HARDWOOD FOREST ASSESSMENT IN WESTERN AUSTRALIA

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PREFACE

It has been necessary, for the sake of brevity, to limit the detail presented within each section. The ongoing nature of the inventory process has often resulted in several versions of measurement procedures being developed as a particular assessment method was adjusted for specific needs. In these instances a generalised version has been presented to outline the principles involved.

SUMMARY

Initial estimates of the extent and quality of the forest resource of W.A. were prepared by individuals charged with the responsibility of reporting to the governing authorities of the colony. These estimates were highly subjective, being largely based upon cursory observations obtained during horseback touring of the forests.

With the establishment of a Forest Service and the legislation to provide for dedication of State Forest a systematic classification of all timbered country south of Mundaring was undertaken. This work formed the basis for dedication of State Forest and preparation of the earliest working plans.

Early hardwood assessment within State Forests was based on permanent plots, intended for relocation and remeasurement in the European style then favoured.

Permanent line assessment, involving measurement of all trees each side of a base line of specified length, was favoured from 1940 to 1955 but changing marketability standards and lack of uniformity between assessors detracted both from their suitability for remeasurement and the reliability of the figures obtained. The development in the 1950's of a forest classification based upon air photo

interpretation provided a basis for forest stratification and shifted the emphasis to the measurement of temporary striplines within designated strata.

A comprehensive inventory of the forest was undertaken between 1963-1972 to provide resource level estimates as a basis for long term forest planning. Over 10,000 plots were randomly located within designated forest strata. From the mid-1970s inventory has concentrated on providing management level information, typically using a systematic stripline assessment of an area to produce a higher intensity of sampling per unit area of forest than for the earlier resource level estimates.

Several specialised assessment programmes have been undertaken to cater for specific information needs associated with the management of sandalwood and mallet resources.

Throughout the years the forest sampling design associated with inventory for yield calculation has varied in response to factors predominant at the time (e.g. inaccessibility of forests, absence of a reliable basis for stratification). However, the basis of yield calculations has, in principle, remained the same, with yield estimates being determined from simple formulae involving only the area of forest and the volume of growing stock. Assessment procedures have

traditionally involved the measurement of individual tree volumes, necessitating the compilation of tree volume tables for each commercial species. A permanent growth plot network of over 650 plots throughout the forest is maintained to provide increment data for incorporation into long term yield planning.

INTRODUCTION

In W.A. the term given to the determination of stand volume is 'assessment'. Hardwood forest assessment therefore incorporates those procedures involved in obtaining and then processing data to derive volume estimates for yield calculation. Traditionally in W.A. this has involved the measurement and calculation of individual tree volumes, with subsequent 'working up' of this data on an area basis to provide stand and hence forest volume estimates.

Figure 1 illustrates diagrammatically some of the factors that influence the development of a forest inventory system. The starting point in considering the design of inventory is the method to be used to calculate the yield and associated volume estimates. Numerous methods have been developed for calculating the yield or annual cut available from a forest according to the desired method of 'regulating' the forest. These methods differ in their information requirements and therefore in their forest assessment needs. If, for example, annual yield is to be regulated on an area basis only (commonly used for irregular forest under an early phase of management) limited stand detail is necessary. In contrast, a method based upon yield regulation by type and number of products derived from individual trees will require detailed description of size class distributions within the forest.

FIG 1 Here

The majority of factors listed in Figure 1 are interdependent. For example, factors such as the composition, structure, and productive capacity of the forest will each have a marked influence on the extent of the yield, the way it is calculated, and the method of obtaining information on which to base such calculations. Moreover, specific factors may only predominate for a period of time before being subjugated to others (e.g. the limited accessibility of the forest in the 1920's and 1930's was a major influence on inventory design. As accessibility improved this factor had less influence on inventory design).

Furthermore, a forest inventory is not an undertaking which is completed, but a continuous, cumulative work of building and correcting data; at best it is a stocktaking and forecast for a forest area at a specific date and according to specific definitions, as interpreted by workers at that date (Nunn, 1959). Thus, it is worthwhile to view the historical development of forest assessment in Western Australia against the backdrop of interacting influences operating at the time.

1882 THE EARLIEST ESTIMATES

Early estimates of forest area and the volume of merchantable timber available were 'hazy and over-optimistic' (Barrett, 1949). For example, in 1882 the then Surveyor General of W.A., Sir Malcolm Fraser, suggested that the 'untouched' forest area was so enormous that no anxiety need be felt as to the exhaustion of supplies for very many years. Fraser spoke of Jarrah as extending over almost 3.6 million hectares (9 million acres), of Karri as extending over 0.6 million hectares, and of Tuart as extending over 129,000 hectares. In addition, 2.6 million hectares of white gum (Wandoo) and 0.6 million hectares of York Gum were included as timber forest (Fraser and Von Mueller, 1882). Whilst these figures may represent a reasonable approximation of the original geographic extent of each species, no account was taken of the highly variable forest quality (in terms of timber yield) within each species.

In 1895 J. Ednie-Brown (destined to become the first Conservator of the W.A. Woods and Forests Dept.) reported to State parliament on the extent and quality of forests in W.A. His paper describes a tour of inspection of the South West comprising over 5000 miles of travel by rail, buggy, and horseback. Gross estimates of areas of forest types and quantities of crop trees (round timber marketable under prevailing conditions) were drawn from observation and measurement of "1500 individual acres" (Ednie-Brown, 1896).

The proffered estimate of 8.1 million hectares of forest land was accepted for over twenty years, suggesting, as Robertson (1959) comments, that such an outlook may well have ~~harmed the forests by~~ contributing to the complacent attitude which arose regarding the exploitation of the forests during the two following decades.

1916 TIMBER CLASSIFICATION AND SURVEY

A further 20 years of uncontrolled trade cutting was to ensue before more reliable estimates became available. Around 1916 a programme of forest classification was commenced under the direction of the then Conservator C. Lane-Poole. This timber classification was carried out by traversing parallel lines through the bush approximately 800m apart. Assessors walked these compass lines stopping every 200m to record the timber species (jarrah or karri) and estimated volume. Owing to the very dense undergrowth in the karri forests it was found necessary to reduce the distance between the traverses to 300m and, instead of recording data over the whole area between the traverses as had been done throughout the jarrah forests, a strip 40m wide was taken to represent the forest between the traverses.

By 1917 the area surveyed was sufficient to show that all previous estimates of the extent of the jarrah forests had been "...grossly exaggerated. Instead of the 8 million acres {3.1 million ha} so often quoted as the area of the belt, it is doubtful whether more than 2 million acres {0.8 million ha} of prime jarrah forest will be found" (Lane-Poole, 1917 Ann. Rep.). This crude classification mapping took almost 5 years of field survey to complete, with virtually the whole of the south-west forests from Mundaring to Denmark being covered.

This early work, following grid lines, assessed high quality logs acceptable to sawmillers of the period, with the result that forests sometimes assessed at as low as 17 m^3/ha of merchantable volume actually carried as much as 8 times this in standing volume when Marri, pole and pile sizes were included (Harris, 1957).

The first reported forest measurement plots were established in 1916. A total of 25 sample plots were subjectively located throughout the jarrah, karri and tuart belts, with all trees within each 2 ha plot being enumerated for girth and height. In 1920 data collected from the 18 jarrah plots suggested that the jarrah forests were growing at an average rate of 0.35 m^3/ha/yr.

The Forests Act of 1918 laid the foundation for yield regulation on the basis of working plan prescriptions and of prescribing a permissible intake for each sawmilling permit. The system of yield regulation provided for a fixed permissible intake, subsequently equated to the estimated yield from the permit area and for the issue of sawmilling permits or licenses which were annually renewable for period of up to 10 years. The permits were subject to specific conditions regulating the method of working, together with the species and size of timber to be removed (Anon, 1969). Effective implementation of this system took several years to establish.

The timber maps (Appendix 2) were used primarily for the purpose of assisting allocation of sawmilling permits to various timber firms and estimating permissible intake. The size of these permits was intended to allow for a 30 year cutting cycle, with a girth restriction imposed to enforce this policy (only those trees above a specified minimum GBHOB could be felled). Being the first comprehensive record of the extent and quality of the resource the maps also formed an important basis upon which most of the earlier dedications of State Forest and the Working Plan determinations depended (Nunn, 1957). It is of interest, and a tribute to the tenacity of past Conservators, that the 1928 maps delineating areas of 'prime merchantable forest' closely approximate the present extent of dedicated State Forest.

1932 STOCKTAKING IN THE JARRAH BUSH

The first comprehensive attempt to assess the forest was commenced in 1932 with the establishment by A.D. Helms of a series of plots in jarrah bush at Coondle, Ashendon, Holyoake, Tallanalla, Chalk Brook, and Treesville. By 1938 surveys had been completed in over 21 centres (totalling over 100 plots) covering the broad geographic range of jarrah, including the southern forests at Manjimup, Pemberton, and East Witchcliffe.

Plots took the form of continuous strips along grid lines. This approach was favoured largely because of the potential for strip lines to compensate for observed variation in soil type (Stoate and Helms, 1938), although at selected locations along the lines 2 hectare and 4 hectare plots were established and additional information recorded. Assessment involved the measurement of strips 20m wide spaced at intervals of 400m, thereby representing a sampling intensity of 2½%. All trees below 60cm GBHOB were ignored, while marketable and potentially marketable trees above that limit were measured and marked for future remeasurement. Parameters measured included girth at breast height, height to the crown of the log, and diameter at the crown (estimated). In addition, within the 2 and 4 hectare sample plots, trees were further classified according to the canopy class, crown, and bole class. A sample field booking sheet is presented in Appendix 3. Stand volume was calculated as a product of total basal area, mean height (defined as the height corresponding to the mean basal area), and a constant form factor of 0.6.

Data extracted from the assessment were used to examine some of the fundamental relationships which underly the growth and development of Jarrah stands (Bednall, 1938; Stoate, 1940; Stoate and Wallace, 1938; Stoate and Bednall, 1940). For example, in an endeavour to relate soil type with site quality, considerable work was done on deriving a girth-height index for jarrah. Co-dominant trees were girthed, their total heights measured, and from a table the heights were adjusted to read the height they attained or would attain at 240 (94") GBH. The resultant figure was called index height. Additional 2ha sample plots were laid down on the major soil types and detailed measurements of stocking present and ensuing timber removals were taken. However, considerable variation in total marketable volume for the same soil type occurred and the work lapsed during the early war years. Forest stratification based on soil characteristics was therefore abandoned.

Demarcation of quality class in the jarrah forest remained a matter of some difficulty. Delineation according to the quantity and quality of Jarrah logs produced was the desired criterion, but the measure of this was far from straight-forward. For example, within the predominantly virgin forests species composition was often quite variable, with varying proportion of marketable and non-marketable Jarrah mixed with non-

marketable Marri. Hence, the merchantable log volume of a particular site was not consistently related to 'site quality'. Furthermore, this criterion was likely to become less useful as the nature of the stands altered with management, and utilisation standards changed.

1940-1950 : JARRAH FOREST ASSESSMENT LINES AND PLOTS

Prior to about 1940 the strip method of forest assessment on about a 2½% basis had been used, but generally such assessments were not of long-term value because of the booking of only the logs then considered to be merchantable and to the lack of a uniform school of thought amongst assessors (Nunn, 1959).

Thus, subsequent to the work of Stoate and Helms (1938) permanent line assessments were commenced, with a view to more accurate records and as a basis for further growth studies and working plans. The primary objective was to obtain volume under bark estimates of standing and removed timber and to select trees to remeasure for increment calculation.

Location of these lines was subjective. For example, "It was decided for convenience in the Dwellingup Division that permanent lines should be run starting from a convenient map reference such as a numbered tree or location peg at approximately 80 ch {1.6 km} intervals. Lines were ended or tied in approximately every 2 miles {3 km}". (Notes to Assessors, 1942). Originally a base line was established and assessment lines offset at right angles and at regular intervals from the baseline - the intervals varied from 400 to 800 to 1600 metres. All

standing trees considered to be of timber value, within 20m on either side of the assessment line, were measured. Examples of the measurements and parameters assessed are appended in an example of the 1942 version of the field assessment book (Appendix 4).

Until about 1945, most assessments considered only the volumes per acre then acceptable to sawmillers and sleeper cutters. It soon became apparent that these volumes were a very low percentage of the actual wood volume, or even of the volume that would be accepted by sawmillers on latter day standards (Nunn, 1957).

link paragraphs

Consequently, the early Working Plans (1928, 1939), and even the 1945 Plan, were extremely conservative in determining the cut, the basis being in essence to regard the total marketable volume over 225cm girth as the source of supply for 60 years in the expectation that the volumes under 225cm girth would by then supply the future cut, reduced if necessary.

AIR PHOTO INTERPRETATION

Kessell and Stoate (1936) record the first use by the Department of aerial photographs (supplied by Western Mining Corporation) in the assessment of timber supplies for the goldfields (Kalgoorlie district). Determination of broad vegetative type groups was made on contact prints (with stereoscopic overlap) at a scale of 1:7200-9600. In sections of the country over which this aerial survey had not been carried out it was necessary to locate the vegetative types by strip assessment. During the early 1930's some 7800 square km in the Wiluna district were examined and type maps prepared.

Urgent wartime needs caused a hastening in the development of aerial photography and in 1945 the Dept. commenced experiments to determine the feasibility of interpreting from vertical photographs the classification of the forest, including species identification and site quality (Anon, 1969). It was proved that photo-interpretation combined with field checks was a satisfactory alternative to ground classification and in 1949 a programme of mapping was initiated. By 1951 when a conference of management officers from the State and Commonwealth was held in N.S.W. fairly definite methods had been decided in W.A., and the work of stratifying the forest from that date proceeded rapidly. Following initial experimentation the interpretation became fairly comprehensive.

The forest was assessed into species, height and density classes, and forest type. Interpretation was based on assessment lines run through the forest types, augmented by data from the permanent assessment lines. An example of an Air Photo Interpretation (API) map and explanation of the codes employed is appended (Appendix 5).

1950-1955 MAY'S PERMANENT ASSESSMENT LINE

During the development of API techniques a further line assessment system was established. The high cost of temporary assessment procedures (e.g. the significant proportion of unproductive time spent walking to plots) and concern over the extent of broadscale variation being covered by the subjectively located plots prompted the establishment of what is commonly referred to as May's Line.

May's Assessment Line was a permanent, continuous assessment line running North/South through Divisions from Gleneagle to the Southern Ocean (south of Manjimup). Almost 200 miles long (Appendix 6), each Division was given responsibility to complete their section of the line. However, some sections of the line were not fully assessed. Many shorter lines were established parallel but offset to the main line e.g. +E8 (8 miles east of May's line) in the Mundaring Division (25 miles long), +W8 (miles west of May's line) Harvey, Collie Divisions (26 miles long), +E16 Collie (10 miles long), +W8 Collie, Kirup, Manjimup, Pemberton (93 miles long).

Work on the lines commenced in 1951 with the same assessment procedures employed as in previous (1940's) permanent assessment lines e.g. all trees 20m either side of the line were assessed - see sample field booking sheet, Appendix 7.

The project represented a substantial committment of staff and financial resources for a relatively small Dept. Field survey, mostly completed by early 1954, was based on old topographical maps, although API strata classification was used when it became available for the areas assessed. Field books were submitted to a centralised data extraction unit where personnel worked up volume estimates for each section of the line. The absence of any form of stratification necessitated volume estimates to be compiled on a volume proportional to area basis. These estimates assisted a review of the first statement of forest capital of W.A. made in 1951 for the Royal Commissioner.

Although the project required a substantial committment of staff and financial resources for a relatively small Department, Nunn (1959) comments unfavourably on the permanent line assessment procedures. "Permanent line assessments, commenced in 1940 and continued until 1953... proved abortive, due again to the difficulty of uniformity by assessors and to a misconception as to the staggering extent and cost of such work. Some 661 miles were established, cost rising as high as £40 per mile, but still no real picture of the forest was obtained".

1955-1963 ASSESSMENT USING API STRATIFICATION OF FOREST AREAS

Following completion of the aerial mapping programme forest assessment procedures were based upon air photo interpretation and a stratification by height and density classes. Thus, the essential difference between the assessments then made and those previously was that small plots or lines were now being used to sample areas of forest type - mapped (stratified) from air photo studies. Six height classes with two species classes, further subdivided into density classes were used. Stratification of second - growth forest provided some problems, but after considerable research it was found possible to follow the general stratification specifications, although particular attention had to be given to percentage of crown cover of the various strata in the stand structure, and where an upper strata crown cover percentage exceeded 40%, more intensive field sampling became necessary.

For practical purposes planning sections (comprised of Working Plan Areas ranging in size from 15 000-55 000 hectares) were adopted as the basic units of inventory. Field trials involving sampling based upon stratification by height classes showed that with a sampling intensity of 0.3% of net forest area, sampling errors less than 10% of gross volume were obtained for each stratum. Standard tables were used for volume determination in the field to reduce subsequent office work.

Working Plan Assessments

In 1954 a programme of assessment was initiated in the Southern Region to consolidate resource estimates for working plan preparation. Temporary assessment lines of varied length were located so as to cover 0.3-0.5% of the forest area within a Working Plan Area. All trees of all species over 150 cm G.B.H. within 10m on each side of the line were recorded for marketable volume within girth classes (see Appendix 8). The quantity of non-marketable and removed timber was also assessed. Forest type (defined by species density) and co-dominant height were recorded to provide a check for API work.

Quarterly Assessment of Cut-Over Bush

Within each Division temporary assessment lines were run by the treemarkers on each quarter's (3 months) cutting to assist their awareness of the volumes marked and trees retained as a planned proportion of the forest. The assessment lines, commencing from a known point such as a reference tree or track junction, were selected so as to be representative of the area cut over during the quarter. The treemarker ran a compass line and measured distances by pacing or chaining. Volumes removed and retained for all trees over 150 cm G.B.H. (including Marri) were recorded within a distance of 10m on each side of the line.

This type of assessment provided the basis for a map record of areas cutover and volume removed. However, incorporation of the data into working plan calculations was limited by the varied reliability of the data. For example, the treemarker was not required to measure all girths, although sufficient measurements had to be taken to provide an effective check on estimation.

1963 - 1972 : RESOURCE LEVEL INVENTORY

(i) Objectives

In 1963 a conference on Forest Inventory Procedure was held in Canberra. Nunn and McNamara (1963) listed the following as the projected information needs of management for W.A. hardwood forests for the subsequent decade:

(a) API mapping as a basis for all management, fire control and engineering.

(b) Assessment data for planning of Sustained Yield Units, reliability ±15%.

(c) Growth data for MAI calculations.

(d) Total over-bark volumes and Merchantable % by species and size classes in units related to existing industry and anticipated industries. Forest areas by tenure, species and silvicultural condition.

A resource level inventory (RLI) was designed to meet some of these information needs. Several factors, acting in concert, had combined to stimulate this comprehensive timber inventory of the total resource. Throughout the years inventories of the hardwood

forest had been carried out as the need arose and to the market specifications prevailing at the time. This often rendered data from previous inventories inappropriate as product standards, and indeed the forest, changed. For example, during the early to mid 1950's both the jarrah and karri tree volume tables were expanded to accommodate the smaller size classes associated with the smaller sized material which was now considered to be marketable. Furthermore, the completion of API stratification for the entire forest and the advent of computers for processing large data matrices provided the opportunity for a comprehensive review of the forest's marketable timber resources.

(ii) Sampling Procedure and Assessment Details

The basic sampling unit was the Forest Block, typically an average area of 2000-4000ha representing an operational management unit defined by physical boundaries (roads, creeks) Approximately 10-20 forest blocks comprised a sawmill permit area.

Following the development of the API programme, forest areas had been stratified on the basis of

Crown Cover (density)

Height Class (Co-dominant Ht)

Structure of Stand

Species Present

Between 1960 and 1963 assessments were undertaken in various forest areas, providing an opportunity to investigate the potential for forest stratification based on API types. Initial assessment of forest types showed that the correlation between crown cover and merchantable timber volume was too weak to allow stratification and subsequent sample allocation based solely on API types. For example, field assessment lines commonly found significantly less merchantable volume in an M60 (massed - at least 40% in upper strata) than in a P30 (30% upper strata) stand. There was also a wide range, and hence overlap of merchantable volumes between various API strata.

Sample stratification based on each individual API category was therefore abandoned (Williamson*, pers. com.). Suitably grouped, however, the forest types have provided a basis for all subsequen inventory designs.

Stratification of the forest areas was eventually based on two managerial parameters, viz. presence/absence of Dieback, and cutting history (cutover pre or post 1940). Virgin and Non-forest areas were also demarcated. The dieback factor was mapped from previous API work, whilst

the cutting history was available from map records. This broad stratification was adjusted according to the particular requirements of each Division.

Temporary plots, 400m by 20m, were used to obtain data for the planning of 'sustained yield units'. Proportional allocation of sample plots to strata was combined with random locating of plots within strata (Appendix 9). The number of plots per stratum was dependent upon the sampling error i.e. calculated on the basis of the coefficient of variation of merchantable volume within each stratum. If there was no other data available a pilot survey was undertaken to obtain the information required to estimate the number of plots to be used (Williamson, 1965). In general, sufficient sampling had been done to compute estimates of the coefficient of variation and use it to estimate the number of plots required in adjacent sections i.e. in many cases sampling of previous years ~~would be~~ was sufficient to provide an estimate of coefficient of variation. A worked example of plot allocation technique is provided in Appendix 10.

Trees within each 0.8ha plot (strip) were assessed for GBHOB and merchantable height (hence volume from standard tables), according to the prevailing market specifications. A field booking sheet is appended (Appendix 11). Subplots

(4 by 0.2ha) were assessed for checking optimum plot size and for recording regrowth below merchantable limits (150cm girth).

Between 1964 and 1971 over 10 000 plots were measured, representing a sampling intensity of 0.4%. Whilst the acceptable S.E. for each forest block was ±20% at the 95% confidence level, the derived S.E. for the resource estimate for a sawmill permit (comprising 10+ blocks) was generally less than ±10%.

(iii) Acceptable Loadage Plots

A recurrent problem in RLI (and indeed previous inventory) was the differing standards of marketability encountered from one sawmill permit to another. It was therefore of major importance to ensure consistency between volumes assessed as being marketable and the cutting standards characteristic of the mill concerned, (Batini and Williamson, 1971).

The practice of carrying out 'Acceptable Loadage' within specified plots of each sawmill permit was introduced to assist assessors to accurately assess marketable volumes within the permit. The procedure involved assessment of marketable volumes in trees before they were felled and then measurement (on the

ground) of log volumes actually accepted. Mill standards were therefore gained from their respective bush crews.

The data extracted provided an estimate of the percentage of timber assessed in each block which would be accepted by the mill concerned.

(iv) Data Output/Application to Management

The data was processed with the aid of a FORTRAN computer program written by Officers of the Inventory and Planning branch of the Department. Input data, entered by plot, was internally summarised to produce output for a given SMP or Division broken down by strata, species and marketability class (Appendix 2). This inventory provided much greater detail on stocking of stems, stem diameter class distributions, sawlog volumes and volume of marginal logs (Hopkins, 1983). Individual tree or individual plot data is not available, thereby losing flexibility for application to changing management objectives. In the context of planning for sustained yield, summarised data was extracted for decisions relating permissible intakes of sawmill permits with long term yield estimates. Data from previously established permanent plots enabled growth rate estimates to be incorporated in the planning process.

1972 INTENSIVE MANAGEMENT UNIT ASSESSMENT

In 1971 it was proposed to delineate those areas of jarrah forest (both northern and southern) which would warrant financial investment to upgrade their productivity and ensure protection from dieback. Such areas were to be individually designated as Intensive Management Units (I.M.U.'s).

The original definition of suitable forest areas was based on an inspection of API plans and dieback plans for each Division involved. Generally only 'JA' bush (Appendix 5), considered relatively free from dieback, was demarcated.

IMU assessment was commenced in 1972 with the intention to cover all the IMU's as rapidly as possible to enable broad-scale priorities to be established. Future work was planned on a more intensive scale in the higher priority areas within each IMU.

The sampling intensity and level of precision required was unspecified. Within each IMU, plots were subjectively allocated to cover the variation in each area, concentrating on those dieback free API types potentially suitable for unmerchantable thinning (e.g. P20/50 stands). A sequential stocked - quadrat sampling technique was used to assess forest stocking. The stocked quadrat method (Dick, 1963) involves an assessment of the effectiveness of stocking

by maintaining a sequential tally of those plots which are fully stocked (according to prescribed stocking standards). The proportion of units stocked within each recognised type is computed and expressed as a percentage which is applied to the whole.

The total line length per plot was nominally 500m, with sampling spots 10m apart (a 50 spot sequential sample should give results which are ±15% at the 95% probability level). Ideal stocking levels were set for each girth class (e.g. 120 stems/ha for trees 150-225cm G.B.H., 1800 stems/ha for regen seedlings) and each spot was stocked if it carried a respective stem within a specified radius of the assessor (e.g. 1 stem 150-225cm G.B.H. within 5m radius of assessor). A sequential stocking assessment graph was used to assess if stocking was over or under the 65% crown cover decision limit for adequate stocking. The sequential sampling technique was also applied to the selection of stands for pole thinning. An example of a field booking sheet is provided in Appendix 13 .

Sawlog and mining timber assessment to current mill standards involved recording marketability class, GBH and estimating volume per unit area. S.E.C. poles were counted per plot (assessment of 5m either side of the line represented a 0.4ha plot size). The assessors opinion was sought on whether the area could support an S.E.C. pole cut, an unmerchantable thinning,

a sawlog cut, or a mining timber cut. A comment on API type was required as many of the 1951 maps were now unreliable due to trade cutting since compilation.

The IMU assessment system was continually changed to provide useful results at minimal cost. Initial problems with the inaccuracy of API plans were overcome by increasing sampling intensity. To reduce the total cost of assessment the IMU lines (which were essentially classification lines) then relied heavily upon the assessor's experience in estimation.

Results of each assessment were summarised onto a series of maps showing 1) forest stocking 2) recommendations for unmerchantable pole thinning 3) broadscale summary of sawlog cutting estimates (Appendix 4) 4) collective summary of pole and pile cutting potential and 5) dieback occurrence.

By June 1973 broadscale assessment of over 75% of the IMU's in the central and northern regions (Collie to Mundaring) had been completed i.e. 138 000ha of the 176 000ha. Further assessment to provide a basis for intensive management was suspended in the northern and central regions due to the uncertainties associated with the potential rate of spread of dieback and the extent and location of proposed bauxite mining in the Darling Range. In the southern region IMU assessment was interrupted by proposals to fully integrate the logging system.

1974 MANAGEMENT LEVEL INVENTORY

Background

By May 1973 it was apparent that a Marri Chip Operation in the Southern Division was imminent. Existing resource level data had been used for estimating volumes since 1968 but such figures would not provide data of sufficient accuracy to intensively manage and control the chipwood operations. For example, the stratification used in resource inventory was usually too broad or of a different type to that required for logging. Furthermore, the volumes for relatively small parts of a sample unit could have no reliability placed on them, and the volume of such component areas could vary markedly from the overall broadscale strata mean. The resource inventory had, by design, been based upon a fairly standard system which was not sufficiently flexible for the specific requirements of a particular area.

Thus, because marketability standards changed due to changes in availability and market conditions it was necessary to assess areas of forest for likely quantities of forest products as close to harvesting as possible. It was therefore proposed that a new system of intensive assessment be introduced which would follow along from the Intensive Management Unit assessment that was under way in the Northern Division and which had been tested in the South.

Several trial sampling methods and reassessments were carried out and a tentative procedure put forward. Various distances between lines were tried and compared. Width of assessment lines were also studied. Over the remaining summer months through to July 1974 the procedure of intensive assessment was altered in parts and streamlined for efficiency to satisfy the needs of planning of mill cutting over the next 5 years. This procedure was named Management Level Inventory (M.L.I.).

Procedure

a) Southern Region

Each forest block is divided into cutting coupes, the boundaries of which are selected with regard to summer and winter access, stream and road reserves, nature and scenic buffer zones. The maximum size of coupes has been laid down by Environmental Impact Assessment. In Jarrah forest each coupe is approximately 650 to 800ha (compared with a 800ha maximum) whereas in Karri coupes are typically less than 150ha in size compared with a 200ha maximum.

M.L.I. involves a systematic line sampling system within a coupe. The initial line is subjectively located, with subsequent lines parallel and generally 400m apart. The location of the assessment lines for a coupe are presented in Appendix 15 .

The distance between the lines is uniform throughout the block and was decided upon according to the required sampling intensity. The parallel assessment lines are selected in each coupe in turn on an API map showing coupe boundaries.

Total line width is 10m Jarrah and 20m Karri. There is no restriction on length except that it shouldn't take longer than half a day's work to complete assessment on it. All trees within these narrow 'line plots' are recorded if greater than 30cm DBHOB. Each tree is assessed for its products, not simply classified into a marketability class. For example, each tree may have one, two or three products, either sawlog (marketable timber that present mill could obtain for sawn timber purposes), chipwood (timber suitable only for chipping), or waste (unmarketable part of tree due to rot, charcoal). For each product within the tree the length (in metres) is estimated (Appendix 7) and the volume calculated.

For Jarrah, Karri, and mixed Marri types the corresponding portions of the lines are extracted and summarised for each coupe, to give an average volume for each coupe of species products in cubic metres per hectare. Total area for each type is extracted and multiplied against the average volume per hectare for each type. In this way a total volume for each species and their products is

calculated for each coupe and is presented on a summary sheet.

Volume information is extracted from this summary sheet and placed on a Hardwood Operations Control System (H.O.C.S.) card. The H.O.C. system supplies a means of recording, prescribing and describing resource and operations carried out in each coupe. However, since it's inception in 1974 substantial progress has been made towards computerisation of data processing. The development of such a system has enabled an expansion of original tree product codes and has provided greater versatility in resource description. For example, for the sequencing and integration of operations, it is useful to know the quantities of certain products by status i.e. identification of the major product or highest value produce within the tree. Similarly, the product code assigned to a log within a tree identifies the use to which that log is most likely to be put given the type of cutting regime expected to take place. Twelve utilization codes are presently used including big mill/ small mill sawlog, S.E.C. pole, sleeper log, and peeler log.

b) Northern and Central Regions

Although M.L.I. was developed for Southern Region needs it has been expanded for use in the Northern and Central Regions.

In 1980 M.L.I. was commenced to determine hardwood sawlog resource for general purpose mills and S.E.C. pole resource north of Harvey. A secondary purpose was to determine the quantity of firewood (green and dry, standing and on ground) and chipwood in these forests.

Initial sampling intensity was 2½% for general purpose, salvage mill logs and S.E.C. poles (i.e. a 20m wide line every 800m) and 0.625% for firewood and chipwood (i.e. 5m on right hand side only of the line). Similar plot location and assessment procedures as in the Southern Region were used. Trees were assessed according to designated product specifications (min/max length, DBHOB, TDOB) and priorities (i.e. assess bole for most valuable products first - S.E.C. poles, then G.P. sawlogs, salvage sawlogs, chipwood, firewood, and finally waste).

UTILIZATION APPRAISAL

Incorporated in MLI procedure were regular Acceptable Loadage plots, aimed at maintaining marketability standards within ±10%. Data from the plots provided a basis for applying correction factors to resource estimates.

In latter years Utilization Appraisal is the name given to the metric equivalent of Acceptable Loadage Plots. Currently in Utilization Appraisal, trees are selected and marked for later identification, assessed for utilizable products, relevant heights are estimated and DBHOB is measured. When the tree is dropped and docked, stump height, the lengths of individual logs and their mid diameter are recorded (Appendix 18). In this manner the assessor can quantify his accuracy in length and quality assessment and adjust them for the local conditions (or products) and then apply this in his assessment of that area.

1979 MALLET INVENTORY

In 1979 an inventory of the plantation mallet (E. astringens) forests in the Narrogin district was initiated to provide resource level data specified by products. Previous inventory (ca. 1971) had established predictive relationships between various product specifications (e.g. tool handles) and the standing mallet tree. Secondary objectives included the collection of growth and mortality data.

Sample type and size varied according to forest type. Initial stratification was by forest blocks and planting years. Temporary striplines formed the basis of the assessment, but due to variation in quality and size specification of the products and the large number of stems per hectare different plot sizes were used. Plot length was 100m, with width varying from 2m wide (fencing material 5-10cm DBH) to 20m wide (mallet tool handle mill logs).

Sampling intensity varied from approximately 2% in pole and mature stands (< 40 years) to 1% in overmature and younger stands. In each transect trees were assessed for DBH, log utilisation and length, bole height and total height.

Permanent plots (same dimensions as the temporary) were established to improve the data base for volume estimation.

Within these plots, in addition to the parameters measured in the temporary plots, diameters (U.B.) were recorded at nominated heights up the tree (to 6m).

A computer program was developed to meet the specific requirements for data processing by product codes. Output summaries included presentation of product numbers per unit area (e.g. tool handles/ha).

1980 SANDALWOOD SURVEY

A survey of the commercially available sandalwood (Santalum spicatum) of the eastern goldfields and Murchison district (approx. 35 million ha) was commenced in 1980. This programme was the first systematic survey of the sandalwood resource carried out in W.A. and was initiated in response to concern over the extent of the remaining commercially available sandalwood and hence life of the sandalwood industry (Williamson, 1982 unpublished report).

The survey was, therefore, both a resource estimate and a management aid, providing a preliminary estimate of the life of the sandalwood industry whilst serving to pinpoint those pastoral leases having a commercially available resource.

A two man team was used to assess pastoral lease tracks and mineral exploration lines from a 4 wheel drive vehicle. Some trackless areas were assessed using a motor-bike for cross-country transport. All sandalwood present within 20 metres of each side of all tracks travelled in a pastoral lease were assessed. The diameter of each live sandalwood stem within this 40m strip was estimated and recorded in one of the following four size classes : 0-25mm diameter; 25-75mm; 75-125mm; and greater than 125mm. All stems greater than 125mm diameter at 150mm above ground level are of merchantable size.

At several localities within selected pastoral leases, for a distance of 1km along the track, the diameter of all sandalwood stems was measured (not just estimated) to enable growth to be taken into account when calculating the long-term life of the sandalwood industry.

Air photos were used as a basis for calculating the total sandalwood resource on each pastoral lease visited. Those vegetation types on the lease that did not have any sandalwood on them were identified using air photos and LANDSAT imagery. The remaining area of the lease was considered to have sandalwood on it at the same rate as the area assessed. A relationship had been developed between stem size and stem weight, hence the total sandalwood resource (in tonnes) on the pastoral lease could be calculated.

In the first two years of the survey, 0.8% of the total area of 4.6 million hectares of the pastoral leases visited was assessed. ~~Although~~ Assessment procedures were developed for a geographically dispersed resource in a region where vehicular access was not limiting, and ~~this~~ has proved to be a simple and effective method for carrying out an inventory over vast distances in semi-arid areas of W.A.

TREE VOLUME TABLES

The development in W.A. of an inventory system based upon measurement of individual tree volumes has necessitated the compilation of volume tables for each major species. Similarly, the desire to incorporate forest increment estimates into resource appraisal has required the development of a permanent plot network.

(i) Jarrah and Karri

Prior to 1918 log volume tables had been compiled to ascertain the volume of mill logs on log landings, based upon measurement of the length of log and girth under bark at the centre of the log (Huber's formula). With the promulgation of the Forests Act in 1918 standard tables were necessary (Regulation 32) to enable the volume of timber in the round contained in standing jarrah and Karri trees to be calculated.

The log volume tables (developed for royalty assessment) formed the basis of the first 'tree' volume tables used in W.A. (Harding, 1939). To facilitate the calculation necessary to ascertain the mid girth under bark (of a potential mill log) from the girth over bark at breast height (of the standing bole), tables were prepared that allowed for both taper and bark for various length logs. Measurements of a large number of felled trees were taken

and the average taper from breast height to mid-girth determined. For Jarrah the tables were constructed on a ~~base~~ basis of 2.5cm decrease in girth per 30cm of length for trees whose GBH was between 180cm and 270cm, and 3.8cm decrease per 30cm of length for trees over 270cm GHB. Originally published in tabular form (Anon., 1927), the taper table was eventually incorporated into alignment charts, where expressions of GBHOB and estimated merchantable height of log were aligned to derive an estimate of centre girth; this was then referred to log volume tables. A major disadvantage was that for both Jarrah and Karri these tables had been based upon, and were therefore only representative of, reasonably mature trees in virgin forest.

Around 1945 a Standard Volume Table for Jarrah was compiled in which volume was calculated using both centre girth under bark and log length. Few details of compilation procedures are available. GBHOB was probably calculated using a GBHOB/GBHUB relationship based on bark thicknesses measured in the Mundlimup Thinning Plots, with GBHUB presumably calculated using an average taper.

Similar methods were used to assemble Regrowth Volume Tables for Jarrah and Karri, published in 1956. Poles and piles of each species were measured for butt girth u.b., crown girth u.b., centre girth u.b., and log length. Stump height was not recorded (assumed to be 30cm), nor

was GBH or bole height. As previously, volume was calculated using centre girth u.b. and log length. Less than 200 trees, collected mainly from the Pemberton area (due to the difficulty of locating trees of the appropriate size elsewhere) were sampled for the Karri table. Representative points in height classes were plotted and then curve smoothing was used to produce the table.

Any volume table required periodic updating to incorporate changes in the population of interest. In 1957 a revised Jarrah volume table was produced using volume curves derived from (i) the "Regrowth Volume Table" produced 1956; (ii) the "Standard Volume Table" produced about 1945; and (iii) measurements of other sample trees measured up to 1957. The table related GBHOB and bole height to volume underbark from stump height to bole height. A graphical method of volume table construction was used.

Between 1960 and 1964 a new Karri table was developed using a data base of 311 trees for which acceptable sectional volume measurements were available. The distribution of sample trees within girth and height classes was heavily weighted in small sizes with inadequate representation of intermediate and very large sizes. (Ferguson, 1964 unpublished report). Because of the small number of

trees over a very large range of volumes and the costs associated with 'fitting' complex volume equations, the simple 'Combined Variable' equation was used to analyze the data.

i.e. $V = a+bxG^2Ht$

where V = volume underbark
G = girth at breast height under bark
Ht = length of bole
a,b = regression coefficients

Data processing involved partitioning the observations into thirteen separate G^2Ht groups and calculating (by computer) a separate regression equation for each group. The values listed in the resultant bole volume table therefore jumped irregularly from the high end of one range to the low end of the next. These values were then plotted on graph paper within height classes and harmonised curves were fitted to them by eye. From these harmonised curves volumes under bark were tabulated for combinations of GBHOB and bole height.

This Karri table was published in 1965, together with a revision of the 1957 Jarrah table incorporating a wider size class range to accomodate changing resource and utilization standards. For example, the 1957 table was

expanded to cater for smaller sized Jarrah material (down to 90cm) and provided for a nominal stump height and long butt allowance. The earlier Karri Volume Table was relative to average stump heights of 100cm for trees up to 270cm g.b.h. and 145cm for trees over 270cm g.b.h. Stump heights had, however, dropped significantly with the introduction of lightweight chainsaws.

In 1976 both of these tables were metricated with minor modifications (such as the addition of volumes to 1m and 2m bole lengths) to the 1965 imperial versions.

Work commenced in 1974 on the development of a new mature karri volume table. A mathematical model predicting diameter overbark at any particular height using DBHOB and height at crown break was developed for the purposes of constructing the tree volume table. Data was gathered from samples of standing trees using a photodendrometer method (Bradshaw, 1972). A total of 351 trees across 28 forest blocks were sampled to ensure coverage of the geographic range of karri. The model was used in conjunction with an underbark rule to calculate underbark diameter at nominated heights up the tree bole. The volume underbark of a particular section of the bole was then calculated using a mid-section diameter method (Huber's formula).

In 1976 the compilation of a karri pole volume table was initiated. The regrowth trees were felled and measured on the ground and came from a restricted area where large

size karri regrowth grows. Both the pole and mature volume tables are based on diameter models which predict diameter at any height based on DBHOB and a tree height measure. The table is entered by height class, which in the case of mature stems is bole height class and for regrowth stems it is total height class. The volumes in the table are total (under bark) volumes from the top of the stump to that particular height. Volumes of sections of the tree can be calculated by subtraction of volume to the top and bottom of the log. Both these tables were published in 1983.

(ii) Marri

Prior to 1969 the volumes of standing Marri trees were calculated using the Jarrah Volume Table of the time.

In 1968 over 200 Marri trees in the Manjimup/Pemberton area were sampled to provide a basis for a Marri Tree Volume Table. The plots, which were individual trees, were selected randomly, but an adequate representation of geographic range was ensured. Accurate sectional measurements were taken and volumes computed by weighted regression analysis of the form:

$$V = a + bG^2 + cG^2H + dG^4H^2 + eH + fH^2$$

where:

V = volume under bark

G = girth (b.h.) over bark

H = merchantable log length

a - f = regression coeffieients

This table was published in 1969.

Over 1970/71 a further 60 sample tree plots for Marri were measured throughout the northern and central regions. Each plot consisted of a tree from each of 4 girth classes (45-90cm; 90-150cm/ 150-225cm; 225+cm GBHOB) i.e. 240 trees were sampled. Trees selected were representative of the standard acceptable for chipwood in hardwood assessment, and after felling were measured on the ground using standard sectional method. This data was incorporated into a metricated revision of the Marri Volume Table, published in 1976.

Thus, over the years continual recompilation of the tree volume tables has been necessary. This ongoing need is due to a number of factors. For example, within each species the forest tree population developed into a mozaic of cutover, virgin, and regrowth stands as timber milling and management practices were applied. The differing growth characteristics of these forest types necessitated specific regrowth tables to be developed. However, the geographic area from which data was drawn was often limited by the extent of the resource (as was the case for the Karri regrowth table). Such tables could require revision as they are applied to an increasing range of sites.

Technological innovation has also contributed to the need for volume table revision. For example, the introduction of chainsaws markedly reduced stump allowances, whilst in the future, if total tree utilization were introduced major revision of the present tables would be necessary.

The advent of computer technology has enabled a wider range of analytical techniques to be used in volume table preparation. For example, the 'curve smoothing by eye' technique (1957 Jarrah table) has given way to elaborate regression models (1983 Karri tables). It is conceivable that the trend toward increasing complexity of computer analysis will continue for future volume table compilation.

LOG VOLUME MEASUREMENT

Hardwood log volume measurement in W.A. was originally based on the "Hoppus" or "Quarter Girth" system of measurement. Regulations incorporated in the Forests Act of 1918 introduced the full cubic measurement of timber for Royalty assessment purposes. The standard departmental method of calculating log volume has tradionally been to multiply the cross-sectional area at mid-log (under bark) by the log length. The volume underbark is computed on the assumption that the log is a perfect cylinder. Tables listing the volume of a log for each particular combination of length and mid girth were calculated and applied using a 2.5cm girth deduction as a bark allowance for each 30cm of log mid-girth, to a maximum of 20cm deduction.

The first complete set of tables were issued in handbook form in 1920 and reprinted in 1933. In 1946 a revised and extended version was published, reprinted in 1955 and 1968. With metrication in 1974 the emphasis shifted to diameter at mid girth measurement involving a new bark deduction rule of 10mm for each 100mm diameter of bark under the tape to a maximum of 70mm. This 1974 version, entitled "Cubic Contents of Hardwood Logs' is the current table.

HARDWOOD PERMANENT PLOTS

a) Permanent Growth Plots

Throughout the forest, a number of hardwood increment plots, intended for re-location and re-measurement at planned intervals, have been established. Their primary purpose is to monitor growth and increment but they are also used to supplement temporary sample plot data for resource estimation.

Campbell and Lush (1979) have detailed current procedures for the establishment and maintenance of increment plots in W.A. Plots (20m wide and varying in length up to a maximum of 400m) have been randomly located within all strata of the major forest types. The intensity of sampling varies with the forest type and stratum in the range 0.015 to 0.02%. Such a low sampling intensity does not provide sufficient plots to allow sound statistical analysis for the many different strata in the major forest types. By 1981 over 650 increment plots were registered, this cumulative total representing a build up over many years. For example, many of the jarrah plots pre-date 1945, whereas a substantial proportion of karri plots were established during since RLI (1963+). Many of the current plots have been established on previous permanent assessment lines (e.g. May's Line), but the differences in assessment standards over the years have presented problems when comparing previous assessments.

the Resource Level Inventory

For the purposes of growth estimates the plots are measured on a 5 or 10 year cycle. Tree parameters recorded include species, marketability class and diameter (DBHUB)/. Appendix 19. The log length or bole height estimates used for volume calculation have been derived as area - averages (for each DBHUB class) from RLI data.

Growth data are processed by a computer system which stores the data derived from every measurement. Selected pairs of measurements may be retrieved to produce statements of current plot stocking, basal area and volume, and estimates of the periodic MAI in diameter, basal area and volume. All of these parameters are tabulated by species, tree marketability class, and tree diameter. Estimates of mortality and ingrowth are also presented.

This represents a low cost method of obtaining broadscale growth data on selectively cut stands. The volume increment rate is used in the calculation of long term yield estimates. The rate of growth on these forest types (particularly jarrah) is relatively slow and has minor impact on medium term yield estimates.

Recently (1982) over 200 increment plots have been established throughout the regrowth karri resource of the south-west. The resource comprises a large area (6000ha) of 1930's regeneration and virtually nothing from then until the late 1960's when clearfelling restarted. Hence the distribution of the regrowth karri resource

through an envisaged rotation of 100 years is very skewed. Plots have therefore been subjectively located to represent as many age classes as possible. The skewed age distribution has meant that not all age classes are able to be presently sampled so stem analysis has been carried out on older trees to gather the missing information.

The regrowth plots are square (30m x 30m) and have a variable remeasurement schedule dependent upon the age of the trees e.g. it is planned to remeasure every 2 years until age 5, every 5 years from 5 - 20 years, and every 10 years thereafter. The size of the subplots within each plot will also be varied with age to compensate for natural thinning processes within the stand.

b) Permanent Plots for Utilization Standards

Permanent plots have also been established for the specific purpose of enabling changing utilization standards to be monitored in future years and, in the short term, to relate MLI to RLI estimates. These plots have been seen as providing an essential link with the temporary hardwood inventory. The temporary assessment of the hardwood forest at management level inventory represents a considerable investment of time and money in collecting, processing and providing information for the hardwood inventory system. By establishing a subsample of

permanent plots a standard can be provided on which to gauge any changes and adjust the information supplied by the larger sample of temporary assessment.

For convenience, in each region the permanent plots have been incorporated into the growth plot network. Measurements recorded in the permanent plots therefore include the length and utilization class of each log likely to be produced by every sample tree. The log measurement data may then be used to calibrate temporary sample plot data which often do not include log measurements.

DISCUSSION

Figure 2 outlines the chronological sequence of major hardwood assessment programmes in W.A. Hypothetical time periods over which several factors influencing inventory design (Fig. 1) have predominated are also presented.

The design of inventory has been dominated by the changing nature of the information required. For example, the need for a basis upon which to justify reservation of land as State Forest (rather than be cleared for agriculture) was a major impetus for initiation of the 1916-1921 timber classification. Design of the survey reflected the limited forest access and the paucity of skilled personnel characteristic of that era. In latter years the adoption of a sequential sampling system for IMU assessment reflected the specific management need of assessing the effectiveness of stand stocking as an aid to thinning decisions. The shift from resource to management level inventory in the 1970s represented a need for more precise, comprehensive resource data to facilitate intensive forest management.

Many factors have led to modification of measurement procedures without changing the actual basis of yield calculation. For example, whilst the changing forest structure and hence marketability standards have continually altered the girth limit above which trees have been measured, other components of the forest sampling design (plot size, allocation) have tended to remain the same. The accessibility of the forest and availability of funds and skilled personnel have represented limiting factors to the geographic extent or intensity of sampling until comparatively

recently (~~post~~ after 1950s). These factors may have indirectly influenced the nature of forest sampling designs, in particular the use of permanent assessment lines of substantial length (e.g. May's line) in preference to randomly located plots (e.g. RLI).

Thus, despite the use of a number of forest sampling designs, within the inventory system the essential characteristics of yield calculation in W.A. have remained the same. Yield estimates have traditionally been determined from simple formulae involving only the area of forest and the volume of growing stock: consequently temporary sampling units have predominated. Volume of the growing stock is derived as the sum of the volumes of individual trees; these being determined by referring tree DBHOB (previously GBHOB) and an expression of height to 2-Way tree volume tables. The nomination of the upper limit of "merchantability" is done visually according to current mill specifications. Defect, potentially a major source of bias in estimates of the growing stock and its increment, is accounted for by nominating log length deductions when assessing individual trees.

The efficient implementation of any system of yield regulation based on individual trees requires information on the nature of those trees in relation to the harvesting process. For this purpose trees are often classified according to those attributes with which increment is correlated and which guide the decision to remove or retain a particular tree e.g. stem quality, size and position of crown. According to their utilisation potential the trees have been classified as sawlogs, poles, chip logs, or fire-wood.

Changes in standards of utilisation or silvicultural methods necessitate adjustment or updating of this data base. Data processing and storage by computers facilitates such adjustments as and when necessary.

HARDWOOD ASSESSMENT IN THE 1980's

Outputs from the hardwood inventory system currently service management level planning and resource level planning, and cater for working plan revision data, changes in sawlog marketability, permit life, growth calculations, long-term yield estimates, new project data, and control system checks.

The recent installation of on-line computer facilities at Regional centres has facilitated the storage and processing of inventory data. Concurrently, attention has focused upon the investigation of several sampling designs (e.g. multiphase ground sampling) which may enable standardisation of field sampling techniques for both resource and management level inventories.

Hopkins (1983) predicts the development of more flexible evaluation procedures to cater for the increased information requirements associated with multiple use forestry. The focus will be towards total inventory, whereby a range of biophysical attributes - not simply timber values - are recorded within a given sampling frame. Coupled with computerised information systems this should allow available raw data to be assembled to provide the best classification for the current decision process.

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APPENDICES

Although metric units have been presented through the text, it has been necessary to include appendices in imperial units. The following conversion factors are included to provide a basis for comparison.

Appendix 1 indicates the approximate location of assessment referred to in the forest.

LENGTH	1 inch	=	2.54 cm
	1 foot	=	0.305 m
	1 chain	=	20.12 m
	1 mile	=	1.61 km
AREA	1 acre	=	0.405 ha
VOLUME	1 load	=	50 cu ft
		=	1.416 m^3
	1 cu ft	=	0.0283 m^3
OTHER	1 cu ft/acre	=	0.07 m^3/ha

LIST OF ABBREVIATIONS

A.P.I.	Air Photo Interpretation.
cm	Centimetres.
D.B.H.O.B.	Diameter at Breast Height Over Bark.
D.O.B.	Diameter Over Bark.
G.B.H.	Girth at Breast Height.
G.B.H.O.B.	Girth at Breast Height Over Bark.
G.B.H.U.B.	Girth at Breast Height Under Bark.
G.P.	General Purpose.
ha	Hectares.
H.O.C.S.	Hardwood Operations Control System.
I.M.U.	Intensive Management Unit.
Km	Kilometres.
m	Metres.
M.A.I.	Mean Annual Increment.
M.L.I.	Management Level Inventory.
mm	Millimetres.
R.L.I.	Resource Level Inventory.
S.E.	Sampling Error.
S.E.C.	State Electricity Commission.
S.M.P.	Sawmill Permit.
T.D.O.B.	Top Diameter Over Bark.
U.B.	Under Bark.

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U.B.	Under Bark.

HARDWOOD ASSESSMENT IN WESTERN AUSTRALIA

Reference Material Documentation

this one
not for public
but to be available at
the library + 14 P offices

The material referenced herein was consulted in the course of writing the report 'Hardwood Assessment in Western Australia' (Rayner and Williamson).

The list should be considered a starting point for further investigation, as it is by no means complete. Many historical records are poorly documented, and often only one individual at a particular location had any knowledge of what was stored or available (eg. Dick Speldwinde or Owen Loneragan). None of the archive stores visited were properly indexed.

M. RAYNER

March 13, 1984

TOPIC		FILE DESCRIPTION
RLI	Statistical formulae used in sampling.	B1.1 Vol 1 (Arch) 7/1/71
RLI	Stratification schemes used by Manjimup W.P.O. since 1965/66.	B1.1 Vol 1 (Arch) 19/5/70
RLI	Policy and procedure re Marketability Classes.	B1.1 Vol 1 (Arch) 10/3/70 18/12/69
RLI	Marketability Codes 1969.	B1.1 Vol 1 (Arch) 18/3/69
RLI	Statistical procedures for plot allocation.	B1.1 Vol 1 (Arch) 8/9/67 11/9/67
RLI	Assessment Procedures : Instruction to Assessors (10 Page booklet and complete field sheet) 1966.	B1.1 Vol 1 (Arch) 13/1/66
RLI	Costs per plot : Shannon Project 1969.	B1.1 Vol 2 (Arch) 12/6/73
RLI	Plot allocation : Dwellingup & Kelmscott.	B1.1 Vol 2 (Arch) 16/2/71
MLI	Experimental Development.	B7.1 4/4/73 9/11/73
MLI	Background information (Southern Region) Field assessment procedures.	B7.1 9/9/74 B7.1 9/9/74 appended
MLI	Integrated Logging Plan 1980 (Northern Region) Permanent Plots (Procedure) API Classification Marketability Specifications)	B7.1 5/7/81)) appended
MLI	Rationale.	B7.1 10/5/72
MLI	Comparison of line distances (between lines).	B7.1 9/11/73
MLI	Procedure/Original Design.	B2.1 7/2/79
MLI	FD 629 Codes as @ 22/9/76.	B2.1 23/4/75
	Mallet Inventory 1971	B1.2 3/11/70
	Mallet Inventory 1979 Procedures	B1.1 Vol 1 16/8/79

	Comparison of assessment standards for Southern Region: MLI vs RLI	B1.8 26/2/76-6/8/76
	Southern region: changes in marketability standards.	B1.9 (General B1.8 25/11/74
	Regrowth Karri Mensuration needs.	B2.1 4/3/81
	Permanent Inventory Plots.	B2.1 5/12/79
	Computerisation of Hardwood Inventory Systems.	B1.1 Vol 3 1/12/81
	Current Utilization Appraisal Techniques.	M1.4 11/6/80
	Timber royalties 9/74.	B1.1 Vol 2 (Arch) 7/9/74
	Preliminary HOCS design.	B1.1 Vol 2 (Arch) 12/6/73
	Acceptable Loadage Procedure for MLI (includes sample field sheet).	B7.1 10/9/74
	Marketability standards (1974) for Karri and Jarrah.	B7.1 Appendix 10/9/74
MLI	Rate of MLI Assessment	B7.1 22/8/74
	Summary of inventory techniques/procedures used by Australian Forestry Depts/ Commissions @ 1969.	B2.1 Vol 2 (Arch) 15/10/70
	Metrication of Log Volume Measurement.	M3.2 Vol 1 (Arch) 8/5/73
	Calculation of Cubic Content of Logs.	258/65 8/11/66 (FOF) 11/7/66 5/6/58
TVT	Jarrah Regrowth Volume Table. Taper studies, sample tree data, derivation of tables.	HOF 1591/38 (Arch)
TVT	Taper tables and tree volumes for Karri. Documentation of first tree volume table for Karri. Includes data sheets for sample trees.	HOF 695/43 (Arch)

IP	Costs of measurement of Hardwood increment plots. Central Region, 1970.	BUN B2.2 21/1/71
IP	Map of location of Hardwood increment plots for central and Northern region as at 31/12/71.	BUN B2.1 (Arch) 31/12/71
IMU	Assessment fieldsheets and worksheets for Harvey, Mundaring, Collie, Dwellingup, Kelmscott, Kirup.	BUN D19.1-8 (Arch)
TVT	Procedure for Mundlimup Thinning Plots.	BUN B2.1 (Arch) 14/6/71
TVT	1963 Karri Volume Table Compilation.	MAN M1.4 (Arch)
TVT	Alignment Chart for obtaining Mid-Girth Under Bark of Mill Logs Contained in Standing Jarrah Trees.	MAN M1.4 (Arch) 12/2/56
IP	1956 Assessment Procedure for remeasurement of hardwood increment plots.	BUN B2.1 (Arch) 18/9/56
IP	Remeasurement of Half-acre Jarrah and Karri Sample Plots.	BUN B2.1 (Arch) 7/9/59
IP	Increment plot selection and procedure.	BUN B2.1 (Arch) 11/12/62
	1936 Soil-Site Quality Survey of 40,000 acres of Wilga scrub (Kirup). Original report.	MAN 14/37, 44/37 (Arch)
	1936 Jarrahwood Soil Survey and Assessment (Helms and O'Donnell). Original report.	MAN 13/36 (Arch)
	1935 Stocktaking in the Jarrah Bush. Soil and Forest Assessment Report for Jarrahwood/Cundinup area.	MAN 13/36 (Arch) 14/9/35
	1937 General Working Plan for Jarrah Notes on information requirements, compilation procedures.	MAN 31/37 (Arch)

	Mallet Project (Narrogin)	B7.1	19/8/81
IP	Jarrah and Marri Increment Plots. 1961 Instructions to assessors.	B2.1 Vol 2 (Arch)	13/12/60
IP	Field procedure for 1972 hardwood increment plot remeasurement. Includes sample field sheet (FD 575).	B2.1 Vol 2 (Arch)	4/5/72
IP	Location map of hardwood increment plots for Northern Region as at 6/1/72.	B2.1 Vol 2 (Arch)	31/12/71
IP	Hardwood increment plots to 1975.	B2.1 Vol 2 (Arch)	12/9/75
IP	Increment summaries from 1959, 1964, and 1970 measurements of Hardwood increment plots.	B2.5 Vol 1 (Arch)	
IP	1972 Increment Plot remeasurement. Includes Increment Plot fieldsheet FD 575, 1972.	B1.1 Vol 1 (Arch)	4/5/72
IP	Increment Plot procedure	B2.1	5/5/81
IP	Lush and Campbell (1979): full summary of information.	B2.1	7/2/79
IP	Costs of establishment and remeasurement till 1971.	B2.2	26/1/71
IP	FD 575 Sample field sheet.	B2.2	21/7/80
IP	Hardwood Increment Plot Register Includes Year of establishment, subsequent cut-overs and remeasurement for all plots	B2.6	
IP	Increment Plots in even-aged Karri stands.	B2.10	
IMU	Intensive Management Units Kirup experimentation.	D10.5	
IMU	Collie. Complete Documentation including cost of assessment, procedures, plans prepared, sample field sheets, and recommended prescriptions.	D10.4	

IMU	Manjimup Trial Assessment.	D10.6 1/6/73
IMU	General Policy and procedure Objective re dieback.	D10.1 30/5/72 20/6/72
TVT	1957 Jarrah Volume Table App 2 is a plot of the Volume Table.	M1.4 12/4/72
TVT	Jarrah Vol Table Metric Converstion.	M1.4 25/7/73
TVT	Metrication of Hardwood Vol Tables	M1.4 1.7.75 4/11/74
TVT	Hardwood Volume Table Revision/Comparisons.	M1.4 11/6/80
TVT	Comparison of Volume Tables using Acceptable Loadage Plot data 1973.	M1.4 11/6/80 (App)
TVT	1976 Karri Volume Table.	M1.4 25/2/76
TVT	Mature Karri Volume Table.	M1.4 22/7/82 - current
TVT	Marri Tree Volume Table 1969. Revision	M1.5 1967, 68, 69 Correspond. 1970
TVT	Mature Karri Volume Table	
	- photodendrometer studies	M3.4 18/6/79 N5.1 Vol 2 9/7/79
	- shape model derived/ testing	N5.1 Vol 2 23/8/80
	- geographic distribution of sample trees	N5.1 Vol 2 5/11/80
	- development of dendrometer techniques	M3.4 1974
TVT	Pole Karri Volume Table	
	- diameter at height models	M1.6 23/1/81
	- model requirements	M1.6 4/6/80
TVT	Karri Bark thickness studies	M4.3
	Hardwood Pole Assessment 1970	B1.1 Vol 1 (Arch) 29/7/70
	Changes in sawlog marketability standards 1970 to 1975 (Assessment of increment plots to give change in merchantability standards).	B1.7 26/2/76

TVT	Jarrah Regrowth Table.	HOF 1592/51 (Arch)
TVT	Jarrah Regrowth Volume Table. Log form and Bark Thickness (Taper Tables).	HOF 581/35 (Arch) (Held in State Archives)

MATERIAL	LOCATION/CONTACT OFFICER
May's Permanent Assessment Line Field books for lines north of Collie. Original topographical maps.	Como Research O. Loneragan
Permanent Assessment Lines pre 1955 (including May's Lines, temporary assessment lines, quarterly cutting assessments); 80-scale series of maps for south-west.	Como I&P J. Williamson
1928 Map of Forest Areas. Presumably compiled on the basis of 1916-1921 timber classification survey.	Como I&P J. Williamson
1963-1972 RLI Assessment. Map of sequence of assessment by forest blocks.	Como I&P J. Williamson
Original worksheets for height-girth studies of Jarrah (1938) and crown size studies (1956).	Como Research O. Loneragan
Karnet and Dombakup Working Plans. Compiled by Campbell and McNamara 1956/57. Copies only.	Bunbury I&P R. Hearn
Permanent Growth Plots. 1956 Remeasurement. Field books/ sheets for Northern Region Southern Region.	Como Research Manjimup I&P
Chalk Brook Permanent Plots. Summary and location of 1937, 1948, and 1957 measurements for 3 plots. Report for 1937 Chalk Brook project. Originals.	Como I&P
Hardwood Assessment 1970-1983. Notes to assessors, procedures. Comprehensive documentation of RLI, development of MLI in Southern Region, application of MLI in Northern Region, Working Plan compilation.	Kelmscott I&P D. Speldwinde (personal copies)
1917-1923 Timber Classification Maps. Complete set of maps covering south-west forests. Includes originals and some copies on Lands Dept. base maps.	Como Store D. Cox (Mapping Branch)

MLI Original field sheets for all Southern Region coupes assessed, indexed by Forest Blocks. Field sheets for miscellaneous assessments (e.g. photodendrometer studies) have also been retained.	Manjimup I&P Store
Working Plan Assessment 1954/55/56. Complete, chronologically indexed set of field books for southern region lines. Example of this field book and parameters assessed in Nunn and McNamara (1963).	Manjimup I&P Store
1959/60/61 Temporary assessments. Field books for Southern region. Same format as presented in 1965 (preliminary RLI work).	Manjimup I&P Store
1938 Southern Region Classification. Incomplete collection of field/note books used to record chainage, estimated marketable loads/acre, loads removed/acre, and "quality" of bush along a traverse. Extent of such survey work is undocumented.	Manjimup I&P Store
1938/40 Permanent Assessment Lines of varying length, offset perpendicular to base lines. Approximately 50 field books of Southern region locations.	Manjimup I&P Store
1954 Quarterly Assessment of Cut-Over Bush. Several field books for southern areas.	Manjimup I&P Store
1931/34 Type mapping of various state forests in Pemberton, Manjimup areas. Note books used to record topographical features along survey lines and classify forest type.	Manjimup I&P Store
1953 Remeasurement of 1943 plots. Limited collection of field books.	Manjimup I&P Store
1946/47 Walpole Assessment. Field books to record (estimate) volume of millable timber (loads/acre) in 3 girth classes for Jarrah and Karri.	Manjimup I&P Store

1953 API Assessment lines. Field books for lines, containing original API codes.	Manjimup I&P Store
Permanent Increment Plots. Complete set of field books (i.e. for each remeasurement) for plots No. 822, 823, 827, 828, 829.	Manjimup I&P Store
1961 Permanent Increment Plots. Over 50 plots established (Southern Region), complete set of field books.	Manjimup I&P Store
1930 Land/Forest Type Classification Maps. Limited coverage of southern region, appears that on basis of 1920 maps areas of prime forest were re-surveyed.	Manjimup I&P Store
RLI Complete set of API plans showing location of each RLI plot and when it was measured, for the southern region. Indexed by W.P.A.'s and Forest Blocks.	Manjimup I&P Store
Cutting Plan Assessments 1960. Maps showing location of lines run for Central region estimates.	Bunbury I&P
RLI Plot sheets (F.D. 523) for each plot in Central region, indexed by Divisions.	Bunbury I&P File B1.2 (Arch)
1961 field books for remeasurement of hardwood increment plots. Incomplete record of central region plots.	Bunbury I&P
RLI Computer printout summaries of volume estimates by SMP and division. (Central region).	Bunbury I&P
1929 Timber Classification (?) Field Books. Incomplete set.	Como I&P
MLI fieldsheets (F.D. 629, 1977) for each forest division, including volume summaries and SMP index. Central Region.	Bunbury I&P

1983 Assessment of Jarrah Forest. Boyanup, Argyle and Raymond timber surveys (Girth limit for measurement of 72" g.b.h.).	MAN 33/83 (Arch)
Jarrah Taper. Graphs of Pole taper. Original graphs of jarrah diameter-taper work, from 1934 (Helms at Ashendon) through to 1960's (Airey). File 1591/38 refers.	O. Loneragan Como Research

PERSONNEL	SECTION
Owen Loneragan Barney White	May's Line, 1940/1950's permanent assessment procedure
Eric Hopkins	Classification Lines, Total Inventory
Hugh Campbell	Current MLI/Proposed Inventory systems
Jim Williamson	RLI, post 1950's development of inventory
Dick Speldwinde	MLI (Northern Region). Permanent Plot establishment, Utilization appraisal
Allan Lush	MLI (Southern Region) HOCS development
Alan Briggs	Karri Volume Tables, Hardwood increment plots
Roger Hearn	Current development of RLI/MLI work
Phil Shedley	Permanent assessment lines, May's Line.
Dave Lejeune	Permanent assessment lines.

BRG 140°T TIE POINT [illegible]

INVENTORY AND PLANNING HARDWOOD INVENTORY

TITLE:

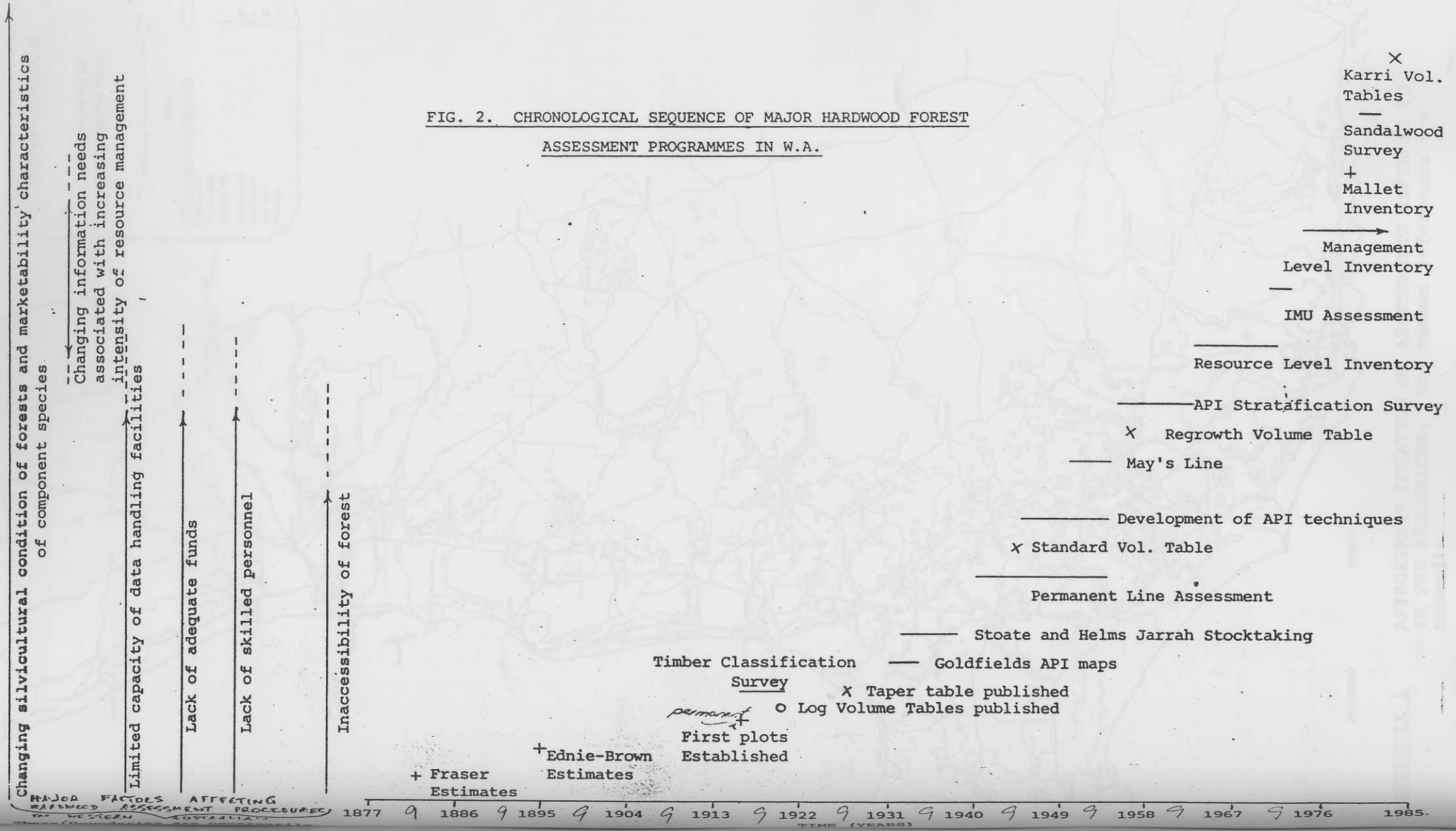
c). Plot: 100.6 m at 140°T

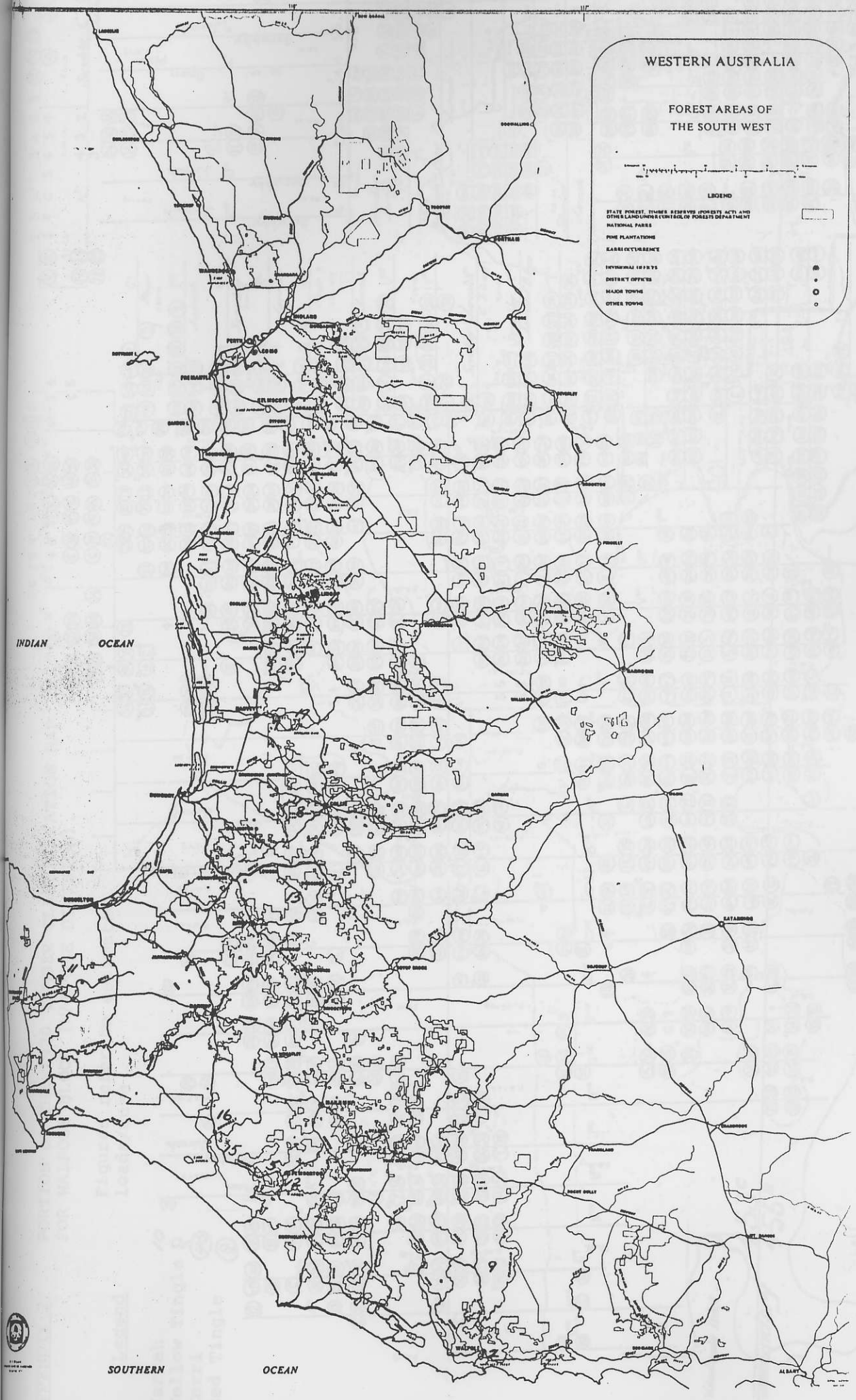
Div No	Blk No.	Cpe No	Ass'mt Line	Type Ass'mt	Subplot Size Length (m)	Subplot Size Width (m)	Prod Class	Block Name	Date Mth	Date Yr	F	D	J	K	L	P	Ass'mt Line Length (m)
1	0	1	4	0 3 5	I	P 1 0 0.6	0 2 0	1 2 4 2 3 4 - 5 6 2 3 4 5 6	KENT	0 5	8 2	1	0	1	0	0	1	1 0 0.6
							Percent	1 0 0 60 50 50 1 0 0 1 0 0 50										

Ass'mt Line No	Distance (m) Tree No	Forest Type	Sp	DBH (cm)	TC	TS	Log 1 U	Log 1 M	Log 1 Ht	Log 2 U	Log 2 M	Log 2 Ht	Log 3 U	Log 3 M	Log 3 Ht	Log 4 U	Log 4 M	Log 4 Ht	Log 5 U	Log 5 M	Log 5 Ht	Log 6 U	Log 6 M	Log 6 Ht
0 3 5	1		5	32	1	6	G		60															
	48		1	49	6	6	F		25															
	4		5	37	1	5	C	1	00															
	6		1	53	1	3	A	1	10	C	1	55												
	9		1	108	1	3	W		20	B		60	G	2	60									
	50		1	89	6	6	F	2	20															
	12		1	60	1	3	A		90	G	1	20	X	1	40									
	14		5	85	1	5	8	1	60															
	52		1	37	6	6	F		70															
	18		1	53	1	3	A	1	00	X	1	15												
Y	26		1	62	1	3	A	1	80															
0 3 5	32		5	50	1	5	C	1	80															

Tree No	Sp	DBH (cm)	TC	TS	Log 1 U	Log 1 M	Log 1 Ht	Log 2 U	Log 2 M	Log 2 Ht	Log 3 U	Log 3 M	Log 3 Ht	Log 4 U	Log 4 M	Log 4 Ht	Log 5 U	Log 5 M	Log 5 Ht	Log 6 U	Log 6 M	Log 6 Ht
2	5	39	1	5	C		60	X	1	20												
3	1	63	1	3	W		15	A	1	00	6	1	40									
5	1	68	1	3	A	1	10	W	1	70	8	1	95	C	2	25						
7	1	49	1	3	A		80	C	1	20	X	1	30									
49	1	45	6	6	A		30															
10	1	32	1	6	G		60															
13	1	60	1	3	A	1	20															
15	1	46	1	5	G	1	30															
17	1	56	1	3	A	1	30															
21	1	66	1	3	W		10	A		80	W	1	05	8	1	45	X	1	75			
27	1	73	1	3	A	1	60	6	2	00												

FIG. 2. CHRONOLOGICAL SEQUENCE OF MAJOR HARDWOOD FOREST ASSESSMENT PROGRAMMES IN W.A.





APPENDIX 1 APPROXIMATE LOCATION OF ASSESSMENTS REFERRED TO IN THE APPENDICES. The number references the Appendix.

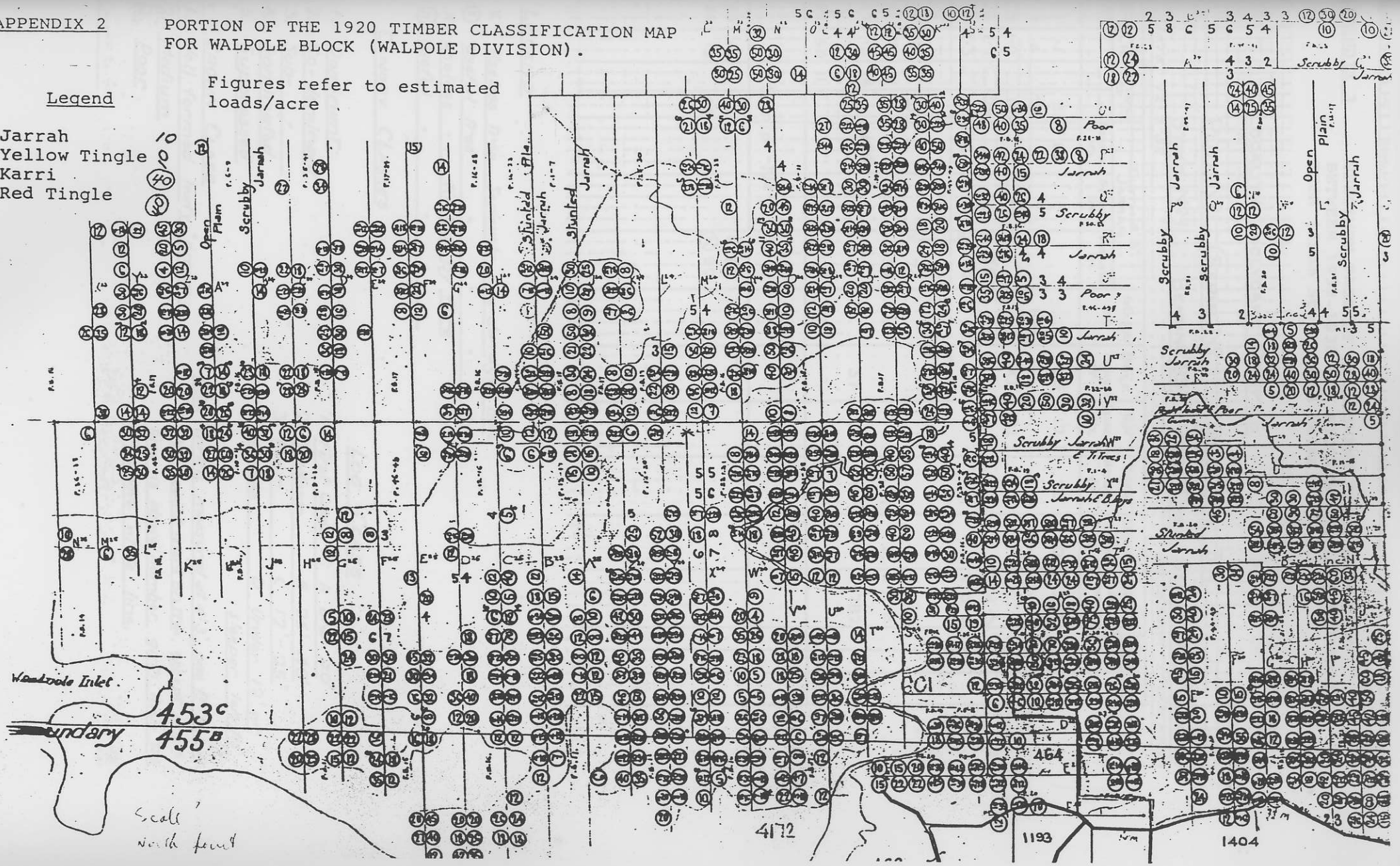
APPENDIX 2

PORTION OF THE 1920 TIMBER CLASSIFICATION MAP FOR WALPOLE BLOCK (WALPOLE DIVISION).

Legend

Figures refer to estimated loads/acre.

Jarrah
Yellow Tingle
Karri
Red Tingle



APPENDIX 3 SPECIMEN PAGE OF ASSESSMENT FIELD BOOK USED BETWEEN 1932-1938 FOR STOCKTAKING IN THE JARRAH BUSH (from Stoate and Helms, 1938).

LOCALITY HOLYOAKE COMPT 5

PLOT No1 (STRIP No) SOIL TYPE 3A

STRIP No4 BEARING 95° ZERO POINT ½CH. N. OF S.W. CORNER

DATE 12.2.38 ASSESSOR P. JACKSON

TREE No	CH	DISTANCE ft −	DISTANCE ft +	GIRTH 4'3" JARRAH Useful in.	Stumps in.	Useless in.	MARRI IN.	BOLE LENGTH ft	TOP DIAM. in.	TOTAL HEIGHT ft	CROWN DIAM. ft	CANOPY LDG. CROWN CLASS	SAPLINGS JARRAH Good	Poor	MARRI
	.1		5	60				35	12	75	20	2·2B3			
2	.4		25				105					2			
3	1.0		10		95			41	21						
4	1.2		20			25						4·4·3			
5	1.3		7			(X) 110						2·3·3			
6															
30	4.9		21			X 74						3·4·3			
31	.3	16				54						3·4·3			
32	.5	26		120											
								37	27	110	42	1·2B2			
62	5.0	11					70					3	2	25	11
				STRIP No 2											
63	.4		15			K 85									
64	.5		25			(K) 92									

LEGEND

X Useless tree. Seriously fire-damaged bole
(X) Useful tree . . . .
K Useless . Killed by fire
(K) Useful . . . .

CANOPY CLASSES

1. Dominant
2. Co-dominant
3. Sub- .
4. Dominated
5. Suppressed

CROWN CLASS

1. Well formed leafy "crown.
2. Medium
3. Poor

LOG CLASS

1. First Class. A over 40'
2. Medium B 25'-40'
3. Poor C 12'-25'
4. Useless D Under 12' or sleeper length.

Note. Girths measured at 4'3" one ft below white paint mark on tree, except when line is above number, girth then taken 1ft above white line.

APPENDIX 4 SAMPLE PAGE FROM A FIELD BOOK USED FOR PERMANENT ASSESSMENT IN THE DWELLINGUP AREA, 1942.

Line No. 6 from 2099 West of FW 53/3 going South 25.3.42

Chainage Links	Dist. ft.	G.B.H.	Merch. Log	Pot Log	Ce.G.	Crown Girth	Lgth.	Crown die	Est. Vol.	Remarks
033	47	113	34				30	8"		25'
190	-45	50½								Kink at
256	-43						30	8"		Scarred 5'
300	-54	77	25	8						8' above. side limb
293	26	84½	30							
273	58	84	52							dead top sap limbs
331	-8	82	23	16						Potential very kinky
441	-24	66					42'	13"		
483	-60	81	24							big lean
511	-66	89	38							
514	6	100	43							
528	-6	95	41							
617	-34	99	16							
666	-56	53½					20'	10"	20' 5-7s.	very kinky
696	51									
830	-42	83	40							
880	-24	86½	38							
920	-5	41					30	6		
975	-21	80½	43							
975	-50	73½	27	5						5' above kink Meas. above & Bel.
1041	-9	66	20							

EXPLANATION OF CODES ASSOCIATED WITH THE 1942 FIELD BOOK

Tree Classification

Standing trees were primarily classified according to girth classes.
"A" class - g.b.h. greater than 90".
"B" class - g.b.h. between 72" and 90".
"C" class - g.b.h. between 60" and 72".
"D" class - trees of below 54" g.b.h. which would made good piles or poles.

These girth classes were sub-divided as follows:

A1	Trees retained, or which will be retained by the marker as growing stock.
A2	Mill logs. Trees retained other than those held as growing stock.
A3	Poor quality mill logs (which should be taken by the mill).
B1	Growing stock - well formed, vigorous trees growing for future cutting, above 90" g.b.h.
B2	Poor quality trees that will probably not reach A class.
C1) C2)	Similar sub classification to B class above.
D(P)	Pole trees. A 20 ft length and 6 inch crown diameter was regarded as minimum recording size.
R1	Removed tree with a stump girth of above 90".
R2	Removed tree with a stump girth below 90".

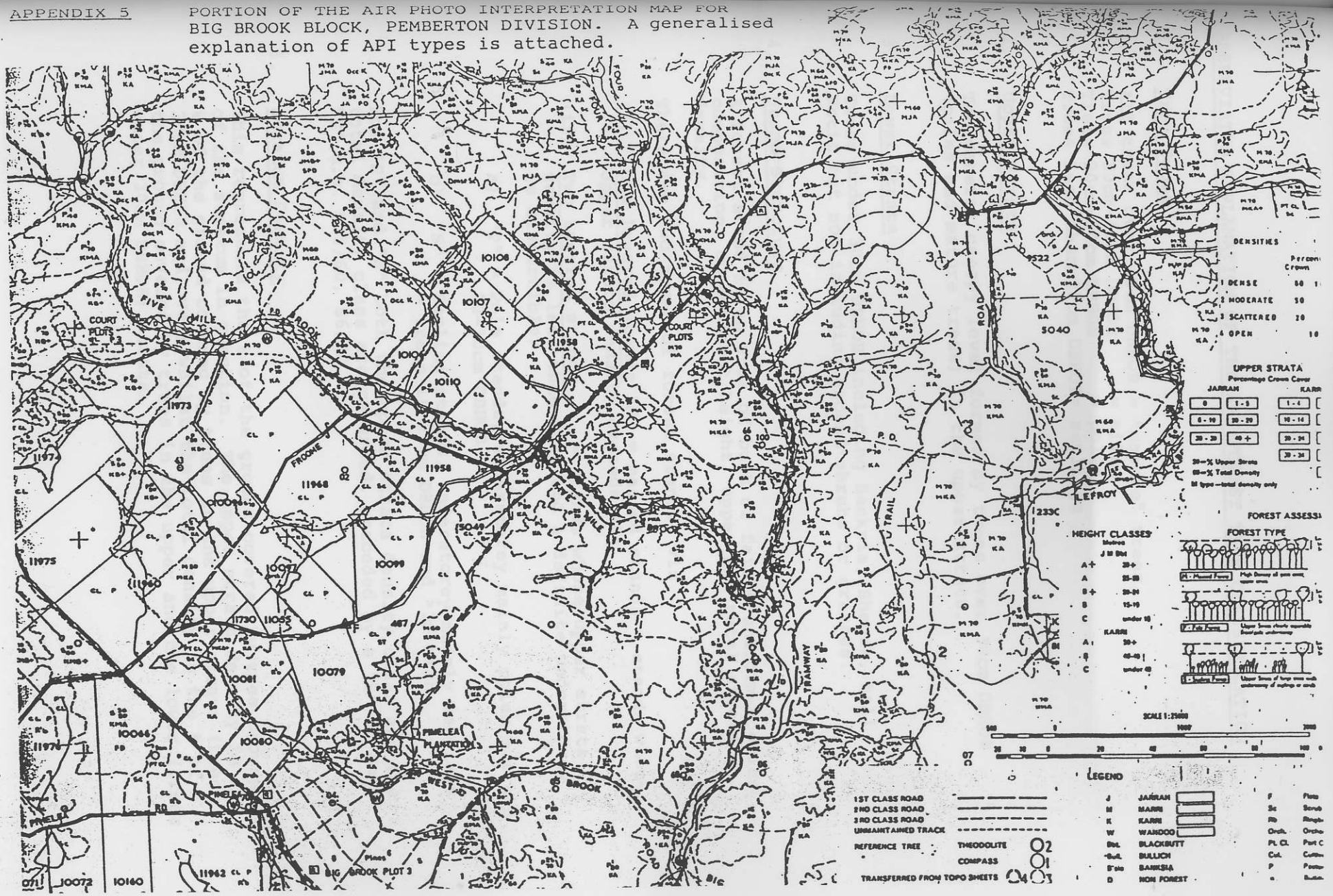
Where two cuttings had taken place the older cut was identified by circuling the R1 or R2.

"Ch"	The chainage of the tree along the assessment line from the starting point.
"Dist"	The distance of the tree at right angles from the assessment line. Trees to the left carry a minus (-) sign, and those on the right a plus (+) sign.
"Sp"	Species - J for Jarrah, M for Marri, B for Blackbutt.
"Class"	According to classification detailed above.
"G.B.H."	Girth measured overbark at 4 ft 3 ms from the ground on the high side of the tree.
"March log"	The length, in feet, of the millable log contained in the tree, measured or estimated from ground level.
"Pot Log"	The length, in feet, of any potential log such as second log growing above the butt log and separated by a large branch.
"Centre Girth"	Not normally used in the field - necessary for volume calculations using the log volume table.
"Crown Girth"	Girth of top or crown at "crowing off" point. (Used in the case of removed timber only.
"Poles and Piles"	Length in feet. Top diameter in inches.

(CROWNING)

APPENDIX 5

PORTION OF THE AIR PHOTO INTERPRETATION MAP FOR BIG BROOK BLOCK, PEMBERTON DIVISION. A generalised explanation of API types is attached.



ABBREVIATED EXPLANATION OF THE API FOREST TYPE CLASSIFICATION

1. Tree Types

All trees over 48cm DBHOB = "mature" trees
Trees 30cm-48cm DBHOB = piles
Trees 20cm-30cm DBHOB = poles
Trees less than 20cm DBHOB= saplings

2. Upper Strata

The general canopy level formed by trees over 30cm DBHOB (piles and mature trees) in the upper strata.

3. Lower Strata

Trees under 30cm DBHOB including Banksia, Sheoak, tall Xetic but not including ground shrubs or grasses.

4. Stand Sturcture

A forest stand is an area of bush of fairly uniform species composition, co-dominant height, upper and total strata density.

There are two types of forest stands, viz

(i) One layered stands "M" = massed stands = stands whose upper strata density exceeds 40%.

(ii) Two layered stands = stands whose upper strata density is less than 40%, and a definite understorey is discernible.

a) "P" = Pole stands, understorey mainly poles = trees 20-30cm DBHOB

b) "S" = Sapling stands, understorey mainly saplings = trees 10-20cm DBHOB and >3m high

For "P" and "S" both the upper strata density class and the total density class are recorded, preceded by a "P" or an "S" e.g. P20/60, S6/20.

5. Stratum Density

This represents the % of the ground covered by tree crowns of the stratum in question. The upper strata density is the % of the ground covered by trees in the upper strata (trees 30cm DBHOB and over) whilst the total density is the % of the ground covered by trees in the upper and the lower (trees under 30cm DBHOB) strata.

..2/

6. Species

When two or more species occur in a stand each species receives a mention in the API classification only if it makes up more than 20% of the stems over 10cm DBH.

The species mentioned first is the major species, having the most trees per hectare over 50cm DBH. Species are coded as follows:

Jarrah	J	Blackbutt	Bbt
Karri	K	Yellow Tingle	TY
Marri	M	Red Tingle	TR
Wandoo	W		

7. Height Class

The stands are classified by co-dominant height class. Co-dominant height is the height of the trees just below the dominants, corresponding to the height, of the general canopy level. There are two height schedules:

a) stands in which karri or tingle and karri are the major species

A	50m and over
B	40-49m
C	<40m

b) stands in which karri is not the major species

A+	30m and over
A	25-29m
B+	20-24m
B	15-19m
C	<15m

8. Additional Classifications

Further descriptions are sometimes added after the A.P.I. classification e.g. 'V' Virgin forest
'F' Flats/non forest in swampy areas
DB Forest affected by dieback

9. Expression of the Classification

a) One layered stands

(stand structure((total density) (species) (height class) (additional classifications)

e.g. M 60 JMA Sc F'D

..3/

b) Two layered stands

(stand structure) $\frac{\text{Upper stratum density}}{\text{total density}}$ (species)
(height class) (additional classifications)

e.g. P_{60}^{30} JMA F'D

10. Examples

a) M60 JMA V

(i) Structure : a one layered forest consisting of trees over 30cm DBHOB (numerous trees under 30cm DBHOB may be present, but they do not form a clearly separable lower strata);

(ii) total density : in the range 60-69%; 40-69

(iii) upper strata density : ~~in the range 60-69%~~ (lower strata density is ~~less than 9%~~); at least 40?-49 0-29?

(iv) the major species is jarrah

- over 20% but less than 80% of the stems over 20cm DBHOB are jarrah
- over 20% but less than 50% of the stems over 20cm DBHOB are marri
- numerous other tree species may be present but none have more than 19% of the stems present

(v) the co-dominant height of the stand is between 25 and 29m;

(vi) the stand is virgin, not fire-damaged;

(vii) the stand may contain one or more patches (less than 2 hectares in extent) of forest of different species composition, co-dominant height, density and other characteristics

b) P_{60}^{30} JMA

(i) structure : a two layered forest, the upper strata composed of trees over 30cm DBHOB. The lower strata is composed mainly of poles (trees 20-30cm DBHOB) though up to 50% of the stems under 30cm may be saplings;

(ii) total density (total crown cover) ranges from 60-69%;

(iii) upper strata density ranges from 30-39%;

(iv) by subtraction, lower strata density lies between 30-39%;

..4/

(v). the major species is jarrah

- over 20% but less than 80% of the stems over 20cm DBHOB are jarrah
- over 20% but less than 50% of the stems over 20cm are marri
- numerous other tree species may be present but none have more than 19% of the stems present.

(vi). the co-dominant height of the stand is between 25 and 29m.

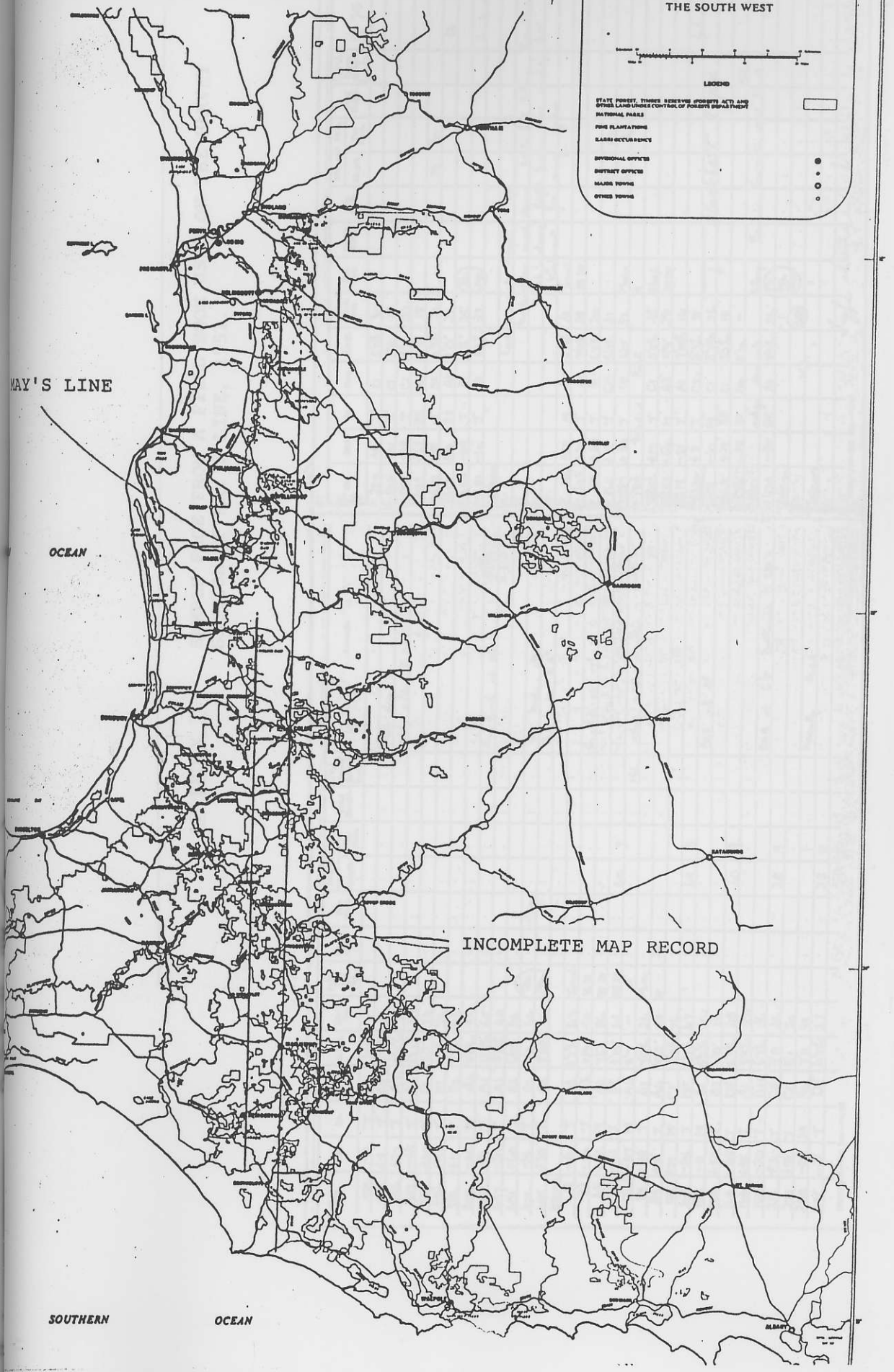
(vii). the stand may contain one or more patches (less than 2 hectares in extent) of forest of different species composition, co-dominant height, density and other characteristics.

Operation areas and permanent assessment lines as at March 1959 ref FD1587

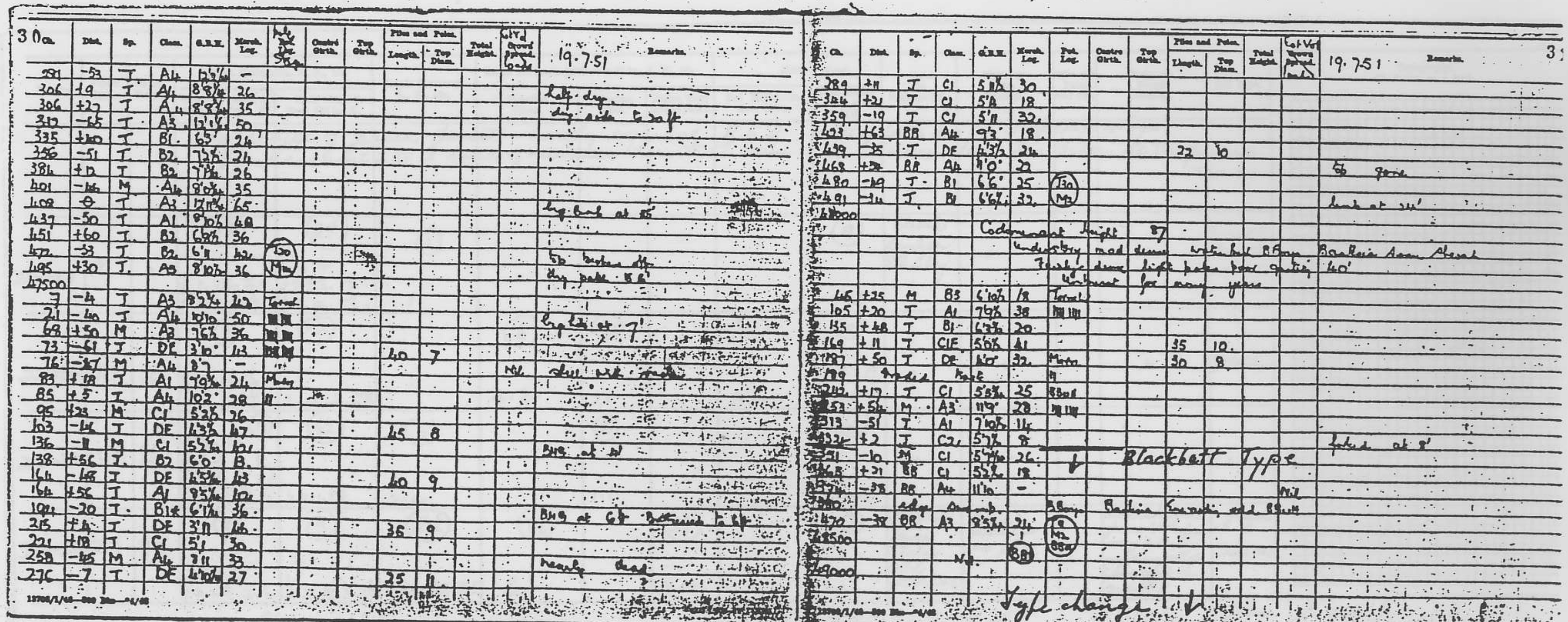
Basis of compilation unknown.

APPENDIX 6

LOCATION OF MAY'S AND ASSOCIATED PERMANENT ASSESSMENT LINES, 1950-1955.



APPENDIX 7 SAMPLE PAGE FROM A FIELD BOOK USED ON THE HARVEY SECTION OF MAY'S LINE, 1951.

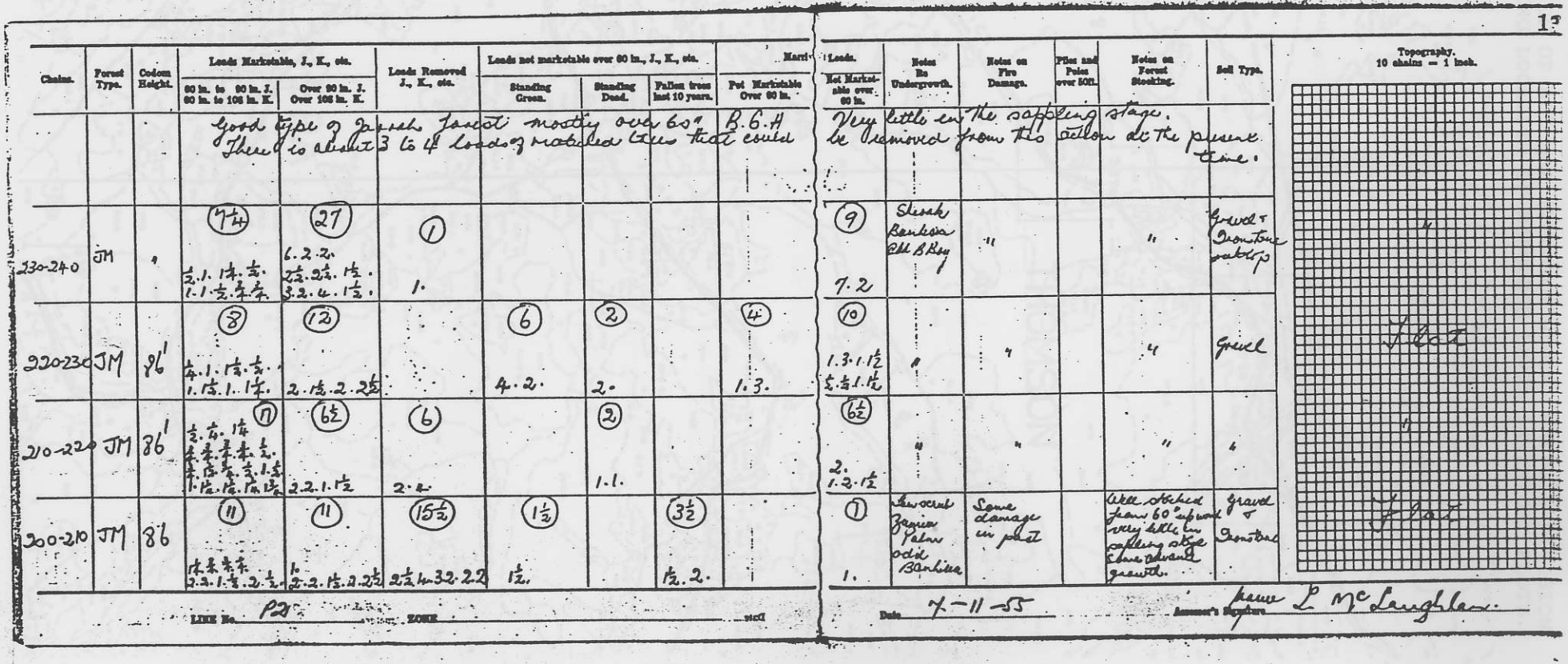


30 Ch.	Dist.	Sp.	Class.	G.B.H.	Merch. Log.	[illegible]	Centre Girth.	Top Girth.	Piles and Poles. Length.	Top Diam.	Total Height.	Crown Spread	19.7.51 Remarks.
281	-53	T.	A4	12'3¼	—								
306	+19	T	A4	8'8¼	26								half dry
306	+27	T	A4	8'8¾	35								[illegible]
312	-65	T	A3	12'1¼	50								
335	+10	T	B1	6'3	24								
356	-51	T	B2	7'2½	24								
384	+12	T	B2	7'1½	26								
401	-16	M	A4	9'0¾	35								
408	0	T	A3	12'11¼	65								[illegible]
437	-50	T	A1	8'10½	48								
451	+60	T	B2	6'8½	36								
472	-33	T	B2	6'11	42	[illegible]							[illegible]
495	+30	T.	A3	8'10½	36								[illegible]
47500													
7	-4	T	A3	8'2¾	42	[illegible]							
21	-40	T	A4	10'10	50	[illegible]							[illegible]
68	+50	M	A3	7'6½	36	[illegible]							
73	-61	T	DE	3'10	43	[illegible]			40	7			
76	-37	M	A4	8'7	—							Nil	[illegible]
83	+18	T	A1	7'9½	24	[illegible]							
85	+5	T	A4	10'2	28								
95	+23	M	C1	5'2½	26								
103	-16	T	DE	4'3½	47				45	8			
136	-11	M	C1	5'5½	42								BHB [illegible]
138	+56	T.	B2	6'0	B.								
164	-68	T	DE	4'5½	43				40	9			
164	+56	T	A1	9'5½	40								
194	-20	T.	B1*	6'1½	36								BHB at 6ft [illegible]
215	+4	T	DE	3'11	46				36	9			
221	+18	T	C1	5'1	30								
258	-45	M	A4	8'11	33								nearly dead
276	-7	T	DE	4'10½	27				25	11			

Ch.	Dist.	Sp.	Class.	G.B.H.	Merch. Log.	Pol. Log.	Centre Girth.	Top Girth.	Piles and Poles. Length.	Top Diam.	Total Height.	Crown Spread	19.7.51 Remarks.
289	+11	T	C1	5'11½	30								
344	+21	T	C1	5'8	18								
359	-19	T	C1	5'11	32								
403	+63	BR	A4	9'3	18								
439	-35	T	DE	4'3½	24				22	10			
468	+34	BR	A4	11'0	22								[illegible] gone
480	-49	T	B1	6'6	25	(130 M3)							
491	-34	T.	B1	6'6½	32								[illegible] at 34'
48000													
				Codominant height 87									
						understory mod dense [illegible]							[illegible]
						Fairly dense light poles poor quality 40'							
						Unburnt for many years							
46	+25	M	B3	6'10½	18	[illegible]							
105	+20	T	A1	7'9½	38	[illegible]							
135	+48	T	B1	6'3½	20								
169	+11	T	C1F	5'0½	41				35	10			
187	+50	T	DE	4'0	32	[illegible]			30	8			
199	[illegible]		[illegible]			[illegible]							
242	+17	T	C1	5'5½	25	[illegible]							
253	+54	M	A3	11'9	28	[illegible]							
313	-51	T	A1	7'10½	14								
332	+2	T	C2	5'7½	8								forked at 8'
351	-10	M	C1	5'7½	26	↓ Blackbutt Type							
368	+21	BR	C1	5'5½	18								
374	-38	BR	A4	11'10	—							Nil	
380		edge [illegible]				[illegible] Banksia [illegible] and [illegible]							
470	-38	BR	A3	8'5½	24	(9 M2 [illegible])							
48500													
				Nil	(BB)								
49000													

Type change ↓

APPENDIX 8 SAMPLE PAGE FROM A FIELD BOOK USED FOR WORKING PLAN ASSESSMENTS IN COLLIE DIVISION, 1955.



Chains.	Forest Type.	Codom Height.	Loads Marketable, J., K., etc. 60 in. to 90 in. J. 60 in. to 105 in. K.	Loads Marketable, J., K., etc. Over 90 in. J. Over 105 in. K.	Loads Removed J., K., etc.	Loads not marketable over 60 in., J., K., etc. Standing Green.	Standing Dead.	Fallen trees last 10 years.	Marri- Pot Marketable Over 60 in.
			Good type of Jarrah forest mostly over 60" There is about 3 to 4 loads of marketable trees that could						B.G.H
230-240	JM		(7¼) ½.1.1¼.½. 1.1.½.¼.¼.	(27) 6.2.2. 2½.2½.1½. 3.2.4.1½.	(1) 1.				
220-230	JM	86'	(8) ¼.1.1½.½. 1.1½.1.1¼.	(12) 2.1½.2.2½.		(6) 4.2.	(2) 2.		(4) 1.3.
210-220	JM	86'	(11) ½.½.1¼ ¼.¼.¼.¼.½. ¼.¼.¼.1.½ 1.1½.1½.1¼	(6½) 2.2.1.1½	(6) 2.2.		(2) 1.1.		
200-210	JM	86	(11) ¼.¼.¼.¼ 2.2.1.½.2.½.	(11) 1. ½.2.1½.2.2½	(15½) 2½.4.3.2.2	(1½) 1½.		(3½) ½.2.	

LINE No. P21 ZONE

Loads. Not Marketable over 60 in.	Notes Re Undergrowth.	Notes on Fire Damage.	Piles and Poles over 50ft.	Notes on Forest Stocking.	Soil Type.
Very little on the sapling stage. be removed from the yellow at the present time.					
(9) 7.2	Sheoak Banksia Blk Boy	"		"	Gravel & Ironstone gabbip
(10) 1.3.1.1½ ½.½.1.1½	"	"		"	Gravel
(6½) 2. 1.2.1½	"	"		"	"
(1) 1.	Flowered Zamia Palm odd Banksia	Some damage in plot		Well stocked from 60" upwards very little in sapling stage Some advance growth.	Gravel & Ironstone

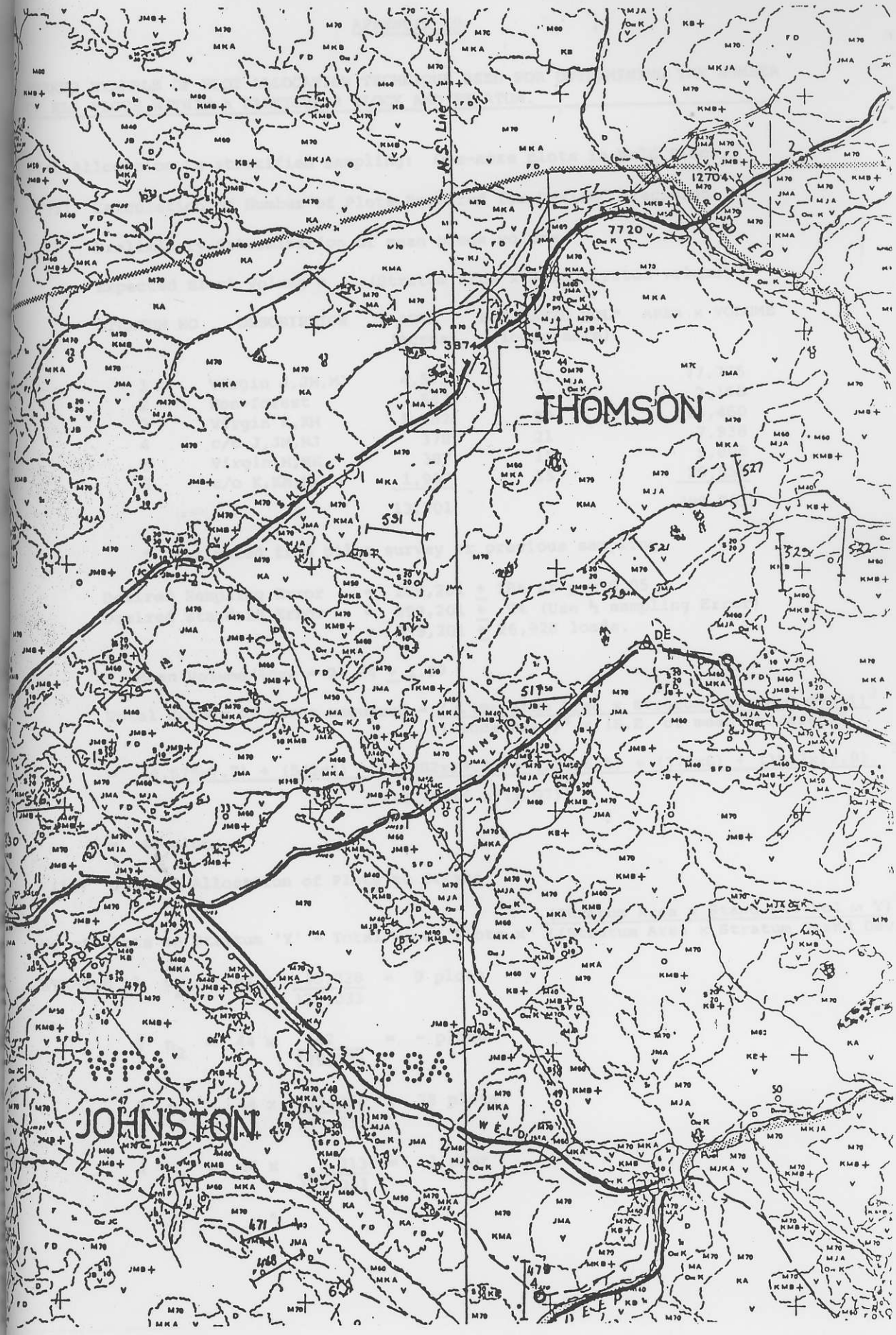
Topography. 10 chains — 1 inch.

Flat

Flat

Date 7-11-55 Assessor's Signature L McLaughlan.

APPENDIX 9 PORTION OF API MAP (THOMSON BLOCK, WALPOLE DIVISION)
scale, north found SHOWING LOCATION OF RESOURCE LEVEL INVENTORY PLOTS.



APPENDIX 10

WORKED EXAMPLE OF PLOT ALLOCATION TECHNIQUE USED FOR DETERMINING THE NUMBER OF RLI PLOTS WITHIN A PARTICULAR BLOCK AND STRATUM.

Plot Allocation in stratified sampling: One-acre plots in Weld Block.

(i) Calculation of Number of Plots Required for Desired Precision

Preliminary determination of mean block volume

Expected Block Volume = (Stratum area x Mean stratum volume)

STRATUM NO	DESCRIPTION	AREA (acres)	ESTIMATED VOL* (loads/acre)	AREA x VOLUME
1	Virgin J,JM,MJ	4,575	17	77,775
2	Non-forest	542	4	2,168
3	Virgin K,KM	5,882	30	176,460
4	c/o J,JM,MJ	378	21	7,938
5	Virgin M,MK	387	15	5,805
6	c/o K,KM,MK	1,937	15	29,055
		13,701		299,201

* Estimated from pilot survey or previous sampling.

Desired Sampling Error = 299,201 ± 18% at p = 0.05
Desired Standard Error = 299,201 ± 9% (Use ½ sampling Error)
= 299,201 ± 26,928 loads.

.. Mean Volume/Acre = 21.84 ± 1.97

$$\text{Total Number of Plots required} = \frac{(\Sigma(\text{Stratum Area} \times \text{Stratum Standard dev.}))^2}{(\text{Block Area})^2 \times (\text{S.E. of mean vol/area})^2}$$

$$= \frac{(4,575 \times 7.7) + (542 \times 1) + (5,882 \times 19.2) + (378 \times 8.5) + (378 \times 6) + (1937 \times 12.8)}{(13,701)^2 \times (1.97)^2}^2$$

= 44 plots

(ii) Optimal Allocation of Plots to Strata

$$\text{No of Plots in Stratum 'Y'} = \text{Total No of Plots} \times \frac{(\text{Stratum Area} \times \text{Stand Dev Vol in Y})}{\Sigma(\text{Stratum Area} \times \text{Stratum Stand Dev})}$$

STRATUM 1 $n_1 = 44 \times \frac{35,228}{179,033} = 9$ plots

2 $n_2 = 44 \times \frac{542}{179,033} =$ - plots

3 $n_3 = 44 \times \frac{112,934}{179,033} = 28$ plots

4 $n_4 = 44 \times \frac{3,213}{179,033} = 1$ plot

5 $n_5 = 44 \times \frac{2,322}{179,033} =$ - plots

6 $n_6 = 44 \times \frac{24,794}{179,033} =$ 6 plots

(iii) The above break-down was used to guide allocation of plots. Additional plots were often added on the basis of local experience.

P 20/50 JMB

DIVISON No	BLOCK No	PLOT No	STRATUM	AREA 1.0' - 3.0'	AREA 3.0' - 5.0'	AREA 5' + MKT.	G.B.H. CODOM	CODOM HT.	DESC.	PRESC.	AREA 5'+UNMKT	DIVISION NAME	BLOCK NAME		
∴ X	X X	X X X	X	X • X	X • X	X • X	X X • X	X X X	X	X	X • X			X X X	X X X X X X X X X X X X X X X
0 1	2 0	0 9 4	4	0 . 2	0 . 2	2 . 0	0 6 . 8	0 5 5	2	1	2 . 0	BUSSELTON	TREETON	1 0 0	OCT 69

SP	G.B.H.	MKT	VOL.	SUB PL	SP	G.B.H.	MKT	VOL.	SUB PL	SP	G.B.H.	MKT.	VOL.	SUB PL	SP	G.B.H.	MKT.	VOL.	SUB PL
X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X
1	0 6 8	4	0 1 4	1	5	0 6 7	3	0 1 1	1	1	0 1 0	3		1	1	0 1 0	3		1
5	0 4 2	3	1 5 7	1	1	0 1 0	3		2	1	0 1 0	3		2	6	0 1 0	3		2
1	0 1 0	3		2	1	0 6 0	4	0 0 8	2	1	0 2 0	3		2	1	0 1 0	3		2
1	0 3 7	3	1 1 0	2	1	0 6 8	4	0 0 7	2	5	0 1 0	3		2	1	0 3 0	3	0 7 0	2
1	0 3 1	4	0 8 0	3	1	0 4 8	4	2 3 0	3	1	0 6 1	4	0 0 8	3	1	0 1 0	3		3
1	0 1 0	3		3	1	0 1 0	3		3	5	0 5 5	3	0 0 6	3	5	0 6 1	3	0 1 0	4
1	0 3 0	4	0 7 5	4	1	0 4 6	4		4	1	0 1 0	3		4	1	0 1 0	3		4

SP	G.B.H.	MKT	VOL.	SUB PL	SP	G.B.H.	MKT.	VOL.	SUB PL	SP	G.B.H.	MKT.	VOL.	SUB PL	SP	G.B.H.	MKT	VOL.	SUB PL
X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X	X	X X • X	X	X X • X	X
5	0 5 8	3	0 0 6	1	1	0 1 0	3		1	1	0 1 0	2		1	1	0 7 8	4	0 0 9	1
1	1 0 3	4	0 2 2	2	5	0 2 0	3		2	1	0 8 1	2	0 1 0	2	5	0 1 0	3		2
5	0 1 0	3		2	6	0 2 0	3		2	1	0 8 7	4	0 1 9	2	1	0 1 0	3		2
5	0 3 6	3	1 2 0	2	1	0 1 0	4		3	1	0 2 0	3		3	1	0 3 7	3	1 2 8	3
1	0 1 0	3		3	1	0 2 0	3		3	1	0 3 6	3	0 9 0	3	5	0 5 8	3	0 0 9	3
1	0 8 3	4	0 1 9	4	1	0 6 8	4	0 0 8	4	1	0 1 0	3		4	1	0 1 0	3		4
5	0 1 0	3		4	5	0 1 0	3		4	1	0 4 4	4	1 9 0	4	9				

Plot location details (left margin, bottom to top):
Junction Bell & Hubert rds. — A — North along Bell Rd 50 chns. — B — 270° 11.00 chns. — C — Plot 245° 20 chns. — D

← Plot location details

WORKING PLANS HARDWOOD INVENTORY :

ADDITIONAL DESCRIPTION

I) IN THE FIRST COLUMN BELOW FOREST TYPE
DIEBACK
0 DIEBACK NOT PRESENT ON, OR IN VIEW OF PLOT
1 DIEBACK PRESENT ON, OR IN VIEW OF PLOT

II) IN COLUMN 2
REGENERATION
0 REGEN. NOT ABUNDANT OVERALL OR IN PATCHES
1 DENSE REGEN. - ABUNDANT REGEN. COVERS WHOLE PLOT AND NEAR VICINITY
2 MODERATE REGEN. - REGEN. ABUNDANT IN PATCHES IN PLOT AND NEAR VICINITY

III) IN COLUMN 3
PATHOGEN KILLED KARRI
0 ABSENT
1 PRESENT OR NOT CERTAIN (REPORT TO W.P.O.)

SPECIES

JARRAH	1
KARRI	2
TO BE DEFINED	3
TO BE DEFINED	4
MARRI	5

MARKETABILITY

CROP OR POT CROP	1
SHOULD BE REMOVED	2
UNMKT FOR SAWLOG	3
DEAD	4

SUB PLOT

1ST 5 CHN	1
2ND 5 CHN	2
3RD 5 CHN	3
ETC	

G.B.H.

TREES	1.0' - 1.9'	- 01.0
TREES	2.0' - 2.9'	- 02.0
TREES	3.0' +	- FT. & DECIMALS

VOLUME

1.0' - 2.9'	G.B.H.
3.0' - 4.9'	G.B.H. CU.FT & DECIMALS
5.0' +	G.B.H. LOGS & DECIMALS

END OF PLOT

AFTER LAST TREE, RECORD 9 IN SPECIES COLUMN.

HEIGHT CLASSES

J,M,M DOMINANT	CODOMINANT
A+	110'+
A	90' - 109'
B+	70' - 89'
B	50' - 69'
C	UNDER 50'
K DOMINANT	
A	170'+
B+	150' - 169'
B	130' - 149'
C	UNDER 130'

DESCRIPTION

NOT FIRE DAMAGED	
< 33% TREES AFFECTED	1
FIRE DAMAGED	
33%-66% TREES AFFECTED	2
SEVERE FIRE DAMAGED	
> 66% TREES AFFECTED	3

PRESCRIPTION

CLEAR CUT, TOTAL UTILISATION	1
CLEAR CUT WITH SEED TREES	2
SELECTION CUT, HEAVY	3
SELECTION CUT, LIGHT	4
SALVAGE CUT	5
POLE THINNING, MARKETABLE	6
POLE THINNING, UNMARKETABLE	7
LEAVE UNCUT	8

DIEBACK TYPES

1 TREES & SCRUB HEALTHY
2 TREES AFFECTED, SCRUB DEAD
3 TREES & SCRUB DEAD
4 NON FOREST
5 TREES HEALTHY, SCRUB AFFECTED

MINIMUM SAWLOG DIMENSIONS

SPECIES	LENGTH	CROWN D.U.B.
JARRAH	7'	10"
KARRI	9'	12"
MARRI	12'	15"

HARDWOOD ASSESSMENT PROG. HDWDS2 STATE FOREST AND TR/25 PAGE 1 OF PRINTOUT HA

TOTAL VOLUME (CU-METRES UB) IN VOLUME IN RESOURCE INVENTORY JAN_75 - PEMBERTON RUN ON 75/06/03

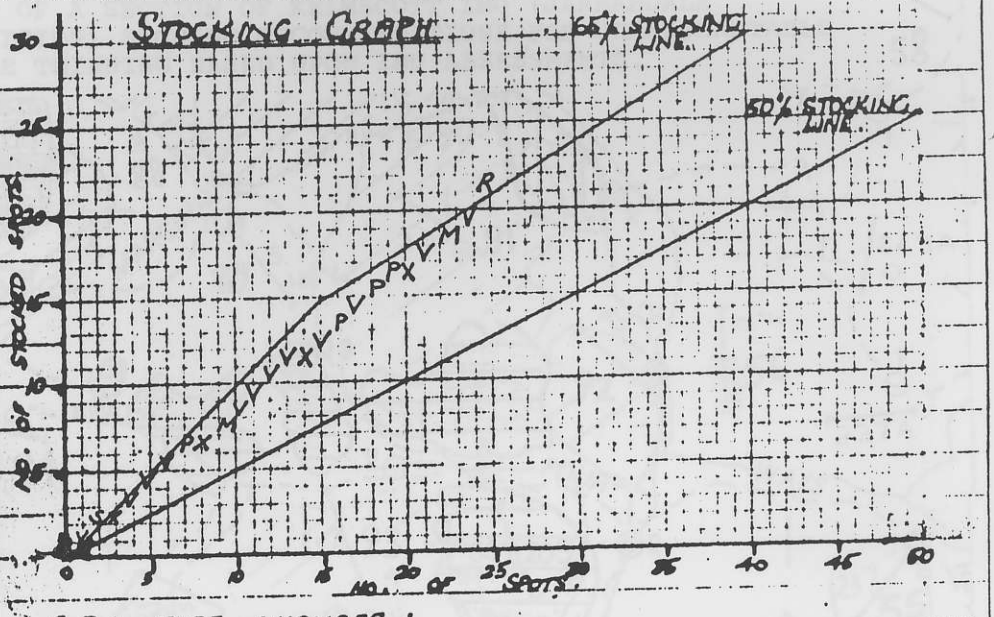
TYPE	VIRGIN K	C/O K	SUB-TOT	VIRGIN J	C/O J	SUB-TOT	TOTAL
AREA HECTARES	53973	26452	80425	55234	29349	84583	165008
NUMBER OF STRATA	63	29	92	42	27	69	161
NUMBER OF PLOTS	595	195	790	278	150	428	1218
COMB. SAMP. ERROR(%)	5	8	4	14	10	11	5
JARRAH SPECIES NO(1)							
1+FT MKT 1+2	327276	128078	455353	3639939	1530454	5170393	5625747
2+FT MKT 1+2	322699	126360	449059	3619192	1520438	5139629	5588688
3+FT MKT 1+2	314001	124498	438499	3556422	1485542	5041964	5480463
4+FT MKT 1+2	305009	116332	421341	3449935	1435089	4885025	5306365
5+FT MKT 1+2	281269	105307	386576	3251660	1286537	4538198	4924774
6+FT MKT 1+2	255647	97012	352658	2914138	1119203	4033341	4385999
7+FT MKT 1+2	222786	83070	305856	2423189	880352	3303542	3609398
8+FT MKT 1+2	179435	66983	246418	1888470	623935	2512405	2758822
KARRI SPECIES NO(2)							
1+FT MKT 1+2	8460097	2254977	10715074	692148	162979	855127	11570201
2+FT MKT 1+2	8426659	2223383	10650042	688089	160746	848836	11498878
3+FT MKT 1+2	8359238	2154705	10513943	679279	158575	837853	11351796
4+FT MKT 1+2	8316066	2114666	10430732	676366	154782	831148	11261880
5+FT MKT 1+2	8263777	2049397	10313174	670664	152218	822882	11136056
6+FT MKT 1+2	8210593	2004706	10215300	662590	148265	810855	11026155
7+FT MKT 1+2	8113686	1949571	10063257	642729	142131	784860	10848117
8+FT MKT 1+2	7952699	1861086	9813785	615298	129161	744459	10558245
BLACKBUTT SPECIES NO(4)							
1+FT MKT 1+2	14867	4315	19182	23798	36950	60749	79931
2+FT MKT 1+2	14610	4315	18925	23798	36860	60659	79583
3+FT MKT 1+2	14610	4315	18925	22237	36237	58475	77399
4+FT MKT 1+2	14610	4315	18925	22237	36237	58475	77399
5+FT MKT 1+2	14118	4315	18433	20011	34225	54235	72668
6+FT MKT 1+2	13617	4217	17835	18428	31716	50144	67978
7+FT MKT 1+2	12055	3274	15329	15262	28187	43449	58777
8+FT MKT 1+2	11743	2280	14023	12519	24382	36902	50925
MARRI SPECIES NO(5)							
1+FT MKT 1+2	446701	245584	692285	218569	116262	334831	1027116
2+FT MKT 1+2	445956	243276	689233	216676	115284	331959	1021192
3+FT MKT 1+2	444433	241264	685697	214891	114039	328930	1014626
4+FT MKT 1+2	442283	238492	680775	211924	112296	324220	1004995
5+FT MKT 1+2	437617	233366	670983	205369	110490	315859	986842
6+FT MKT 1+2	422671	224330	647001	196400	102446	298845	945847
7+FT MKT 1+2	395553	207028	602582	180338	89554	269892	872474
8+FT MKT 1+2	354658	182409	537067	148660	71525	220184	757251

APPENDIX 12 SAMPLE OUTPUT OF COMPUTER - SUMMARISED VOLUME

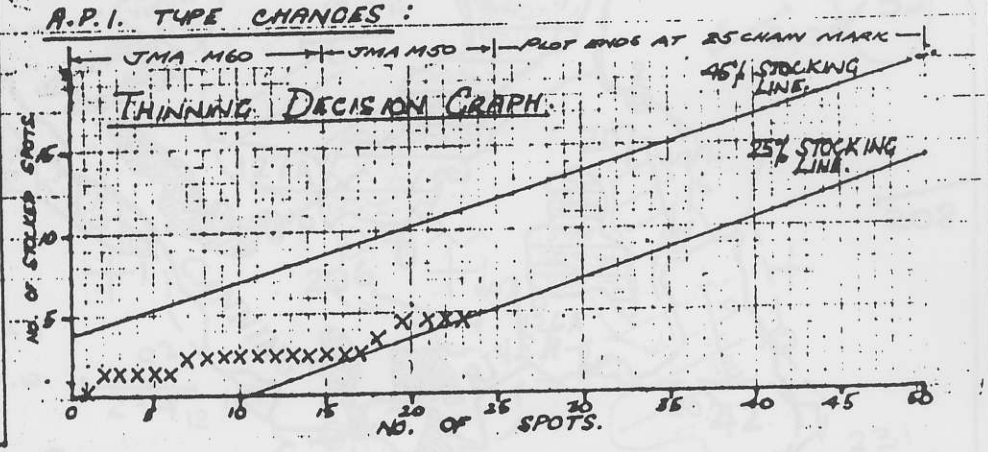
IN PRESTON BLOCK, KIRUP DIVISION.

KING SHEET.

K NAME: PRESTON
NO: 002
ING: 103°T
INT: SW CORNER
OF LOC 33335
285°T FOR 17 CHNS
: 17-5-73
SSOR: K. Phillips-Jones
LE: 0
CK: 0
MINER: 1
IPTION: MATURE
MASSED STAND WITH
BIG VETERANS.
RIPTION:
AVY. CUT TOTAL
SATION. REMOVE
CULLS. SOME VERY
REGEN. ARMOX
IGH.



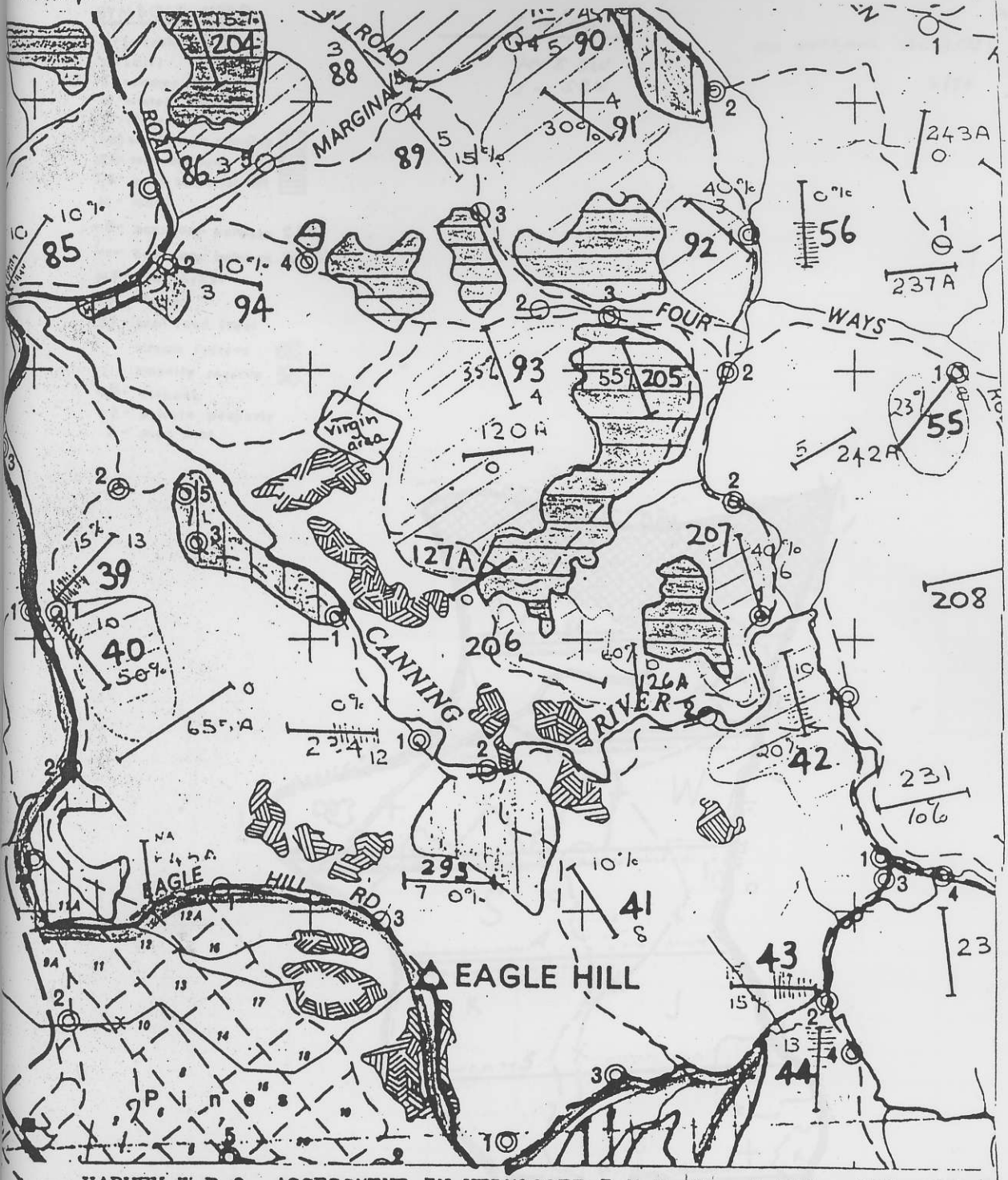
A.P.I. TYPE CHANGES:



BANKSIA >1" DBH.			SAWLOG TIMBER MKT 1&2 >5' GBHOB				S.E.C. POLES			CULLS No.		MARRI LDS/AC >5' GBH		MARRI	
SPOT	DOM.	COM.	SP.	GBH	MKT.	VOL.	HEAVY	STD.	LIGHT	1-3'	>3'	GBH	VOL.	3'-5' (Cu. Ft.)	Potential Crop.
2	1									1	1	6.6	1.0		
3	2											7.4	1.0		
5	1													19.2	
6	1		1	10.2	2	1.7				III				11.8	
														8.8	
														25.7	
10	1	1													
			1	8.2	2	2.1				1					
			1	5.6	2	0.7									
			1	6.3	2	0.7									
			1	15.2	2	7.3				III					
			1	7.2	2	1.4				II	1				
			1	10.5	2	2.0									
			1	5.1	2	0.5									
24	1		1	17.0	2	3.4									
25	1		1	12.8	2	3.5									
	8	1				24.3				12	2		2.0	65.5	

PPENDIX 14 MAP OF A SECTION OF KELMSCOTT IMU (JARRAHDALE DIVISION) SHOWING RECOMMENDATIONS FOR UNMERCHANTABLE POLE THINNING BASED UPON IMU ASSESSMENTS.

Scale with found



HARVEY W.P.O. ASSESSMENT IN KELMSCOTT I.M.U. No. 2 JAN - MAY 1973

PLAN 2 : 22/6/73 UNMERCHANTABLE POLE THINNING

SUITABLE FOR UNMERCH. POLE THINNING (30% +)

NOT QUITE SUITABLE " " (20 - 29%)

UNMERCH. POLE THINNING NOT JUSTIFIED

AREAS ALREADY UNMERCHANTABLE THINNED

AREAS WITH 10 + CULLS PER ACRE

FIGURES % SUITABLE FOR THINNING, CULLS/ACRE OVER 5' GBH 35% 6

CAREY BLOCK - coupe 3

SYMBOLS USED:

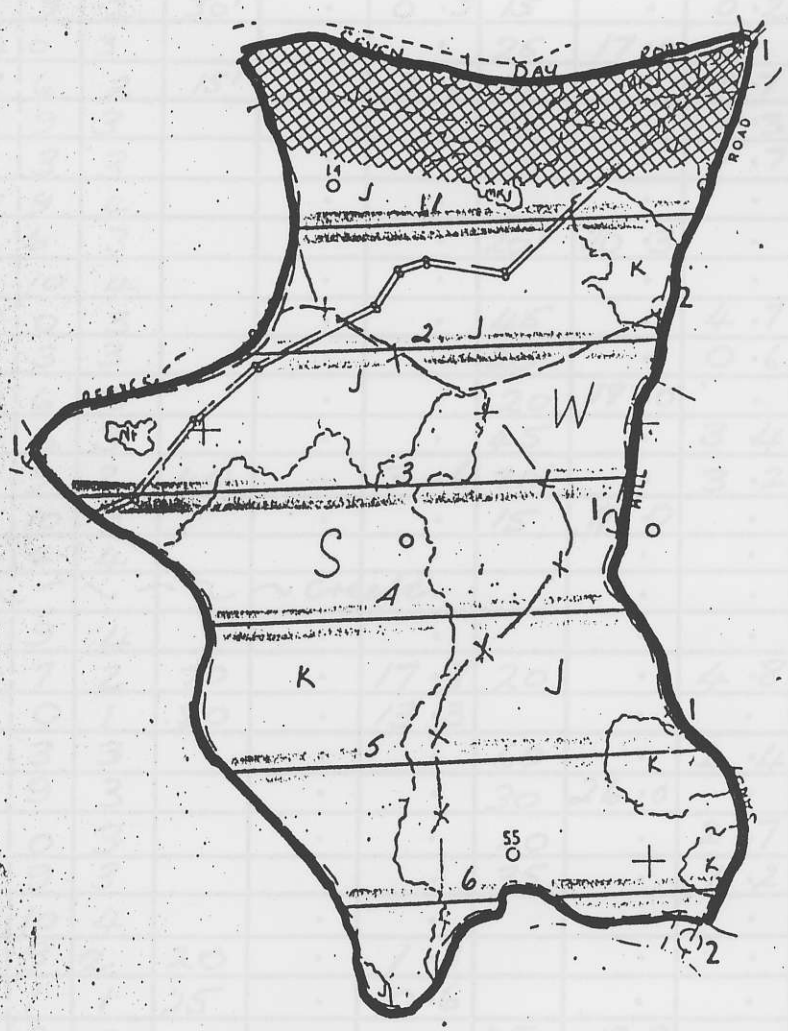
J • jarrah
K • karri
S • summer logging
W • winter logging
C/F • clear fallen
S.T.S. • seed trees standing
REN • regeneration
G/S • group selection cut
M • marri
-X- boundary between S&W
-e- boundary between S.M.P.'s
N F • non forest
Cl • cleared
S.T. • karri seed trees
stream reserve
amenity reserve
D/B • dieback
P.P. • private property
P • pine plot

LINES

K - S CW
J - SEW

NO CUTTING AT 6/74.

6/74



APPENDIX 15 MAP OF A MANAGEMENT COUPE (CAREY BLOCK, PEMBERTON DIVISION) SHOWING LOCATION OF MANAGEMENT LEVEL INVENTORY LINES.

APPENDIX 16 SAMPLE FIELD SHEET FOR MANAGEMENT LEVEL ASSESSMENT, IFFLEY BLOCK, MANJIMUP DIVISION.

F.D 612

MANAGEMENT LEVEL ASSESSMENT SHEET - Manjimup W.P.C.

BLOCK IFFLEY COUPE No. 3 LINE No 7

ASSESSOR J. ~~BLOW~~ HALL DATE 4-7-74

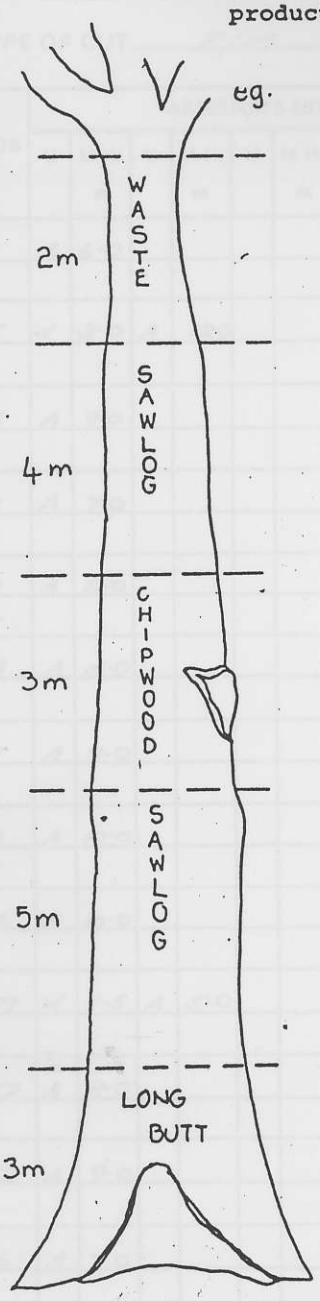
BEARING 0°T TIE POINT REF. TREE HB 51 1 DESC. 1 D/B 0 L/M 0 P/H 1

TIE: EAST ALONG IFFLEY RD 120 metres WIDTH OF LINE: 5 metres

MST. & PI TYPE	SPECIES	GBHOB Ft	GBHOB ins	MKT	PRODUCTS WITHIN EACH TREE: SAWLOG LENGTH (ft)	SAWLOG CU. FT	SAWLOG LOADS	CHIPWOOD LENGTH (ft)	CHIPWOOD CU. FT	CHIPWOOD LOADS	WASTE LENGTH (ft)	WASTE CU. FT	L
MJB+	3	6	9	3		·	·	30'	·	1·3		·	
M50	3	4	6	4		·	·		·	·	30'	24·8	
100m	5	3	6	3		·	·	20	10·6	·	20	8·4	
200m	5	4	3	3		·	·	35	25·1	·		·	
	5	5	5	3		·	·	25	·	0·8		·	
JMA	1	5	9	2	30'	·	0·9	15	·	0·2		·	
M60	5	4	0	3		·	·	25	17·0	·		·	
	1	12	6	2	15'	·	2·2	10'	·	1·7		·	
	1	6	9	3		·	·	35	·	1·3	5'	·	C
300m	5	6	3	3		·	·	45	·	1·7		·	
C/O J	5	7	9	4		·	·		·	·	70	·	3
	1	4	6	3		·	·	20'	20·3	·	25	15·0	
	1	3	10	4		·	·		·	·		·	
400m	5	10	0	3		·	·	45	·	4·7		·	
	1	5	3	3		·	·	20	·	0·6		·	
TK	2	4	6	3		·	·	20	18·0	·		·	
M60	5	8	6	3		·	·	45	·	3 4	15	·	C
	2	10	9	2	40	·	3·6	30	·	3·2	10	·	1
500m	1	3	10	3		·	·	15	11 0	·		·	
	4	3	6	4		·	·		·	·	10	7·5	
550m	~	~	~	~	~	~	~ Creek.		·	·		·	
	2	19	9	4		·	·		·	·	90	·	27
K A	2	17	7	2	70	·	17·8	20	·	4·8		·	
M60	2	14	0	1	80	·	13·3		·	·		·	
600m	2	7	3	3		·	·	60	·	2·4	10	·	0
640m	2	4	9	3		·	·	30	26·0	·		·	
MJK	5	8	0	3		·	·	40	·	2·7		·	
M60	5	5	9	3		·	·	35	·	1·2		·	
	5	14	10	4		·	·		·	·	70	·	14
700m	1	7	9	2	20	·	1·3		·	·	10	·	C
	1	5	1	1	25	·	0·6		·	·	20	·	0
770m	1	4	3	3		·	·	25	19·9	·	10	4·1	
	—	—	—	—	—	—	— Road.		·	·		·	
	5	4	2	3		·	·	15	·	13·0		·	
800m	1	9	3	2	15	·	1 4		·	·	30	·	1
	1	4	3	3		·	·	15	·	15·7		·	
						·	·		·	·		·	
				LINE ENDS AT EASTER ROAD AT 860 metres									
						·	·		·	·		·	
	NG		MKT 4 = WANDOO.			·	·		·	·		·	
						·	·		·	·		·	
						·	·		·	·		·	

CALCULATING VOLUMES OF MULTI-PRODUCT BOLE

Care should be taken in calculating volumes of products within boles of multi-product trees :



Species : JARRAH

D.B.H.O.B. = 90cm

Total Bole Length = 17m
Total volume = 5.6m

Vol. to 15m = 5.1
Vol. to 11m = 4.1
Vol. to 8m = 3.3
Vol. to 3m = 1.5

1. Vol. of waste = (Total Vol.) - (Vol. t (Vol. to 3m).
= 5.6 - 5.1 + 1.5
= 2.0

2. Vol. of chipwood = (Vol. to 11m) - (Vol. to 8m).
= 4.1 - 3.3
= 0.8

3. Vol. of sawlog = (Vol. to 15m) - (Vol. + (Vol. to 8m) - (Vol
= 5.1 - 4.1 + 3.3
= 2.8

N.B. Addition of the 3 products must = Total Volume

APPENDIX 17 EXAMPLE OF VOLUME CALCULATION FOR MULTI-PRODUCT BOLES WHEN ASSESSING TREES FOR MANAGEMENT LEVEL INVENTORY.

APPENDIX 18 SAMPLE FIELD SHEET USED FOR UTILIZATION APPRAISAL (formerly Acceptable Loadage Plots).

INVENTORY AND PLANNING HARDWOOD INVENTORY UTILIZATION APPRAISAL

S.M.P._____ BLOCK_____ ASSESSOR_____

TYPE OF CUT T/M DATE 27-8-79

TREE No.	DBHOB cm	ASSESSOR'S ESTIMATE									ACCEPTED BY MILL					REMARKS
		U	M Ht m	U	M Ht m	U	M Ht m	U	M Ht m	VOL. m^3	WASTE LBt QC m	CDOB cm	CDUB cm	L m	VOL. m^3	
1	74	A	6·0							1·8		F.N.	T.		1·5	Smashed
2	105	W	3·0	A	12·0					4·2		81	74	12·0	5·23	
3	105	A	9·0							4·8		102	95	9·4	6·78	Double heart
4	52	A	7·0							0·9		41	37	8·4	0·93	
5	69	A	8·0							1·8	1·3	57	52	6·6	1·43	Dry side in butt
6	73	A	5·0							1·5		65	59	6·0	1·67	
7	55	A	9·0							1·2	1·0	46	42	11·1	1·56	Rot in butt
8	73	A	10·0							2·4		56	51	9·6	2·0	
9	106	A	10·0							5·3	1·2	90	83	8·4	4·6	Rot in butt
10	77	W	1·5	A	5·0					1·1	1·2	67	61	3·1	0·9	
11	52	A	8·0							1·0		46	42	8·3	1·2	
12	53	A	9·0							1·0		40	36	8·5	0·9	
13	66	A	7·0							1·5	1·0	57	52	6·8	1·47	

VOL. ESTIMATED 28·5 VOL. UTILIZED 30·1

VOL. DIFFERENCE = 1·6 m^3

% DIFF. $\left(\frac{\text{DIFF.}}{\text{VOL. UTIL.}}\right)$ X 100 = +/- 5·3 %

% Accepted = Vol Utilized / Vol Estimated = 106·7

105958/8/78-1M-P906

HARDWOOD PERMANENT PLOT LOCATED IN KENT BLOCK (HARVEY DIVISION). The one plot is measured for increment data and for product information.

INVENTORY AND PLANNING HARDWOOD PERMANENT PLOT TIE SKETCH

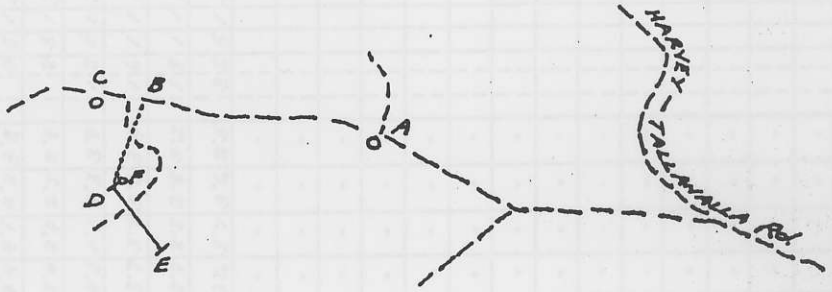
DIVISION HARVEY A.P.I. MAP No. 238 ASSESSOR G. REES

BLOCK KENT MAP SQUARE DV/65 DATE 25/5/82

PLOT No. 35

Diagramatically show all plot details

Approx Scale 1:



PLOT LOCATION	STATION	F.S.B.G.	B.S.B.G.	METRES
A TRACK JUNCTION BY REF. TREE DV/65/4	A to B	W along	track	5·83
B POINT ON SIDE OF TRACK (SHIELD 814 P35)	B to C	" "	"	112·7
C POINT ON TRACK BY REF. TREE DV/65/3	B to D	196°T	17°T	181·0
D START OF PLOT	D to E	140°T	320°T	100·6
E END OF PLOT	D to F	38°T	218°T	11·0
F SHIELD P/19/1	to			
G	to			
H	to			

LEGEND

- Tracks and roads
- Fence Lines
- Tie Lines
- Plot
- Railways

REMARKS

BRG 140°T TIE POINT R.T. DV 65/4

FORESTS DEPARTMENT OF WESTERN AUSTRALIA
INVENTORY AND PLANNING HARDWOOD INCREMENT PLOT

b). 181m at 196°T

c). Plot : 100.6m at 140°T

105388/5/78–5M–P72

PLOT No.	DIV. No.	BL No.	MSP	PLOT AREA HA 10-30 cm	30-50 cm	50+ cm	YEAR LAST CUT OVER	DATE MEASURED MTH	YEAR	BLOCK NAME	MC	BC	CODOM HT m	F	D	J	K	L	P	M 60 JMA
0315	10	14	1	0·12	0·10	0·20	1925	05	1982	KEMTI	7	2	28	0	01	00	1			

PLOT No.	TREE No.	SP	SR	MKT	DBHOB cm	BT 1	BT 2	BT 3	BT 4	TREE No.	SP	SR	MKT	DBHOB cm	BT 1	BT 2	BT 3	BT 4	TREE No.	SP	SR	MKT	DBHOB cm	BT 1	BT 2	BT 3	BT 4	TREE No.	SP	SR	MKT	DBHOB cm	BT 1	BT 2	BT 3	BT 4	TREE POSITIONS TREE 1 DIST	TREE 1 ± M	TREE 2 DIST	TREE 2 ± M	TREE 3 DIST	TREE 3 ± M	TREE 4 DIST	TREE 4 ± M
0315	1	5	2	4	32·5	0·0	0·0	2·4	3·2	12	5	1	3	39·7	2·8	2·8	2·9	2·4	3	1	1	2	16	7·0	4·9	4·1	4·2	3·8	14	5	1	3	37·1	3·6	4·0	4·0	4·0		·		·		·		·
	15	1	1	1	16	8·9	2·7	3·2	2·8	2·7	16	1	1	2	15	3·3	2·3	2·3	2·5	2·3	17	1	1	2	14	9·5	2·4	2·4	2·7	2·9	18	5	1	3	12	5·0	2·8	2·7	2·6	2·8		·		·		·		·
	19	1	1	2	11	8·5	3·8	3·9	4·0	3·7	110	1	1	4	13	2·5	3·4	3·3	3·2	3·8	11	5	1	3	12	7·0	4·3	4·2	4·3	3·9	112	1	1	2	10·2	1·7	2·0	2·0	1·8		·		·		·		·
	13	1	1	1	16	10·7	3·0	3·5	4·0	4·0	114	5	1	3	18	5·3	3·8	3·3	3·7	3·9	15	1	1	2	14	6·0	3·7	3·7	3·6	3·4	16	1	1	1	19·5	2·3	2·9	2·5	2·0		·		·		·		·
	17	1	1	2	13·8	2·1	1·7	1·5	2·0	17	1	1	1	15	6·2	2·8	2·8	3·2	3·7	18	1	1	2	15	3·3	2·7	2·8	2·8	3·2	19	1	1	1	18·4	2·8	2·7	2·8	2·7		·		·		·		·
▼	21	1	1	2	16	6·7	2·6	2·7	2·3	2·8	216	1	1	1	16	2·0	3·7	3·5	2·8	3·4	217	1	1	2	17	3·6	3·2	3·7	3·6	3·5	312	5	1	3	50·1	3·2	2·3	3·0	2·7		·		·		·		·
0915	19	5	3	4																																			·		·		·		·

NOT FOR PUNCHING