Roundwood production from private sector forests 2009-2028

A geospatial forecast

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Foreword

Ireland's private forest estate is fast becoming a considerable wood resource. According to the National Forest Inventory, the area of privately-owned forest in 2006 was 300,000 ha. A further 20,000 ha has been planted since 2006. Growing stock is estimated as 18.5 million cubic metres of roundwood.

Most of the private forest estate has been established over the past two decades, with many areas now entering the first thinning stage. Estimates of production have largely been based on the 2001 COFORD publication: *Forecast of Roundwood Production from the Forests of Ireland 2001-2015*. Since that time better information on forest location and productivity has become available, and the private estate has expanded considerably in area. In addition, the use of first thinnings for energy generation has greatly expanded, with ambitious national targets for further expansion.

Recognising the need for updated and improved information on wood supply, COFORD is publishing this report: *Roundwood production from private sector forests 2009-2028 - A geospatial forecast*. The report is from the COFORD-funded FORECAST project team, based at UCD. It sets out the annual potential level of roundwood supply from privately-owned forests, which is predicted to increase 8-fold over present levels, to reach almost 3 million m^3 by 2028.

Realising such a level of increase in potential production will entail significant capital investment in roads, harvesting equipment and IT systems by forest owners, contractors and the state. Given the disperse nature of the private forest resource and the small average plantation size, innovation in wood procurement, harvesting and transport is essential to drive down costs, reduce measurement overheads, and eliminate double handling. Existing sales/procurement systems are too costly and are in need of radical overhaul. Savings due to economies of scale by combined selling of wood from clusters are also possible; Teagasc has such technology now available.

To supplement the report the FORECAST team has developed a number of web-based tools which will enable local forecasts to be derived, as well as enabling the location of all forests to be displayed. It is anticipated these will become available over the second half of 2009.

Work underway in other aspects of the FORECAST project will also bear dividends over the next 3-4 years, when an updated forecast will issue. COFORD is also compiling an all-island forecast of roundwood production, which will combine this forecast with those from Coillte and the Northern Ireland Forest Service. When this work is finished it will provide the first-ever roundwood production forecast for the full island.

Michael Lynn
Chairman

Dr Eugene Hendrick
Director

Réamhfhocal

Tá eastát foraoise príobháideach na hÉireann á léiriú féin go tapa mar acmhainn adhmaid shuntasach. De réir an Fhardail Foraoise Náisiúnta, ba é 300,000 ha achar na foraoise faoi úinéireacht phríobháideach i 2006. Táthar tar éis 20,000 ha breise a chur ó 2006 i leith. Meastar gur ionann an stoc méadaithe agus 18.5 milliún méadar ciúbach de lomáin chruinne.

Táthar tar éis formhór an eastáit foraoise phríobháidigh a bhunú le linn fiche bliain anuas, le go leor limistéar ag tosú ar chéim an tanúcháin anois. Bhí meastacháin ar tháirgeadh bunaithe go mór ar foilseachán 2001 de chuid COFORD: *Forecast of Roundwood Production from the Forests of Ireland 2001-2015*. Ón am sin i leith tá eolas níos fearr curtha ar fáil mar gheall ar shuíomh agus táirgiúlacht foraoise, agus tá an t-eastát príobháidach tar éis leathnú go suntasach sa limistéar. Chomh maith leis sin, tá leathnú mór tagtha ar úsáid na gcéad tanúchán le haghaidh giniúint fuinnimh, le spriocanna náisiúnta uaillmhianacha i gcomhair breis leathnaithe.

Ag aithint an ghá atá le heolas nuashonraithe agus feabhsaithe ar sholáthar adhmaid, tá COFORD ag foilsiú an tuarascáil seo a leanas: *Roundwood production from private sector forests 2009-2028 - A geospatial forecast*. Tá an tuarascáil á chur i gcrích ag foireann tionscadail FORECAST arna mhaoiniú ag COFORD, lonnaithe i gColáiste na hOllscoile Baile Átha Cliath. Leagann sí amach an leibhéal féideartha bliantúil de sholáthar lomáin chruinne ó fhoraoisí faoi úinéireacht phríobháideach, a dtuartar go dtiocfaidh méadú faoi 8 air thar leibhéil eiseacha, agus go sroichfidh sé beagnach 3 milliún m^3 faoin mbliain 2028.

D'fhonn a leithéid de leibhéal méadaithe i dtáirgeadh féideartha a bhaint amach beidh infheistíocht chaipitil shuntasach i mbóithre, trealamh sábhála agus córais TF riachtanach ó úinéirí foraoise, conraitheoirí agus an stát i gcoitinne. Mar thoradh ar nádúr scaipthe na hacmhainne foraoise príobháidí agus meánmhéid beag na plandála, tá nuálaíocht i soláthar adhmaid, sábháil agus iompar ríthábhachtach chun costais a laghdú, forchostais tomhais a ísliú, agus láimhseáil dhúbailte a dhíbirt. Tá córais díolacháin/soláthair eiseacha ró-chostasach agus tá gá le hathrú iomlán radacach orthu. Tá coigiltis de bharr eacnamaíochtaí scála trí chomh-dhíol adhmaid ó chnuasaigh féideartha chomh maith; tá a leithéid de theicneolaíocht ar fáil ag Teagasc anois.

Ar mhaithe le forlíonadh a dhéanamh ar an tuarascáil tá líon áirithe uirlisí gréasán-bhunaithe forbartha ag foireann FORECAST a chumasóidh cruthú réamhaisnéisí áitiúla, mar aon le cumasú suíomh na bhforaoisí uile a léiriú. Táthar ag súil go gcuirfear iad seo ar fáil i gcaitheamh an dara leath de 2009.

Cruthóidh obair atá ar siúl i ngnéithe eile de thionscadal FORECAST díbhinní freisin i gcaitheamh na chéad 3-4 bliana atá le teacht, nuair a eiseofar réamhaisnéis nuashonraithe. Tá réamhaisnéis ar tháirgeadh lomáin chruinne uile-oileáin á gcur le chéile ag COFORD freisin, rud a chuirfidh an réamhaisnéis seo i dteannta leo siúd ó Coillte agus Seirbhís Foraoiseachta Thuaisceart Éireann. Nuair a bheidh an obair seo críochnaithe soláthróidh sí an chéad réamhaisnéis riamh ar tháirgeadh lomáin chruinne don oileán in iomlán.

Michael Lynn — An Dr Eugene Hendrick

Cathoirleach — Stiúrthóir

Executive Summary

Introduction

The Irish government is committed to increase the national area of forest to 17% by 2030 and to increase the utilization of wood, particularly for the generation of energy from renewable and sustainable sources. Development is constrained, however, by the lack of private sector roundwood supply forecasts, for energy and traditional size assortments.

This report presents a geospatial[1] forecast using available spatial data on a national and catchment basis for privately-owned forests for a twenty year period (2009-2028) to replace the current private sector forecast for 2001-2015, developed by Gallagher and O'Carroll in 2001.

Data sources

Three main spatial data sources were used in developing a comprehensive database as input to the forecasting process. These were:

- the Forest Inventory and Planning System FIPS98 dataset (108,552 ha), which includes Private Grant Aided (28,421 ha) and Private Non-Grant Aided forests (80,131 ha);
- the Premiums dataset (169,169 ha) which includes areas in receipt of premiums from 1989 to 2007; and
- the Western Package WP08 dataset (27,471 ha) which covered areas in receipt of grant aid and planted prior to 1989/90.

Depending on the data source, additional information on age, species, site productivity and silvicultural management regime was required at individual polygon (plantation) level before the geospatial roundwood supply forecast could be developed.

Yield models and assortment tables

Forestry Commission yield models were used for all species except lodgepole pine (coastal) where Irish models were used. Where gaps occurred in the range of models for a species, substitute models were used. Irish assortment tables were used for Sitka spruce and Forestry Commission assortment tables were used for all other species. A sensitivity analysis using alternative assortment tables common to all species was also undertaken and is described in the full report.

Forecasting rules

Three volume reductions were applied. A stocking reduction of 12.5% based on an analysis of forest open areas in the National Forest Inventory (NFI) was applied to the Premiums and private non-grant aided areas. A 10.2% reduction was applied to the Western Package areas and a 25% reduction was applied to private grant aided areas. An attrition factor of 5% was applied to all areas to cater for the loss in productive area over time due to windblow and disease. Finally, volume reductions of between 5.5% and 25% were applied to standing volumes to account for losses during harvesting.

[1] Geospatial refers to datasets used in geographic information systems (GIS) and here refers to forest and other datasets which are georeferenced with respect to the Irish National Grid.

Forecasting process

All spatial analyses were undertaken in ArcGIS 9.3. The data processing element of the interim forecast was carried out using Microsoft Access.

Forecast results

The overall net roundwood production from privately owned forests will increase from an estimated 0.38 million m^3 in 2009 to 2.95 million m^3 by 2028. Volume reductions and harvest losses averaged 28%. Volume production, compared with 2009, more than doubles within the first 10 year period and then trebles within the second 10 year period.

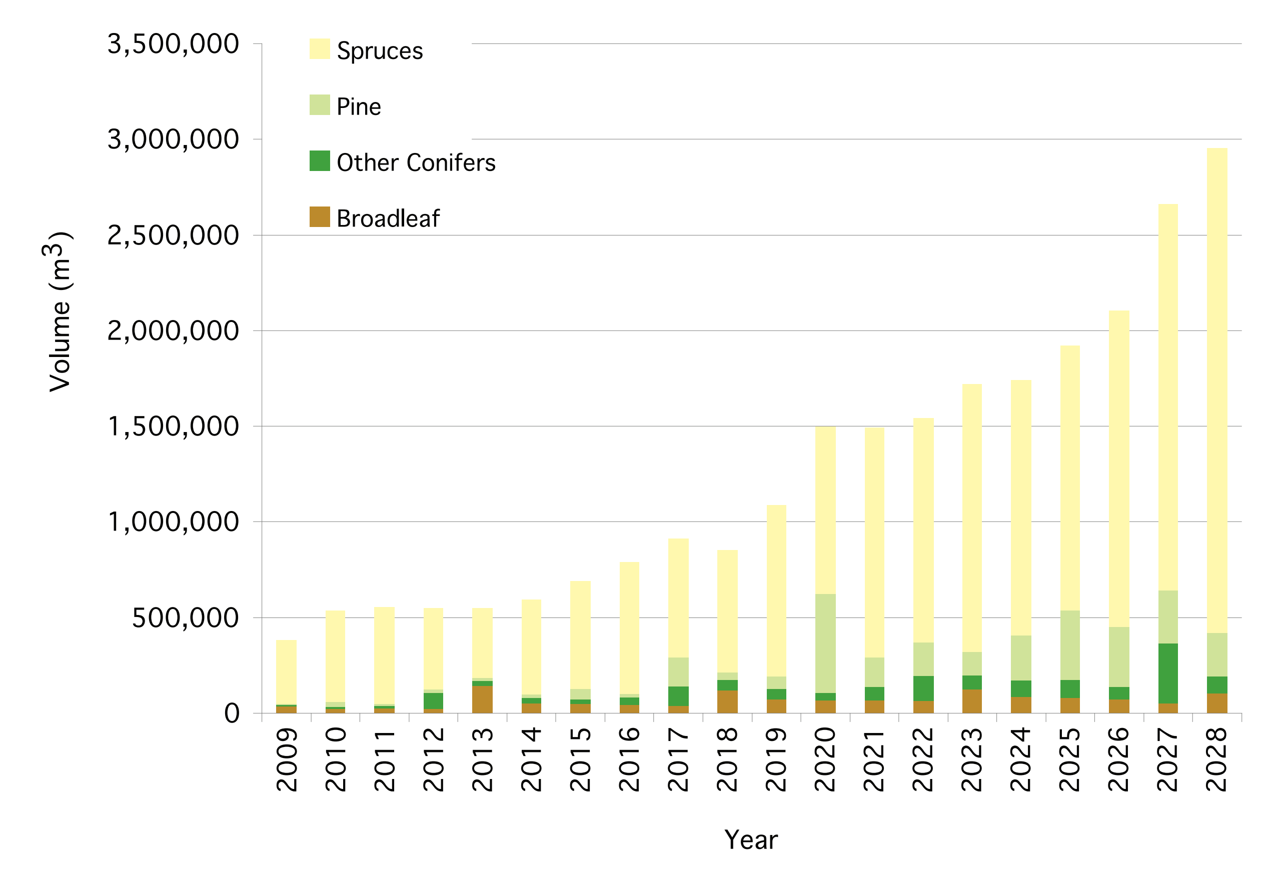
The net energy assortment volume, which includes the 7-13 cm volume assortment, totals 10.75 million m^3 equivalent over the forecast period and increases from an estimated 0.30 million m^3 equivalent in 2009 to 0.63 million m^3 in 2028. Future forecasts could include the use of biomass expansion factors (BEF) and thinning rules for energy wood.

Over the 20-year forecast period Sitka and Norway spruce account for 19.60 million m^3 or 78% of the total net volume production of 25.13 million m^3, pine accounts for 2.81 million m^3 or 11%, other conifers total some 1.41 million m^3 or 6% and broadleaves account for 1.34 million m^3 or 5%.

National net smoothed volume by assortment category (000 m^3 overbark).

Production Year	Net Volume				Energy (000 m^3 equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	257	110	15	381	302
2010	291	134	110	536	341
2011	339	128	88	554	398
2012	329	141	79	549	386
2013	290	144	117	551	346
2014	330	209	56	595	388
2015	369	251	70	689	435
2016	428	279	86	793	503
2017	488	329	95	913	573
2018	445	252	155	851	524
2019	515	362	209	1,086	607
2020	623	571	303	1,497	725
2021	602	541	350	1,494	707
2022	623	568	352	1,543	731
2023	570	613	537	1,720	674
2024	576	627	539	1,743	675
2025	521	674	723	1,919	609
2026	516	715	874	2,104	604
2027	506	942	1,212	2,660	597
2028	530	951	1,472	2,953	626
Totals	**9,150**	**8,539**	**7,443**	**25,131**	**10,752**
% Volume	**36**	**34**	**30**	**100**	

The total thinning area, from first, second, third and subsequent thinnings increases over time and peaks at circa 30,000 ha in 2022. This scale of thinning, to be achieved within the next thirteen years, represents a significant challenge to the overall forestry sector.



Smoothed net volume production (m^3) by species group 2009-28.

Regional, catchment and scenario forecasts

As the datasets used in deriving this forecast are georeferenced, it is possible to produce geospatial forecasts. Forty-two locations were selected throughout Ireland as forecast centres with 60 and 80 km radius catchments. To download these forecasts, two GIS forecast tools are available from www.coford.ie.

Discussion and conclusions

This forecast provides a first step in the development of a modern private sector forecast model based on the best available spatial information. It addresses the need for a forecast of roundwood supply from private sector forests and represents a major advance on previous forecasts. There is now an improved dataset for forecasting with the capacity for regional and catchment-based forecasts.

Forecast volumes are based on a range of assumptions, yield models, inferred management regimes and forecast rules which may or may not be applicable at individual plantation level. Markets may not always be available for the volumes forecasted.

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The authors wish to acknowledge the support and cooperation of Coillte Teoranta in particular for access to their Thinning and Rotation (TRC) data and the volume assortment table for Sitka spruce grown in Ireland and the Forest Service for access to forest datasets, Ordnance Survey Ireland (OSi) for access to the national georeferenced digital databases and the Forestry Commission, Silvan House, Edinburgh for permission to use the Forest Yield software.

Abbreviations

AH ....Farm Forestry Scheme
BE...................................Brown earth
BEF ....Biomass expansion factor
CP...................................Corsican pine
DBH ....Diameter breast height
DEM...............................Digital elevation model
DF...................................Douglas fir
EL...................................European larch
FIPS................................Forest Information and Planning System
FOA................................Forest Open Area (National Forest Inventory)
G.....................................Gley
GF...................................Grand fir
GIS ....Geographic Information System
HC ....High level cutover peat
HL ....Hybrid larch
HV ....High level virgin peat
IFORIS ....Forest Service Integrated Forest Information System
IFS ....Irish forest soils
JL....................................Japanese larch
LC...................................Low level cutover peat
LPN ....Lodgepole pine North Coastal
LPS.................................Lodgepole pine South Coastal
LV...................................Low level virgin peat
MMAI ....Maximum mean annual increment
NF...................................Noble fir
NFI ....National Forest Inventory
NS...................................Norway spruce
OC ....Other conifers
OHB ....Other slow-growing broadleaves
OSB ....Other fast-growing broadleaves
OSi..................................Ordnance Survey of Ireland
P......................................Podzol
PG...................................Planting grant scheme
PGA................................Private grant aided area
PNGA.............................Private non-grant aided area
RC ....Raised cutover peat
RV ....Raised virgin peat
SEI..................................Sustainable Energy Ireland
SP ....Scots pine
SYC ....Sycamore
TRC ....Coillte thinning and rotation classification
WP..................................Western Package Scheme

Table of Contents

List of Figures

List of Tables

Appendices

1. Background

Forest roundwood supply forecasting for both private (Purcell 1979) and state owned forests (Forest Service 1987) was undertaken periodically by the Forest Service up to 1988. Since the formation of Coillte in 1989, there has been no production forecast for privately owned forests apart from a desk study (Gallagher and O'Carroll 2001), which was 'the first step towards quantifying the full production potential of the forest resource of the island of Ireland.' This forecast provided volume information for conifers by county and standard assortment categories for the period 2001-2015. It used a combination of planting records, Forest Information and Planning System (FIPS) data and assumptions on species, yield and thinning to estimate future roundwood production.

The past twenty years has seen a rapid expansion of privately owned forests, which now comprise circa 300,000 hectares (Forest Service 2007a) or 43% of the total forest estate. Some 230,000 hectares have been grant aided since 1980. Roundwood production from these grant aided plantations is expected to increase significantly over the next two decades.

The 2004 National Forest Inventory (NFI), which covered both state and private forests, has been completed (Forest Service 2007a, 2007b, 2007c). It provides a range of information on species and growing stock at national and county level. The first phase of the NFI was not designed to provide roundwood production forecasts. The second phase, currently being planned, will enable increment and future production to be estimated.

In 2006 the Forest Service began work on updating the Forest Information and Planning System (FIPS) forest cover layer for the private forest estate. This is required for a number of reasons including national carbon accounting under the Kyoto Protocol and for environmental modelling and monitoring under the EU Water Framework Directive (EC 2000). This new forest cover layer, known as Forestry07, includes information about all forests, with the level of attribute detail dependent on the data source. It also provides a much improved basis for roundwood production forecasting.

The Irish Government is committed to increase the national area of forest to 17% by 2030 and to increase the utilization of wood, particularly for the generation of energy from renewable and sustainable sources. Development is constrained, however, by the lack of consolidated roundwood supply forecasts, for energy and other traditional assortments (Bacon 2004). There is, therefore, a compelling requirement for a GIS forecast model to generate national, regional and catchment roundwood supply forecasts.

The overall FORECAST project objective is to develop a reliable national GIS-based private sector wood supply forecast model. The project has two parts. The first, which is the subject of this report, relates to the provision of an interim GIS forecast while the second is research orientated focusing on GIS forecasting methods and the use of NFI data in forecasting.

2. Geospatial forecast objectives

The objectives are:

- To develop an interim GIS forecast on a national and catchment basis for privately owned forests for a twenty year period (2009-2028) to replace the current private sector roundwood forecast for 2001-2015 developed by Gallagher and O'Carroll (2001) using available spatial data; and
- To publish an interim private sector roundwood supply forecast within 12 months after consultation with interested parties.

This is an interim forecast of private sector roundwood supply, which will be improved upon as work is carried out under the other components of the FORECAST project, e.g. use of National Forest Inventory data to estimate crop parameters. It will also form part of an overall roundwood supply forecast for all of Ireland to be compiled by COFORD later this year.

3. Methodology

This section of the report describes the data sources used to develop the forecast and what information had to be added. It also describes the approach adopted to allocate management regimes to privately owned forests. The forecasting rules and assumptions are defined. Finally the smoothing process for the forecast volumes is outlined.

3.1 Data sources

The primary forest datasets used in this interim forecast are derived from three sources.

3.1.1 FIPS 1998 (Planting pre 1980 to 1998)

During the period 1993-1997 a forest classification project was carried out with the objective of categorising Ireland's forests into broad species and development classes (Gallagher et al. 1996).

The output from this work was the FIPS95 dataset, which was based on a combination of automatic classification of satellite imagery and on-screen interpretation of Landsat TM imagery (1993-1997), OSi panchromatic orthophotos (1995), and rasterized 25" maps. Forest boundaries were digitised to within 2 m accuracy of the orthophotos, and where appropriate the OSi 25" map series. There were 504,000 ha of forest present in 1995, which included the public and private forest estates. In 1998, private afforestation records were appended to FIPS95, but only for those plantations in receipt of grant/premium aid at the end of 1998. This new dataset was called FIPS98.

There are two distinct categories in the FIPS98 dataset of interest to the FORECAST project:

1. *Private Grant Aided (PGA) – Planting 1989 to 1991*

   This portion of the dataset was captured from private grant aided areas which were delineated on OSi hard copy maps. Species or other attribute information were not available for this portion of the estate.

2. *Private Non-Grant Aided (PNGA) – Planting Pre 1989*

   The forest area in this category generally includes forest areas planted prior to 1980. This encompasses old forest estates, as well as natural succession and other scrub-type broadleaf woodland.

3.1.2 Premiums (Planting 1989 to 2007)

Between 1999 and 2007 no update of the FIPS98 dataset was undertaken. Official Forest Service published statistics indicate that some 99,520 ha were afforested by the private sector between 1999 and 2007, an average of 11,000 ha per annum. Attribute and spatial information relating to the full 99,520 ha has been captured digitally in the Forest Service Integrated Forest Information System (IFORIS). An Oracle database is used to store this attribute and spatial information.

In 2006 the Forest Service began updating the FIPS forest cover layer for the private estate. This new forest cover layer is referred to as Forestry07. The main drivers for producing Forestry07 were a need to produce reliable up-to-date forest cover statistics and related spatial data for carbon accounting under Kyoto, and the need for spatial data related to environmental modelling and monitoring under the Water Framework Directive (EC 2000).

The Premiums data were extracted from the IFORIS database and refer only to private plantations. This includes plantations that were in receipt of premium in 2005, when IFORIS went live. All plantations with a spatial component in IFORIS were extracted and given attribute information including planting year and species. As the Premiums dataset contains only those plantations that were in receipt of premium when IFORIS went live in 2005, the earliest planting year available is 1989.

3.1.3 WP08 (Plantings 1980 to 1990)

In 2008 the Forest Service compiled a spatial database of privately owned plantations afforested between 1980 and 1990 (Forest Service, 2009). The project was co-funded by the Forest Service and Sustainable Energy Ireland (SEI).

The project focused primarily on plantations established under the Western Package (WP) scheme, but also included the State Scheme (NPG), Farm Forestry Scheme (AH) and Planting Grant Scheme (PG) as these schemes were operational during the 1980-1990 period. The Forest Service retains all afforestation hardcopy files at Johnstown Castle, Co Wexford. In total, there are 6,000 hardcopy files relating to these four schemes. Due to the duration of the schemes, forest areas with planting years ranging from the 1960s (PG) up to the mid 1990s (WP) were included.

Hardcopy files formed the basis of the data capture process. The areas identified on the hardcopy maps were digitised using the OSi 2004 air-photos. The plantation area was then attributed with the species and planting year information detailed in the file.

3.1.4 Summary of source datasets

The datasets used in the development of the interim forecast were:

- The **Premiums** dataset which covers private plantations in receipt of premiums between the years 1989 to 2007.
- The **WP08** dataset which covers private plantations that were in receipt of grant aid prior to 1989/1990.
- **FIPS98** which covers the remainder of the private estate, i.e. private grant aided area (PGA) and private non-grant aided area (PNGA).

The area of private forest ownership by data source (Table 1) was derived from the updated Forestry07.shp which illustrates the FORECAST dataset distribution (Figure 1).

Table 1. Private forest ownership by data source.

Ownership category	Area ha	Planting years
Premiums	169,169	1989 to 2007
Private Non-Grant Aided	80,131	Pre 1989
Private Grant Aided	28,421	1989 to 1991
WP08	27,471	1980 to 1988
Total	**305,192**	

Figure 1. Privately-owned forests in Ireland.

3.2 Appending forest attributes

The previous section outlined the private forest estate spatial data used in the forecast. Depending on the data source, additional information on age, species, site productivity and silvicultural management regime was required at individual polygon (plantation) level to run the GIS-based roundwood production forecast. This section outlines the approach adopted and identifies the additional data appended to the spatial data.

3.2.1 Species information

The Premiums and WP08 datasets contain species and age data suitable for forecasting. The FIPS98 species groups are too general for forecasting and age is missing. Estimates of discrete species and age classes were therefore derived for each of the FIPS98 species categories using the NFI (Forest Service 2007a) and the 1973 Inventory of Private Woodlands (Purcell 1979) (Table 2).

3.3 Appending spatial data

For each polygon in the forecast dataset, a centroid was established using the easting (m) and northing (m) Irish National Grid coordinates which were imported as point data. Centroids were intersected with an OSi digital elevation model (DEM) to obtain elevation (m). The Irish Forest Soil (IFS) type data (Fealy et al. 2006) were appended using the same approach.

Table 2. Re-classification of FIPS98 species and age classes.

FIPS species	Forecast species	Assumed age	% area
BMB - Mature Beech (1998)	Beech	80	100
BMK - Mature Oak (1998)	Oak	75	100
BMO - Mature Other Broadleaves (1998)	Birch	65	100
BYB - Young Beech (1998)	Beech	35	100
BYK - Young Oak (1998)	Oak	35	100
BYO - Young Other Broadleaves (1998)	Birch	15	100
C - Cleared (1998)	Ash	8	15
C - Cleared (1998)	Sitka spruce	10	60
C - Cleared (1998)	Birch	10	25
CML - Mature Larch (1998)	European larch	70	100
CMO - Mature Other Conifers (1998)	Douglas fir	65	100
CMP - Mature Pine (1998)	Scots pine	70	100
CMS - Mature Spruce (1998)	Sitka spruce	42	100
CYL - Young Larch (1998)	Japanese larch	18	100
CYO - Young Other Conifers (1998)	Douglas fir	18	100
CYP - Young Pine (1998)	Scots pine	18	100
CYS - Young Spruce (1998)	Sitka spruce	18	100
MPS - Mature Pine/ Spruce Mix (1998)	Norway spruce	45	100
MXM - Mixed Forest Mature (1998)	Birch	35	25
MXM - Mixed Forest Mature (1998)	Scots pine	80	25
MXM - Mixed Forest Mature (1998)	Oak	80	50
MXY - Mixed Forest Young (1998)	Birch	18	25
MXY - Mixed Forest Young (1998)	Scots pine	25	25
MXY - Mixed Forest Young (1998)	Oak	30	50
O - Other Forest (1998)	Birch	35	100
PGA - Young Unknown (1998)	Sitka spruce	18	70
PGA - Young Unknown (1998)	Japanese larch	18	15
PGA - Young Unknown (1998)	Lodgepole pine (south coastal)	18	15
YPS - Young Pine/ Spruce Mix (1998)	Norway spruce	18	100

3.4 Management regime

There is little information available for privately owned forests regarding the types of management regime planned or being implemented. To identify the most appropriate range and type of management regimes and to determine a relationship between site factors and management regime, Coillte made available Thinning and Rotation Classification (TRC) inventory data for counties Cork, Offaly, Roscommon and Tipperary. Cork was chosen due to its large size and range of site types, Roscommon as being representative of Sitka spruce plantings, Tipperary as having a relatively high proportion of broadleaves and Offaly as being representative of midland areas. The total area was 80,700 ha or almost one quarter of Coillte's productive forest estate. In total, some 21,260 records of subcompartment details were provided. The TRC assigns a thinning regime (standard – according to Forestry Commission yield tables, solitary, two thin or three thin) and a rotation type (standard – in line with Operational Directive 1/77 issued by Forest and Wildlife Service, extended or local) to the main conifer species in each subcompartment with the underlying assumption that minor conifer species within the subcompartment will receive the same treatment. Any deviation from the standard thinning treatment or standard rotation must be accompanied by an explanation.

3.4.1 Thinning

Initially an area and frequency summary of thinning types by main species (Sitka spruce, Norway spruce, Douglas fir, lodgepole pine (south coastal), lodgepole pine (north coastal), Japanese larch and Scots pine), by Coillte soil type classification[2] (BE, P, G, HV, HC, RV, RC, LV, LC) by elevation class (<100 m, 100-200 m, 200-300 m and >300 m) was undertaken. The area/frequency information was then expressed as a percentage within each soil group. This allowed for trends and possible patterns to be more readily identified.

The number of possible thinning regimes was reduced to three: (i) standard (according to Forestry Commission yield tables on a regular cycle), (ii) thin (two thinnings) and (iii) no thin. The soil types were amalgamated into two groupings: mineral (brown earth, podzol and gley) and peats (high level peat, low level peat and raised peat).

Data were summarised into a single table where it was possible to identify patterns and trends both between and within species and between different elevation classes. The data were then amended and smoothed to eliminate any obvious contradictions, e.g. larger no thin area with decreasing elevation. Finally the data for Scots pine, Douglas fir and Japanese larch were combined to provide values for the 'Other Conifer' category. The results (Table 3) provide the initial default thinning regime for the forecast.

Table 3. Default thinning type by species, by soil group by elevation class (% area).

		SS		NS		LP		DF		JL		SP		OC	
Elevation class	**Thin category**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**
< 100 m	**No Thin**	15	30	15	30	40	80	20	15	45	40	45	50	*35*	*35*
	Thin	15	25	20	25	35	10	30	50	15	30	30	40	*25*	*40*
	Standard	70	45	65	45	25	10	50	35	40	30	25	10	*40*	*25*
100-200 m	**No Thin**	15	30	15	25	40	80	15	25	15	30	35	50	*20*	*35*
	Thin	15	25	20	30	35	5	15	35	15	5	25	40	*20*	*25*
	Standard	70	45	65	45	25	15	70	40	70	65	40	10	*60*	*40*
200-300 m	**No Thin**	25	35	15	40	50	80	15	30	15	45	35	50	*20*	*40*
	Thin	20	25	15	30	25	5	20	40	20	20	15	40	*20*	*35*
	Standard	55	40	70	30	25	15	65	30	65	35	50	10	*60*	*35*
>300 m	**No Thin**	25	35	40	*60*	65	80	25	30	30	50	*40*	*50*	*50*	*45*
	Thin	20	35	25	*15*	15	10	*10*	20	30	20	*10*	*40*	*10*	*25*
	Standard	55	30	35	*25*	20	10	*65*	50	40	30	*50*	*10*	*40*	*30*

Note: M = mineral soil, P = peat soil. Values in ***red italics*** are inferred.

[2] See list of abbreviations for full description.

Those crops in the WP08 dataset which were identified during the digitising process as having lower productivity due to stocking and/growth check were assigned a no thinning regime.

This default thinning regime can be amended in subsequent forecasts through the application of thinning rules for yield class and minimum harvest volume required to undertake harvesting. The values in Table 3 represent a default starting baseline position.

While it was possible to assign thinning type for the main conifer species, a convention was required for minor conifer species and for broadleaved species. Each of these species was assigned a TRC species for the purpose of determining the thinning type and rotation type, e.g. ash was assumed to be treated similarly to Sitka spruce while beech was assumed to be treated similarly to Scots pine.

Overall thinning status

Approximately 30% of the private forest estate was classified as no thin, 50% as standard thin and the remaining 20% as thin, i.e. it would receive two thinnings (Figure 2). The proportion of no thin was greatest in the WP08 dataset – almost 60% – due to low stocking and growth check and least in the Premiums dataset where it was 26%.

3.4.2 Rotation lengths

The current convention on rotation lengths for conifers in state-owned plantations is to grow crops to a rotation of maximum mean annual increment (MMAI) with the exception of Sitka spruce (20% below age of MMAI), Norway Spruce (30% below age of MMAI) and lodgepole pine (coastal) (30% below age of MMAI) (Forest and Wildlife Service 1976).

The underlying assumption used in this forecast is that owners will, on average, wish to manage their plantations to maximize returns and use a financial rotation. The rotation of maximum discounted revenue was taken as the definition of financial maturity. A decision indicator in terms of minimum difference in discounted revenue required to alter rotation length was developed (Phillips 2008). An economic analysis was undertaken for the main conifer species using updated timber prices - ten year price size curve 1998 to 2007 - and the standard rotation lengths currently in use were amended as appropriate.

Standard and local rotations

Standard rotation lengths were determined for conifer species based on the findings from the economic analysis (Phillips 2008). Broadleaved species were assigned a rotation of MMAI.

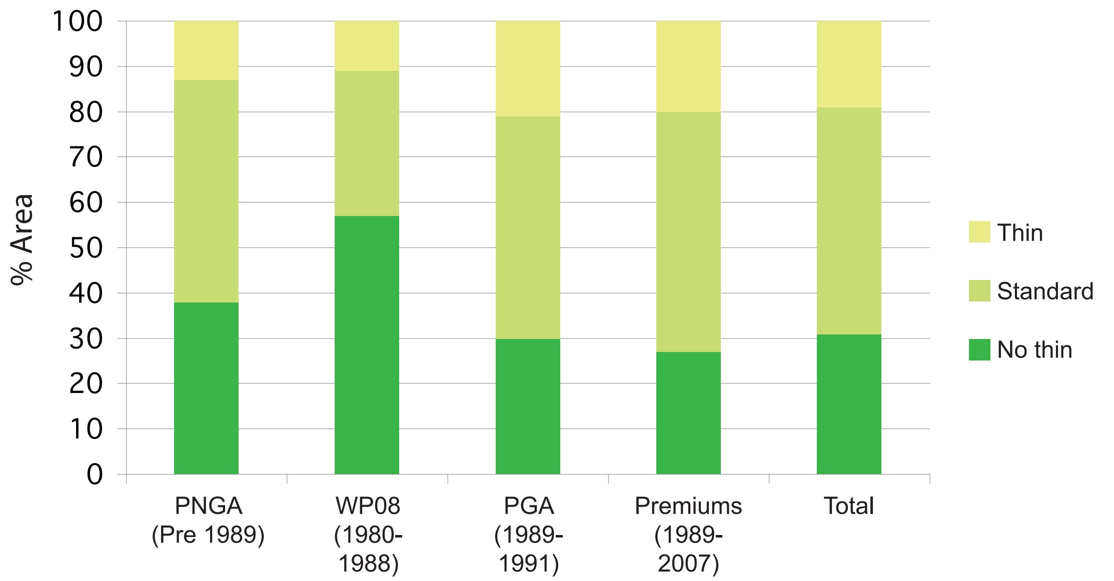

Figure 2. Thinning treatment % by data source.

Local or reduced rotations apply where crops, due to instability, cannot reach the age specified in the standard rotation. The local rotation lengths were based on the age required to reach a top height of 21 m. Where this age was either within four years of the standard rotation or greater than the standard rotation age, the local rotation was made equal to the standard rotation minus five years. For example, a Norway spruce yield class 10 crop reaches 21 m top height at age 63 years. However, the standard rotation age is 52 and thus the local rotation is equal to 52 minus 5 or 47 years.

Assigning rotation type

An analysis of the reasons behind the decision to assign an extended rotation (Phillips 2008a) revealed that in 96% of occurrences, the reason was either contiguity with adjoining areas to provide an economic harvest volume or environmental. The environmental reason could in future analyses be inferred on the basis of spatial datasets, but contiguity in relation to the timing of clearfells is not currently possible to infer for privately-owned plantations. Thus, it was decided to reduce the number of rotation types to two, i.e. standard and local.

Soils were combined into mineral and peats and an overall master default table (Table 4) was constructed. Missing data were inferred by reference to values for closely related species. However, to simplify the underlying assumptions and spatial modelling, areas having standard thinning were assigned a standard rotation and areas with either no thinning or two thinnings were assigned a local rotation.

3.4.3 Yield class

There is no reliable source of information on yield class for privately-owned forests. Neither the NFI, FIPS nor the Forestry07 datasets contain such information. The summary management plan required for grant-aided crops does record a notional yield class but this information is available only in hard copy, and as yet these plans represent only a small proportion of the privately-owned forest estate.

The Coillte sample TRC data provides information on yield class by species by soil type and by elevation class. A multiple regression model was developed to predict yield class for Sitka spruce using elevation class and soil type as independent variables. The model's statistics indicated a significant relationship between yield class and ordinal soil type and elevation classes. The model behaves in a rational manner with yield class decreasing with increasing elevation within each soil type (Table 5). There is also a decrease in yield class with decreasing soil productivity classes from mineral to peat soils. The

Table 4. Rotation types (% area).

		SS		NS		LP		DF		JL		SP		OC	
Elevation class	**Rotation type**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**	**M**	**P**
<100 m	**Local**	15	15	30	55	65	40	30	25	15	15	25	35	***25***	***25***
	Standard	85	85	70	45	55	60	70	75	85	85	75	65	***75***	***75***
100-200 m	**Local**	15	15	30	45	30	35	25	***30***	20	55	25	30	***25***	***30***
	Standard	85	85	70	55	70	65	75	***70***	80	45	75	70	***75***	***70***
200-300 m	**Local**	15	15	30	50	30	30	30	60	25	15	30	***35***	***30***	***35***
	Standard	85	85	70	50	70	70	70	40	75	85	70	***65***	***70***	***65***
>300m	**Local**	30	30	30	50	45	50	50	***50***	35	30	***30***	***35***	***40***	***40***
	Standard	70	70	70	50	55	50	50	***50***	65	70	***70***	***65***	***60***	***60***

Note: M = mineral soil and P = peat soil. Values in ***red italics*** are inferred.

Table 5. Predicted yield class ($m^3ha^{-1}a^{-1}$) by soil type and elevation class.

	Soil type					
Elevation	**BE**	**GY**	**PZ**	**FP**	**PT**	**OP**
<100 m	21	20	19	18	18	17
100-200 m	20	19	18	17	16	15
200-300 m	19	18	17	16	15	14
>300 m	18	17	16	15	14	13

predicted average yield class range is from 13 to 21.

One of the shortcomings of this approach is that the model assigns a predicted average yield class for each soil type/elevation class combination. Thus it is not possible to simulate the inherent variation or range of yield classes that occur in practice under field conditions. This has implications for forecasted volumes, especially the timing of thinnings, but these are minor in terms of the overall forecast.

The model accounted for only 19% of the total variation in yield class. However, the 95% confidence intervals of the prediction, when expressed as a percentage of the fitted values (Table 6) quantifies the precision for each soil and elevation combination. The 95% errors range from 1.7 to 6.1% which indicate acceptable levels of precision. The most precise estimates are associated with high yield classes occurring on the better soils, at lower elevations.

During the digitising of the WP08 dataset, the attribute 'productivity status' was added where crops were understocked or were in check. This was based on interpretation of orthophotography. For those areas, the estimated yield class for Sitka spruce was reduced by two[3] for example if the estimated yield class was 18, it was reduced to 14.

Teagasc have developed a productivity model which assigns a yield class for Sitka spruce based on a combination of soil, elevation, rainfall and exposure/aspect (Farrelly et al. 2009). This could provide a more robust basis for assigning yield class. When the Teagasc model is fully completed the intention is to use it to assign yield classes for the privately owned forests and to rerun the forecast.

Yield class for minor species

The approach taken was to use the sample TRC data provided by Coillte and determine if there was a relationship between the yield class for Sitka spruce and that of other conifer species. The TRC data were interrogated and all subcompartment records where Sitka was the main species and where there was a second conifer species were analysed and the weighted average yield class was calculated. Using this as a baseline and eliminating those species for which there were insufficient data, it was possible to provide an estimate of the yield class for the second species (Table 7).

The published upper yield class for Sitka spruce is 26; the assumption is that above this point the yield class of the second species will not change.

Table 6. 95% confidence interval % for predicted yield class ($m^3ha^{-1}a^{-1}$).

	Soil type					
Elevation	**BE**	**GY**	**PZ**	**FP**	**PT**	**OP**
<100 m	1.7	2.0	2.3	2.7	3.1	3.5
100-200 m	2.1	2.5	2.8	3.3	3.7	4.2
200-300 m	2.6	3.0	3.5	3.9	4.5	5.1
>300 m	3.2	3.7	4.2	4.7	5.4	6.1

Table 7. Default yield class estimates for second/minor species.

	Yield class Sitka spruce ($m^3ha^{-1}a^{-1}$)										
Second species	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**
Corsican pine	4	6	6	8	8	10	10	10	12	12	14
Douglas fir	6	8	10	10	12	14	16	16	18	18	20
European larch	4	6	6	6	8	8	8	8	10	10	10
Grand fir	4	6	8	10	12	14	16	18	20	22	24
Hybrid larch	4	6	6	8	8	10	10	10	12	12	14
Japanese larch	4	6	6	8	8	10	10	10	12	12	14
Lodgepole pine north coastal	6	8	8	10	10	12	12	12	12	12	12
Lodgepole pine south coastal	6	8	8	10	10	12	12	14	14	16	16
Noble fir	6	8	10	12	12	14	16	16	18	20	20
Norway spruce	6	8	10	10	12	14	16	18	20	20	22
Other conifer	4	6	8	10	10	12	12	14	16	16	18
Scots pine	4	6	8	8	10	10	12	12	12	14	14

[3] A yield class is 2 m^3 ha^{-1} a^{-1}.

Broadleaf species

Coillte's TRC does not contain any information on yield class for broadleaf species. A default yield class for the range of equivalent yield classes for Sitka spruce was constructed. This was then discussed with a number of forestry professionals and adjustments were made to incorporate their views (Table 8).

Average yield class

Arising from the application of the rules and assumptions to estimate yield class, the overall weighted average yield class for conifers was 16.7 (PGA and PNGA 16.4, Premiums 16.9 and WP08 15.8). The weighted average yield class for broadleaves was 4.6 (PNGA 3.1, WP08 7.3 and Premiums 7.8). The weighted average yield class for Sitka spruce was 18.5 in the Premiums dataset and 17.5 in the WP08 dataset.

3.5 Assortment tables

Two assortment tables were used to provide relative volumes overbark to tip and to 7cm top diameter. Three standard roundwood assortment categories were used: 7-13 cm, 14-19 cm and 20+ cm. An energy assortment combining the volumes from 7-13 cm and from 7 cm to tip and the volume arising from reduced harvest losses was calculated (3.6.3). It is important to remember that this energy assortment includes the volume in the 7-13 cm category. The proportion of harvested volume in the 7-13 cm category entering the energy market will be dependent on price. The assortment table specific to Sitka spruce grown in Ireland was obtained from Coillte (Jordan 1992). The second assortment table, which was used for all other species, was the Forestry Commission stand assortment table for conifers and small hardwoods (Forestry Commission 1971). The Irish Sitka spruce assortment table has a maximum mean diameter breast height (dbh) of 32 cm; for larger mean diameters the Forestry Commission table was used. A separate sensitivity analysis forecast was run using alternative Forestry Commission assortment tables (Forestry Commission 1975).

3.6 Forecast rules and assumptions

This section outlines the forecast rules and assumptions made for stocking, attrition, harvest loss and yield models.

3.6.1 Stocking

Traditionally a 15% reduction in forecast volumes has been used in Ireland to allow for roads, rides and other unproductive areas. The same approach is used in the UK (Forestry Commission 1981).

Due to a combination of afforestation compliance requirements for grant aid and the separation out of biodiversity areas from planted areas, 15% may be an overestimate. The NFI analysis of Forest Open Area (FOA) indicated a stocking reduction factor of circa 10% due possibly to limited roading and lack of ridelines in the private forest estate. As a compromise between the traditional 15% and the 10% from the NFI, a stocking reduction of 12.5% was applied to the Premiums and PNGA data. As the PGA dataset included a number of unplanted polygons the stocking reduction factor was increased to 25%. The WP08 dataset already excluded open areas, which totalled 2.3%; consequently a smaller reduction of 10% was applied to these areas.

Table 8. Default yield classes for broadleaf species.

	Yield class Sitka spruce ($m^3ha^{-1}a^{-1}$)											
Second species	**6**	**8**	**10**	**12**	**14**	**16**	**18**	**20**	**22**	**24**	**26**	**28**
Alder	4	4	4	6	6	6	8	8	8	8	8	8
Ash	4	4	4	6	6	8	8	8	10	10	12	12
Beech	4	4	4	4	4	6	6	6	8	8	8	8
Birch	4	4	4	4	6	6	6	8	8	8		
Oak	4	4	4	4	4	6	6	6	8	8	8	8
Sycamore	4	4	4	6	6	8	8	8	10	10	12	12
Other fast-growing broadleaves	4	4	4	6	6	8	8	8	10	10	12	12
Other slow-growing broadleaves	4	4	4	4	4	6	6	6	8	8	8	8

3.6.2 Attrition

Attrition is the loss in productive capacity due to the incidence over time of windthrow and disease. Traditionally in Ireland an attrition factor of 7.5% has been used in roundwood production forecasting. When the attrition concept was first introduced, double mouldboard ploughing and systematic one line in three first thinning, were standard practice. Both contributed to the onset and severity of windthrow. In the interim, the greater proportion of the productive private forest estate has been established using improved cultivation methods e.g. mounding, and will receive either a rack and selection or line and selection first thinning. Furthermore, there is a smaller proportion of the estate planted on the more exposed/wind prone sites than for state owned forests. An attrition factor less than 7.5% is thus more appropriate. In the absence of research to provide guidance, a default attrition factor of 5% was used. This 5% was converted to an annual attrition volume between the age of first thinning and the age of MMAI and was deducted from forecast volumes.

3.6.3 Harvest loss

To allow the forecast to estimate roundwood volumes post harvesting at roadside, as well as standing volumes, it was necessary to determine the extent of harvest loss. Based on sample data provided by Coillte and on discussions with a number of stakeholders, losses from 5.5% to 25% of standing volume were assumed, depending on harvesting stage and species (Phillips 2008b). Harvest losses from 5.2% (clearfell) to 12.5% (first thinning) of standing volume were used in calculating the energy assortment.

3.6.4 Yield models

This forecast is based on Forestry Commission yield models (Forestry Commission 1981) apart from lodgepole pine (south coastal) where Irish models (Forest and Wildlife Service 1975) were used. For a number of species, the yield class range in the yield models did not encompass the range of yield classes in practice. In those instances, substitute yield models based on the nearest equivalent species and thinning regime were used. No-thin models were unavailable for all broadleaf species and a series of no-thin default models were developed (Redmond and Phillips 2008). No-thin models for lodgepole pine were developed using GROWFOR[4] and initial stand input parameters from the Irish thin models.

3.7 Smoothing the forecast

The volume generated over the 20 year period of the forecast is directly related to the year of planting, the rotation length and yield class. Peaks and troughs in the level of planting will therefore be mirrored in the forecast volumes. The two peaks in forecast volume of roundwood supply in 2010 and 2020 (Figure 3) arise due to the allocation of a single estimated age for each of the FIPS98 species categories (Table 2) and for the PGA areas. From an overall planning and industry development perspective, the accepted practice is to smooth the forecast volumes over time to show longer term trends more clearly.

In Coillte's forecast for state forests, volumes are smoothed by adjusting the production year of individual plantations with the objective of smoothing volume production nationally. A similar smoothing process in the private forest estate may be considered unrealistic, as it would be impossible to implement at a stand, plantation or owner level. However, as the forecast is of the roundwood supply potential, the benefits of smoothing the original forecast volumes are worthwhile in terms of enabling industry to phase expansion in line with sustainable roundwood supply.

3.7.1 Smoothing process

The original forecast volume was smoothed using a simple exponential function (Figure 3) which shows the increase in volume production over the period. However, to smooth the actual data would require significant re-allocation of volumes across a large number of years. This was considered unrealistic and in practice forecast volumes rarely if ever follow a completely smooth pattern.

The approach adopted was to allow only 20% of the volume estimate for any given year to be re-allocated

[4] GROWFOR is an interactive suite of dynamic yield models developed using Irish data. The models and manuals are available on licence from COFORD.

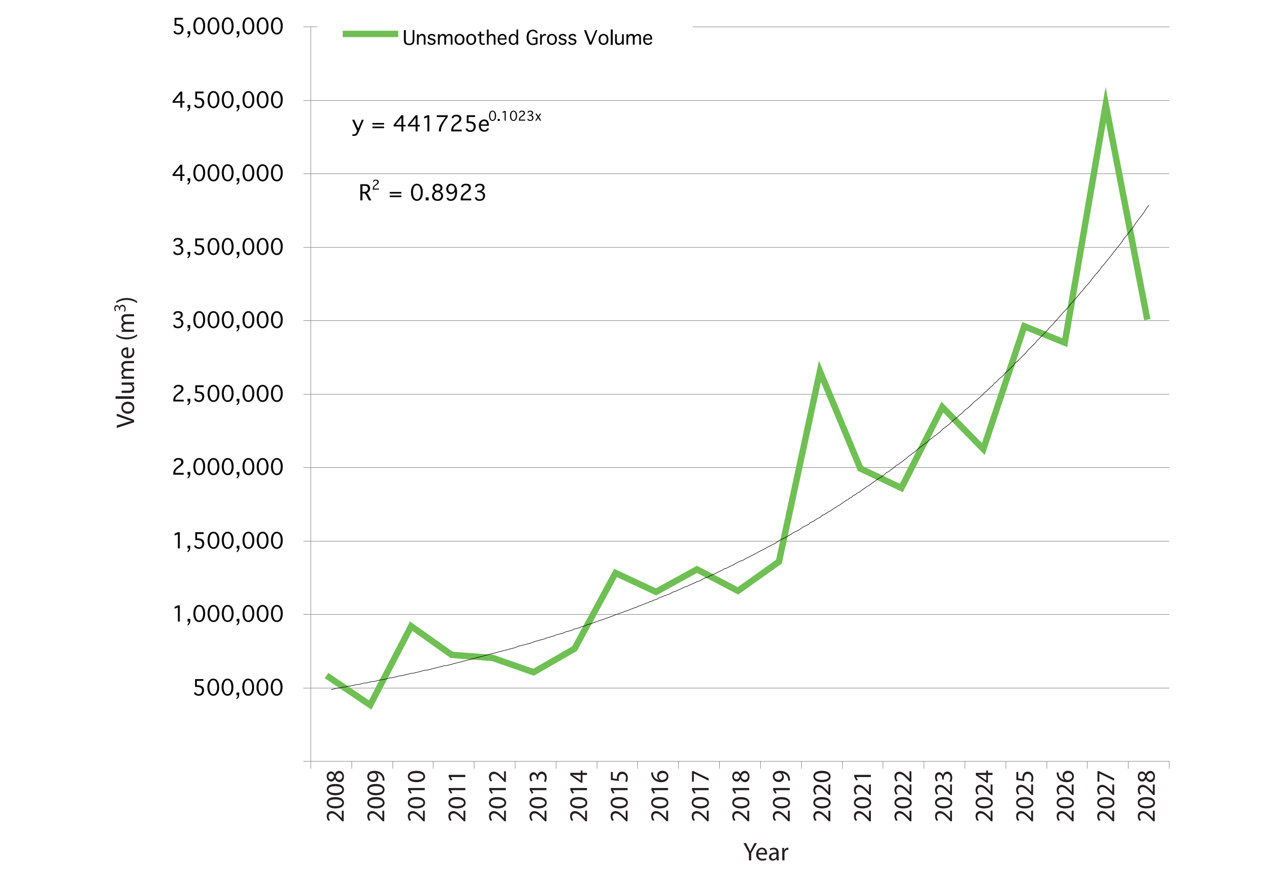

Figure 3. Smoothing of forecast production volumes.

within ± 2 years. If the volume was carried forwards or backwards a 5% annual volume increment was used to adjust for growth. Thus if 20,000 m^3 was brought forward for one year, growth of 5% equivalent to 1,000 m^3 (20,000 x 0.05) was added. The smoothed volume was then divided by the original forecast volume to provide a correction factor for each year which was applied to all subsequent reporting tables. No adjustments were made to volume assortments to allow for either an increase or decrease in mean diameter breast height.

3.8 Overview of forecast process

A summary of the forecasting process (Figure 4) illustrates the spatial datasets and spatial attributes required for the forecast. All spatial analyses were undertaken in ArcGIS 9.3. The data processing element of the interim forecast was carried out using Microsoft Access.

4. Results

This section outlines the main results from the forecast including unsmoothed and smoothed net volumes by standard assortment categories and for the energy assortment. Forecast volumes by species group, harvest type and data source category are commented upon and tabular data are provided in the appendices. The underlying harvest areas by harvest type are also shown.

4.1 Total forecast volume

The effect of smoothing the total gross and net forecast volume is negligible and of the order of an increase in total volume production of 0.45% over the forecast period. The small difference is due to growth during the reallocation of volumes, and the fact that the smoothing took into account volumes in years 2008, 2029 and 2030. The overall gross smoothed roundwood production from privately owned forests is forecast to increase from an estimated 0.52 million m^3 in 2009, to 3.86 million m^3

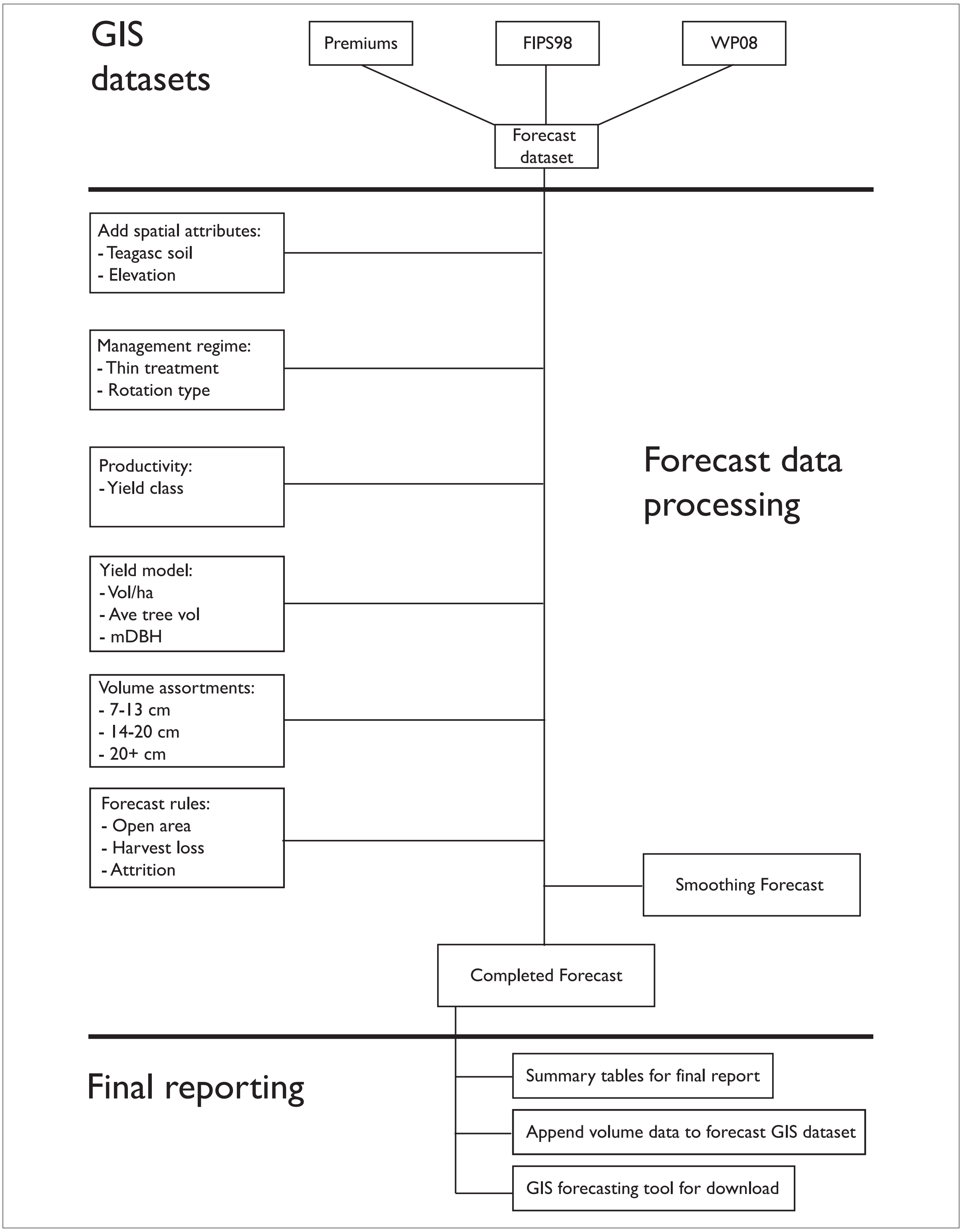

Figure 4. Schematic illustration of the forecasting process.

in 2028 (Table 9). When allowance is made for volume losses due to stocking, attrition and harvest losses, the net forecast volumes are: 0.38 million m^3 and 2.95 million m^3 respectively (Table 10 and Figure 5). Volume reductions and harvest losses averaged 28% over the forecast period and vary within the range 23% to 30%, depending on the year and the mix of harvest type and species.

Forecast roundwood production more than doubles within the first 10 year period compared with 2009 and then trebles within the second 10 years period. The relative proportion by assortment category is 36% (7-13 cm), 34% (14-19 cm) and 30% (20+ cm) (Table 10). Coillte's long term forecast (Coillte Teoranta 2006) for the same time period indicates 20% (7-13 cm), 31% (14-19 cm) and 49% (20+ cm).

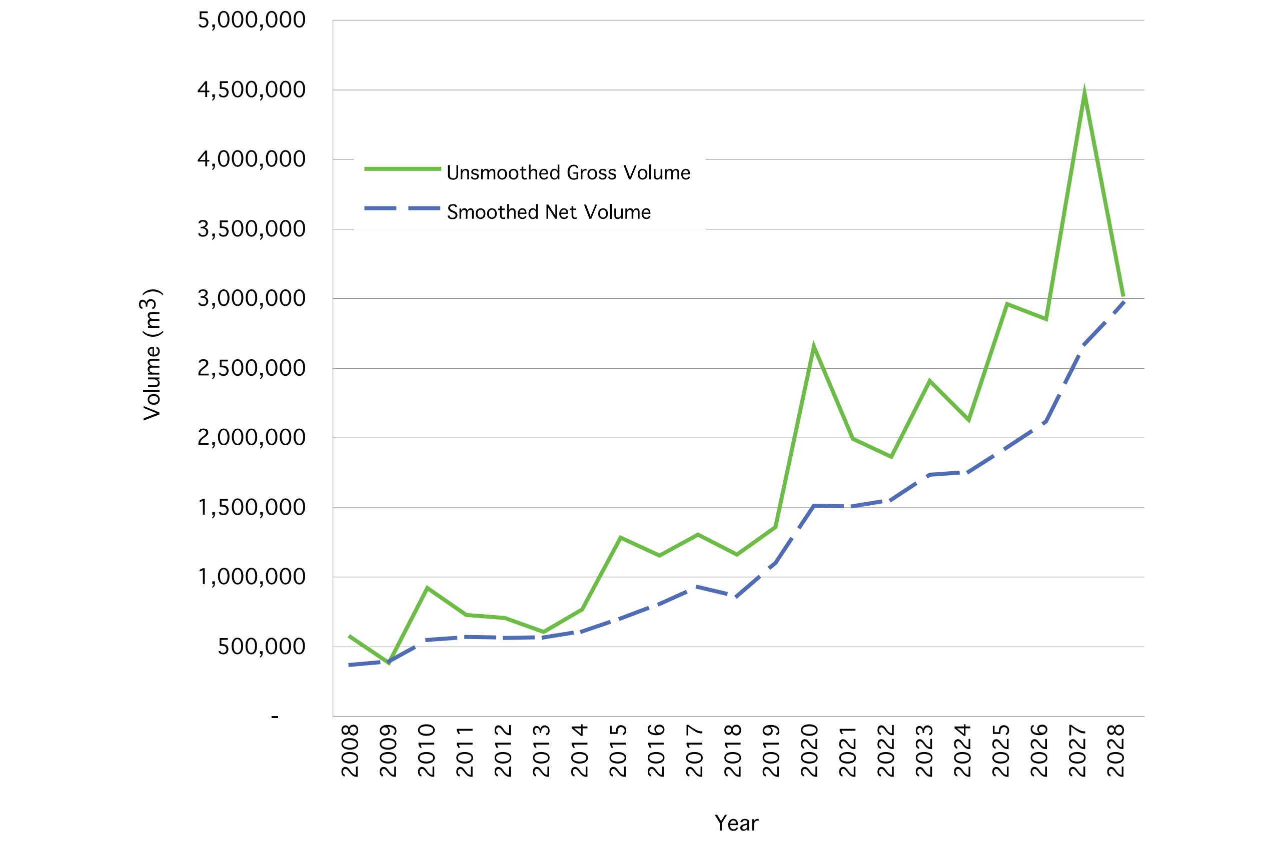

Figure 5. Gross unsmoothed and net smoothed production forecast volumes.

Table 9. National gross smoothed volume by assortment category (000 m^3 overbark).

Production year	Gross volume				Energy (000 m^3 equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	349	150	20	520	408
2010	415	191	137	743	483
2011	480	179	110	769	559
2012	469	201	100	771	546
2013	396	196	149	741	468
2014	451	303	83	837	528
2015	528	382	105	1,015	617
2016	601	416	122	1,140	700
2017	680	478	133	1,291	792
2018	599	346	202	1,148	701
2019	698	505	291	1,495	816
2020	865	812	436	2,113	1,000
2021	828	772	489	2,089	965
2022	860	802	477	2,139	1,001
2023	795	862	739	2,396	932
2024	793	867	733	2,393	921
2025	719	938	995	2,652	834
2026	707	979	1,151	2,838	822
2027	705	1,315	1,635	3,655	827
2028	718	1,269	1,868	3,856	843
Totals	**12,659**	**11,965**	**9,976**	**34,599**	**14,764**
% Volume	**36**	**35**	**29**	**100**	

Table 10. National net smoothed volume by assortment category (000 m^3 overbark).

Production year	Net volume				Reduction %	Energy (000 m^3 equivalent)
	7-13 cm	14-19 cm	20+ cm	Total		
2009	257	110	15	381	27	302
2010	291	134	110	536	28	341
2011	339	128	88	554	28	398
2012	329	141	79	549	29	386
2013	290	144	117	551	26	346
2014	330	209	56	595	29	388
2015	369	251	70	689	32	435
2016	428	279	86	793	30	503
2017	488	329	95	913	29	573
2018	445	252	155	851	26	524
2019	515	362	209	1,086	27	607
2020	623	571	303	1,497	29	725
2021	602	541	350	1,494	29	707
2022	623	568	352	1,543	28	731
2023	570	613	537	1,720	28	674
2024	576	627	539	1,743	27	675
2025	521	674	723	1,919	28	609
2026	516	715	874	2,104	26	604
2027	506	942	1,212	2,660	27	597
2028	530	951	1,472	2,953	23	626
Totals	**9,150**	**8,539**	**7,443**	**25,131**	**27**	**10,752**
% Volume	**36**	**34**	**30**	**100**		

The interim forecast's greater percentage volume in the smaller assortment categories is due to the limited clearfell during the early part of the forecast and the overall greater volume contribution of thinnings. The 20+ cm assortment category shows a large increase over the last 5 year period. This is in line with increases in clearfell areas from 2023 onwards, which reflect the pattern of private afforestation during the mid to late 1980s.

The relative proportion of volume in the three assortment categories differs from the previous forecast (Gallagher and O'Carroll 2001) with 56% of volume in the two larger assortment categories compared with 37% over the period 2009 to 2015. That forecast, due to the underlying assumptions about the FIPS98 forest classes, showed a constant annual volume production of 0.11 million m^3 in the 20+ cm assortment category over the period 2008 to 2015. The smallest size assortment accounted for 63% of total volume during the same period due in the main to the assumptions regarding thinning volumes.

4.1.1 Wood energy assortment

Wood as a source of energy is becoming more important. There is a limited but increasing area being thinned to produce wood energy assortment. In addition, analyses have been undertaken to determine the feasibility of harvesting wood energy assortments from clearfelled sites. This forecast includes a wood energy assortment which is expressed in 000 m^3 roundwood equivalent. However, it is possible to run specific scenario type forecasts which include biomass expansion factors (BEF) and assumptions regarding proportion of thinning areas suitable for energy wood.

The gross energy assortment volume over the forecast period totals 14.76 million m^3 equivalent and increases from an estimated 0.41 million m^3 equivalent in 2009 to 0.84 million m^3 in 2028. When allowance is made for volume losses due to stocking, attrition and harvest losses, the net forecast volumes are: 0.30 million m^3 equivalent and 0.63 million m^3 equivalent respectively (Table 10). These volumes include the volume in the 7-13 cm assortment category.

4.1.2 Sensitivity analysis – assortment tables

When the forecast was run using only the Forestry Commission assortment tables (Forestry Commission 1975), the net smoothed volume in the 20+ cm assortment category was reduced by 18.2% over the period of the forecast (Appendix 1). The size of this reduction is in part due to the high proportion of volume in this category coming from thinnings. Towards the end of the forecast period, differences are less, as clearfells with larger average diameters than thinnings, contribute more to volume in the 20+ cm category. The volumes in the energy, 7-13 cm and 14-19 cm categories increased by 12.5%, 2.6% and 5.1% respectively over the forecast period.

The differences were much less for broadleaved species where the volume reduction in 20+ cm and 14-19 cm categories was 7.8% and 8.2%. The increase in the energy and 7-13 cm assortments was 3.7% and 4.4% respectively.

4.2 Volume by species group

Over the forecast period, spruce accounts for 19.60 million m^3 or 78% of the total smoothed net roundwood production of 25.13 million m^3 (Figure 6 and Appendix 2). The relative proportion of spruce gradually decreases during the second half of the forecast period apart from 2028 which has a relatively large clearfell area. Pine accounts for 2.80 million m^3 or 11% of total smoothed net roundwood volume supply. Other conifers total some 1.41 million m^3 or 6% of total net roundwood volume supply. Volume in this category shows a significant increase during the second half of the forecast period. Broadleaves account for 1.34 million m^3 or 5% of the total net smoothed roundwood volume supply.

Net smoothed conifer volumes (Figure 7 and Appendix 3) illustrate the expected patterns of forecast volume for pulp, and small and large sawlog over the forecast period. The two larger assortments show an increasing trend in roundwood volume production. In contrast, the 7-13 cm category, shows a fluctuating pattern for the first half of the forecast period and remains relatively stable at around 0.5 million m^3 from 2020 onwards. The underlying assumption that reforested crops are not included in the forecast will tend to slightly underestimate volumes in the smaller assortments during the second half of the forecast period. The energy assortment increases up to 2020 and then remains stable until 2024 following which it decreases. The volume in the energy assortment is closely related to the relative proportion of first and second thinnings and the decrease from 2024 onwards reflects the increase in clearfell volumes. While the 7-13 cm and the energy assortments are illustrated (Figure 7) only one or the other will be available for pulp or energy utilization depending on the price.

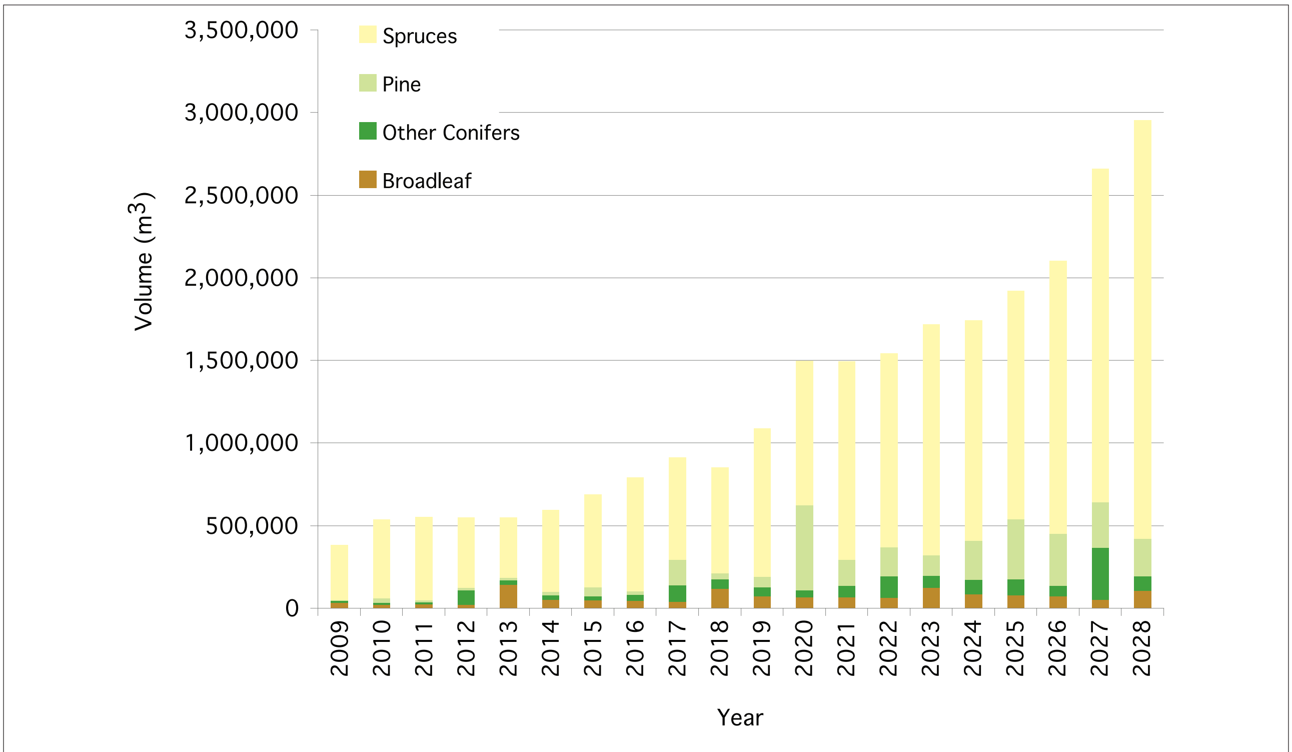

Figure 6. Smoothed net volume production by species group.

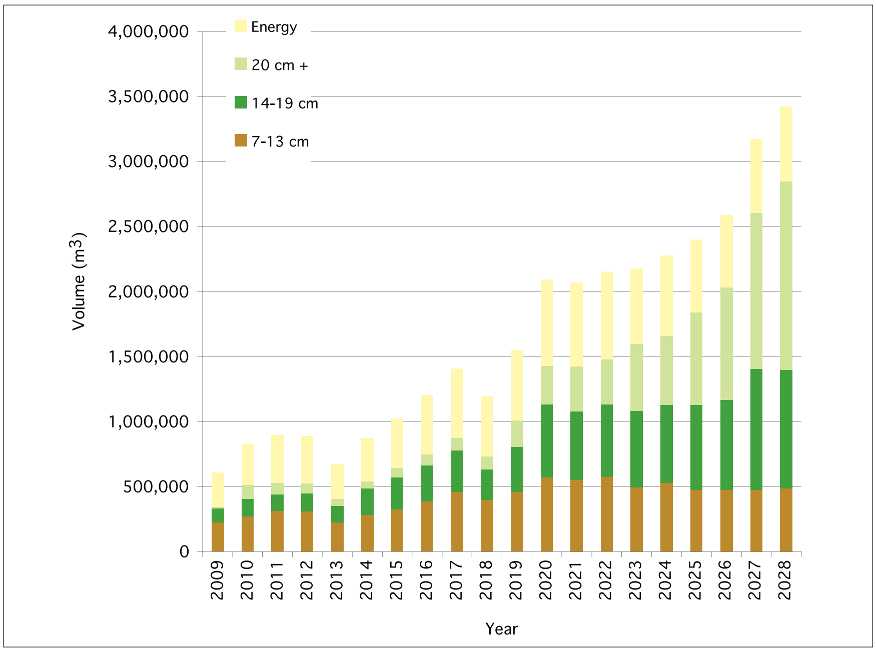

Figure 7. Net smoothed conifer volume production by assortments.

4.3 Volume by harvest type

Smoothed net volume by harvest type (Figure 8 and Appendix 4) illustrates the forecast volume arising from first, second, third and subsequent thinnings and clearfells. First and second thinning volumes decrease during the latter half of the forecast period.

In contrast, both third and subsequent thinning and clearfells show increasing volume production over the forecast period.

Harvest areas by harvest type (Figure 9 and Appendix 5) indicate the area associated with the smoothed net forecast volume production arising from first, second, third and subsequent thinnings and clearfells. First thinning peaks at 10,000 ha in 2011, 2018 and 2019. As noted under volume by species group, reforested areas are not included in the forecast of volume production. The total thinning area (first, second, third and subsequent thinnings) increases over time and peaks at circa 30,000 ha in 2022. This scale of thinning, to be achieved within the next thirteen years, represents a significant challenge to the overall forestry sector. Clearfell areas (ha) become important from 2020 onwards.

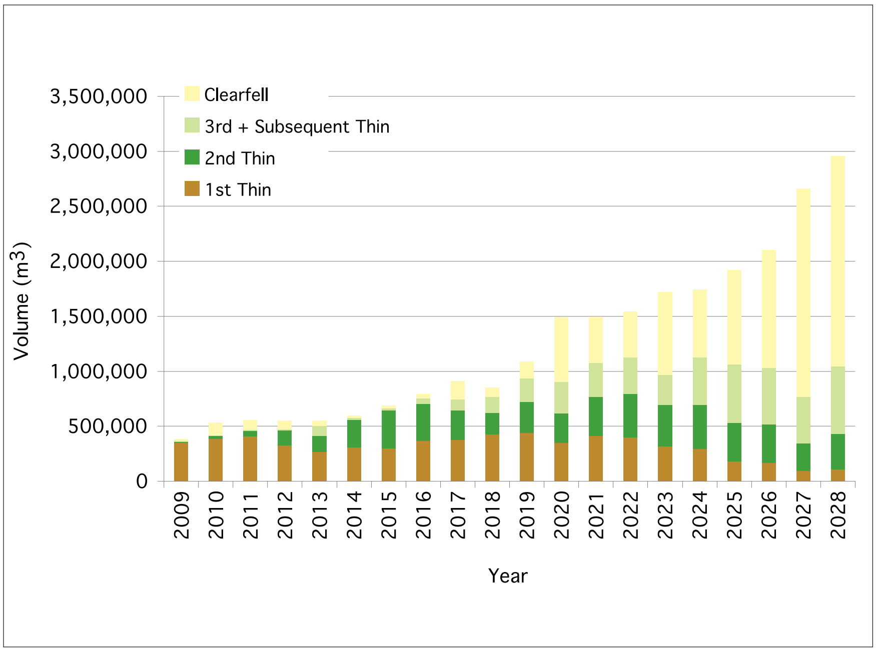

Figure 8. Smoothed net volume production by harvest type.

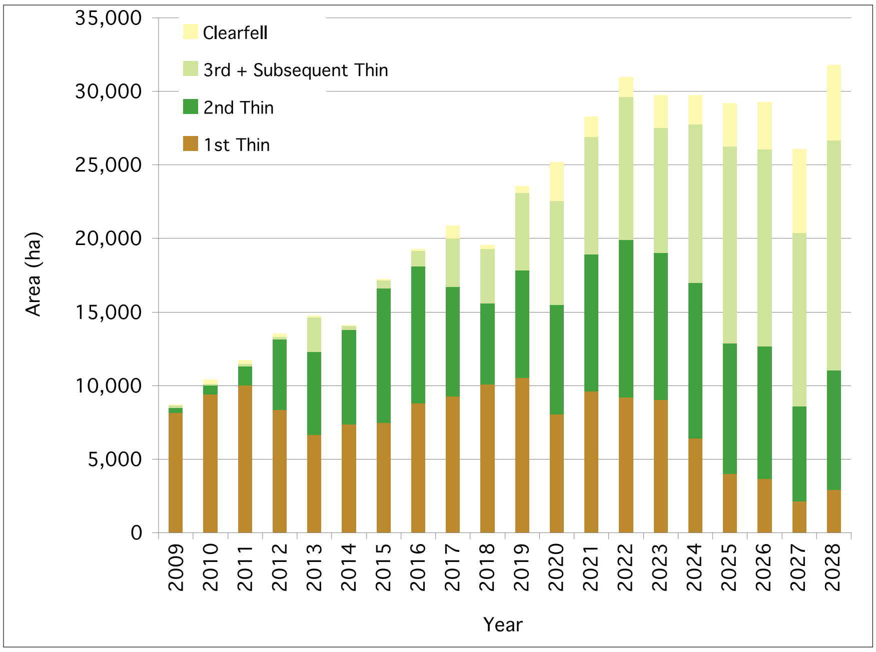

Figure 9. Gross harvest area by harvest type.

4.4 Volume by data source category

The Premiums dataset accounts for 13.55 million m^3 or 54% of total smoothed net roundwood volume supply over the forecast period (Figure 10 and Appendix 6). With some minor fluctuations, the volume in the Premiums category increases steadily throughout the forecast period.

The WP08 dataset accounts for 5.95 million m^3 or 24% of total smoothed net forecast volume. Apart from 2009 and 2019, it shows a steady increase year on year throughout the forecast period.

Private Grant Aided volume accounts for 4.37 million m^3 or 17% of total smoothed net forecast volume. Production volumes in this category fluctuate considerably year-on-year. This is due to the underlying age and species assumptions for these areas.

The Private Non-Grant Aided category accounts for 1.26 million m^3 or 5% of total smoothed net forecast volume production. Similar to the PGA category, forecast volumes fluctuate considerably year-on-year. This is again due to the underlying age assumptions about the species categories in FIPS98 (Table 2).

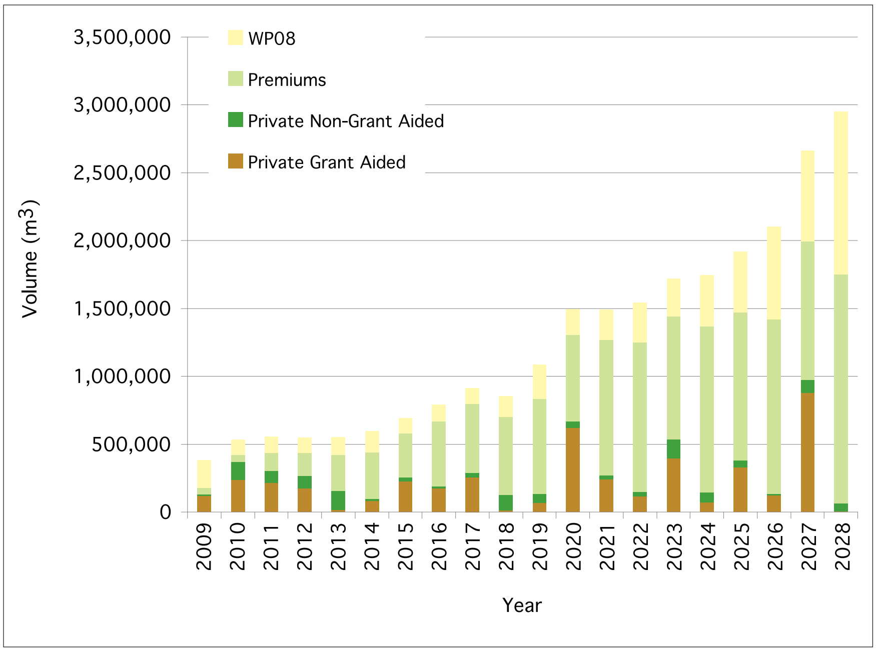

Figure 10. Smoothed net forecast volume production by data source category.

4.5 Volume production by county

The total net conifer roundwood volume supply varies markedly between counties (Figure 11 and Appendix 7). Five counties account for 40% of the net conifer roundwood supply – Kerry (10.5%), Cork (9.0%), Clare (9.0%), Mayo (7.0%) and Leitrim (5.9%). In contrast, the five counties of Carlow, Dublin, Louth, Meath and Monaghan account for only 2.5% of forecast net conifer volume production.

Three counties account for 30.5% of forecast net broadleaf roundwood volume production – Cork (11.7%), Tipperary (11.3%) and Kerry (7.5%). In contrast counties Dublin, Louth and Monaghan account for less than 2% of net broadleaf volume production.

5. Regional, catchment and scenario forecasts

As the datasets used in deriving this forecast are georeferenced, it is possible to produce geospatial forecasts. Forty-two towns were selected throughout Ireland including the locations of the larger timber processing facilities (Figure 12). These locations provide a broad geographic spread for the forecast.

Two catchments were selected around these primary locations to represent average sawmill roundwood haulage distances and preferred haulage distances for existing or potential new entrants. Following discussions with the wood processing industry, two haulage distance thresholds were selected as being of interest in any forecast - 75 km and 100 km. As a horizontal distance on a GIS equates to a longer driving distance by road, it was necessary to reduce the radius around each primary location by 20%[5] to 60 km and 80 km, representing the 75 km and 100 km haulage distances respectively (Figure 13). These catchments enclose 11,300 km^2 (60 km) and 20,100 km^2 (80 km) respectively.

Two GIS forecast tools are available at the COFORD website (www.coford.ie) to enable national, provincial, county and 60 and 80 km regional production forecasts to be downloaded, and will include the following data for each production forecast catchment:

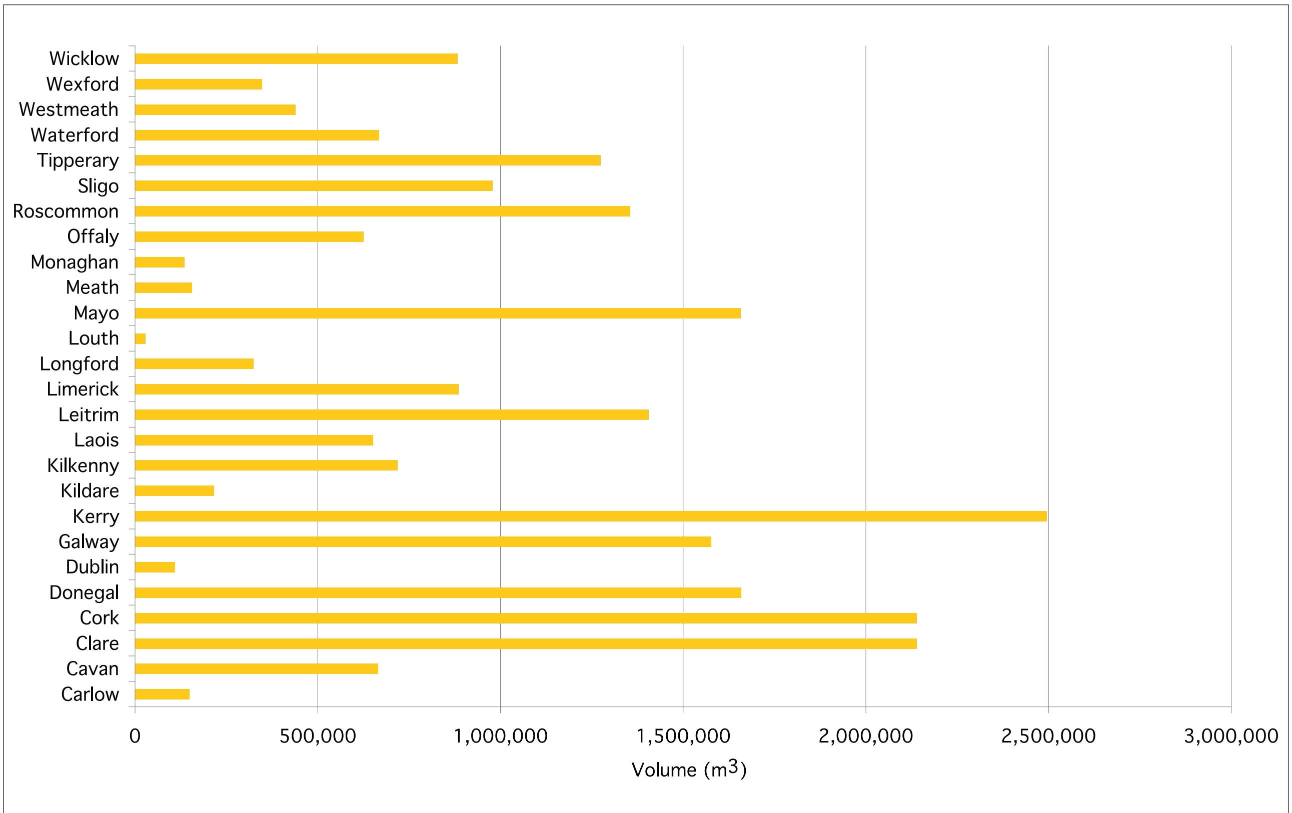

Figure 11. Total net conifer forecast volume production by county (2009-2028).

5 Based on a comparison between linear and driving distances between randomly selected towns.

- Gross and net volume by assortment category and production year;
- Gross and net volume by assortment category, production year and species group;
- Gross and net volume by assortment category, production year and data source; and
- Gross and net volume by assortment category, production year and harvest type.

The reliability of forecast production volumes decreases in line with the size of the area selected. Thus while it is possible to produce forecasts at national, provincial, county and 60 and 80 km regional catchment levels, the forecast volumes for the lower levels should be treated as being indicative.

Again as the datasets used in this interim forecast are georeferenced and as the forecast methodology estimates a volume for each spatial area, it will be possible to produce forecasts for a range of scenarios. The more obvious scenario is to set a minimum economic harvesting area for all thinnings and to examine the impact this has on forecast volumes and assortments. Such scenario modelling will be helpful for policy development and analysis.

5.1 GIS forecast tools

Two GIS forecast tools have been made available through Adoble Reader, in portable document format (pdf), and through ArcReader in published map format (pmf). Instructions on how to use these GIS forecast tools can be downloaded from the COFORD website (www.coford.ie).

Use of the GIS forecast tools will enable wide dissemination of the geospatial forecasts of private sector roundwood timber supply in Excel (xls) format at national, provincial, county, 60 and 80 km regional catchment levels.

Furthermore, the ArcReader GIS forecast tool will enable all state and private forests to be displayed with respect to the detailed road network.

The functionality of the GIS forecast tools should be of immediate practical benefit to all those involved in the forestry and renewable energy sectors in the Republic of Ireland.

6. Discussion

Good decisions require good information. Decisions on the future development of the forestry sector have to date been based on partial information on projected roundwood production volumes from privately-owned forests. This geospatial production forecast provides another advance in the development of a modern private sector forecast, based on spatial information.

While the forecast represents an improvement on the previous forecast, it has some shortcomings which will be addressed under the broader overall FORECAST project. The intention is to update the forecast after two years to reflect improved data sources and forecasting methodology.

6.1 Strengths of the current production forecast

The appending of yield class, thinning and rotation attributes to the spatial data has provided a very much improved basis for forecasting roundwood production. The main strengths of the forecast are that it is based on spatial data and on the most complete and up-to-date information on private forests. It includes species information which facilitates the forecasting of volume production by species group, which was missing in previous private sector forecasts. The spatial basis enables the catchment and other scenario-based forecasts to be readily produced. Such forecasts will have increasing importance in planning the location of new wood using enterprises related to energy and other end uses. Furthermore, information on species composition will allow for more informed decision-making.

The data processing element of the forecast methodology uses a Microsoft Access database. This provided a flexible basis for the development of the forecasts and the generation of results. It also allows for underlying assumptions and forecast rules to be changed.

Figure 12. Distribution of regional forecast centres.

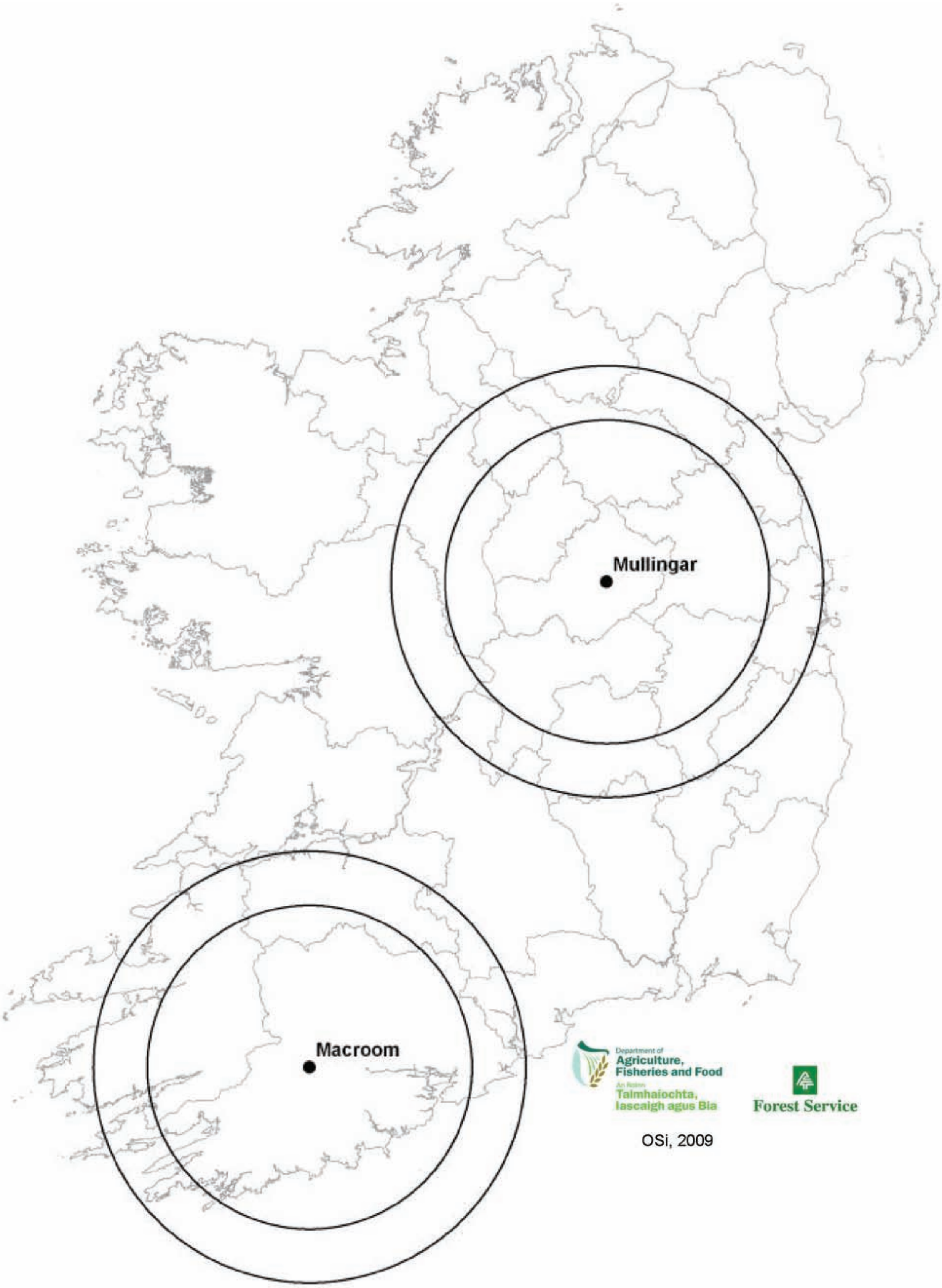

Figure 13. Example of 60 and 80 km catchment forecast approach for two towns.

6.2 Limitations of the private sector roundwood production forecast

The limitations of the forecast are:

- The datasets do not include information on accessibility of plantations;
- No age and limited species information for FIPS98 areas;
- No information on the quality of broadleaves;
- Limited information on stocking in privately owned plantations;
- Little information on the management intentions of private forest owners;
- The productivity estimate for each plantation is based on a sample analysis of the Coillte forest estate which may not be fully representative of private forests;
- The model currently assumes that clearfelled crops are not included in forecast production volume; and
- The Forestry Commission yield models used are based on UK data, and the assumed thinning regime is inflexible.

Future forecasts should be able to address most but not all the shortcomings. Accessibility could be interpreted based on orthophotos, OSi spatial datasets on road networks and proximity of adjoining plantations. As indicated, site productivity could be based on the Teagasc model for Sitka spruce (Farrelly et al. 2009) which should improve the reliability of production forecasting. This could increase the estimated yield class, thereby increasing the estimated volume production. Clearfelled crops could in future forecasts be assumed to be regenerated with the same or similar species. Also, the intention is to evaluate the use of GROWFOR and other models in future forecasts.

6.3 Caveats on the interpretation of the interim forecast

The forecast volumes are based on a range of assumptions, yield models, inferred management regimes and forecast rules which may or may not be applicable at individual plantation level. Markets may not always be available for the volumes forecasted.

The volumes presented in this report are indicative of the expected forecasts of private sector roundwood timber supply over the 2009-28 period. Professional advice should be sought prior to using the forecasts as an integral component of the decision-making process. The authors, nor the institutions they represent, accept any responsibility for decisions made by third parties based on the interim forecasts.

7. Conclusions

There is an urgent need for a forecast of roundwood supply from privately owned forests to support the development of the forestry sector. This interim geospatial roundwood production forecast represents a major advance on previous forecasts. There is now an improved dataset for forecasting with the capacity to produce regional and catchment forecasts with information on species group and harvest areas.

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Appendix 1. Gross and net volume using alternative assortment tables.

Production year	Gross volume (000 m³ overbark)				Energy (000 m³ equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	394	113	12	520	67
2010	470	147	127	743	73
2011	529	143	97	769	84
2012	521	164	85	771	81
2013	438	171	132	741	78
2014	511	274	53	837	81
2015	598	352	64	1,015	97
2016	683	381	76	1,140	105
2017	761	445	85	1,291	116
2018	669	313	166	1,148	107
2019	785	491	219	1,495	123
2020	938	853	322	2,113	141
2021	937	787	365	2,089	142
2022	972	818	349	2,139	147
2023	906	911	579	2,396	142
2024	896	908	589	2,393	132
2025	805	1,018	829	2,652	122
2026	800	1,064	974	2,838	121
2027	824	1,469	1,362	3,655	124
2028	829	1,421	1,605	3,856	129
Total	**14,128**	**12,271**	**8,045**	**34,445**	**2,186**
% Volume	**41**	**36**	**23**	**100**	

Production year	Net volume (000m³ overbark)				Reduction %	Energy (000 m³ equivalent)
	7-13 cm	14-19 cm	20+ cm	Total		
2009	289	83	9	381	27%	53
2010	329	104	103	536	28%	55
2011	373	103	78	554	28%	63
2012	365	116	68	549	29%	60
2013	321	126	105	551	26%	60
2014	372	187	36	595	29%	63
2015	417	229	44	689	32%	72
2016	485	253	55	793	30%	80
2017	545	306	62	913	29%	88
2018	495	227	129	851	26%	84
2019	578	350	158	1,086	27%	96
2020	675	597	225	1,497	29%	106
2021	679	549	265	1,494	29%	109
2022	703	578	261	1,543	28%	112
2023	649	647	424	1,720	28%	107
2024	651	658	434	1,743	27%	101
2025	582	731	605	1,919	28%	92
2026	582	778	743	2,104	26%	92
2027	590	1,054	1,016	2,660	27%	93
2028	611	1,070	1,272	2,953	23%	99
Total	**10,181**	**8,746**	**6,038**	**24,965**	**28%**	**1,663**
% Volume	**41**	**35**	**24**	**100**		

Appendix 2. Unsmoothed and smoothed net volume by species group.

Production year	Unsmoothed net volume by species group (000 m³ overbark)				
	Broadleaf	Other conifer	Pine	Spruce	Total
2009	27	7	4	236	274
2010	25	13	34	581	653
2011	24	12	9	468	513
2012	20	78	12	382	492
2013	115	21	12	293	441
2014	46	25	17	447	535
2015	60	30	68	703	861
2016	45	36	20	691	792
2017	39	101	151	622	913
2018	119	57	36	639	851
2019	67	49	58	804	978
2020	82	54	644	1,091	1,871
2021	65	66	145	1,139	1,415
2022	55	112	151	1,015	1,333
2023	125	71	126	1,399	1,721
2024	75	77	208	1,179	1,539
2025	87	107	402	1,536	2,132
2026	74	64	314	1,652	2,104
2027	63	384	338	2,459	3,244
2028	81	71	176	1,980	2,308
Totals	**1,291**	**1,434**	**2,926**	**19,314**	**24,965**

Production year	Smoothed net volume by species group (000 m³ overbark)				
	Broadleaf	Other conifer	Pine	Spruce	Total
2009	35	9	5	333	382
2010	21	10	28	476	535
2011	26	13	10	506	555
2012	22	87	13	426	548
2013	143	27	15	366	551
2014	52	27	19	497	595
2015	48	24	55	563	690
2016	45	36	20	691	792
2017	39	101	151	622	913
2018	119	57	36	639	851
2019	74	54	64	894	1,086
2020	66	43	516	872	1,497
2021	68	69	154	1,202	1,493
2022	64	129	175	1,175	1,543
2023	125	71	130	1,399	1,725
2024	85	87	239	1,335	1,746
2025	79	96	362	1,382	1,919
2026	74	64	314	1,652	2,104
2027	52	315	277	2,017	2,661
2028	103	91	225	2,534	2,953
Totals	**1,339**	**1,413**	**2,800**	**19,580**	**25,132**
% Volume	**5**	**6**	**11**	**78**	**100**

Appendix 3. Unsmoothed and smoothed net volume for conifers and broadleaves by assortments.

Production year	Unsmoothed net volume for all conifers (000 m³ overbark)				Energy (000 m³ equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	160	76	10	246	185
2010	331	162	134	628	385
2011	292	116	81	489	341
2012	276	125	71	472	323
2013	181	102	43	326	212
2014	255	183	51	489	298
2015	407	308	87	801	476
2016	389	273	85	747	454
2017	455	324	95	875	532
2018	396	234	103	732	464
2019	413	311	186	910	484
2020	716	697	376	1,789	829
2021	522	499	329	1,350	610
2022	498	479	301	1,278	582
2023	493	590	512	1,596	579
2024	466	531	466	1,464	545
2025	531	721	793	2,044	620
2026	475	692	863	2,030	555
2027	582	1,130	1,468	3,180	686
2028	378	715	1,133	2,227	447
Totals	8,217	8,270	7,187	23,674	9,607

Production year	Smoothed net volume for all conifers (000 m³ overbark)				Energy (000 m³ equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	225	107	15	347	261
2010	271	133	110	515	315
2011	315	126	88	529	368
2012	308	139	79	526	360
2013	227	128	53	408	265
2014	284	204	56	544	331
2015	325	246	70	641	380
2016	389	273	85	747	454
2017	455	324	95	875	532
2018	396	234	103	732	464
2019	459	346	207	1,012	538
2020	572	557	301	1,431	663
2021	551	527	347	1,425	645
2022	576	554	348	1,479	673
2023	493	590	512	1,596	579
2024	528	602	528	1,657	617
2025	478	649	713	1,840	558
2026	475	692	863	2,030	555
2027	478	927	1,204	2,608	563
2028	484	915	1,450	2,850	572
Totals	**8,291**	**8,274**	**7,228**	**23,792**	**9,607**
% Volume	**35**	**35**	**30**	**100**	

Production year	Unsmoothed net volume for all broadleaves (000 m^3 overbark)				Energy (000 m^3 equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	22.5	1.8	0.2	24.6	29.3
2010	24.4	1.4	0.0	25.9	31.7
2011	21.9	1.6	0.0	23.6	28.1
2012	18.4	1.5	0.2	20.0	23.4
2013	50.5	13.3	50.7	114.6	64.0
2014	41.3	4.8	0.3	46.4	51.4
2015	54.2	5.8	0.2	60.1	68.0
2016	39.3	5.7	0.4	45.4	48.9
2017	32.9	5.2	0.4	38.5	40.9
2018	48.6	17.7	52.5	118.7	60.2
2019	50.5	13.9	2.0	66.5	61.8
2020	63.5	16.4	2.4	82.3	77.2
2021	48.2	13.4	2.9	64.5	58.9
2022	40.7	11.5	2.9	55.1	49.9
2023	77.1	22.5	24.9	124.5	94.6
2024	42.9	22.1	10.3	75.2	51.2
2025	48.1	28.1	11.0	87.2	56.8
2026	41.1	22.3	10.5	73.9	48.9
2027	35.1	18.7	9.4	63.3	41.8
2028	35.5	28.1	17.2	80.8	41.8
Totals	**836.7**	**256.1**	**198.4**	**1,291.1**	**1,028.8**

Production year	Smoothed net volume for all broadleaves (000 m^3 overbark)				Energy (000 m^3 equivalent)
	7-13 cm	14-19 cm	20+ cm	Total	
2009	31.8	2.6	0.3	34.6	41.3
2010	20.0	1.2	0.0	21.2	26.0
2011	23.7	1.8	0.0	25.5	30.4
2012	20.5	1.7	0.2	22.3	26.1
2013	63.2	16.7	63.5	143.4	80.0
2014	45.9	5.4	0.3	51.6	57.1
2015	43.4	4.6	0.1	48.1	54.4
2016	39.3	5.7	0.4	45.4	48.9
2017	32.9	5.2	0.4	38.5	40.9
2018	48.6	17.7	52.5	118.7	60.2
2019	56.2	15.5	2.3	73.9	68.7
2020	50.8	13.1	1.9	65.8	61.8
2021	50.9	14.2	3.1	68.1	62.2
2022	47.2	13.3	3.3	63.8	57.7
2023	77.1	22.5	24.9	124.5	94.6
2024	48.6	25.0	11.6	85.2	58.0
2025	43.3	25.3	9.9	78.5	51.1
2026	41.1	22.3	10.5	73.9	48.9
2027	28.8	15.4	7.7	51.9	34.3
2028	45.4	36.0	22.0	103.4	53.5
Totals	**858.5**	**265.1**	**214.9**	**1,338.5**	**1,056.2**
% Volume	**64.1**	**19.8**	**16.1**	**100.0**	

Appendix 4. Unsmoothed and smoothed net volumes by harvest type.

Production year	Unsmoothed net volume by harvest type (000 m³ overbark)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	244	11	5	11	270
2010	472	28	5	148	653
2011	375	47	9	82	513
2012	293	121	7	71	492
2013	214	114	74	39	441
2014	279	225	11	20	535
2015	371	434	26	30	862
2016	368	338	46	40	793
2017	380	264	100	169	913
2018	422	200	145	84	851
2019	395	252	195	134	977
2020	437	334	357	742	1,871
2021	394	333	293	394	1,414
2022	344	343	289	357	1,333
2023	317	379	268	756	1,720
2024	257	355	385	541	1,539
2025	202	389	589	952	2,132
2026	165	352	516	1,071	2,104
2027	113	307	513	2,311	3,244
2028	81	258	475	1,494	2,308
Totals	**6,124**	**5,083**	**4,309**	**9,448**	**24,965**

Production year	Smoothed net volume by harvest type (000 m³ overbark)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	344	15	7	15	381
2010	387	23	4	122	536
2011	405	50	10	89	554
2012	327	135	7	79	549
2013	267	143	92	49	551
2014	310	250	13	22	595
2015	297	347	21	24	689
2016	368	338	46	40	793
2017	380	264	100	169	913
2018	422	200	145	84	851
2019	440	281	217	148	1,086
2020	350	268	286	594	1,497
2021	416	351	309	417	1,494
2022	398	397	335	413	1,543
2023	317	379	268	756	1,720
2024	291	402	436	613	1,743
2025	181	350	530	857	1,919
2026	165	352	516	1,071	2,104
2027	93	252	421	1,895	2,660
2028	104	330	608	1,911	2,953
Totals	**6,264**	**5,126**	**4,371**	**9,370**	**25,131**
% Volume	**25**	**20**	**17**	**37**	**100**

Production year	Unsmoothed net energy assortment by harvest type (000 m^3 equivalent)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	206	5	1	3	214
2010	394	13	1	8	416
2011	340	21	1	7	369
2012	267	73	1	6	346
2013	192	74	6	5	276
2014	246	98	2	3	349
2015	333	202	5	4	544
2016	330	159	9	6	503
2017	348	134	29	62	573
2018	383	103	22	16	524
2019	359	121	38	28	546
2020	390	176	63	277	906
2021	353	162	60	95	669
2022	310	170	61	91	632
2023	291	183	64	135	674
2024	228	170	62	136	596
2025	179	179	90	229	677
2026	146	163	85	210	604
2027	102	143	90	393	728
2028	79	114	87	209	489
Totals	**5,475**	**2,463**	**777**	**1,921**	**10,636**

Production year	Smoothed net energy assortment by harvest type (000 m^3 equivalent)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	291	7	1	4	302
2010	323	11	1	7	341
2011	367	23	1	7	398
2012	297	81	1	6	386
2013	240	92	7	6	346
2014	274	109	2	3	388
2015	266	161	4	3	435
2016	330	159	9	6	503
2017	348	134	29	62	573
2018	383	103	22	16	524
2019	399	135	42	31	607
2020	312	141	51	222	725
2021	373	171	63	100	707
2022	358	196	71	106	731
2023	291	183	64	135	674
2024	258	193	71	154	675
2025	161	161	81	206	609
2026	146	163	85	210	604
2027	84	117	74	322	597
2028	101	145	111	268	626
Totals	**5,603**	**2,486**	**790**	**1,873**	**10,752**
% Volume	**52**	**23**	**7**	**17**	**100**

Appendix 5. Unsmoothed and smoothed harvest areas by harvest type.

Production year	Unsmoothed harvest area by harvest type (ha)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	5,768	252	122	33	6,175
2010	11,486	738	100	382	12,706
2011	9,291	1,162	184	209	10,846
2012	7,470	4,312	146	193	12,121
2013	5,319	4,520	1,838	109	11,785
2014	6,627	5,767	257	56	12,707
2015	9,325	11,483	644	81	21,533
2016	8,810	9,288	1,073	110	19,282
2017	9,252	7,467	3,294	886	20,899
2018	10,086	5,515	3,722	242	19,564
2019	9,439	6,625	4,741	385	21,190
2020	10,044	9,324	8,790	3,330	31,489
2021	9,102	8,803	7,598	1,283	26,786
2022	7,951	9,239	8,415	1,164	26,769
2023	9,005	10,027	8,498	2,223	29,753
2024	5,659	9,346	9,493	1,747	26,245
2025	4,425	9,897	14,874	3,278	32,474
2026	3,654	9,016	13,360	3,245	29,275
2027	2,608	7,865	14,363	6,964	31,800
2028	2,290	6,328	12,226	4,008	24,851
Totals	**147,610**	**136,974**	**113,737**	**29,929**	**428,250**

Production year	Smoothed harvest area by harvest type (ha)				
	1st Thin	2nd Thin	3+Sub Thin	Clearfell	Total
2009	8,134	355	173	47	8,709
2010	9,419	605	82	313	10,419
2011	10,037	1,255	199	226	11,716
2012	8,335	4,811	162	216	13,524
2013	6,655	5,655	2,299	136	14,745
2014	7,370	6,413	286	62	14,131
2015	7,460	9,187	515	65	17,227
2016	8,810	9,288	1,073	110	19,282
2017	9,252	7,467	3,294	886	20,899
2018	10,086	5,515	3,722	242	19,564
2019	10,496	7,366	5,272	428	23,562
2020	8,036	7,459	7,032	2,664	25,191
2021	9,613	9,297	8,024	1,355	28,288
2022	9,204	10,695	9,741	1,347	30,987
2023	9,005	10,027	8,498	2,223	29,753
2024	6,408	10,584	10,750	1,979	29,721
2025	3,982	8,907	13,387	2,950	29,227
2026	3,654	9,016	13,360	3,245	29,275
2027	2,139	6,449	11,778	5,711	26,076
2028	2,930	8,097	15,644	5,129	31,799
Totals	**151,021**	**138,450**	**115,290**	**29,334**	**434,095**

Appendix 6. Unsmoothed and smoothed net volume by data source.

Production year	Unsmoothed net volume by data source (000 m³ overbark)				
	PGA	PNGA	Premiums	WP08	Total
2009	84	8	35	144	270
2010	292	159	67	136	653
2011	198	83	121	111	513
2012	154	85	153	100	492
2013	14	109	212	106	441
2014	75	12	307	141	535
2015	287	30	405	140	862
2016	174	14	482	123	793
2017	255	35	507	115	913
2018	12	118	569	152	851
2019	64	57	632	225	977
2020	777	58	800	236	1,871
2021	228	27	945	213	1,414
2022	99	29	950	255	1,333
2023	395	141	907	278	1,720
2024	64	64	1,080	331	1,539
2025	368	52	1,212	500	2,132
2026	123	12	1,283	685	2,104
2027	1,072	116	1,246	810	3,244
2028	6	43	1,323	937	2,308
Totals	**4,739**	**1,253**	**13,233**	**5,739**	**24,965**

Production year	Smoothed net volume by data source (000 m³ overbark)				
	PGA	PNGA	Premiums	WP08	Total
2009	119	11	49	203	381
2010	239	130	55	112	536
2011	214	90	131	120	554
2012	171	95	170	112	549
2013	17	137	265	133	551
2014	83	14	342	157	595
2015	229	24	324	112	689
2016	174	14	482	123	793
2017	255	35	507	115	913
2018	12	118	569	152	851
2019	71	63	702	250	1,086
2020	622	46	640	189	1,497
2021	241	29	998	225	1,494
2022	115	33	1,099	295	1,543
2023	395	141	907	278	1,720
2024	72	73	1,223	375	1,743
2025	331	47	1,091	450	1,919
2026	123	12	1,283	685	2,104
2027	879	95	1,021	664	2,660
2028	7	55	1,692	1,198	2,953
Totals	**4,370**	**1,262**	**13,550**	**5,949**	**25,131**
% Volume	**17**	**5**	**54**	**24**	**100**

Appendix 7. Unsmoothed net conifer and broadleaf volume by county.

Unsmoothed net conifer volumes by county (000 m³ overbark)

COUNTY	2009	2010	2011	2012	2013	2014	2015	2016	2017	2018
Carlow	3	5	2	3	3	6	7	4	5	7
Cavan	10	18	9	11	7	15	20	11	22	24
Clare	27	79	30	34	30	42	85	78	78	66
Cork	21	59	38	39	30	42	77	60	78	65
Donegal	8	21	18	32	31	24	37	62	85	54
Dublin	0	21	4	4	1	1	6	6	5	2
Galway	18	22	31	41	16	33	43	41	52	52
Kerry	17	57	56	82	32	46	90	85	111	80
Kildare	4	9	18	13	2	5	7	5	6	4
Kilkenny	7	20	15	11	7	21	29	29	33	18
Laois	6	15	18	16	10	13	31	27	24	25
Leitrim	20	38	31	25	26	30	48	33	45	47
Limerick	12	11	10	11	12	21	24	23	33	27
Longford	3	6	6	8	6	6	7	11	9	10
Louth	1	1	0	0	0	1	2	0	2	0
Mayo	7	28	42	19	13	25	48	57	45	42
Meath	3	3	2	2	1	3	4	4	5	6
Monaghan	1	3	3	2	2	2	3	7	5	5
Offaly	6	15	18	13	11	15	20	24	21	17
Roscommon	13	27	30	21	17	23	38	39	32	36
Sligo	9	17	19	17	14	21	26	27	33	29
Tipperary	16	49	25	21	18	32	50	42	48	40
Waterford	10	25	18	11	9	20	31	20	25	18
Westmeath	9	13	8	6	6	13	15	12	16	13
Wexford	7	10	5	4	6	11	15	11	13	14
Wicklow	8	52	34	26	14	18	38	28	44	33
Total	**246**	**628**	**489**	**472**	**326**	**489**	**801**	**747**	**875**	**732**

Unsmoothed net conifer volumes by county (000 m³ overbark)

COUNTY	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	Total
Carlow	6	10	7	9	11	10	15	12	13	11	149
Cavan	31	46	37	35	52	58	79	49	79	53	665
Clare	77	179	122	110	150	118	164	204	288	178	2,140
Cork	78	168	127	107	153	117	216	149	274	241	2,140
Donegal	51	121	111	128	93	114	216	130	208	115	1,658
Dublin	2	9	5	3	4	2	6	5	11	11	108
Galway	60	122	71	69	84	107	138	133	290	152	1,576
Kerry	83	203	141	141	170	129	168	192	361	251	2,495
Kildare	7	19	7	6	11	13	16	20	26	18	216
Kilkenny	30	51	38	48	53	44	60	63	71	70	718
Laois	20	55	38	28	47	36	47	61	88	46	651
Leitrim	61	102	77	72	109	56	103	173	155	152	1,404
Limerick	41	63	60	58	65	89	85	75	88	77	884
Longford	10	24	15	15	22	27	29	24	50	34	324
Louth	1	2	2	1	1	2	3	1	5	1	29
Mayo	73	127	106	81	91	118	124	161	284	163	1,657
Meath	8	14	11	10	12	13	16	13	12	14	156
Monaghan	5	7	9	6	9	10	9	15	24	8	134
Offaly	21	40	38	39	35	35	55	49	103	51	625
Roscommon	47	83	57	66	87	80	117	149	231	162	1,355
Sligo	41	67	62	58	56	65	71	94	144	108	978
Tipperary	59	95	70	74	101	87	97	111	120	119	1,274
Waterford	26	54	43	36	46	35	56	46	77	60	668
Westmeath	24	37	29	15	33	33	35	34	54	35	440
Wexford	18	31	24	16	28	26	34	20	26	27	348
Wicklow	28	61	40	47	73	40	83	48	97	71	882
Total	**910**	**1,789**	**1,350**	**1,278**	**1,596**	**1,464**	**2,044**	**2,030**	**3,180**	**2,227**	**23,674**

Unsmoothed net broadleaf volumes by county (000 m³ overbark)										
COUNTY	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Carlow	0.2	0.1	0.1	0.0	1.4	0.5	0.3	0.3	0.2	1.0
Cavan	0.3	1.1	0.9	0.4	2.2	1.1	2.1	1.8	1.1	3.8
Clare	1.2	1.6	1.5	1.4	7.1	2.5	3.7	2.8	2.5	5.0
Cork	1.2	1.6	1.4	2.7	17.9	3.7	4.7	4.0	5.6	20.0
Donegal	0.7	0.7	0.8	0.8	5.2	1.4	2.2	1.5	1.5	5.4
Dublin	0.2	0.1	0.1	0.1	1.8	0.3	0.3	0.1	0.2	0.9
Galway	0.8	1.1	0.8	0.6	5.9	1.7	2.2	1.3	1.6	5.8
Kerry	0.6	0.6	0.9	0.8	16.5	1.5	2.0	2.3	2.5	11.1
Kildare	1.0	1.0	0.7	0.4	2.6	1.7	1.9	1.2	1.1	3.4
Kilkenny	0.6	1.4	1.2	1.0	2.3	1.0	2.3	2.1	1.9	2.8
Laois	0.8	1.1	0.9	0.3	3.2	1.4	2.9	1.5	0.7	3.9
Leitrim	0.6	0.8	0.8	0.4	1.3	1.0	1.6	1.4	0.6	2.0
Limerick	0.3	0.9	0.5	0.7	4.0	1.6	2.6	1.4	1.8	3.3
Longford	0.4	0.1	0.1	0.3	0.4	1.1	0.5	0.4	1.4	1.0
Louth	0.0	0.0	0.1	-	1.7	0.0	0.0	0.1	0.1	2.7
Mayo	0.5	0.5	0.7	0.8	5.0	1.7	3.5	1.5	1.8	4.5
Meath	5.2	1.3	1.1	0.9	3.6	6.2	3.1	2.1	1.4	4.1
Monaghan	0.1	0.1	0.1	0.2	1.7	0.2	0.4	0.1	0.2	1.8
Offaly	1.3	0.8	1.8	0.3	3.5	2.6	2.4	3.1	0.9	4.0
Roscommon	0.2	0.3	0.4	0.8	1.5	0.6	1.1	0.9	1.1	1.6
Sligo	0.8	0.7	0.7	0.6	0.8	1.2	1.3	1.2	0.9	1.0
Tipperary	3.3	4.5	3.5	2.0	5.7	6.7	8.9	6.5	3.7	8.4
Waterford	0.9	1.5	1.1	1.7	3.7	1.7	2.7	1.9	2.1	5.1
Westmeath	0.5	2.5	2.0	1.0	3.7	1.8	3.6	3.5	1.7	5.3
Wexford	0.8	0.8	0.7	1.4	4.1	1.8	2.1	1.3	1.5	3.0
Wicklow	1.9	0.6	0.7	0.4	7.6	1.5	1.7	1.2	0.6	7.6
Total	**24.6**	**25.9**	**23.6**	**20.0**	**114.6**	**46.4**	**60.1**	**45.4**	**38.5**	**118.7**

Unsmoothed net broadleaf volumes by county (000 m³ overbark)											
COUNTY	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
Carlow	0.6	0.5	0.4	0.5	1.0	0.8	0.6	0.4	0.6	1.2	11.0
Cavan	2.0	2.7	2.1	1.5	3.5	2.5	3.8	2.8	1.6	1.5	38.8
Clare	3.8	5.4	4.8	3.6	13.2	4.9	5.8	5.6	4.5	4.3	85.2
Cork	6.4	7.3	7.7	8.6	16.1	8.6	7.7	8.9	9.6	7.8	151.2
Donegal	1.8	3.3	1.8	1.5	5.6	1.9	3.5	1.7	1.9	1.9	45.0
Dublin	0.4	0.3	0.1	0.3	0.5	0.4	0.3	0.2	0.3	0.2	7.1
Galway	3.2	2.8	2.2	1.9	3.9	3.3	2.9	2.2	2.1	2.1	48.6
Kerry	3.5	3.6	4.6	4.7	16.7	4.5	3.8	4.9	5.4	6.5	97.2
Kildare	2.1	1.9	1.5	1.2	3.2	2.2	2.1	1.9	1.5	2.5	35.1
Kilkenny	1.9	3.2	3.3	3.2	2.9	2.2	3.7	3.8	3.6	3.5	48.0
Laois	1.6	3.1	1.6	0.9	3.3	1.6	3.1	2.4	1.0	3.0	38.3
Leitrim	1.3	1.9	1.4	0.9	2.3	1.7	2.1	1.8	1.2	1.3	26.5
Limerick	3.0	3.7	2.8	2.9	4.0	3.3	4.0	3.0	3.2	3.5	50.4
Longford	1.6	0.8	0.9	1.9	2.5	1.9	0.7	1.0	2.0	0.8	19.8
Louth	0.1	0.0	0.2	0.2	1.2	0.1	0.0	0.2	0.2	0.1	6.9
Mayo	2.5	5.6	2.1	2.3	5.7	2.5	4.9	2.3	2.3	3.9	54.5
Meath	6.7	3.8	2.8	1.6	3.5	7.1	4.2	2.8	1.8	3.1	66.5
Monaghan	0.4	0.5	0.3	0.3	1.2	0.3	0.5	0.6	0.3	0.7	9.7
Offaly	2.8	2.8	3.2	1.2	4.1	3.0	3.2	3.3	1.2	3.4	48.7
Roscommon	0.8	1.7	1.2	1.3	2.0	0.8	2.0	1.3	1.3	1.6	22.4
Sligo	1.4	1.6	1.4	0.8	1.3	1.5	1.6	1.6	0.9	1.2	22.7
Tipperary	9.3	12.3	8.2	6.3	8.0	10.5	12.6	10.1	7.0	8.4	146.0
Waterford	2.3	3.5	2.6	2.8	3.1	2.3	3.5	3.2	4.0	3.4	53.0
Westmeath	2.5	4.3	4.1	2.0	6.1	2.8	4.7	4.1	2.1	8.7	67.2
Wexford	3.0	2.8	2.0	1.8	3.8	2.8	2.8	2.1	2.4	3.4	44.4
Wicklow	1.5	2.8	1.4	0.7	5.9	1.9	3.1	1.8	1.1	3.0	47.0
Total	**66.5**	**82.3**	**64.5**	**55.1**	**124.5**	**75.2**	**87.2**	**73.9**	**63.3**	**80.8**	**1,291.1**

Unsmoothed net conifer energy assortment (000 m³ equivalent)										
COUNTY	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Carlow	2.1	3.6	1.8	2.2	2.2	3.1	3.4	2.3	2.9	4.1
Cavan	7.0	11.7	4.4	5.8	4.7	6.5	9.2	5.8	10.8	13.8
Clare	19.2	45.7	21.4	22.8	17.2	23.9	46.6	47.5	45.6	37.5
Cork	15.4	39.9	26.5	28.5	20.6	25.8	45.8	39.6	46.3	42.0
Donegal	5.6	9.7	14.9	27.8	12.1	18.1	28.0	47.3	62.7	41.3
Dublin	0.3	2.5	3.4	3.2	1.2	0.3	4.9	4.0	2.7	1.1
Galway	15.4	17.7	26.3	23.9	11.2	20.5	28.3	23.1	28.6	31.0
Kerry	13.4	34.1	39.9	59.1	25.7	31.9	58.2	54.2	66.9	52.7
Kildare	2.6	3.5	6.0	2.3	0.9	3.3	4.5	2.5	3.5	1.9
Kilkenny	5.3	16.1	12.6	9.0	5.7	14.5	16.9	18.7	22.5	13.3
Laois	4.1	12.5	14.6	7.0	6.4	8.4	19.5	15.8	15.1	14.5
Leitrim	15.3	28.9	11.7	11.3	16.2	14.6	23.8	14.9	25.3	25.3
Limerick	9.5	9.0	7.9	9.5	7.3	12.0	16.3	16.0	22.8	19.3
Longford	1.9	3.8	5.5	5.4	3.9	2.7	3.8	6.8	4.9	5.7
Louth	0.9	0.9	0.0	0.2	0.1	0.3	0.9	0.0	0.8	0.2
Mayo	5.8	22.5	37.3	15.1	10.2	18.4	30.1	34.1	28.5	29.5
Meath	1.9	2.6	1.1	0.7	0.5	1.1	1.9	2.5	4.0	5.3
Monaghan	1.0	2.0	2.2	1.6	1.2	1.0	1.2	3.8	2.2	2.8
Offaly	5.0	7.7	14.4	8.2	8.7	10.0	11.9	14.7	13.7	8.9
Roscommon	9.9	20.1	22.9	13.7	9.6	14.3	20.2	19.5	16.1	19.7
Sligo	6.8	13.0	14.6	11.2	7.5	13.3	14.5	14.6	18.7	16.9
Tipperary	11.1	24.7	16.0	18.3	12.9	19.1	29.6	26.1	29.3	27.0
Waterford	7.7	16.6	12.5	9.0	7.6	11.8	18.1	10.7	15.4	11.4
Westmeath	7.0	9.6	6.5	3.6	3.7	5.8	8.0	7.2	10.1	9.0
Wexford	5.7	7.6	3.5	3.4	4.6	5.4	9.4	7.8	7.1	9.2
Wicklow	5.5	18.6	12.6	20.0	10.4	11.5	20.7	14.5	25.9	20.6
Total	**185.2**	**384.5**	**340.6**	**322.8**	**212.2**	**298.0**	**475.6**	**454.3**	**532.2**	**463.9**

Unsmoothed net conifer energy assortment (000 m³ equivalent)											
COUNTY	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
Carlow	1.9	3.9	2.4	3.0	2.9	2.3	3.3	3.1	2.5	2.0	54.9
Cavan	13.2	18.3	12.9	14.5	20.3	17.8	15.4	15.4	14.7	10.6	232.8
Clare	34.5	73.4	57.1	45.4	47.7	40.2	44.3	44.7	54.0	34.6	803.4
Cork	40.2	75.2	58.6	52.8	54.5	42.5	64.0	43.9	60.2	46.1	868.3
Donegal	31.5	71.3	56.6	65.1	44.4	54.4	98.5	46.8	63.0	33.0	832.1
Dublin	1.7	3.9	1.9	1.1	0.8	1.0	1.3	0.8	2.1	1.4	39.7
Galway	31.7	56.6	30.9	30.0	33.9	35.0	34.6	39.0	62.7	29.0	609.1
Kerry	48.2	98.6	71.9	68.5	68.0	49.9	47.3	50.5	75.9	49.1	1,064.1
Kildare	3.1	10.8	2.8	3.6	5.4	4.7	5.2	4.9	6.1	4.9	82.5
Kilkenny	16.5	25.0	16.4	20.5	19.8	14.4	18.0	15.3	15.1	14.6	310.3
Laois	11.5	26.1	17.2	13.4	16.6	14.3	13.6	14.3	18.3	10.4	273.7
Leitrim	21.5	35.8	23.0	24.6	29.2	19.7	24.0	23.5	25.4	17.8	432.0
Limerick	23.3	36.2	35.4	31.2	31.5	36.3	33.6	24.1	24.5	18.2	424.1
Longford	5.9	13.4	7.4	8.3	7.6	8.9	12.7	8.2	11.8	8.7	137.3
Louth	0.3	0.7	0.9	0.4	0.2	0.5	1.1	0.5	0.9	0.4	10.2
Mayo	51.9	63.9	51.1	42.5	34.5	52.5	42.4	52.8	66.1	40.2	729.4
Meath	5.4	7.9	5.6	5.4	6.2	5.1	6.9	6.0	4.0	4.6	78.7
Monaghan	3.2	2.9	3.7	2.6	3.1	3.4	2.3	3.2	4.4	1.6	49.1
Offaly	10.5	18.7	19.1	20.2	13.3	14.2	16.4	19.4	25.0	13.4	273.5
Roscommon	22.1	33.4	23.7	24.9	27.3	29.5	26.5	31.8	39.7	24.4	449.2
Sligo	19.9	27.9	20.2	20.9	19.8	21.3	21.0	28.1	23.0	15.8	349.3
Tipperary	35.0	46.3	34.7	33.7	39.2	33.8	33.2	36.4	33.6	28.1	568.0
Waterford	12.4	21.3	17.8	15.3	13.4	10.5	14.9	13.0	16.4	10.0	265.8
Westmeath	14.9	16.9	11.5	7.5	10.5	14.4	13.7	13.0	12.7	10.2	195.8
Wexford	9.2	14.0	9.5	8.0	9.5	6.9	9.7	6.4	7.0	5.6	149.7
Wicklow	14.1	26.8	17.8	18.3	19.7	11.1	16.1	10.1	17.4	12.3	323.8
Total	**483.9**	**829.0**	**610.5**	**581.8**	**579.0**	**544.6**	**619.9**	**555.1**	**686.5**	**447.1**	**9,606.8**

Unsmoothed broadleaf net energy assortment (000 m³ equivalent)										
COUNTY	**2009**	**2010**	**2011**	**2012**	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**
Carlow	0.3	0.2	0.2	0.1	0.6	0.6	0.4	0.2	0.2	0.4
Cavan	0.3	1.2	1.0	0.5	2.0	1.3	2.2	1.9	1.2	1.9
Clare	1.5	1.9	1.8	1.7	4.3	2.8	4.1	3.0	2.7	3.2
Cork	1.4	2.0	1.7	3.3	8.9	4.3	5.4	4.5	6.1	7.5
Donegal	0.9	0.8	1.0	0.9	2.1	1.5	2.6	1.7	1.5	1.5
Dublin	0.3	0.1	0.1	0.1	0.6	0.3	0.3	0.1	0.2	0.1
Galway	0.9	1.3	1.0	0.7	2.6	1.9	2.5	1.4	1.9	2.4
Kerry	0.8	0.8	1.1	0.9	4.8	1.7	2.4	2.6	2.7	4.6
Kildare	1.2	1.2	0.8	0.5	2.3	1.9	2.1	1.2	1.2	2.3
Kilkenny	0.7	1.7	1.4	1.1	1.7	1.1	2.5	2.2	2.0	1.7
Laois	1.0	1.4	1.1	0.4	2.7	1.5	3.4	1.6	0.8	2.6
Leitrim	0.7	1.0	1.0	0.4	1.2	1.2	1.8	1.6	0.7	1.0
Limerick	0.4	1.1	0.5	0.8	2.1	1.9	2.9	1.6	2.0	2.3
Longford	0.5	0.1	0.1	0.4	0.4	1.3	0.6	0.5	1.7	1.0
Louth	0.0	0.0	0.1	-	1.0	0.0	0.0	0.0	0.1	0.3
Mayo	0.7	0.6	0.9	1.0	3.0	2.0	4.2	1.7	2.0	3.0
Meath	6.5	1.6	1.3	1.1	2.4	6.1	3.6	2.2	1.5	2.6
Monaghan	0.1	0.1	0.1	0.2	1.2	0.2	0.4	0.1	0.2	0.5
Offaly	1.7	1.0	2.2	0.3	2.8	2.9	2.7	3.4	1.0	3.3
Roscommon	0.3	0.3	0.5	0.9	1.2	0.6	1.3	1.0	1.0	1.2
Sligo	1.0	0.9	0.9	0.8	0.6	1.2	1.4	1.4	0.9	0.9
Tipperary	4.0	5.5	4.1	2.2	4.5	7.5	9.9	6.7	4.1	6.9
Waterford	1.2	1.9	1.3	1.9	2.4	1.8	2.9	1.9	1.8	1.7
Westmeath	0.6	3.1	2.4	1.2	3.6	2.1	3.9	3.7	1.8	4.1
Wexford	1.0	1.0	0.9	1.6	2.2	2.1	2.5	1.4	1.2	1.6
Wicklow	1.3	0.7	0.9	0.5	2.8	1.4	1.9	1.2	0.6	1.5
Total	**29.3**	**31.7**	**28.1**	**23.4**	**64.0**	**51.4**	**68.0**	**48.9**	**40.9**	**60.2**

Unsmoothed broadleaf net energy assortment (000 m³ equivalent)											
COUNTY	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**Total**
Carlow	0.6	0.6	0.3	0.6	0.9	0.5	0.4	0.3	0.6	0.6	8.5
Cavan	2.1	2.2	1.8	1.4	3.4	1.9	1.9	1.8	1.1	0.9	31.8
Clare	3.7	5.3	4.5	3.2	13.5	3.8	3.9	4.2	3.2	2.3	74.6
Cork	6.6	7.2	7.9	8.1	12.6	6.4	5.5	7.0	6.9	4.3	117.6
Donegal	1.7	3.3	1.6	1.2	2.3	1.3	2.3	1.0	1.0	1.2	31.4
Dublin	0.3	0.3	0.1	0.3	0.5	0.2	0.2	0.1	0.3	0.2	4.6
Galway	3.3	2.6	2.0	1.8	3.3	2.5	1.8	1.5	1.2	1.2	37.8
Kerry	3.8	3.8	4.9	4.9	6.9	4.1	3.1	3.8	4.0	3.7	65.3
Kildare	1.8	1.6	1.2	1.1	2.7	1.3	1.3	1.0	1.0	1.3	29.2
Kilkenny	1.9	2.9	2.9	3.1	2.5	1.8	2.6	2.3	2.5	1.7	40.4
Laois	1.3	2.8	1.3	0.9	2.4	0.9	1.7	1.8	0.8	1.5	32.0
Leitrim	1.2	1.6	1.1	0.8	2.2	1.2	1.4	1.2	0.9	0.7	23.1
Limerick	3.2	3.6	3.0	2.7	3.4	2.6	2.8	2.2	2.0	1.8	42.8
Longford	1.6	0.9	1.0	1.9	2.8	1.3	0.6	0.9	1.4	0.4	19.4
Louth	0.1	0.0	0.1	0.2	1.3	0.1	0.0	0.2	0.2	0.1	3.8
Mayo	2.5	6.1	1.9	2.0	4.1	1.8	3.5	1.5	1.4	2.2	45.9
Meath	4.5	3.4	2.5	1.3	2.7	3.2	2.7	1.6	1.1	1.4	53.3
Monaghan	0.4	0.4	0.3	0.2	1.1	0.2	0.3	0.6	0.2	0.3	7.3
Offaly	2.3	2.7	2.6	1.2	3.5	1.7	2.1	1.8	0.8	1.7	41.6
Roscommon	0.8	1.8	1.1	1.1	2.0	0.6	1.6	0.9	0.7	1.0	19.9
Sligo	1.1	1.4	1.2	0.6	1.2	0.8	1.0	1.1	0.5	0.7	19.7
Tipperary	8.3	11.3	7.0	5.8	6.4	6.0	7.7	5.6	5.0	4.2	122.7
Waterford	2.1	2.9	2.2	2.0	2.1	1.4	2.0	1.9	1.8	1.4	38.5
Westmeath	2.5	3.5	3.4	1.7	4.8	2.1	2.3	2.2	1.2	3.4	53.7
Wexford	2.9	2.6	1.8	1.1	3.6	2.0	1.8	1.3	1.1	1.8	35.2
Wicklow	1.3	2.7	1.2	0.6	2.5	1.4	2.3	1.1	0.8	1.8	28.6
Total	**61.8**	**77.2**	**58.9**	**49.9**	**94.6**	**51.2**	**56.8**	**48.9**	**41.8**	**41.8**	**1,028.8**