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RESOURCE COMMUNICATION

OPEN ACCESS

EucaTool®, a cloud computing application for estimating the growth and production of *Eucalyptus globulus* Labill. plantations in Galicia (NW Spain)

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Abstract

Aim of study: To present the software utilities and explain how to use EucaTool®, a free cloud computing application developed to estimate the growth and production of seedling and clonal blue gum (*Eucalyptus globulus* Labill.) plantations in Galicia (NW Spain).

Area of study: Galicia (NW Spain).

Material and methods: EucaTool® implements a dynamic growth and production model that is valid for clonal and non-clonal blue gum plantations in the region. The model integrates transition functions for dominant height (site index curves), number of stems per hectare (mortality function) and basal area, as well as output functions for tree and stand volume, biomass and carbon content.

Main results: EucaTool® can be freely accessed from any device with an Internet connection, from http://app.eucatool.com. In addition, useful information about the application is published on a related website: http://www.eucatool.com.

Research highlights: The application has been designed to enable forest stakeholders to estimate volume, biomass and carbon content of forest plantations from individual trees, diameter classes or stand data, as well as to estimate growth and future production (indicating the optimal rotation age for maximum income) by measurement of only four stand variables: age, number of trees per hectare, dominant height and basal area.

Keywords: forest management; biomass; seedling; clones; blue gum; forest tool.

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Introduction

Growth and yield models are very useful tools for foresters. Adequate simulation of present and future growth and yield of forest stands after different silvicultural treatments, together with accurate estimation of forest goods (e.g. volume) and services (e.g. biomass and carbon content), allows forest owners, companies and forest managers to adopt appropriate actions for sustainable forest management.

In Spain, different forest growth and yield models have been developed during the last few decades (Bravo *et al*., 2011). Such models usually comprise a series of complex equations and relationships and are not easy to use in practice. Moreover, very few such models are implemented on software that enables end users to use them easily. Some of the most remarkable exceptions are the GesMO© program (Diéguez-Aranda *et al*., 2009) and the web-based platform SIMANFOR (Bravo *et al*., 2012).

Blue gum (*Eucalyptus globulus* Labill.) is one of the most important tree species in Spain in terms of production. The annual average total harvested volume with bark of the species in Galicia is about 3.5-4 million m^3 (CONFEMADERA, 2013). This implies that Galician blue gum plantations provide almost 38% of the total volume (of all tree species) harvested annually in Spain (MAGRAMA, 2012). This species is the main source of short pulp fibre (of highest quality) throughout the European Union, and Spain and Portugal are the main producers of BEKP (bleached eucalypt kraft pulp).

A dynamic growth and production model has recently been developed for seedling and clonal plantations of *Eucalyptus globulus* in Galicia (García-Villabrille, 2015). This model replaces the limited and outdated previous forest models for blue gum in Spain (none of which are available on any forestry computer simulator) and, as a novel feature, is also valid for new clonal planting material. To facilitate use of this complex model by potential users (owners, companies and forest managers, scientist, students, etc.), the model has been implemented in an easy-to-use cloud computing application called EucaTool®.

The objective of this paper is to present the software utilities and explain how to use EucaTool®, freely available at http://app.eucatool.com.

Specifications

EucaTool® is a cloud computing application developed to simulate the growth and production of first rotation seedling and clonal plantations of *Eucalyptus globulus* in Galicia (NW Spain).

The application implements a dynamic growth and production model that is valid for clonal and non-clonal blue gum plantations in the region. The model integrates different transition functions for dominant height (site index curves), number of stems per hectare (mortality function) and basal area, along with equations for tree and stand volume and biomass and carbon content (García-Villabrille, 2015).

EucaTool® has been programmed in Visual Studio Web 2012 Express, using MVC technology. It uses the following languages: C #, XML for models, drivers and configuration, Razor, HTML, Javascript, and CSS for displays. All forest models have been developed with R (R Core Team, 2014). The current language of the application is Spanish.

System description

EucaTool® access

EucaTool® is a cloud-based application, i.e. it is accessible via the Internet and no specific installation is required. It can be freely accessed from any Internet-connected device (desktops, laptops, mobile phones, smartphones, tablets, etc.) at http://app.eucatool.com.

Access must be made via a browser and the application is compatible with the most common available (Chrome, Firefox, Opera, Safari), although there may be some incompatibilities with Internet Explorer.

EucaTool® is hosted in a server owned by the company that has developed the application: VSonCloud S.L. (http://www.vsoncloud.com).

EucaTool® conditions of use

The application is only applicable to regular first rotation *Eucalyptus globulus* stands in NW Spain, aged between 3 and 21 years, with dominant heights up to 40 m and diameters up to 70 cm.

The application is provided "as is" without any warranty, express or implied. The EucaTool® developers also reserve the right to make changes and to translate the application to other languages without notice.

EucaTool® is open to use by the forestry community (foresters, scientists, students, etc.); however, the authors are not responsible for wrong use or interpretation of the results obtained by the application.

Using EucaTool®

Information on the use of the application (User's Manual) is published on a website linked to the application: http://www.eucatool.com.

Once the user has accessed EucaTool®, the "Main Menu" appears with the following options (Figure 1):

- Calculations using tree data:
  - Data on individual trees.
  - Data on diameter classes.
- Calculations using average data on forest stands.

Calculations using tree data provide results on volume and biomass, and there are three options for entering the data: (i) enter data for individual trees; (ii) import data for individual trees (the user can drag and drop the data, tab-separated in ASCII format); or (iii) enter data for diameter classes.

The following information is required in option (i): dbh (cm) and total height (m) of each individual tree.

The following information is required in option (ii): dbh (cm) for each individual tree and total height (m) for all, some, or no trees. In cases where data is incomplete (not all heights are specified), another two variables must be added: dominant height (m) and dominant diameter (cm) of the stand origin of the data.

Figure 1. Main Menu of EucaTool®.

The following information is required in option (iii): mean diameter (cm), mean total height (m) and number of trees/ha for each diameter class.

After the user has completed the required information, data from each entered or imported tree or diameter class will be included in the list of trees or classes. Some variables are calculated in the list and the corresponding volumes and dry biomass weights are added in a summary row (in green), as shown in Figure 2. The meaning of the different variables from the list of trees/classes will appear when the user hovers the mouse over each item.

Calculations using average data of forest stands provide information on volume, biomass, carbon content, medium and current annual volume increment and about the site index and the optimal rotation age for maximum income of the stand. This requires entering the following information:

— Stand age (years).
— Number of trees/ha.
— Dominant height (m), estimated as average height of the 100 thickest trees per hectare of the stand.
— Basal area (m^2/ha). This data can be simulated by pressing the attached calculator button, although use of real inventory data is recommended to minimize errors.
— Surface (hectares) of the stand.

Once the user has included the stand data, simulation of the growth and production of the stand proceeds, and a results table indicating the value of different variables from year to year appears (Figure 3). EucaTool® only provides results until a stand age of 21 years, because of the constraints of the experimental data used to fit the equations used. The meaning of each variable in the table will appear when the user hovers the mouse over the item.

A qualitative site index rating (low, medium-low, medium, medium-high or high) and a quantitative site index rating (indicating the value of the dominant height at reference age of 7 years) are shown above the results table.

Information about optimal rotation age for maximum income of the stand is shown at the bottom of the results table.

EucaTool® provides the option to print reports from the performed simulations. In addition, a QR code for

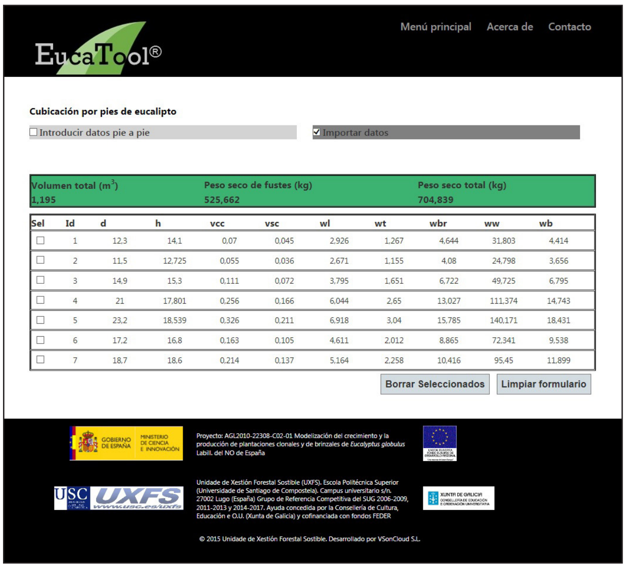

Figure 2. Example of a list generated by EucaTool® showing estimates of imported trees data (heights of trees 2, 4 and 5 have been estimated from stand variables).

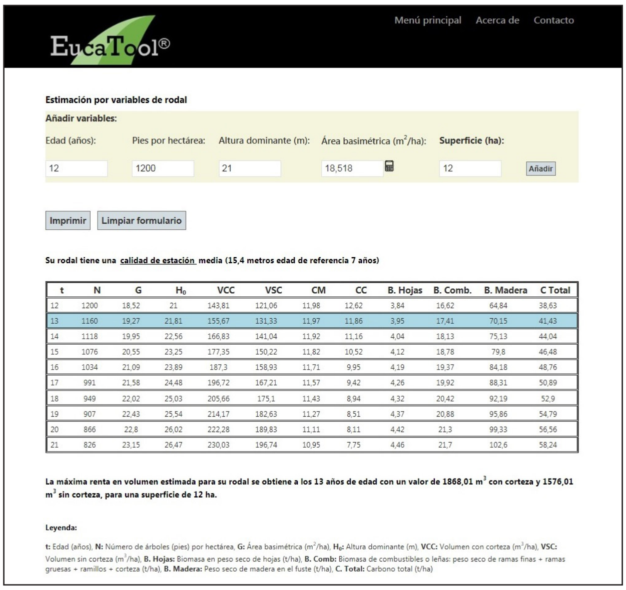

Figure 3. Example of a table of results generated by EucaTool® showing stand estimates.

accessing the digital simulation from any QR reader is generated in the reports.

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