1 INTRODUCTION

H.Campbell

1.1 Background

Some two million hectares of jarrah (*Eucalyptus marginata*) forest are managed by the Department of Conservation and Land Management (CALM). This forest contains a mixture of jarrah and marri (*E. calophylla*) together with about twenty-five minor species. Timber production is permitted in 1.4 million ha that lie within multiple use zones of the forest (Fig.1). The remaining areas are either reserved for conservation purposes or will be reserved when management plans published in 1987 are fully implemented (CALM 1987a).

Over the past decade, land use policies have resulted in reservations that have reduced the available area of jarrah forest for timber production by about 17 per cent. These reductions have led to progressive reductions in the allowable annual cut of sawlogs, amounting to about 20 per cent for first-grade sawlogs since 1977.

The impacts of such land use policies on the sawmilling industry have been twofold: a reduction in the level of sawmilling activity and a lowering of confidence in the long-term viability of the industry. The effect of reducing the areas of available forests has been offset to some extent by a lowering of utilization standards, resulting in sawlogs of lesser quality now being used. The perceived lack of secure raw-material supplies to industry has, however, mitigated against investment in new sawmilling technology. Such investment is essential to enable the utilization of a greater range of wood grades and, in particular, the utilization of immature and small dimension logs becoming available from regrowth forests.

1.2 Timber production strategies

The Department of Conservation and Land Management's timber production strategies, also published in 1987 (CALM 1987b), set radically new directions for organizing the supply of timber to a restructured sawmilling industry. The strategies seek to :

- restore confidence in the security of access to timber;
- promote investment in new technology;
- at least maintain the current level of sawmilling activity and to increase its contribution to the economy of the State by directing its out-turns to locally based, value-adding industries;
- promote the establishment of new industries capable of utilizing sawmill residues and inferior quality logs not suitable for sawmilling.

An important consequence of the strategies is a realization of the need to modify the basis for regulating the yield of the jarrah forest. The strategy requires a redetermination of the sustainable yield of jarrah sawlogs of all grades, together with the allowable annual cut, by 1992. Currently the basis for yield regulation is the sustainable yield of first grade sawlogs. In order to recalculate an allowable cut and plan for the supply of a wide range of timber quality-grades it is necessary to carry out a new inventory because the required information cannot be obtained from the existing jarrah inventory.

1.3 Existing jarrah inventory

The last jarrah inventory, carried out from 1964 to 1971, is considerably out of date and even with progressive past adjustments it fails to account completely for depletions in growing stock owing to logging since 1971, or for the substantial forest growth that has occurred since that time.

The 1964 - 1971 inventory provides estimates of sawlog volumes according to the standards of that time. These standards do not apply today and will be even less applicable in the future because of incentives that encourage changes in utilization standards. Many of the industrial developments being promoted by the current timber production strategies will depend upon the supply of timber grades that have either not been measured at all, or have not been measured exhaustively in past inventories.

1.4 New jarrah inventory

1.4.1 Corporate objectives

The new inventory has been designed to facilitate implementation of the timber production strategies by providing information required to :

- recalculate annual allowable cut as prescribed by the strategy, thereby placing upper limits on total processing capacities for different products by the various industrial sectors;
- determine the optimum location and capacities for individual industrial units;
- plan a strategic road network to service the industries.

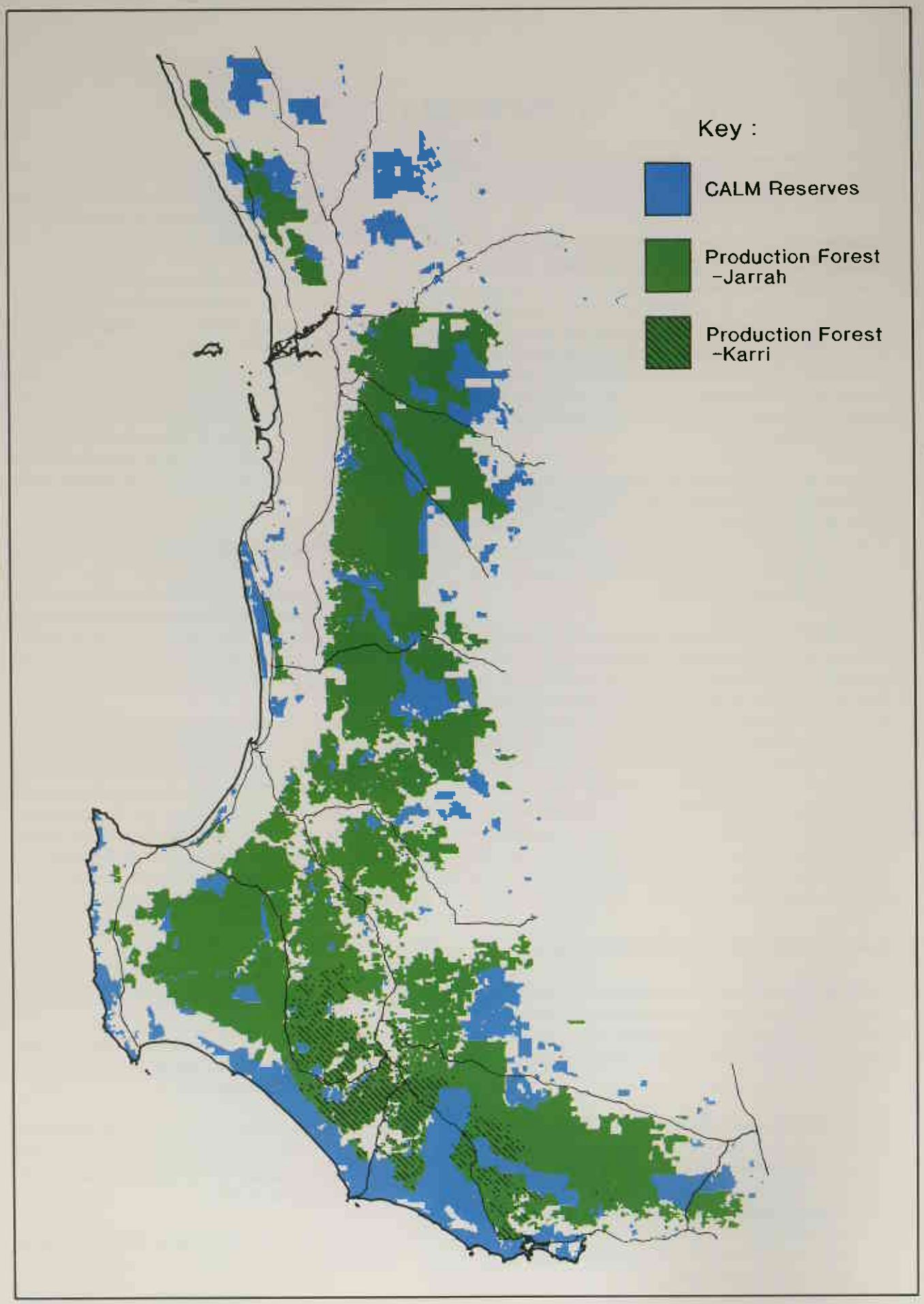

Figure 1
Geographic distribution of the jarrah forest within multiple use areas and conservation reserves in Western Australia.

The new inventory data will also contribute to medium range logging planning. This level of planning broadly directs and sequences logging operations in a manner which allows contractual commitments to be met, minimizes adverse visual impacts, and conforms to the silvicultural and fire protection priorities.

1.4.2 Inventory design objectives

Inventory design features that are essential for achieving the corporate objectives are :

- the techniques adopted must allow for completion of the inventory by 1991 (i.e. within three years);
- the inventory must provide volume estimates for all potentially utilizable wood. This includes the whole of the gross bole volume, some of the crownwood, all of the standing dead wood and some of the fallen dead wood of 28 tree species occurring in the jarrah forest;
- the sampling error associated with the sawlog volume estimate for management units of about 10 000 ha should not exceed 25 per cent (with 95 per cent confidence);
- the design must accommodate the facility to partition the gross bole volume into timber grades suitable for supply to a variety of industries and, without remeasurement, to repartition the gross bole volume as utilization standards change.

The Department's Geographic Information System (GIS) is well developed and is capable of supporting an inventory processing subsystem. An integrated processing system of this kind has the potential to provide a very powerful planning tool, therefore an additional design objective was adopted :

- to establish the inventory as a subsystem of the GIS.

1.4.3 Design principles

An important aim was to integrate the data collection tasks to meet current and perceived future planning needs. The benefits of integration are associated with the facility that a computerized GIS provides to isolate zones of forest with specific characteristics of significance to particular planning problems. Significant characteristics may be related, for example, to land use, tenure, management responsibility, disease status, various land attributes or any combinations of these factors. Zones of interest defined in terms of their spatial relationships with wood processing centres or access routes are relevant to the logistical problems of timber supply.

To fully exploit the benefits of an integrated inventory design, an inventory subsystem must be capable of providing resource-estimates that are free of association with predetermined forest units. Otherwise, unbiased estimates will not be available for any particular zones of interest. For example, stratified random designs do not provide unbiased estimates for forest units which overlap strata.

The new jarrah inventory uses a systematic sampling design, in spite of its higher costs, because of its great flexibility in addressing multiple objectives, many of which cannot be foreseen during the design phase. Its integration with a GIS provides the means to fully realize its potential in this regard, which adequately justifies the acceptance of the higher costs involved.

The new inventory has been designed as a two-phase sample. In the first phase, sample plots are interpreted and measured on approximately 1:1000 scale aerial photographs taken at points on a rectangular grid. The second phase is a systematically selected subsample of the first phase plots which are measured intensively from the ground. This very efficient technique is being used to achieve the first design objective, the time limit.

Plot data from the first phase sample include spatial co-ordinates for the plot centres. These coordinates are calculated by a Global Positioning System (GPS) receiver interfaced with the camera control system. The positional data provide the means for consolidating the sample plot measurements within the GIS.

The achievement of the fourth design objective depends on data obtained from the second phase plots. In conventional inventories, the technique used to partition the bole volume of sample trees into quality timber grades relies on the expert knowledge of trained assessors. Specifically, the assessors correlate visible bole characteristics with internal defects to divide each tree into hypothetical logs that meet the various standards for established industries.

As the *processed* data generated in this way are clearly inadequate to meet flexible product objectives, it has become necessary to record the *raw* data describing visible bole features and then to develop complex sorting algorithms to process these data to meet a variety of product-specifications.

1.5 Report objectives

The objectives of this report are to describe the methods that have been developed and the reasons for their selection in order to stimulate interest in their wider application and further development.