EUROPEAN JOURNAL OF REMOTE SENSING
2018, VOL. 51, NO. 1, 932–944
https://doi.org/10.1080/22797254.2018.1521250

Above-ground biomass estimation for *Quercus rotundifolia* using vegetation indices derived from high spatial resolution satellite images

Fabrício L. Macedo[a], Adélia M. O. Sousa[b], Ana Cristina Gonçalves[b], José R. Marques da Silva[b], Paulo A. Mesquita[b] and Ricardo A. F. Rodrigues[c]

[a]Centro de Investigação e de Tecnologias Agro-Ambientais e Biológicas (CITAB), Universidade de Trás-os-Montes e Alto Douro, Vila Real, Portugal; [b]Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, Instituto de Ciências Agrárias e Ambientais Mediterrânicas (ICAAM), Instituto de Investigação e Formação Avançada, Universidade de Évora Apartado 94, Évora, Portugal; [c]Departamento de Fitossanidade, Engenharia Rural e Solos, Universidade Estadual Paulista – UNESP/FE Campus de Ilha Solteira, Ilha Solteira, SP, Portugal

ABSTRACT

The estimation of vegetation parameters, such as above-ground biomass, with high accuracy using remote sensing data, represents a promising approach. The present study develops models to estimate and map above-ground biomass of Mediterranean *Quercus rotundifolia* stands using one QuickBird satellite image in pan-sharpened mode, with four multispectral bands (blue, green, red and near infrared) and a spatial resolution of 0.70 m. The satellite image was orthorectified, geometrically and radiometrically corrected. Object-oriented classification methods and multi-resolution segmentation were used to derive a vegetation mask per forest species. Data from forest inventory (24 plots) and vegetation indices (NDVI, EVI, SR and SAVI) derived from high spatial resolution satellite images were used for an area of 133 km^2, in southern Portugal. The statistical analysis included correlation, variance analysis and linear regression. The linear regression models fitted included the arithmetic mean and the median values of the vegetation indices per inventory plot as explanatory variables. The overall results of the fitted models show a trend of better performance for those with the median value of the vegetation index as the explanatory variable. The best fitted model (R^2 = 75.3) was associated with the Simple Ratio (SR) median value as an explanatory variable. A *Quercus rotundifolia* above-ground biomass map was produced.

ARTICLE HISTORY
Received 21 February 2017
Revised 16 August 2018
Accepted 5 September 2018

KEYWORDS
Above-ground biomass; high spatial resolution; vegetation indices; linear regression

Introduction

The CO_2 accumulation in the atmosphere has a great contribution from two activities, burning of fossil fuels and deforestation (Watzlawick, Koehler, & Kirchner, 2006), which led to an increase of studies related to biomass evaluation and carbon sequestration (Melo & Durigan, 2006), such as the sustainable forest management, timber management, forest productivity prediction, carbon sink evaluation and the global carbon cycle (Brown, Schroeder, & Kern, 1999; Houghton, 2005; Lu, 2006; Palacios-Orueta, Chuvieco, Parra, & Carmona-Moreno, 2005; Ryu, Chen, Crow, & Saunders, 2004).

Allometric functions at tree-level species and site-specific are most commonly used to estimate biomass, frequently with diameter at breast height and total height as explanatory variables (Flombaum & Sala, 2007; Foroughbakhch, Reyes, Alvarado-Vázquez, Hernández-Piñero, & Rocha-Estrada, 2005; Nelson et al., 1999; Parresol, 1999; Peichl & Arain, 2006; Segura & Kanninen, 2005).

Improvements in remote sensing technology enhanced the development of functions to estimate biomass and carbon stocks (Watzlawick & Kirchner, 2004), using different sensors with different spatial resolution. According to Navulur (2006), this data is classified depending on the pixel size: coarse (30 m or greater), medium (2.0–30 m), high (0.5–2.0 m) and very high (lower than 0.5 m) spatial resolution. With the purpose of estimating biomass and carbon stocks, several studies have been developed using coarse spatial resolution data (Baccini, Laporte, Goetz, Sun, & Dong, 2008; Dong et al., 2003; Yin et al., 2015) or high and very high spatial resolution (Baccini, Friedl, Woodcock, & Warbington, 2004; Häme, Salli, Andersson, & Lohi, 1997; Lu, 2006; Muukkonen & Heiskanen, 2007; Sousa, Gonçalves, Mesquita, & Marques da Silva, 2015; Viana, Aranha, Lopes, & Cohen, 2012). These indirect methods have a better cost-benefit relation and much less time is needed for the assessment when compared with methods based on forest inventory plots and extrapolation methods. Due to their flexibility, it is also possible to analyse the above-ground biomass variation within different regions or in time, as well as the impact of disturbances, such as deforestation or fire (Potter, 1999).

CONTACT Adélia M. O. Sousa asousa@uevora.pt Departamento de Engenharia Rural, Escola de Ciências e Tecnologia, Instituto de Ciências Agrárias e Ambientais Mediterrânicas (ICAAM), Instituto de Investigação e Formação Avançada, Universidade de Évora, Apartado 94, Évora, Portugal