Developments to the Sylvan Stand Structure Model to Describe Wood-Quality Changes in Southern Bottom-land Hardwood Forests Because of Forest Management

David R. Larsen and Ian R. Scott

ABSTRACT

GROWTH MODELS CAN PRODUCE A WEALTH of detailed information that is often very difficult to perceive because it is frequently presented either as summary tables, stand view or landscape view visualizations. We have developed new tools for use with the Sylvan model (Larsen 1994) that allow the analysis of wood-quality changes as a consequence of forest management. Sylview is a new computer program that allows users to visualize wood-quality characteristics of stands and individual trees within a stand. These include the effects of spacing and thinning on taper, branch size, and clear wood production.

KEYWORDS: Stand structure model, crown change, wood quality, silviculture

INTRODUCTION

The Sylvan Stand Structure model (Larsen 1991a, 1991b, 1994) was developed to allow foresters to study the development of specific stands of various species mixes based on empirical data from a subject stand and from forest stand dynamics principles. This model was developed after watching foresters try to make empirical forest-growth models fit a subject stand with species not included in the growth model or fit densities and forest structures not included in original data upon which the models were built. These foresters would try to force the model to work by substituting species or simply extrapolating the results. In Sylvan, two design criteria were adapted; first, basic stand dynamics principles guide the general function of all trees; and second, to make effective forest management decisions, the relative dynamics and the range of outcomes were more important than estimated volume or size. With these ideas in mind, Sylvan uses a 3-dimensional spatial pattern defined by stem maps and tree heights plus the crown size, defined by crown length and crown width, to provide the basis for predicting future stand structure.

THE SYLVAN S-PLUS/R DISPLAY

The programming for the original model was written in C programming language with a simple tree-list-in and tree-list-out approach. In the early 1990's a series of functions in S-plus language were used to provide graphical output. While these were just fine for research and publication, they were not very convenient for foresters to use.

SYLVAN DISPLAY PROGRAM

One early attempt to build a program to display the model output of the Sylvan Stand Structure model is the Sylvan Display program (Davison 1995). This program was written by a computer science masters student and had several design criteria, two of which were 1) the program should be cross platform (Unix, Window, Mac), and 2) it should have 2-dimensional and 3-dimenstional views, graphs, and tables of the model output. The student was successful in satisfying both of these criteria. One major limitation was the maturity of the windowing library used at the time.

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David R. Larsen (larsendr@missouri.edu) is a professor of quantitative silviculture and chair of the Department of Forestry-203 ABNR, The School of Natural Resources, University of Missouri-Columbia, Columbia, MO 65211, USA and **Ian R. Scott** is a software engineer at Silicon Navigator, 10050 N. Wolfe Rd Suite SW2-260, Cupertino, CA 95014, USA.

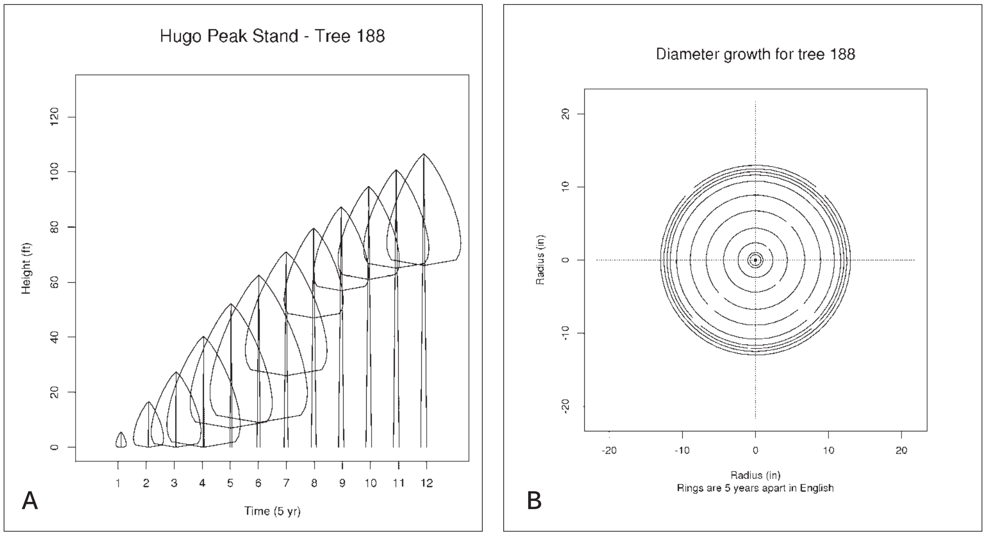


Figure 1— Typical output for a single tree from the Sylvan Stand Structure model using the Sylvan S-plus/R visualization tools. Figure 1a is an illustration of the tree profile at each time step of the model simulation. Figure 1b is a cross-section of the stem at breast height (1.37 m) rings are 5-year increments. Images from Larsen (1991a) are Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA.*

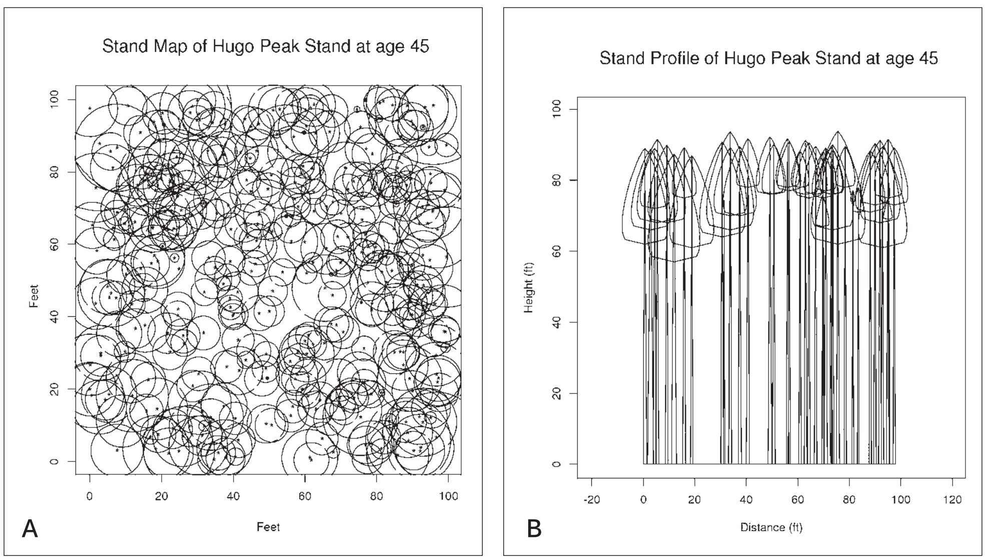


Figure 2— Typical output for a single tree from the Sylvan Stand Structure model using the Sylvan S-plus/R visualization tools. Figure 2a is a stand crown map at time step 9. Figure 2b is a stand profile at time step 9. Images from Larsen (1991) are Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA.*

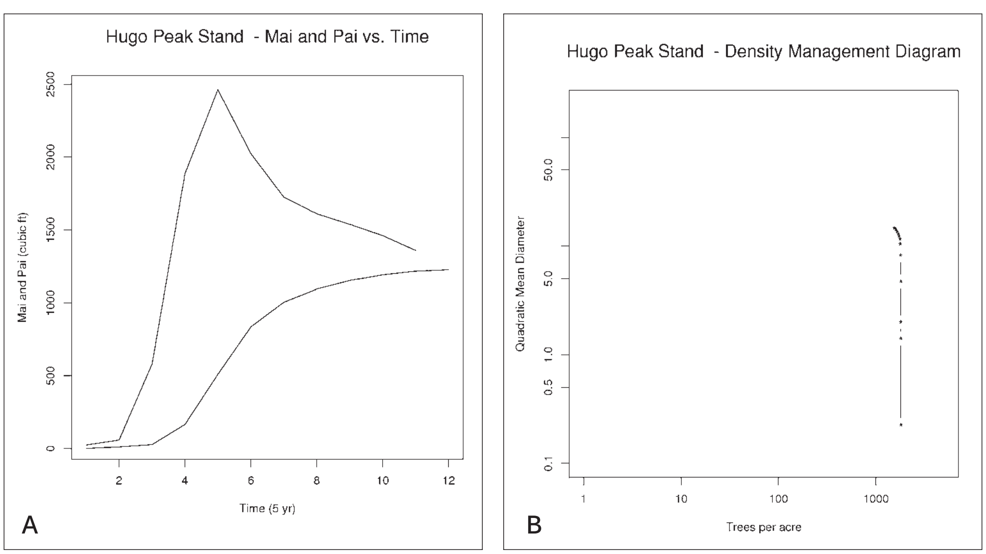


Figure 3— Density management diagram and mean annual increment (MAI) over periodic annual increment (PAI) curve for the modeled stand. Volumes are in cubic feet and quadratic mean diameters in inches. Images from Larsen (1991) are Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA.*

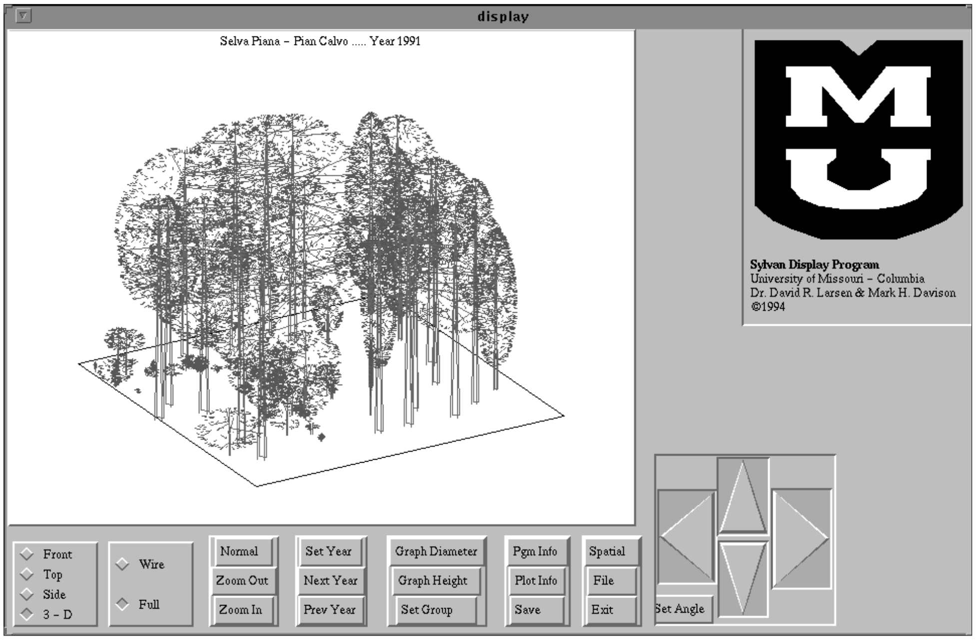


Figure 4 — An example of the Sylvan Display program (Davison 1995). The stand illustrated is European beech (Fagus sylvatica *L.) in Central Italy.*

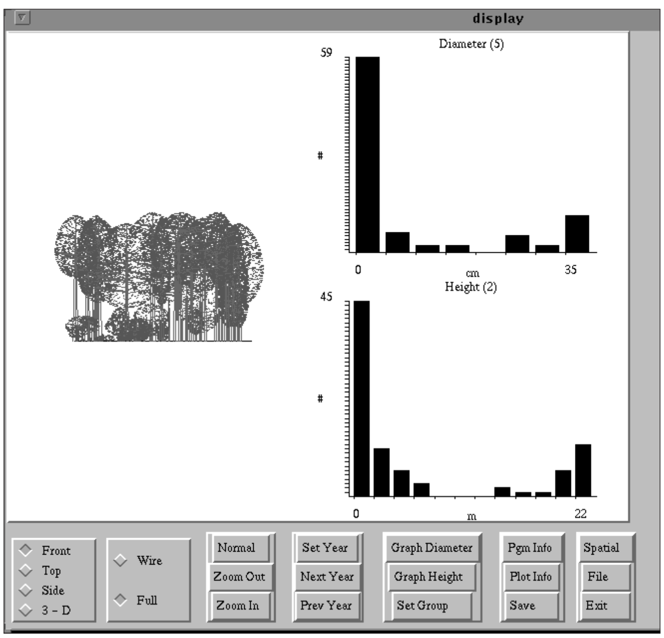


Figure 5— An example of the Sylvan Display program (Davison 1995). This view displays the diameter distribution and the height distribution. The stand illustrated is European beech (Fagus sylvatica *L.) in Central Italy.*

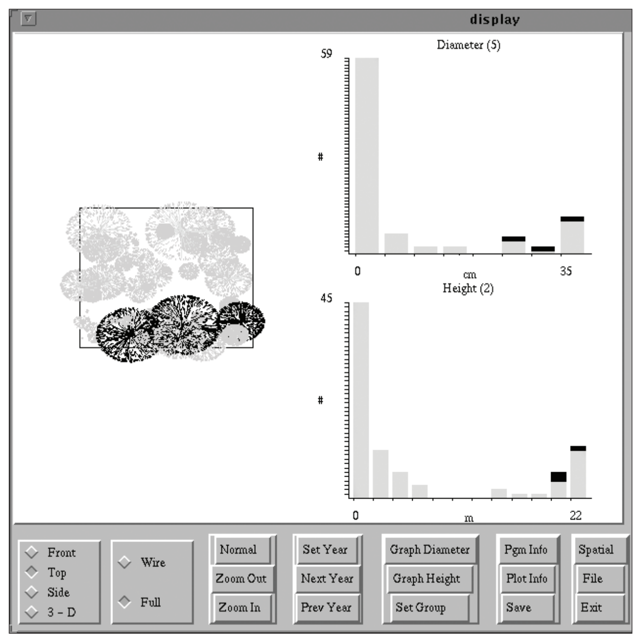


Figure 6— An example of the Sylvan Display program (Davison 1995). Trees selected for cutting are highlighted in black in both the stand map and the histograms of the size distributions, whereas residual trees are in light gray. The stand illustrated is European beech (Fagus sylvatica *L.) in Central Italy.*

STAND VISUALIZATION SYSTEM (SVS)

The Stand Visualization System (SVS) (McGaughey 1997) is a good stand-level visualization tool for the Windows operating system. In the initial phase of the recent Sylvan Stand Structure model development, SVS was considered our primary visualization tool. The Sylvan Stand Structure model has modules that produce SVS-ready files for visualization.

However, after using the program for some time, we recognized several areas for improvement in the SVS interface. While the 3-dimensional interface (see Figure 7) looks nice, we found it difficult to determine specific information about individual trees. A model output visualization tool should

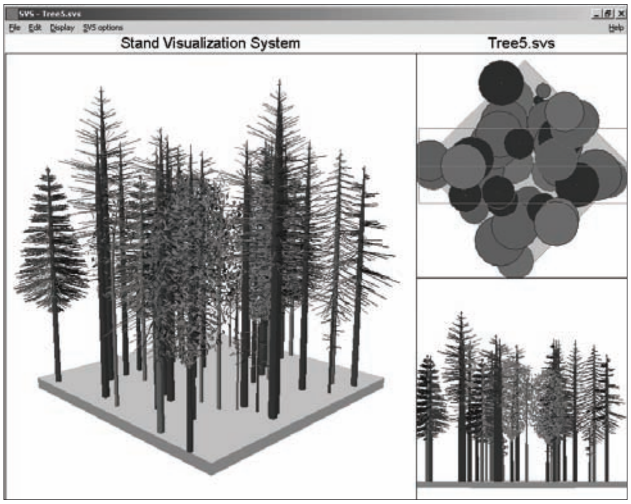


Figure 7— An example of the Stand Visualization System (SVS) program (McGaughey 1997). The stand illustrated is Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA*

be designed to convey information about the changes in tree dimensions and the interactions of neighboring trees.

Many components, while present in SVS, were not always in the most logical location for the user to access. For example, to change the display interface one must select "SVS Options", then "Screen Layout", then the desired screen configuration. This requires accessing a third-level menu item to accomplish a very common task (see Figure 8). Changing the perspective of the 3-dimensional view also required a pop-up window to set the viewing parameters requiring a multi-step process to change this view. Individual tree data is available in the interface, but requires entering the tree-marking interface and then selecting individual trees. All of these items are workable but not very convenient for the user to master.

We realized that there is a lot of information available in the Sylvan tree list that is not utilized by the SVS program. Additionally, the Sylvan Stand Structure model's main development platform is Linux and some team members were also using MacOS. We decided to create a new visualization tool, Sylview. The design criteria for this program are detailed in the following section.

SYLVIEW

The Sylview program was designed to be a stand-level visualization tool used to examine the output of the Sylvan Stand Structure model and allow the user to grasp the stand dynamics principles that are built into the Model. It was designed so that the viewer could fully utilize avail-

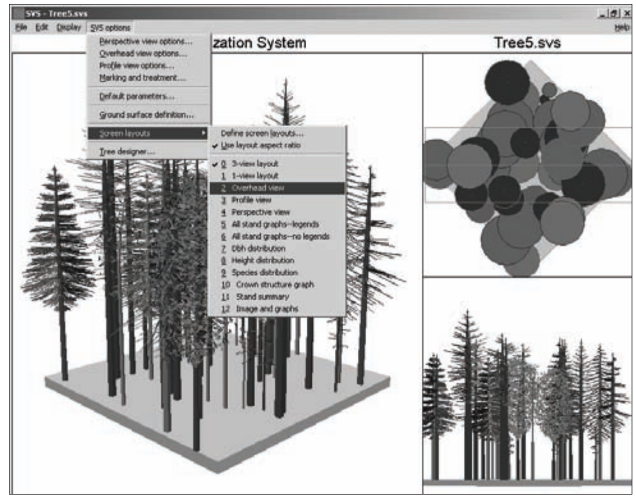


Figure 8— An example of the Stand Visualization System (SVS) program (McGaughey 1997). This image illustrates the multiple menus used to change the screen layout. The stand illustrated is Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA.*

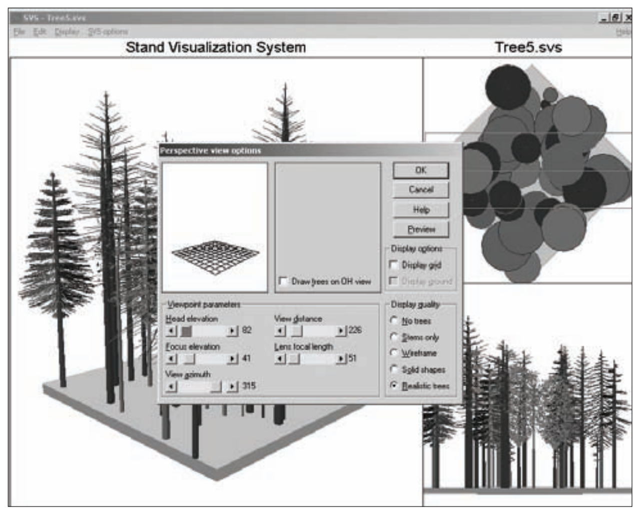


Figure 9—An example of the Stand Visualization System (SVS) program (McGaughey 1997). This screen allows the user to change the 3-dimensional perspective for the 3-dimensional view seen under the pop-up window. The stand illustrated is Douglas-fir (Pseudotsuga menziesii *(Mirbel) Franco) from western Washington USA*

able information within the tree list, information which illustrates tree interactions likely to occur during stand development. The following design criteria for the Sylview software were established:

Practical Considerations

- It should present a plot of trees in map and profile views
- It should be very easy to see tree growth through time, both individually and collectively

- The user should be able to inspect the internal wood character of each tree

Technical Considerations

- It should work on multiple platforms (Linux, Windows, MacOS)
- It should relay 2-dimensional vector graphics for easy-to-understand views with smooth screen and print display

In Practice

- It is written in C++ language with the Qt cross-platform application framework
- It uses the Sylvan C++ libraries to allow common file format and access to the Sylvan functions

We Also Followed the Following Principles:

- Principle of least surprise—the user should not be surprised by the results of his or her actions. For example, if a user points to a tree object, then the user should get more information about that object.
- Intuitively obvious—the function of an object should be what the user expects.

Because we were calculating the internal character of the wood we used profile or taper equations to predict the diameter of the stem at any given height. These taper equations must be sensitive to crown dimensions to appropriately illustrate change in the internal structure of the stem as it is influenced by stand density and crown competition. All depictions of a tree's vertical profile in Sylview are drawn with correctly scaled taper equations. The equations in the current version are based on the method of Walters and Hann (1986). The predicted wood-quality zones are based on the relationship of the wood to the crown at the time of wood formation.

In the Sylvan Stand Structure model we want users to be able to learn about the relationship of tree competition (in both species and density) and crown size to the resultant wood formed in the tree. Additionally, we would like this model to be easily adapted to different tree species in different places in the world. To accomplish this, the model can be parameterized using data collected in the plot to be simulated.

Currently, there is a set of R functions that are used to accomplish this task. They are cumbersome and require a large number of steps to confirm that the parameters are appropriate and reasonable. We are in the early stages of developing an additional module that will process users' plot data and produce a valid parameter file with statistical feedback on the nature of the selected parameters.

We feel that the Sylview program allows a user to examine model output at a level of interactivity that was difficult until now. The design of Sylview was also focused on visualizing data in a manner that provides users with clear information about the stand they are studying. We opted for graphical forms that convey information versus images that present

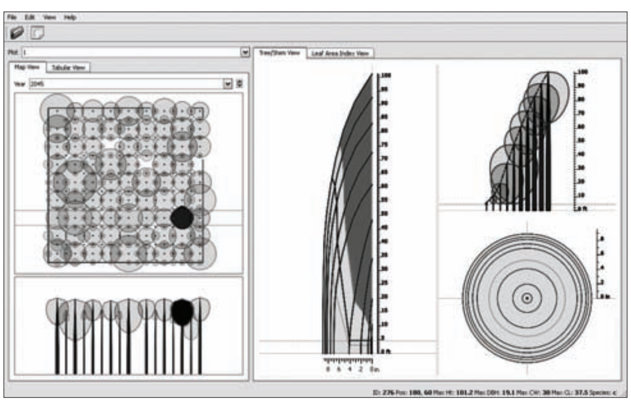


*Figure 10— An example of the Sylview Program (Scott 2006). The stand illustrated is cherrybark oak (*Quercus pagoda *Raf.)-sweetgum (*Liquidambar styraciflua *L.) from Mississippi, USA. This is a one-acre plot plantation with alternating species in both directions. The profile view displays the trees in the grey horizontal box in the map view. The highlighted tree in black at left is also displayed at right showing internal wood structure, individual tree crown over time, and the stem cross-section. Also note that the tree-list data are displayed in the status bar at the bottom of the screen. This screen was captured under the Windows XP operating system.*

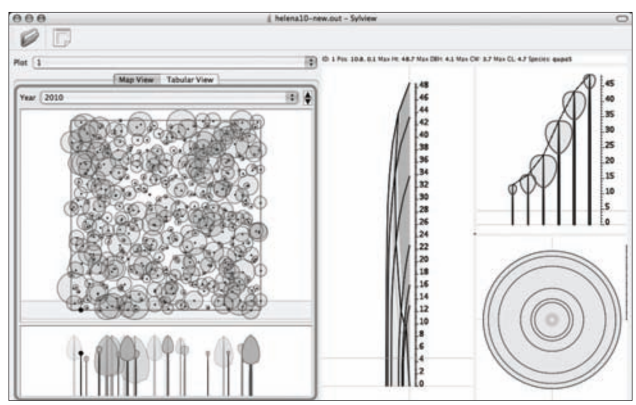


*Figure 11— An example of the Sylview Program (Scott 2006). The stand illustrated is cherrybark oak (*Quercus pagoda *Raf.)-sycamore (*Platanus occidentalis *L.) from Arkansas, USA. This is a one-acre plot natural stand. The profile view displays the trees in the grey horizontal box in the map view. The highlighted tree in black at left is also displayed at right showing internal wood structure, individual tree crown over time, and the stem cross-section. The screen was running on the MacOS.*

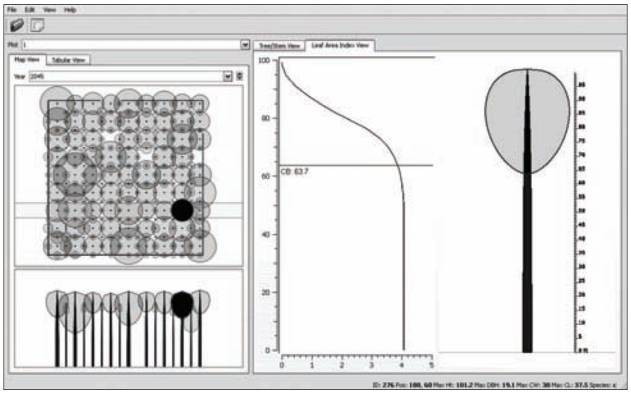


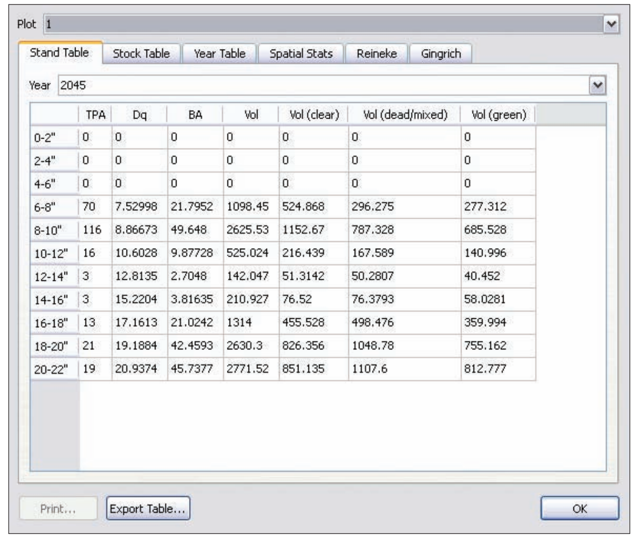
Figure 12— An example of the Sylview Program (Scott 2006). The stand illustrated is cherrybark oak (Quercus pagoda *Raf.*)*-sweetgum* (Liquidambar styraciflua *L.*) *from Mississippi, USA. This is a one-acre plot plantation with alternating species in both directions. The profile view displays the trees in the grey horizontal box in the map view. The highlighted tree in black at left is also displayed at right showing vertical cumulative leaf area index from the top of the stand to the neighbor trees of the selected tree. This information is used in the crown base change function.*

confusing visuals. We tried to make the software intuitive and easy to use, with a lot information available and few hidden menus to navigate. The submenus are typically software-preference dialogs and are seldom changed.

In our attempts to covey information we have provided model results using both traditional and innovative methods. Some of our traditional outputs include stand tables (stand statistics by diameter class), stock tables (stand statistics by species), and changes in the spatial statistics/density management diagrams (both Reineke and Gingrich). Figures 8 and 9 illustrate this type of output. Please note that the stand and stock tables also report the volume in clear wood, mixed knot wood, and green wood. These zones are specified by the relationship of the ring of wood to the tree's crown at the time of wood formation.

CONCLUSIONS

The Sylview program is one program in the set of programs called the Sylvan Stand Structure model. It is a vital component allowing users to fully appreciate the complex stand-development simulation data generated by the other programs. It allows users to comprehend the relationship of crown size and stand density to wood quality and stem shape. We have several new components planned for Sylview including the addition of branch size and number predictions based of the work of Oswalt (2007). We also plan to develop a log-sort table that will break the trees in the stand into logs of various wood characteristics. The current version of Sylview also includes a method to conduct stand treatments in the user interface. However, this component was not implemented at the time of the meeting.



Plot 1

Stand Table | Stock Table | Year Table | Spatial Stats | Reineke | Gingrich

Year 2045

	TPA	Dq	BA	Vol	Vol (clear)	Vol (dead/mixed)	Vol (green)
0-2"	0	0	0	0	0	0	0
2-4"	0	0	0	0	0	0	0
4-6"	0	0	0	0	0	0	0
6-8"	70	7.52998	21.7952	1098.45	524.868	296.275	277.312
8-10"	116	8.86673	49.648	2625.53	1152.67	787.328	685.528
10-12"	16	10.6028	9.87728	525.024	216.439	167.589	140.996
12-14"	3	12.8135	2.7048	142.047	51.3142	50.2807	40.452
14-16"	3	15.2204	3.81635	210.927	76.52	76.3793	58.0281
16-18"	13	17.1613	21.0242	1314	455.528	498.476	359.994
18-20"	21	19.1884	42.4593	2630.3	826.356	1048.78	755.162
20-22"	19	20.9374	45.7377	2771.52	851.135	1107.6	812.777

Print... | Export Table... | OK

Figure 13— An example of the Sylview Program (Scott 2006). The stand illustrated is cherrybark oak (Quercus pagoda *Raf.*)*-sweetgum* (Liquidambar styraciflua *L.*) *from Mississippi, USA. This window is a standard stand table (average statistics by diameter class). Units are Dq in inches, BA in square feet per acre, and volume in cubic feet per acre. This table also provides the volume of clear wood, mixed knot wood, and green knot wood.*

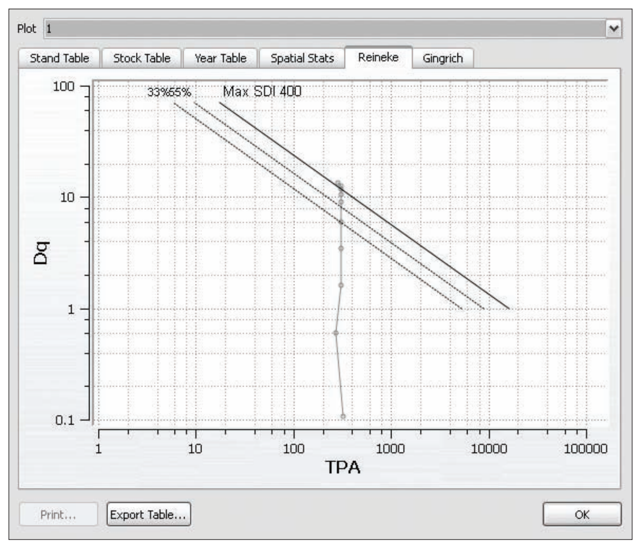


Figure 14— An example of the Sylview Program (Scott 2006). The stand illustrated is cherrybark oak (Quercus pagoda *Raf.*)*-sweetgum* (Liquidambar styraciflua *L.*) *from Mississippi, USA. This is a standard density-management diagram of the model's data from this plot.*

ACKNOWLEDGEMENTS

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