3D Coppice Poplar Canopy Architecture (3D-CPCA)

3D Coppice Poplar Canopy Architecture (3D-CPCA)

A new biometric methodology, measuring the three-dimensional architecture of fast-growing SRC, has been developed by E. Casella at Forest Research and H.Sinoquet of Intitut National de la Recherche Agrinomique(INRA) -Université Blaise Pascal, France.

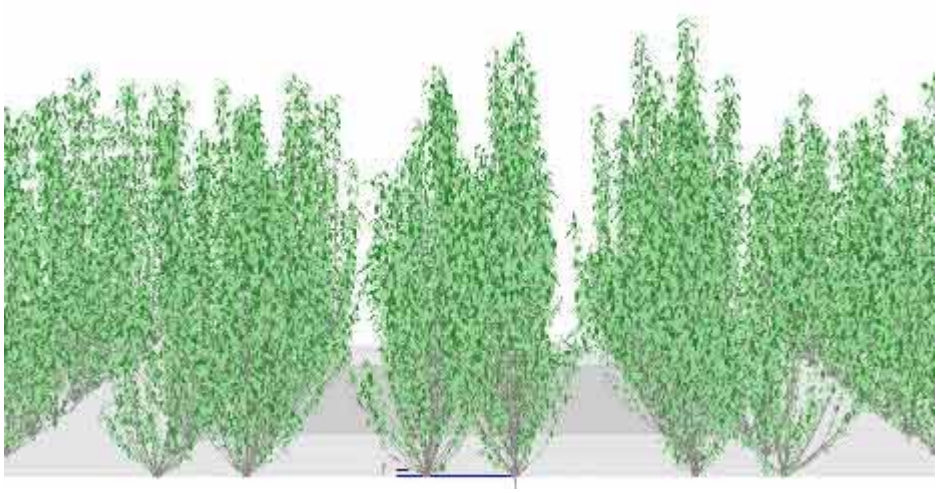
The methodology is used to describe 2-year-old poplar varieties during the 2nd rotation, and create the 3-Dimensional Coppice Poplar Canopy Architecture model (3-D CPCA). To account for expressions of genetic variability observed within this species, the method has been applied to two varieties (*Trichobel* and *Ghoy*) showing differences in:

- growth potential
- leaf morphology
- coppice and canopy structure.

Example Model Representations

Figure 1.
Examples of a virtual 2-year-old poplar crop image, computer-generated by the POV-Ray™ software for poplar variety Trichobel in May 2001.

- Crop canopies, consisting of 100 plants each, are viewed from the South to the North.
- Axes lengths represent 1 m.



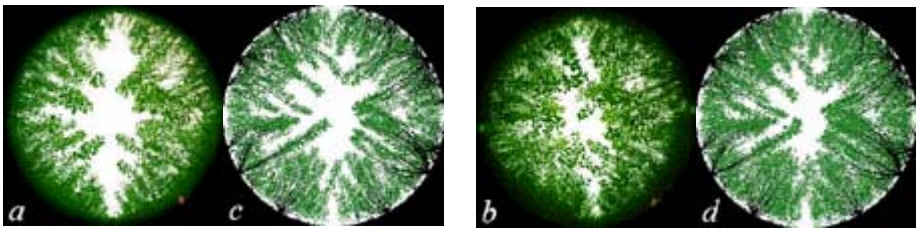
The empirical functions form the basis for the 3D CPCA model that recreates the 3-D architecture and canopy structure of fast-growing coppice crops at the plot scale.

This view shows that the model is capable of generating a convincing representation of a stand of poplar, using empirical functions.

Figure 2.
Examples of visual comparisons between hemispherical 'fisheye' photographs and computer-generated fisheye images:

- photographs: *a* (June) and *b* (September)
- computer-generated: *c* (June) and *d* (September).

From the 3-D CPCA model outputs by the POV-Ray™ software for poplar variety Ghoy. Crop canopies consist of 100 plants each.



The model provides fisheye images (*a*-*d*) using the ray tracing software POV-Ray™ that are used to assess model outputs through visual and quantitative comparisons between actual photographs of the coppice crop and simulated images. The figure shows that the modelled hemispherical view shows a very similar degree of canopy openness to the real hemispherical photograph. The figures also show the model accurately represents the increased canopy closure from June to September.

Methodology

The method operates at the stool level and describes the plant as a collection of functional units:

- axes (shoots and branches)
- growth units (shoots, branches, petioles and leaves)
- internodes

Branching and connection between the plant units (plant topology) and their spatial location, orientation, size and shape (plant geometry) describe the plant architecture.

The methodology has been used to describe the plant architecture of 15 stools per variety over a five month-period. On individual stools, shoots have been selected from three classes spanning the diameter distribution range:

- small
- medium
- large

At the shoot level empirical allometric relationships and distribution functions have been developed to parameterise and/or explain functional units of the plant, topological relationships and geometry (for example, distribution of shoot diameters, shoot attributes from shoot diameter).

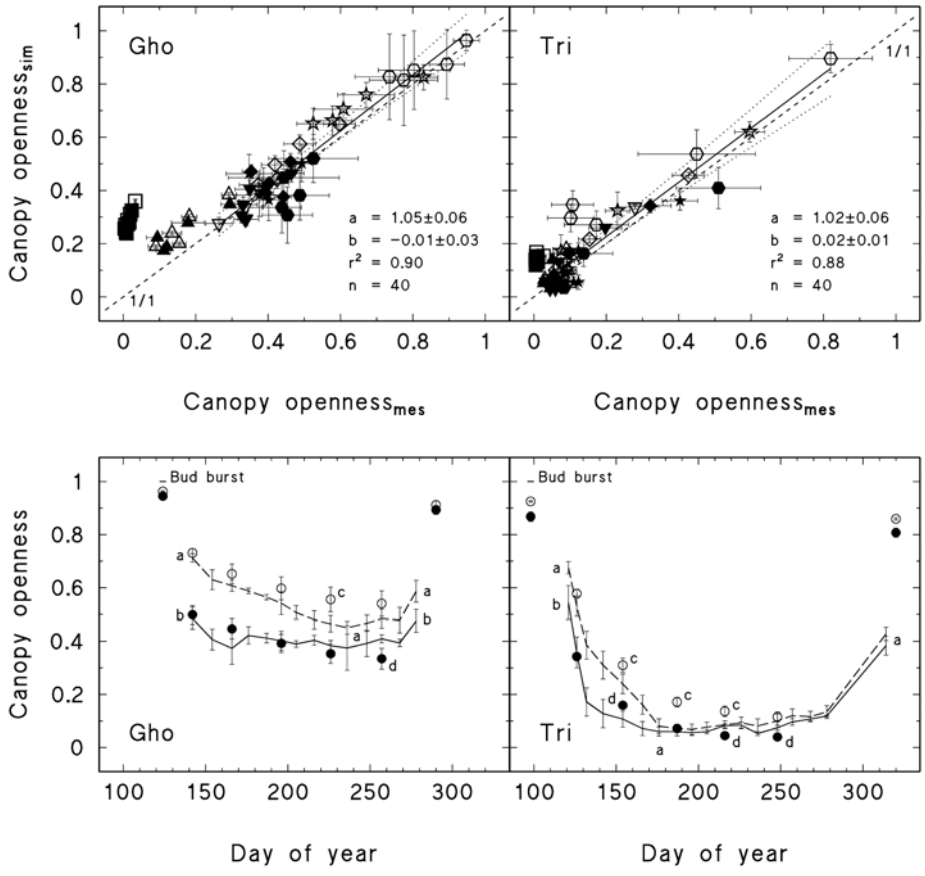
Predictive Ability

Figure 3.
Comparison between measured (mes) and simulated (sim) canopy openness over:

- over six sky-map zenith divisions (hexagon = 0–15° star = 15–30° diamond = 30–45° inverted triangle = 45–60° triangle = 60–75° and square = 75–90°)
- 2001 growing season
- temporal course of the canopies openness (lines = measured and symbols = simulated) for poplar varieties Ghoy (Gho, left-hand column) and Trichobel (Tri, right-hand column).

Notes about the graphs:

- Open and closed symbols show the differences for between- and inside-row locations, respectively.
- Vertical and horizontal bars indicate the standard deviation of the mean (n = 5 or 10 for the inside- or between-row location, respectively).
- Letters indicate significant differences (t-test, P<0.05) between row locations and results obtained from field measurements and the modelling process.
- Relationships canopy $openness_{sim}$ vs. canopy $openness_{mes}$ were fit, for four zenith angles (0–60°), to the following linear regression: y = a(+/-SD)x+b(+/-SD).
- The dotted lines depict the confidence interval of the regression at P<0.05.



Overall, results indicate a good predictive ability of the 3-D CPCA model (Figure 3), with the model picking up the trends of the canopy openness very well, though the graphs show that the model tends to over-predict canopy openness when the measured canopy openness is small (up to about 20% measured canopy openness for *Ghoy*, and 10% for *Trichobel*).