SPECIALIST INVENTORY SERVICES AVAILABLE TO SUPPORT WOODLOT MARKETING AND HARVESTING

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INTRODUCTION

The application of specialist inventory services is becoming increasingly important for all parties involved in the sale and purchase of woodlots.

The inventory of forests involves two principal types of activity:

- Area and terrain description
- Assessment of the forest crop

AREA AND TERRAIN DESCRIPTION

This component of the inventory is most conveniently presented in maps, and other graphical illustrations, supported by area schedules. The features described should include relevant boundaries, stocked area, and pertinent topographical, soil and hydrological details.

Boundaries

First priority should be given to **legal boundaries,** and with these identified, the **forest boundaries** should be compared. It is best determined at the outset of planning that some of a forest crosses a legal boundary, and is in fact on a neighbour's place. It can be most inconvenient if it is instead discovered part way through logging, or after the event, and not uncommonly leads to legal action. Unless there are special arrangements relating to forest tenure, the law is quite clear on forest ownership - the trees attach to the land beneath them.

Even with confident determination of where legal boundaries lie, a woodlot purchaser or logging contractor may pursue the certificate of title. This is to ensure that the vendor, (or apparent owner), has the legal right to sell the woodlot. A number of woodlots have been established in recent years as joint ventures between landowners and investors, under the provisions of the Forestry Rights Registration Act 1983. Increasingly, woodlots offered for sale may be owned by someone other than the person who owns the land.

Situations may arise where the current land owner is not the same person who originally entered into the joint venture agreement and is less familiar with any special conditions of the agreement as they relate to harvesting of the woodlot. As part of the process of being satisfied that the block is "available", purchasers and harvesters need to be familiar with any conditions identified in the joint venture agreement between the current land owner and the owners of the trees.

Area

Subject to exclusions for forest that the vendor does not own, the forest boundaries can then be applied in determining **net stocked area.** This differs from the **gross area** of the forest block through the deduction of gaps (i.e unstocked areas). These may arise from various reasonable causes such as roads, landings, riparian strips, indigenous forest reserves, livestock aggregation areas, etc. They may also arise from less commendable reasons such as failed planting, uncontrolled grazing, erosion, wind damage and over-exuberant thinning practice.

Whatever the cause, some rigour should be applied in excluding gaps from the stocked area assessment. Different conventions as to what constitutes a gap are applied in the industry. Alternative definitions are acceptable, provided a consistent interpretation is applied when establishing the sample plots used for volumetric assessment.

Terrain

A definitive statement of the stocked area within the identified boundaries is clearly a useful start to forest inventory. However it conveys little assistance in harvest planning without an accompanying description of the terrain. This can include the following

- **topography.** This is the shape of the land surface, and is of fundamental importance in harvest planning. It affects system selection, location of roads and landings, and setting layout. Two components of topography are:
    - **slope classification.** Quantification of slope and mapping slope classes may represent a useful means of describing the topography. The analysis should extend to more than just slope steepness - it is important also to describe slope length.
    - **aspect**. This is important when stratifying the forest for tree vigour, in considering drying conditions for roads and landings, and in anticipating exposure to wind.
- **hydrology**. The size and pattern of waterways is intimately linked with the topography, since in conjunction with soil types (pedology) and underlying geology, water flows have been responsible for the shape of the land. The nature of the streams and their flows figures prominently in the RMA consent process and also in logging system selection and deployment
- **visual appearance.** Increasingly, it is important to identify which parts of a site are most visible, and most likely to generate reaction.

Having described what should be presented, it is necessary to consider how the necessary information may be obtained, and presented. Various means are available.

Sources of information

These may include:

- Formal ground survey, by a qualified surveyor.
- "Informal" survey, by someone familiar with a compass, clinometer and tape, and with a grasp of elementary trigonometry.
- The application of Global Positioning Systems (GPS) technology, to determine field locations.
- Photogrammetric interpretation of aerial photographs, to capture not only the boundaries of features, but also the shape of the terrain.
- Purchase of digital terrain information.

The sources may be complementary and it is not unknown for all to be utilised together in preparing a forest map.

Formal survey is authoritative, but the requirement for rigorous procedures may make it comparatively expensive. It nonetheless provides a good reference framework within which less exacting methods may be applied.

Informal **"chain and compass"** surveys have been a time-honoured method of field data capture amongst foresters and harvest planners. The methods still have a place, and not least of their advantages is that they require the planner to "walk the block", thereby getting to know it first hand. Computer spreadsheets now take the drudgery and potential for error out of the data processing.

GPS provides what is literally a space-age technology, determining field position from a suite of satellites orbiting some 80km above the earth's surface. The potential accuracy is determined by the quality of the GPS receiver, atmospheric conditions, interference from tree canopies, and the entitlement of the US military to provide some artificial signal disruption when it suits their purposes. GPS technology is finding an expanding role both as a means of directly recording traverses, and as a means of establishing control points for aerial photograph interpretation.

Aerial photographs remain an enormously important source of information for maps. Importantly, however, they must be used advisedly. In their most common format, aerial photographs are distorted, with the distortions attributable to lens characteristics, tilt of the camera, and the shape of the terrain. As such, measurements taken directly off an aerial photograph are inherently inaccurate.

Conveniently, the distortion in aerial photographs also allows them to be extremely useful. Two adjacent photographs from a sequence can be used to provide a stereo pair, and the relative distortion provides a perception of terrain depth. With appropriate equipment, it is then possible to prepare a contour map or construct a digital terrain model. With knowledge of camera characteristics and some other critical measurements it is possible to produce an undistorted, or orthogonally correct representation from which distances and areas can be accurately scaled.

Some information for map production is available "off-the-shelf" already in digital form and therefore in a state in which it can be readily imported into mapping software. One source of such data is Terralink, formerly known as DOSLI (Department of Survey and Land Information). Forest owners frequently acquire cadastral boundary data, and it is also possible to obtain all of the types of information represented on New Zealand Map Series 260. Example information which forest consultants may routinely acquire includes:

- Public roads and State highways
- Streams
- Contours

The contour interval in the Map Series 260 data is 20m. While this is generally wider than desirable for detailed harvest planning, it nonetheless provides a good start point from which to commission further field measurements.

Presenting the terrain information

The presentation of terrain information requires, at minimum, a topographic map. Ideally this would be 1:5 000 scale, with 5m contours marked. In practice, a scale of 1:10 000 is more commonly demonstrated.

Other systems include slope class and aspect class maps, and perspective plots (variously referred to as "3-D images", "fishnet plots" etc). The software for preparing such representations is becoming more readily available, and less expensive. Increasing computer speed has also helped in the heavy data processing these applications require.

Figure 1 illustrates a topographic map, employing digital data obtained from Terralink. Forest boundaries have been transferred to the map from recent aerial photographs. An array of further, linked representations is included. (perspective plot, slope plot, aspect plot, cadastral map, road grade profile, skyline profile, catchment area).

CROP DESCRIPTION

There can be an inclination to think that the crop, like the terrain, is a "given" - i.e. "there it is... make the most of it". This is not really the case at all, because generally there is a choice as to **when** to harvest the crop. The timing of harvest will determine what quantity and quality of timber is there.

The growth performance of an example stand of trees over time can be represented graphically, as shown in Figure 2.

Figure 2 Stand Growth

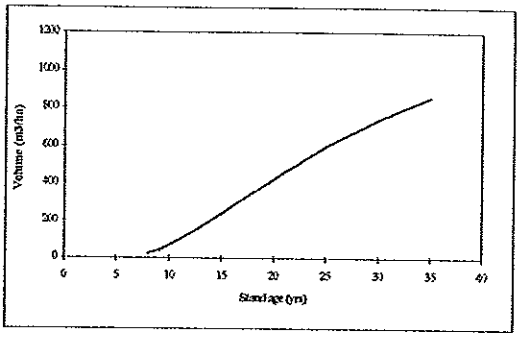
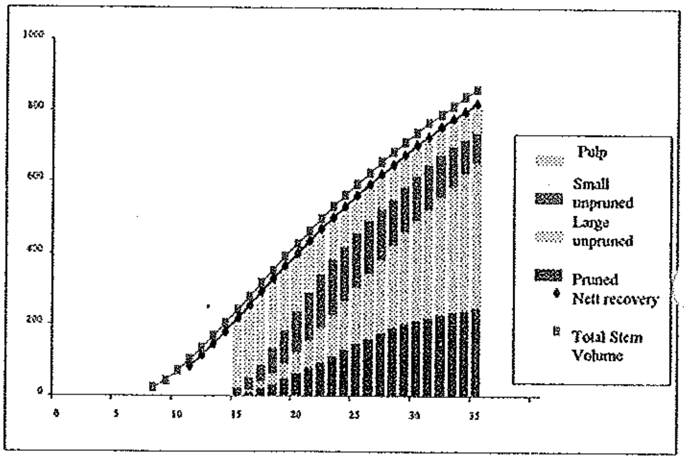


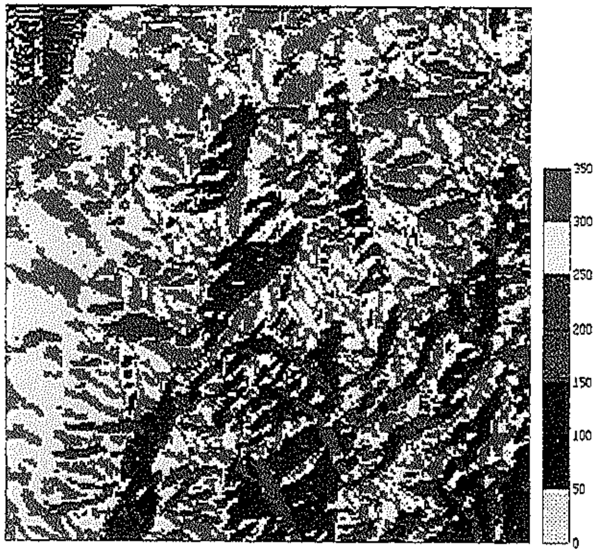
Figure 2 illustrates the so-called Total Standing Volume, per hectare, within the forest, as a function of stand age. In practice there will be a component of the crop which is not recovered, with losses due to stump volume, breakage and docking waste. Within the recoverable volume can be identified production by log grades.
Figure 3 illustrates the effect; as the stand gets older, and the trees larger, the proportion within the larger log sizes increases.

Figure 3 Standing Volume by Product

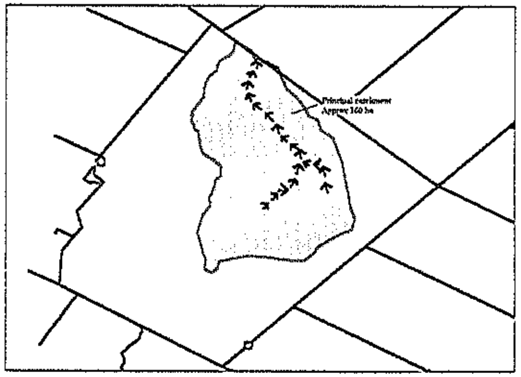


The methods for assessing expected outturn from the stand depend upon when within the rotation the assessment takes place. Figure 4, illustrates the alternatives.

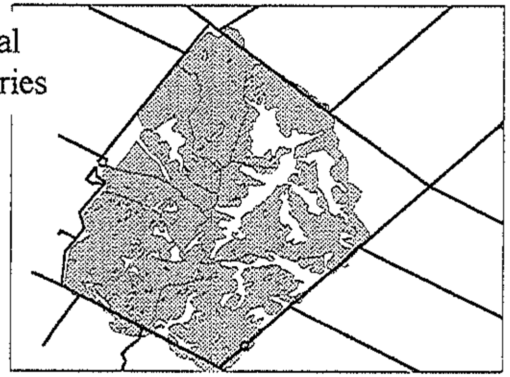
Figure1
Forest Area Analysed



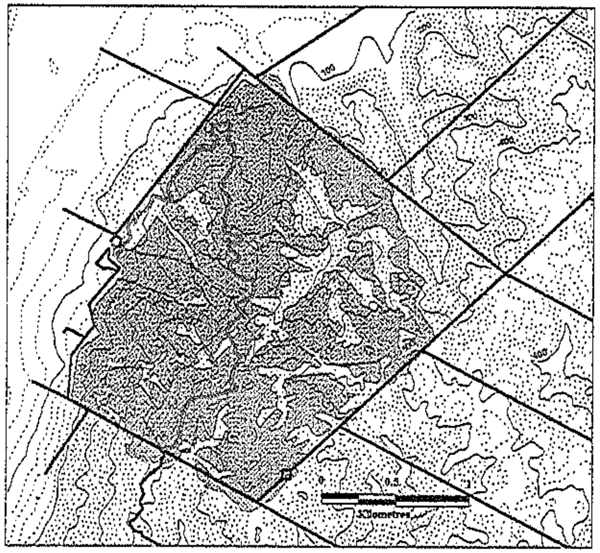
Aspect Map
(Degrees)

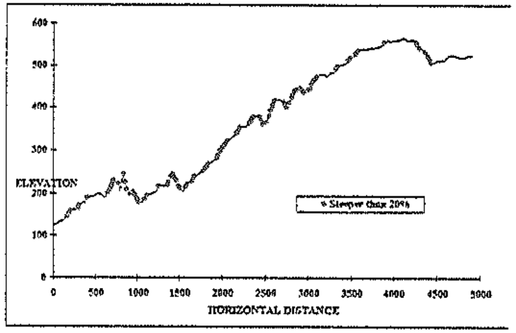


Catchment Area

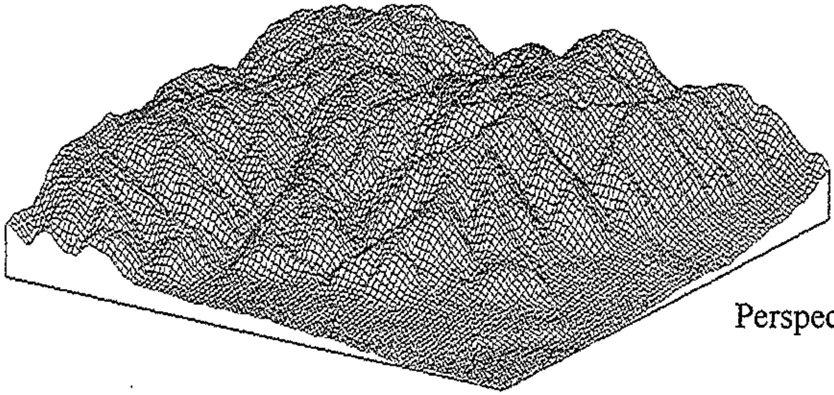


Cadastral
Boundaries

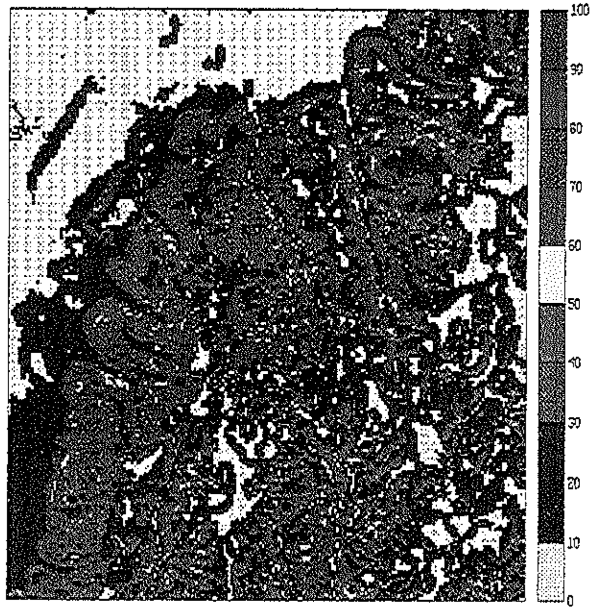




Roadline
Profile

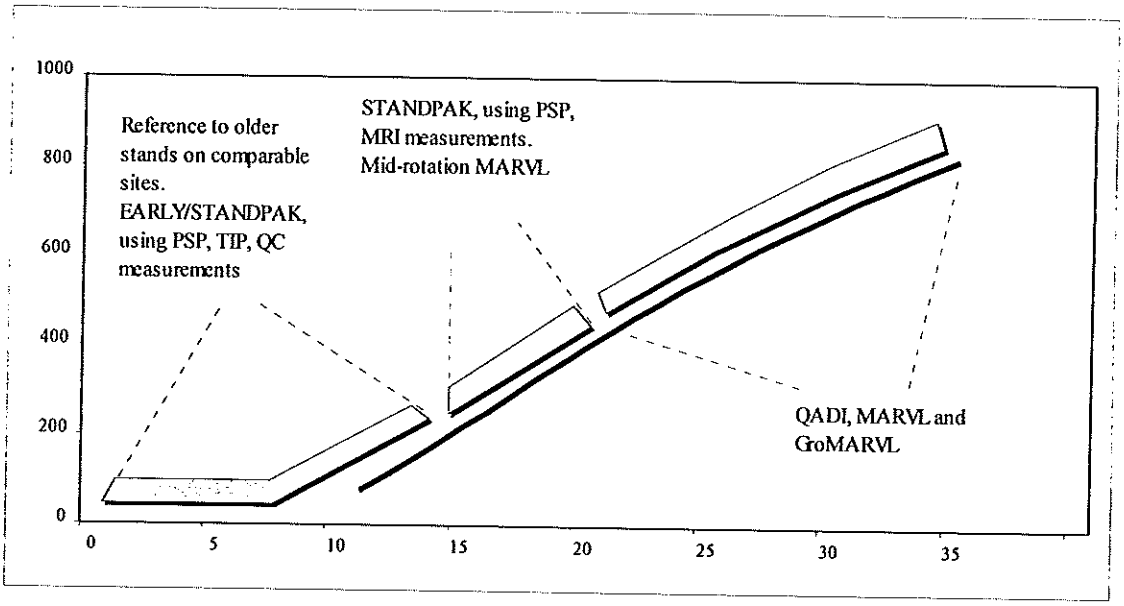


Perspective



Slope Map
(Percent)

Figure 4 Methods for Assessing Expected Outturn



For the uninitiated, the acronyms warrant explanation:

STANDPAK: This is the best known growth modeling package in New Zealand. It is obtainable under license from the New Zealand Forest Research Institute, and incorporates a series of regional growth models. Stand growth at young ages, when the effects of pruning may need to be recognised, is simulated within a model appropriately known as "**EARLY**".

MARVL (Method of Assessing Recoverable Volume by Log Type): This package, also prepared by the NZFRI, represents both a system of pre-harvest inventory, and the software package for simulating the logmaking function. It is discussed further, below. **GroMARVL** integrates the growth models contained in STANDPAK with MARVL, allowing the inventory data to be "grown" forward.

PSP: Permanent Sample Plots. As their name implies, these are plots maintained over a period of time, in order to provide a consistent time series of tree growth information. While a very desirable entity, they do represent a significant ongoing cost. Woodlots are generally not well endowed with PSP's, although some enthusiastic owners do provide the exception. NZFRI, with impetus from the Stand Growth Modeling Cooperative, have produced a bulletin describing preferred PSP design and measurement procedures.

TIP: Temporary Inventory Plots. These tend to be established from time to time to capture information for a specific purpose. This might include the assessment of silvicultural strategy, or forest valuation.

QC: Quality Control plots. These are established during silvicultural operations (e.g. planting, pruning and thinning), in order to confirm that the required specifications are being met. The information gathered tends to be oriented to the type of operation being checked. Increasingly, however, forest owners seek to record the information gathered from QC sampling in the forest database.

MRI: Mid Rotation Inventory. In an industrial forest estate, woodflows are modelled well into the future. To have the assurance that levels of harvest are sustainable, it is common practice to assess stands' performance at mid-rotation. Such plots are a special case of TIP's.

QADI: "Quick And Dirty" Inventory. A full MARVL inventory is comparatively demanding of financial and time resources. Where the information requirement is less demanding, QADI sampling may be applied.

The projection of future yield potential involves modeling biological processes. Inevitably, they cannot be modelled precisely, and important influencing factors such as the climate defy accurate prediction. The longer the prediction period, the less reliable the projection is likely to be.

Accordingly, the recommendation regarding inventory for harvesting and marketing is quite simple - do it when harvesting becomes imminent. While results from earlier inventory or modeling provide some guidance, they are no substitute for the purpose-designed pre-harvest inventory.

Pre-harvest inventory

The system which has become the de-facto standard in New Zealand is MARVL. The system comprises the following components:

- A method of describing tree characteristics
- Specification of the measurements to be captured
- A log-making algorithm, which maximises the value recovery from the assessed stems.

The system has significant advantages, and these include;

- Avoidance of a need for upper stem diameter measurements. The program instead employs taper functions to describe the stem. There is now a substantial suit of functions available, and the capacity to develop new functions for a particular location if there is reason to believe the stems have a distinct shape. Upper stem measurements are time consuming and difficult to capture accurately.
- Independence from log specifications - this is one of the cornerstones of the MARVL methodology. It is possible to take a common set of inventory data, and rerun it for different log specifications and/or different log prices.
- Support of different sampling designs - The variety of sampling methods supported includes fixed area plots, strip plots, and unbounded plots. Double level sampling may be applied, such as where bounded plot data is augmented with basal area sweeps. The program supports various levels of output. For a verification of the program's workings, at the risk of 'paralysis by analysis', it is possible to report results at an individual tree level.

Example MARVL Output

The workings of the program are best described by reference to some example output:

- Taper, Volume and Breakage functions.
  A suite of functions describing tree stem shape, volume relative to height and diameter and for predicting the breakage point are available. The selection of the most appropriate model for the woodlot being harvested is necessary.

In this example, Function 182 (ALL NZ, *P. radiata*, direct sawlog regime) has been used for Taper and Volume and Function 7 for breakage.

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MicroMARVL V2.5                        scfl1011                   Page   1
Groome Poyry - Auckland                                           Run 14/09/1996

Functions used:
    Volume: 182 P.RAD ALL NZ D.SAW LOG 1980
     Taper: 182 P.RAD ALL NZ D.SAW LOG 1980
  Breakage: 7 P.RAD TIRU 1982    AK

SAMPLING________

    Data file     c:\mvl\data\scfl1011.out
    Sampling by angle gauge points + angle gauge secondary points

----STRATUM-----  -PLOTS-- -------------------FUNCTIONS USED-----------------
 NO AGE     AREA  FULL  BA     HEIGHT     BREAKAGE      VOLUME         TAPER
  1  30      4.5     5   5  Regression 7 P.RAD TIRU 182 P.RAD AL 182 P.RAD AL
  2  30     10.2     7   7  Regression 7 P.RAD TIRU 182 P.RAD AL 182 P.RAD AL
Totals:     14.7    12  12
```

- Stem description codes.
  Quality features of the tree stem are described with reference to pre-defined alphabetic codes. Typically these codes describe sections of the tree with respect to branch size, sweep, pruned status etc., although a description of other features of interest may be included. The stem description codes should reflect anticipated market log specifications and should be flexible enough to be useful in describing a number of potential market options.

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QUALITY CODE DICTIONARY_______________________

    Dictionary file: c:\mvl\lib\auck.dic


    CODE  DESCRIPTION
      A   PRUNED,STRAIGHT PEELER,O.O.R.<10%,MIN.FLUTE,SWEEP <SED/4,EQIV. 5.5M
          LNGTH
      B   PRUNED,STRAIGHT,NOT PEELER,O.O.R.>10%,SWEEP <SED/4,
      C   UNPRUNED, STRAIGHT PEELER,BR.<7CM, O.O.R.<10%,SWEEP <SED/4,EQUIV.5.5
          LNGTH
      D   UNPRUNED, STRAIGHT NOT PEELER,O.O.R.>10%,BR.<7CM,SWEEP <SED/4
      E   UNPRUNED STRAIGHT,BR.>7-14CM,SWEEP <SED/4
      L   UNPRUNED STRAIGHT, BR. >14-24CM, SWEEP <SED/4
      P   PULP
      W   WASTE
```

- Log specifications and prices.
  A log bucking strategy reflecting potential market grade specifications and prices is developed allowing the model to generate log volumes by grade.

LOG TYPE lengths	MIN SED (cm)	MAX SED (cm)	MAX LED (cm)	$ /cu.m	QUALITIES
S1 4.90 - 6.10m	35.0	150.0	150.0	85.00	ABCD
S2 3.70 - 6.10m	23.0	100.0	150.0	62.00	ABC
MWC_RP 2.50 - 6.50m	8.0	65.0	65.0	10.00	ABCDELP
PR374346 3.70m 4.30m 4.60m	35.0	150.0	150.0	137.00	A
TDCL3 4.90m 5.50m 6.10m	30.0	100.0	100.0	32.00	ABCDE
KINHDPLP 2.40 - 6.00m	25.0	90.0	90.0	1.00	ABCDELP

Output from the MARVL system provides a number of useful statistics and these are largely self explanatory.

- Total volume, breakage and stump volume.

VOLUME ANALYSIS

	VOLUME cu.m/ha	VOLUME %	FREQUENCY trees/ha	SIZE cu.m/tree
Breakage	6.2	1.3	96	0.064
Stumps	4.0	0.9	152	0.026
Unmerch. stems	0.0	0.0		
Residues subtotal	10.1	2.2	152	0.067
Extracted stems	451.4	97.8	152	2.976
TOTAL (live trees)	461.5	100.0	152	3.042
+/- @ 95.0% conf.	73.9	16.0		

- Volume by Log grade, logs per hectare and piece size.

PRODUCT ANALYSIS

LOG TYPE	VOLUME %	VOLUME cu.m/ha	VOLUME +/-	VALUE %	VALUE $/ha	LOGS no/ha	SIZE cu.m/log
S1	48	213.3	32.7	56	18133	233	0.917
S2	17	76.4	31.5	15	4740	214	0.358
MWC_RP	15	64.4	23.1	2	644	304	0.212
PR374346	13	59.5	33.6	25	8157	67	0.883
TDCL3	6	27.8	12.0	3	889	41	0.672
KINHDPLP	0	0.9	2.0	0	1	1	1.077
TOTAL RECOVERABLE	100	442.4	71.7	100	32564	860	0.514
Cutting waste		9.0					

- other parameters, including statistics describing the standing resource.

STANDING RESOURCE

	STOCKING stems/ha	%	BASAL AREA sq.m/ha	%	MEAN DBH cm
Dead	0	0.0	0.0	0.0	0.0
Live	152	100.0	38.2	100.0	56.6
TOTAL	152	100.0	38.2	100.0	56.6

Mean live tree height 35.1
Mean Top Height (100) 37.5 m   Mean Top Diameter   61.2 cm

Not shown here are additional tables which report the log volume by small end diameter class. The component that those using the results must be careful to examine is that which reports the precision. In general the more precise the estimate the more confidence can be held in the results.

Precision of Estimates - interpreting the MARVL output

Typically, MARVL output presents mean volume estimates for each log grade with corresponding confidence intervals. Analysing the MARVL data from our example resource indicates that the total stand volume is 461.5 m^3/ha +/- 73.9 m^3/ha. Typically in MARVL, the confidence level is expressed at the 95% level. Thus in the above example that you could be 95% sure that total volume will lie between 535.4 m^3/ha and 387.6 m^3/ha.

The precision of the estimate can be improved by increasing the number of plots established, stratifying the resource to reduce the variation within a stratum or a combination of both. Maps such as those described earlier can be most useful in this stratification. The precision achievable depends on the variability of the features being measured within the resource. However a trade-off will always exist between the cost of a more intensive inventory and the level of precision achieved.

The owners of this resource who were marketing their own wood required a greater level of precision than was provided in the first assessment and the resource was stratified into two areas based on stocking.

The precision of the volume estimate will vary between log grades and plots. The sum of the errors associated with the volume estimates by individual log grades is larger than the error associated with the total volume estimate (Figure 5).

Figure 5 Precision of Volume Estimate

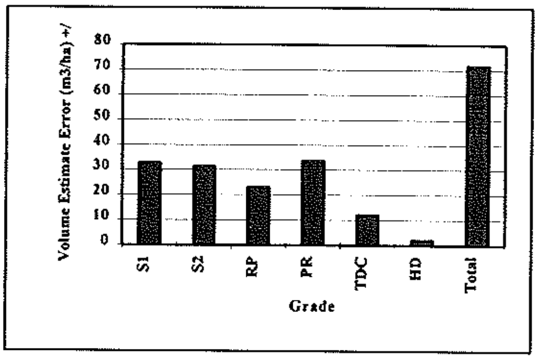
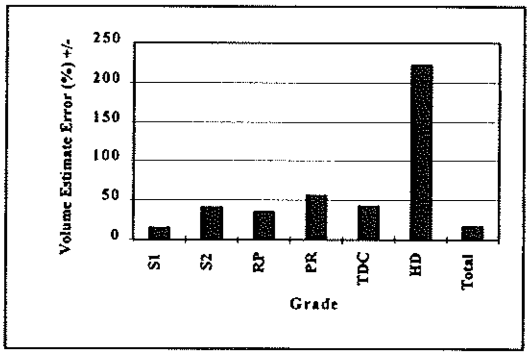


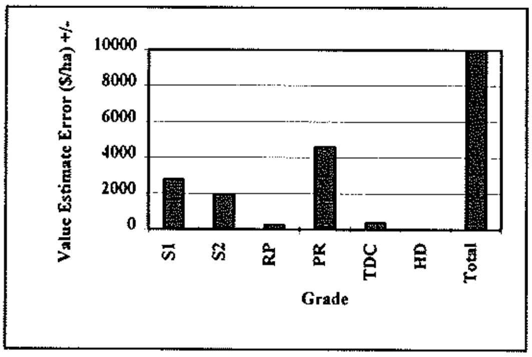
Figure 6 provides a different representation of the precision, here expressing the confidence limits as a percentage of the estimated value. In this case, the HD and TDC log types have relatively high imprecision but given they only comprise a small fraction of the crop , they may not warrant further sampling. The next least precise are the S2 and Pr grades.

Figure 6 Volume Error as a Percentage of Grade Volume



The effect of precision becomes more significant when an examination of the stand value is conducted. The estimated stumpage value for our example stand was $32 560/ha, with an estimated value range of +/- $10 000/ha (or 31%). Figure 7 illustrates that most of the error in the value estimation is related to estimates of S1, S2, and PR volumes.

Figure 7 Precision of Value Estimate



Integrating the Area, Terrain and Crop Information

With the description of the area, terrain and crop in place, we can then proceed to the next phases of producing a harvest plan. This involves an analysis of harvesting systems, an examination of market opportunities, and consideration of logistical matters. The procedures are discussed elsewhere in this and other LIRO conferences, and have been introduced and developed in various LIRO and industry courses on harvest planning.

So what does the woodlot owner need?

Should the forest owner commission the terrain and crop description? Invariably the woodlot owner has as much to gain, from having a reliable resource description as any other party.

With reliable data the owners are placed in a stronger position from which to assess opportunities and offers from outside buyers as well as determining the best time to harvest the woodlot.

The cost of the inventory and analysis need not be entirely at the owners expense. The costs associated with a well designed and conducted inventory may be recouped by offering the information to prospective purchasers, in addition to, or instead of data they plan to collect themselves.

Within small woodlot owners are a contingent who prefer to undertake management tasks themselves. What prospect is there that they might undertake the inventory functions?

In considering the "do it yourself" option it is necessary to understand the types of equipment and software necessary for the efficient production of a reliable forest description.

Hardware: To take advantage of the available technology, you require a computer (fast), a digitiser and printer (preferably colour). GPS equipment, a Vertex and field datalogger would be nice.

Software: MARVL, GroMARVL, CAD or GIS package, GPS software, other terrain representation software (e.g. SURFER), harvest planning software (e.g. LoggerPC, PLANZ, PLANEX, LIRO Contractor Costing Software), Roading planning packages.

In recent years a number of skilled contractors and service providers have developed within the forest industry, providing skills and services in a range of areas. Providers of such services include, mensuration contractors, forest industry consultants, and LIRO. The advantage of purchasing expertise from specialist providers is that the standard of work is generally more consistent and the operation is more efficient than can be obtained from operators who may only occasionally practice the skills.

The development of the forest description could be left to the wood buyer, with the added benefit that the information is likely to be compiled and analysed at no expense to the woodlot owner. Importantly though, the woodlot owner should not feel embarrassed to ask what planning routines, and what technological support the woodlot buyer will be deploying in the process and feel free to seek external advice on the appropriateness of the proposed methodologies and approach.

The wider trend in forest description

The inventory procedures described constitute part of what is referred to among the corporate forest owners as a "Forest Description". The necessity for an accurate Forest Description is receiving increasing levels of attention by owners and purchasers of forest areas. Most of the corporate forest owners and increasingly the independent forest managers have developed data collection and reporting standards to ensure consistent procedures are applied and target levels of precision obtained. The "Description" is often the subject of external audit, particularly for valuation and insurance purposes.

Forestry is becoming an increasingly information intensive activity. This is not because of any special predilections of foresters as a group, or because of their gullibility under the onslaught of computer salesmen. Rather it is the necessary precursor to maximising forest profitability.