_{adj} = 0.9565 \quad S.E = 23.43 \quad n = 0.0001 \quad m = 0.5999 \quad Bais = 0.0008$$

B- Estimation equation of leaves' wet weight by denotation of diameter quadratic mean, height mean and channel 4 ( $B_4$ ):

$$WGL = -480.222 + 1.0DG^{0.3635}Hm^{0.2624}B_4^{1.0331}$$

$$R^2_{adj.} = 0.9449 \quad S.E = 18.45 \quad n = 0.2971 \quad m = 0.9987 \quad Bais = 0.0508$$

5 – Estimation equations of the total wet weight by denotation of field and space data :

A. Wet weight equation by denotation of diameter quadratic mean, height and density mean :

$$WGT = 209.586 + 0.01049DG^2/0.4278Hm^{0.8595}N^{1.074}$$

$$R^2_{adj.} = 0.9872 \quad S.E = 458.01 \quad n = -0.004 \quad m = 1.0 \quad Bais = 0.0052$$

B. Total wet weight equation by denotation of  $B_4$ , SR :

$$WGT = -20621.4 + 263.387B_4 - 2584.56SR$$

$$R^2_{adj.} = 0.3582 \quad S.E = 2588 \quad n = -0.7128 \quad m = 1.0001 \quad Bais = -0.1180$$

C. Total wet equation by denotation of diameter quadratic mean, height mean and SR:

$$WGT = -40145.5 + 571.409DG + 949.826Hm + 11952.8SR$$

$$R^2_{adj.} = 0.8764 \quad S.E = 1517 \quad n = 0.0058 \quad m = 0.9999 \quad Bais = -0.0590$$

6. Stem's dry weight equation by denotation of stand variables and space data :

A. Stem's dry equation by denotation of density, diameter quadratic mean and height mean :

$$WDS = -1314.2 + 67.564N + 413.13DG + 592.838Hm$$

$$R^2_{adj.} = 0.9128 \quad S.E = 856.18 \quad n = -0.043 \quad m = 1.0001 \quad Bais = -0.011$$

B. Stem's dry weight equation by denotation of channel 4 :diameter quadratic mean and height mean :

$$WDS = -16411.4 + 142.06B_4 + 1.0DG^{1.8557}/Hm^{-1.3074}$$

$$R^2_{adj.} = 0.9625 \quad S.E = 561.41 \quad n = 2.090 \quad m = 0.9999 \quad Bais = 0.5026$$

7 . Dry weight equation of branches by denotation of stand variables and space data :

A. Branches' dry weight equation by denotation of diameter quadratic mean, height and density mean :

$$WDB = -893.88 + 2.10712DG^2 + 1.0Hm^{1.2667}N$$

$$R^2_{adj.} = 0.9514 \quad S.E = 146.005 \quad n = 0.6418 \quad m = 0.9993 \quad Bais = -0.0109$$

B. Branches' dry weight equation by denotation of diameter quadratic mean, height mean and channel ( 4):

$$WDB = -1447.21 + 1.874DG^2 + 1.8293(Hm \times B_4)$$

$$R^2_{adj.} = 0.9024 \quad S.E = 213.73 \quad n = -0.0233 \quad m = 1.0002 \quad Bais = -0.0739$$

8 . Leaves' dry weight equation by denotation of stand variables and space data :

A. Leaves' dry weight equation by denotation of diameter quadratic mean, density and height mean :

$$WDL = -138.26 + 0.2958DG^2 + 0.64441NHm^{0.7456}$$

$$R^2_{adj.} = 0.9620 \quad S.E = 19.72 \quad n = -0.0005 \quad m = 1.0 \quad Bais = 0.0134$$

B. Leaves' dry weight equation by denotation of diameter quadratic mean, height mean and channel(4):

$$WDL = -818.714 + 0.2560DG^2 + 23.943Hm + 6.1172B_4$$

$$R^2_{adj.} = 0.9480 \quad S.E = 23.08 \quad n = -0.0002 \quad m = 1.0 \quad Bais = -0.001$$

9. Estimation equations of total dry weight by denotation of stand variables and space data :

A. Total dry weight equation by denotation of diameter quadratic, height and density mean :

$$WDT = -11.3349 + 0.032963DG^2Hm^{0.755262}N^{1.04044}$$

$$R^2_{adj.} = 0.9885 \quad S.E = 412.063 \quad n = 0.0043 \quad m = 1.0 \quad Bais = 0.993$$

B. Total dry weight equation by denotation of channels (4,5,7):

$$WDT = -29982.9 + 235.785B_4 + 206.266B_5 - 188.135B_7$$

$$R^2_{adj.} = 0.4651 \quad S.E = 2821 \quad n = 0.0049 \quad m = 0.9999 \quad Bais = -0.047$$

C. Total dry weight equation by denotation of diameter quadratic mean, height mean and channel (4):

$$WDT = -30736.3 + 463.979DG + 808.684Hm + 176.392B_4$$

$$R^2_{adj.} = 0.9289 \quad S.E = 1028 \quad n = 0.0058 \quad m = 0.9999 \quad Bais = -0.059$$

10. Stem's volume estimation equations by denotation of stand's variables and space data :

A. Stem's volume equation by denotation of diameter quadratic mean and density :

$$VS = 0.2069 + 0.00004DG^{2.8897}/N^{-1.07778}$$

$$R^2_{adj.} = 0.9855 \quad S.E = 0.33 \quad n = 0.0007 \quad m = 0.9998 \quad Bais = -0.0141$$

B. Stem's volume equation by denotation of diameter quadratic mean, density and channel (4):

$$VS = 0.0000003DG^{2.6944}N^{0.66602}B_4^{1.11173}$$

$$R^2_{adj.} = 0.9910 \quad S.E = 0.28 \quad n = 0.0075 \quad m = 0.9995 \quad Bais = 0.1671$$

11. Branches' volume estimation equation by denotation of stand variable and space data :

A. Branches' volume equation by denotation of diameter quadratic mean and density :

$$VB = 0.396747 + 0.000051DG^{1.95863}N^{1.17125}$$

$$R^2_{adj.} = 0.9796 \quad S.E = 0.23 \quad n = 0.0007 \quad m = 0.9999 \quad Bais = -0.005$$

B. Branches' volume equation by denotation of diameter quadratic mean, density and channel (4):

$$VB = -0.033208 + 0.0000089DG^{1.66072}N^{0.7104}B_4$$

$$R^2_{adj.} = 0.9814 \quad S.E = 0.20 \quad n = 0.0002 \quad m = 1.0008 \quad Bais = 0.0889$$

12. Volume estimation equations by denotation of stand variables and space data :

A. Total volume equation by denotation of diameter quadratic and density:

$$VT = 0.74006 + 0.00002DG^{2.55213}N^{1.12446}$$

$$R^2_{adj.} = 0.9814 \quad S.E = 0.57 \quad n = 0.0002 \quad m = 0.9999 \quad Bais = -0.0041$$

B. Total volume equation by denotation of channels (3,4,5,7):

$$VT = -59.101 + 0.6653B_3 + 0.1484B_4 + 8.7999(B_5/B_7)$$

$$R^2_{adj.} = 0.5123 \quad S.E = 3.22 \quad n = 0.0001 \quad m = 1.0001 \quad Bais = -0.0001$$

C. Total volume equation by denotation of diameter quadratic mean, density and channel (4):

$$VT = 0.9560 + 0.000001DG^{2.39891}N^{0.75594}B_4$$

$$R^2_{adj.} = 0.9883 \quad S.E = 0.49 \quad n = 0.0001 \quad m = 0.9999 \quad Bais = -0.0014$$