SITE-SPECIFIC GROWTH AND YIELD SIMULATION FOR FAST GROWING EVEN-AGED STANDS

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ABSTRACT. —South Africa is blessed with a warm, temperate climate and this results in the fast growth of our timber species. Rotations range from 6 to 30 years, depending on the species and the final product. With these short rotation periods and the limited availability of land suitable for forestry, it is essential for forest managers to accurately predict the growth of the crop. The growth and yield simulator (GYS) is a software tool that addresses this need. Built on an ArcView® platform, the GYS accesses site variables from the spatial data base and with the input of silvicultural regimes from the user, it is able to predict all the growth variables necessary for decision making. The GYS runs on growth prediction coefficient sets, which are set up by the user to predict the growth of a particular species based on the rotation length and the site. The output of the GYS is shown on basic graphs, and various scenarios can be viewed on top of each other. The total output data set can be saved to a database, which in turn can be viewed and interpreted through ArcView®.

INTRODUCTION

South Africa is self-sufficient in wood and paper, but is destined to deplete its supplies by 2020 if its current rate of population growth does not decrease. South Africans already manage their plantations intensively, with rotations varying from 30 years for sawtimber down to as little as 6 years for pulpwood. Present management regimes are based on espacement experiments established as far back as 1930, and often these regimes are applied as a standard without any consideration to the site qualities. The development of GIS technology has enabled South Africans to incorporate soil, climate, and biotic factors to design and implement a site classification system specific to their timber species.

Only 2 percent of South Africa is suitable for afforestation, and this land is in short supply primarily because agriculture occurs in the same area. The key objective of the local forestry companies is to maximize the production from their current land holdings. This goal can only be achieved through a forest management system that incorporates site classification and district-specific growth and yield models.

THE SITE CLASSIFICATION SYSTEM

Site classification within the context of South African forestry is usually performed at a scale of 1:10,000. The term site is defined as a homogenous area that has a unique composition of climate, topography, geology, and soil type. Sites are often described as “areas of homogenous silvicultural practice.”

The most common characteristic from the site classification to be used in growth and yield prediction is site index. Site index is defined as the predicted height of a particular species for a given age, usually 20 years for sawtimber (SI_{20}). Actual tree growth data and site characteristics help determine site index equations for each of the major timber species. From these equations, site indices for each site are predicted. Figure 1 maps different site types across various compartments.

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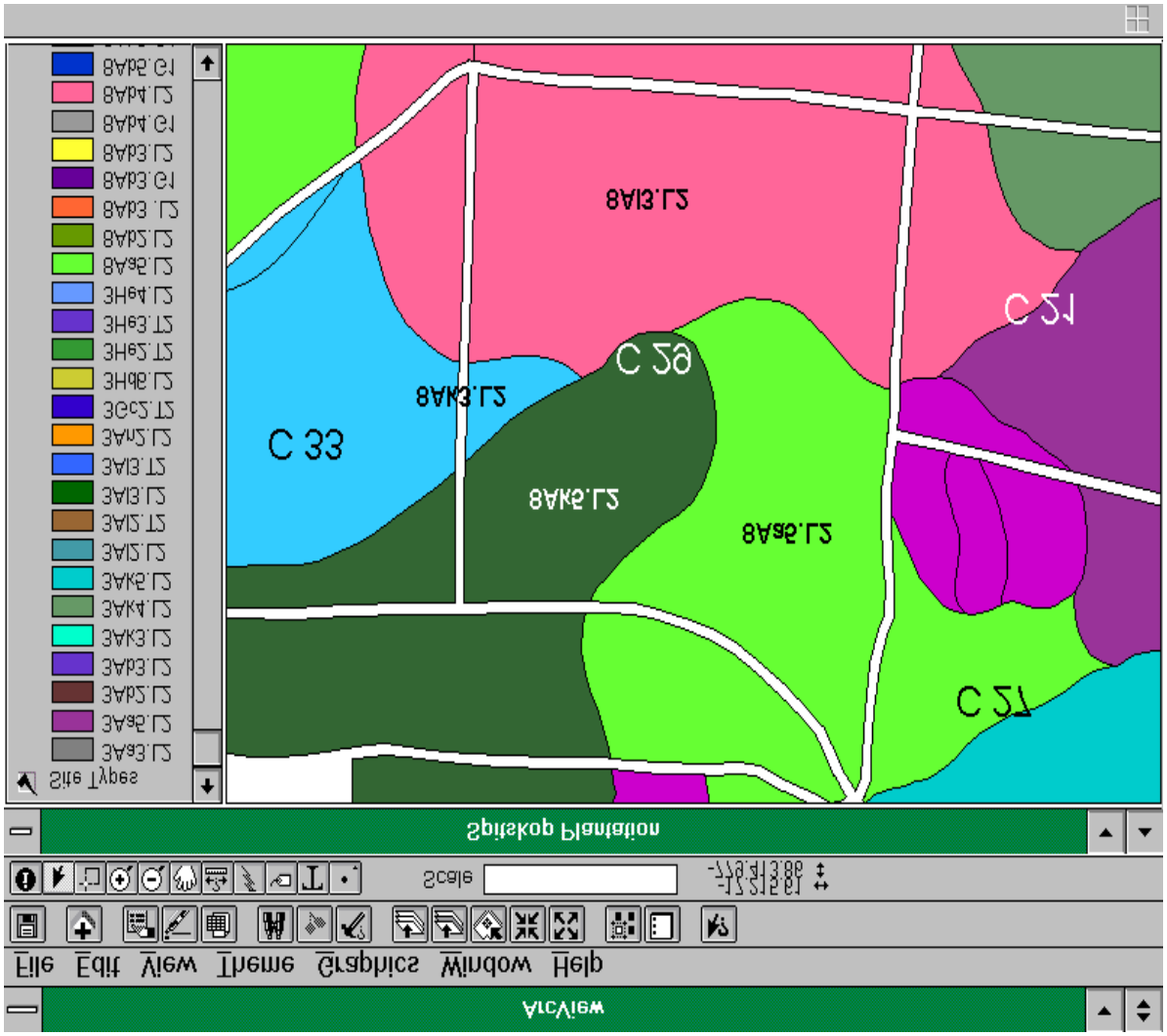

Figure 1.—Map of compartments and site types.

THE GROWTH AND YIELD SIMULATION

By viewing the plantation coverage, the forest manager can now select the compartment on which he wishes to perform the simulation. Once selected, the growth and yield simulator (GYS) can be accessed via a custom ArcView® interface. Figure 2 shows the beginning screen of the GYS.

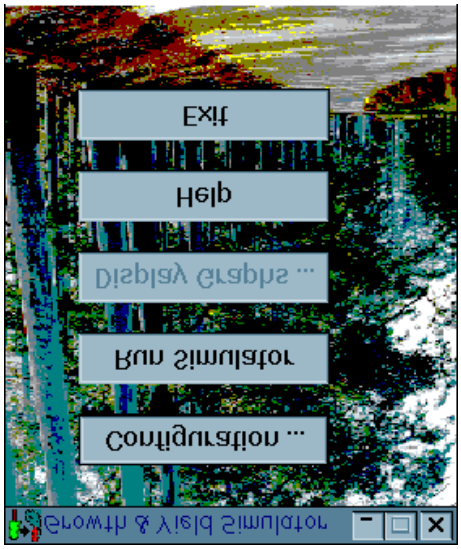

Figure 2.—The beginning screen of the GYS.

Various sections within the GYS require user input before the simulation can take place (Fig. 3). The user first needs to define which growth and yield model configuration is best representative of the area. Each coefficient set represents a particular species for a specific district. The choice of prediction method is associated with the coefficient set.

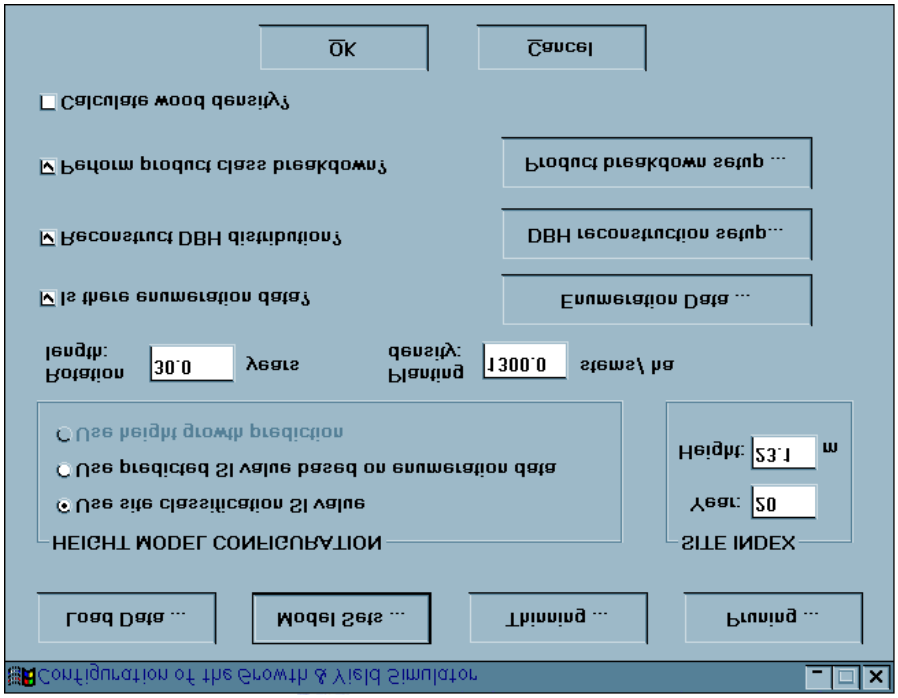

Figure 3.—Configuration screen of the GYS, where the user inputs information about the site type.

If the stand is to be grown on a sawtimber rotation, then thinning and pruning regimes need to be included. The thinning regime can be a function of either age, quadratic diameter, or relative spacing (Fig. 4).

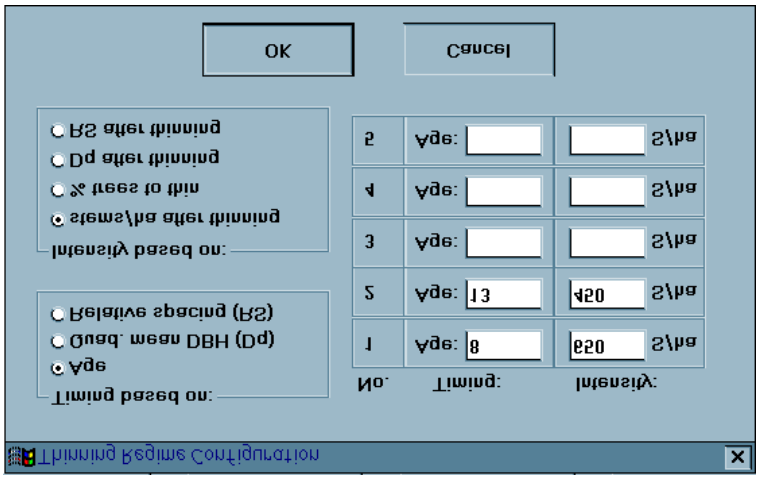

Figure 4.—The thinning regime configuration screen of the growth and yield simulator.

The pruning regime can be a function of either age or a limiting diameter. Further options include whether the user requires diameter at breast height (d.b.h.) distributions at thinnings and at clear-felling. If a financial analysis is to be carried out, then the d.b.h. distribution prediction is a necessity. Height growth prediction can be done two different ways. If there is enumeration data, the height measurement can be used for a projection of a future height, otherwise the site index can be used for prediction. Young stands or unplanted areas generally do not have enumeration data. If one selects the site index method, then the simulator reads in a weighted mean site index for the chosen species. Once the configuration is set, the program can be run.

Output from the program is presented in two ways. The first is a series of small graphs that indicate the growth trends of different variables, i.e., d.b.h. , height, volume, and basal area. The second method of presentation is output data saved as a dBase file that can be used later from ArcView®. The output scenario can be saved and after changes have been made to the original configuration, the new output can be viewed with the original scenario.

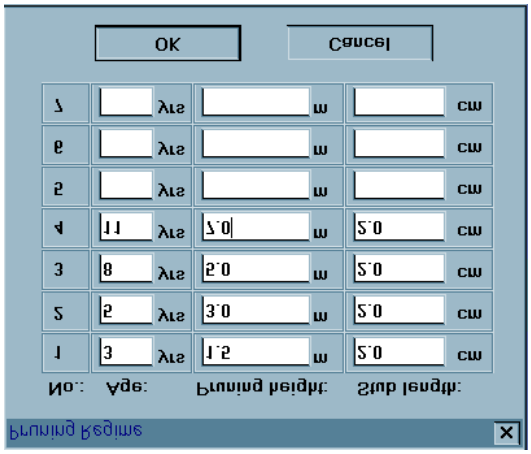

Figure 5.—The pruning regime configuration screen. The screen shows a regime that is a function of age.

AN EXAMPLE

Compartment C29 (Fig. 1) is to be planted for a softwood sawtimber market. It consists of four different site types, each of which have a site index for three species—*Pinus patula, P. taeda,* and *P. elliottii* (Table 1).

Table 1.—Compartment C29's four different site types with their areas, site indices for the three *Pinus* species, and the weighted average for the whole compartment

Site Type	Area	Site Indices		
		P. patula	*P. elliottii*	*P. taeda*
	ha	*- - - - - - meters at 20 years - - - - - -*		
8Aa5.L2	4.236	24.5	24.0	24.3
8Ak5.L2	2.740	24.7	24.2	24.4
8Al3.L2	6.122	21.5	22.2	20.9
8Ak3.L2	0.355	21.8	23.2	21.1
Total	13.453			
Average		23.1	23.2	22.7

The first run is done with *P. patula* as the species of choice. The coefficients are set for *P. patula* in the same area. The weighted average site index is 23.1. The age-based thinning regime is as follows:

- Established at 1,300 stems per hectare (spha),
- Thinning at 8 years to 650 spha,
- Thinning at 13 years to 450 spha, and
- Harvested at 30 years.

The pruning regime consists of four lifts and is also age related:

- 3 years: 1.5 meters,
- 5 years: 3.0 meters,
- 8 years: 5.0 meters, and
- 11 years: 7.0 meters.

Figure 6 shows the output of the run for the three species. The change in volume for every thinning can be seen.

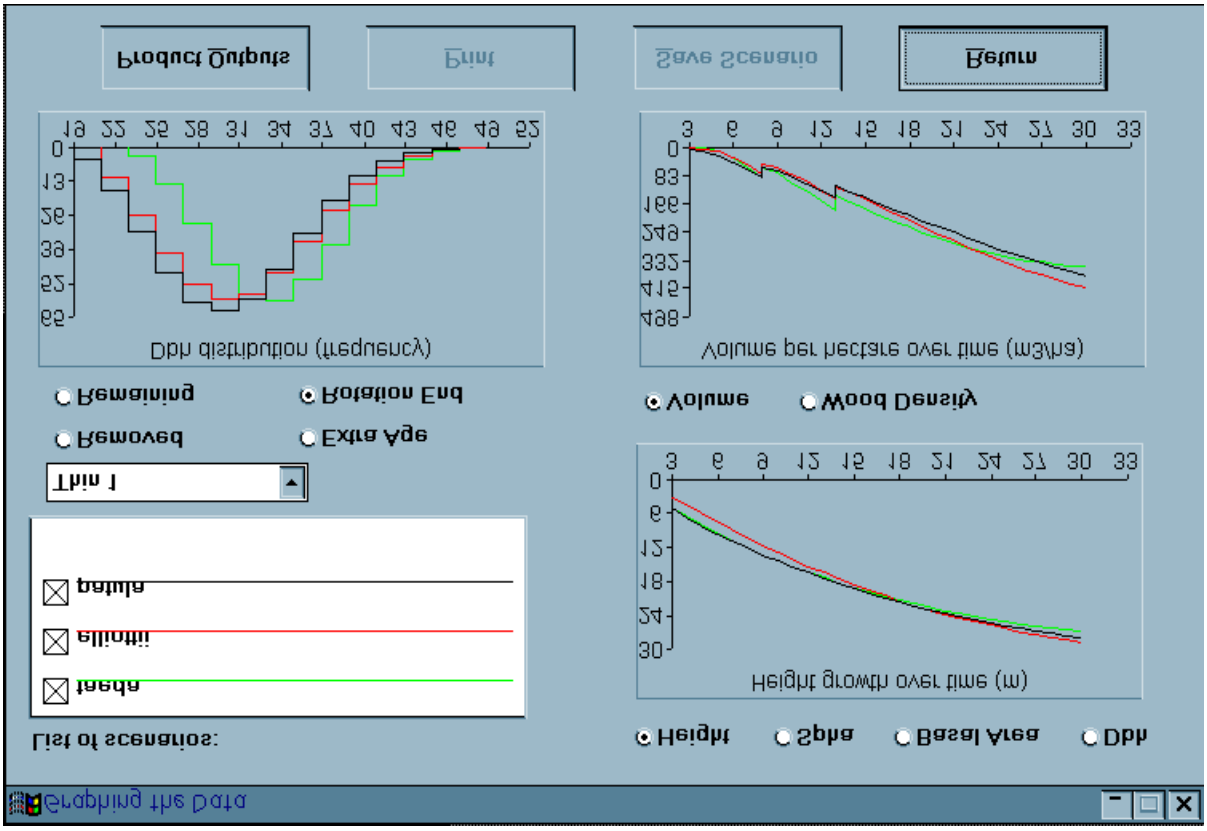

Figure 6.—Output of the GYS run for the three species in Compartment C29.

Runs for all the species are done, keeping the thinning and pruning regimes constant. The results from the growth and yield simulations are used to determine the Land Expectation Value (LEV) and the Net Present Value (NPV) for each of the species (Table 2).

Table 2.—The results of the growth and yield simulations in terms of utilizable volumes, Land Expectation Value (LEV), and Net Present Value (NPV) for the three different *Pinus* species

Species	Utilizable Volume	Terminal Value	LEV	NPV
	m^3/ha	- - - - - - - - - - *R/ha* - - - - - - - - -		
Pinus patula	311.85	79,178.18	4,088.02	8,393.09
Pinus elliottii	412.05	107,951.79	14,166.37	15,756.35
Pinus taeda	203.68	53,225.85	-4,654.73	1,979.20

R = Rand, the monetary unit of South Africa. May 1997 exchange rate: US$1.00 = R4.50

The first thing we notice in Table 2 is that the LEV for *Pinus taeda* is negative. This is relatively common within South African forestry because the value addition takes place during the timber processing procedure. Most of the forestry companies have vertical structuring (i.e., both the plantations and the processors are owned by the same company). Another reason for the negative values is the high nominal cost of capital at 3.36 percent due to the high inflation rate and the poor financial control exhibited within the country. Although the site indices for *P. patula* and *P. elliottii* are very similar, the differences in financial criteria are much larger. The reason for this is

the quality-based log grading system that benefits growers that adhere to a sound pruning practice that promotes the formation of knot-free timber.