Biomass Estimation of Pinus Radiata (D. Don) Stands in Northwestern Spain by Unmixing CCD CBERS Data

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1. INTRODUCTION

Information from satellite imagery is an important data source for forest management. Remote sensing techniques provide information about volume, biomass and other biophysical parameters of forest stands. The estimation of biomass by satellite remote sensing has been tested considering a wide range of spatial scales and environments [1] [2] [3]. Chinese-Brazilian Earth Resources Satellite (CBERS) data had not been used in Europe yet. In this work, we examined the potential of CBERS CCD data for estimating radiata pine stand attributes, especially biomass, in a Northwestern Spain region.

2. MATERIAL AND METHOD

The study area was El Bierzo, in the Northwestern Spain. Climate and decline of agriculture have favoured the establishment of extensive commercial forest plantations in the study area. Even if relatively recently introduced in the region of El Bierzo, radiata pine currently occupies an area of approximately 150 km² [4].

Data from field inventory carried out during the summer of 2003 in 45 permanent sample plots of the network established by the University of León (Spain) in pure radiata pine plantations were employed. Concerning remote sensed data, a CBERS image (20 x 20 m) acquired on November 5th, by the high resolution Charge-Coupled Device (CCD) sensor was used. CBERS CCD images have 5 spectral bands: blue, green, red, infrared, and panchromatic.

The applied methodology had the following steps:

1.-Preprocessing the field inventory data: the following variables were considered: stand volume (V, m³ha⁻¹), stand aboveground biomass (W, t·ha⁻¹), stand stem biomass (Ws, t·ha⁻¹), carbon pools in stand aboveground biomass (C, t·ha⁻¹), carbon pools in stem biomass (Cs, t·ha⁻¹), age (t, years), dominant height (H, m), stand basal area (G, m²ha⁻¹), quadratic mean diameter (Dg, cm), dominant diameter (Do, cm), mean height (Hm, m), number of stems per hectare (N), and Site Index (SI, m).

2.-Preprocessing the CBERS CCD image: as fraction images from spectral unmixing show biophysics properties more easily than original bands (they represent physical aspects of ground covers), Spectral Mixture Analysis (SMA) was applied to the original image [5].
3.-Work database formation: an average 3x3 filter was applied to the image as a previous step to the extraction of the digital values that corresponded to the considered field plots. These values were stored together with the field inventory information in order to form the work database.

4.-Statistical analysis of the work database: the statistical relationships were performed using correlation analysis, whereas predictive linear and non-linear regression models were consequently selected for estimation trials. The regression models tested in this study were mainly the proposed by [2] [3] [6] [7]. Comparison of the different fitted models was based on numerical analyses. Three statistical criteria obtained from the residuals were examined: the coefficient of determination ($R^2$), showing the proportion of the total variance of the dependent variable explained by the model; the root mean square error (RMSE), which states the accuracy of the estimates for basal area and stand volume; and the mean percent standard error ($S\%$), that indicates the size of error as a percentage of the mean of the estimated variable distribution.

### 3. RESULTS AND DISCUSSION

The correlation analysis showed that both the original band infrared and the shade fraction images were significantly correlated to $W$ and $C$ (Pearson correlation coefficient equal 0.53 and 0.55, respectively, p-value = 0.01). This result was not surprising; different authors ([8] and [9], among others) stated that the shade fraction image was the best band to estimate forest biophysical stand variables. The non-linear regression model described by [3] showed the best performance considering the randomly defined training plots. This model was validated using the remained plots.

### 4. CONCLUSION

The preliminary results showed that CBERS CCD data can be used to estimate biophysical forest stand variables, concretely biomass and carbon pools. Using SMA allowed obtaining a regression model statistically significant that can help forest management.

### 5. REFERENCES


