

## Silvia: a flexible system for integrated forest management

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**ABSTRACT:** Silvia, the Forest Management System is a computer application designed to help managers and technicians in the sustainable management of forest plantations. Silvia version 2 includes a plantations database, an equations database, and modules to simulate current and future productivity, process inventories data and make financial analysis. Map layers in several GIS formats can be linked to Silvia to render several types of thematic maps. Simulations can be run with sets of equations provided by Silvia or by the user from his own growth studies. Silvia can be used for projects of different sizes, from small farms to multinational forest companies without any limitation regarding the number of stands or species.

**KEYWORDS:** Forest management, forest plantations, growth equations, financial analysis

### INTRODUCTION

The 1960s saw the launching of large-scale plantation programs in many tropical and subtropical countries, and between 1965 and 1980 the area devoted to tropical plantations trebled. Plantations often benefited from direct subsidies, and they were mostly managed by state organizations. The last three decades of the past century saw also the establishment of trials and research of many forest species in many tropical countries. During this same time the computing sciences suffered a huge advance and computers use became widespread at global level.

But poor management, marketing and a failure to establish viable links between plantations and industrial consumers of wood products meant that many tree-planting activities slowed down when external support ceased, especially in the case of small scale plantations. Research support also ceased or moved towards other fields than silviculture, model developing and plantations monitoring. The development in computing sciences didn't result in an adequate offer of forest related software, especially for the management of forest plantations.

There are several software tools for forest plantations management such as the Remsoft Spacial Planning System (Remsoft, 2004), Assisi Forest (Assisi Software, 2004) and SGI – Sistema de Gestão da Informação (Athena Software, 2004). According to Hennesy and Damian, 2000, the majority of the software for forest plantations management is of limited use due to the following reasons:

- Limited applicability in terms of models, species or data hierarchy
- Not available for purchase
- High complexity
- Does not fulfill users' expectations.
- High price

The Tropical Agricultural and Higher Education Center, CATIE, in collaboration with Helsinki University, and the financial support from the Academy of Finland, initiated the development of Silvia in 1999 as a flexible tool for the management of forest plantations in terms of species, models and kind of users.

Objectives of the development of Silvia were to provide forest-based enterprises and forest manager with a flexible and low cost tool for managing forest plantations, with the ability to use field data to increase models accuracy. The focus of this tool was to design a system which allows the use of information and data from field measurements, sample plots and from literature in a modular way. This paper describes the structure, functioning and use of Silvia.

## DESCRIPTION OF THE SYSTEM

Silvia, the Forest Management System is a 32 bit Windows application, suited to be used in Windows 98/Me/200/NT/Xp. Silvia was designed to help managers and technicians in the sustainable management of forest plantations. The application is composed by a set of modules, each focused in specific tasks of forest management, and can be used for projects of different sizes, from small farms to multinational forest companies without limitations regarding the number of stands or species.

Version 2 includes the following six modules:

### Plantations module

This module is used to consult and edit stand-related information linked to “projects” (which can be a simple set of communal or private owned plantations up to a big set of plantations located in several countries), list species and define basic characteristics of projects, such as hierarchy and name of subdivisions, as well as all stand related information (management activities, detailed characteristics of each stand, future planting plans, inventory results at stand level, and actual costs of activities). Stands can be grouped using the defined hierarchies, and several queries can be defined to filter data. Graphs window allows the user to define several kinds of graphics (species composition, inventories data, stands by age, etc).

### Equations module

This module is used to store taper, volume, growth, yield, site index and other forest management related equations. These equations can be later used in the Simulation and Inventories module, to calculate inventories data and estimate current as well as future stocks at stand level or at any hierarchy level. Database contains currently near to two hundred equations collected in Latin America, from different published sources, including complete sets of equations for 15 species of widespread use in afforestation and reforestation in the tropics. Besides these equations, user can also type and later use his own sets of equations.

### Maps module

This module allows linking a map layer or a group of layers to a given Silvia project to render dynamically different kinds of maps in the Plantations and Simulation module: Plantation by age, query results and stand location. Silvia stores only the location of the original file(s) as well as rendering preferences, so that the user can continue using and editing the same files with other GIS applications.

Silvia recognizes several GIS layers formats such as raster images, Arc-View, Arc-Info, MrSid and AutoCad.

### Simulation module

This module uses the information stored in the plantations module to do the following tasks:

- Stand management profiles definition (a set of equations and management rules to simulate growth, management and productivity of stands).
- Generic growth tables generation using predefined stand management profiles.
- Growth tables generation for existing stands, based on predefined profiles and the last inventory data of the stand, including thinnings and final harvests.
- Inventory tables for a group of stands, including scheduled thinning and harvests with detailed estimated harvest volumes to be obtained.
- Yield tables at short and medium term for a group of stands or project(s), optionally including yields from additional planting plans.

User can define his own set of models to define detailed management plans for each stand or group of stands stored in the Plantations Module using a “wizard” or a management profile editor. These models can be based on empirical or theoretical growth models.

## Inventories module

This module is used to calculate temporary inventory plots to obtain mean data at stand level. These data can be stored in the Plantations module and then used by the system to feed models used to simulate a given stand with observed variables values.

## Financial module

Calculates mean costs of stand related labors as well as land expected values, annual percentage growth of land value and immature stand value, and suggest the optimum rotation length for any stand, based on management costs and price of products from thinnings and final harvests.

## APPLICATION

Silvia can be used for forest plantation projects design and for monitoring a broad variety of forest plantation projects in terms of project size, number and type of species, available growth models and management regimes. Silvia can also be used for interactive dynamic growth models development, detailed and general definition of management programs, from stand to project level, as well as for research and education.

## Plantations module

Plantations database includes all stands of one or more projects. Stands can be queried by species or geographical hierarchies defined by the user (i.e. province, land owner, compartment, block, etc). This database is updated automatically when new inventory data has been collected. Thus, the plantations manager has always the most updated data of the state of the plantation in the project (Figure 1). Data can also be queried graphically displaying species proportions or different variables as a function of age (Figure 2).

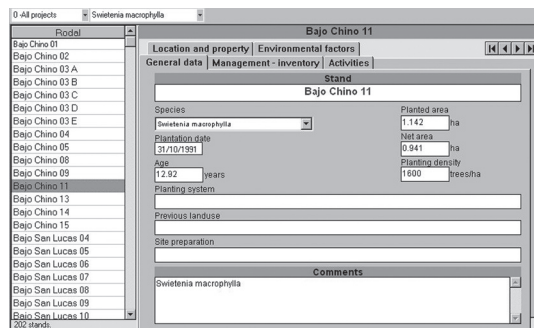


Figure 1. Stands window of the Plantations module

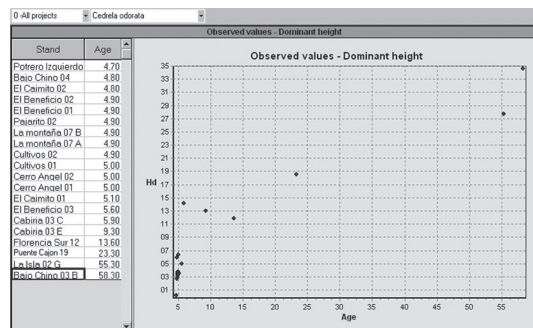


Figure 2. A graphical query showing dominant heights for all measured *Cedrela odorata* stands in database.

## Simulations module

In simulations module, user selects any stand to be simulated from the plantations database (Plantations Module). When user clicks a column in the results table, Silvia shows the corresponding graph and the model or equation used to simulate a given variable. First row in the results table is the last inventory data (shown in graphs as dots). The next rows are the simulated values of the variables. Rows in light blue are data of simulated thinnings (Figure 3). Future stocks can be simulated for the whole company or for any hierarchy defined by the user, such as a given species or plantation block (Figure 4).

## Maps module

Thematic maps are rendered by Silvia for any category of data in the plantations database (Figure 5).

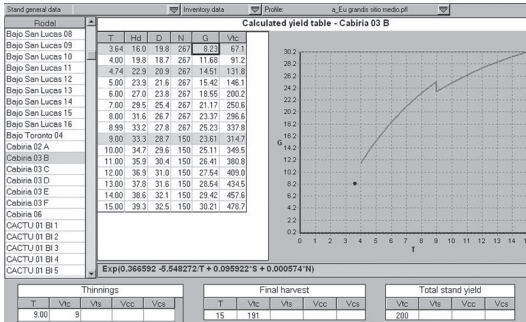


Figure 3. Growth table for *Eucalyptus grandis* in a mixed coffee-eucalyptus plantation at Turrialba, Costa Rica.

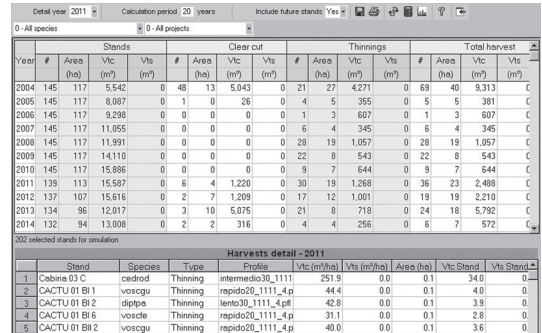


Figure 4. 20 years harvests and thinnings projection at project level

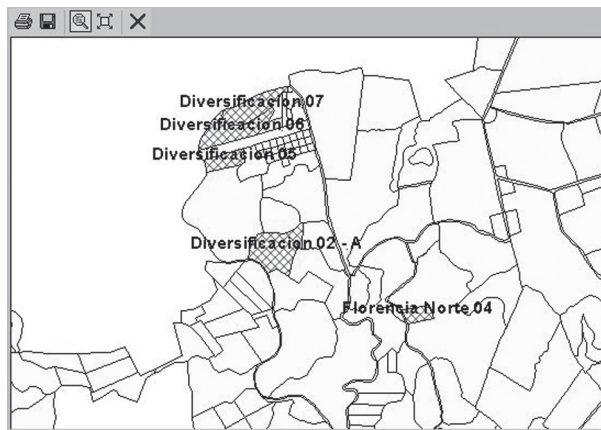


Figure 5. Location of *Swietenia macrophylla* stands at CATIE rendered by the maps module using the stands database.

### Financial module

Financial analysis of any stand or the whole enterprise is carried out in the Financial Module. The variables calculated are: maximum forest land value, maximum annual percentage growth of land value and optimum land expected value. These can be used to obtain the optimum financial rotation age (Figure 6).

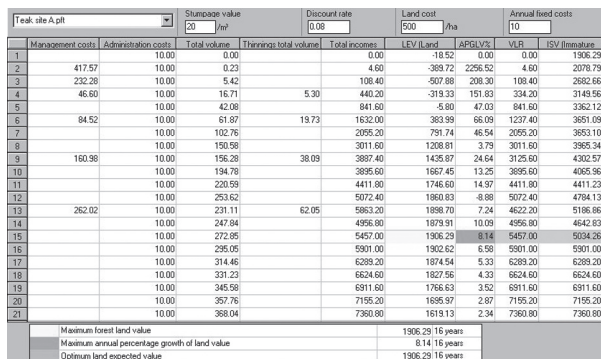


Figure 6. Profitability analysis for teak plantations at CATIE, Costa Rica.

The software has been tested with beta user representing different types of organizations/users, such as medium-sized forestry companies, cooperatives and small land owners with cattle-forest plantations and coffee-forest plantations mixtures. User feedback has been used to develop and improve the functionality of Silvia. There are currently more than one hundred users in more than twelve countries mainly in Latin America. For more information about Silvia, see the website at <http://www.catie.ac.cr/silvia>

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