Forest Systems
26 (3), eRC03, 4 pages (2017)
eISSN: 2171-9845
https://doi.org/10.5424/fs/2017263-12047
Instituto Nacional de Investigación y Tecnología Agraria y Alimentaria O. A., M. P. (INIA)

RESOURCE COMMUNICATION

OPEN ACCESS

ApkFor©, an Android Open-Source Project for research and technology transfer in forest management

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Abstract

Aim of the study: To introduce and describe ApkFor©, an Android Open-Source Project to generate basic mobile applications to transfer forest growth and yield models for even-aged stands.

Material and methods: ApkFor© was developed in Android Studio using Java and XML languages integrating transition functions for dominant height and basal area, equations of tree and stand volume and structural models. The project was applied and validated for *Pinus pinaster* Ait. stands in Northeastern Portugal.

Main results: ApkFor© is an Open-Source project freely available from the Source Force repository: https://sourceforge.net/projects/apkfor/, licensed under the GNU General Public License version 3.0 (GPLv3).

Research highlights: This project has been designed and created to provide the code and promote its re-use and modification to develop simple growth and yield mobile applications in Android, and with it to transfer research results of forest modelling to forest managers. Moreover, an example of application of the compiled code is provided using the models of *Pinus pinaster* Ait. previously validated for the Northeastern Region of Portugal.

Additional keywords: Java; growth and yield; dynamic models; *Pinus pinaster* Ait.; Northeastern Portugal.

Authors´ contributions: Conception and design: FPR and MMM. Drafting of the manuscript: FPR, JCA and MMM. Supervision and coordination of the research project: JCA. All authors read and approved the final manuscript.

Citation: Pérez-Rodríguez, F.; Azevedo, J.; Menéndez-Miguélez, M. (2017). Resource communication: ApkFor©, an Android Open-Source Project for research and technology transfer in forest management. Forest Systems, Volume 26, Issue 3, eRC03. https://doi.org/10.5424/fs/2017263-12047

Received: 19 Jul 2017. **Accepted:** 15 Dec 2017.

Funding: EU 7th Framework Programme for research, technological development and demonstration (agreement no 613762: SIMWOOD - Sustainable Innovative Mobilisation of Wood).

Competing interests: The authors have declared that no competing interests exist.

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Introduction

The estimation of growing stock, both in terms of volume and biomass, is an essential aspect of forest management (Menéndez-Miguélez *et al.*, 2016). This requires field tree measurements and the development of models and tools such as height growth models and biomass or volume equations, to represent in a simplified way the complexity of forest ecosystem dynamics (Burkhart & Tomé, 2012). Numerous static (Barrio-Anta *et al.*, 2006; Diéguez-Aranda *et al.*, 2006; Menéndez-Miguélez *et al.*, 2014) and dynamic models (Castedo-Dorado *et al.*, 2007; Crecente-Campo, 2008) are now available for different forest species. These models allow managers to simulate forest dynamics and growth, with the prediction of how forests will be at particular times in the future, helping them to make sound decisions regarding sustainable management. This is more likely to occur when models are implemented as user-friendly computer tools providing a diversity of examples of applications (Borges *et al.*, 2014). However, in many cases model transfer between researchers and forest managers is not efficient preventing advanced knowledge and tools to reach those who intervene in forest stand management in practice. According to Larocque *et al.* (2015), the lack of transfer between these two groups may be due to the fact that researchers dedicated to modelling invest all their time obtaining the model or do not have the capacity to develop models and tools to be transferred to the final users.

The development of mobile applications has increased in recent years (Nagappan & Shihab, 2016) and available integrated development environments,

such as Android Studio, make the development of applications easy. This trend has not being observed in forestry where major contributions are still in the form of desktop and cloud applications (Borges *et al.*, 2014). Exceptions include applications for forest fires survey (Liu *et al.*, 2014), forest inventory and mensuration (Molinier *et al.*, 2016; Forest Inventory App, 2017; Forest Metrics, 2017), tree identification (Blanco-Alambiaga, 2015), mushrooms identification (Segarra, 2017) or support participatory agroforestry planning (De Sousa *et al.*, 2015). There are not, however, examples of forest growth and yield Open source Android applications in the literature.

In order to promote the development of forest mobile modelling and management applications and to increase efficiency in transferring knowledge and practical tools from forest modellers to forest managers, we present here an application developed for managers to directly use in the field forest models developed by modellers. Applications designed for mobile devices are simpler and faster than web-based applications and operate without an internet connection, which is a major advantage for forest fieldwork. The objective was to create an Android Open-Source Project (AOSP) that can be replicated, re-used and modified by other programmers to promote the development of mobile applications, transferring growth and yield models in an easy way to forest managers without spending unnecessary time in the development process. Moreover, an example of a compiled project is provided.

Specifications

The ApkFor© Open-Source Project is a set of files developed in Android Studio that combined the interfaces and procedures required to run a dynamic growth and yield modelling framework. It integrates different transition functions for dominant height (site index curves) and basal area, along with equations of tree and stand volume and structural models to plan thinning operations of different intensity. The program languages used were Java and XML. The compiled example provided as *.apk can be installed in platform Android 2.2 or higher and was translated into three languages: Portuguese, Spanish, and English.

Project description

Structure and models

The project was designed to generalize the procedures required to run common growth and yield models for even-age stands. Inputs of key stand level variables were used for the development of a generic library in Java that can be modified easily by changing equations in the code. The variables were Current age (t_1), Dominant Height (H_0), Number of trees per hectare (N), Basal area (G) and Age to simulate (t_2).

Moreover, thanks to the increasing capacity of mobile devices, the developed library has the capability of parametrizing a two–parameter Weibull distribution which is required to estimate tree distribution by size class in thinning operations. The project uses SQLite to save the set-up and options. Create, modify, and delete commands were implemented in the code.

Forms and design

Android projects use xml language to create menus. The forms and menus were designed for simplicity. The elements that make up this menu are:

i)"Start", through which the input screen is accessed,

ii)"Thinning planning", leading to definition of parameters regarding thinning operations (max. number of thinnings, minimum age for the first thinning, thinning frequency, and thinning intensity),

iii)"Options", leading to the screen where language and output options can be selected ,

iv)"Model information", by means of which the sources of equations used in the App can be listed, and

v)"Exit", which closes the application.

The results of simulations are displayed in a table, year by year. These results are presented for the output variables selected by the user and describe the evolution of these parameters in the stand over the simulation period. When thinning is applied, the number of trees, volume and basal area are displayed. Under “Options”, it is possible to identify in the table (in yellow) the application of this management practice.

Access

The code and the prototype are available to download from the SourceForge repository (https://sourceforge.net/) with an example titled “ApkFor.apk” that can be installed and run in Android operated mobile devices. The direct link to the repository is https://apkfor.sourceforge.io. SourceForge was used due to its simplicity and reliability.

Example of application

The compiled ApkFor.apk application provided in the repository is an example of how the code can be used in practice. In this example we implemented the *Pinus pinaster* Ait. models validated for the Northeastern region in Portugal (Pérez-Rodríguez *et al.*, 2016). The resulted application has the main splash screen as shown in Fig. 1 and can produce simulation outputs as shown in Fig. 2.

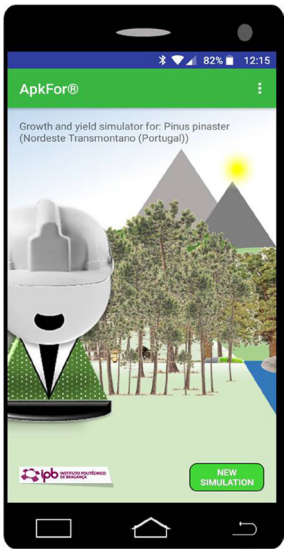

Figure 1. Main splash screen of the compiled example "ApkFor.apk", composed by a background image, main menu and a direct access button to a "new simulation".

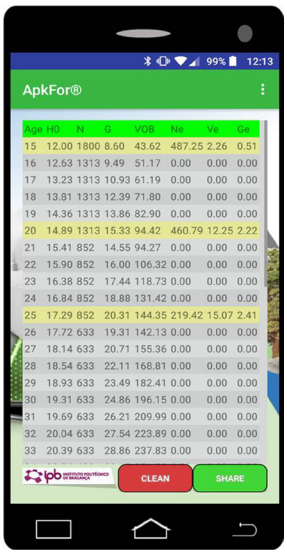

Figure 2. Tabular display of the results of an ApkFor simulation in the compiled example "ApkFor.apk". Thinning is indicated in yellow. "Age" is stand age (yrs), "H0" is dominant stand age (yrs), "N" is tree density (number of trees/ha), "G" is basal area (m^2/ha), "VOB" is overbark volume (m^3/ha), "Ne" is number of trees extracted (number of trees/ha), "Ve" is volume extracted (m^3/ha) and "Ge" is the basal area of the trees extracted (m^2/ha).

Final considerations

Computer tools are efficient vehicles for transferring knowledge and models developed in research to practitioners and other final users in forest management. Nowadays, programming languages allow the development of attractive and user-friendly tools that can also be used in the field in mobile devices. Applications for mobile devices have gained importance in recent years due to their ease of use, and differ from developments in the cloud in that they do not require an internet connection, an important aspect in forestry since this type of coverage is often lacking in the working places. The development of generic applications provided as Open Source project favours model transfer in a simple way through reusing and modifying the code and minimizing development costs. Moreover, this kind of developments allows collaborative improvements from several developers. ApkFor© is the first application of this kind in forestry and we expect its use to impact forest management in the Northeast Region of Portugal and other areas.

ApkFor© license and conditions of use

ApkFor© is an Android Open-Source Project. It can be redistributed and/or modified under the terms of the GNU General Public License (GPLv3 or higher) as published by the Free Software Foundation (http://www.gnu.org/licenses/). According to the GNU General Public License, ApkFor© is distributed in the hope that it will be useful, but WITHOUT ANY WARRANTY; without even the implied warranty of MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.

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