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Forest and Wood Products Research and Development Corporation

Plantation Yield Regulation System PLYRS:
A Computer Based System to Assist in the Management of *Pinus radiata* Plantations

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Plantation Yield Regulation System PLYRS: A Computer Based System to Assist in the Management of *Pinus radiata* Plantations

Prepared for the

**Forest & Wood Products
Research & Development Corporation**

by

I. Wild, M. Strandgard and D. Chong

1. Project Summary

The Information Technology for Forest Management Group of the School of Resource Management, The University of Melbourne has completed the development of the *"Pinus radiata Plantation Yield Regulation System (PLYRS)"*. The project was sponsored by the South Australian Cooperative of Auspine Limited, Green Triangle Forest Products (GTFP), ForestrySA and the Forest and Wood Products Research and Development Corporation (FWPRDC).

PLYRS is a modern, integrated forest management and yield prediction system that assists users in managing their plantation estate. Its primary function is to assist plantation managers in the preparation of detailed harvesting plans that are consistent with an organisation's long term management goals and commitments.

PLYRS allows users to rapidly evaluate the effect of applying various silvicultural treatments and harvesting plans on the wood and cash flows from a selected area of plantation. Harvesting plans can be fine tuned to meet market demands for specific products and/or specific periods of time and identify potential short falls or surplus product volumes. Thus the system can be used to minimise risk and to maximise the returns from a plantation within the constraints of commitments and resource availability.

PLYRS has been designed to form the basis of a system that can be adapted to the management of a range of plantation species through the implementation of appropriate biometric functions. The system has been developed in a Visual Basic – Access environment and runs on standard PC's running Windows 95/98, Windows 2000 or NT.

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2.   Project Objectives and Achievements

The objectives of the project, as documented in the Research Agreement between the three sponsoring organisations and the FWPRDC, and the extent to which they have been addressed are summarised below:

Objective 1:   *To develop within three years a growth and yield prediction system for plantations that will estimate the current and future wood available to industry to allow optimum resource planning.*

PLYRS enables users to predict wood availabilities from part or all of their plantation resource. As such, PLYRS can be used to assist in the preparation of long term plans to meet commitments as well as short term plans to meet fluctuations in market demands. Shortfalls in supply and/or product volumes surplus to commitments can be identified well in advance, providing time to negotiate other options and thus assisting to minimise risk. The basic concepts and components of PLYRS are discussed in detail in section 3.

The time taken to develop PLYRS exceeded three years for a range of reasons that are outlined in section 5.

Objective 2:   *To develop a cooperative yield regulation system and yield models in the Green Triangle Region to promote, through cooperation, regional coordination and efficient use of technical resources.*

A cooperative was formed between Auspine Limited, GTFP and ForestrySA, three major plantation growers within the Green Triangle Region, to sponsor the development of PLYRS. Each organisation brought with it their existing systems, biometry and other related work practises that were built into PLYRS. This cooperative development approach has enabled the sponsors to cost-effectively replace their existing systems with a more up to date, flexible system. This approach will also decrease the cost to each organisation of maintenance and further development and enhancement of PLYRS.

Objective 3:   *To develop a system, incorporating new technologies, to allow the evaluation of alternative silvicultural and marketing strategies for plantations.*

PLYRS has been developed to allow users to rapidly evaluate the effect of applying various silvicultural practices and harvesting regimes on the wood and cash flows from a selected area of plantation.

PLYRS was developed utilising modern desktop computing technology. Specifically, PLYRS:
- Was written using the Visual Basic programming language and the ACCESS DBMS,
- Incorporates a familiar and easy to use "Windows" style user interface,
- Takes advantage of modern computing hardware,

- Interfaces with current presentation packages for flexibility and ease of reporting, and
- Uses "state of the art" data modelling structures.

Furthermore, PLYRS utilises the latest biometry available for the Green Triangle Region and is structured such that new biometry can be easily implemented provided it conforms to the current SA biometric and mensuration format.

<u>Objective 4</u>:   *To develop a research based centre of excellence at The University of Melbourne to foster national expertise in forest management through education and the provision of goods and services to industry.*

To facilitate the development of PLYRS, The University of Melbourne established the Information Technology for Forest Management Program.

All program members are acknowledged specialists with collectively greater than 50 years expertise in the areas of:
- Forest inventory and yield regulation, and
- The development and implementation of forest resources databases and information technology for:
  - Spatial and inventory data,
  - Field data capture systems, and
  - Plantation management systems.

The program is aligned with the long-term vision of the Institute of Land and Food Resources, The University of Melbourne and the Forest Science Centre. There is a firm commitment by the University and the Forest Science Centre for the continuation of the program, given sufficient funding.

3.   Research results and achievements

3.1. Basic Concepts

PLYRS is a modern, integrated plantation management and yield prediction system that assists users to manage their plantation. PLYRS allows users to:

- Examine the consequences of a range of silvicultural and management alternatives and hence make comparisons to identify the better alternative.
- Schedule wood flows to meet commitments over both the short term and long term planning horizons.
- Perform detailed operations planning and management using "current day" estimates of expected yields on a stand by stand basis.
- Simulate available wood and cash flows for land purchase proposals.
- Conduct a full financial analysis of each simulation run.
- Carry out forest valuation and/or land expectation value analysis.

PLYRS is flexible, easy to use and non-prescriptive in its operation, thus allowing plantation managers to use PLYRS in the way that best suits them and their organisation's work practices.

PLYRS was written using Microsoft Visual Basic and Microsoft Access. The system runs on standard Intel compatible personal computers running Microsoft Windows operating platforms. The structure of the system is such that future developments can be added relatively simply by either developing the underlying database and/or developing new component modules.

PLYRS readily interfaces with industry standard databases, and thereby allows an organisation to use its current resources database whether it is spatial (GIS based) or non-spatial. Spatial resource databases can be used to view the spatial impact of PLYRS outputs. The primary reason for this approach is to provide organisations with the flexibility to use whatever GIS package they desire and/or change packages as the need may arise.

The following sections describe the major concepts on which PLYRS is based.

3.1.1. *The Forest Resource*

The basic entity used to describe the plantation resource within PLYRS is the Resource Area. A Resource Area is homogeneous in terms of administrative boundaries, site characteristics and operational history.

Operations Units are a logical grouping of Resource Areas for the purposes of applying a common schedule and/or management regime. They may or may not be contiguous and they must consist of 1 or more whole Resource Areas. Examples may be a collection of compartments all planted in the same year or may simply be a single compartment. Resource Areas forming an Operations Unit do not necessarily share the same operational history.

Resource Areas and Operations Units in PLYRS can be linked back to their spatial equivalents in the organisation's GIS for spatial display and analysis of operations.

3.1.2. *Management Strategy*

A management strategy expresses how an area is to be managed to meet organisational objectives. Plantation managers can tailor individual strategies for each Operations Unit, apply generic strategies to groups of Operations Units, or apply a combination of these approaches. Management strategies have been implemented in PLYRS using schedules and regimes (described below), each of which consists of a series of events.

3.1.2.1. Events

Events are defined as any operation or activity that may occur within or to a plantation that has an impact on its stocking and structure, growth, yields and financial returns. Logically, events are categorised into four groups:

- Area – events that alter the area available for commercial timber production – ie land purchase.
- Stocking – events that affect the stocking – ie planting, harvesting, mortality.
- Productivity – events that alter a stand's productivity or Site Quality – ie weedicide, fertilising.
- Managerial – events that only affect the economics of commercial timber production – ie fire protection, assessment.

Events may have already occurred (history) in which case they are taken into account to modify future growth, yield and cost, or may be scheduled and, when processed during simulation will also modify future growth, yield and cost. An event's attributes (parameters) control how it is to be simulated. Examples of event attributes include residual stocking and extraction row (out row) frequency for thinning events.

3.1.2.2. Operational History, Schedules and Regimes

PLYRS groups events into Operational History (past events), Schedules (scheduled events) and Regimes (event templates). Central to the operation of PLYRS is the ability to dynamically link operational history, a schedule and a management regime during the simulation of an Operations Unit or group of Operations Units.

Operational History
Operational history is defined as a sequence of events that have already occurred. Each event is defined by its attributes (parameters) and the date that it occurred. Operational history is recorded against Resource Areas.

Schedules
Similarly, schedules are defined as a sequence of events, but in this case each event is defined by its attributes (parameters) and the date that it is planned to occur. A schedule can be either approved or proposed:
- Approved schedules basically form the organisation's approved operations plan (including the cutting schedule). Events will occur when nominated unless management actively brings forward or postpones the event.
- Proposed schedules are a sequence of events used to test a management option being proposed by the forest planner.

Regimes
Regimes are defined as a sequence of events whose timing is set relative to previous events (ie at an age rather than a date). Two subtypes of regime are recognised:
- SA-Regime. The SA-Regime is specific to the South–East of South Australia. It is tailored to the silviculture practised in the region and the timing of thinning events is based on the average site quality for the logging category or Operations Unit which in turn is calculated from the nominated but fixed rotation age
- User defined Regime. User has full control over event attributes and timing.

Regimes are used by PLYRS as a template to generate schedules. Regimes are linked to the last scheduled event, or last operational history event if there are no scheduled events. Figure 1 demonstrates the relationship between Operational History, Schedules and Regimes. In the example, three Resource Areas (two planted in 1990,

one in 1991) have been combined into the one Operations Unit. The Operations Unit has a first thinning scheduled in 2004. The assigned regime has linked on the scheduled first thinning and created second and third thinnings.
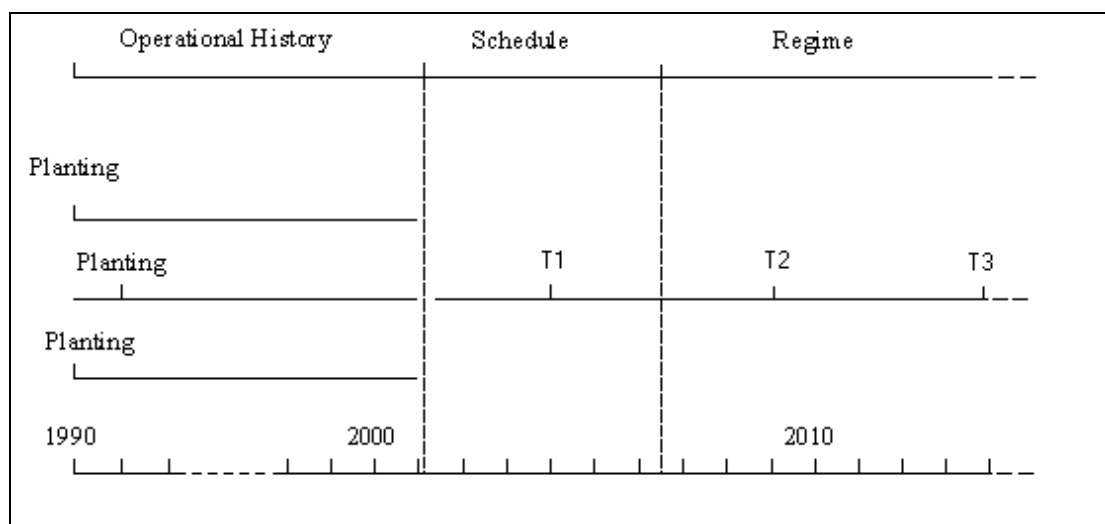

Figure 1: Relationship between Operational History, Schedules and Regimes.

3.1.3. *Biometry*

Biometric functions are tables and equations that are used by PLYRS to simulate growth and the effect of events on Operations Units. Where there is a choice of functions, the selection of biometric functions to be applied to specific locations is entirely under user control. This feature is extremely flexible and user friendly, incorporating standard Windows "drag and drop" functionality.

To allow testing of different combinations of biometric functions and to promote their re-use, sets of biometric functions applied to locations are stored in biometric libraries. Each library can then be applied to one or more Operations Units.

The biometry implemented in PLYRS has been developed for the *Pinus radiata* plantations located in the southeast of South Australia and is largely that documented in the Woods and Forests Department, South Australia, Bulletin No. 23 (1976). The implementation of the biometry is modular and allows the inclusion of biometry for other locations and or species providing it is of the same form, that is, dependant on Site Quality mapping and volume growth rather than basal area and height growth.

3.1.4. *Products Revenues and Costs*

The biometric functions in PLYRS predict total stem volume to a small end diameter of 10 cm. The user can then elect how this volume is to be allocated to user-defined products by size assortment classes. Similarly, revenues and costs can be assigned to products in terms of dollars per cubic metre. Costs can also be defined in terms of dollars per hectare, primarily for non-harvesting events.

Depending on the availability of suitable biometry, future development could incorporate product mixes determined from a range of inventory methods and/or estimates made by comparisons between actual and previously predicted harvest volumes.

3.2. Components of PLYRS

This section describes the major components available to PLYRS users.

Stand Information System

The Stand Information System manages the addition, editing, deletion and reporting of Resource Areas, Operations Units, operational history, and schedules. It is textually based and linked to an organisation's spatially based resources data.

Inventory

The inventory component provides the means to enter, validate, verify and store inventory plot data in PLYRS, and to establish the links between inventory data and the resources it represents. Inventory data can be directly entered into PLYRS, or imported from external files.

Selection/Filtering Tools

The initial step in performing most actions in PLYRS is to locate and select the required record(s). PLYRS provides a comprehensive set of selection and filtering tools for tabular data:
- Sorting. Columns can be sorted in ascending or descending order.
- Extended selection. PLYRS supports Windows standard record selection using the Shift and Control keys.
- Simple filtering. This allows users to select records based on the data in any one column. This mechanism also allows users to "cut and paste" a list from another source eg a document, to use as the selection criteria.
- Advanced filtering. This allows users to select records based on the data in one or more columns. Selected records are those that meet all specified criteria.
- Excel/Access. Users can use any of the selection and filtering tools available in Excel and Access to select desired records in PLYRS.

Yield Simulation

The Yield Simulation component allows users to evaluate management alternatives on selected Operations Units in terms of wood and cash flows.

To set up a yield simulation run, users must define the area to be simulated (one or more Operations Units), the events to be processed (operational history, schedules and regimes) and the biometric functions to be applied. For each Operations Unit to be simulated, PLYRS processes historical events, scheduled events then regime events. The regime is linked to the last scheduled event (see section 3.1.2.2).

PLYRS simulates growth responses and event behaviour on each Resource Area making up an Operations Unit. The results for each Resource Area are then aggregated up to get Operations Unit level results. This approach improves the precision of estimates over the sponsors existing systems' approach of using Operations Unit averages, particularly when there is a deal of variability within an Operations Unit.

PLYRS provides feedback of the results of a Yield Simulation run to allow verification of the results of selected options and to guide further refinement of the management strategy. Users can view the simulation results on the screen, print the results or export them to an external file.

PLYRS can also be used to simulate the management of a single Operations Unit and hence generate yield tables for selected stand types.

Yield Regulation tools

PLYRS can be used to develop schedules of events that produce regulated wood flows of one or more products. Regulation involves fine-tuning of scheduled operation attributes and occurrence dates to produce desired wood flows over specified periods of time eg 20,000 m3 per annum of sawlog for the next 10 years. The key element in this fine-tuning is a suite of PLYRS tools to allow users to make bulk changes to event occurrence dates and event attributes on Operations Units.

Financial Analysis

The Financial Analysis component computes the financial consequences of a schedule of events using user-defined products, costs and revenues. Outputs are cash flows, Net Present Value at user-defined interest rates and base date, and Internal Rate of Return. This component provides the basic information necessary for forest analysts to carry out sensitivity analyses to test economic parameters as well as undertake forest asset valuation exercises.

Data Import

Users are able to import basic resources data that describes a plantation. Such data includes stand areas, stand characteristics, inventory and operational history. This data can be imported via intermediate files from a variety of sources, including GIS, databases and portable data loggers.

Data is imported in context, eg Operations Unit data is imported within the Stand Information System.

Data Export and Reporting

All information displayed in PLYRS is available for export and a number of utilities are available throughout the system to assist the user in filtering and selecting the information of interest. Resources data, management information and the results of simulation and financial analysis may be readily extracted and passed into standard presentation packages, (eg. WORD, EXCEL) or into other management information

systems such as GIS. This enables the user to invoke the power of those packages for reporting and further analysis.

Help

PLYRS has an integrated help facility to:
- Explain and describe the processes within the system
- Explain how to use the system
- Describe the implemented biometry
- Provide definitions of terms used.

Figure 2 shows the main PLYRS screen with the "Stand Record Search", "Biometric Library" and "Regime" components.
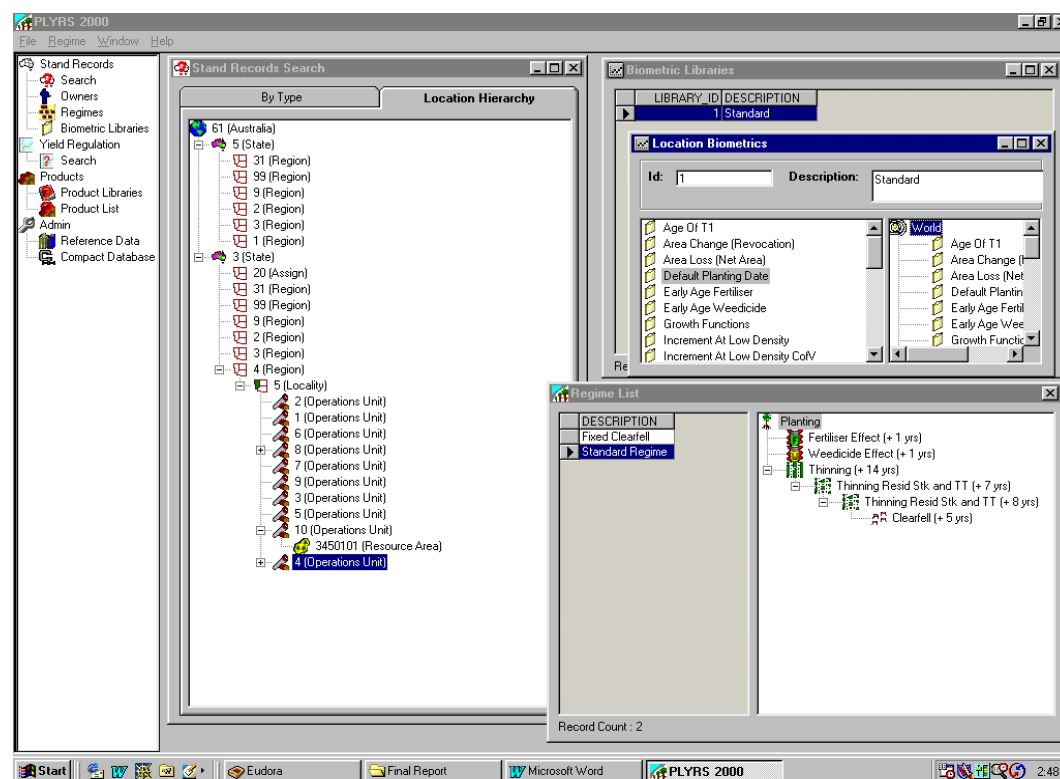

Figure 2:   Main PLYRS User Interface showing Stand record Search, Regime and Biometric options screen options.

3.3. Improvements Over Existing Systems

PLYRS incorporates a number of major improvements over the systems previously in use by the sponsoring organisations. These improvements are, in summary:
- Reduced overall process time. PLYRS allows users to rapidly examine the effect of changes to simulation parameters, allowing more management alternatives to be evaluated or more rapid refinement of a selected option.
- Ease of use. Ease of system use has recently become an important issue in plantation management because staff are expected to become rapidly

proficient in the use of a system and will often only occupy a position for a few years. Systems previously in use by the sponsors could take considerable time (years) for users to achieve an acceptable level of proficiency.

- Flexibility. Basic functionality (such as user-selectable biometry) is now under user control. In previous systems such functionality required re-coding of the software.

- Integrated help facility. The information about what PLYRS does and how to use it is an integral part of PLYRS rather than being in separate documents or passed by word of mouth.

- Increased precision by processing Resource Areas. Previously used systems processed average values for Operations Units, which masks underlying variability. PLYRS processes the Resource Areas making up an Operations Unit then averages the results to provide users with both Resource Area and Operations Unit level results.

- Improved reporting/export of results. PLYRS is a very open system in that virtually all visible data can be printed and/or exported. In addition, PLYRS stores its data in Microsoft Access, which itself provides easy to use and powerful reporting facilities.

4. Commercial Implementation of the Results

Development of PLYRS has been completed in accordance with the sponsors' requirements. The system is currently being used commercially for plantation management within the Green Triangle Region by Auspine Limited, GTFP and ForestrySA. Ongoing support and maintenance of PLYRS is being provided under the terms of a maintenance agreement between these three organisations and the University of Melbourne.

The Sponsors and the development team are doing a considerable amount of promotion of the system to other plantation growers, both in Australia and New Zealand. Considerable interest is being shown and requests concerning availability are being made.