



Forecast Types

A document describing how different forecast types are implemented in the 2011 Production Forecast system.

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Background

Different 'types' of forecast are possible for a specified area of forest, depending on assumptions about management and related factors. Rather than defining one particular Forecast Type, there is a requirement to represent a range of Forecast Types within the forecast system.

Different types of forecast are needed to address specific applications, ranging from planning operations in Forestry Commission districts through to high-level forecasts for Great Britain. There is particular interest in understanding how environmental and operational constraints on production in forests affect the pattern and level of volume production compared to what might be possible in the absence of such constraints.

It is important to distinguish between Forecast Types as defined here and different types of forecast output such as timber volume production, standing volume or carbon stocks. In principle all types of forecast output can be produced for any Forecast Type. This document is based on a low-level specification which details for the programmers how the Forecast System should handle, for each implemented Forecast Type, the input data relating to all aspects of both PFE and NFI Forecasts.

Throughout this document, reference is made to 'sub-components'. A 'sub-component' is the smallest entity that can be identified in Forester, *i.e.* a portion of a component that has been split by a coupe boundary which does not match the boundary of the original sub-compartment containing the component.

Base data

The data for running the forecast are obtained from two sources:

- the Forestry Commission sub-compartment database (SCDB) for all sub-components within the Public Forest Estate; or
- the National Forest Inventory (NFI) database (containing the results of a field assessment of 1 hectare grid squares in both publicly- and privately-owned land).

The data required to produce each forecast output (*e.g.* timber volume production forecast, standing volume forecast, carbon stocks forecast, *etc.*) are detailed in the requirements document for each forecast output (see the List of Forecast System Documentation on page 22). A description of the NFI data is given in the NFI field manual and supporting documentation.

Data validation

There are two fundamental ways of running a forecast on a forest component, depending on the source data and current land-use:

- forecasting from year zero, based on initial stand conditions (whether assessed or assumed); or
- forecasting from the date of assessment of a growing stock point made between year zero (*i.e.* planting/regeneration) and the present date.

Forecasting from a properly assessed growing stock point will always result in the most reliable possible forecast as it inevitably reduces the period of stand growth that has to be modelled.

Whether forecasting from year zero or from an assessed growing stock point, the forecast input data must be subject to pre-forecast checks in order to ensure the validity of the forecast outputs. Although some validation takes place at the time of data input, the forecast system performs a series of further checks using a supplementary programme module which has been given the development title of 'the Archangel device' and which was originally specified in the internal document "*Checking the validity of growing stock 'inventory point' data*" (Jenkins, 2011).

The Archangel device runs validation checks on the data being passed to the Forecast System, whether these data are describing initial stand conditions or a growing stock point, and either inserts missing values or (where there is not enough information to fill the gaps) recommends rejection of the sub-component being validated. Where missing values are inserted, the sub-component is included in the forecast calculations. Where this is impossible, the sub-component is not included in any subsequent forecast calculations until such time as valid data are recorded in the relevant source database (NFI or SCDB). The forecast system produces a report listing any rejected sub-components/areas which are not included in a forecast.

Statement of Forecast Types

The six main Forecast Types specified within the 2011 forecast system are: Zero Intervention, Biological Potential, Strategic Regional, Management Plans, Target Assortments, and Quick. The priorities for implementation of the above Forecast Types are presented in the section '*Initial priorities and future developments*' on page 20 of this document.

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It is assumed that the Management Plans forecast type will be the default forecast type for all forecasts for the Public Forest Estate based on data from the Forestry Commission sub-compartment database (SCDB). If the user requests a different forecast type, *e.g.* zero intervention, then this is a 'change' from the 'standard' management plans forecast. In order for 'non-standard' forecast types to be calculated correctly, the forecast system needs to assume that all sub-components have been managed according to 'management plans' up until the start of the forecast period. The management regime pertaining to the 'non-standard' forecast type would only apply from the start of the forecast period.

For forecasts based on NFI data, the 'standard' forecast type will be Strategic Regional. Use of this forecast type is necessary because management plans data are not generally collected for NFI squares. Because of the way that NFI data are collected, most components will have a growing stock point recorded together with an indication as to whether the stand has been previously thinned. In order for the forecast to be calculated correctly, the forecast system needs to assume that all sub-components have been managed according to the appropriate (thin or no-thin) standard growth model for that tree species between the date of the NFI assessment and the start of the forecast period.

All of the six main Forecast Types (and, in the case of Biological Potential, three sub-types) are outlined below, each with examples to illustrate the main underlying assumptions. The illustrative examples presented below are all based on a forest sub-component with the following characteristics:

- Scots pine
- yield class 8
- initial spacing 1.4 m
- planting year 1960
- previously thinned to management tables on a 5-year cycle, with LISS management (shelterwood) introduced in 2015 on a 10-year thinning cycle
- LISS final removal year is 2045
- for examples relevant to NFI, it is assumed that an estimate of growing stock is available for the year 2010
- for examples relevant to the FC Estate, it is assumed that an estimate of growing stock has not been collected and entered into the SCDB (*i.e.* the data are missing)
- DAMS score = 20.

The forecast period is taken to be from 2011 to 2100.

Zero Intervention

A 'Zero Intervention' forecast is based on the assumption of no forest management of any type, notably, no thinning and no felling. In addition, the effects of major natural disturbances, *e.g.* fire, windthrow and disease, are not accounted for.

This is clearly a highly theoretical Forecast Type. Its main application would be to indicate how the growing stock of forests might develop in the absence of any management or disturbance. The results could be used as a theoretical benchmark against which growing stock outputs of the Forecast Types might be compared. This may be of particular relevance when considering forest carbon stocks.

Example with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system 'grows on' the sub-component. No thinnings or fellings are removed over the forecast period. There may be some loss of trees and volume *etc.* over time depending on the level of competition between the trees forming the sub-component. (This is handled automatically by the growth model.) The sub-component will continue to exist over the full forecast period (2011 to 2100).

Example with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards the forecast system 'grows on' the sub-component. No thinnings or fellings are removed over the forecast period. There may be some loss of trees and volume *etc.* over time depending on the level of competition between the trees

forming the sub-component. (This is handled automatically by the growth model.) The sub-component will continue to exist over the full forecast period (2011 to 2100).

Biological Potential

A 'Biological Potential' forecast is based on the principle of maximising potential volume production, subject to certain assumptions. In the context of the forecast system, this is assumed to mean that all sub-components are clearfelled at either the age of maximum mean annual increment or, for one forecast variant, the age at which a threshold 'terminal height' is achieved on sites exceeding a user-specified DAMS score¹. The relevant fell age is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and an appropriate assumption regarding thinning.

Three sub-types of the Biological Potential Forecast Type are defined:

- a 'no-thin' sub-type in which all stands are assumed not to be thinned from the beginning of the forecast onwards, and are clearfelled at the age of maximum mean annual increment;
- a 'thin' sub-type in which all stands are assumed to be thinned from the beginning of the forecast onwards, and are clearfelled at the age of maximum mean annual increment; and
- a 'thin constrained by wind and previous thinning history' sub-type in which
 - all stands which have previously been thinned continue to be thinned during the forecast period and are clearfelled at the age of maximum mean annual increment;
 - all stands with a DAMS score lower than the user-defined threshold² that are younger than the tabulated age of first thinning are thinned during the forecast period and are clearfelled at the age of maximum mean annual increment; and
 - all other stands are assumed not to be thinned and are clearfelled at the age at which a user-defined terminal (top) height¹ is reached or at the age of maximum MAI, whichever occurs first.

¹ Although the DAMS 'limit' and terminal height are user-definable in the Forecast System, if not explicitly entered by the user for the current production forecast these thresholds will be set as DAMS ≥ 17 and terminal [top] height ≥ 21 m.

² In the forecast system, the default DAMS threshold has currently been globally set to be consistent with OGB 9 recommendations. "*Where windiness (DAMS) scores are 17 or more on less well-drained sites or on shallow soils, the opportunities for thinning are limited. On these sites, non-thin is often the best management approach.*" This default value can, however, be overridden by the user prior to running the forecast.

Following clearfell, restock sub-components are assumed to be managed according to standard thinning prescriptions or with no thinning, as appropriate for the sub-type.

Example for a 'no-thin' sub-type with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to the model (see Appendix 1) but subject to no thinning. The forecast system overwrites the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of no thinning. It is important to note that for the purposes of this sub-type the age of maximum mean annual increment is taken from the 'standard' growth model, assuming no-thinning. For this example the age of maximum mean annual increment is 73 years, giving a fell year of $1960+73 = 2033$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Example for a 'no-thin' sub-type with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. Even though the Biological Potential sub-type is no-thin, it is assumed that thinnings have taken place up to the time of the start of the forecast because this is how the stand has been managed up to this point. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to an appropriate growth model (see Appendix 1) but subject to no thinning. The

forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of no thinning. It is important to note that for the purposes of this sub-type the age of maximum mean annual increment is taken from the 'standard' growth model, assuming no-thinning. For this example the age of maximum mean annual increment is 73 years, giving a fell year of $1960+73 = 2033$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Example for a 'thin' sub-type with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system uses the newly-imposed management prescription. Under the new prescription the forecast system 'grows on' the sub-component by reference to an appropriate growth model (see Appendix 1) but subject to an 'imposed' management prescription based on thinning according to standard management tables. The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of MT thinning. For this example the age of maximum mean annual increment is 84 years, giving a fell year of $1960+84 = 2044$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Example for a 'thin' sub-type with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin

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model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to an appropriate growth model (see Appendix 1) but subject to an 'imposed' management prescription based on thinning according to standard management tables. The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of MT thinning. For this example the age of maximum mean annual increment is 84 years, giving a fell year of $1960+84 = 2044$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Example for a 'thin constrained by wind' sub-type with growing stock data available

In this example, the DAMS threshold is set at 17 and terminal height is set at 21 m.

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system imposes one of two management prescriptions, dependent on the DAMS score associated with the sub-component.

Because the recorded DAMS score (20) is not less than the threshold (17), from 2011 onwards, the forecast system 'grows on' the sub-component by reference to the model (see Appendix 1) but subject to no thinning. The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is the minimum of the standard age of maximum MAI or the age at which 21 m terminal (top) height is reached. In this case standard age of maximum MAI and the age at which 21 m top height is reached are found from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of no-thin. For this example the age at which a top height of 21 metres is reached is 74 years and the age of maximum MAI is 73 years. Therefore, age of maximum MAI is the minimum of these two ages, giving a revised fell year of $1960+73 = 2033$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

If the DAMS score had been less than the defined threshold (17 in this example), the forecast system would have 'grown on' the sub-component onwards by reference to an appropriate growth model (see Appendix 1) but subject to an 'imposed' management prescription based on thinning according to standard management tables. The forecast system would have over-written the LISS final removal year of 2045 with a new clearfell year. Because of the low DAMS score, the clearfell year would have been based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of MT thinning. For this low wind risk example the age of maximum mean annual increment is 84 years, giving a fell year of $1960+84 = 2044$. Had this calculated fell year occurred before the start of the forecast (2011), a fell year of 2011 would have been assigned.

Example for a 'thin constrained by wind' sub-type with no growing stock data available

In this example, the DAMS threshold is set at 17 and terminal height is set at 21 m.

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

Because the recorded DAMS score (20) is not less than the threshold (17), from 2011 onwards, the forecast system 'grows on' the sub-component by reference to the model (see Appendix 1) but subject to no thinning. The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is the minimum of the standard age of maximum MAI or the age at which 21 m terminal (top) height is reached. In this case standard age of maximum MAI and the age at which 21 m top height is reached are found from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of no-thin. For this example the age at which a top height of 21 metres is reached is 74 years and the age of maximum MAI is 73 years. Therefore, age of maximum MAI is the minimum of these two ages, giving a revised fell year of $1960+73 = 2033$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

If the DAMS score had been less than the defined threshold (17 in this example), the forecast system would have 'grown on' the sub-component onwards by reference to an appropriate growth model (see Appendix 1) but subject to an 'imposed' management prescription based on thinning according to standard management tables. The forecast system would have over-written the LISS final removal year of 2045 with a new clearfell year. Because of the low DAMS score, the clearfell year would have been based on the planting year of 1960 and an assumed age of maximum mean annual increment, which is obtained from a 'standard' run of M1, *i.e.* based on species, GYC, spacing and the assumption of MT thinning. For this low wind risk example the age of maximum mean annual increment is 84 years, giving a fell year of $1960+84 = 2044$. Had this calculated fell year occurred before the start of the forecast (2011), a fell year of 2011 would have been assigned.

Strategic Regional

A 'Strategic Regional' forecast is based on a set of rules determining forest management, generally defined and applied at large scales, *e.g.* across a region. Forest areas have different management prescription applied, depending on:

- species (or user-defined species group)
- yield class
- planting year
- DAMS score
- previously thinned
- forecast flag
- percentage area

or a subset of categories drawn from this list.

In a Strategic Regional forecast, it may be desirable to quickly specify the same management prescription simultaneously for more than one species, if it is intended that these are to be treated in the same manner (*i.e.* thinning regime, conversion to LISS (if applicable), fell age *etc.*). The mechanism by which species can be grouped together by the user for the purposes of a Strategic Regional forecast is given in Appendix 2.

Appendix 2 also describes how rule sets are interpreted in terms of hierarchy and resolution of apparent conflicts (*e.g.* two different rules potentially applying to the same area).

Management prescriptions can be defined in terms of:

- thin/no-thin flag
- thinning cycle
- thinning intensity
- thinning type
- year of conversion to LISS
- age of conversion to LISS
- LISS type
- LISS cycle
- LISS thinning intensity
- fell age
- fell year
- fell top height.

There are restrictions on how these terms can be combined, specifically:

- if the thin/no-thin flag is set to 'no-thin', all thinning and LISS terms are ignored
- the setting of the thin/no-thin flag is mandatory
- if the thin/no-thin flag is set to 'thin', then Thinning cycle, Thinning intensity, and Thinning type must be specified
- the options for thinning type are limited to 'Intermediate' and 'Neutral'
- if both Year of Conversion to LISS and Age of Conversion to LISS are specified, the actual year of conversion applied to a sub-component is taken as the maximum of the Year of Conversion to LISS and (Planting Year + Age of Conversion to LISS)
- the LISS type can only be set in broad terms as either 'shelterwood' or 'selection'
- if the LISS type is 'shelterwood', the LISS thinning intensity is ignored
- either Fell age or Fell year must be specified but not both, unless the LISS type is 'selection' in which case the setting of Fell age or Fell year is optional
- there are certain constraints on the setting of numerical values such as Thinning cycle and Thinning type.

An example of how rules for management prescriptions might be set is given in Appendix 3.

Example with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

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From 2011 onwards, the forecast system 'grows on' the sub-component by reference to an imposed management prescription determined by the 'rule set'.

In the rule set specified for the Strategic Regional forecast, two rules are included, one applying to areas of Scots pine, and the second applying to Scots pine yield class 8 with a DAMS score greater than or equal to 17. The second rule is more specific and therefore takes precedence over the first rule and is applied to the sub-component. The management prescription associated with the rule is:

- thin/no thin flag set to no thin
- fell age is set to 73 years (note that this is the age when Scots pine yield class 8 attains a top height of 21 m).

The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and the specified fell age of 73 years, *i.e.* $1960+73 = 2043$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Example with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to an imposed management prescription determined by the 'rule set'.

In the rule set specified for the Strategic Regional forecast, two rules are included, one applying to areas of Scots pine, and the second applying to Scots pine yield class 8 with a DAMS score greater than or equal to 17. The second rule is more specific and therefore takes precedence over the first rule and is applied to the sub-component. The management prescription associated with the rule is:

- thin/no thin flag set to no thin
- fell age is set to 73 years (note that this is the age when Scots pine yield class 8 attains a top height of 21 m).

The forecast system over-writes the LISS final removal year of 2045 with a new clearfell year. The clearfell year is based on the planting year of 1960 and the specified fell age of 73 years, *i.e.* $1960+73 = 2043$. In cases where the calculated fell year occurs before the start of the forecast (2011), a fell year of 2011 is assigned.

Management Plans

A 'Management Plans' forecast is based on bespoke management prescriptions associated with individual forest sub-components (where such prescriptions are available). Prescriptions of this type are routinely applied to forest sub-components in the public forest estate as part of the specification of Forest Design Plans in FC forest districts.

Management prescriptions for individual forest sub-components in NFI data for private woodlands may be available, based on available administrative data. In some cases a full management plan may be available. In many cases involving private woodlands, relevant administrative data will not be available. For some of these cases a management prescription could be based on a local assessment current management made by an NFI surveyor. In all other cases a default management prescription is applied based on a rule set as already described for a Strategic Regional forecast.

For forecasts based on approved Forest Design Plans, it is assumed that all the physical, legal, policy and market implications that were current at the time the FDP was drawn up and approved, have been taken into account for the area it covers. These factors may change during the life span of the FDP.

Example with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to the bespoke management prescription for the sub-component, if this is available. If a bespoke management prescription is not available, one may be constructed using the same methodology as for a Strategic Regional forecast. This would require relevant Strategic Regional management prescriptions and associated rule sets to be

provided as input data. If such data are not provided, a management prescription of no thinning and no felling is assumed.

Example with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system 'grows on' the sub-component by reference to the bespoke management prescription for the sub-component, if this is available. If a bespoke management prescription is not available, one may be constructed using the same methodology as for a Strategic Regional forecast. This would require relevant strategic regional management prescriptions and associated rule sets to be provided as input data. If such data are not provided, a management prescription of no thinning and no felling is assumed.

Target Assortment

A 'Target Assortment' forecast is based on the principle of maximising a particular, specified volume assortment, subject to certain assumptions. All sub-components are felled at the age where the specified volume assortment is first achieved. Apart from age of felling, the management prescription for the sub-component is based on a Strategic Regional forecast assumptions or bespoke management plan, as appropriate.

Example with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a

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no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system 'grows on' the sub-component on the same basis as for a Management Plans forecast, until the fell year specified for the target volume assortment is reached.

The fell year for the target volume assortment needs to be estimated on a bespoke basis for each sub-component. The methodology for estimating the fell year consistent with the target assortment is described in Appendix 4.

The forecast system over-writes the LISS final removal year of 2045 with the target fell year. If the target fell year is within one (LISS) thinning cycle of the year in which LISS management is planned for introduction ($2015 + 10 = 2025$), a clearfell management regime is assumed with standard thinning intensity and 5-year cycle.

Example with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system 'grows on' the sub-component on the same basis as for a Management Plans forecast, until the fell year specified for the target volume assortment is reached.

The fell year for the target volume assortment needs to be estimated on a bespoke basis for each sub-component. The methodology for estimating the fell year consistent with the target assortment is described in Appendix 4.

The forecast system over-writes the LISS final removal year of 2045 with the target fell year. If the target fell year is within one (LISS) thinning cycle of the year in which LISS management is planned for introduction ($2015 + 10 = 2025$), a clearfell management regime is assumed with standard thinning intensity and 5-year cycle.

Quick

A 'Quick forecast' is based on the assumption that all forest sub-components covered by the forecast are scheduled for clearfelling in the same year, generally a few years into the future. Quick forecasts are usually local in scale and are carried out when making an assessment of the impact of clearing specified areas of forest *e.g.* for road development or wind farm establishment.

Example with growing stock data available

The forecast starts from the growing stock estimate provided in 2010. From 2010 to 2011, the forecast system grows the sub-component according to the management prescription originally specified for the sub-component. The example forest sub-component considered here involves a thinning prescription however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.

From 2011 onwards, the forecast system is based on a clearfell management prescription and a fell year specified by the user as part of the Quick forecast. Suppose the Quick forecast fell year is 2013. The period from 2011 to 2013 is too brief for thinnings to be removed. The forecast system overwrites the LISS final removal year of 2045 with the clearfell year specified in the Quick forecast (2013 in this example).

Note: in the unlikely circumstance that the Quick forecast fell year was to be more than one thinning cycle into the future, then thinnings would be removed according to the existing management prescription for the sub-component.

Example for a 'thin' sub-type with no growing stock data available

The forecast starts from the planting year of 1960. An appropriate growth model (see Appendix 1) is used to work out the development of the growing stock up to the time of first thinning. From this point, thinnings take place at standard intensity every 5 years until 2011. These periodic thinnings obviously result in removals from the growing stock. In this way, the forecast system estimates an initial growing stock for the forecast starting in 2011. (This is the case for the example forest sub-component considered here, however, if it had been a no-thin sub-component, then a no-thin model would initially be applied and no thinnings would be carried out in the period up to 2011.)

From 2011 onwards, the forecast system is based on a clearfell management prescription and a fell year specified by the user as part of the Quick forecast. Suppose the Quick forecast fell year is 2013. The period from 2011 to 2013 is too brief for thinnings to be removed. The forecast system overwrites the LISS final removal year of 2045 with the clearfell year specified in the Quick forecast (2013 in this example).

Note: in the unlikely circumstance that the Quick forecast fell year was to be more than one thinning cycle into the future, then thinnings would be removed according to the existing management prescription for the sub-component.

Forecast Types and restock

The document '*Requirements for Restocking in the Forecast*' describes the restocking of forest sub-components when they are clearfelled or removed progressively as part of LISS management. This document also describes several optional restocking types. In principle, any of the Forecast Types described above can be associated with any of the restock types however, in practice, some combinations will not be meaningful. Table 1 (below) specifies which restock types can be associated with each Forecast Type.

Table 1: Restock types available for each of the Forecast Types specified above.

Forecast Type	Restock type
Zero Intervention	<ul style="list-style-type: none">• restock not applicable
Biological Potential	<ul style="list-style-type: none">• like-for-like
Strategic Regional	<ul style="list-style-type: none">• Strategic Regional• like-for-like
Management Plans	<ul style="list-style-type: none">• Strategic Regional• like-for-like• Strategic Regional• Management Plans
Target Assortment	<ul style="list-style-type: none">• like-for-like• Strategic Regional• Management Plans
Quick	<ul style="list-style-type: none">• restock not applicable

The forecast assumptions for a restock sub-component can vary with Forecast Type as described in the document '*Requirements for Restocking in the Forecast*'

Constraints

The Zero Intervention and the Biological Potential types as outlined above are very much theoretical concepts. In all likelihood, management practices will be limited by particular circumstances. These circumstances may be:

- physical;
- legal;
- policy;
- market.

Each of these will result in a variation of the management prescription for the particular circumstance. An example is the management practice adopted where there is a significant risk of wind damage. In such a case, the fell year is determined by top height, and there may be no thinning. Where there is currently no access, there may be Zero Intervention management.

These detailed constraints on forecasts can be handled by selective application of the different Forecast Types described in this document.

Initial priorities and future developments

The following Forecast Types are high-priority for implementation for the 2011 forecast:

- Biological Potential
- Strategic Regional (for forecasts from NFI data only)
- Management Plans
- Quick forecast
- Zero Intervention.

The following Forecast Types are desirable for implementation for the 2011 forecast, but may involve a longer timescale for delivery:

- Strategic Regional (for forecasts from the FC SCDB)
- Target Assortment.

Further forecast types may be developed in the longer term, specifically 'scenario' forecasting, 'decision support' forecasting and 'climate change' forecasting.

Scenario forecasting

The forecast system can be used to report estimates of growing stock and production under certain 'what if' scenarios. An example of such is 'what if':

- Pests and diseases cause reduced (or even zero) increment in certain regions.
- Policy decisions to increase harvesting (*e.g.* to boost supply of timber and wood fuel) will have impacts on increment. Similarly, introduction of policies for 'forest carbon management' may have impacts.
- Decisions about forest removals (deforestation) and afforestation will affect the extent and increment of the available forest resource.
- Policy decisions about species diversification (*e.g.* as part of a climate change adaptation policy) will affect the increment, and potentially also the extent, of the available forest resource.

Decision Support forecasting

The forecast is currently used as a tool for reporting projections of production and of growing stock as modelled from various management assumptions. The forecast can also play a role as a Decision Support System. An example of such a use is:

- 'Coupe optimum' forecast
 - based on current growing stock,
 - based on current management coupe structure,
 - report the year where the growing stock or the production conform to particular criteria (e.g. where cumulative production volume is maximised across the coupe, where cumulative discounted revenue from production³ is maximised across the coupe)

Climate change forecasting

It is likely that, at some time in the future, account will need to be taken of the effects of climate change (*e.g.* increased windiness, increased incidence of drought and changes to the growth rate of existing species). There may also be the establish stands of timber-producing tree species which are better adapted to cope with the prevailing and future climatic conditions.

In order that the Forecast System is able to adequately represent the effects of climate change, consideration may need to be given to:

- the production of growth and yield models for new species, where mapping is inappropriate;
- the re-calibration of existing growth and yield models;
- the further development of external adjustment routines/procedures (for which suitable field data will be required).

Outstanding issues

Once a shelterwood sub-component has passed the year of conversion to LISS, it is not possible to convert it back to clearfell management within the forecast system. Although a solution has been identified, this will not be implemented for the 2011 forecast.

³ Revenue arising from production may be specified in various ways.

References

Forestry Commission (2010) *Operational Guidance Booklet 9: Thinning*. Forestry Commission internal guide.

Jenkins, T.A.R (2011) *Checking the validity of growing stock 'inventory point' data*. Internal Specification Document prepared for the Forest Resources Evaluation Group, Forest Research Agency, Alice Holt Lodge.

Tom Jenkins, Robert Matthews, Ewan Mackie and Lesley Halsall
March 2012

List of Forecast System Documentation

Forecast Types (this document)

[Felling and Removals Forecasts](#)

Biomass Removals Forecasts*

[Growing Stock Volume Forecasts](#)

[Volume Increment Forecasts](#)

Growing Stock Biomass Forecasts*

Growing Stock Carbon Forecasts*

Straightness Forecasts*

[Restocking in the Forecast](#)

*Publication of Forecast Technical Documentation detailing forecasts involving straightness, biomass and carbon will follow.

Appendix 1 – Selection of an 'appropriate' growth model

An 'appropriate growth model' is selected for each forest sub-component on the basis of tree species, yield class, initial spacing and broad thinning prescription, essentially 'thin' or 'no thin', based on the setting of the PREVIOUSLY_THINNED flag. It is therefore crucial that this flag is set appropriately for every forecastable sub-component.

The model is selected to reflect how the stand has been managed up to the point that the latest inventory assessment was made, or to the start of the forecast period, in order to determine the initial conditions in the model from which to 'grow' the forest sub-component on from the start of the projection. This is illustrated with simple examples below.

Example 1: A Biological Potential (no-thin sub-type) forecast for a previously thinned stand

Initial stand conditions:

- Douglas fir
- yield class 18
- initial spacing 2.0 m
- planting year 1974
- previously thinned to management tables on a 5-year cycle

For the purposes of this example, suppose that the current year is 2011 and the forecast period is 2013 to 2032. Even though the Forecast Type is Biological Potential (no-thin sub-type), from the management information (previously thinned flag) it is clear that the sub-component has been thinned in the past. Therefore the appropriate model is one involving thinning. The actual 'base model' selected automatically within the forecast system is DF, GYC 18, 1.7 m initial spacing, crown thin to MTI on a 5 year cycle.

There are two possible scenarios:

- current growing stock data are available
- no growing stock data are available.

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Suppose that growing stock data are available for an assessment made earlier in the current year (2011). The forecast system 'grows on' the forest sub-component under Biological Potential (no-thin) assumptions from the current age (37 years, 2011). However, the forecast system only starts reporting from 2013 (*i.e.* when the sub-component is 39 years old).

Where there are no available growing stock data, the forecast system uses the basic yield relationships in the selected base model to 'grow' the sub-component from the planting year (1974) to the present date (2011). Because the PREVIOUSLY_THINNED flag is set, the forecast system diligently 'thins' the sub-component, at standard intensity and on a 5-year cycle, from the age of first thinning specified in the selected model (18 years in this example) until the present date (2011). The outputs from the selected base model for the year 2011 are then used as the initial conditions from which the sub-component is 'grown on', under Biological Potential (no-thin) assumptions, using the appropriate model but subject to no-thin.

Although Biological Potential (no-thin) assumptions are applied in 2011, the forecast system only starts reporting from 2013 (*i.e.* when the sub-component is 39 years old).

Example 2: A Management Plans forecast specifying thinning in a previously unthinned stand

Initial stand conditions:

- Norway spruce
- yield class 12
- initial spacing 2.0 m
- planting year 1976
- previously unthinned

For the purposes of this example, the current year is 2011 and the forecast period is 2013 to 2037. The model selected to 'grow' the sub-component to the start of the forecast period (2013) is matched as closely as possible to the initial stand conditions listed above; in this case, the model selected is NS, GYC 12, 2.0 m initial spacing, no-thin.

There are two possible scenarios:

- current growing stock data are available
- no growing stock data are available.

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Where growing stock data are available, the forecast system uses the selected no-thin model to 'grow' the forest sub-component from age 34 (2010) to age 37 (2013), starting with the growing stock estimate taken in 2010. The resultant stand conditions are used as the starting point for the 2013-2037 Management Plans forecast.

Where there are no available growing stock data, the forecast system uses the selected no-thin model to 'grow' the sub-component from the planting year (1976) to the start of the forecast period (age 37, 2013). The resultant stand conditions are used as the starting point for the 2013-2037 Management Plans forecast.

Although the same no-thin model is used in both scenarios, it has been applied over different timescales and from different initial stand conditions. The resulting estimates for the growing stock at the start of the forecast are therefore likely to be different in most situations.

In the absence of any management plan information on the timing, intensity and cycle of future thinnings, the forecast system 'grows on' the sub-component from the projected initial starting condition using the appropriate model but subject to thinning on a 5-year cycle from the next tabulated thin age (39 years, 2015). However, if information on the timing, intensity and cycle of future thinnings is specified in the management plan, the forecast system will use this information as the basis for the forecast. All forecast outputs are generated on this basis.

Example 3: A Biological Potential (no-thin sub-type) forecast for a previously thinned stand which has an inventory point from a survey made 6 years in the past.

Initial stand conditions:

- Douglas fir
- yield class 18
- initial spacing 2.0 m
- planting year 1974
- previously thinned to management tables on a 5-year cycle

A growing stock estimate is available for an assessment made in 2005.

For the purposes of this example, suppose that the current year is 2011 and the forecast period is 2013 to 2032. Even though the Forecast Type is Biological Potential

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(no-thin sub-type), from the management information (previously thinned flag) it is clear that the sub-component has been thinned in the past. Therefore the appropriate model is one involving thinning. The actual 'base model' selected automatically within the forecast system is DF, GYC 18, 1.7 m initial spacing, crown thin to MTI on a 5 year cycle.

In this example, growing stock data are available for an assessment made six years ago (2005). The forecast system uses the selected model to 'grow' the forest sub-component based on its 'initial' condition in 2005 (*i.e.* when the latest growing stock inventory was taken, stand age 32 years) to the current time (2011, stand age 37 years). Because the PREVIOUSLY_THINNED flag is set, the forecast system applies the thinning event specified by the standard model to take place at age 33 (2006). The forecast system thus estimates the growing stock in 2011, based on a projection from 2005, allowing for the original management prescription.

The forecast system then 'grows on' the forest sub-component under Biological Potential (no-thin) assumptions from the current age (37 years, 2011).

The forecast system starts reporting results from 2013 (*i.e.* from the start of the forecast period, when the sub-component is 39 years old).

Appendix 2 – Specification of a rule set for a Strategic Regional Forecast

Note: Following the specification outlined in this Appendix, the Strategic Regional Forecast rule set was implemented using machine-readable 'Extensible Markup Language' (XML), rather than as the plain text files described here. However, the general principles described below remain unchanged.

Strategic Regional Forecasts are specified with 'rule sets', which include two or more lines (there must be default lines for conifers and broadleaves respectively) with two 'parts' of information in each line:

- a 'stratification part' defining the rules for group(s) of sub-components in the forecast to which particular management prescriptions are applied and
- a 'management/prescription part' which specifies the management to be carried out in each stratification part.

The series of stratification and management rules to be applied in a Strategic Regional Forecast are listed in a user specification file (USF), an example of which is shown in Figure A2.1.

Settings for some of the parameters in both the stratification and management/prescription parts (of a rule set) are preset as defaults to ensure that, if the user only gives a minimal specification for the Strategic Regional Forecast, a valid result is always produced. For example, the ultimate default for the stratification part of the rule set is conifer or broadleaf, *i.e.*, these two default rules will determine how management is applied to all of the sub-components in the forecast unless there is a specific case dealing more closely with any sub-component(s).

Rule sets (*i.e.* two or more lines of data including a stratification and management/prescription part) are specified in a Strategic Regional Forecast USF, one rule per line. The last two lines in the USF specify the highest level stratification and corresponding management prescriptions, *i.e.* those applied generically to conifers and broadleaves respectively.

Separate USF's will be required for handling NFI forecasts and forecasts based on the FC SCDB.

It is not intended to implement the Strategic Regional Forecast Type for the public forest estate (FC SCDB) forecast for 2011. Initial development will instead focus on

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the forecast from NFI, where a Strategic Regional Forecast will be the default Forecast Type.

```
CP,,,,,N,Y,,,,,,,,,,,,,2011,
CP,,,,,Y,Y,,T,,1.3,,,,,,,,,
LX,,,,,,20,,,,,,,,,,,,,2011,
LX,,,,,,20,,,,,,,,,,,,,2012,
LX,,,,,,20,,,,,,,,,,,,,2013,
LX,,,,,,20,,,,,,,,,,,,,2014,
LX,,,,,,20,,,,,,,,,,,,,2015,
CON,,,,,36,,,,,NT,,,,,,,,,21
CON,,,,,16,,,,,T,,,,,,,,,
CON,,,,,13,,,,,,,,,2011,,,,,
CON,,,,,,,,,,,,,
BDL,,,,,,,,,,,,,
```

Figure A2.1 Example of a Strategic Regional Forecast user specification file (USF)

Rule sets: stratification part

The following sub-component parameters are used to specify each stratification rule in a set:

- species (or user-defined species group)
- yield class*
- planting year*
- Public Forest Estate Land-Use Code†
- DAMS score*
- PREVIOUSLY_THINNED flag
- FORECAST flag
- percentage split‡

* For ordinal-numeric parameters it is assumed the values take the form 'equal to or less than', the rule set can therefore be built up and 'nested' to allow ranges to be specified. See section on 'Hierarchy and ordering of rules', page 29.

† For forecasts from SCDB data only (*i.e.* not applicable to NFI forecasts). For certain FC Land-Use Codes (*e.g.* LHP, NAR, PBU, PFA, PFE and PWC) it would not be relevant or valid to specify a rule set.

‡ This is described in the section on 'Rule sets: Proportional allocation', page 33.

In a Strategic Regional forecast, it may be desirable to quickly specify the same management prescription simultaneously for more than one species, if it is intended that these are to be treated in the same manner. This is done in a separate user

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specification file (USF) from that containing the stratification and management rules. The file will be structured so that each unique user-specified species group code⁴ (alphanumeric, 2 or 3 characters) is followed by a comma separated list of the standard codes for the species comprising that group. A full list of the standard species codes used by the Forecast System can be found in the '[PF2011 Tree Species](#)' document. One species group will be defined per line within the USF. Any species not included in a group will be treated individually for the purposes of the forecast.

The sub-component parameters defining a stratification part (within a rule) are listed in the form of a comma-separated list, *e.g.*:

```
SS,12,,,,Y,,, [Management prescription part]
```

In a Strategic Regional Forecast USF the example line above would specify that the management prescription part is applied to all sub-components in the forecast which are Sitka spruce, yield class 12 and have been previously thinned. In this case the planting year, land-use code, DAMS score, Forecast flag and percentage split parameters have not been specified and are therefore not considered. There will be a series of lines in a rule set specifying all of the strategically important strata, in this way different management prescriptions can be accurately applied to specific, targeted sub-components in the forecast.

An example of a series of stratification rules would be:

```
SS,12,1970,,,,,, [Management prescriptions for SS, YC 12, planted before 1970]
SS,,1970,,,,,, [Management prescriptions for SS, planted before 1970]
SS,12,,,,,, [Management prescriptions for SS, YC12]
CON,,,,,, [Management prescriptions for conifers]
BDL,,,,,, [Management prescriptions for broadleaves]
```

Hierarchy and ordering of rules

Where there is an apparent conflict in rule sets (*e.g.* two different rules potentially applying to the same sub-component) 'earlier in the list' or a more comprehensive specification, implies precedence. For example in the list of stratification rules above, Sitka spruce sub-components which are yield class 12 will have a specific

⁴ The user is able to specify any species group code (alphanumeric, 2 or 3 characters), however this must not be the same as any of the pre-existing species/species group codes. A full list of the standard species codes used by the Forecast System can be found in the '[PF2011 Tree Species](#)' spreadsheet.

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management prescription applied. Sitka spruce planted in 1970 (or before) will have another specific management prescription applied. The sub-components which are Sitka spruce yield class 12 planted in 1970 or before will have a different specific management prescription applied because they are an exclusive sub-set of the sub-components identified in the first two rules. This situation is illustrated in Figure A2.2.

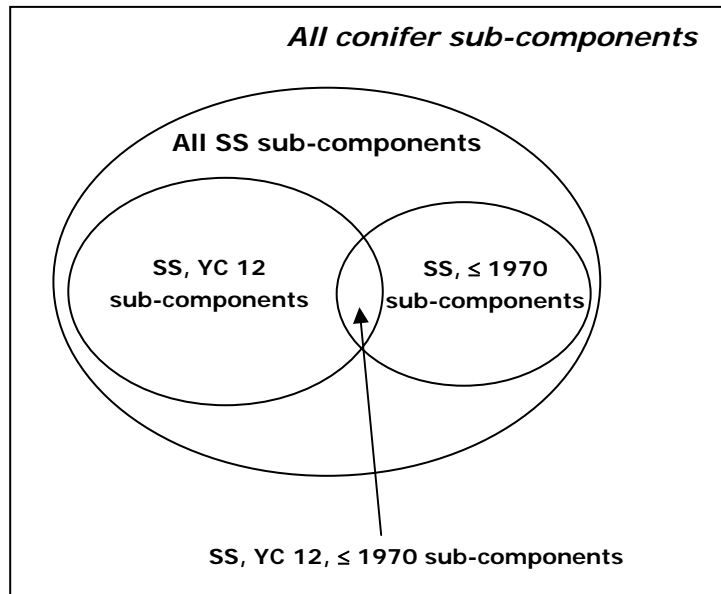


Figure A2.2 Diagram representing example groups of sub-components to which different management prescriptions would be applied in a Strategic Regional Forecast

If the following stratification rule is removed from the rule set illustrated above

```
SS,12,1970,,,,,,,,[Management prescriptions for SS, YC 12, planted before 1970]
```

the next stratification rule in the rule set will take precedence. All sub-components in the intersection illustrated in Figure A2.2 would therefore be assigned exclusively to the following stratification rule, as this is the next rule in the list:

```
SS,,1970,,,,,,,,[Management prescriptions for SS, planted before 1970]
```

This is illustrated in Figure A2.3 below.

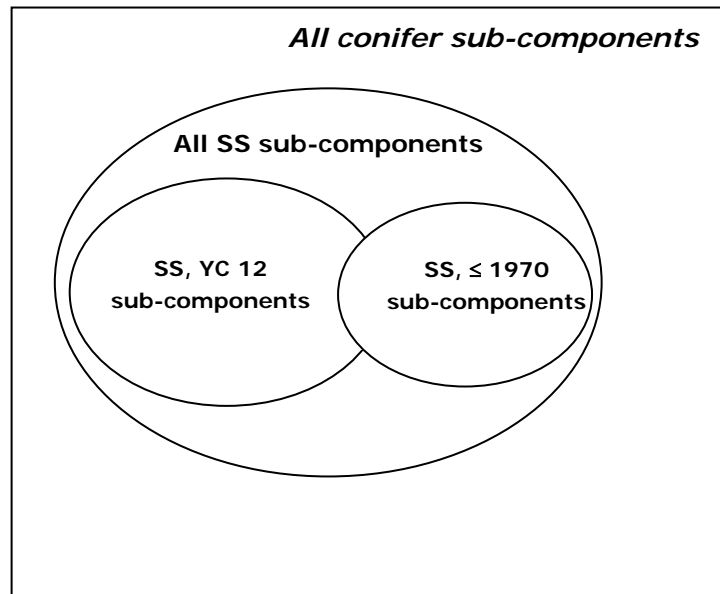


Figure A2.3 Diagram representing example groups of sub-components to which different management prescriptions would be applied in a Strategic Regional Forecast where there is a potential conflict which has not been dealt with by an explicit rule in the USF. See Figure 2.2.

Three of the sub-component parameters that can be specified in the stratification part(s) of a rule set are numerical and the convention is that these take the form 'equal to or less than'. This means a rule set can be specified which will allow a particular management prescription to be applied to a specified set of sub-components based on ranges, or combinations of ranges, of yield class, planting year, land-use code and/or DAMS score. For example, for a Strategic Regional Forecast that runs to 2100, if the user wants to specify that a particular management prescription ('B') is applied to all sub-components that were planted between 1975 and 1990, the following lines in the rule set could be defined:

```
,,2100,,,,,, [Management prescription A]  
,,1990,,,,,, [Management prescription B]  
,,1974,,,,,, [Management prescription A]
```

It can be seen that the ordering of rules in the USF for a Strategic Regional Forecast needs to be considered carefully if a number of strata and associated management prescriptions are required.

Rule sets: Management part

All stratification 'parts' of the rule set must be associated with a corresponding management part (this may specify a default prescription). The parameters that can be specified for a management prescription relate to thinning, felling or conversion to LISS. A list of the management parameters, available ranges and their default values is given in Table A2.1.

Table A2.1 List of management parameters, ranges and defaults

Management parameter	Available range	Default
thin/no-thin flag	T/NT	T
thinning cycle	3-12 (years)	5
thinning intensity	0.5-1.4 (MTI)	1.0
thinning type	I/N (intermediate/neutral)	I
year of conversion to LISS	1990-2050	no default
age of conversion to LISS	25-100 (years)	no default
LISS type*	shelterwood/selection	selection
LISS thinning cycle*	3-20 (years)	5
LISS thinning intensity*	0.5-2.0 (MTI)	1.2
fell age	25-250 (years)	no default
fell year	{now}-{now+250} (years)	no default
fell top height	10-50 (metres)	no default

* These parameters are only used if "year of conversion to LISS" or "age of conversion to LISS" are specified.

There are restrictions on how the management parameters can be combined, specifically:

- if the thin/no-thin flag is set to 'no-thin', all thinning and LISS terms are ignored
- the setting of the thin/no-thin flag is mandatory
- if the thin/no-thin flag is set to 'thin', then Thinning cycle, Thinning intensity, and Thinning type must be specified
- the options for thinning type are limited to 'Intermediate' and 'Neutral'
- if both Year of Conversion to LISS and Age of Conversion to LISS are specified, the actual year of conversion applied to a sub-component is taken as the maximum of the Year of Conversion to LISS and (Planting Year + Age of Conversion to LISS)
- the LISS type can only be set in broad terms as either 'shelterwood' or 'selection'
- if the LISS type is 'shelterwood', the LISS thinning intensity is ignored
- either Fell age or Fell year must be specified but not both, unless the LISS type is 'selection' in which case the setting of Fell age or Fell year is optional

- there are certain constraints on the setting of numerical values such as Thinning cycle and Thinning type.

An example of how rules for stratification and management prescriptions might be set is given in Appendix 3.

Rule sets: Proportional allocation

As well as being able to specify how sub-components are to be stratified and managed in a Strategic Regional Forecast, the forecast system also allows different management prescriptions to be applied to fractions of sub-components. For example, the stratification part of a rule set may specify that Japanese larch (JL), yield class 10 which has been previously thinned is specified for particular management treatment in the forecast. The forecast system allows for sub-components of JL, YC 10 and previously thinned to be split (into sub-sub-components), by percentage *e.g.* 38.5 and 61.5% respectively, each of which is assigned a different management prescription. This example would be specified in the USF for the rule set as:

```
JL,10,,,Y,,38.5,[Management prescription 1]
JL,10,,,Y,,61.5,[Management prescription 2]
JL,8,,,,,,[Management prescription 3]
```

Note that because the yield class parameter is numerical, the third line is needed to specify that JL with yield classes less than 10 are managed differently. There are a number of rules which are applied if the Strategic Regional Forecast is to include proportional allocation of management prescriptions:

- The percentage split must add up to 100%.
- The percentage split must be to one decimal place or less.
- The maximum number of splits for a sub-component, or specified set of sub-components, is ten.

The smallest entity that can be identified in Forester is a 'sub-component', *i.e.* a portion of a component that has been split by a coupe boundary which does not match the boundary of the original compartment containing the component. This means that the fractions of sub-components described here, which can be specified in the Forecast system, will not be recognised by the Forester GIS. Therefore a further external routine/module is required, which has been given the development name of 'Pandora'. The purpose of this module is to take the sub-components selected for a Strategic Regional Forecast from Forester and (where specified) split these based on

the percentages defined in the Strategic Regional Forecast USF and then pass the resulting 'sub-sub-components' to the Forecast System for processing. Once the Forecast system has run the Strategic Regional Forecast the results for the 'sub-sub-components' are recombined in 'Pandora' into results for the original sub-components and passed back to Forester. This process is shown in Figure A2.3

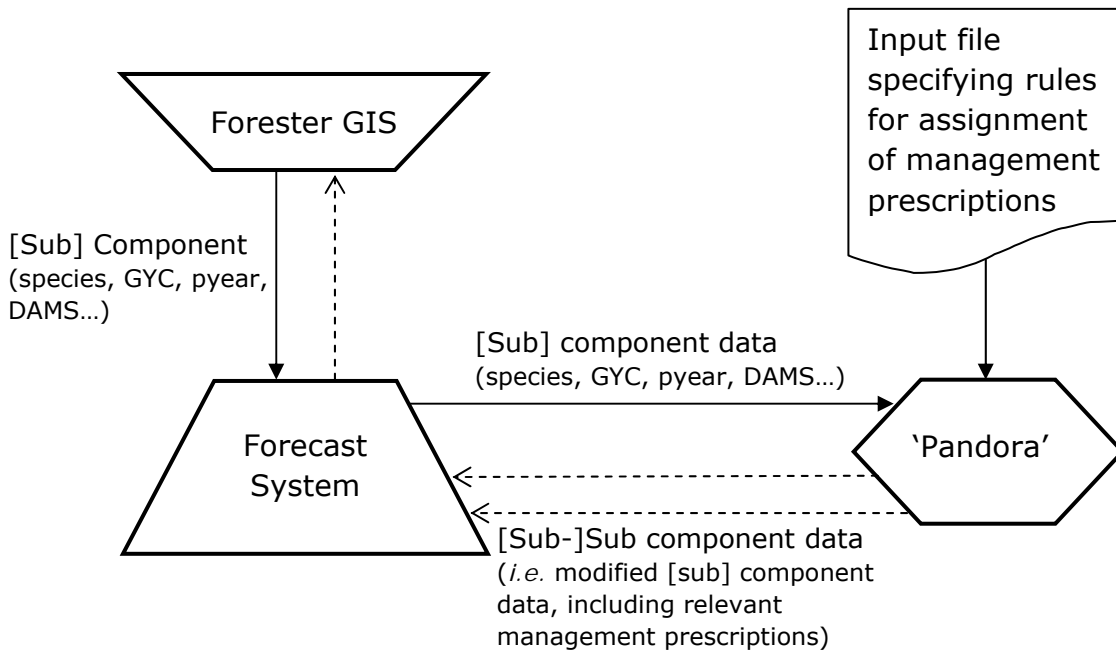


Figure A2.3 Diagram illustrating of the role of 'Pandora' in the Forecast System

An example of how rules for management prescriptions might be set for a specific scenario is given in Appendix 3.

Appendix 3 – Example rule set for a hypothetical Strategic Regional Forecast

Please see the note at the start of Appendix 2 on page 27.

An example rules dataset is given in Figure A3.1. It is perhaps worth noting that five rules in this particular dataset make reference to the user-defined 'LX' species group. This species group is defined in a USF which contains the following line, assigning all larch species to the 'LX' code.

```
LX, EL, JL, HL, XL
```

The following hypothetical Strategic Regional management scenario, containing multiple prescriptions has been specified in the rules dataset. In this scenario:

- All Corsican pine sub-components, which have the forecast flag set and have not been previously thinned, will be felled in 2011.
- All Corsican pine sub-components, which have the forecast flag set and have been previously thinned, will now be thinned at an intensity of $1.3 \times \text{MTI}$. No other thinning parameters are defined, so the species-specific default thinning type and thinning cycle will apply.
- Equal proportions of the total area occupied by larch sub-components (which have been grouped within the user-defined code 'LX') will be felled each year over a five-year period (2011-2015).
- Other conifer sub-components will be subject to different management prescriptions, based on their DAMS scores:
 - Sub-components with DAMS scores up to and including 13 will be converted to LISS management in 2011. No other LISS parameters are defined, so the species-specific default LISS types, cycles and intensities will apply.
 - Sub-components with DAMS scores between 14 and 16 will be thinned in future, irrespective of previous management. No other thinning parameters are defined, so the species-specific default thinning types, cycles and intensities will apply.
 - Sub-components with DAMS scores of 17 and above will not be thinned in future, irrespective of previous management. These sub-components will also be felled when top height ≥ 21 m. Note: the maximum possible DAMS score is 36, which specifies the upper limit of this range.

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- All conifer and broadleaf sub-components that have not so far been defined within the rule set, for example conifer sub-components that do not have a DAMS score recorded, will be forecast on the basis of the default conifer ('CON') and broadleaf ('BDL') rules respectively.

The stratification and management USF for the above hypothetical Strategic Regional management scenario contains the following twelve lines:

```
CP,,,,N,Y,,,,,,,,,,,,,2011,  
CP,,,,Y,Y,,T,,1.3,,,,,,,,,  
LX,,,,,20,,,,,,,,,,,,,2011,  
LX,,,,,20,,,,,,,,,,,,,2012,  
LX,,,,,20,,,,,,,,,,,,,2013,  
LX,,,,,20,,,,,,,,,,,,,2014,  
LX,,,,,20,,,,,,,,,,,,,2015,  
CON,,,36,,,NT,,,,,,,,,,,,,21  
CON,,,16,,,T,,,,,,,,,,,,,  
CON,,,13,,,,,,,,,,,,,2011,,,,,,,,,  
CON,,,,,,,,,,,,,,,,,,,,,  
BDL,,,,,,,,,,,,,,,,,,,,,
```

The comma delimited fields comprising each line are:

- Field 1: species (or user-defined species group)
- Field 2: yield class
- Field 3: planting year
- Field 4: DAMS score
- Field 5: PREVIOUSLY_THINNED flag
- Field 6: forecast flag
- Field 7: percentage split
- Field 8: thin/no-thin flag
- Field 9: thinning cycle
- Field 10: thinning intensity
- Field 11: thinning type
- Field 12: year of conversion to LISS
- Field 13: age of conversion to LISS
- Field 14: LISS type
- Field 15: LISS thinning cycle
- Field 16: LISS thinning intensity
- Field 17: fell age
- Field 18: fell year
- Field 19: fell top height

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Fields 1-6 are defined in the section headed 'Rule sets: stratification part' (page 28), Field 7 is defined in 'Rule sets: Proportional allocation' (page 33) and Fields 8-19 in 'Rule sets: Management part' (page 32).

Appendix 4 – Estimating the year by which the target assortment is achieved

The target assortment is the desired percentage of total volume production achieving a specified minimum top diameter over-bark or under-bark. There are only three parameters required in order to specify this:

- minimum top diameter;
- the percentage of total volume assortment exceeding that specified top diameter in order to trigger felling;
- whether the specified volume assortment is over-bark or under-bark.

The year in which the target assortment is reached (and in which the sub-component should be felled) is determined by a routine/module with the development name 'Focus'. At this stage of specification it is not known whether 'Focus' will be implemented as an external programme module or whether it will be fully embedded within the within the main Forecast System

The target assortment parameters are specified in a user specification file (USF) which is read by 'Focus'.

The interaction between the Forecast System and 'Focus' is specified as follows:

1. If the data passed from Forester to the Forecast System include a request for a Target Assortment Forecast Type, step 2 is implemented. However, if there is no request for a Target Assortment Forecast Type, the forecast continues as normal for that sub-component and step 7 is implemented.
2. The Forecast System runs an 'off-line'⁵ 250-year forecast and passes the output to 'Focus'.
3. 'Focus' examines the output received from the Forecast System and compares the before-thin forecast volume assortment against the target assortment, starting from {NOW}.

⁵ In this context 'off line' means that the forecast is run for the specified sub-component(s) but that the outputs are not included in forecast reports.

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4. The earliest age at which the before-thin forecast volume assortment is greater than or equal to the target assortment is identified as the fell age by routines within 'Focus'.
5. If the before-thin forecast volume assortment does not achieve the target assortment during the 250-year period, the fell age is set to {NOW}+250 years by routines within 'Focus'. (It is assumed that the forecast period is shorter than {NOW}+250 years.)
6. The fell age resulting from step 4 or 5 is passed back to the Forecast System, and the forecast is run for that sub-component using the fell age received from 'Focus'.
7. The next sub-component is requested from Forester and step 1 is implemented for the next sub-component.

The above steps 1 to 7 are repeated for each sub-component forming the forecast.

Appendix 5 – Estimating the year by which a limiting top height is reached

There may be instances where a sub-component may need to be scheduled for felling at the age at which a specific top height is achieved. An example could be where conifer sub-components have an assigned DAMS score ≥ 17 and have an assigned 'terminal height' of 21 m. The rule specifying the precise conditions will be included in a user specification input file for 'Pandora'.

The year in which the limiting top height is reached (and in which the sub-component should be felled) is determined by a routine/module with the development name 'Icarus'. At this stage of specification it is not known whether 'Icarus' will be implemented as an external programme module or whether it will be fully embedded within the within the main Forecast System.

The interaction between the Forecast System and 'Icarus' is specified as follows:

1. If the input USF contains a rule specifying a limiting top height, step 2 is implemented. However, if the relevant rule does not contain a request specifying a limiting top height, the Strategic Regional forecast continues as normal for the sub-component and step 7 is implemented.
2. The Forecast System runs an 'off-line'⁶ 250-year forecast and passes the output to 'Icarus'.
3. 'Icarus' examines the output received from the Forecast System and compares the forecast top height against the specified limiting top height, starting from {NOW}.
4. The earliest age at which the forecast top height is greater than or equal to the specified limiting top height is identified as the fell age by routines within 'Icarus'.
5. If the forecast top height does not achieve the specified limiting top height during the 250-year period, or the estimated fell age is greater than the standard age of maximum MAI⁷, then the fell age is set as the age of maximum MAI by routines within 'Icarus'.

⁶ In this context 'off line' means that the forecast is run for the specified sub-component(s) but that the outputs are not included in forecast reports.

⁷ For the appropriate species, yield class, spacing and thinning regime.

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6. The fell age resulting from step 4 or 5 is passed back to the Forecast System, and the forecast is run for that sub-component using the fell age received from 'Icarus'.
7. The next sub-component is requested from the forecast input dataset and step 1 is implemented.

The above steps 1 to 7 are repeated for each sub-component forming the forecast.