An overview of Coillte's forest resource inventory and timber production forecasting system[1]

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Introduction

Coillte was established in 1989 as a state-owned commercial forestry company. The forest asset value of its estate is over £800 million (1994). Coillte has over 1,400 employees (both industrial and non-industrial). Turnover increased from £42 million in 1993 to £57 million in 1994. Net profit in 1993 was £1.7 million, and this is expected to increase substantially in 1994. The company planted over 10,000 ha in 1994, and sold over 2 million m^3 of timber. The current (1994) size of Coillte's estate is 415,000 ha, of which 390,000 ha are planted. The average yield class for conifer species is 14.6 m^3/ha/yr. The estate is mainly Sitka spruce (59%) and lodgepole pine (23%). Other main conifer species are Scots pine, Norway spruce, Japanese larch and Douglas fir. Broadleaves make up only 3% of the estate - most broadleaf areas were transferred to other state agencies when Coillte was established. It is company policy to increase the level of broadleaf planting, subject to suitable land becoming available.

Coillte's estate is extremely scattered and consists of numerous properties, reflecting the pattern of acquisition over the past 50 years. With the exception of the blanket peats in the west, acquisitions were largely made up of small farms or holdings which in turn were comprised of many small fields. The scattered nature of Coillte's estate with relatively few large forest blocks is in contrast with plantation forestry in other countries, such as New Zealand, where large blocks of more or less uniform composition are the norm.

The forest resource inventory in Coillte

The forest inventory carried out in Coillte is intensive in that the entire estate is visited and stand mapped down to the subcompartment level. Although contrasting with the sampling approach more commonly used world-wide, a complete inventory is employed due to the scattered nature of the estate and extreme

variations in growth rates and crop quality. Large variations have also arisen as a result of previous establishment practices of matching species to the vegetation type. Such practices have created a patchwork effect of small stands of varying species in many areas, again necessitating a complete inventory. Another feature of Coillte's forest inventory is that the process is now continuous, with an annual programme including the inventory of all new plantations and the recording of areas which have been clearfelled. As Coillte's inventory database has been built up over a number of years, the company is now engaged in resurveying selected stands.

Coillte's estate is divided into compartments, the boundaries of which are delineated on the ground by ridelines. Ridelines, which are typically unplanted strips 10-20 m wide, often follow ordnance details such as ditches and streams. There are approximately 22,000 compartments in the Coillte estate, each identified by a unique code consisting of a five digit number and a letter. The average compartment size is 19 ha, although more recent plantations tend to have compartments which are considerably larger. Each compartment is in turn divided into subcompartments or stands by the inventory operation, with each stand numbered uniquely within the compartment. By combining the compartment and the subcompartment numbers, a unique identification code for each stand in the entire estate is obtained.

Coillte's forest inventory is carried out using ground surveys supplemented in certain circumstances by aerial photography. Ordnance Survey of Ireland (OSI) 1:10,560 series maps are used in the field work. The boundary of each stand is identified on the ground and copied onto the OSI map using a scale ruler. Detailed guidelines and rules are followed in order to ensure consistency throughout the company. The inventory fieldwork is carried out by specially trained staff who undergo intensive training prior to starting the inventory.

An important aspect of any inventory is the need to maintain consistency in both interpretation and the standard of work. This is particularly crucial if different staff are involved in different parts of the country. Part of Coillte's approach to ensuring consistency is to employ local inventory managers responsible for the inventory within their specific areas, the work of whom is overseen by an overall company inventory auditor.

The forest inventory records a variety of information about each stand, including the following.

- Location in terms of forest property, county, OSI map number, etc.
- Gross area of the stand in hectares to 0.1 ha, and an understocking adjustment factor. The area is obtained from Coillte's Geographical Information System (GIS) after the stand outline has been digitized into the computer.
- Species composition following standard codes, eg. "SS" for Sitka spruce, etc. The presence of up to four species can be recorded for each stand.

- Planting year and an indication of whether the crop is first or second rotation. Codes are also used to record other related aspects, e.g. "E" where the age is uncertain, etc. The correct estimation of age is important for assessing yield class.
- The general yield class of the conifer species (two species in the case of a mixture). This is estimated by measuring top height, or, if the crop is too young, by subjective assessment. Such assessments are coded for separate identification.
- The spacing of conifer crops at establishment. This is of particular relevance to crops planted between the mid 1970s and mid 1980s, when spacings wider than the normal 2.0 m were more common.
- Classification into one of 14 land use types (LUTs), which provides broad land use data. The bulk of Coillte's estate is in the LUT referred to as Conifer High Forest.
- Where applicable, a constraint or explanation as to why a stand cannot be managed as a commercial forest crop, eg "Amenity" where the area is being managed primarily as an amenity site.

Information on the location of forest roads is essential for harvest planning. The forest road network in each property is drawn on the inventory map and later stored as a separate layer on the GIS. The GIS can then be used to carry out various analyses such as identifying how much land or timber is serviced by a particular road network.

Site information is recorded for an area referred to as a section, which is made up of one or more compartments which are broadly uniform in terms of the site parameters being recorded. The composition of a section can be altered as site conditions change, particularly in terms of accessibility. For example, an area previously regarded as being inaccessible may be joined to an existing accessible section on completion of a new road.

The Coillte estate is currently divided into 6,100 sections, with an average size of 70 ha. The information recorded for each section includes site fertility and machine workability, elevation, exposure, drainage and windthrow hazard, soil type, and accessibility. Site information is recorded on a majority basis. For example, a section classed as moderately exposed may in fact contain areas of greater or lesser exposure. As site information is essentially compartment-based, it is possible to view this information in relation to any compartment or stand within a compartment. The purpose of the site information is to assist in the overall long term timber production planning process.

Processing of inventory data

Although data loggers, i.e hand-held computer data recording devices, have been used by Coillte research staff for some years, inventory information is still recorded on paper in the field. This is due partly to cost, and partly to the rela-

tively small amount of data being recorded each day. This aspect of work, however, is currently under review. A key element of the processing of inventory data is the use of the GIS to store both the data and maps on computer. This allows the quick and easy recording of changes and the generation of a vast array of different types of maps.

Forest inventory information forms the basis of valuing the estate, day-to-day management, and, through its key role in generating the timber production forecast, planning future development.

Thinning and Rotation Classification

Due to site (soil type and method of cultivation) and climatic (mainly wind) considerations, it is not possible to thin all forest crops in Ireland. There may also be economic reasons for not thinning certain crops. In addition, many crops cannot grow to the expected rotation because of the risk of windthrow. In order to take these factors into account in estimating future timber production levels, forest managers in Coillte set out a long term plan for every stand. This plan, referred to as the Thinning and Rotation Classification (TRC), specifies the most suitable thinning regime and rotation length of each crop, taking into account not only the factors mentioned above, but also the performance of the existing crop and the potential of the site. Underperforming crops of poor quality are earmarked for early replacement, while productive stands are assigned a specific thinning and rotation treatment.

The thinning component of the TRC specifies a thinning treatment for each stand (including no thinning), and indicates the year in which first thinning will occur. Where normal thinning cannot take place, the number of thinnings which the crop will receive is recorded, along with the interval between each thinning (thinning cycle) and an explanation as to why normal treatment is not possible. This latter information can be used, for example, to identify where crop instability is the main factor in the decision not to thin or to carry out fewer thinnings. The rotation component of the TRC specifies the year in which the stand will be clearfelled, and, if applicable, an explanation as to why the crop is being grown on a longer or shorter rotation than normal. This second piece of information can be used, for example, to identify areas where crop instability is the main reason for specifying a shortened rotation. Also recorded as part of the TRC process is an estimate of the capacity of each stand to produce sawlog at clearfell stage. This is done in the form of a code indicating the potential of the stand to produce (i). pulpwood only, (ii). medium sawlog and pulpwood, or (iii). large and medium sawlog and pulpwood. This information is used in the timber production forecasting system to generate a product type forecast.

While a TRC is applied to every stand, the thinning and clearfelling decisions

for each stand are not taken in isolation but as part of an overall harvesting unit. In the case of thinning, this unit may represent an entire property. In the case of rotation, the harvesting unit may consist of one or more stands, depending, among other factors, on the volume of material involved and the area.

The TRC is a key component, along with the inventory data and yield models, of Coillte's timber production forecasting system, and ultimately sets the timber production targets of the company. It is also used to indicate future harvesting capacity and reforestation expectations.

Coillte's timber production forecasting system

There are two elements to Coillte's timber production forecasting system:

- the long term production forecast, typically for the next 20 years, and
- the medium to short term forecast, usually for the next five years.

Both forecasts use the same base data, but may have different assumptions regarding which stands are to be harvested in a given year. The inputs into the forecasting system are:

- inventory data,
- yield models,
- yield model adjustments,
- TRC,
- forecast assumptions, including factors such as thinning intensity and cycle, reductions for unstocked areas, etc.,
- top diameter assortment tables, and
- forecast computer program.

Coillte uses a combination of Forestry Commission yield models, Forest Service yield models for lodgepole pine, and its own models. These models are referred to as static models as they assume that a particular regime is followed. It is intended to incorporate more dynamic yield models into the forecasting system in the near future.

The accuracy of the forecast estimates is regularly tested and adjustments are made were necessary. As a result of a number of such surveys, various adjustments are made by the forecast program to the estimates of mean dbh, stems/ha, volume/ha and stand area generated by the forecast system. The following estimates are generated for each stand processed by the forecast program:

- mean dbh,
- volume/ha,
- stems/ha,
- area,
- harvest type,
- production year, and

- stand identification.

Other information, such as the species, timber grade, etc., is accessed from the inventory or TRC databases.

In addition to generating estimates of total stand volume, the forecast program also uses top diameter assortment tables (one for Sitka spruce, and one for other conifer species) to generate estimates of the volume in different top diameter categories, usually 7-13 cm, 14-19 cm and 20+ cm, using the forecasted mean dbh. The figures for each stand are then accumulated and summarized according to year, harvest type and species. A summary report by forest or other unit can be outputted. Two types of forecast are produced:

- top diameter assortment breakdowns, for thinnings and clearfellings separately, and
- potential end product (PEP) breakdown, for thinnings and clearfellings separately (timber grade information is used to recategorize top diameter volumes into estimates for large sawlog, medium sawlog and pulp).

Depending on the number of thinnings, a stand may generate forecast estimates for several different years, culminating in a clearfelling in the year specified in the TRC. The forecast report shows the area, total volume, volume in each top diameter category or PEP, and average tree size for thinnings and clearfellings for each year. If a species forecast is requested, the above figures are reported by species. Forecast figures are produced for each forest, district, etc., as requested.

The forecast produced by applying a TCR to every stand typically shows year-to-year fluctuations in timber volume for thinnings, and more especially, for clearfelling. These fluctuations are evened out by applying a five-year averaging and by amending the TRC of certain stands. An option exists to view the forecast reports in either the unsmoothened or smoothened out version. The latter version is usually used when a long term view is more appropriate.

The forecast generated by applying a TRC to every stand can be regarded as the optimum production potential, particularly with regard to thinning volume. This is because the forecast generates volume estimates for every stand using the specified thinning cycle. For operational reasons, the actual thinning cycle in the short term may differ from that assumed in the long term forecast. For example, a stand on a three-thin option with an average thinning cycle of six years may, in reality, receive its second thinning five years after the first, and its third thinning seven years after the second. In order to allow for such variation, a medium term forecasting system, referred to as the harvest forecast, also exists. This system typically covers a rolling five-year period, starting in the current year plus one. The harvest forecast predicts production only for those stands identified as being part of a group of stands planned for harvesting in a specified year. The same basic forecasting system is used to generate the estimates of volume, etc., but more detailed breakdowns of the forecast figures are available. The harvest fore-

cast forms the first step in the timber sales process in Coillte.

In conclusion, the key features of Coillte's timber production forecasting system are summarized in Figure 1.

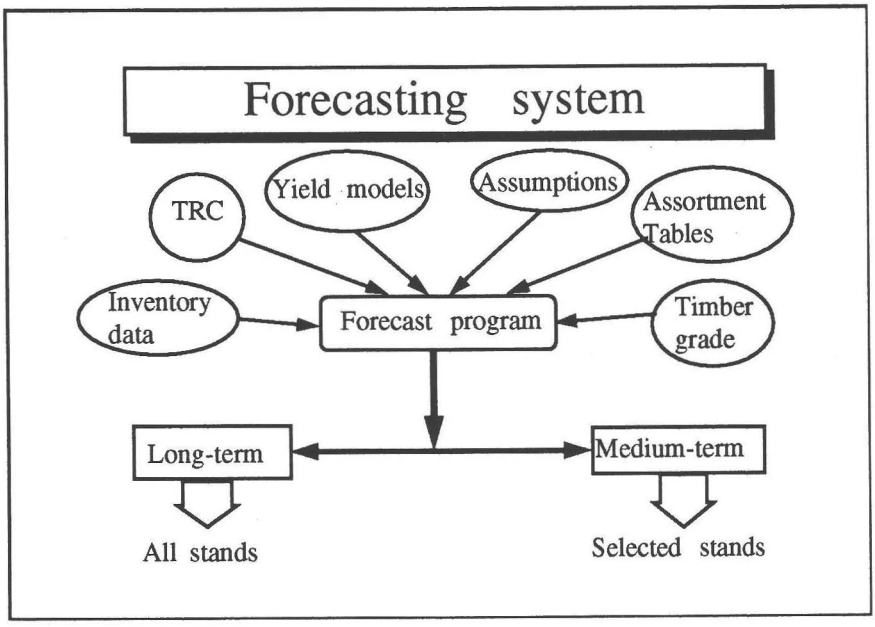

Figure 1. *Key features of Coillte's timber production forecasting system.*