Low carbon supply chains for forest products in the East of England

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A report commissioned by the East of England Development Agency and produced by InCrops Ltd with BRE, Forestry Commission and Norwich Business School

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1. Executive Summary

1.1. Background

Commissioned by the East of England Development Agency, this report presents the case for a need to deliver a step change within the supply and use of wood in construction in the East of England. Initiating this step change will boost the delivery of low carbon and low impact solutions to meet increasing demand for housing in the region.

The project described in this report links the expertise and knowledge around the wood resource in the East England in the Forestry Commission Estate, private estates and other woodlands with a comprehensive understanding of the end use requirements for wood products.

The work was produced by InCrops Enterprise Hub and an in-house project team of independent BRE experts in materials and construction products, expertise in forestry in the region from Forestry Commission and supply chain specialists from the Norwich Business School. The work was organised as five work packages:

- WP 1: Mapping exercise. Using knowledge of the region and construction industry and wood products a mapping exercise has been conducted
- WP 2: Forest characterization. The woodland resource and its potential has been studied
- WP 3: Supply chain modelling. A series of model supply chains for the East of England
- WP 4: Corsican pine strength testing. Experts in the assessment of timber have generated new strength data
- WP 5: Draft phase II proposal

The project started in earnest with a presentation (see Appendix H) given by InCrops Business Innovation Manager Mark Coleman in March 2010 at the EcoBuild conference in London. His presentation outlined the issues on Red Band Needle Blight and the potential impact on volumes of timber.

In June, a stakeholder event was held in Thetford Forest with representatives from all areas of the East of England timber supply chain (see appendix A). At this event, an overview of the report was given that outlined the current supply chain, current levels of timber, the impact of red band needle blight and innovations in timber. Stakeholders were invited to comment on each of the presentations and to summarise the barriers and opportunities in using East of England timber. The comments guided the team in producing this report.

1.2. Key Findings

The project presented in this report has concluded on a number of key points:

- The UK is the second largest net importer of timber in the world, by value, at US$ 11 billion per annum.

- There is approximately 144,000 hectares of woodland in the East of England, representing 7.6% of the land area. Approximately 26,000 hectares (18%) of this is managed by the Forestry Commission with the majority (82%) owned by other public bodies, charities or private companies and individuals. East of England woodland is very fragmented and of small block size with a total of 7,767 woods over 2 hectares with a mean wood area of 14.6 hectares.

- The region has a diverse woodland resource with broadleaved woodland the dominant forest type representing 61% of all woodland. Conifer woodland represents 22%, mixed woodland 11% and open space within woodlands and felled areas 6%. Corsican pine is the main conifer species and Oak the main broadleaf species.

- Despite the presence of Red Band Needle Blight (RBNB), this project has shown that the disease does not have a negative effect on the timber properties.

- Woodland and its forest products have a significant role in a low carbon economy. The estimated standing biomass/carbon stocks in the East of England amount to 8.4 million tonnes of carbon (MtC) or 30.7 million tonnes of carbon dioxide equivalent ($MtCO_2e$).This carbon sink can have an impact on carbon reduction targets if we maintain or increase our woodland and we use it in buildings as long service life construction products. In addition, the substitution effect of not using carbon intensive materials outweighs the carbon stored in the products[1].

- UK softwood usage in housing construction in 2007, totalled 6.4 million m^3 of which only 15%, or just below 1 million m^3, was produced in the UK, with 85% imported.

- The value of the market for sawn softwood in construction in the region is estimated to exceed £100 million per annum.

- The East of England either contains or is close to a number of growth zones (Cambridge, Milton Keynes, East Thames corridor) which will be significant users of timber in construction and in energy uses. New build housing need within the East of England over the period 2009 to 2021 is stated as being 349,000 new dwellings. If each of these dwellings uses an average of 2.8m^3 of sawn softwood the total required over this period for new build would be 977,000 m^3. An estimated 10% of total timber consumption is in new build use with the rest in repairs, maintenance and improvements.

- Estimates from the Forestry Commission and the Private Sector suggest that from 2022 to 2026 there is approximately 365,000m^3 roundwood softwood available per annum. In 2009 the softwood consumption by the existing sawmills was 146,000 green tonnes (for pine it is reasonable to say that 1 green tonne is equivalent to 1 m^3). Some of this capacity will be imported from other parts of the UK and abroad; some regional timber will be exported.

- There is at least 200,000m^3 of additional softwood theoretically available by 2022-26 than currently milled. Estimates suggest that 29,000 green tonnes of softwood is used for biomass energy providing the opportunity for the remaining sawn softwood to provide timber for almost 36,000 new houses per annum if those homes were traditional brick and block houses or 10,000 new homes if they were timber framed houses.

- If innovative twin laminates form a structural frame and flooring as detailed in this report are selected then the 36,000 houses could store an additional 194,400tCO_2. This would also unlock a key substitution effect for replacing the blocks in the structure. A house with 60m^3 blocks in its walls has a net emission of 12tCO_2 per house associated with the embodied energy in the blocks. This equates to a saving of 432,000tCO_2 for 36,000 houses.

[1] Combating climate Change – a Role for UK Forests: www.forestry.gov.uk/readreport

- Although biomass energy demand is likely to increase, conservative estimates of hardwood (broadleaved) timber indicate that there is at least 100,000m^3 of unutilised hardwood timber in the East of England plus a similar volume of wood that could be used sustainably for woodfuel.

- This report has identified a number of barriers and opportunities:

    - Timber technology can add to a limited managed resource in the region. Innovative engineering of wood can utilize more of the standing tree in the construction product; create more construction products per hectare of woodland and store more carbon in our buildings. One of the possible products studied was an innovative inside out beam. This beam uses 85% of the round wood in the final product. A square beam of equivalent performance uses no more than 50% of the round wood in the product. This is not in conflict with existing supply chains.

    - The region can be creative with woodland resource and productivity but it needs a radical change in strategy. For example, if an inside out beam requires a tree of half the maturity of the equivalent square cut beam; in the same time period a hectare yields two times as many beams and possibly up to four times as many beams if planting density can be increased.

    - Co-products from manufacture such as chips for panel products, biomass energy, animal bedding, surfacing and mulch have significant values and can influence whether or not product manufacture is profitable and thereby if the supply chain is viable.

    - Corsican pine from Thetford forest is of sufficient quality to be used in a range of structural construction product end uses. It meets as a minimum machine strength grading “C16” class.

- This report argues that there is increasing pressure on the existing managed woodland resource. There is not enough to meet the ambition for energy use and low impact construction products requiring more unmanaged woodland to be brought into production as well as increasing afforestation. This report recommends that a balanced scorecard approach is used to provide clarity on strategies for the future. Such a balanced scorecard could include:

    i. The percentage of the harvested timber in the resultant final product.

    ii. The products impact on available land use for future forestation.

    iii. The return on invested capital generated by individual products.

    iv. The extent to which the final products can be used to replace high CO_2 emitting traditional alternatives, such as steel, concrete and plastics.

    v. The products CO_2 storage potential per m^3 of source timber, together with the length of time that storage is likely to last.

    vi. The products potential to create additional employment opportunities.

List of Figures

2. Mapping the current supply chain

2.1. Study Structure

The supply chain model below was chosen for use in this project and is one based on a hierarchical structure of four tiers (**Figure 1**); with analysis being concentrated in the top two tiers during this phase of the study.

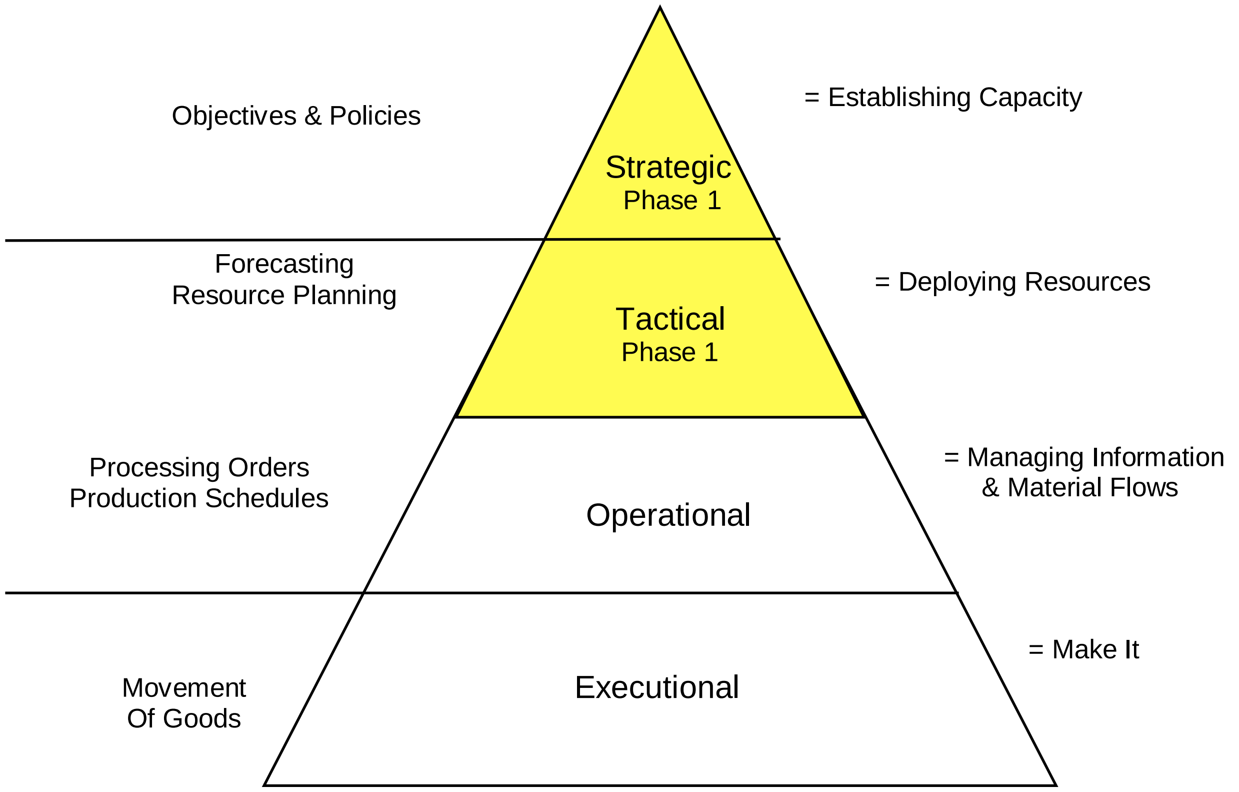

Figure 1 *Schematic representation of the supply chain model showing the yellow study area*

When looking at the region’s timber industry resource capability it was decided, with the exception of the major sawmills, to concentrate on those companies who are members of one or more of the major trade bodies within the industry. This approach was adopted on the assumption that these companies are likely to be the larger regional organizations. It was also assumed, based on the Pareto effect, (ie the 20/80 ‘rule’), that they would represent 20% of the companies in the industry, who between them would account for 80% of the region’s timber manufacturing capacity and capability.

2.2. Sawnwood Imports

In this project material focus has been on the use of sawn softwood (i.e. wood milled from conifer species). Two of the key questions have been -

- From where is this material sourced?
- What quantity of material passes through the supply chain?

In 2007, (the latest year for which comparable figures are available), the UK was the second largest net importer of timber in the world, by value, at US$ 11 billion[2]. And was, on a per capita basis, the world's largest importer by value.

In 2009 the UK imported 5.2 million m^3 of sawn wood, the vast majority of which was softwood, and produced 2.8 million m^3. These imports cost £930 million at an average cost of £181 per m^3 [3]. Comparable average import prices for 2007 & 2008 were £180 and £184 per m^3.

2.3. Wood Use and its Value in Housing [4]

UK softwood usage in housing construction in 2007, totalled 6.4 million m^3 of which only 15%, or just below 1 million m^3, was produced in the UK, with 85% imported.

Of this 6.4 million m^3 only 622,000 m^3, just less than 10%, was used in the building of new properties, with the remainder being used for repairs, maintenance and improvements (RM&I), to the existing housing stock.

In 2007 there were 220,000 housing starts in the UK, of which 45% were flats, 18% detached houses, with the remainder classified as 'other'. The average amount of timber used per dwelling was therefore circa 2.8 m^3.

The housing need within the East of England over the period 2009 to 2021 was stated, in a recent Regional Assembly report, as being approximately 349,000[5]. Therefore if each of these dwellings uses an average of 2.8 m^3 the amount of sawn softwood required over this period for new builds would be 977,000 m^3.

If within the region the New Build to RM&I ratio of timber used in housing construction mirrors the national average of 10% versus 90%, then the amount used in RM&I, over this same period, would be 8.8 million m^3.

The total timber requirement would therefore be c. 9.8 million m^3; an average of 750,000 m^3 in each of the 13 years, (ie.2009 to 2021).

Once again if the regional picture mirrors the national one, then 85% of this timber will need to be imported, ie 630,000 m^3 per annum. This volume of timber at £181 per m^3 would equate to an import cost of £114 million per annum.

2.4. Resource Capacity

As mentioned earlier, in the Study Structure section, the assessment of the region's timber industry resources was based on a sample of companies.

Each company sampled was a member of one, or more, of the following trade bodies

- The British Woodworking Federation (BWF)
- The Furniture Industry Research Association (FIRA)
- The Timber Research & Development Association (TRADA)
- The Timber Trade Federation (TTF)

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[2] Forestry Facts & Figures 2009 - A summary of statistics about woodland & forestry by the Forestry Commission

[3] Economics & Statistics UK Production & Trade (provisional figures) 13 May 2010 by the Forestry Commission

[4] Improved Timber Utilisation Statistics 2007 by N Moore, March 2009 for the Forestry Commission - Latest Available Figures

[5] East of England Regional Assembly - People, Places, Housing - East of England Housing Statement 2010 to 2014

- The UK Timber Frame Association (UKTFA)
- The UK Forest Products Association (UKFPA)
- The Wood Protection Society (WPA)
- The Wood Window Alliance (WWA)

Information on the number of sawmills in the region was obtained via other analysis.

The number of companies and their stated core activities, obtained from this sampling exercise was as follows:-

Importers & manufacturers	3
Importers & distributors	7
Saw mills (primary producers)	25
Manufacturers (secondary processors)	65
Distributors/retailers	31
Building companies	7
Erectors/installers	5

In looking further into the core competencies of the secondary processing companies, as stated by them in the Register of Members of their respective trade associations, the following picture emerged.

Joinery/carpentry	38
Doors	37
Windows	35
Stairs	23
Timber frames	14
Roofing/rafters	7
Floors	7
Fencing	5
Joists	3
Cladding	2
Beams & posts	1
Laminated beams	1
Carcassing	1

As mentioned above the assumption is that this sample represents those companies who between them account for approximately 80% of the available regional manufacturing capacity.

2.5. The Current Supply Chain

The following diagram (**Figure 2**) pulls together the key points to emerge from the above analysis to present a high level picture of the existing supply chain in relation to the Regions future new house building needs, together with those for the repair, maintenance and improvements to the existing housing stock.

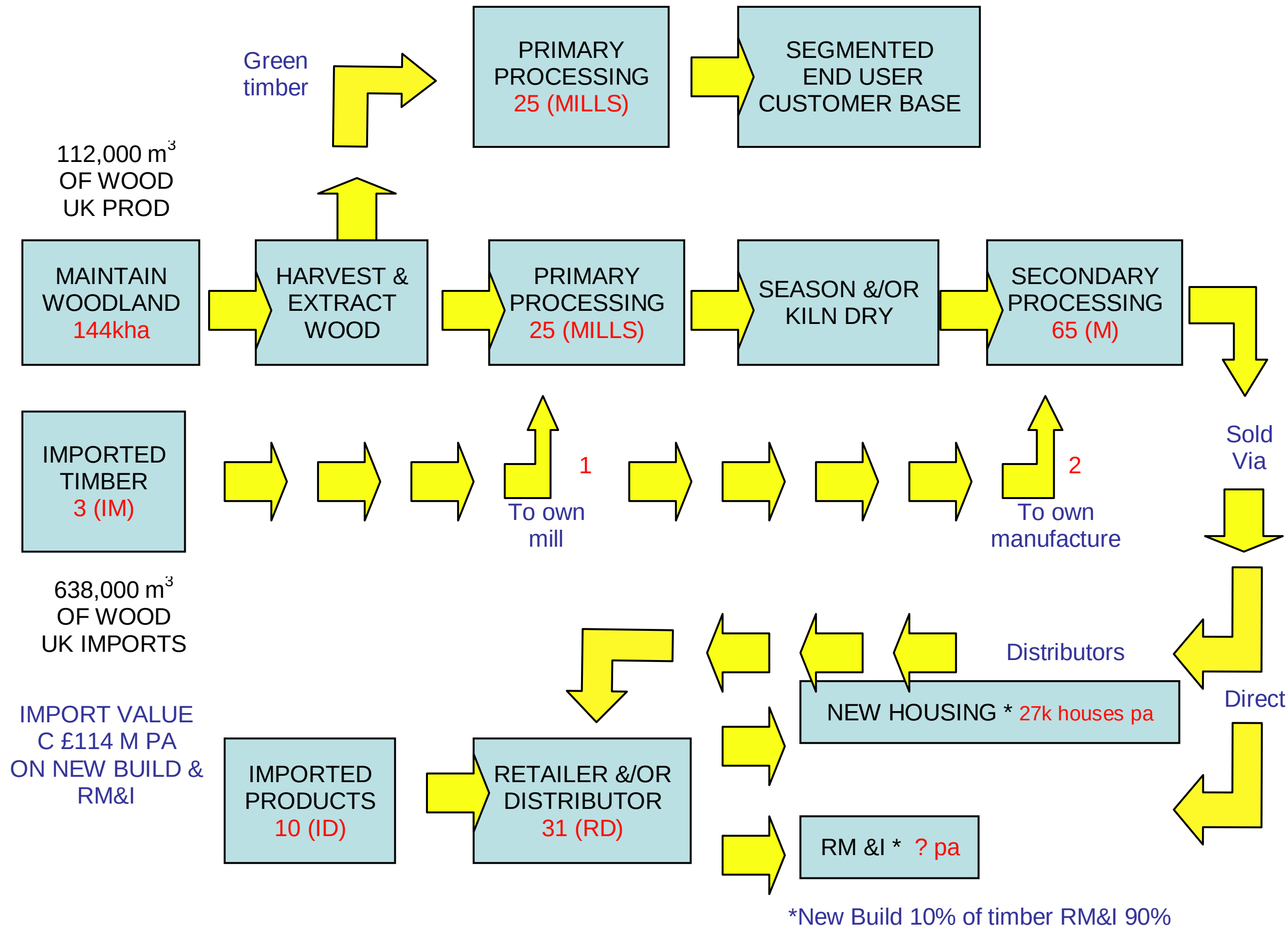

Figure 2 *Schematic diagram of the supply chain structure for sawn softwood with an indication of scale and number of businesses.*

3. Understanding the current woodland resource

3.1. The woodland resource in the East of England

3.1.1. National woodland surveys

Accurate, up-to-date information about the size, distribution, composition and condition of Britain's woodlands is essential for developing and monitoring policies and guidance for their sustainable management.

To gather this information and keep it up to date, the Forestry Commission carries out periodic national woodland surveys. The information gathered, along with information obtained from other sources, for example, aerial photographs, is compiled into the National Forest Inventory (previously known as the National Inventory of Woodland and Trees (NIWT)[6].

The Forestry Commission are now surveying for a new National Forest Inventory, and surveyors will be visiting 15,000 one hectare plots of woodland across England, Scotland and Wales between 2009 and 2014. These data are, unfortunately, not available so the assessment of the woodland resource in the East of England is compiled largely from data published in 2002[7].

3.1.2. Woodland resource

The total area of woodland of 0.1 hectares and over in the East of England region is estimated at 144, 428 hectares[8].

The area of land covered by woodlands increased by over 26,000 hectares from 5.8% to 7.3 % between 1980 and 1998. Since 1998 an additional 5361 hectares of woodland has been planted increasing the land cover to 7.6% (**Figure 3**). By comparison, the UK woodland cover is 12%; Europe is 44%[9].

Broadleaved woodland is the dominant forest type representing 61% of all woodland. Conifer woodland represents 22%, mixed woodland 11% and open space within woodlands and felled areas 6%.

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[6] www.forestry.gov.uk/inventory

[7] East of England Inventory Report National Inventory of Woodland and Trees (*Forestry Commission 2002*)

[8] 139,112 ha from NIWT plus 5361 ha from FC Woodland Grant Schemes, Natural England Higher Level Scheme and Local Authority grant aided schemes - Forestry Commission pers comm

[9] Forestry Facts & Figures 2009 www.forestry.gov.uk/statistics

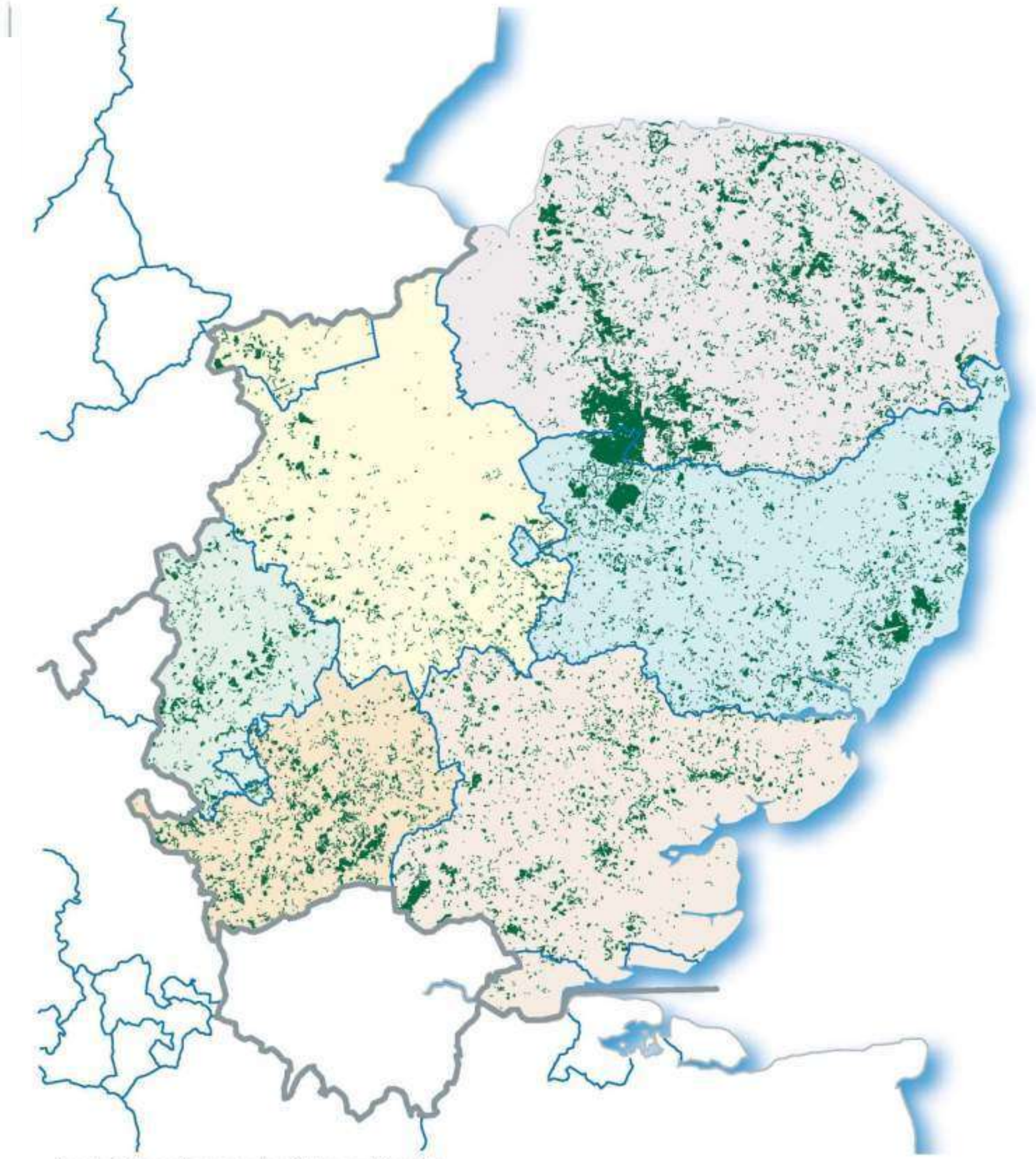

Figure 3 *Distribution of woodland in the East of England (> 2ha in 2002)*

The main broadleaved species is oak covering 23,500 hectares or 26% of all broadleaved species. Other broadleaved species include ash, sycamore, birch, beech and hornbeam (**Figures 4 and 5**).

Species	Area (hectares)
Oak	19,231
Beech	4946
Sycamore	6185
Ash	12,136
Birch	6761
Poplar	2177
Sweet chestnut	2021
Hornbeam	3802
Other/mixed	18,081[10]
Total	**75340**

Figure 4 *Areas of broadleaved species in the East of England*

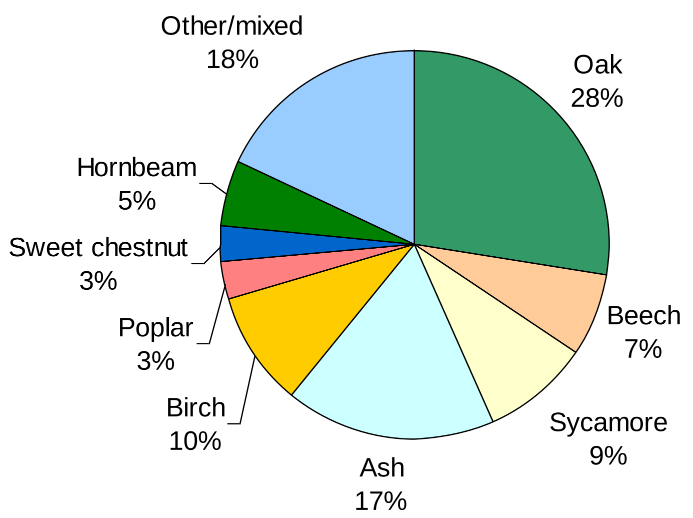

Figure 5 *Percentage of broadleaved species in the East of England*[11]

[10] Comprised 12720 ha from NIWT and 5361 ha of additional planting (see 3 above) where species mix is not specified

[11] Based on NIWT data i.e. the 12720 ha. Therefore does not tally with Figure 2 above.

The main conifer is pine covering 30,068 hectares or 79% of all conifer species. The other main conifer species is larch (7%), with smaller percentages of Douglas fir and spruce. (**Figures 6 and 7**)

Species	Area (hectares)
Pine	30,068
Larch	2653
Other/ mixed	5221
Total	**37,942**

Figure 6 *Areas of conifer species in the East of England*[12]

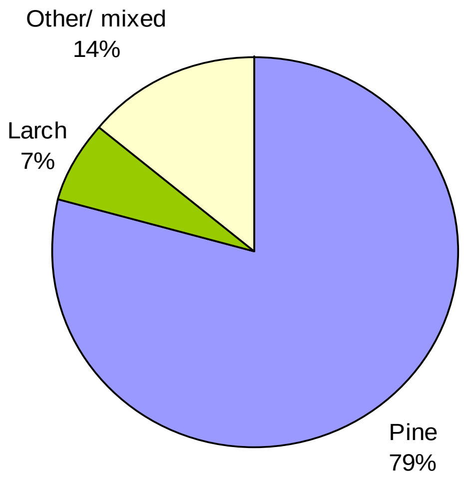

Figure 7 *Percentage of conifer species in the East of England*

26096 hectares (18%) of woodland is owned by or leased to the Forestry Commission[13]. The remaining woodland (82%) is usually described as "private woodland" but is, in fact, owned by a number of organisations and individuals in the first, second and third sectors[14]. The first – public - sector owners other than the Forestry Commission in the East of England are typically Local Authorities. The second sector owners are typically farmers or traditional mixed estates, but there are an increasing number of newer owners, sometimes described as "hobby" or "lifestyle" owners (both descriptors appear pejorative; many new owners are actively and progressively managing their woodland.) Third sector owners include voluntary and community organisations, charities, social enterprises and cooperatives. They include organisations such as the Wildlife Trusts, The Woodland Trust, the National Trust, the RSPB and the Community Forests.

[12] Data from NIWT; very little or no conifer woodland creation has taken place since 1996 - Forestry Commission *pers comm*

[13] As at 29th June 2010. Forestry Commission *pers comm*

[14] There are no definitive data on woodland ownership in the East of England. Anecdotal evidence provided by the Forestry Commission *pers comm*.

Woodland is typically very fragmented and of small block size. In the East of England there are a total of 7,767 woods over 2 ha with a mean wood area of 14.6 hectares. There are a total of 45,004 woods from 0.1 - <2.0 hectares with a mean wood area of 0.6 hectares. In addition there are 13.6 million live park, hedge and street trees. There are an estimated 5056 agricultural holdings in the East of England containing 50255 hectares of woodland[15] (an average of less than 10 hectares per holding).

3.2. Carbon

An assessment of standing biomass and carbon stocks has been undertaken for this report based on the Forestry Commission's sub-compartment database (2003) and the National Inventory of Woods and Trees (woodlands >2 hectares; reference date 31st March 1998). As with the assessment of the woodland resource, the base data is therefore somewhat dated. Fieldwork on a new National Forestry Inventory is in progress, which will report measured biomass/carbon stocks for a 0.5 to 1% sample (by area) of British woodlands greater than 0.5 ha. A new digital woodland map will be published in summer 2010, with interim results from the 5-year field survey available in 2013 and final results in 2015.

Biomass for the parts of the stem presently marketed were obtained from the data sources indicated above and biomass expansion functions applied to extrapolate from this portion of the stem to all biomass components (excluding fine roots). Standing and lying deadwood are not included in the analysis.

Estimated standing biomass/carbon stocks in the East of England amount to 8.4 million tonnes of carbon (MtC) or 30.7 million tonnes of carbon dioxide equivalent ($MtCO_2e$)[16]. Clearly, woodland area has increased as a result of grant-aided woodland creation since 1998, while carbon stocks will have increased in woodlands that have not been harvested and declined in those that have.

Although actual CO_2 uptake by the region's woodlands has not been calculated, an estimate of the ***potential*** uptake can be derived after making a number of assumptions. Of the 131,000 ha of woodland reported (reference date 1998) in the National Inventory of Woodland and Trees (excluding open space, felled and windblown areas) 46,111 ha are conifer/mixed and 85,006 ha are broadleaf, coppice or coppice with standards. Chapter 8 of the Read Report[17] provides estimates of average abatement calculated over 100 years (see Table 8.8). These include an abatement delivered through fossil fuel substitution (both direct and indirect), rather than being restricted to abatement delivered solely by sequestration in growing biomass. The values given below are the underlying data behind three of the woodland creation options, for sequestration in growing biomass only (less emissions associated with establishment and management) over a full rotation. Figures exclusive and inclusive of changes in soil carbon stock are given (including carbon stored in litter and deadwood).

[15] Agricultural and Horticultural Survey – England June 2007
www.defra.gov.uk/evidence/statistics/foodfarm/landuselivestock/junesurvey/results.htm

[16] The estimates of biomass and carbon stocks in the East of England were derived by Dr Mark Broadmeadow from the Woodfuel Resource website (www.eforestry.gov.uk/woodfuel)

[17] Combating climate Change – a Role for UK Forests: www.forestry.gov.uk/readreport

- **Case D1:** (native "Yield Class[18] 4" Sycamore/ash/birch unmanaged woodland, assumed over 100 years): 6.2 and 8.8 tonnes of carbon dioxide per hectare per year (tCO_2/ha/yr).
- **Case E1:** (Yield Class 16 Douglas Fir/ Sitka Spruce managed over 60 year rotation):10.5 and 12.0 tCO_2/ha/yr.

Note that these values are calculated as the standing biomass at the end of the rotation (before felling) divided by the length of rotation. The carbon removed during thinning operations is not included. Total abatement is obviously higher if substitution benefits are accounted for.

The *potential* net carbon uptake associated with existing woodland, assuming a uniform age distribution would therefore amount to 484 $ktCO_2$/yr for conifer woodland and 527 $ktCO_2$/yr for broadleaf woodland (total of 1.1 $MtCO_2$/yr), excluding soil carbon sequestration.

The carbon uptake associated with woodland planted since 1998 can be included using the same approach, applying a figure of 8 tCO_2/ha/yr for simplicity. This would amount to an additional 43 $ktCO_2$/yr.

DECC published guidance on valuing carbon for policy evaluation purposes[19]. Non-traded sector values should be assumed for emissions/removals through afforestation, reforestation and deforestation. It should be noted that the valuations should be used to evaluate the cost or added value of policies that lead to emissions or removals.

3.3. Timber availability

3.3.1. Introduction

A Production Forecast[20] provides volumetric predictions of timber production from a given area of forest over certain timescales. It is based on mensuration data derived from field sampling and models for each main timber species, categorised by productive capacity ('Yield Class') and age. A fuller explanation of the methodology employed for the data utilised in this study is contained in **Appendix B**.

A true Production Forecast has been carried out on the Forestry Commission 'Public Forest Estate'; a less accurate forecast of timber availability has been produced for the 'Private Sector' (see 'Definitions' below). This is due to the different information available for the two sectors and what predictions can be forecast from this.

Production forecasts are theoretical in that actual production will be determined by a number of 'real world' factors, including economic viability, supply chain capacity, natural phenomena (weather, pest & diseases) and wider market conditions. These are discussed in section 3.

3.3.2. Definitions

- Forestry Commission – all that land managed (owned or leased) by the Forestry Commission
- 'Private Sector' – all land not managed by the Forestry Commission, including other public sector organisations (e.g. local authorities, MOD).

[18] Cubic metres of timber grown per hectare per year at specified spacings and on an ideal site.

[19] http://www.decc.gov.uk/en/content/cms/statistics/analysts_group/analysts_group.aspx - see table 3.
http://www.decc.gov.uk/en/content/cms/what_we_do/lc_uk/valuation/valuation.aspx

[20] See http://www.forestry.gov.uk/forestry/infd-74jjfk

3.3.3. Forestry Commission

The volumes and assortments published in the forecast reflect the cumulative impact of managing the FC estate (as of 31st March 2005) in accordance with approved Forest Design Plans. For the period 1st April 2006 – 31st March 2011 the forecast represents a Production Plan for the FC Estate in each country. FC intend that, at national level, these or equivalent volumes will be available through a combination of existing contracts and new opportunities for purchase. It is conceivable that a proportion of the areas currently planned for harvest may not be economically viable and the extent to which such areas are worked will depend on conditions prevailing at the time. Conversely there are limited and localised areas where additional volume may be brought forward in response to changing circumstances.

Forest Design Plans are subject to 5 yearly review and whilst the cumulative (national) impact of such reviews is unlikely to be significant in the first 5 years of the forecast, there is more uncertainty regarding the timing and nature of harvesting in subsequent periods. Forecast volumes and assortments post 2011 should therefore be regarded as a statement of likely availability rather than of definite management intent.

The production forecast for the Forestry Commission estate (**Figures 10 and 11** and **Appendix C**) indicates that the total volume of available timber (all species) rises from some 147k cubic meters (m^3) in the current period to 172k, 167k and 175k respectively in the succeeding 5-year periods (**Figure 8**). The apparent fall in volume in the period 2027-2031 is due to modelling assumptions about restocking rather than a steep decline in actual availability.

Period	Volume (cubic metres over bark)			
	Top diameter class 7-14cm	Top diameter class 14-18cm	Top diameter class 18+cm	**Total volume**
2007-2011	33,959	24,007	89,175.00	**147,141**
2012-2016	35,631	28,164	108,554.00	**172,349**
2017-2021	34,041	28,755	103,713.00	**166,509**
2022-2026	30,505	28,500	115,735.00	**174,740**
2027-2031	6,161	8,477	71,818.00	**86,456**

Figure 8 *Production forecast summary: Forestry Commission Estate in the East of England.*

3.3.4. Private Sector

The Private Sector forecast is based on information about the species composition of forest stands obtained from the National Inventory of Woodland and Trees (Smith and Gilbert, 2001, 2002ab, 2003). This is combined with a set of prescriptions describing management and restocking in the Private Sector. These prescriptions were developed by Forecast Working Groups for each country, whose members were drawn together by FC Wales, FC England and FC Scotland and included representatives of private sector growers, harvesters and processors as well as the FC.

Private woodlands encompass a multiplicity of ownerships and prescriptions are intended to represent the broad patterns of stand management and restocking in the Private Sector rather than specific individual or collective plans to harvest timber at a particular time. Forecast results for the Private Sector therefore represent estimates of volume potentially available, rather than a forecast of production. These estimates are based on the full productive potential of the growing stock when managed according to the prescriptions provided by the Working Groups.

The National Inventory, based on a 1% sample of woodland area in Great Britain, provided the basic stand data in terms of the areas of the principal conifer species in private woodlands by planting year. The areas in the forecast are net productive areas. Information on areas of new planting since the National Inventory was carried out has also been incorporated. These basic inventory calculations have been carried out separately for geographic zones of Great Britain. Forecasts have also been made for each geographic zone and national forecasts derived by combining results for relevant zones within each country.

The Private Sector forecast does not routinely include broadleaved species. This is clearly an issue in that almost two-thirds of all woodland in the East of England is composed of broadleaved species, and the majority of that is in the "private" sector. Accordingly an assessment of likely volumes from broadleaved species was carried out for this report. This only assessed 'Category 1 High Forest' for woodland over 2 hectares and thus underestimates the volume of wood available for woodfuel for example (see biomass estimates).

The volume assessment for the Private Sector (**Figures 12 and 13** and **Appendix D**) indicates that the total volume of available timber (all species) from some 322k cubic meters (m^3) in the current period rising to 331k, 341k and 361k respectively in the succeeding 5-year periods (**Figure 9**).

Period	**Volume (cubic metres over bark)**		
	Softwood (conifers)	Hardwood (broadleaves)*	Total
2010-2011	158,029	164,088	322,117
2012-2016	166,937	164,088	331,026
2017-2021	177,519	164,088	341,608
2022-2026	190,458	170,552	361,011
2027-2031	191,374	170,552	361,927

* *central stem only*

Figure 9 *Timber availability summary: Private sector in the East of England.*

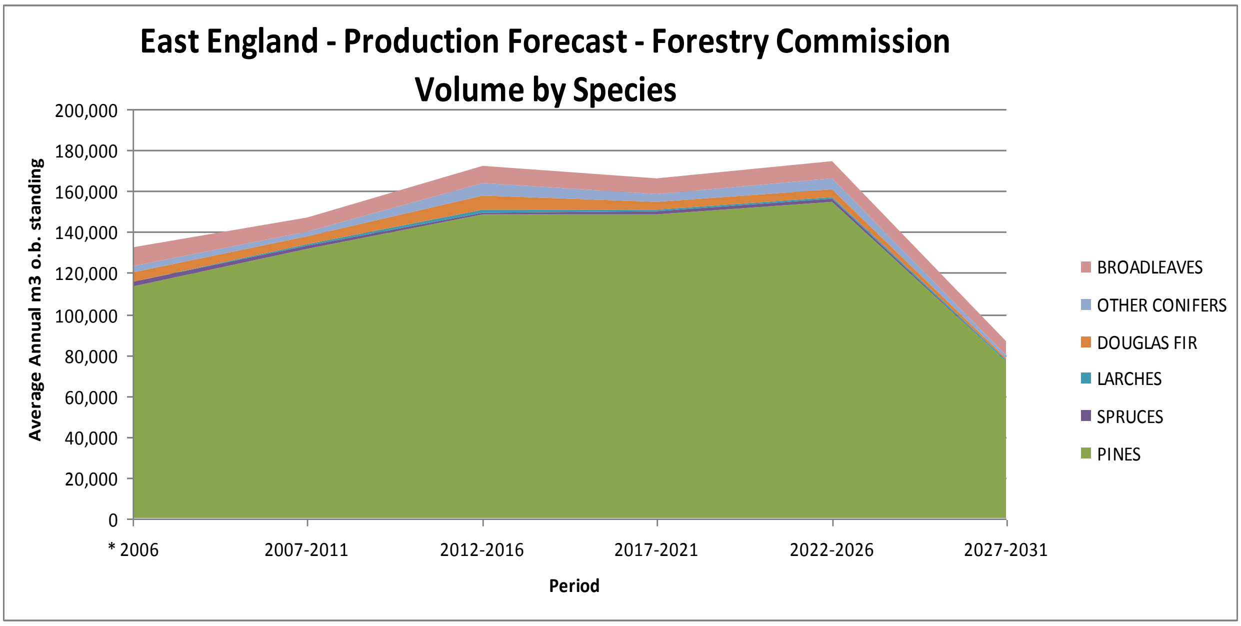

Figure 10 *Forestry Commission: Production Forecast, Volume by Species*

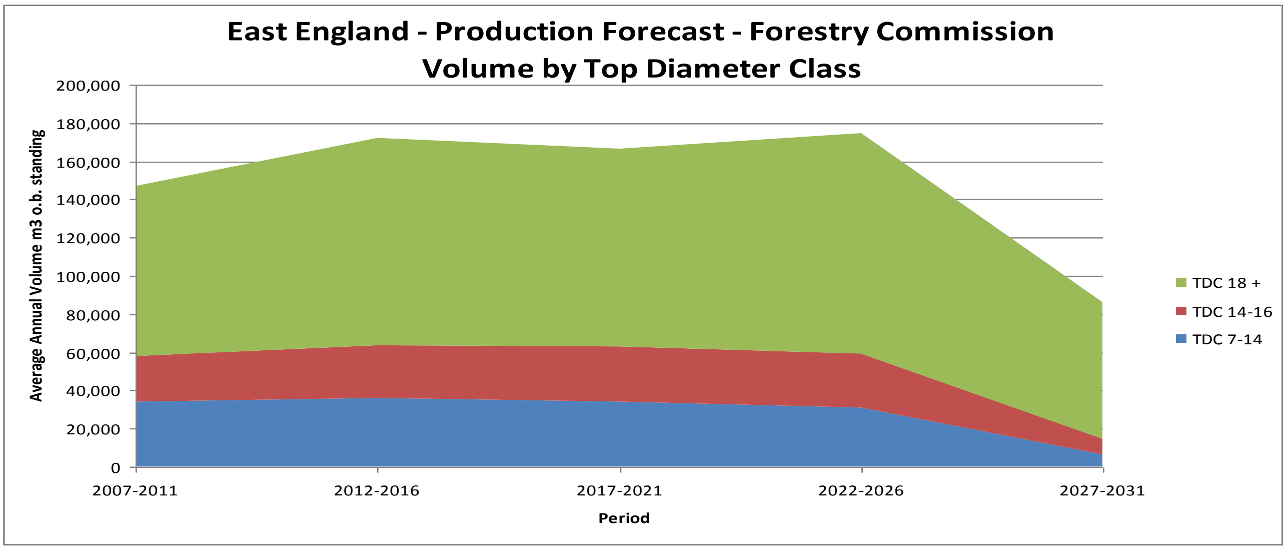

Figure 11 *Forestry Commission: Production Forecast, Volume by Top Diameter Class*

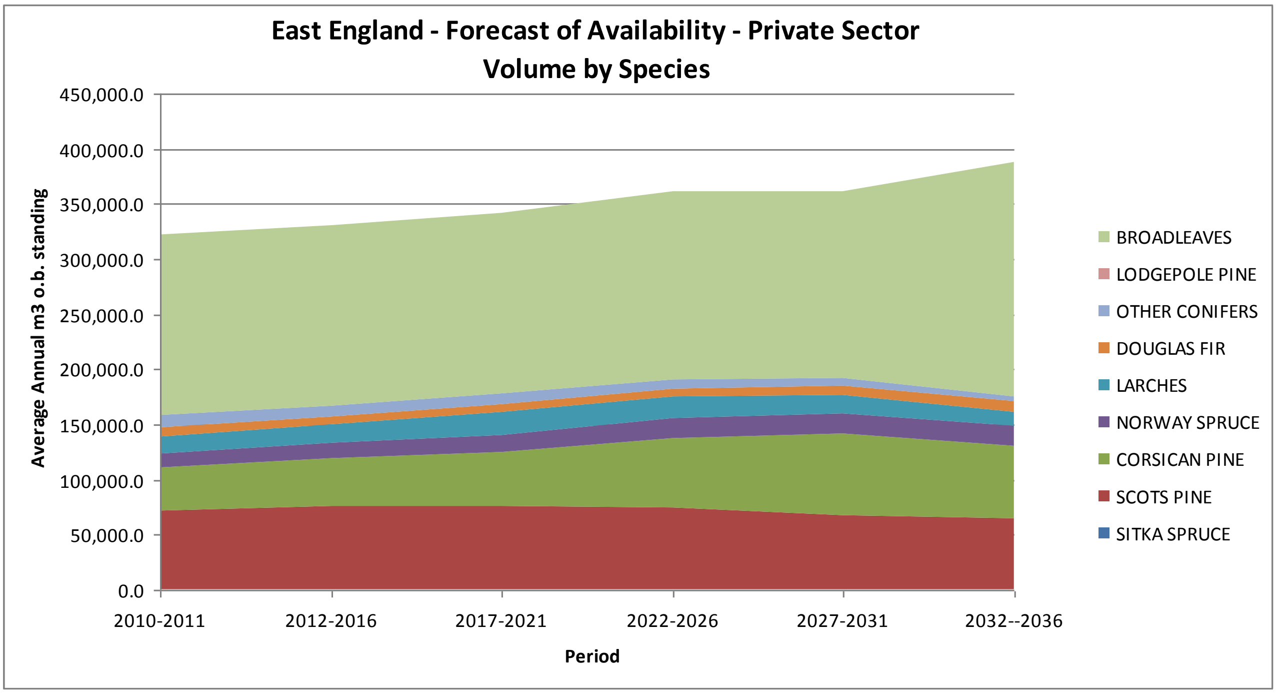

Figure 12 *Private Sector Forecast of Timber Availability, Volume by Species*

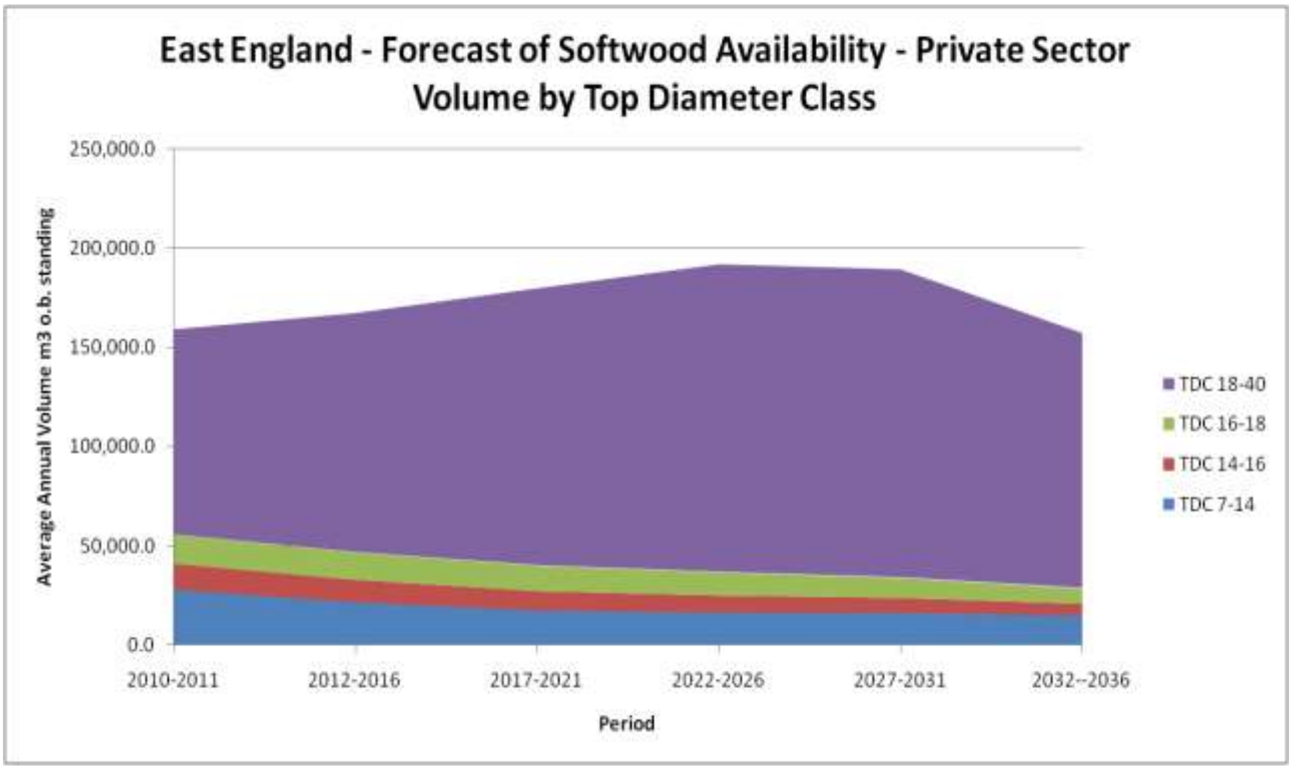

Figure 13 *Private sector Forecast of Timber Availability, Volume by Top Diameter Class (Softwood Only)*

3.4. Biomass assessment

There is considerable interest in the use of wood as an energy source. Current and impending environmental legislation, and world-wide demands and agreements to reduce carbon emissions, are all factors driving the demand for wood as a fuel. The end product use will determine raw material requirement and woodfuel specifications. There is potential for forestry to meet the demand for woodfuel from brash (foliage, branches and stems usually <7cm diameter), thinnings, or poor quality final crops in both conifer and hardwood crops. There is also the potential for the use of arisings from primary processing mills; this source will be heavily market dependent. Increasing legislation on the disposal of arisings from arboricultural operations offers the opportunity of another resource.

A study into the potentially available woodfuel resource of Great Britain was carried out by the Forestry Commission in 2003[21]. These data demonstrate that there is over 16 million oven dried tonnes technically available from woodlands > 2 hectares in the East of England (**Appendix E**). Between 2012-16 there is some 258,000 oven dried tonnes technically available annually. (**Appendix F**).

In Figure 14 we assume a 29,000 green tonnes annual demand for biomass energy in the region. This estimate is based on an installed capacity of woodfuel boilers in the region estimated as 13,000 kilowatts. Assuming 4380 hours of use per year and system efficiency of 0.85[22] this installed capacity would utilise 22329 tonnes of wood at 35% moisture content, or 29029 green tonnes

It is worth noting that energy will be highly sensitive to world markets and supply of other energy sources. Biomass for energy will challenge wood stocks and even higher grade wood stocks if the price rises.

Estimates from the Forestry Commission and the Private Sector suggest that from 2022 to 2026 there is approximately 365,000m^3 of roundwood softwood available per annum. This is equivalent to 365,000 green tonnes of softwood. The standard volume (m3): weight (tonnes) conversion factor for freshly felled timber for Corsican Pine is 1.00[23].

In 2009 the softwood consumption by the existing sawmills was 146,000 green tonnes (for pine it is reasonable to say that 1 green tonne is equivalent to 1 m^3). Some of this capacity will be imported from other parts of the UK and abroad; some regional timber will be exported.

This would indicate that there is at least 200,000 green tonnes (or m^3) of additional softwood theoretically available by 2022-26 than currently milled. This is equivalent to at least 106,000m^3 of sawn softwood. It is possible to assess the size classes and species from the production forecast figures. In total 72% of non-FC softwood will be pine in 2022-26.

The additional softwood that is theoretically available would provide timber for almost 38,000 new brick and block traditional houses per annum. However, not all of this resource will flow into construction; we estimate that 29,000 green tonnes will be used for biomass energy

[21] www.eforestry.gov.uk/woodfuel

[22] source www.northwoods.org.uk/ignite

[23] Matthews, R & Mackie, E (Forestry Commission 2006)"Forest Mensuration. A handbook for practitioners" Table 5.1 (Page 134)

generation. The remaining softwood could provide timber for almost 36,000 new brick and block houses per annum (**Figure 14**).

		2010-2011	2012-2016	2017-2021	2022-2026	2027-2031
Private sector OBm3	softwood	158,029	166,937	177,519	190,458	191,374
Public sector OBm3	softwood	147,141	172,349	166,509	174,740	86,456
	total OBm3	305,170	339,286	344,028	365,198	277,830
	total green tonnes	305,170	339,286	344,028	365,198	277,830
Current consumption	processors green tonnes	146,000	146,000	146,000	146,000	146,000
	woodfuel green tonnes	29,000	29,000	29,000	29,000	29,000
timber available for other processing	remaining green tonnes	130,170	164,286	169,028	190,198	102,830
	sawn softwood tonnes	68,990	87,072	89,585	100,805	54,500
Numbers of new houses per annum	bricks and mortar houses (2.8m3)	24,639	31,097	31,995	36,002	19,464
	timber framed houses (10m3)	6,899	8,707	8,958	10,080	5,450

***Figure 14** Summary information on forecast and estimated volumes of softwood available for house construction.*

Estimates of hardwood (broadleaved) timber are more problematic. However, conservative estimates indicate that there is at least 100,000m^3 of unutilised hardwood timber in the East of England plus a similar volume of wood that could be used sustainably for woodfuel[24].

3.5. Constraints to Realising Forecast Production

In England it is estimated that less than 45% of the annual sustainable timber yield is actually harvested. Although empirical data is not available at a regional level, the East of England region is considered to broadly reflect this pattern. The reasons for this are many and complex, but the fact underlines the disparity between *theoretical* production forecasts and *actual* harvesting volumes – especially in the private sector.

[24] Hardwood estimates are based on primary research carried out by the Countryside and Community Research Institute of the University of Gloucestershire in 2003 for the East of England Woodland Wealth Appraisal (http://www.woodlandforlife.net/wfl-woodbank/DisplayArticle_2304.html) updated to 2010. The 2003 study reported that 60,000 green tonnes of hardwood logs was being consumed in the East of England. The Stoves Industry Alliance collated figures for woodburning stove sales at an England level of 186,000 for 2008. This increase in capacity is estimated to have resulted in an increase in demand of about 100,000 tonnes/annum of logs. Assuming an even distribution throughout England that would have resulted in an increase in demand of 12,500 tonnes in one year in the East of England (i.e. a 20% increase on the baseline figure). According to anecdotal evidence from stove installers, 2008 and 2009 were particularly active for woodburning stoves, but 2004 to 2007 less so. We have assumed 10% non-compounded increases in log consumption in 2004, 2005, 2006, 2007; 20% in 2008 and 2009 and 15% in 2010, thus giving an increased consumption of 58,000 green tonnes on the 60,000 tonnes baseline.

A number of constraints to realising forecast production are described below.

3.5.1. Timber harvesting

Timber from sustainably managed forests is one of the most environmentally friendly materials available. Active management not only produces timber, but also usually increases biodiversity and improves visual amenity.

All Forestry Commission woodland is certified under the UK Woodland Assurance Scheme[25] and is actively managed within an approved Forest Design Plan. Only approximately one third of other woodland is actively managed with an approved felling licence or grant scheme[26].

All The Forestry Commission currently harvests and markets around 5 million green tonnes of round timber per year, currently around 50% of GB softwood (conifer) production[27]. In the East of England the Forestry Commission harvests and markets an estimated 82% of softwood; the majority of hardwood (broadleaves) comes from the "private" sector.

Estimates of hardwood production are not available at the regional level. In 2003 it was estimated that some 60,000 cubic metres (m^3) of hardwood was harvested in the East of England for firewood[28].

Figures are available for sawmill consumption of softwood (**Figure 15**)[29]. It is not possible to accurately separate out regionally grown material from these data: some milled softwood may have been imported from abroad or elsewhere in the UK and some regional timber may be milled outside. Anecdote would, however, suggest that the imports and exports are modest[30].

There are 11 softwood sawmills in the East of England[31], three of which – all near Norwich – mill the majority of regionally grown timber. The increase in capacity from 2005 corresponds to the rebuilding of these sawmills after a fire, and the large scale refurbishment of another.

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25 www.ukwas.org.uk

26 Forestry Commission personal communication

27 www.forestry.gov.uk/website/forestry.nsf/byunique/hcou-4u4j3x

28 Woodland Wealth Appraisal for the East of England (Countryside and Community Research Unit of the University of Gloucestershire. 2003) www.woodlandforlife.net/wfl-woodbank/DisplayArticle_2304.html

29 Forestry Statistics 2009 www.forestry.gov.uk/forestry/infd-7aqdgc

30 Forestry Commission personal communication

31 Forestry Statistics 2009 www.forestry.gov.uk/forestry/infd-7aqdgc

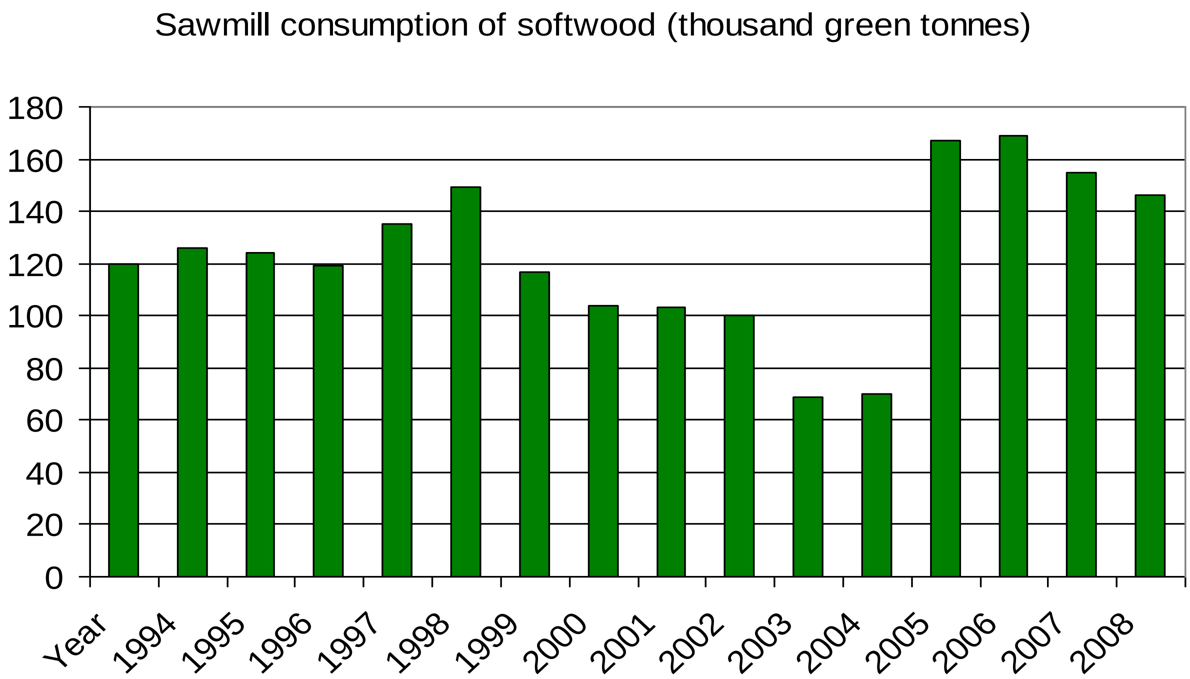


Figure 15 *Sawmill consumption of softwood (thousand green tonnes[32])*

3.5.2. Owner Attitudes

A major factor that will determine what volume of timber will come to market is the attitude of owners and managers to the creation and management of woodlands. Such attitudes will be influenced by a number of factors, including objectives (i.e. what are their primary motives for owning woodlands – financial, sporting, landscape), knowledge of woodland management needs and techniques (i.e. do they know what needs doing and if so do they know how to do it), resources (finance, staff, time) and perception of regulatory and fiscal (dis)incentives (felling licences, grant aid).

Forest Research has recently conducted a review[33] of the evidence relating to landowners attitudes to woodland creation and management. It is noteworthy that, in most studies, timber production and profit came low in the list of priorities for most owners, meaning that a range of other motivations must be satisfied before owners will take action that will lead to timber being harvested. For those that do cite it as a high priority the low timber prices that the UK has experienced since the late 1990's has only acted as a further disincentive.

Availability of independent and expert advice was also considered to be important and in this context the Forestry Commission's Woodland Officers were 'highly regarded'.

3.5.3. Red Band Needle Blight

Due to the presence of Red Band Needle Blight (RBNB)[34], a fungal disease that is having a serious effect on the growth and survival of Corsican pine in the Region, there is likely to be a significant reduction in the future production of Corsican pine within the East of England over the medium to long term. At present Forest Research and Forest Enterprise are

[33] See http://www.forestresearch.gov.uk/fr/ownerattitudes
[34] See http://www.forestry.gov.uk/forestry/infd-74jjfk

looking into both quantity and quality issues associated with this disease. Results are expected to be available for the next published Production Forecast, due in 2011.

Red band needle blight (*Dothistroma septosporum*), so called because of the colourful symptoms it shows on pine, is an economically important disease of conifers. It causes premature needle defoliation, resulting in loss of yield and, in severe cases, tree death. Until recently the disease was primarily of concern in the Southern Hemisphere, particularly on radiata pine (*Pinus radiata*). However, since the 1990's there has been an increase in disease incidence in Europe, mainly on sub-species of black pine (*Pinus nigra*) and also on lodgepole pine (*Pinus contorta* ssp. *latifolia*) in Canada. Since the late 1990's the disease status has changed markedly in Britain. It is now found in many forests growing susceptible pine species and threatens the future of one of the most productive commercial pine species, Corsican pine (*Pinus nigra* ssp. *laricio*).

RBNB was first recorded in Great Britain in 1954 on nursery stock in Dorset, where it recurred sporadically until 1966. Apart from occurrences in forest stands in Wales in 1958 and 1989, there were then no reports of the disease until the late 1990s. Between 1997 and 2005 the majority of reports were on Corsican pine in the East of England, although it was identified in several other parts of Great Britain during this period.

A survey was undertaken in Forestry Commission forests in 2006 to determine the extent of the disease across Britain. It found the disease on Corsican pine in all of the Forestry Commission's Forest Districts in England, the majority in Wales and several in Scotland. Overall, 70% of the Corsican stands inspected had the disease, and it is estimated that 44% of these infected stands had crown infection levels of greater than 30%. 70% of the Corsican pine stands surveyed had the disease. In terms of the East of England, in 2007 it was predicted that over 80% of the East Anglia Forest District Corsican pine crop was infected, with the worst affected forests being in the main block.

Based on experience in New Zealand, (the best presumption available at present), the percentage of crown infection equates to the percentage yield reduction. Research is under way to gain an understanding of the impact on yield on Corsican pine in England.

In other countries where the disease has a significant economic impact, successful methods of control have tended to focus on fungicide treatments. However, in Britain the focus is on the use of resistant species and good stand management.

3.5.4. Supply Chain Capacity

Forestry, like most primary industries, has seen a significant shift to mechanisation and automation in recent decades. Allied to the low relative prices available for timber in the UK, this has led to a focus on larger, potentially more productive, forest units. Many of the latter are owned by the Forestry Commission and private estates who either have in-house staff or employ contractors on (relatively) long term contracts thus enabling investment in machinery (forest processors, forwarders) a reduction in staff employed in harvesting and forest management. A recent report[35] by Lantra, the land based Sector Skills Council, described as 'critical' the skills gaps and shortages in the industry.

However, many private woodlands are within relatively small forest units and require management techniques and equipment which due to the above factors are now in short

35 A Skills Assessment for the Environmental and Land-based Sector. Lantra 2009 http://www.lantra.co.uk/stakeholders/research-documents/skills-assessment

supply. If much of this additional theoretically available volume is to come to market a significant increase in supply chain capacity will have to take place, focussing on: -

- machinery and equipment
- skills and knowledge
- new entrants

3.6. SWOT Analysis of Growing Stock & Markets

Strengths	**Weaknesses**
• substantial timber reserves • ground conditions • timber quality • proximity to market • public highway network • academic/research base	• narrowing contractor base • lack of processing sector • reliance on pine species • fragmented private sector woodland resource
Opportunities	**Threats**
• climate change – species choice • growth zones in and close to East of England • woodfuel • land use change • better information	• climate change – pest & diseases, species choice, water availability, wildfires • workforce availability • land use pressures • proximity of deep water ports (imports)

3.7. Commentary

3.7.1. Strengths

- Substantial Timber Reserves The timber availability forecasts indicates a potential maximum production in excess of 535,000 cubic metres (m^3), per annum to be reached during the period 2022 -26. This is a substantial volume of timber which could support a significant processing sector.

- Ground Conditions. The East of England has relatively favourable ground conditions for timber harvesting and extraction with few steep slopes and, in some areas, well drained soils. Harvesting is possible much of the year round which provides an advantage of other regions and countries where ground conditions can limit operating seasons.

- Timber Quality. Although neither the FC Production Forecast nor the NIWT includes an assessment of timber quality, personal observation indicates that timber quality – especially that of softwoods – is high, with relatively straight trees with light branching and minimal taper. This is probably due to the low rainfall conditions which encourages slow even growth rather than rapid, irregular growth.

- Proximity to Market. The East of England is located adjacent to the largest construction market in the UK i.e. South East England and is well served by road connections.

- Public Highway Network. The public highway network in the East of England is relatively good with most woodland areas served by roads of adequate quality to enable timber transport.

- Academic/Research Base. The East of England has a number of universities and research institutes (UEA, BRE), which foster innovation and best practice.

3.7.2. Weaknesses

- Narrowing Contractor Base. Section 3 describes the shortage of contractors and the reasons for this.

- Lack of Processing Sector. The larger existing softwood sawmills are well equipped and would have some capacity to increase throughput of local timber. There is, however, arguably an over-reliance on these larger mills and a significant increase in would require significant new investment to overcome. In addition to their core output, primary processors also produce co-products (shavings, chip, sawdust) which are the base for other secondary processors and markets (board, pulp, animal bedding, woodfuel).

- Reliance on Pine Species. The description of the existing woodland resource and production forecast clearly describes the heavy reliance on pine species (primarily Corsican and Scots) in the East of England. This is for very good reasons – soils and climate – but does mean that the region lacks a diversity of species which can lead to weaknesses should species specific pests and diseases arise (e.g. Red Band Needle Blight) and limit the available end use markets.

- Fragmented Private Sector Woodland Resource. The NIWT indicates that there are in excess of 45,000 woodlands larger than 0.1 ha in the region and the number of agricultural holdings with woodland alone exceed five thousand.. Creating a robust, sustainable supply chain from an ownership base as large and varied as this is very challenging and fragile.

3.7.3. Opportunities

- Climate Change – Species Choice. Changing climate – primarily elevated temperatures and decreased moisture – is predicted to lead to other species being viable in the East of England.

- Growth Zones in and close to East of England. The East of England either contains or is close to a number of growth zones (London/Cambridge/ Peterborough, South Midlands/Milton Keynes, Thames Gateway, Norwich etc) which will be significant users of timber in construction and energy uses.

- Woodfuel. Woodfuel has emerged a significant market for wood in the UK in recent years and the East of England is amongst the leaders in growing the market. The Woodfuel

East[36] project seeks to stimulate the supply chain and market with significant investment from the Rural Development Programme for England (RDPE).

- Land Use Change. Current debates around global food security and the future of the EU Common Agricultural Policy is predicted to affect significant land use change in the UK. Although in many cases this may lead to intensification as part of re-emphasis on to food production, the resulting focus on productive land and techniques may provide for areas of land to be converted to productive forestry.

- Better Information. The Forestry Commission are currently undertaking a new National Forest Inventory[37] which will provide better information on timber quantities and production forecasts, especially in the private sector. As a result of this additional quantities of available may come to light.

3.7.4. Threats

- Climate Change – pest & diseases, species choice, water availability, wildfires. The adverse affects of climate change – primarily moisture availability and pests & diseases - may lead to restricted species choice, increased drought and incidence of wildfires.

- Workforce Availability. The shortage of staff in the industry has been outlined above and the emergence of new industries in the growth zones and the predicted limitations of immigration may lead to increased shortages of forest workers in both the public and private sectors.

- Land Use Pressures. In addition to demand for housing, industry and transport the re-emphasis on food production described above may lead to a reduction of land availability for forest creation. Although UK forest policy is unlikely to permit forest removal for the purposes of food production, others causes of reduction in woodland area (e.g. restoration of open habitats) could lead to a net reduction in the productive area.
- Proximity of Deep Water Ports (Imports). The UK imports 85% of its timber requirements and most of this comes from the Baltic states, much of it through east coast ports. The presence of these significant timber volumes, at very competitive prices, could lead to the substitution of domestically sourced timber where new markets have been created in the region.

[36] http://www.woodfueleast.org.uk

[37] http://www.forestry.gov.uk/forestry/infd-83uhys

4. Creating the model supply chains

4.1. Study Structure

The supply chain model below (**Figure 16**) was chosen for use in this project and is one based on a hierarchical structure of four tiers; with analysis being concentrated in the top two tiers during this phase of the study as described under WP1.

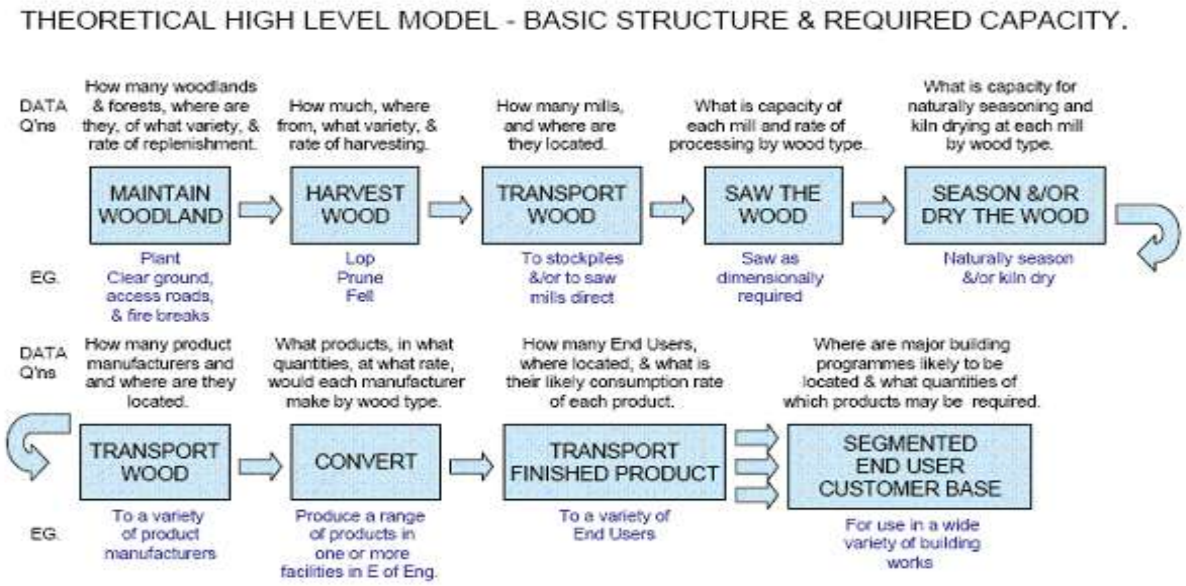


__Figure 16__ The model supply chain for forest products from the woodland through the processing and manufacturing to end use delivery.

Six model supply chains were presented at a Stakeholder event on 27 May 2010 that focussed on different products. Each of these is presented here as a single page summary of the supply chain diagram for the product, key opportunities for the products and the specialist equipment that would be needed for manufacture. Final an assessment was made of the value along the supply chain, the total minimum equipment investment needed and the potential for new employment per facility.

The products considered are:

- The inside out beam – a novel inversion and gluing of small diameter roundwood
- A twin laminate beam – a simple highly stiff and strong element
- Windows – high value hardwood joinery
- Enhanced flooring – impregnated pine sapwood
- Hardwood flooring – defect cut solid timber flooring
- Cladding – exterior wood cladding boards

The assessment of value along the supply chain is based on a values per m^3 of timber at stump in the forest, at the roadside having being harvested, at the first stage of production of the product (e.g. the laminated window joinery blank) and at the final stage of production retail value (e.g. a factor finished wood window). For each of the elements the calculations have used volumes of timber per unit or area of flooring covered by 1 m^3 of timber to advance the calculations.

Typical amounts of carbon stored in wood products in a domestic house have been calculated or taken from the Read report and are presented in **Figure 17**.

The figures of stored carbon are calculated from the typical volume of wood product in each house multiplied by the amount of CO_2 in 1m^3 of kiln dried softwood which is assumed to weigh 500kg and of this approximately 50% is carbon. Carbon is converted to CO_2 by multiplying by the chemical ratio in the molecule which is 3.67 by elemental weight. Therefore each 1m^3 of timber stores approximately 900kg CO_2.

	m^3 in typical house	tCO_2 stored per house	tCO_2 stored in new 36,000 homes	Service life years
Inside out beam	0.13[a] (interior joinery unit)	0.12	4,320	30-60
Twin laminate beam	6.00[b] (structural frame)	5.40	194,400	60
Windows	0.06[c] (per unit)	0.43[e]	15,480	30
Enhanced flooring	0.36[d]	0.32	11,520	15-30
Hardwood flooring	0.36[d]	0.32	11,520	30
Cladding	0.33[d]	0.30	108,000	30

a volume of newel posts in a staircase (4 posts of 0.15x0.15x1.45m)
b Read report (2009) uses 6m^3 in a timber frame – a twin laminate frame is assumed to use this volume[38]
c Calculated in model supply chain 2
d Read report (2009)
e 8 window units in each house

***Figure 17** Comparison of six model supply chain products and carbon storage potential*

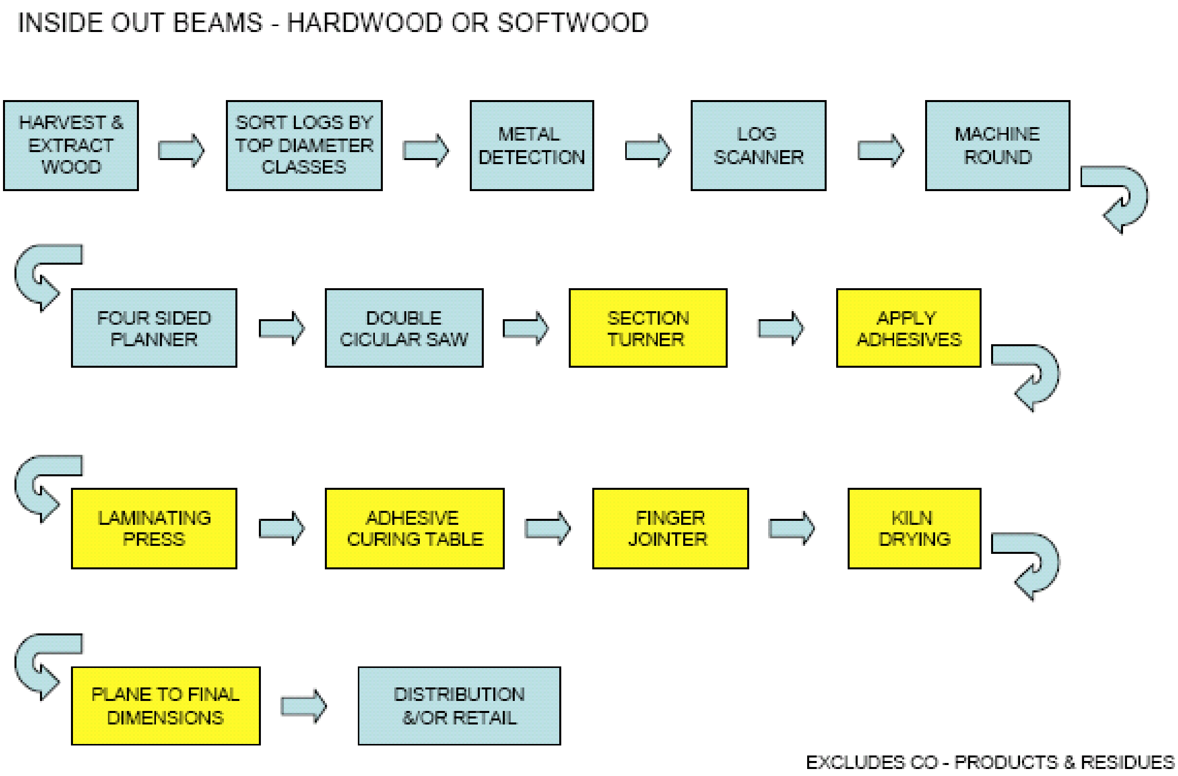
In **Figure 14** the availability data for 2022-26 indicated a potential for providing the timber for 36,000 new brick and block houses. **Figure 17** shows the six model supply chain products. If we assume the twin laminates form a structural frame, and that one of two flooring products is selected then 36,000 houses would store an additional 205,920tCO_2.

The carbon displaced by replacing more fossil fuel intense materials is called the substitution effect. If we assume there is no substitution effect for the inside out beam as internal joinery (as timber would be used) and also the windows as timber windows are likely to used in new build. The key substitution will be of the blocks. A house with 60m^3 [39] blocks in its walls has a net emission of 12tCO_2[40] per house associated with the embodied energy in the blocks. This equates to an additional saving of 432,000tCO_2 for 36,000 houses if timber is used.

[38] Combating climate Change – a Role for UK Forests: www.forestry.gov.uk/readreport
[39] (8 x 8 x 7m) x 0.15m block thickness = 57.6m^3 blocks
[40] 0.2 net tonnes CO_2 emitted per m^3 blocks (RTS data of 1998-2001 Aulisi A, Saucer A & Wellington. World Resources Institute "Trees in the Greenhouse")

4.1.1. Supply Chain 1: Inside out beams

Figure 18 shows the model supply chain for the production of an innovative reengineered timber element that converts a timber round into an inverted or inside out beam that can be used for structural or aesthetical end uses. The timber rounds which come from coppice woodland, hardwoods or softwoods are rounded and machining flats are cut into the rounds. The log is quarter sawn, inverted and glued. This can be conventional gluing after drying or green gluing in a wet state. If green glued then the inside out beams can be air dried or kiln dried as necessary. The inside out beam technology has been developed by BRE under research and development funding from the Forestry Commission[41].




Sweet chestnut coppice wood

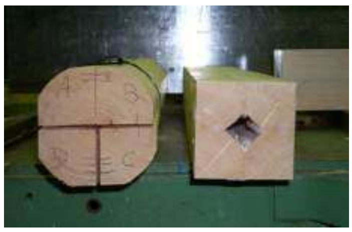

Inside out beam

Figure 18 *The conversion of rounds of timber into inside out beams is shown in the model supply chain.*

[41] BRE Report 225-832 Inside out beams. Forestry Commission

The advantages of such a product include the following opportunities:

- High level of carbon storage over normal methods of conversion. On average 85% of the log is converted into high value construction product.
- The beam could be used in a wide range of applications including but not limited to:
    - portal frame components, capable of containing integrated fixing system
    - ring beams for innovative roofing structures and improving the structural stability of buildings
    - stair parts (newel posts) where high aesthetic values are required.
    - lighting columns and other applications where the hole through the middle would present an advantage to conceal wiring.

The basic specialist equipment that is required to manufacture inside out beams would cost approximately £40,000[42] comprising:

- Machine rounder (£15,000)
- 4 headed planer (£12,500)
- Customised laminating press (£12,500 - manual)

Additional employment per facility is estimated to be 10 people based on a single operator for each piece of specialist equipment plus two shifts of 4 people to feed and operate the manual laminating press.

The key market drivers for this type of product will be the enhanced performance characteristics compared to an existing product and its lower embodied carbon. This will include better surface characteristics, enhanced strength properties and the central void which produces a lighter beam and/or an opportunity for cabling to be concealed.

The value proposition is considered to be good, with profit margins in excess of typical wood processing industry at an estimated 15%. The stump value of a tree is £10/m^3 [43] rising to £37/m^3 [44] for the green roundwood at road side. The process of rounding and manufacturing an air dried inside out beam is estimated to provide a beam value of £350/m^3. It is envisaged that the beam would not require significant further processing or handling to provide a basic product as a structural beam yielding a value of £500/m^3 on the trade market. This is based on the strength properties of the beam and an estimate of aesthetical value. This would be considerably enhanced to £1000/m^3 if the beam was part of a system product for construction of portal frames or ring beams including the connections.

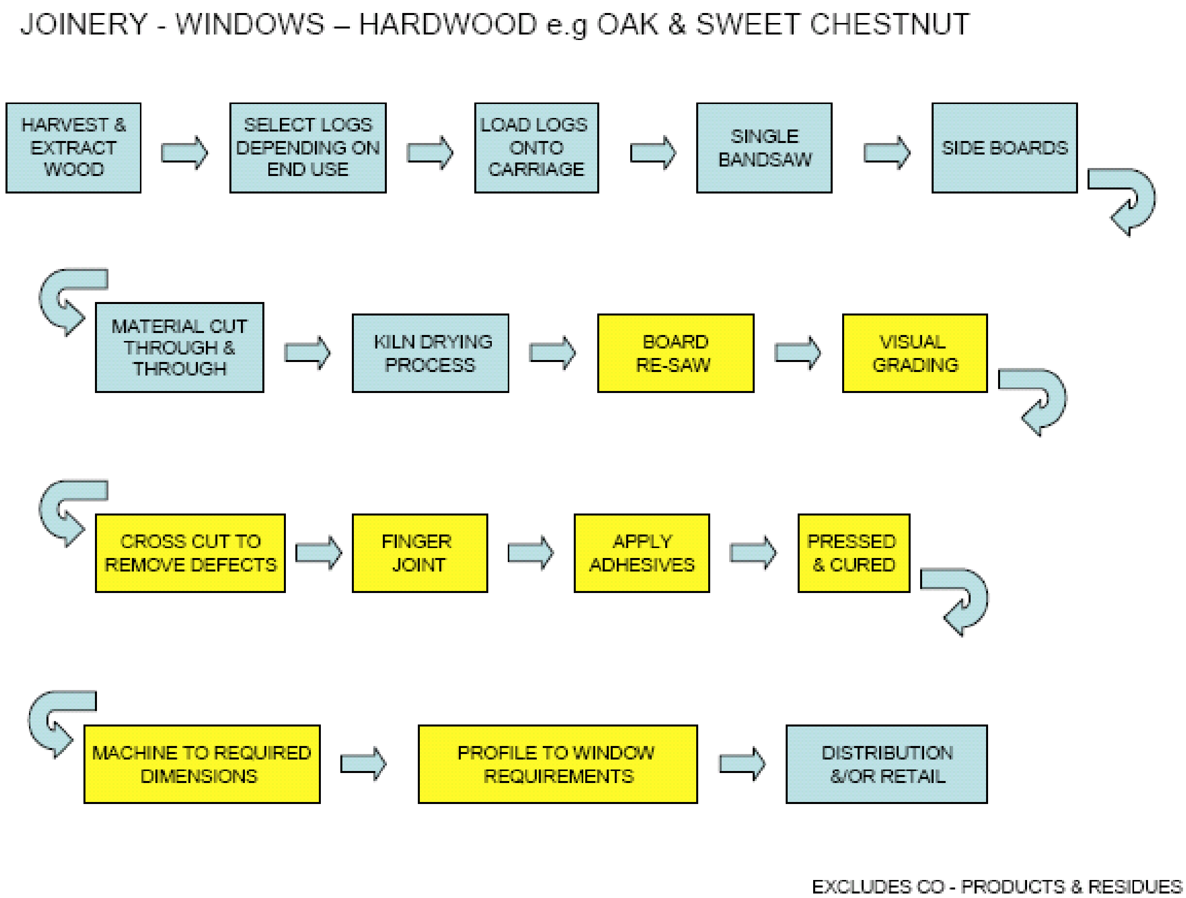
[42] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

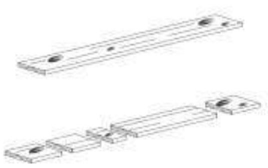
[43] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

[44] Hardwood firewood at roadside. Personal communication Forestry Commission.

4.1.2. Supply Chain 2: Windows

Figure 19 shows the model supply chain for the production of joinery blanks from laminated timber and then their use for manufacture of windows. The boards are sawn and visually graded, a decision is then made on the grade of material for use and or the degree of defect cutting and finger jointing that is required to produce a sufficiently clear grade for the window joinery end use. The boards are then glue laminated to produce joinery blanks which are then machined in profiles for windows. The technology of defect cutting and finger jointing is widely applied across the wood industry and is just starting to appear in UK wood processing. The application to window joinery has been used by BRE under research and development funding from the Greenwood Forests and Forestry Commission[45].




Defect cut


Face laminate


Joinery blank


Window

Figure 19 *The conversion of rounds of timber into window joinery blanks and then windows is shown in the model supply chain.*

[45] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

The advantages of such a product include the following opportunities:

- Use of low value hardwood feed stock
- Improved dimensional stability from glue laminated section
- Improved coating performance from defect cut and selected timber
- Potential to green glue the sections to provide a lower intensity capital equipment outlay
- Encouragement for the enhanced management of hardwood woodlands and including production of co-product for biomass

The basic specialist equipment that is required to manufacture inside out beams would cost approximately £145,000[46] comprising:

- Scanner (£60,000)
- Defect cutting saw (£15,000 - manual feed)
- Finger jointer (finger jointer £30,000 joint press £27,000 glue spray - manual £2,500)
- Laminating press (£10,000 - manual)

Additional employment per facility is estimated to be 15 people based on a single operator for each piece of specialist equipment plus two shifts of 4 people to feed and operate the defect cutting and finger jointing and two shifts of 2 people to feed and operate the manual laminating press.

The key market drivers for this type of product will be the enhanced performance characteristics compared to an existing product (e.g. longer maintenance intervals) and its lower embodied carbon. This will include better surface characteristics, better coating performance and enhanced stability.

The value proposition is considered to be strong. The stump value of a tree is £10/m^3 [47] rising to £37/m^3 [48] for the green roundwood at road side. The process of sawing, selecting, defect cutting and laminating produces a joinery blank of estimated provide value of £350/m^3 [49]. It is envisaged that the joinery blank would then be incorporated into existing window joinery manufacture within the region from profiling, treatment, fully factory finishing with glazing and coatings to produce a high value wooden window. A typical casement window is estimated to contain 0.06m^3 of wood in the frame and opening lights. This utilised 0.15m^3 of timber in joinery blanks to machine the component parts. Therefore 1m^3 of joinery blank timber could manufacture approximately 7 windows. At basic retail prices each of those seven window frames would sell for £450 factory glazed and if the window was full factory finished then the retail price could be £700 to £1000 per unit[50]. This yields in the retail markets for wood window between £3000 - £7000/m^3 of wood. This significant value opportunity values the high value wood product as a whole which includes the quality of finish, its furniture (e.g. handles and stays), the security locks and service life.

[46] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

[47] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

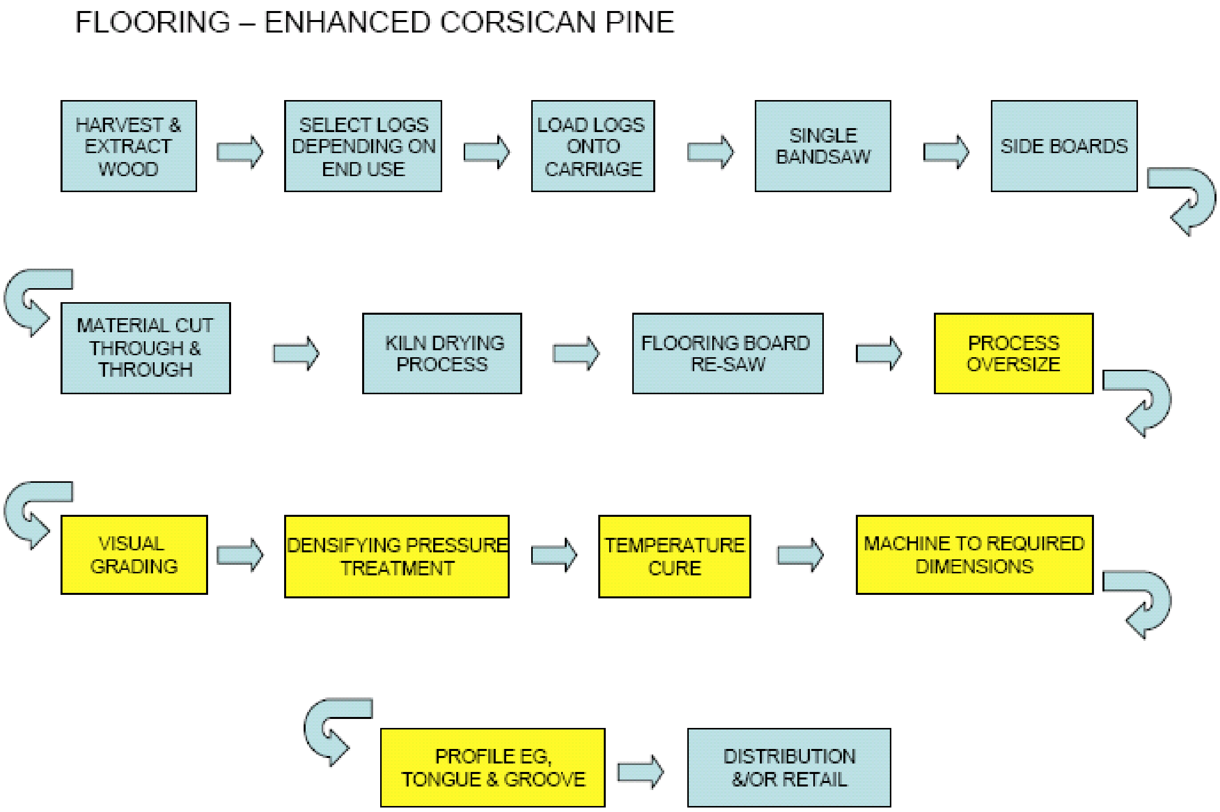
[48] Hardwood firewood at roadside. Personal communication Forestry Commission.

[49] Joinery grade timber price estimate

[50] Jeldwen window and doors catalogue 2010

4.1.3. Supply Chain 3: Enhanced flooring

Figure 20 shows the model supply chain for the production of enhanced flooring from Corsican pine. The boards are sawn and visually graded to select the sapwood boards which are then treated using a densifying technology that pressure impregnates a chemical solution into the wood in the manner of a wood preservative treatment. The monomers are then cured in situ by heating to provide a densified and hard wood product. The boards are then machined and profiled to produce flooring. The technology of enhancing timber though chemical modification technologies has been trialled and commercialised across the globe[51]. Many of the enhanced wood products are on the UK market but no production in the UK exists.



Enhanced flooring

Figure 20 *The conversion of timber into flooring in a model supply chain.*

[51] BRE Digest 504 Modified Wood – an introduction to products in UK construction. www.ihsbrepress.com

The advantages of such a product include the following opportunities:

- High sapwood proportion and treatability of Corsican pine
- Wood modification e.g. hardening type product, acetylation
- Improved hardness and density leading to enhanced wear resistance
- Improved durability
- Colour impregnation through the whole section is possible to produce a range of colours

The basic specialist equipment that is required to manufacture enhanced flooring would cost approximately £130,000[52] comprising:

- Pressure impregnation plant (small £60k to £120k)
- Curing facility (£10,000)

Additional employment per facility is estimated to be 4 people based on two shifts of two to operate the treatment plant.

The key market drivers for this type of product will be the sustainability of the timber and its chain of custody, enhanced performance characteristics compared to an existing product (e.g. hardness) and its lower embodied carbon. This will include better surface characteristics, better coating performance and enhanced stability and wear resistance.

The value proposition is considered to be good. The stump value of a tree is £10/m^3 [53] rising to £37/m^3 [54] for the green roundwood at road side. The process of drying, processing and selecting the wood and then impregnating a technology to enhance performance of the wood as a floor product is estimated to provide a product value of £600/m^3. It is envisaged that the floor would not require significant further processing or handling to provide a basic product yielding a value of £700/m^3 on the trade market. If the floor product was 18mm thick then 1m^3 would provide 55m^2 of flooring at £13/m^2 [55]. The retail value based on the improved hardness, wear resistance and dimensional stability of the floor and an estimate of aesthetic value to the end customer could be in excess of £30/m^2 [56] which converts to £1650/m^3.

[52] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

[53] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

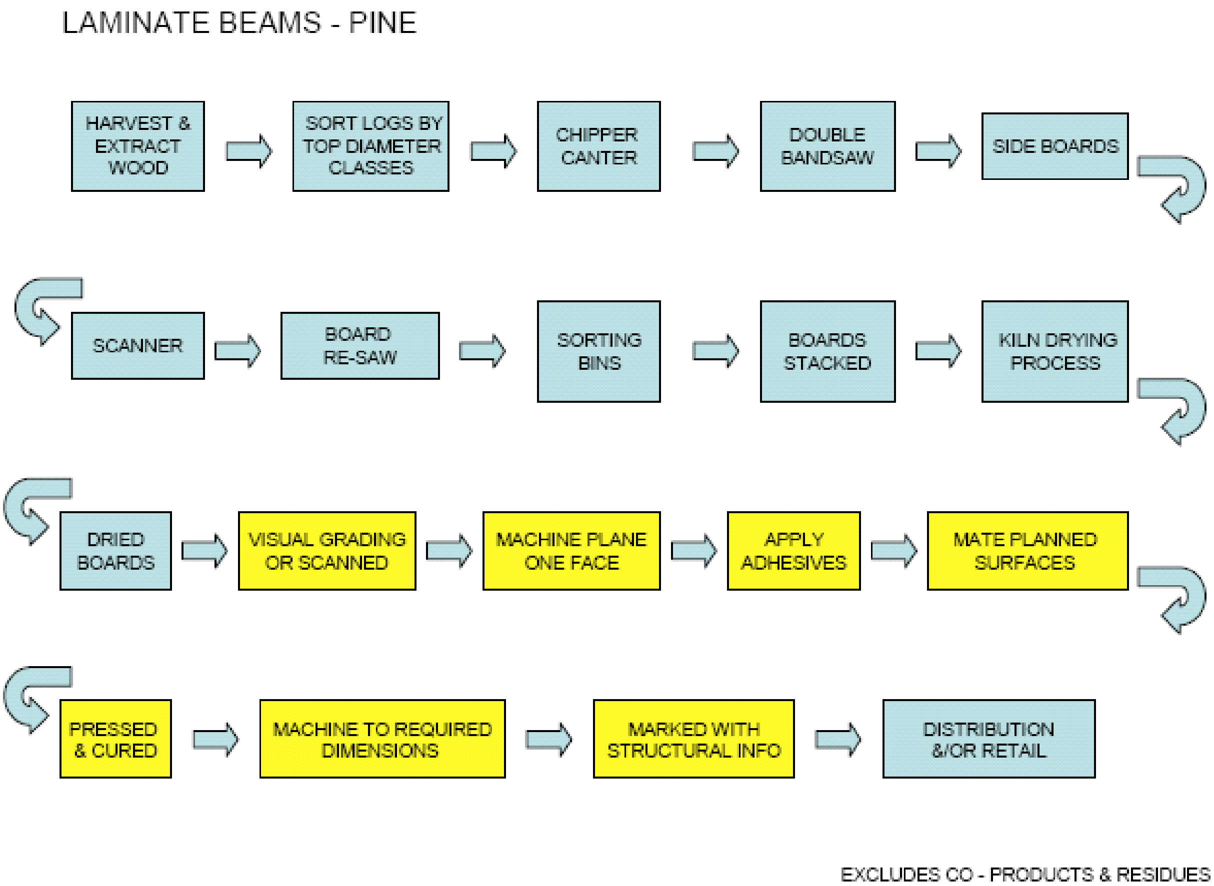
[54] Hardwood fire wood at roadside. Personal communication Forestry Commission.

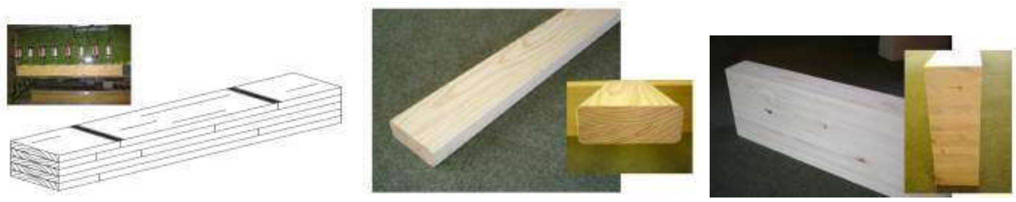
[55] Flooring product prices guides from www.flooringsupplies.co.uk

[56] Flooring product prices guides from www.flooringsupplies.co.uk

4.1.4. Supply Chain 4: Laminated beams

Figure 21 shows the model supply chain for the production of an innovative reengineered twin laminate beam and multiple glue laminated timber elements for structural use. The timber is graded, machine planed to prepare smooth face for bonding, glue bonded and pressed until cured. The twin laminate would then be machined to required lengths and marked with structural information. The twin laminate technology has been developed by BRE under research and development funding from the Forestry Commission[57].





Face laminate *Twin laminate* *Glulam beam*

Figure 21 *The conversion of timber into laminate beams including the twin laminate shown in the model supply chain.*

57 BRE Report 225-822 Scots pine falling boards twin laminates. Available on www.forestry.gov.uk/research

The advantages of such a product include the following opportunities:

- Improved strength and stiffness for section profile e.g. a twin laminate pine can upgrade timber from a falling board which may be less then C14 to C35
- Uses such as:
    - Flanges for I-beams and press metal web beams
    - Bottom chords in attic trusses
    - Ring beams
    - Improved performance joists and rafters in refurbishment

The basic specialist equipment that is required to manufacture a twin laminate would cost approximately £75,000[58] comprising:

- Board scanning / grading (£60,000)
- Economical glue spreading equipment (Glue spray - manual £2,500)
- Laminating press (£12,500 - manual)

Additional employment per facility is estimated to be 10 people based on a single operator for each piece of specialist equipment plus two shifts of 4 people to feed and operate the glue line and manual laminating press.

The key market drivers for this type of new product will be the sustainability of the timber and its chain of custody, enhanced performance characteristics compared to an existing product (e.g. strong and light) and its lower embodied carbon. A new structural product will need design tables to be prepared for engineers and architects to utilise the product.

The value proposition is considered to be good. The stump value of a tree is £10/m^3[59] rising to £37/m^3[60] for the green roundwood at road side. The process of sawing and processing the timber is conventional techniques, the grading and selection of boards is not currently conducted in the region. This is estimated to provide a basic twin laminate beam value of £250/m^3. It is envisaged that the beam would not require significant further processing or handling to provide a basic product as a structural beam yielding a value of £500/m^3 on the trade market. This is based on the strength properties of the beam and its thin section. This would be considerably enhanced to £1000/m^3 if the beam was part of a system product for construction of ring beams including the connections or for structural improvements in existing buildings.

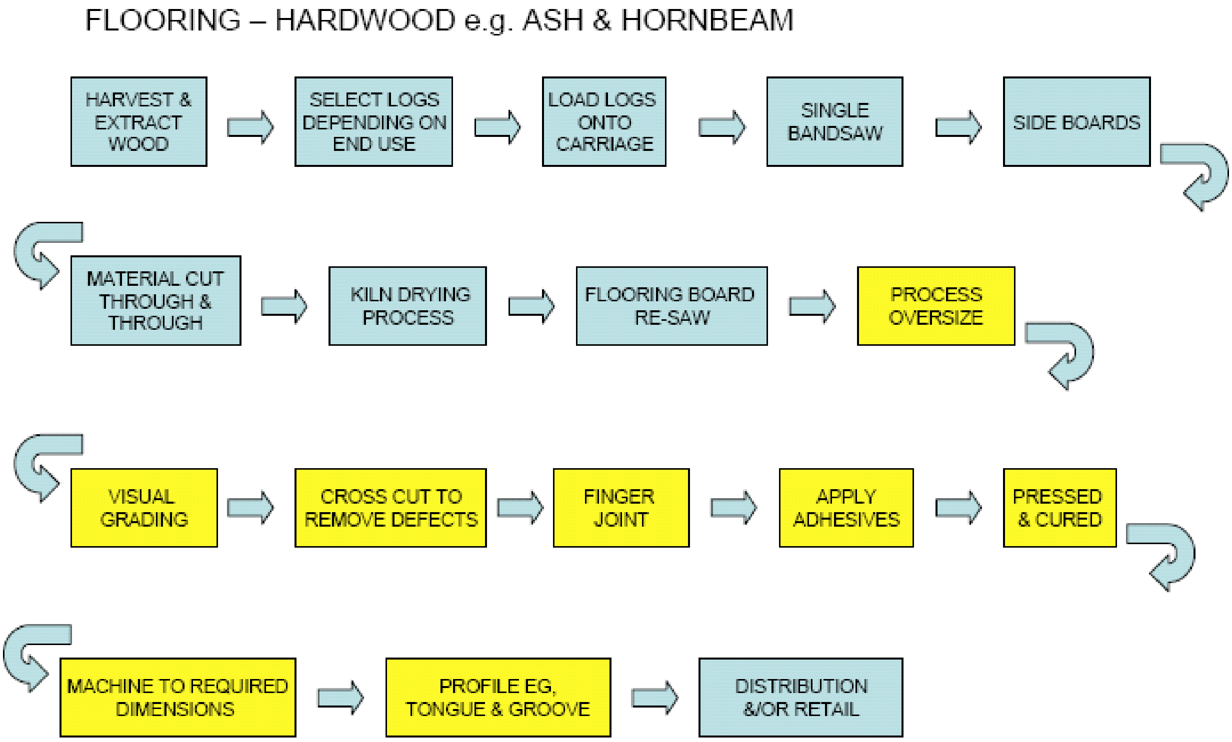
[58] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

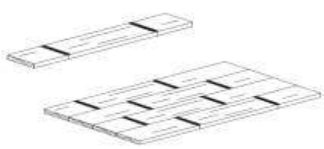
[59] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

[60] Hardwood firewood at roadside. Personal communication Forestry Commission.

4.1.5. Supply Chain 5: Hardwood flooring

Figure 22 shows the model supply chain for the production of flooring from hardwood species e.g. ash, hornbeam. The boards are sawn and visually graded to select the boards which can then be defect cut and finger jointed if required and pressure and cured into an engineered flooring blank. The boards are then machined and profiled to produce flooring product. The technology of defect cutting and finger jointing is widely applied across the wood industry and is just starting to appear in UK wood processing. The application to flooring has been used by BRE under research and development funding from the Greenwood Forests and Forestry Commission[61].




Edge laminate


Oak flooring


Sycamore flooring

Figure 22 *The conversion of timber into flooring in a model supply chain.*

[61] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

The advantages of such a product include the following opportunities:

- Lower value underutilised timbers might be used
- Excellent abrasion resistant timbers could be selected
- Hard radial faces can be orientated for use
- Feature appearance and aesthetic value realised (e.g. black heart in ash)
- Cost effective product against other species for heavy use floors
- Bring under-managed woodland back in to use

The basic specialist equipment that is required to manufacture hardwood flooring would cost approximately £135,000[62] comprising:

- Scanner (£60,000)
- Defect cutting saw (£15,000 - manual feed)
- Finger jointer (finger jointer £30,000 joint press £27,000 glue spray - manual £2,500)

Additional employment per facility is estimated to be 10 people based on a single operator for each piece of specialist equipment plus two shifts of 4 people to feed and operate the defect cutting and finger jointing.

The key market drivers for this type of product will be the enhanced performance characteristics compared to an existing product (e.g. aesthetic appeal, hardness) and its lower embodied carbon. This will include better surface characteristics, better appearance and enhanced stability.

The value proposition is considered to be good. The stump value of a tree is £10/m^3 [63] rising to £37/m^3 [64] for the green roundwood at road side. The process of sawing, selecting, defect cutting and finger jointing produces a flooring blank of estimated provide value of £350/m^3. It is envisaged that the flooring would then be incorporated into existing interior joinery manufacture within the region to produce a high value wooden hardwood floors. It is envisaged that the floor would not require significant further processing or handling to provide a basic product yielding a value of £500/m^3 on the trade market. If the floor product was 18mm thick then 1m^3 would provide 55m^2 of flooring at £9/m^2. The retail value based on the improved hardness, wear resistance and an estimate of aesthetic value to the end customer could be in excess of £30/m^2 [65] which converts to £1650/m^3.

[62] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

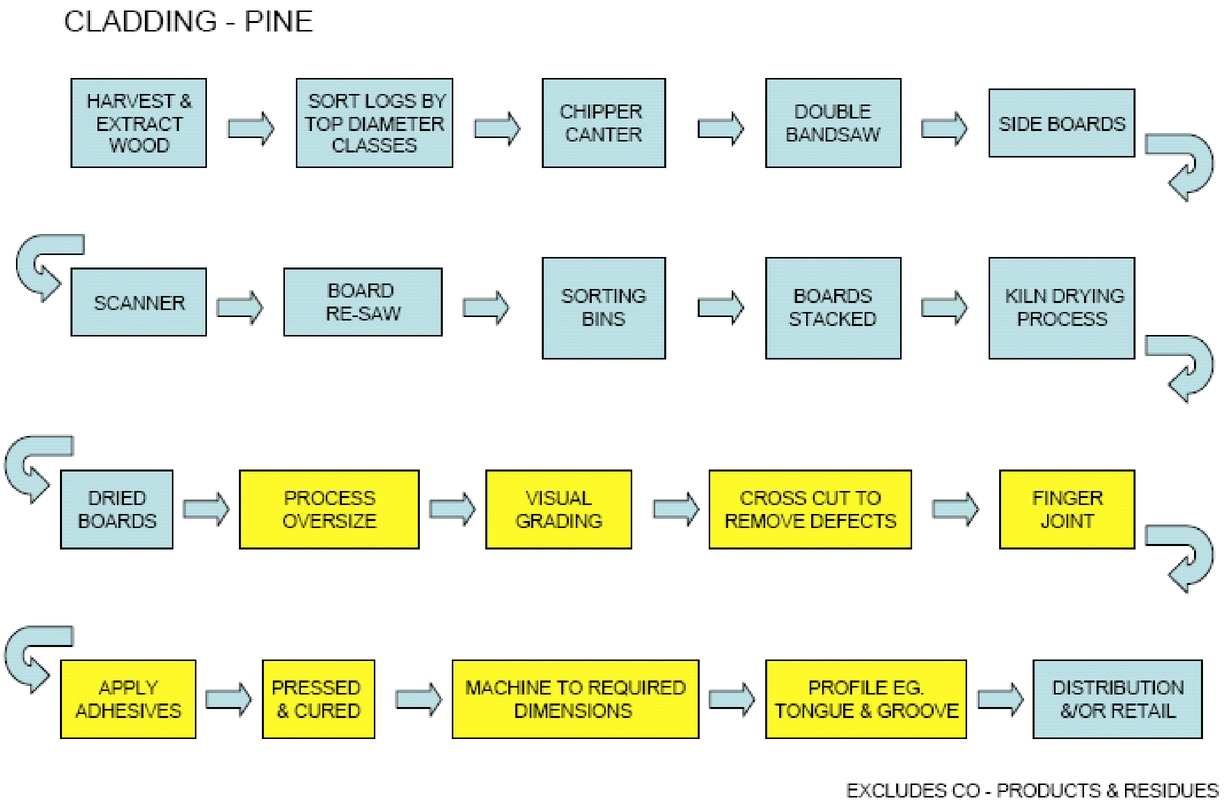
[63] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

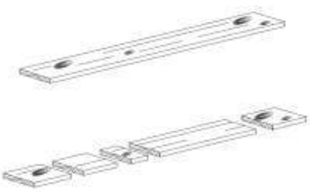
[64] Hardwood firewood at roadside. Personal communication Forestry Commission.

[65] Flooring product prices guides from www.flooringsupplies.co.uk

4.1.6. Supply Chain 6: Exterior cladding

Figure 23 shows the model supply chain for the production of cladding boards from selected timber. The boards are sawn and visually graded, a decision is then made on the grade of material for use and or the degree of defect cutting and finger jointing that is required to produce a sufficiently clear grade for the cladding end use. The boards are then profiled to produce cladding boards and in some cases may be treated to enhance performance (e.g. wood preservative, fire retardants, UV stabilisers). The technology of defect cutting and finger jointing is widely applied across the wood industry and is just starting to appear in UK wood processing.




Defect cut


Finger joint


Exterior wood cladding

Figure 23 *The conversion of timber into cladding boards in a model supply chain.*

The advantages of such a product include the following opportunities:

- Excellent treatability of Corsican pine
- Potential to defect cut and finger joint
- Modification to existing supply chain rather than new supply chain
- Product range can be diverse – basic boards to factory finished systems

The basic specialist equipment that is required to manufacture cladding boards would cost approximately £75,000[66] comprising:

- Defect cutting saw (£15,000) - manual feed)
- Finger jointer (finger jointer £30,000 joint press £27,000 glue spray - manual £2,500)

Additional employment per facility is estimated to be 6 people based on a single operator for each piece of specialist equipment plus two shifts of 2 people to feed and operate the finger jointing.

The key market drivers for this type of product will be the enhanced performance characteristics compared to an existing product (e.g. aesthetic appeal, dimensional stability) and its lower embodied carbon. This will include better surface characteristics, better appearance, long maintenance intervals for coatings and enhanced stability.

The value proposition is considered to be good. The stump value of a tree is £10/m^3 [67] rising to £37/m^3 [68] for the green roundwood at road side. The process of sawing, selecting, defect cutting and finger jointing produces a cladding section of estimated value of £250/m^3. It is envisaged that the cladding board could then be incorporated into existing joinery manufacture within the region to produce a high value wooden cladding. The cladding boards would not require significant further processing or handling to provide a basic product yielding a value of £300/m^3 on the trade market. If the cladding product was 18mm thick then 1m^3 would provide 55m^2 of cladding at £5.5/m^2. The retail value based on a fully factory coated cladding system with fixings could be significantly in excess of the basic wood product around £50/m^2 which converts to £2750/m^3 of wood. These figures compare favourably to treated pine cladding at £13/m^2 and western red cedar at approximately £40/m^2 [69].

[66] BRE report 219-008 Green gluing feasibility study. Greenwood Community Forest Partnership

[67] Conifer stump value of tree is £9.72 www.forestry.gov.uk/statistics Timber prices indices March 2010. Hardwood likely to be higher.

[68] Hardwood firewood at roadside. Personal communication Forestry Commission.

[69] Prices for timber cladding www.russwood.co.uk

5. Testing the strength of Corsican Pine

5.1. Study Structure

An evaluation of the existing strength qualities of Corsican pine associated with Red Band Needle Blight (RBNB) has been identified as a fundamental barrier that needs to be addressed as priority. This task is constructing a sample collected from as wide an area as possible, to reflect the incidence of RBNB in southern England. This includes material from Cannock Chase (West Midlands) and the New Forest (South East) as well as Thetford Forest (East of England). The material has been tested to destruction at the BRE laboratories in Hertfordshire following the procedures in BS EN 408[70] to determine strength, modulus of elasticity and density. The analysis of the resultant data will be according to BS EN 384[71].

From the strength data generated the characteristic values for the sample can be determined to give the innate strength stiffness and density for the material. This has been carried out on the data from the BRE data base and the results compared statistically. Both sets of data can also be graded against the current machine setting for “British pine” C16 and each samples characteristic values determined and again compared statistically based on the actual sample distributions obtained. This would give a valid indication as to the effect of RBNB upon the structural properties.

5.1.1. Review of the properties of Corsican pine – both infected and un-infected by red band needle blight.

The influence of red band needle blight on the properties of UK grown Corsican pine were not fully understood before this work was carried out, but now there is a clearer insight into how the disease affects strength and density, in particular, of the timber from infected trees.

Corsican pine is an important commercial species for the East of England along with Scots pine and a disease that could have an adverse impact on the properties of the timber is unwelcome. Stakeholders, buyers and users of the timber need to be aware of the influences the disease has and how it is likely to affect their commercial activities.

The investigation carried out on infected and un-infected timber sourced from the three locations within England and additionally bench marked against data for the national supply dating from the 1970’s clearly shows that rather than having a dramatic impact on strength the disease, if any anything, may slightly improve strength and density.

The nature of the investigation using the three sites clearly demonstrated that the general trend was for infected material to yield the better results. As this was common to all three sites, great confidence can be placed in the results. The material from Thetford and the New Forest showed almost identical results; whilst the results form Cannock were in general lower in all respects and had a greater differential between the infected and un-infected material, as shown in **Figure 24**.

[70] British Standards Institution, London.
[71] British Standards Institution, London.

Source Geographical regions	Number of specimens	Strength (N/mm^2)	Stiffness (N/mm^2)	Density (kg/m^3)
Cannock	**66**	**76.68**	**8302**	**483**
	66	**59.2**	**6136**	**396**
Thetford	**66**	**84.72**	**9780**	**508**
	66	**83.41**	**8920**	**498**
New Forest	**66**	**80.39**	**9125**	**539**
	66	**78.2**	**9003**	**521**
National data (1970's)	**38 whole trees and 20 joists**	**81**	**9200**	**481**
	Infected material		Un-infected	

Figure 24 *Comparison of results for the three geographical sites and the national data from the 1970's*

The comparison of the national data from the 1970's with the results of the three geographical regions demonstrated that the infected material still matched or was a slight improvement on the results from the historical data in terms of strength and density. The stiffness is slightly lower overall but this is not considered to be significant. It was important when comparing historical data with recently carried out research to ensure that any differences detected are due to the causative agent being investigated and is not a result of some other un-noted phenomenon. In this case the corroborative results of the three geographical sites adds confidence to the belief that the results obtained were correctly attributed to the influence red band needle blight and not some other feature of the data.

Whist material strength and density appear to be slightly improved by the influence of the disease the question of structural strength remained. However, Corsican pine has been investigated for structural properties in the 1990's and it was shown in that work that the greatest influences on the structural performance for Corsican pine was the size and frequency of the knot whorls. These occur at intervals of 400 to 800mm along the length of the logs and act to localise stresses due to the deviation of the grain around and through the knot whorls, making them the significant weak point. It is therefore considered that the influence of red needle blight is such that it would not influence or reduce the affect of the knot whorls; therefore structural strength would remain unaffected.

The influence on rate of growth is such that the disease reduces the rate of growth and reduces growth ring width but does not reduce the overall ratio of latewood to earlywood within the growth ring. It is the latewood that is the overall controlling factor in the density of the timber as it is where most of the wood substance is laid down. To the naked eye there appears to be more latewood in the un-infected growth rings. Examination under the microscope however shows that the growth rings of the un-infected timber showed a gradual transition from early wood to latewood with a large transition zone, whereas the infected timber shows an abrupt demarcation between the earlywood and the latewood. Though the transition zone looks similar to the mature latewood to the naked eye it is not as dense therefore giving a false indication as to the effective size of the latewood development. It is this influence on the latewood development that has maintained the overall density of the infected material and has a great bearing on the measured strength.

It is therefore considered that the influence of red band needle blight on the properties of Corsican pine is, overall, marginally beneficial. This suggests that for the log sizes investigated that the timber can continue to be used for the normal uses it has traditionally been put to and the manufactures can continue to use the material with no overall loss of quality to their product. It also allows those who wish to and do not do so already to either machine or visual strength grade the timber to meet structural requirements for construction timber.

Corsican pine is imported in to the East of England from the Cannock area; this was the region that showed the lowest values for strength, stiffness and density. From the results obtained for the three geographical sites it would beneficial for manufactures using material from Cannock to supplement their supply to purchase material from the New Forest in preference as this is almost identical to that from the Thetford region and is of overall better quality than the Cannock supply.

6. Preparing the Phase 2 Proposal

The Stakeholder event has brought forward a number of organisations and regional businesses that are keen to take forward initiatives with home-grown East of England timber. The project team propose around the table discussion on the best prospects for wood products in East of England to take forward to try and kick start the supply chains, creating wealth, jobs and lower impact buildings.

This report argues that there is increasing pressure on the existing managed woodland resource. There is not enough to meet the ambition for energy use and low impact construction products requiring more unmanaged woodland to be brought into production as well as increasing afforestation as recommended in the Read Report (2009). This report recommends that a balanced scorecard approach is used to provide clarity on strategies for the future. Such a balanced scorecard could include:

1. The percentage of the harvested timber in the resultant final product.
2. The products impact on available land use for future forestation.
3. The return on invested capital generated by individual products.
4. The extent to which the final products can be used to replace high CO_2 emitting traditional alternatives, such as steel, concrete and plastics.
5. The products CO_2 storage potential per m^3 of source timber, together with the length of time that storage is likely to last.
6. The products potential to create additional employment opportunities.

The proposed way forward is to seek key stakeholder support and develop a proposal for kick starting priority low carbon forest product supply chains in the region. A project consortium will be built and a proposal drafted alongside the establishment of advocacy group including local reference and early adopters. The platform of the stakeholder network and the rigor of the mapping exercise can be used to develop an integrated proposal for work to establish these product supply chains. Elements are likely to include:

- Bridging gaps in the knowledge of the resource
- Technical challenges for adding value to timber
- Best practicable options for the timber resource
- Supply chain modelling and reconfiguration
- Further production of demonstration products
- Demonstration buildings that are monitored
- Map and measure impact and carbon
- Marketing and branding input
- Management accounting and value engineering
- Stakeholder engagement and Steering Group
- Dissemination/Publication
- Codes and Standards
- Future proofing and horizon scanning
- Capital interventions and new processing capacity
- Knowledge transfer

7. CONCLUSION

The project presented in this report has concluded on a number of key points:

- The UK is the second largest net importer of timber in the world, by value, at US$ 11 billion per annum.

- There is approximately 144,000 hectares of woodland in the East of England, representing 7.6% of the land area. Approximately 26,000 hectares (18%) of this is managed by the Forestry Commission with the majority (82%) owned by other public bodies, charities or private companies and individuals. East of England woodland is very fragmented and of small block size with a total of 7,767 woods over 2 hectares with a mean wood area of 14.6 hectares.

- The region has a diverse woodland resource with broadleaved woodland the dominant forest type representing 61% of all woodland. Conifer woodland represents 22%, mixed woodland 11% and open space within woodlands and felled areas 6%. Corsican pine is the main conifer species and Oak the main broadleaf species.

- Despite the presence of Red Band Needle Blight (RBNB), this project has shown that the disease does not have a negative effect on the timber properties.

- Woodland and its forest products have a significant role in a low carbon economy. The estimated standing biomass/carbon stocks in the East of England amount to 8.4 million tonnes of carbon (MtC) or 30.7 million tonnes of carbon dioxide equivalent ($MtCO_2e$).This carbon sink can have an impact on carbon reduction targets if we maintain or increase our woodland and we use it in buildings as long service life construction products. In addition, the substitution effect of not using carbon intensive materials outweighs the carbon stored in the products[72].

- UK softwood usage in housing construction in 2007, totalled 6.4 million m^3 of which only 15%, or just below 1 million m^3, was produced in the UK, with 85% imported.

- The value of the market for sawn softwood in construction in the region is estimated to exceed £100 million per annum.

- The East of England either contains or is close to a number of growth zones (Cambridge, Milton Keynes, East Thames corridor) which will be significant users of timber in construction and in energy uses. New build housing need within the East of England over the period 2009 to 2021 is stated as being 349,000 new dwellings. If each of these dwellings uses an average of $2.8m^3$ of sawn softwood the total required over this period for new build would be 977,000 m^3. An estimated 10% of total timber consumption is in new build use with the rest in repairs, maintenance and improvements.

- Estimates from the Forestry Commission and the Private Sector suggest that from 2022 to 2026 there is approximately $365{,}000m^3$ roundwood softwood available per annum. In 2009 the softwood consumption by the existing sawmills was 146,000 green tonnes (for pine it is reasonable to say that 1 green tonne is equivalent to 1 m^3). Some of this capacity will be imported from other parts of the UK and abroad; some regional timber will be exported.

[72] Combating climate Change – a Role for UK Forests: www.forestry.gov.uk/readreport

- There is at least 200,000m^3 of additional softwood theoretically available by 2022-26 than currently milled. Estimates suggest that 29,000 green tonnes of softwood is used for biomass energy providing the opportunity for the remaining sawn softwood to provide timber for almost 36,000 new houses per annum if those homes were traditional brick and block houses or 10,000 new homes if they were timber framed houses.

- If innovative twin laminates form a structural frame and flooring as detailed in this report are selected then the 36,000 houses could store an additional 194,400tCO_2. This would also unlock a key substitution effect for replacing the blocks in the structure. A house with 60m^3 blocks in its walls has a net emission of 12tCO_2 per house associated with the embodied energy in the blocks. This equates to a saving of 432,000tCO_2 for 36,000 houses.

- Although biomass energy demand is likely to increase, conservative estimates of hardwood (broadleaved) timber indicate that there is at least 100,000m^3 of unutilised hardwood timber in the East of England plus a similar volume of wood that could be used sustainably for woodfuel.

This report has identified a number of barriers and opportunities:

- Timber technology can add to a limited managed resource in the region. Innovative engineering of wood can utilize more of the standing tree in the construction product; create more construction products per hectare of woodland and store more carbon in our buildings. One of the possible products studied was an innovative inside out beam. This beam uses 85% of the round wood in the final product. A square beam of equivalent performance uses no more than 50% of the round wood in the product. This is not in conflict with existing supply chains.

- The region can be creative with woodland resource and productivity but it needs a radical change in strategy. For example, if an inside out beam requires a tree of half the maturity of the equivalent square cut beam; in the same time period a hectare yields two times as many beams and possibly up to four times as many beams if planting density can be increased.

- Co-products from manufacture such as chips for panel products, biomass energy, animal bedding, surfacing and mulch have significant values and can influence whether or not product manufacture is profitable and thereby if the supply chain is viable.

- Corsican pine from Thetford forest is of sufficient quality to be used in a range of structural construction product end uses. It meets as a minimum machine strength grading “C16” class.

- This report argues that there is increasing pressure on the existing managed woodland resource. There is not enough to meet the ambition for energy use and low impact construction products requiring more unmanaged woodland to be brought into production as well as increasing afforestation. This report recommends that a balanced scorecard approach is used to provide clarity on strategies for the future. Such a balanced scorecard could include:

    vii. The percentage of the harvested timber in the resultant final product.

    viii. The products impact on available land use for future forestation.

    ix. The return on invested capital generated by individual products.

x. The extent to which the final products can be used to replace high CO_2 emitting traditional alternatives, such as steel, concrete and plastics.

xi. The products CO_2 storage potential per m^3 of source timber, together with the length of time that storage is likely to last.

xii. The products potential to create additional employment opportunities.

8. APPENDICES

8.1. Appendix A: Companies who participated in this project

Attendees for the Stakeholder Meeting Thursday May 27th

Ian	Alston	Honingham Thorpe Farm	Managing Director
Paul	Astle	Pick Everard	Graduate Engineer
Richard	Bland	Pattrick and Thompsons Ltd	Timber Engineering Sales
Oliver	Booth	Writtle Park	
Edward	Brun	Anglia Woodfuels Ltd	Chairman
Malcolm	Carrington	MCS	Owner
Claude	Choules	Big K Products UK Ltd	Timber Buyer
Alan	Corson	Forestry Commission	Marketing Officer England
Jason	Dorks	Howarth Timber Engineering Ltd.	Business Development Manager
Clive	Ellis	Woodland Management	
Andrew	Falcon		
Mizi	Fan	Brunel University	Head of Research, Civil Engineering
Steve	Fowkes	Forestry Commission	Policy & Programme Officer (Business & Markets)
Terry	Green	Flight Timber Products Ltd.	Business Development Manager
Brian	Griffiths	Westbank Timber Ltd	Managing Director
Ross	Guyton	Landmarc Support Services Limited	Woodland Management & Arboricultural Advisor
Richard	Harris	University of Bath	Professor of Timber Engineering
Steve	Howard	The Brecks	RDP facilitator
John	Hutchinson	Parliamentary Estates	Conservation Architect
Lord Edward	Iveagh	Eleveden Estates	Owner
Julian	Jacob	Howarth Timber Engineering Ltd.	Buyer
Neil	Jarvis	Forestry Commission	Woodland Officer, Norfolk
Terry	Jennings	Forestry Commission	Public Forest Estate Operations Manager East of England
Julian	Kerby	Acermetric Ltd	Operations Manager

Paul	Kings	Purcell Miller Tritton LLP	Architect
Diana	MacMullen	The Verderers Ltd	Director
Corinne	Meakins	Forestry Commission	Regional Development Advisor East of England
Marc	Mimeau	UPM Tilhill	Area Timber Harvesting Manager
Justin	Mumford	Lockart Garrett	ConFor
Trevor	Neve	Even Forestry Ltd	
Paul	Plummer	Norfolk Wood	
David	Prince	UPM Tilhill	Forest Manager
Caroline	Ramsay	Lovell	Chief Buyer
Mike	Render	Forestry Commission	Rural Development Advisor England
Trevor	Round	Big K Products UK Ltd	General Manager
Jim	Rudderham	Elveden Estate and Farms	Forestry & Conservation Manager
Ben	Rumbelow	Glazing Vision Ltd	
Leanne	Sargeant	Essex Wildlife Trust	Reserves Manager
Stewart	Schleip	Babergh	Open Space Manager
Nick	Seymour	The Naturist Foundation	
Michael	Smith	David Smith St. Ives Ltd.	Managing Director
Simon	Thompson	Sotterley Farms	Farm Manager
Mark	Wilkinson	TRADA	Head of Business Development
Cyril	Williams	Woodlink UK GmbH & Co. KG	
Matthew	Wood	Architect	Consultant

Other interviews include:

- Allen, T. Owner R.D.Wallers. Interviewed by: Binns, B; Haines, B; Holland, C (18th June 2010)
- Cushion, D, Owner Cushions. Interviewed by: Binns, B; Haines, B; Holland, C (18th June 2010)
- Jacob, J. Buyer Howarth Timber Engineering. Interviewed by: Binns, B (17th June 2010)
- Jones, M, Managing Director, Wherry Housing. Interviewed by Binns, B. (11th June 2010)
- Thomson, B, Owner of Thomson Sawmill. Interviewed by: Binns, B; Haines, B; Holland, C (18th June 2010)

8.2. Appendix B: Production Forecasting for the National Forest Estate – September 2009

Production Forecast Data

Table 1: Forestry Commission - Average Annual Felling Volumes (Thinning plus Final Fell) – Cubic Metres, Over Bark

** The period 2006-2006 covers 01APR2005 to 31MAR2006*

		PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	31,121	173	56	161	464	2,122
IN RANGE	2007-2011	32,027	206	119	213	219	1,179
7-14 CM	2012-2016	33,498	119	154	269	418	1,173
TOP DIAMETER	2017-2021	32,658	79	151	133	174	845
	2022-2026	29,151	67	121	216	188	762
	2027-2031	5,772	8	16	66	31	266
VOLUME	* 2006	18,346	179	40	110	647	1,356
IN RANGE	2007-2011	22,371	176	60	187	327	887
14-18 CM	2012-2016	26,074	100	98	312	583	997
TOP DIAMETER	2017-2021	27,465	67	72	139	220	792
	2022-2026	27,261	81	98	130	243	689
	2027-2031	8,074	10	23	60	43	270
VOLUME	* 2006	64,277	1,473	399	4,234	1,927	5,280
> 18 CM	2007-2011	77,484	995	802	3,132	1,811	4,952
TOP DIAMETER	2012-2016	88,741	1,045	882	6,408	5,508	5,971
	2017-2021	88,901	843	471	3,664	3,531	6,303
	2022-2026	98,572	892	770	3,941	4,558	7,002
	2027-2031	62,800	152	289	1,184	1,091	6,302
TOTAL VOLUME	* 2006	113,744	1,824	495	4,506	3,038	8,756
TO 7 CM	2007-2011	131,882	1,377	981	3,532	2,355	7,016
TOP DIAMETER	2012-2016	148,311	1,262	1,134	6,989	6,511	8,140
	2017-2021	149,021	991	695	3,936	3,923	7,941
	2022-2026	154,984	1,041	989	4,285	4,989	8,454
	2027-2031	76,645	170	329	1,310	1,165	6,838

TOTAL ALL SPECIES			
	TDC 7-14	TDC 14-16	TDC 18 +
2007-2011	33,959	24,007	89,175.0
2012-2016	35,631	28,164	108,554.0
2017-2021	34,041	28,755	103,713.0
2022-2026	30,505	28,500	115,735.0
2027-2031	6,161	8,477	71,818.0

Table 2: Private Sector - Average Annual Felling Volumes (Thinning plus Final Fell)

Summary per Species Group, Cubic Metres, Over Bark

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	BROADLEAVES	TOTAL
2010-2011	125.4	70,726.5	40,003.4	12,398.2	15,684.0	8,064.9	10,897.5	129.4	38,467.2	158,029.3
2012-2016	267.6	75,235.0	43,506.3	13,481.5	17,695.4	6,597.5	10,087.7	66.6	38,467.2	166,937.6
2017-2021	289.3	74,983.7	49,618.9	15,796.9	19,916.2	7,360.6	9,509.1	45.0	38,467.2	177,519.7
2022-2026	137.4	73,745.2	63,232.9	17,825.8	20,161.5	7,234.7	8,093.5	27.6	41,699.2	190,458.6
2027-2031	85.9	67,229.0	74,103.8	18,643.8	17,195.0	8,324.1	5,792.1	1.0	41,699.2	191,374.7
2032--2036	158.6	64,297.7	66,078.3	17,532.5	12,602.5	9,721.9	4,442.2	1.3	63,313.2	174,835.0

Summary per Top Diameter Class, Cubic Metres, Over Bark
(Softwood only)

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2010-2011	27,985.9	13,088.3	14,517.5	103,454.6	159,046.3
2012-2016	21,700.6	11,305.5	13,676.1	120,621.2	167,303.5
2017-2021	17,629.3	9,704.6	12,725.2	139,722.2	179,781.4
2022-2026	16,589.4	8,542.7	11,572.3	155,217.5	191,921.5
2027-2031	16,450.8	7,467.3	10,025.3	155,431.2	189,374.5
2032--2036	15,095.5	5,896.1	7,576.6	128,652.5	157,220.8

8.2.1. What is a Production Forecast?

In its broadest terms, the Production Forecast (PF) is an estimate of the future timber volumes arising from thinnings and fellings. In their simplest form, Production Forecasts from the National Forest Estate (NFE) are based on:

- the current stand structure including: species, age, yield class (estimate of productivity) and area;
- the planned management intent including: general management intent (e.g. clearfell or Continuous Cover), thinning regime and timing of any thinning and felling operations;
- growth and yield models estimating the production for a stand under specific management.

The Production Forecast is not a schedule of production and effectively provides a "first-cut" of the volume likely to be produced from an area under specific management.

8.2.2. The NFE Production Forecast

The NFE Production Forecast is based on:

- the land use and stand structure of the NFE for GB as described in the Sub-Compartment Database (SCDB).
- the planned management as agreed in the Forest Design Plans (FDPs) and held in the felling and thinning coupes in Forester[73].
- the FC growth and yield models are produced by the Forest Resources Evaluation Group within Forest Research.

8.2.3. NFE Stand Data

There are 29 Forest Districts (FDs) in GB These undertake the management of the NFE in their locality. As a consequence, the "live" stand (and management) data for the NFE is held by the local FD and they have responsibility for the timely maintenance of the data so that it is fit for the many purposes for which it is used. All changes to the stand structure resulting from either management action or as a consequence of an event such as windblow, must be made within 12 weeks or for the 31st March.

Inventory, Forecasting and Operational Support (IFOS) are responsible for setting the data standards and business rules that apply to the stand data[74]. IFOS also provide data integrity tools, collaborate with FC's Learning and Development staff to provide hands-on training and support for the overall system to ensure it is fit-for-purpose[75].
An annual GB dataset is created each year holding a "snapshot" of the NFE land holdings, stand structure and management plans as of 31st March. NFE forecasts are based on the most recent annual dataset.

8.2.4. NFE Management Data

As with the stand data, the management intent is held locally within the FD. The data are derived from the Forest Design Plans[76] with the approved design plan being captured and held in Forester. As part of the design planning process, the FD set up alternative design plan scenarios and produce a Production Forecast based on the alternative management to evaluate the impacts of the potential changes in management. Once a design plan has

[73] Forester is a bespoke GIS system written for the Forestry Commission, and used to store, manage and maintain the sub-compartment database, the Forest Design Plans, and many other data sets used to describe and manage the NFE. Forester also has a set of reporting tools one of which is the FC Production Forecast modelling and reporting system.
[74] Details of the SCDB and associated business rules can be found in Operational Guidance Booklet 6 and the Survey Handbook.
[75] Details of the requirements for forecasting can be found in Operational Guidance Booklet 32 Production Forecasting
[76] Refer to Operational Guidance Booklet 36 Forest Design Planning.

been approved, this becomes the “master” design plan and is used for the annual forecasts.

8.2.5. NFE Forecast Publication

The NFE forecast is published every 5 years along with forecasts for the private sector and Northern Ireland[77]. The most recent of these was published in 2005. The Forestry Commission also produces an annual forecast report distributed internally for the NFE, which is based on the most recent annual dataset.

IFOS will also supply production forecast reports for specific projects such as this analysis of the South West Woodlands Resource.

8.2.6. Basic Forecast Methodology

The data for the NFE Production Forecast program is collated by Forester into the various stand and management combinations. The forecast is calculated for each stand and then amalgamated to give the volumes arising from thinning and felling for the forecast area.

There are three basic methods for calculating the forecast depending on the management type defined with the Forest Design Plan. These are:

- Clearfell
- Low Impact Silvicultural System – “even number of trees”
- Low Impact Silvicultural System – “heavy thinning”

8.2.7. The basic steps in calculating a clearfell forecast are:

1. Apply business rules to the data to confirm that it is valid. Only stands where the combination of stand and management data is valid can be forecast.

2. If thinned, from the specified year of next thinning onwards:

    - At each thinning year, the program will read the thinning volume for the yield table age nearest to the age for the specified thinning.
    - The thinning DBHs will be calculated using an algorithm.

3. The felling volume will be calculated as the difference between the cumulative volume production from the yield table and the cumulative volume removed in thinnings. The felling DBH will be calculated using an algorithm.

4. The PF program will assume that the stand has been managed according to the regime described in the basic yield model. The program therefore estimates the cumulative volume of thinnings removed prior to clearfell as the sum of the specified future thinnings and an assumed pattern of historical thinnings based on the basic yield model. The pattern of historical thinnings exactly matches that shown in the yield table for years preceding the historical year.

[77] United Kingdom: New Forecast of Softwood Availability. Available from the FC Internet site at http://www.forestry.gov.uk/website/forestry.nsf/byunique/hcou-4u4jgx. A summary of the main results of the 2005 forecast for the UK was published in the October, 2006 edition of Forestry & British Timber.

8.2.8. The basic steps in calculating a Low Impact Silvicultural System – "even number of trees" forecast are:

1. Apply business rules to the data to confirm that it is valid. Only stands where the combination of stand and management data is valid can be forecast. All stands with this management must be thinned.

2. The way the program works out thinning volumes depends on the age of the component and the setting of two parameters referred to as:
   - Transformation Age
   - Transformation Thinning Intensity (TTI).

The Transformation Age is used to work out a time in the stand component's development when the process of conversion to LIS starts. These can be set locally to reflect local Forest District practice, or a set of default values can be used. The default values of Transformation Age are around the age of maximum mean annual increment.

3. The PF program then finds the specified thinning that occurs just before the Transformation Age.

4. From the specified year of next thinning up to but not including the year the stand reaches Transformation Age:
   - The thinning volumes will be read directly from the yield table;
   - The thinning DBHs will be calculated using an algorithm, but will be similar to those shown in the table.

5. From the year the stand reaches Transformation Age onwards:
   - Periodic thinning volumes are estimated as (TTI x 0.7 x Yield Class x Thinning Cycle) cubic metres per hectare (i.e. TTI times the MT intensity with due allowance for thinning cycle). The default setting for TTI is 2.0.
   - The thinning type is assumed to be neutral;
   - The thinning DBHs will be calculated using an algorithm.

6. There is no felling volume for this type of management. However, at some point, the process of transformation through thinning will result in the removal of the last trees forming the component, and the stand ceases to exist. The volume produced by this final thinning event will be calculated as the difference between the cumulative volume production and the cumulative volume removed in thinnings up to that point. Cumulative volume production is based on the pattern in the selected yield table but with increment adjustments to account for the intensity of thinnings specified as appropriate for the transformation period. The DBH of the final thinning will be calculated using an algorithm.

7. The PF program will assume that the stand has been managed according to the regime described in the basic yield model. The program therefore estimates the cumulative volume of thinnings removed prior to clearfell as the sum of the specified future thinnings and an assumed pattern of historical thinnings based on the basic yield model. The pattern of historical thinnings exactly matches that shown in the yield table for years preceding the historical year.

8.2.9. The basic steps in calculating a Low Impact Silvicultural System – “heavy thinning” forecast are:

1. Apply business rules to the data to confirm that it is valid. Only stands where the combination of stand and management data is valid can be forecast. All stands with this management must be thinned.

2. The way the program works out thinning volumes depends on the age of the component and the setting of a parameter referred to as Transformation Age.

The Transformation Age is used to work out a time in the stand component’s development when the process of conversion to LIS starts. These can be set locally to reflect local Forest District practice, or a set of default values can be used. The default values of Transformation Age are around the age of maximum mean annual increment.

3. The PF program then finds the specified thinning that occurs just before the Transformation Age.

4. From the specified year of next thinning up to but not including the year the stand reaches Transformation Age:
    - The thinning volumes will be read directly from the yield table;
    - The thinning DBHs will be calculated using an algorithm, but will be similar to those shown in the table.

5. From the year the stand reaches Transformation Age onwards:
    - The PF program works out the number of trees per hectare standing in the year of Transformation Age.
    - The PF program works out how many thinning events take place between this year and the specified felling year.
    - The PF program assumes that each thinning removes an equal proportion of the number of trees that were standing in the year the stand reaches Transformation Age.
    - The thinning type is assumed to be neutral.
    - The thinning volumes will be calculated based on projected stand volume increment, which is derived from estimates of cumulative volume production. Cumulative volume production is based on the pattern in the selected yield table but with increment adjustments to account for the intensity of thinnings specified as appropriate for the transformation period.
    - The thinning DBHs will be calculated using an algorithm.

6. Although a felling year is specified for this type of management, strictly speaking there is never a clearfell event, only a point in time when the last remaining trees of a given component are removed. Therefore, production in the specified felling year is reported by the PF program as a thinning, not a felling.

7. The PF program will assume that the stand has been managed according to the regime described in the basic yield model. The program therefore estimates the cumulative volume of thinnings removed prior to clearfell as the sum of the specified future thinnings and an assumed pattern of historical thinnings based on the basic yield model. The pattern of historical thinnings exactly matches that shown in the yield table for years preceding the historical year.

Lesley Halsall
Inventory, Forecasting and Operational Support 31st August 2009

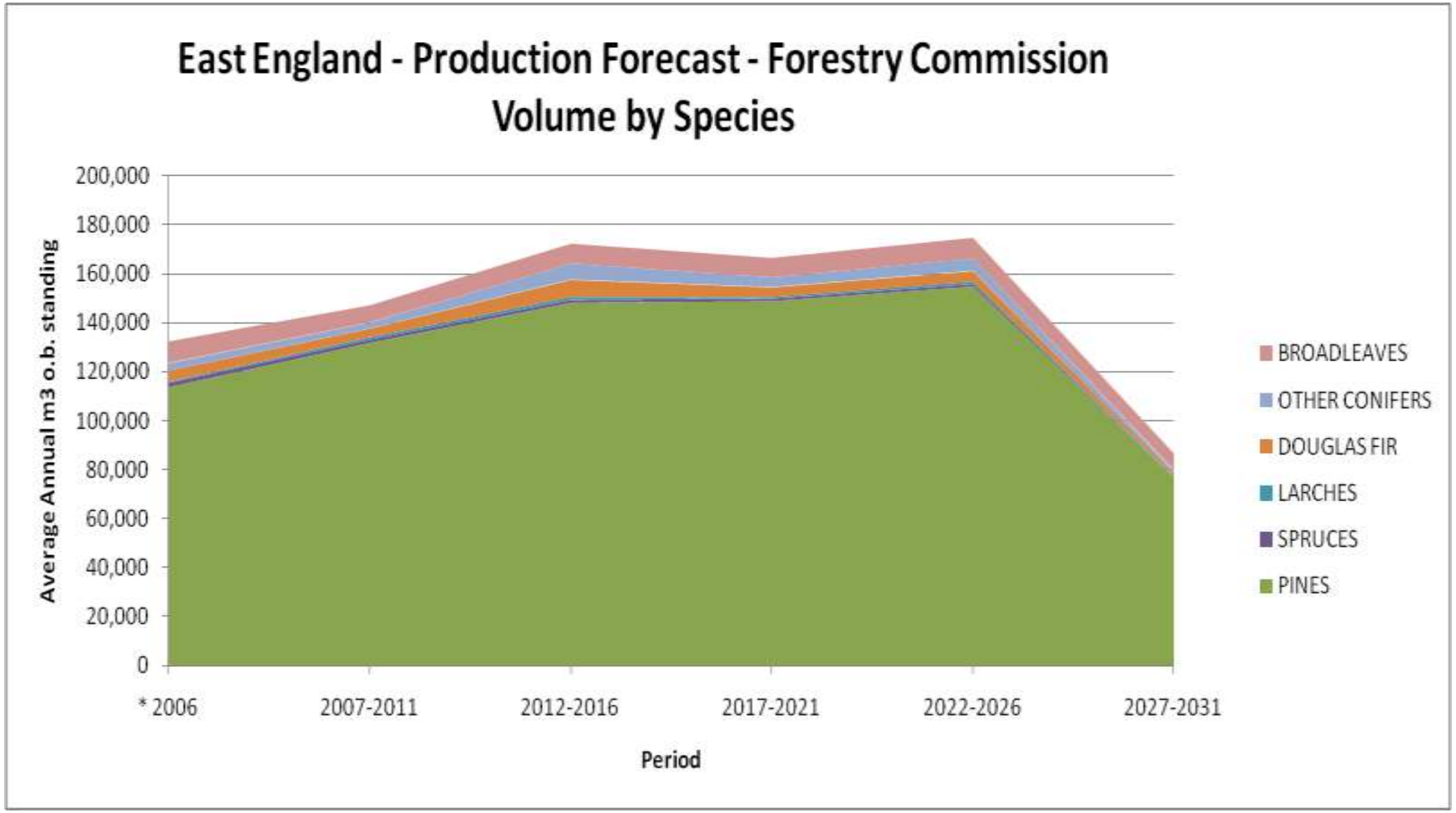
8.3. Appendix C: Production forecast - Forestry Commission Public Forest Estate in the East of England

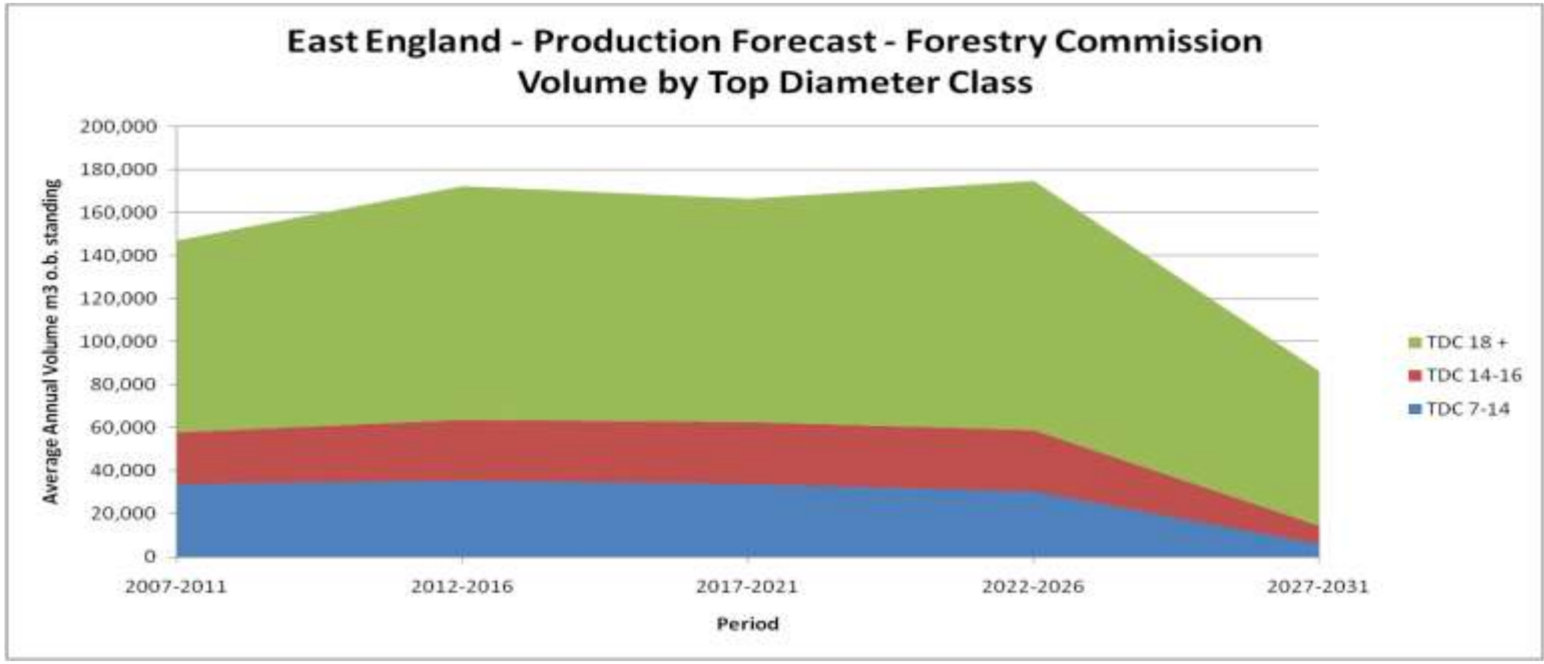
AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

		PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES		TDC 7-14	TDC 14-16	TDC 18 +
VOLUME	* 2006	113,744	1,824	495	4,506	3,038	8,756				
TO	2007-2011	131,882	1,377	981	3,532	2,355	7,016	2007-2011	33,959	24,007	89,175.0
7 CM	2012-2016	148,311	1,262	1,134	6,989	6,511	8,140	2012-2016	35,631	28,164	108,554.0
TOP DIAMETER	2017-2021	149,021	991	695	3,936	3,923	7,941	2017-2021	34,041	28,755	103,713.0
	2022-2026	154,984	1,041	989	4,285	4,989	8,454	2022-2026	30,505	28,500	115,735.0
	2027-2031	76,645	170	329	1,310	1,165	6,838	2027-2031	6,161	8,477	71,818.0

Territory: MULTI REGION 7:MAY:2010
Forest District: MULTI DISTRICT
Job Name:


East England - Production Forecast - Forestry Commission
Volume by Species
Average Annual m3 o.b. standing
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
* 2006
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
Period
BROADLEAVES
OTHER CONIFERS
DOUGLAS FIR
LARCHES
SPRUCES
PINES


East England - Production Forecast - Forestry Commission
Volume by Top Diameter Class
Average Annual Volume m3 o.b. standing
200,000
180,000
160,000
140,000
120,000
100,000
80,000
60,000
40,000
20,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
Period
TDC 18 +
TDC 14-16
TDC 7-14

BEDFORDSHIRE

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	176	98	74	0	0	0	24	78
IN RANGE	2007-2011	454	360	221	96	8	8	28	95
7-14 CM	2012-2016	371	285	193	63	7	6	17	86
TOP DIAMETER	2017-2021	213	154	109	21	7	2	15	59
	2022-2026	147	91	62	12	6	3	9	56
	2027-2099	14	7	4	2	0	0	1	7
VOLUME	* 2006	192	151	116	0	0	0	35	41
IN RANGE	2007-2011	439	411	302	54	6	12	38	28
14-18 CM	2012-2016	353	336	254	42	4	9	27	17
TOP DIAMETER	2017-2021	219	183	137	21	4	2	20	36
	2022-2026	134	118	81	13	7	4	14	16
	2027-2099	14	8	5	2	0	0	1	6
VOLUME	* 2006	1,061	977	936	0	0	0	41	83
TO	2007-2011	2,367	2,288	1,930	85	55	59	160	79
18 CM	2012-2016	2,273	2,205	1,852	92	33	92	136	68
TOP DIAMETER	2017-2021	2,184	2,070	1,511	73	114	98	274	113
	2022-2026	1,360	1,300	938	44	57	78	184	60
	2027-2099	181	129	62	8	3	11	45	52
VOLUME	* 2006	1,428	1,226	1,126	0	0	0	100	202
TO	2007-2011	3,260	3,059	2,453	235	68	78	226	201
7 CM	2012-2016	2,997	2,827	2,298	196	44	107	181	171
TOP DIAMETER	2017-2021	2,616	2,408	1,757	115	125	102	309	208
	2022-2026	1,642	1,509	1,080	70	70	84	206	132
	2027-2099	210	145	71	11	3	12	47	65

Territory:	MULTI REGION	Run Date:	7:MAY:2010
Forest District:	MULTI DISTRICT	Comments:	
Job Name:		Design Plan:	

CAMBRIDGESHIRE

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	626	497	457	11	1	0	28	129
IN RANGE	2007-2011	139	71	67	1	0	0	3	69
7-14 CM	2012-2016	100	68	65	1	0	0	2	32
TOP DIAMETER	2017-2021	86	51	49	0	0	0	1	35
	2022-2026	56	41	40	0	0	0	1	14
	2027-2099	6	1	1	0	0	0	0	5
VOLUME	* 2006	699	668	605	17	2	0	44	32
IN RANGE	2007-2011	154	74	68	1	0	0	5	80
14-18 CM	2012-2016	128	88	83	2	0	0	3	39
TOP DIAMETER	2017-2021	115	63	61	0	0	0	2	52
	2022-2026	86	62	60	1	0	0	1	23
	2027-2099	8	2	2	0	0	0	0	7
VOLUME	* 2006	2,403	2,338	2,029	184	11	0	115	65
TO	2007-2011	479	225	195	3	2	0	25	254
18 CM	2012-2016	1,173	981	906	49	1	0	25	192
TOP DIAMETER	2017-2021	1,339	865	837	4	1	0	24	474
	2022-2026	826	714	677	14	1	0	22	112
	2027-2099	181	16	14	0	0	0	2	166
VOLUME	* 2006	3,728	3,502	3,091	211	14	0	186	226
TO	2007-2011	772	370	330	4	2	0	33	402
7 CM	2012-2016	1,401	1,138	1,054	52	2	0	30	263
TOP DIAMETER	2017-2021	1,540	979	946	4	1	0	27	561
	2022-2026	967	818	778	15	1	0	24	150
	2027-2099	196	19	17	0	0	0	2	177

Territory:	MULTI REGION	Run Date:	7:MAY:2010
Forest District:	MULTI DISTRICT	Comments:	
Job Name:		Design Plan:	

ESSEX

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	345	32	12	4	0	0	16	313
IN RANGE	2007-2011	185	93	48	32	0	1	11	92
7-14 CM	2012-2016	107	75	63	7	2	2	1	32
TOP DIAMETER	2017-2021	98	72	44	12	0	5	12	26
	2022-2026	76	37	20	16	1	0	1	39
	2027-2099	6	1	1	0	0	0	0	5
VOLUME	* 2006	397	51	17	7	0	0	27	347
IN RANGE	2007-2011	205	138	71	48	1	1	18	67
14-18 CM	2012-2016	160	108	91	10	3	2	2	52
TOP DIAMETER	2017-2021	118	85	49	12	0	6	18	33
	2022-2026	79	50	21	27	1	0	1	29
	2027-2099	6	1	0	0	0	0	1	6
VOLUME	* 2006	637	361	218	56	0	0	87	276
TO	2007-2011	2,191	2,044	1,373	537	4	25	105	147
18 CM	2012-2016	2,197	2,013	1,568	341	29	36	39	184
TOP DIAMETER	2017-2021	3,020	2,776	1,904	431	3	155	283	243
	2022-2026	1,455	1,103	885	162	15	0	40	352
	2027-2099	185	34	11	4	0	2	16	151
VOLUME	* 2006	1,379	444	248	67	0	0	130	935
TO	2007-2011	2,581	2,275	1,492	617	5	28	133	306
7 CM	2012-2016	2,464	2,196	1,722	358	33	40	43	268
TOP DIAMETER	2017-2021	3,235	2,933	1,997	455	4	166	313	302
	2022-2026	1,610	1,190	926	205	16	0	43	420
	2027-2099	198	36	12	4	0	2	17	162

Territory:	MULTI REGION	Run Date:	7:MAY:2010
Forest District:	MULTI DISTRICT	Comments:	
Job Name:		Design Plan:	

HERTFORDSHIRE

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	1,260	144	18	86	4	1	35	1,116
IN RANGE	2007-2011	407	166	86	22	23	10	25	241
7-14 CM	2012-2016	257	134	93	4	6	8	24	122
TOP DIAMETER	2017-2021	257	128	93	7	9	4	16	128
	2022-2026	172	107	55	4	3	7	37	65
	2027-2099	30	10	3	1	1	1	3	20
VOLUME	* 2006	903	134	30	40	5	1	57	769
IN RANGE	2007-2011	355	214	129	16	18	16	35	141
14-18 CM	2012-2016	310	206	150	6	4	14	33	105
TOP DIAMETER	2017-2021	268	120	84	11	8	5	11	148
	2022-2026	194	124	64	7	2	10	41	70
	2027-2099	34	13	5	1	2	1	4	21
VOLUME	* 2006	2,275	641	166	286	10	1	178	1,635
TO	2007-2011	2,082	1,814	1,128	63	433	72	119	268
18 CM	2012-2016	2,271	1,756	1,227	42	34	116	336	516
TOP DIAMETER	2017-2021	2,291	1,761	1,205	210	42	143	161	530
	2022-2026	2,414	1,809	803	136	31	173	666	605
	2027-2099	833	295	76	61	23	36	99	538
VOLUME	* 2006	4,439	918	214	412	20	2	270	3,520
TO	2007-2011	2,844	2,194	1,343	102	474	98	178	650
7 CM	2012-2016	2,838	2,096	1,469	52	44	138	393	742
TOP DIAMETER	2017-2021	2,815	2,009	1,382	229	59	152	187	806
	2022-2026	2,780	2,040	922	147	37	190	744	740
	2027-2099	896	318	83	64	26	38	107	578

Territory:	MULTI REGION	Run Date:	7:MAY:2010
Forest District:	MULTI DISTRICT	Comments:	
Job Name:		Design Plan:	

NORFOLK

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	4,110	4,020	3,876	5	9	90	40	90
IN RANGE	2007-2011	19,583	19,269	19,035	49	32	58	97	314
7-14 CM	2012-2016	19,221	18,419	17,829	24	58	175	333	802
TOP DIAMETER	2017-2021	17,381	17,078	16,907	15	30	43	83	302
	2022-2026	18,621	18,113	17,870	12	31	110	89	509
	2027-2099	3,502	3,352	3,294	2	5	32	19	150
VOLUME	* 2006	3,747	3,683	3,525	7	14	77	60	64
IN RANGE	2007-2011	13,950	13,710	13,398	49	28	83	152	240
14-18 CM	2012-2016	16,024	15,312	14,557	24	64	213	454	712
TOP DIAMETER	2017-2021	15,723	15,470	15,256	17	24	55	118	252
	2022-2026	17,515	17,021	16,759	17	38	93	115	494
	2027-2099	4,759	4,601	4,538	3	7	28	25	158
VOLUME	* 2006	32,863	30,681	26,131	93	263	3,554	640	2,183
TO	2007-2011	47,343	45,657	42,732	270	237	1,488	929	1,686
18 CM	2012-2016	67,842	63,522	54,368	279	717	4,082	4,076	4,320
TOP DIAMETER	2017-2021	54,814	52,877	49,494	103	229	1,391	1,660	1,937
	2022-2026	78,380	73,193	67,267	297	584	3,111	1,934	5,186
	2027-2099	40,371	36,676	35,169	49	138	663	658	3,694
VOLUME	* 2006	40,721	38,384	33,531	105	285	3,722	741	2,337
TO	2007-2011	80,877	78,636	75,165	368	297	1,629	1,178	2,240
7 CM	2012-2016	103,086	97,253	86,754	327	839	4,470	4,863	5,834
TOP DIAMETER	2017-2021	87,918	85,426	81,656	135	283	1,490	1,861	2,492
	2022-2026	114,516	108,327	101,897	326	653	3,313	2,138	6,189
	2027-2099	48,632	44,630	43,002	54	150	722	701	4,003

Territory:	MULTI REGION	Run Date:	7:MAY:2010
Forest District:	MULTI DISTRICT	Comments:	
Job Name:		Design Plan:	

SUFFOLK

AVERAGE ANNUAL THINNING PLUS FELLING VOLUMES - CUBIC METRES, OVER BARK

* The period 2006-2006 covers 01APR2005 to 31MAR2006

	FORECAST PERIOD	TOTAL FOR ALL SPECIES	TOTAL FOR CONIFERS	PINES	SPRUCES	LARCHES	DOUGLAS FIR	OTHER CONIFERS	BROADLEAVES
VOLUME	* 2006	27,581	27,185	26,684	67	42	70	321	396
IN RANGE	2007-2011	13,191	12,823	12,570	6	56	136	55	368
7-14 CM	2012-2016	15,575	15,476	15,255	20	81	78	41	99
TOP DIAMETER	2017-2021	16,006	15,711	15,456	24	105	79	47	295
	2022-2026	11,433	11,355	11,104	23	80	96	51	79
	2027-2099	2,603	2,524	2,469	3	10	33	8	79
VOLUME	* 2006	14,739	14,636	14,053	108	19	32	424	103
IN RANGE	2007-2011	8,904	8,572	8,403	8	7	75	79	331
14-18 CM	2012-2016	11,189	11,117	10,939	16	23	74	64	72
TOP DIAMETER	2017-2021	12,312	12,041	11,878	6	36	71	51	271
	2022-2026	10,492	10,435	10,276	16	50	23	71	57
	2027-2099	3,656	3,584	3,524	4	14	31	12	72
VOLUME	* 2006	38,349	37,311	34,797	854	115	679	866	1,038
TO	2007-2011	34,713	32,195	30,126	37	71	1,488	473	2,518
18 CM	2012-2016	32,798	32,107	28,820	242	68	2,082	896	691
TOP DIAMETER	2017-2021	40,065	37,059	33,950	22	82	1,877	1,129	3,006
	2022-2026	31,300	30,613	28,002	239	82	579	1,712	687
	2027-2099	30,067	28,366	27,468	30	125	472	271	1,701
VOLUME	* 2006	80,668	79,132	75,534	1,029	176	782	1,611	1,536
TO	2007-2011	56,807	53,591	51,099	51	135	1,699	607	3,217
7 CM	2012-2016	59,561	58,700	55,014	277	172	2,234	1,001	862
TOP DIAMETER	2017-2021	68,384	64,811	61,283	53	223	2,026	1,226	3,572
	2022-2026	53,226	52,403	49,381	278	212	698	1,834	823
	2027-2099	36,327	34,474	33,460	37	150	536	291	1,853

Territory: MULTI REGION Run Date: 7:MAY:2010
Forest District: MULTI DISTRICT Comments:
Job Name: Design Plan:

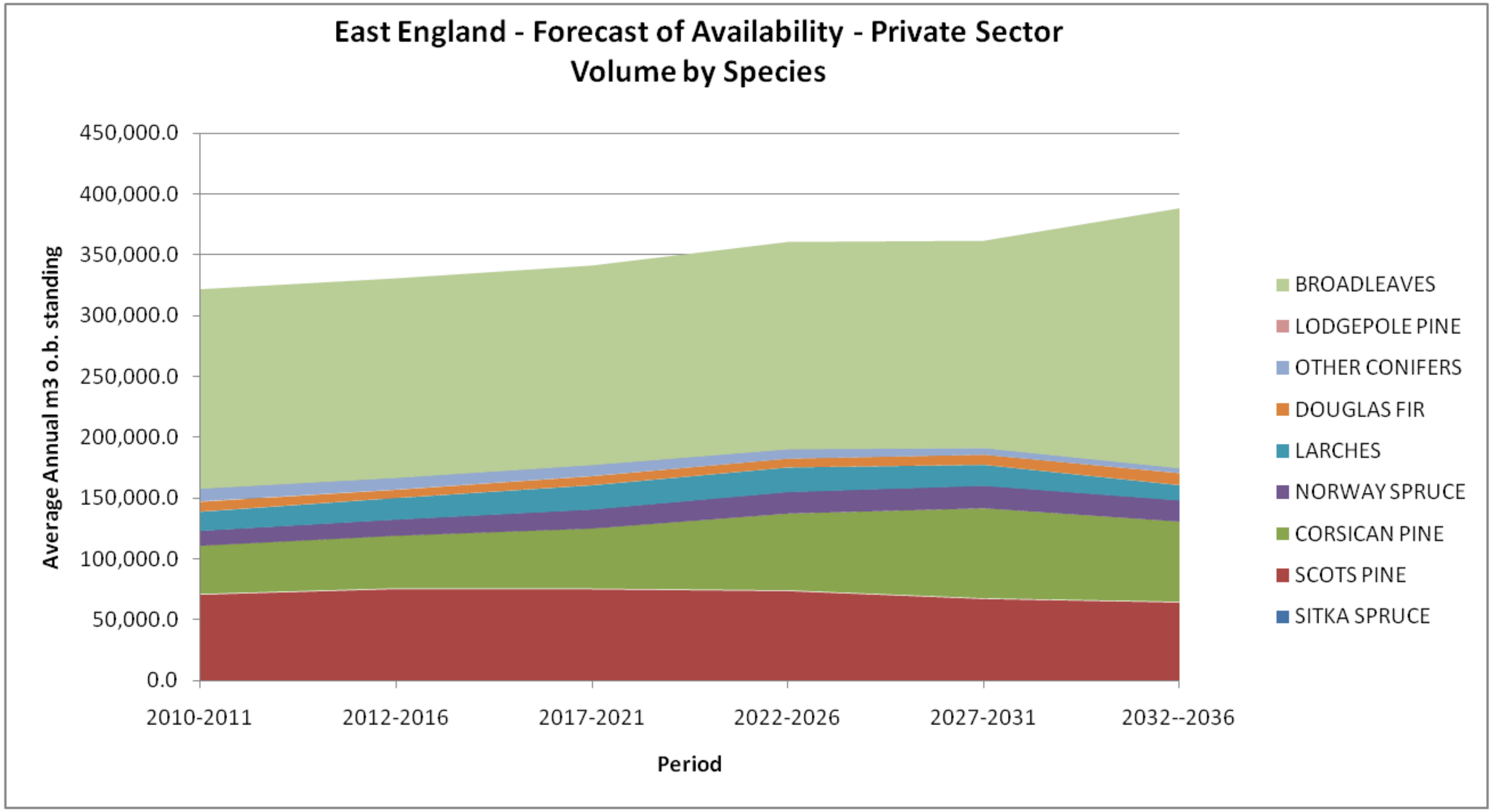
8.4. Appendix D: Production forecast – Private sector in the East of England

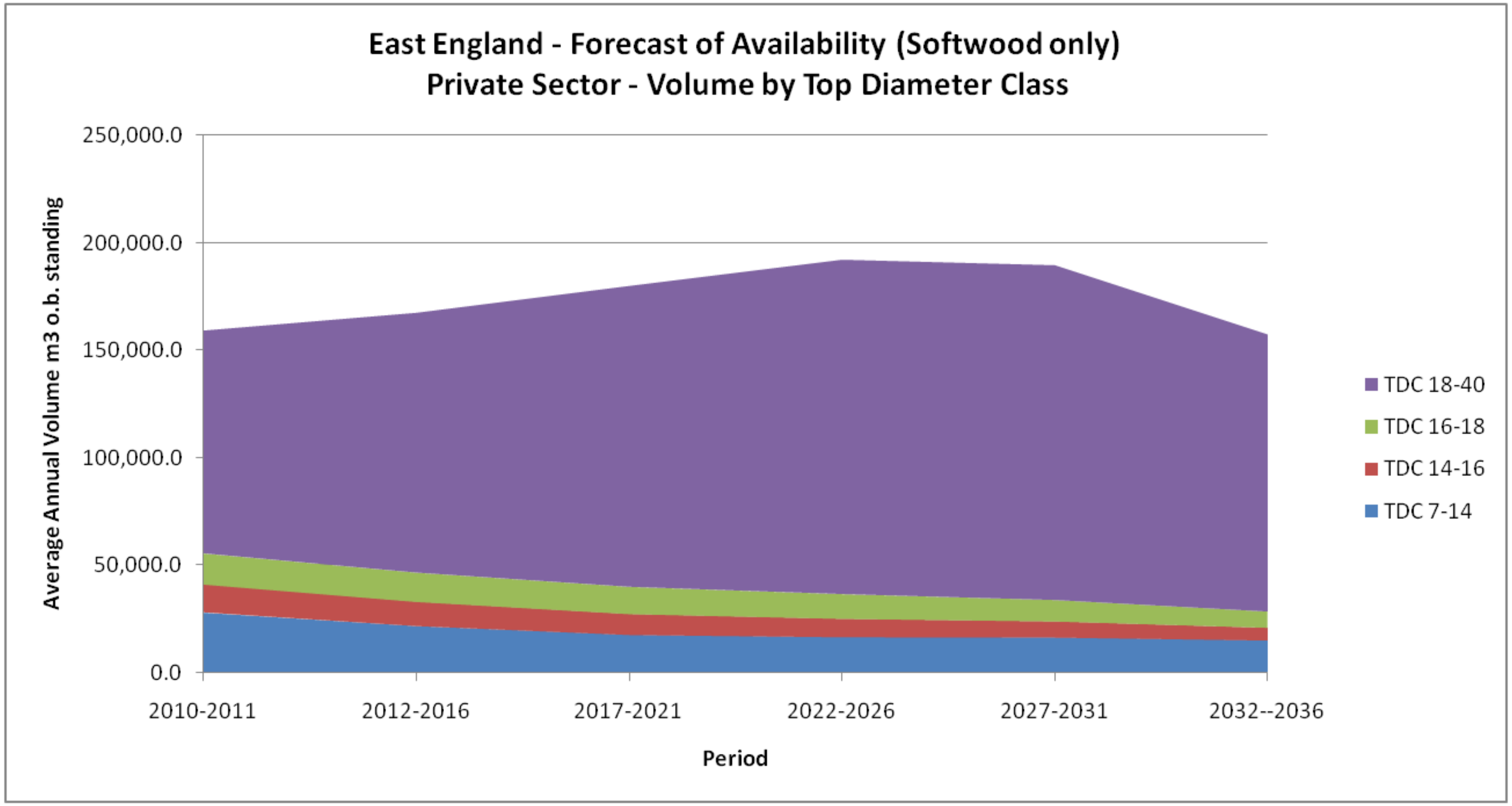
East England - Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	BROADLEAVES	TOTAL
2010-2011	125.4	70,726.5	40,003.4	12,398.2	15,684.0	8,064.9	10,897.5	129.4	164,088.4	322,117.7
2012-2016	267.6	75,235.0	43,506.3	13,481.5	17,695.4	6,597.5	10,087.7	66.6	164,088.4	331,026.0
2017-2021	289.3	74,983.7	49,618.9	15,796.9	19,916.2	7,360.6	9,509.1	45.0	164,088.4	341,608.1
2022-2026	137.4	73,745.2	63,232.9	17,825.8	20,161.5	7,234.7	8,093.5	27.6	170,552.4	361,011.0
2027-2031	85.9	67,229.0	74,103.8	18,643.8	17,195.0	8,324.1	5,792.1	1.0	170,552.4	361,927.1
2032--2036	158.6	64,297.7	66,078.3	17,532.5	12,602.5	9,721.9	4,442.2	1.3	213,780.4	388,615.4

East England - Average Annual Thin Plus Fell TDC Volume Summary (Softwood only)

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2010-2011	27,985.9	13,088.3	14,517.5	103,454.6	159,046.3
2012-2016	21,700.6	11,305.5	13,676.1	120,621.2	167,303.5
2017-2021	17,629.3	9,704.6	12,725.2	139,722.2	179,781.4
2022-2026	16,589.4	8,542.7	11,572.3	155,217.5	191,921.5
2027-2031	16,450.8	7,467.3	10,025.3	155,431.2	189,374.5
2032--2036	15,095.5	5,896.1	7,576.6	128,652.5	157,220.8


East England - Forecast of Availability - Private Sector
Volume by Species
450,000.0
400,000.0
350,000.0
300,000.0
250,000.0
200,000.0
150,000.0
100,000.0
50,000.0
0.0
Average Annual m3 o.b. standing
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032--2036
Period
BROADLEAVES
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE

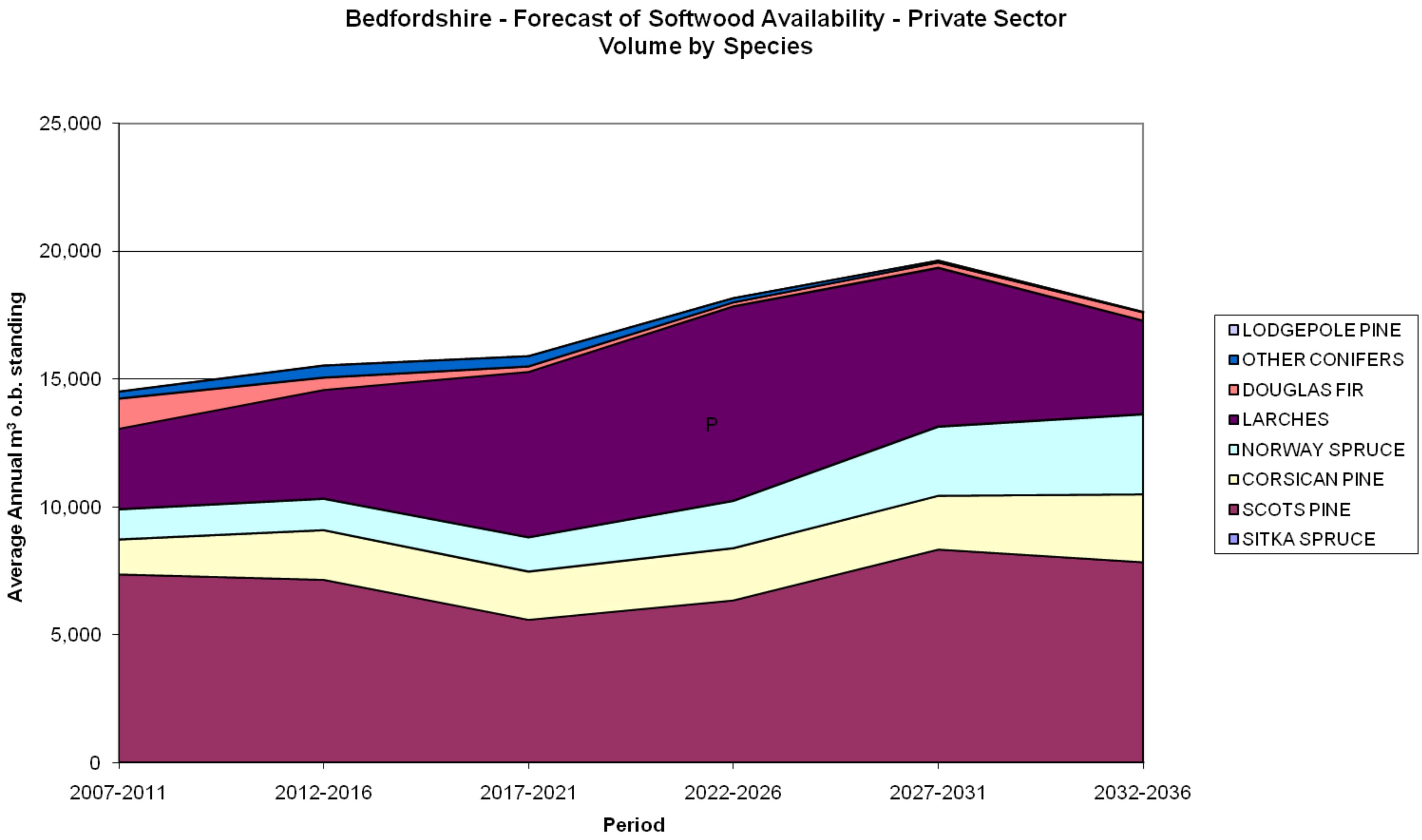

East England - Forecast of Availability (Softwood only)
Private Sector - Volume by Top Diameter Class
Average Annual Volume m3 o.b. standing
250,000.0
200,000.0
150,000.0
100,000.0
50,000.0
0.0
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032--2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14

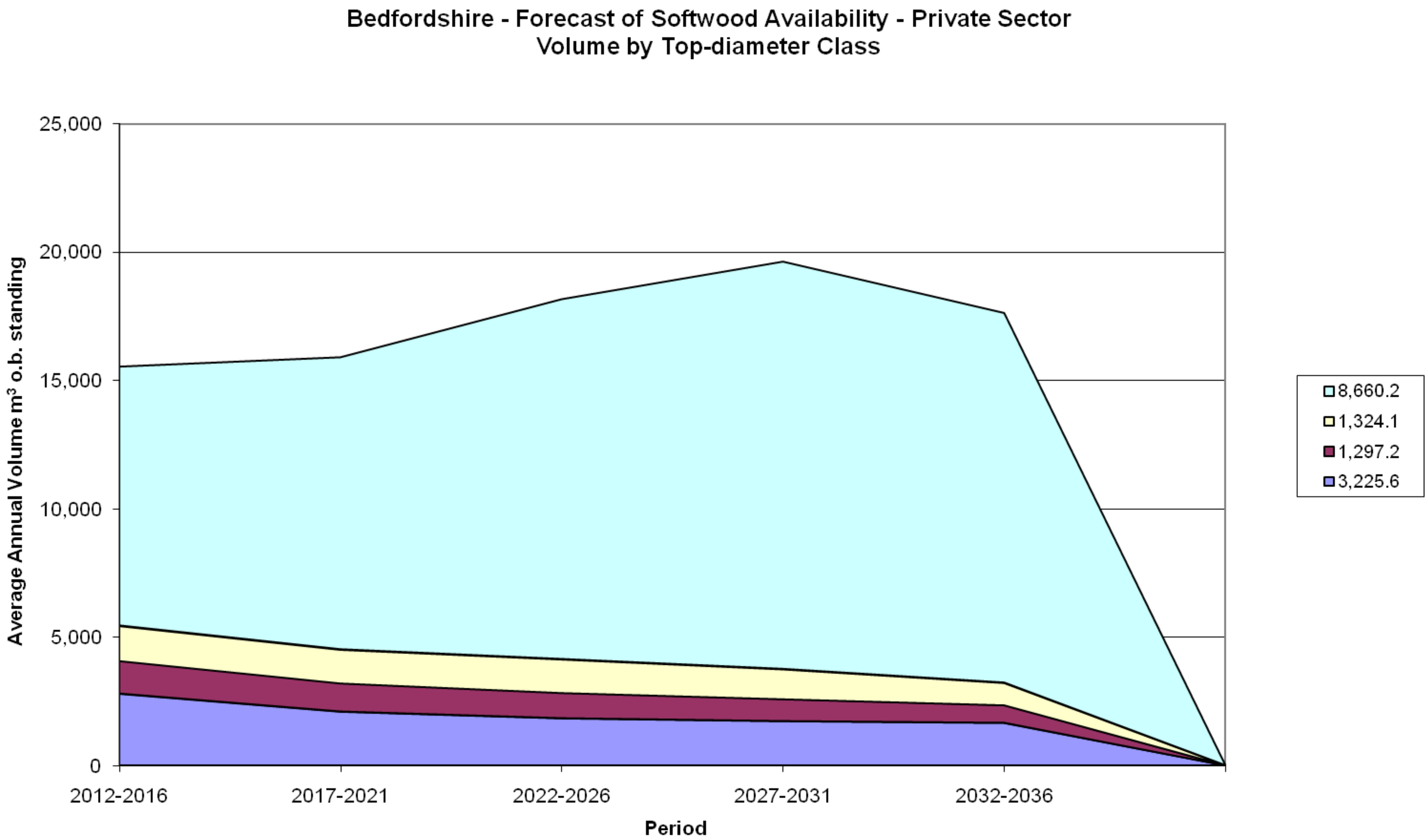
Bedfordshire - Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2007-2011	0.0	7,369.7	1,358.5	1,170.9	3,171.0	1,166.5	270.4	0.0	14,507.0
2012-2016	0.0	7,159.1	1,933.7	1,222.2	4,266.2	472.5	470.3	0.0	15,524.0
2017-2021	0.0	5,596.6	1,874.2	1,329.0	6,482.2	206.3	401.5	0.0	15,889.8
2022-2026	0.0	6,354.6	2,032.7	1,845.4	7,605.4	146.5	166.8	0.0	18,151.4
2027-2031	0.0	8,340.8	2,098.0	2,703.7	6,200.3	198.3	73.4	0.0	19,614.5
2032-2036	0.0	7,845.9	2,649.7	3,130.6	3,654.0	316.2	18.2	0.0	17,614.6

Bedfordshire - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2007-2011	3,225.6	1,297.2	1,324.1	8,660.2	14,507.0
2012-2016	2,796.3	1,281.4	1,367.7	10,078.6	15,524.0
2017-2021	2,097.8	1,105.3	1,314.4	11,372.4	15,889.8
2022-2026	1,837.6	991.5	1,311.3	14,010.9	18,151.3
2027-2031	1,728.3	856.9	1,168.4	15,861.0	19,614.5
2032-2036	1,659.5	691.9	870.3	14,392.7	17,614.4


Bedfordshire - Forecast of Softwood Availability - Private Sector
Volume by Species
Average Annual m³ o.b. standing
25,000
20,000
15,000
10,000
5,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
P
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE

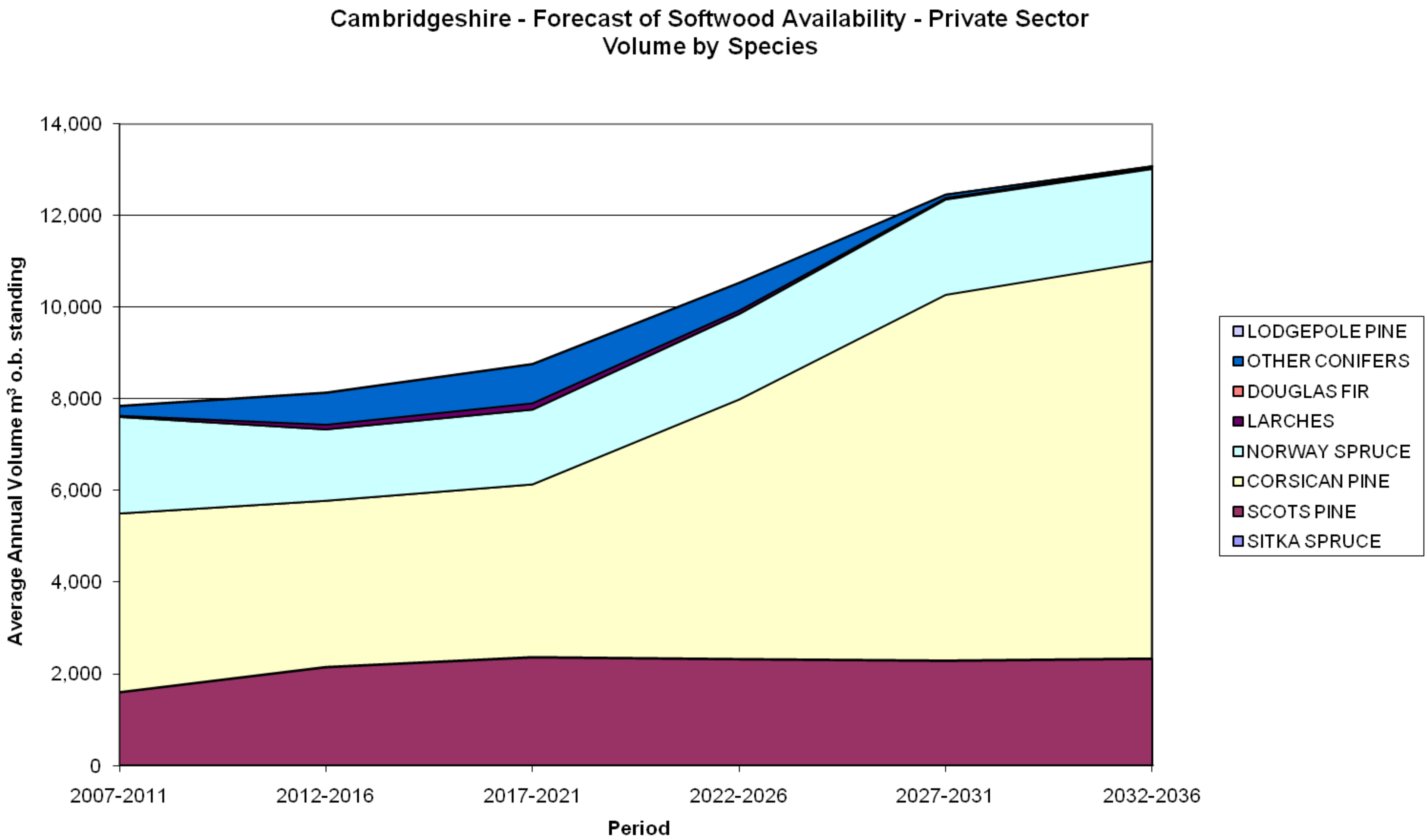

Bedfordshire - Forecast of Softwood Availability - Private Sector
Volume by Top-diameter Class
Average Annual Volume m³ o.b. standing
25,000
20,000
15,000
10,000
5,000
0
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
8,660.2
1,324.1
1,297.2
3,225.6

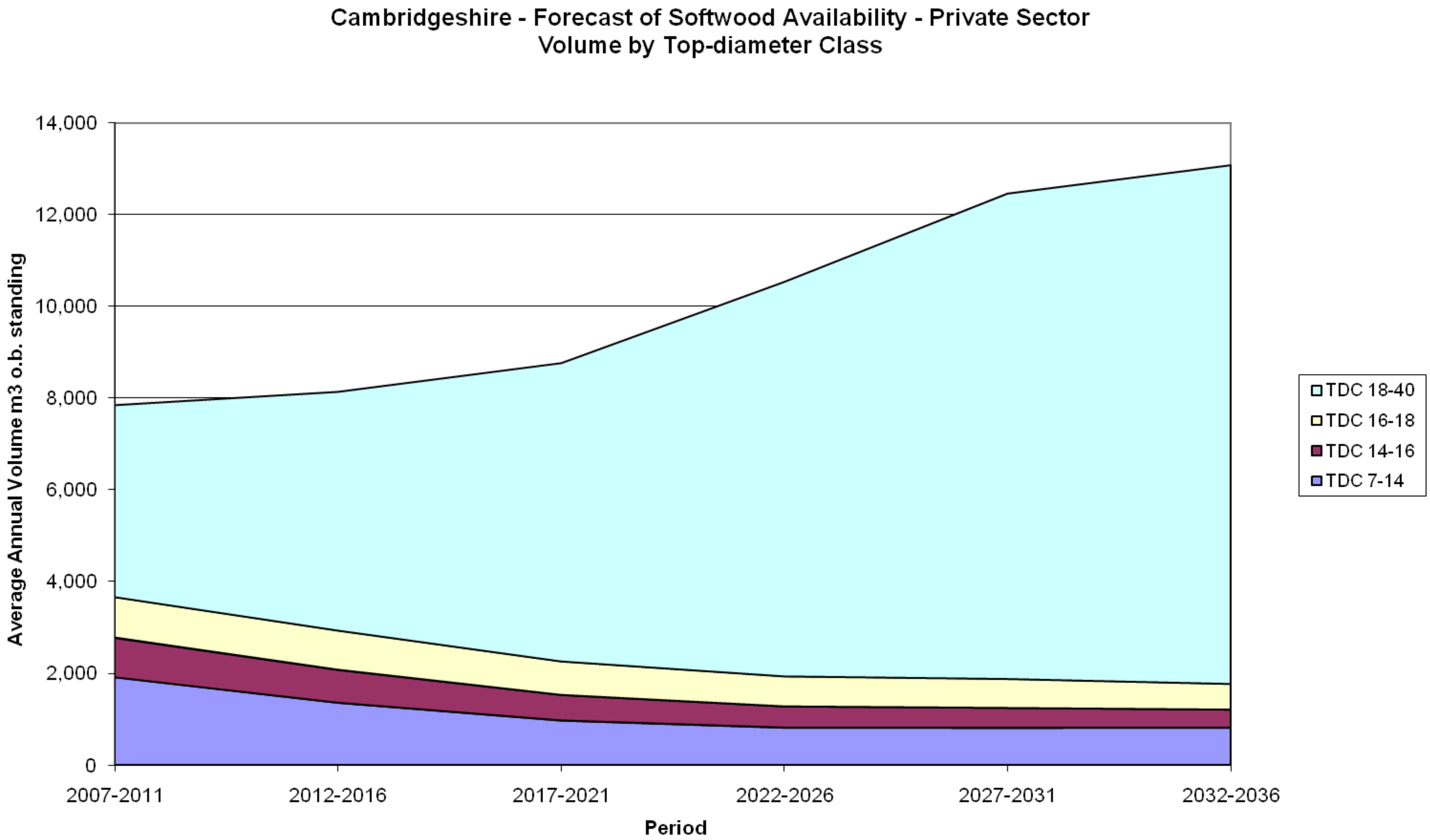
Cambridgeshire Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2007-2011	0.0	1,599.0	3,893.4	2,112.8	35.5	0.0	206.0	0.0	7,846.7
2012-2016	0.0	2,149.5	3,622.1	1,561.3	111.0	0.0	692.6	0.0	8,136.5
2017-2021	0.0	2,365.0	3,764.4	1,635.7	146.4	0.0	850.1	0.0	8,761.6
2022-2026	0.0	2,323.2	5,660.7	1,867.7	79.2	0.0	601.7	0.0	10,532.5
2027-2031	0.0	2,290.0	7,981.7	2,082.7	27.8	0.8	73.4	0.0	12,456.4
2032-2036	0.0	2,334.1	8,673.9	2,013.8	32.2	3.3	18.2	0.0	13,075.5

Cambridgeshire - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2007-2011	1,912.8	864.2	885.1	4,184.6	7,846.6
2012-2016	1,354.4	720.7	858.3	5,203.0	8,136.5
2017-2021	967.4	557.4	735.5	6,501.3	8,761.7
2022-2026	809.8	464.3	660.6	8,597.8	10,532.4
2027-2031	805.0	435.7	637.1	10,578.7	12,456.5
2032-2036	810.1	393.0	567.5	11,304.9	13,075.6


Cambridgeshire - Forecast of Softwood Availability - Private Sector
Volume by Species
Average Annual Volume m³ o.b. standing
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE

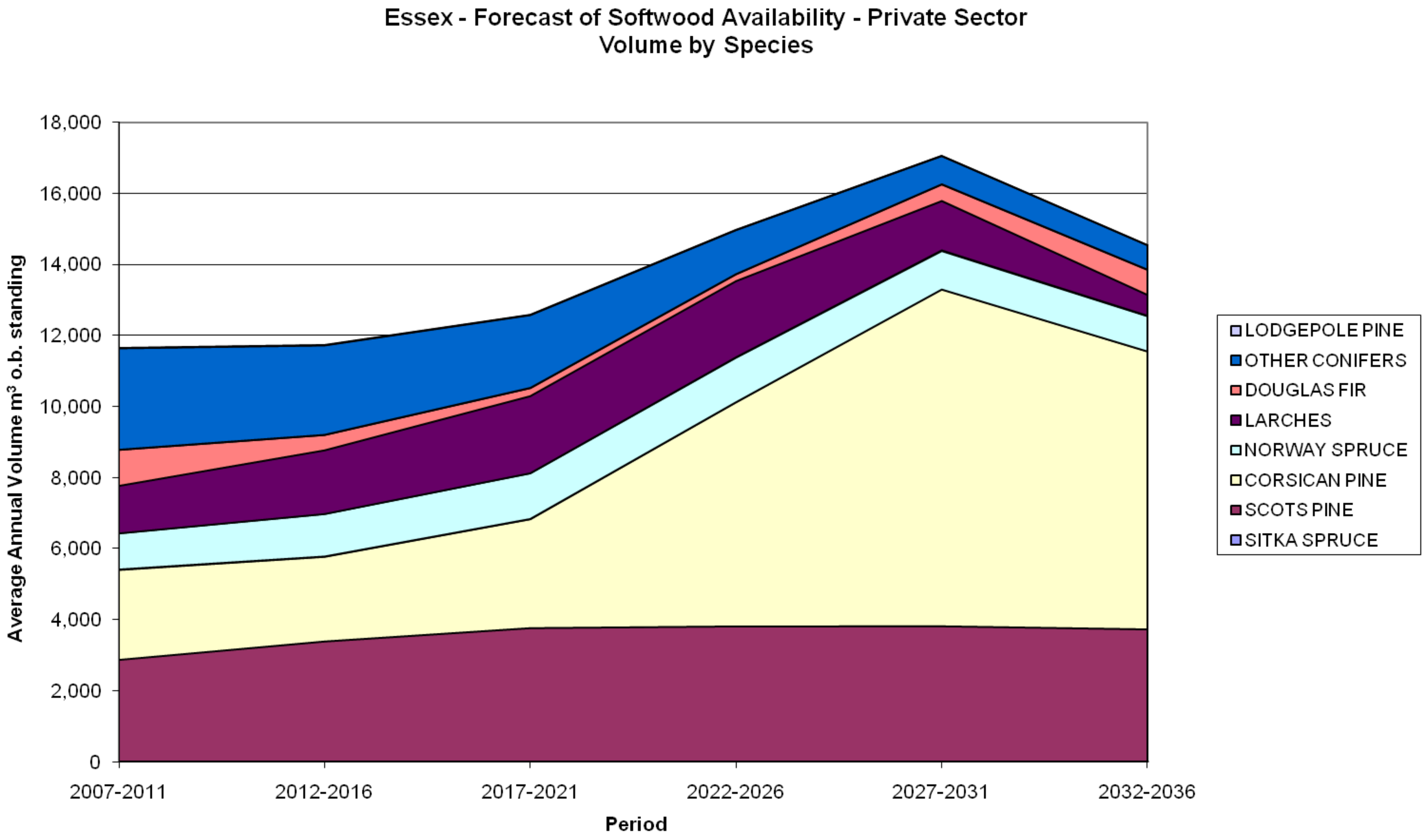

Cambridgeshire - Forecast of Softwood Availability - Private Sector
Volume by Top-diameter Class
Average Annual Volume m3 o.b. standing
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14

Essex - Average Annual Thin Plus Fell Volume Summary per Species Group

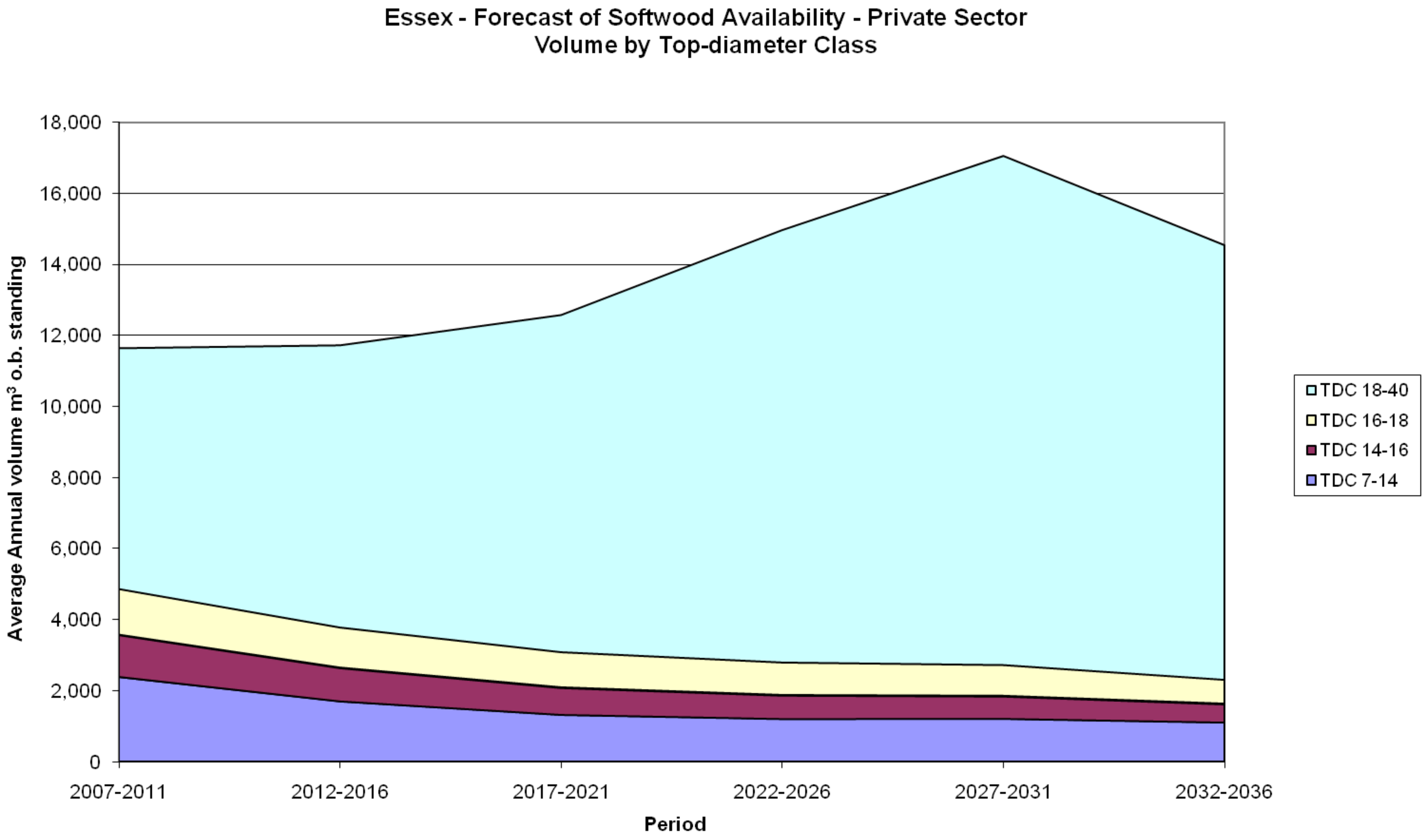
	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2007-2011	0.0	2,875.1	2,527.3	1,024.9	1,351.0	1,011.1	2,849.2	0.0	11,638.6
2012-2016	0.0	3,391.8	2,378.9	1,201.4	1,804.0	431.7	2,512.5	0.0	11,720.3
2017-2021	0.0	3,767.9	3,060.5	1,289.7	2,181.9	226.1	2,044.8	0.0	12,570.9
2022-2026	0.0	3,816.3	6,302.2	1,258.7	2,153.5	191.1	1,237.5	0.0	14,959.3
2027-2031	0.0	3,819.9	9,475.4	1,087.1	1,398.7	465.0	795.8	0.0	17,041.9
2032-2036	0.0	3,732.7	7,816.1	995.5	597.9	704.5	687.6	0.0	14,534.3

Essex - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2007-2011	2,396.8	1,173.4	1,299.7	6,768.7	11,638.6
2012-2016	1,709.0	933.6	1,145.8	7,931.9	11,720.3
2017-2021	1,329.3	756.1	1,010.7	9,474.9	12,571.0
2022-2026	1,213.5	657.2	934.3	12,154.3	14,959.3
2027-2031	1,218.7	627.2	887.9	14,308.2	17,042.0
2032-2036	1,113.8	510.6	693.9	12,216.0	14,534.3



Essex - Forecast of Softwood Availability - Private Sector
Volume by Species
Average Annual Volume m³ o.b. standing
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE



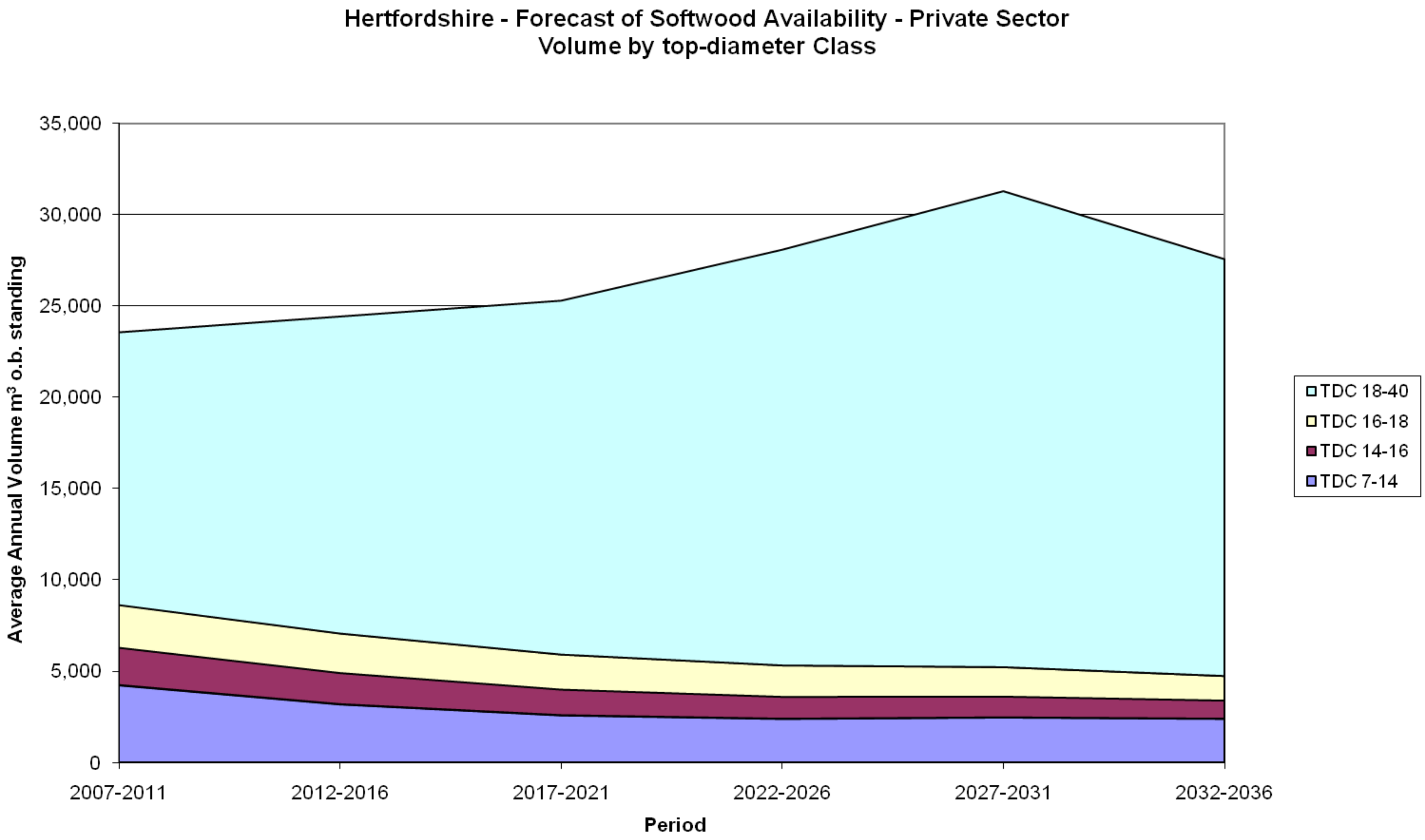
Essex - Forecast of Softwood Availability - Private Sector
Volume by Top-diameter Class
Average Annual volume m³ o.b. standing
18,000
16,000
14,000
12,000
10,000
8,000
6,000
4,000
2,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14

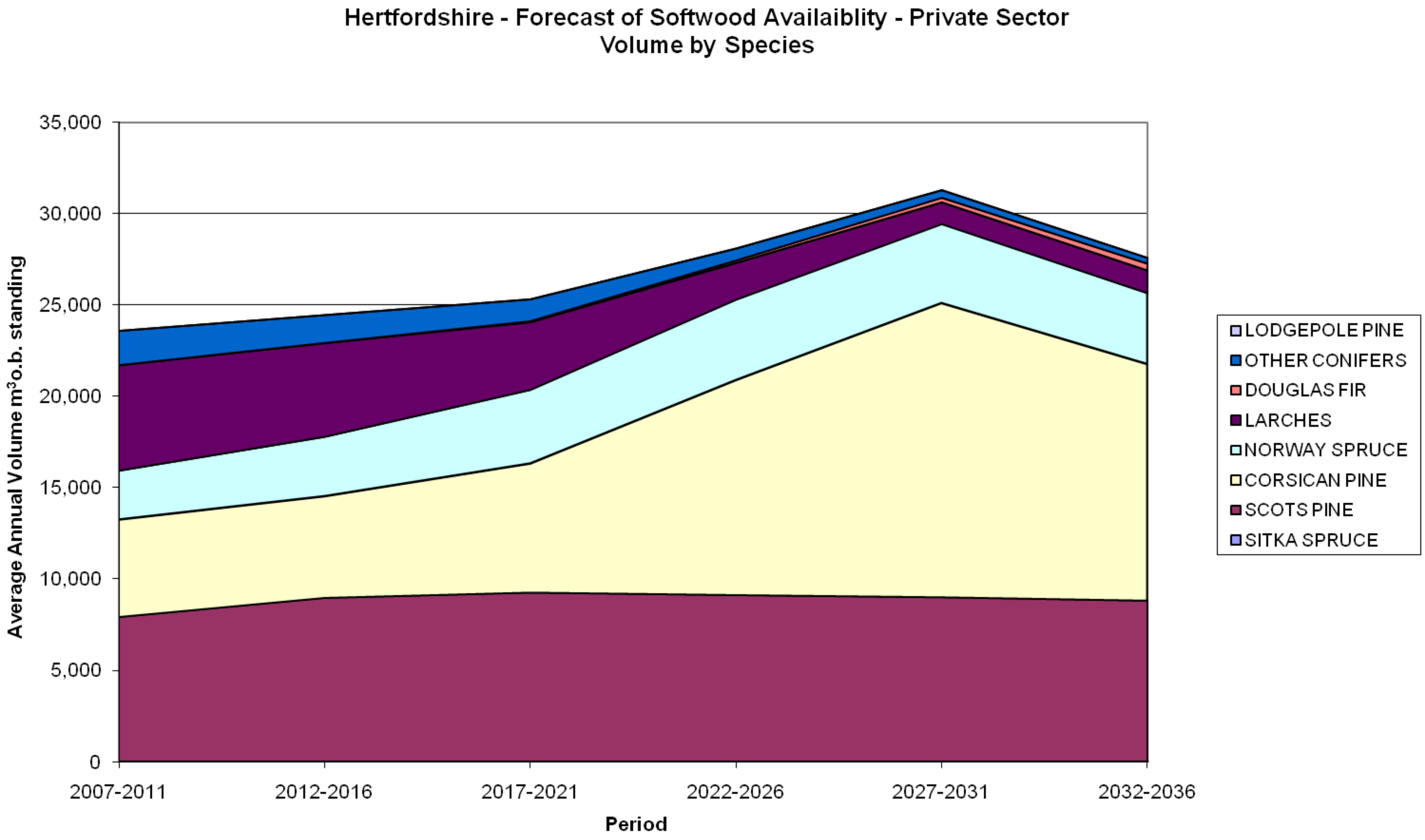
Hertfordshire - Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2007-2011	0.0	7,931.0	5,320.7	2,655.3	5,780.4	0.0	1,879.6	0.0	23,567.0
2012-2016	0.0	8,975.3	5,552.4	3,235.1	5,139.9	2.2	1,527.3	0.0	24,432.2
2017-2021	0.0	9,267.9	7,049.7	4,018.7	3,716.8	48.5	1,198.3	0.0	25,299.9
2022-2026	0.0	9,130.5	11,751.5	4,404.3	2,019.4	127.4	657.8	0.0	28,090.9
2027-2031	0.0	9,010.7	16,086.8	4,340.3	1,188.7	248.0	419.4	0.0	31,293.9
2032-2036	0.0	8,826.3	12,935.0	3,881.4	1,246.3	368.2	315.4	0.0	27,572.6

Hertfordshire - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2007-2011	4,229.4	2,054.0	2,348.9	14,934.7	23,567.1
2012-2016	3,181.8	1,725.7	2,167.8	17,356.8	24,432.2
2017-2021	2,580.8	1,422.9	1,922.3	19,373.8	25,299.9
2022-2026	2,385.2	1,222.9	1,721.0	22,761.8	28,090.8
2027-2031	2,461.0	1,161.6	1,611.7	26,059.5	31,293.8
2032-2036	2,386.8	1,017.6	1,345.6	22,822.7	27,572.6


Hertfordshire - Forecast of Softwood Availability - Private Sector
Volume by top-diameter Class
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Average Annual Volume m³ o.b. standing
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14



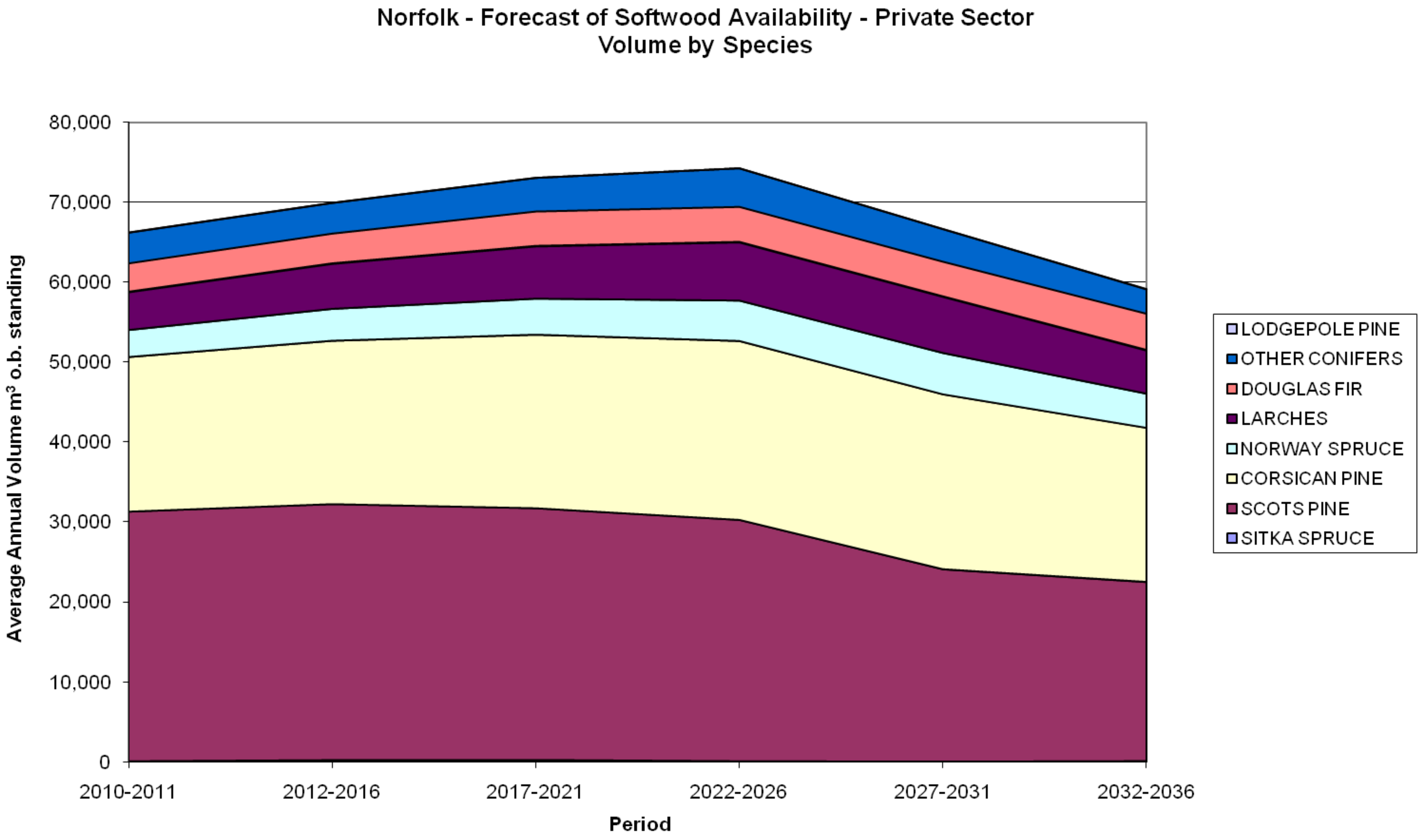
Hertfordshire - Forecast of Softwood Availaiblity - Private Sector
Volume by Species
Average Annual Volume m³o.b. standing
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2007-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE

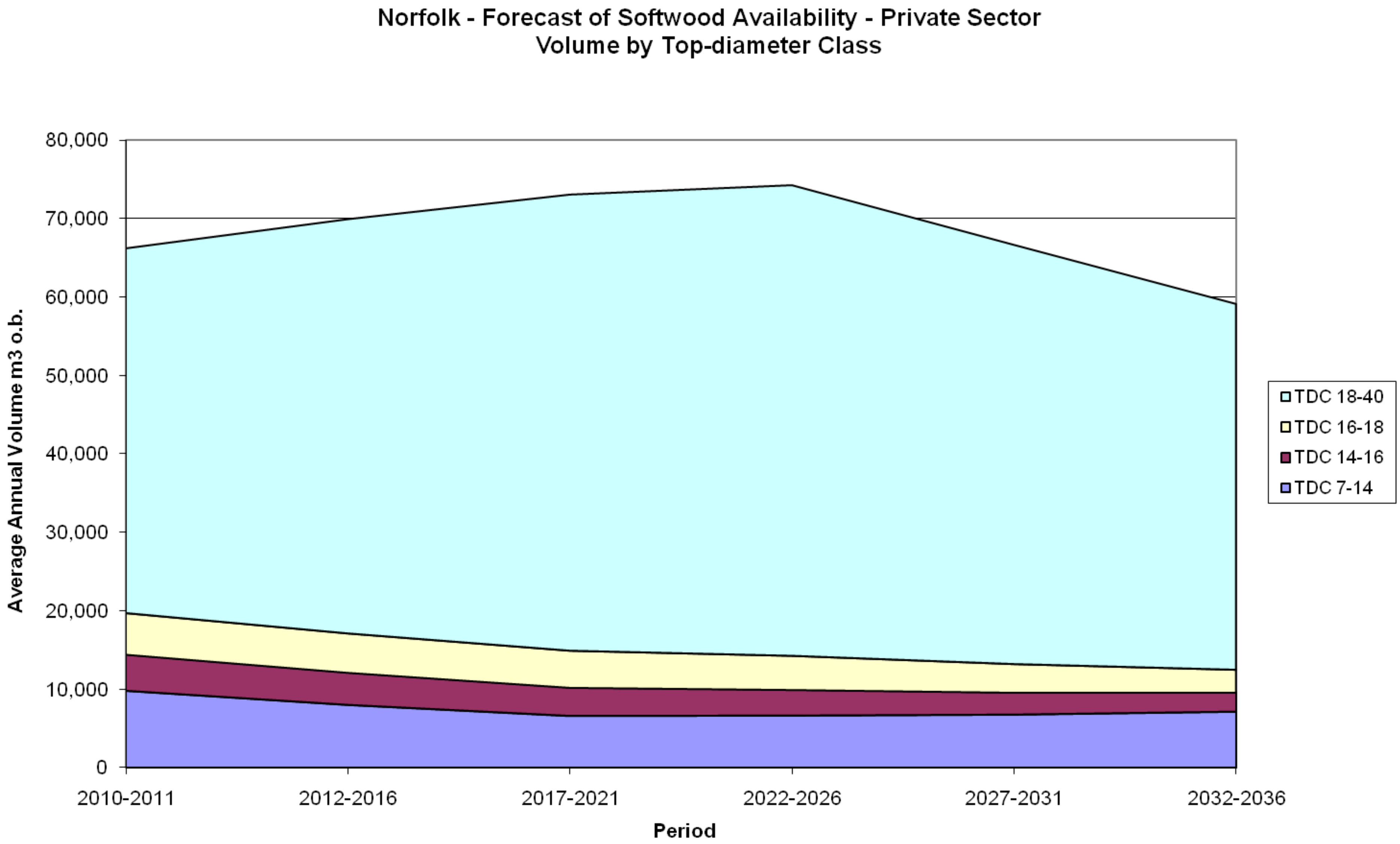
Norfolk - Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2010-2011	125.4	31,165.3	19,386.9	3,375.2	4,720.7	3,619.6	3,833.9	0.0	66,227.0
2012-2016	267.6	31,964.6	20,479.7	3,989.7	5,622.1	3,782.8	3,836.3	0.0	69,942.8
2017-2021	289.3	31,426.3	21,750.3	4,514.4	6,533.9	4,358.1	4,205.1	0.0	73,077.4
2022-2026	135.5	30,123.1	22,422.3	5,061.1	7,271.2	4,440.8	4,821.5	0.0	74,275.5
2027-2031	78.9	24,001.8	21,927.8	5,175.4	7,013.4	4,403.4	4,065.4	0.0	66,666.1
2032-2036	146.0	22,340.2	19,333.7	4,274.7	5,391.1	4,608.6	3,046.5	0.0	59,140.8

Norfolk - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2010-2011	9,796.4	4,627.5	5,297.6	46,505.5	66,227.0
2012-2016	7,999.3	4,117.8	5,018.0	52,807.8	69,942.9
2017-2021	6,587.5	3,613.2	4,725.9	58,150.8	73,077.4
2022-2026	6,637.3	3,294.0	4,346.9	59,997.3	74,275.4
2027-2031	6,763.2	2,811.2	3,649.2	53,442.5	66,666.1
2032-2036	7,138.3	2,433.2	2,925.6	46,643.7	59,140.9


Norfolk - Forecast of Softwood Availability - Private Sector
Volume by Species
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Average Annual Volume m³ o.b. standing
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE

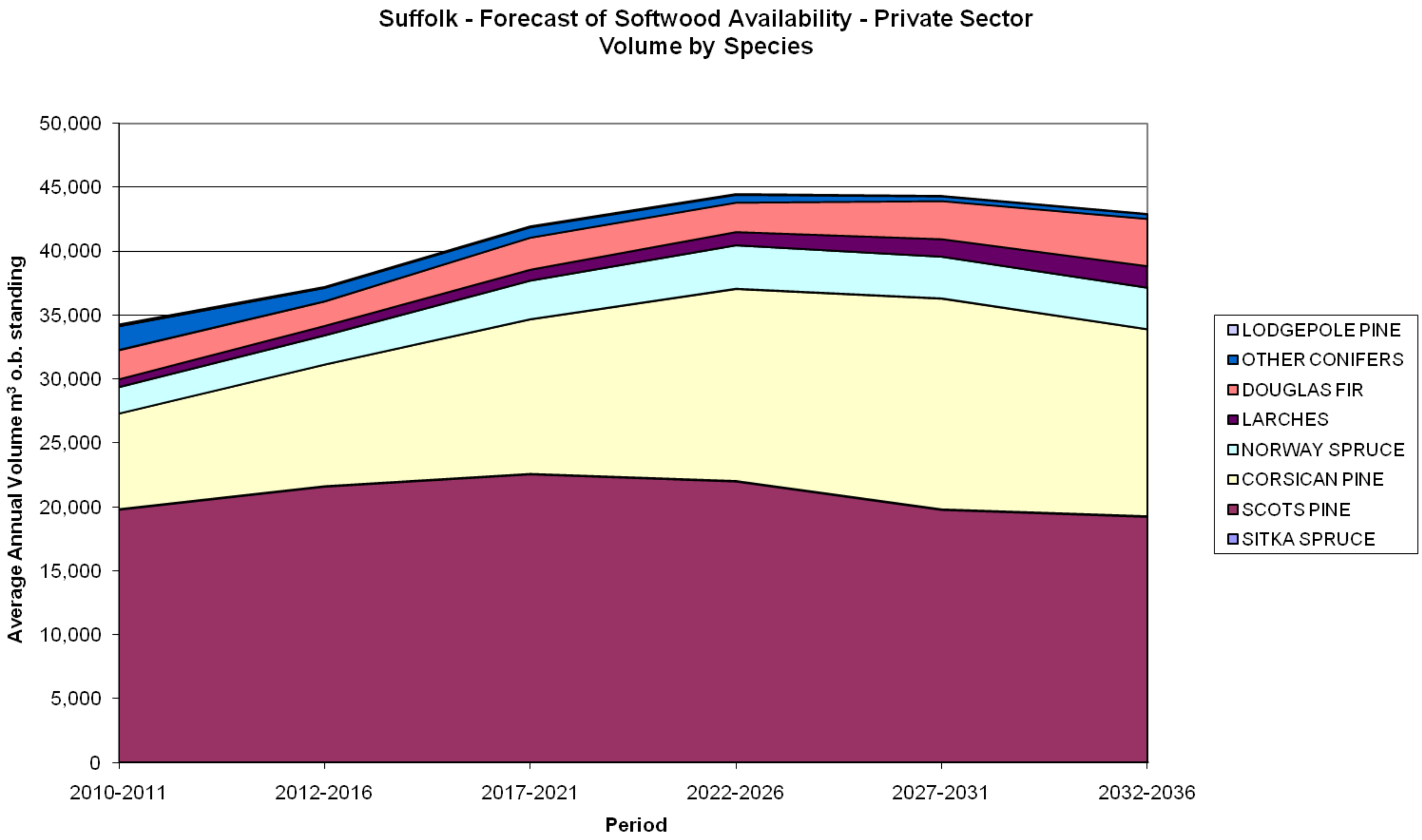

Norfolk - Forecast of Softwood Availability - Private Sector
Volume by Top-diameter Class
80,000
70,000
60,000
50,000
40,000
30,000
20,000
10,000
0
Average Annual Volume m3 o.b.
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14

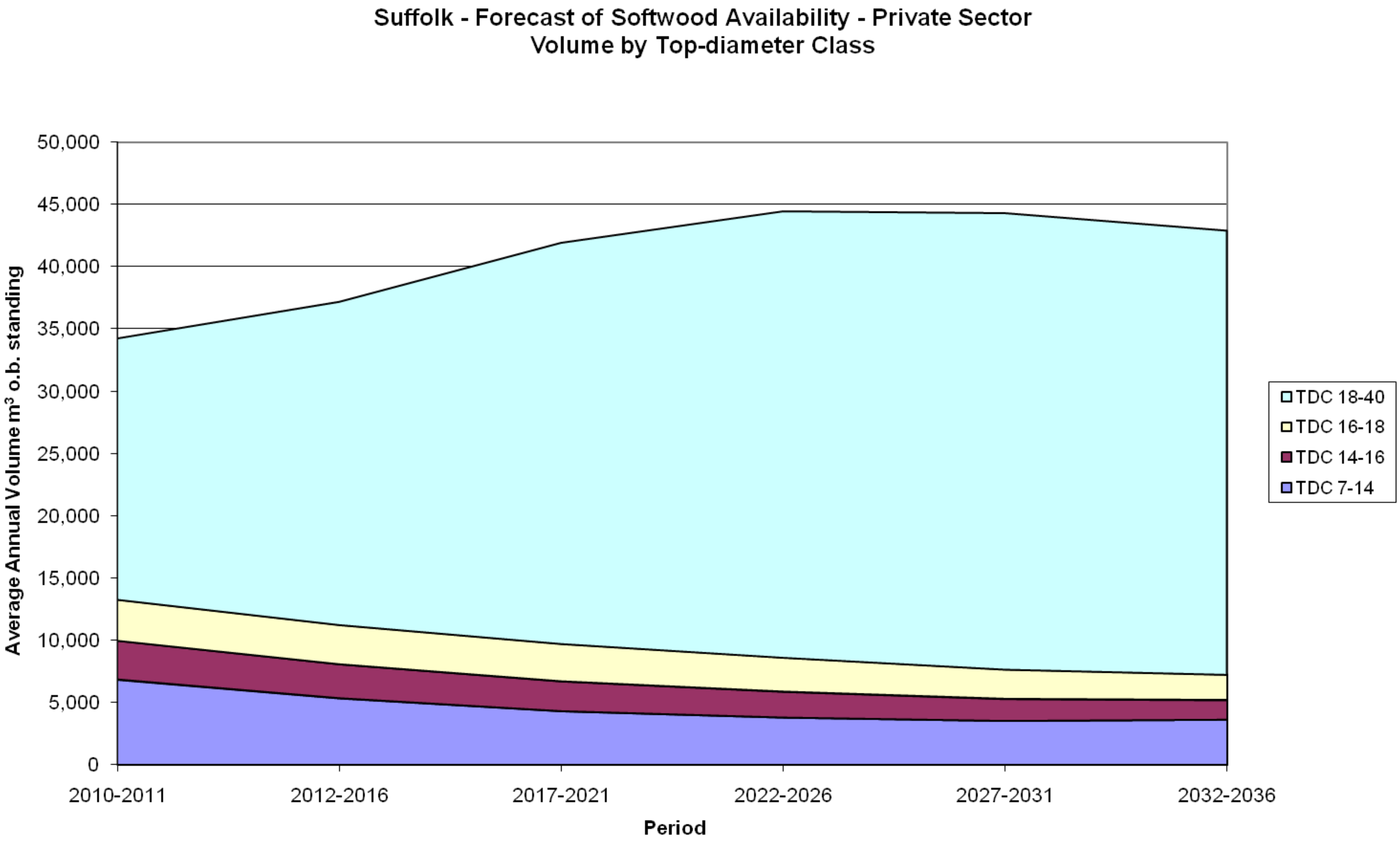
Suffolk - Average Annual Thin Plus Fell Volume Summary per Species Group

	SITKA SPRUCE	SCOTS PINE	CORSICAN PINE	NORWAY SPRUCE	LARCHES	DOUGLAS FIR	OTHER CONIFERS	LODGEPOLE PINE	TOTAL
2010-2011	0.0	19,786.4	7,516.6	2,059.1	625.4	2,267.7	1,858.4	129.4	34,243.0
2012-2016	0.0	21,594.7	9,539.5	2,271.8	752.2	1,908.3	1,048.7	66.6	37,181.8
2017-2021	0.0	22,560.0	12,119.8	3,009.4	855.0	2,521.6	809.3	45.0	41,920.1
2022-2026	1.9	21,997.5	15,063.5	3,388.6	1,032.8	2,328.9	608.2	27.6	44,449.0
2027-2031	7.0	19,765.8	16,534.1	3,254.6	1,366.1	3,008.6	364.7	1.0	44,301.9
2032-2036	12.6	19,218.5	14,669.9	3,236.5	1,681.0	3,721.1	356.3	1.3	42,897.2

Suffolk - Average Annual Thin Plus Fell TDC Volume Summary

	TDC 7-14	TDC 14-16	TDC 16-18	TDC 18-40	TDC 7-40
2010-2011	6,854.2	3,087.8	3,318.5	20,982.5	34,243.0
2012-2016	5,358.3	2,702.4	3,171.8	25,949.3	37,181.8
2017-2021	4,326.7	2,363.5	3,019.5	32,210.5	41,920.1
2022-2026	3,815.3	2,047.4	2,741.1	35,845.3	44,449.1
2027-2031	3,543.4	1,739.7	2,369.1	36,649.6	44,301.7
2032-2036	3,646.5	1,541.7	2,044.0	35,665.2	42,897.4


Suffolk - Forecast of Softwood Availability - Private Sector
Volume by Species
Average Annual Volume m³ o.b. standing
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
LODGEPOLE PINE
OTHER CONIFERS
DOUGLAS FIR
LARCHES
NORWAY SPRUCE
CORSICAN PINE
SCOTS PINE
SITKA SPRUCE


Suffolk - Forecast of Softwood Availability - Private Sector
Volume by Top-diameter Class
50,000
45,000
40,000
35,000
30,000
25,000
20,000
15,000
10,000
5,000
0
Average Annual Volume m³ o.b. standing
2010-2011
2012-2016
2017-2021
2022-2026
2027-2031
2032-2036
Period
TDC 18-40
TDC 16-18
TDC 14-16
TDC 7-14

8.5. Appendix E: Biomass assessment Forestry Commission Estate

Forecast Biomass

Forestry Commission Thinning and Felling Biomass Forecast(Oven Dried Tonnes) estimated average annual production

	Period	Species	Stemwood 7-14 (Oven Dried Tonnes)	Stemwood 14-16 (Oven Dried Tonnes)	Stemwood 16-18 (Oven Dried Tonnes)	Stemwood 18+ (Oven Dried Tonnes)	Poor Quality (Oven Dried Tonnes)	Tips (Oven Dried Tonnes)	Branches (Oven Dried Tonnes)	Foliage (Oven Dried Tonnes)	Total (Oven Dried Tonnes)
East of England	2003-2006	PINES	9,116	5,625	6,663	41,919	0	522	6,031	2,642	72,518
		SPRUCES	173	104	105	420	0	4	40	18	864
		OTHER CONIFERS	567	375	476	4,069	0	32	511	223	6,253
		BROADLEAVES	560	212	201	1,909	0	43	609	0	3,535
	2007-2011	PINES	7,905	4,872	5,812	36,442	0	435	4,884	2,141	62,491
		SPRUCES	52	31	32	159	0	1	13	6	294
		OTHER CONIFERS	244	165	216	1,919	0	14	223	98	2,879
		BROADLEAVES	222	98	102	598	0	17	215	0	1,252
	2012-2016	PINES	6,546	3,995	4,716	27,779	0	378	3,741	1,648	48,803
		SPRUCES	73	50	60	457	0	2	28	12	682
		OTHER CONIFERS	377	262	352	3,220	0	22	395	172	4,800
		BROADLEAVES	154	68	74	522	0	12	175	0	1,005
	2017-2021	PINES	6,499	3,993	4,743	29,313	0	370	3,727	1,653	50,298
		SPRUCES	30	21	25	199	0	1	12	5	292
		OTHER CONIFERS	189	130	177	1,958	0	11	238	103	2,807
		BROADLEAVES	166	89	97	681	0	12	217	0	1,262
Total (Oven Dried Tonnes)			32,873	20,090	23,851	151,564	0	1,875	21,060	8,721	260,035

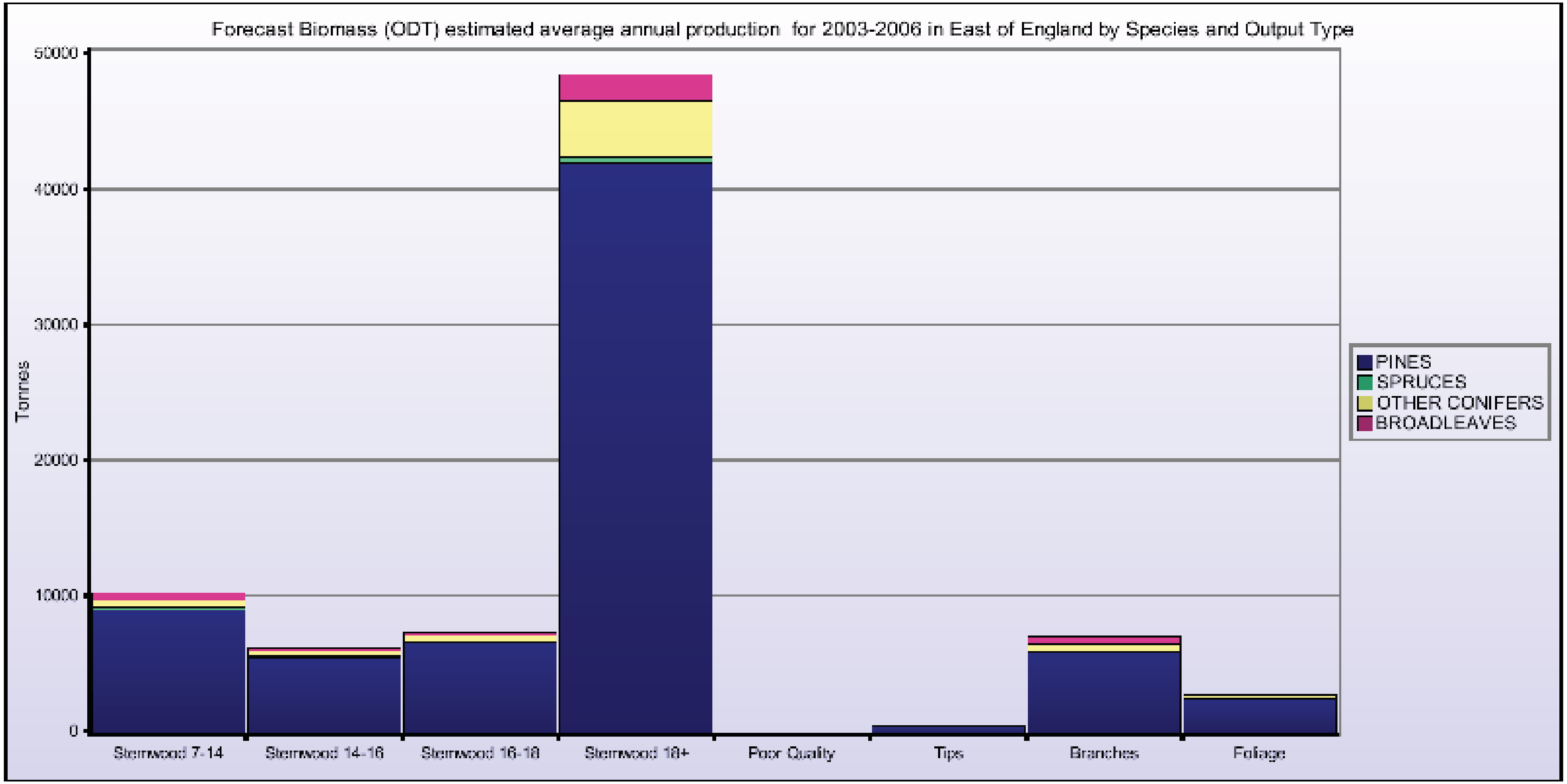
Figures are given in oven-dry tonnes. Woodfuel will never be delivered at this moisture content. Typical moisture contents will vary from 50-60% (measured on a fresh weight basis) for harvesting brash to 25-30% for conditioned woodchips.

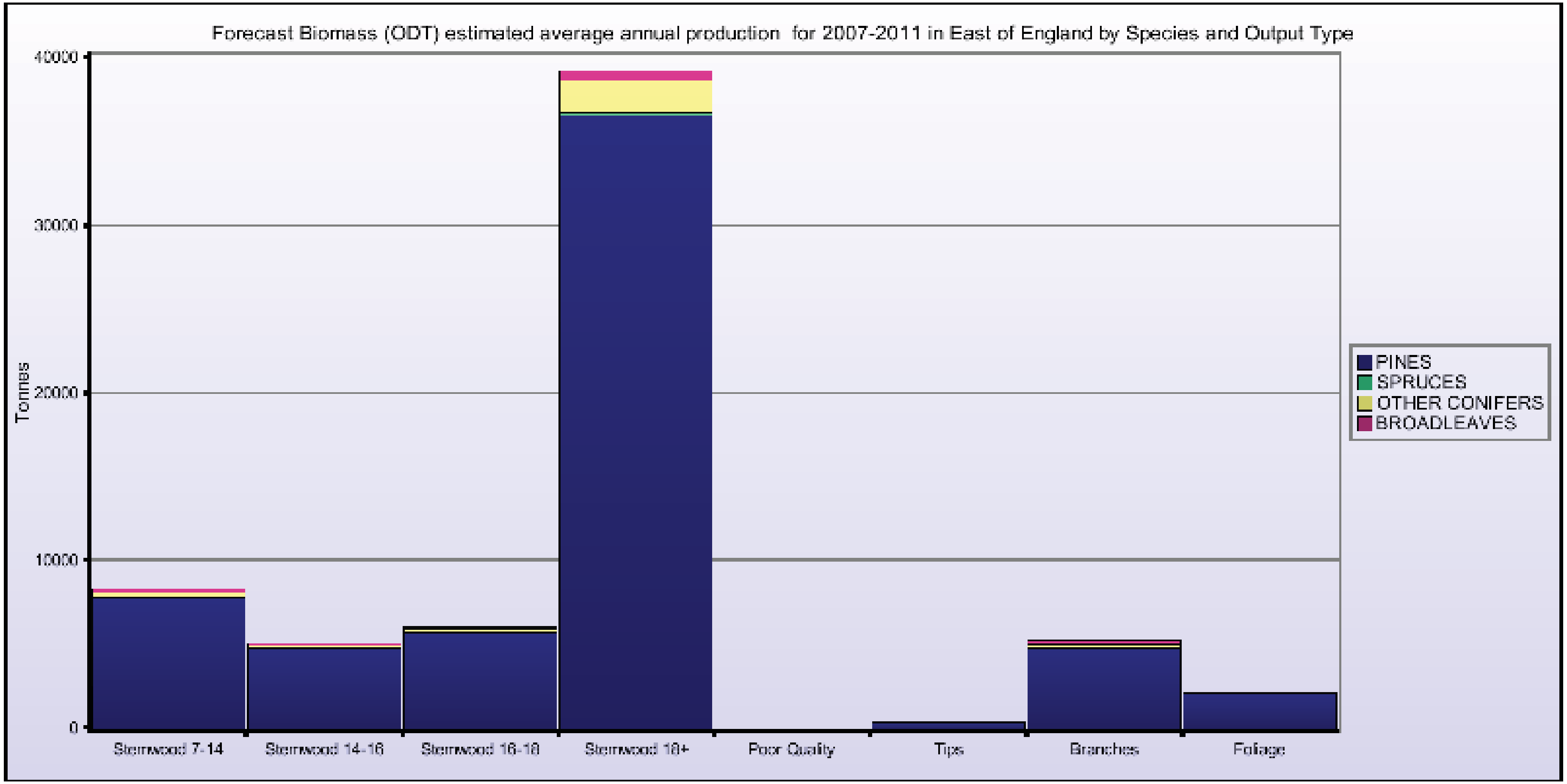
Figures are estimates of the annual sustainable production that can be made available taking account of technical and environmental constraints. They do not take account of economic or market constraints.

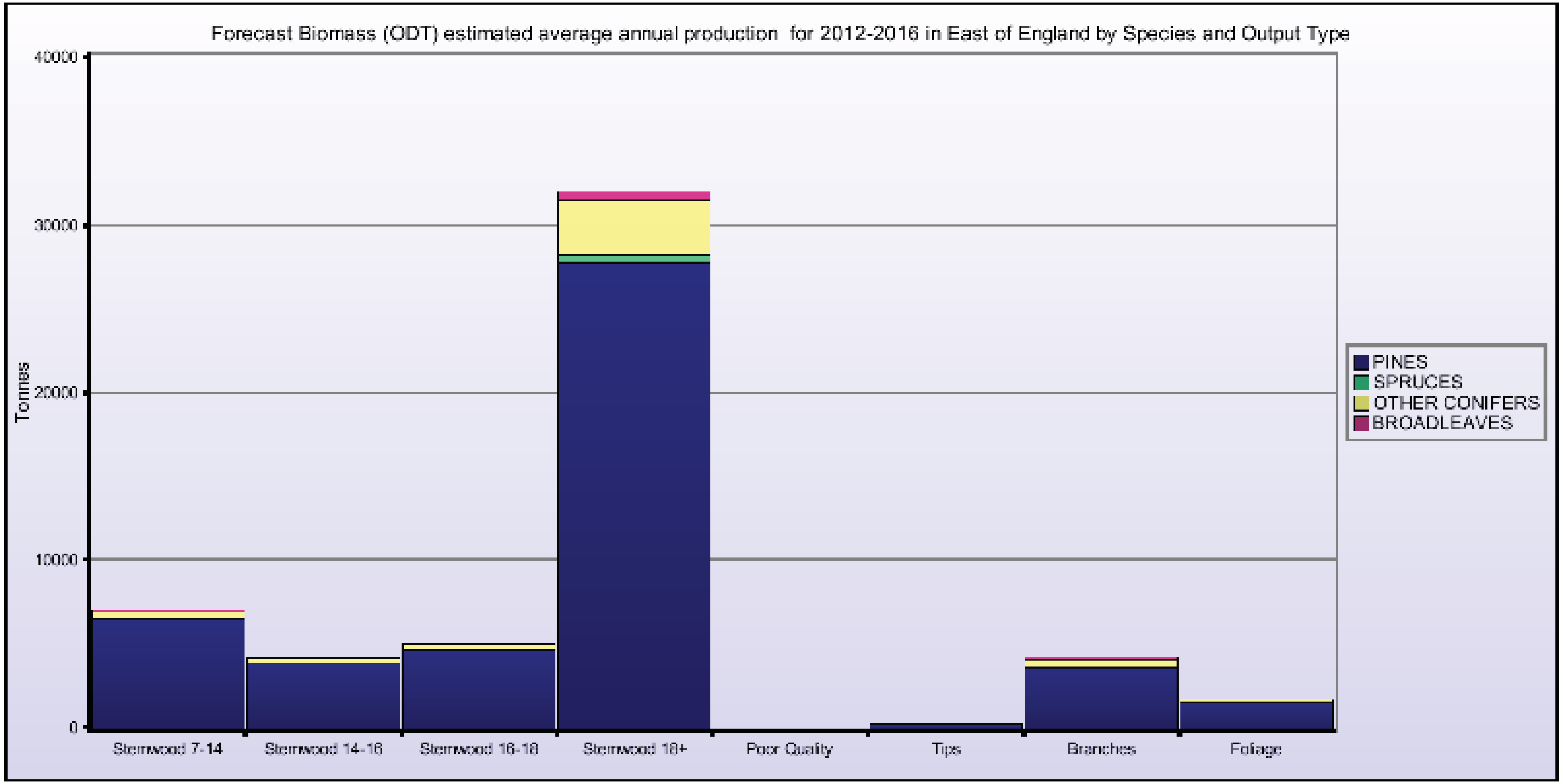
i) It is unlikely that energy-end markets will be sufficiently profitable to allow stemwood greater than 14cm diameter and of good form to be diverted from their existing markets of sawn timber to new energy markets.

ii) Figures for stemwood greater than 7cm top diameter may differ from the standard production forecasts. An explanation of any differences compared to the standard production forecast of stem volume for the Forest Enterprise estate given in Appendix 6 Final Report B/W3/00787/REP, URN 03/1436. The Private Sector Forecasting Model is described in Appendix 7.

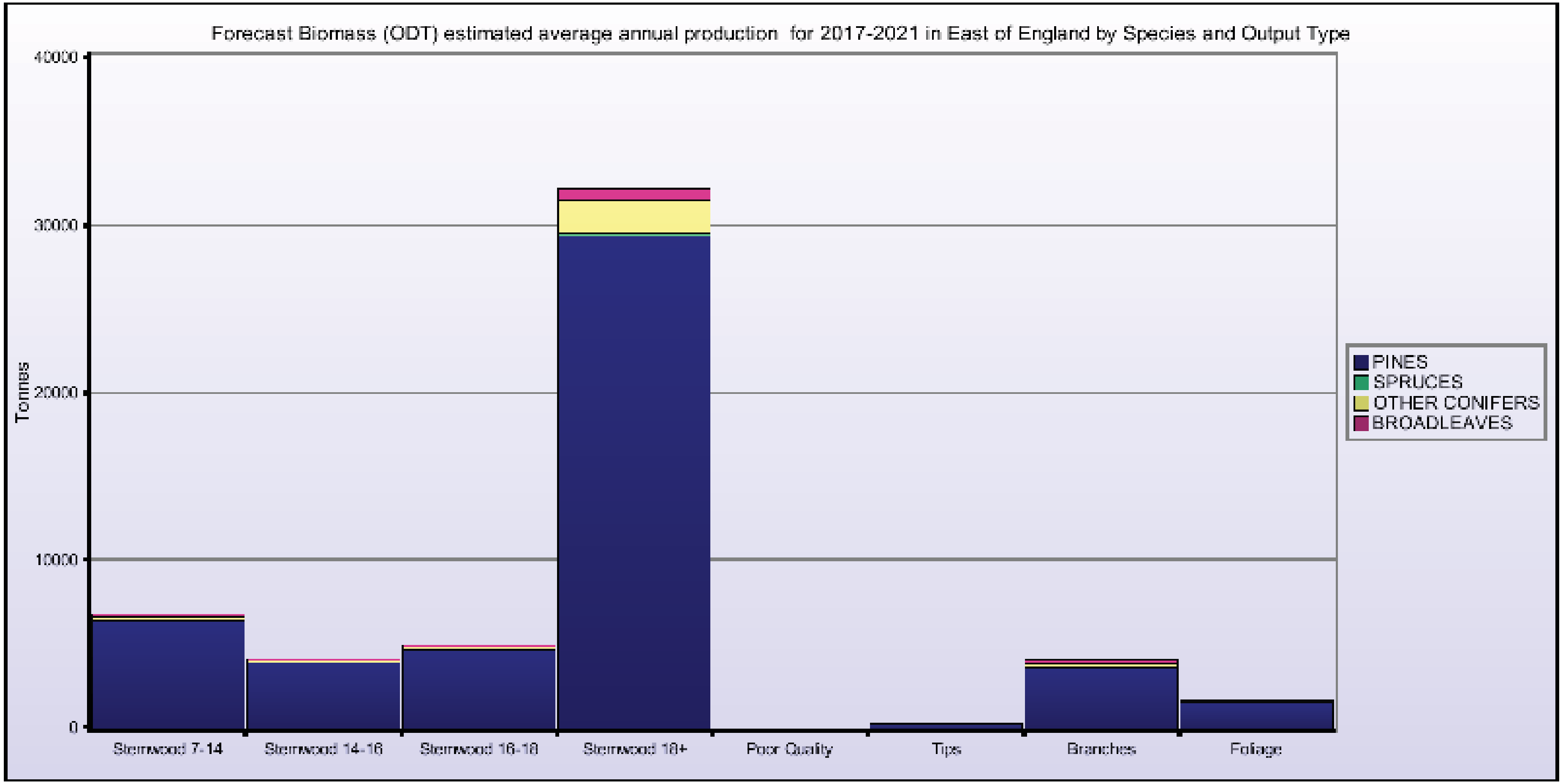
Forestry Commission Thinning and Felling Biomass Forecast(Oven Dried Tonnes) estimated average annual production




Forecast Biomass (ODT) estimated average annual production for 2007-2011 in East of England by Species and Output Type
Tonnes
40000
30000
20000
10000
0
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES



Forecast Biomass (ODT) estimated average annual production for 2012-2016 in East of England by Species and Output Type
Tonnes
40000
30000
20000
10000
0
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES



Forecast Biomass (ODT) estimated average annual production for 2017-2021 in East of England by Species and Output Type
Tonnes
40000
30000
20000
10000
0
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES

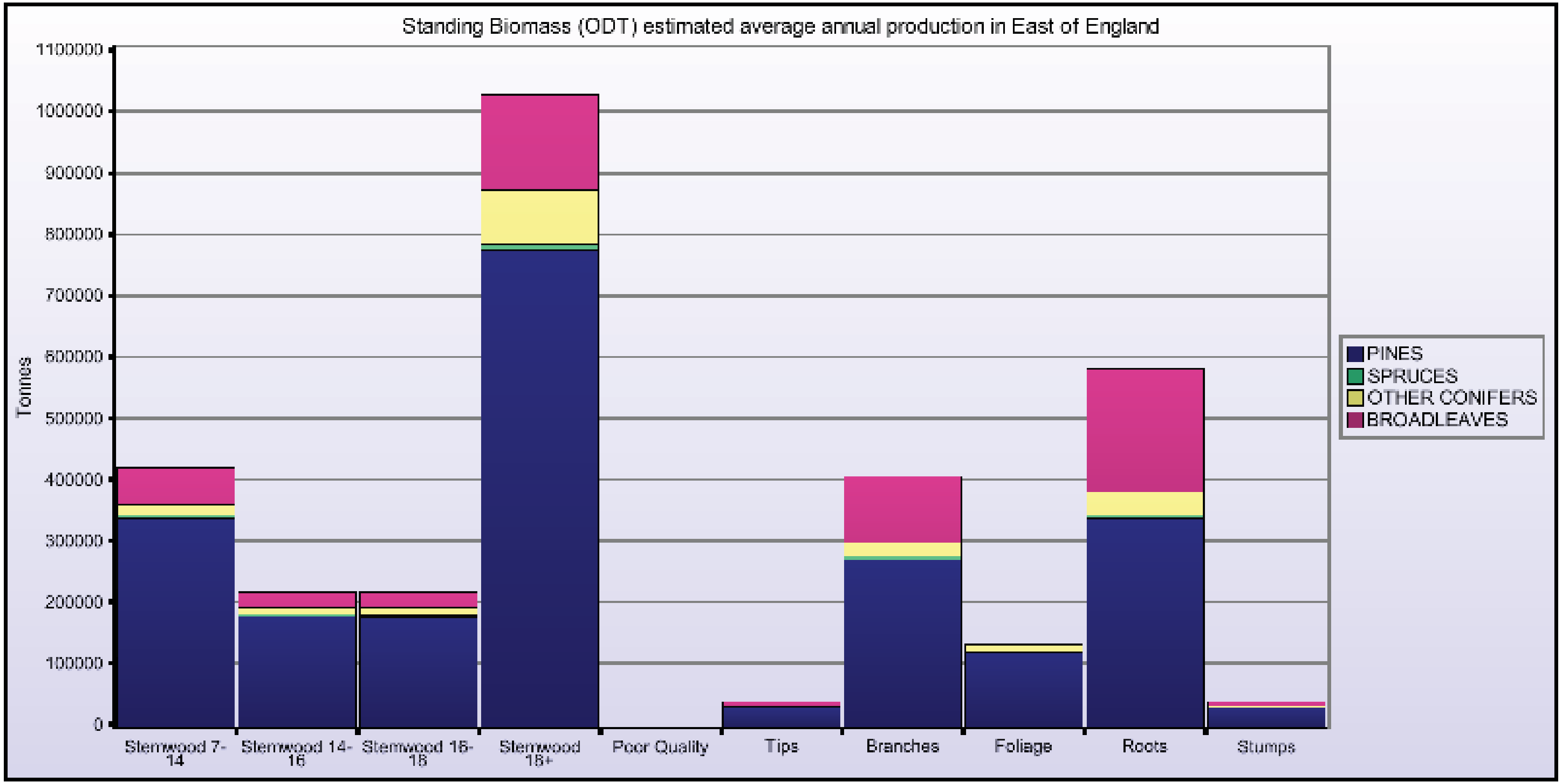
Standing Biomass

Forestry Commission Standing Biomass (Oven Dried Tonnes) estimated average annual production

	Species	Stemwood 7-14 (Oven Dried Tonnes)	Stemwood 14-16 (Oven Dried Tonnes)	Stemwood 16-18 (Oven Dried Tonnes)	Stemwood 18+ (Oven Dried Tonnes)	Poor Quality (Oven Dried Tonnes)	Tips (Oven Dried Tonnes)	Branches (Oven Dried Tonnes)	Foliage (Oven Dried Tonnes)	Roots (Oven Dried Tonnes)	Stumps (Oven Dried Tonnes)	Total (Oven Dried Tonnes)
East of England	PINES	339,808	180,476	178,924	774,304	0	31,980	272,516	122,112	339,028	32,008	2,271,156
	SPRUCES	4,896	2,712	2,580	9,340	0	520	4,944	2,236	5,488	460	33,176
	OTHER CONIFERS	17,572	10,812	12,744	87,928	0	1,776	23,196	10,248	38,356	2,324	204,956
	BROADLEAVES	58,872	25,296	26,028	153,104	0	8,208	106,056	0	199,248	6,424	583,236
Total (Oven Dried Tonnes)		421,148	219,296	220,276	1,024,676	0	42,484	406,712	134,596	582,120	41,216	3,092,524

Figures are given in oven-dry tonnes. Woodfuel will never be delivered at this moisture content. Typical moisture contents will vary from 50-60% (measured on a fresh weight basis) for harvesting brash to 25-30% for conditioned woodchips.
Figures are estimates of the annual sustainable production that can be made available taking account of technical and environmental constraints. They do not take account of economic or market constraints.

Forestry Commission Standing Biomass (Oven Dried Tonnes) estimated average annual production



8.6. Appendix F: Biomass assessment – Private woodland

Forecast Biomass

Private Sector Thinning and Felling Biomass Forecast(Oven Dried Tonnes) estimated average annual production

	Period	Species	Stemwood 7-14 (Oven Dried Tonnes)	Stemwood 14-16 (Oven Dried Tonnes)	Stemwood 16-18 (Oven Dried Tonnes)	Stemwood 18+ (Oven Dried Tonnes)	Poor Quality (Oven Dried Tonnes)	Tips (Oven Dried Tonnes)	Branches (Oven Dried Tonnes)	Foliage (Oven Dried Tonnes)	Total (Oven Dried Tonnes)
East of England	**2003-2006**	PINES	7,873	4,159	3,977	24,195	1,151	526	4,722	2,063	48,667
		SPRUCES	1,189	553	452	1,948	0	27	227	101	4,497
		OTHER CONIFERS	1,810	976	1,095	11,138	86	119	1,304	571	17,098
		BROADLEAVES	9,501	5,714	6,907	68,958	3,854	735	23,709	0	119,378
	2007-2011	PINES	6,162	3,784	4,014	29,226	1,841	411	4,873	2,108	52,418
		SPRUCES	981	538	519	3,314	0	22	261	115	5,750
		OTHER CONIFERS	1,555	910	1,081	12,617	34	104	1,319	573	18,194
		BROADLEAVES	9,084	5,654	6,848	67,880	3,908	688	23,382	0	117,444
	2012-2016	PINES	4,687	3,151	3,672	33,416	882	324	4,706	2,022	52,861
		SPRUCES	768	479	528	4,289	0	18	274	120	6,475
		OTHER CONIFERS	1,313	832	1,053	14,484	85	90	1,370	590	19,816
		BROADLEAVES	9,141	5,924	7,237	71,044	4,749	691	24,551	0	123,337
	2017-2021	PINES	3,618	2,592	3,332	40,044	0	266	4,826	2,050	56,727
		SPRUCES	625	435	551	6,136	0	15	329	142	8,232
		OTHER CONIFERS	1,062	730	980	15,203	295	76	1,397	596	20,339
		BROADLEAVES	8,545	5,484	6,760	75,045	4,968	670	24,929	0	126,401
Total (Oven Dried Tonnes)			67,914	41,915	49,006	478,935	21,853	4,783	122,177	11,050	797,634

Figures are given in oven-dry tonnes. Woodfuel will never be delivered at this moisture content. Typical moisture contents will vary from 50-60% (measured on a fresh weight basis) for harvesting brash to 25-30% for conditioned woodchips.

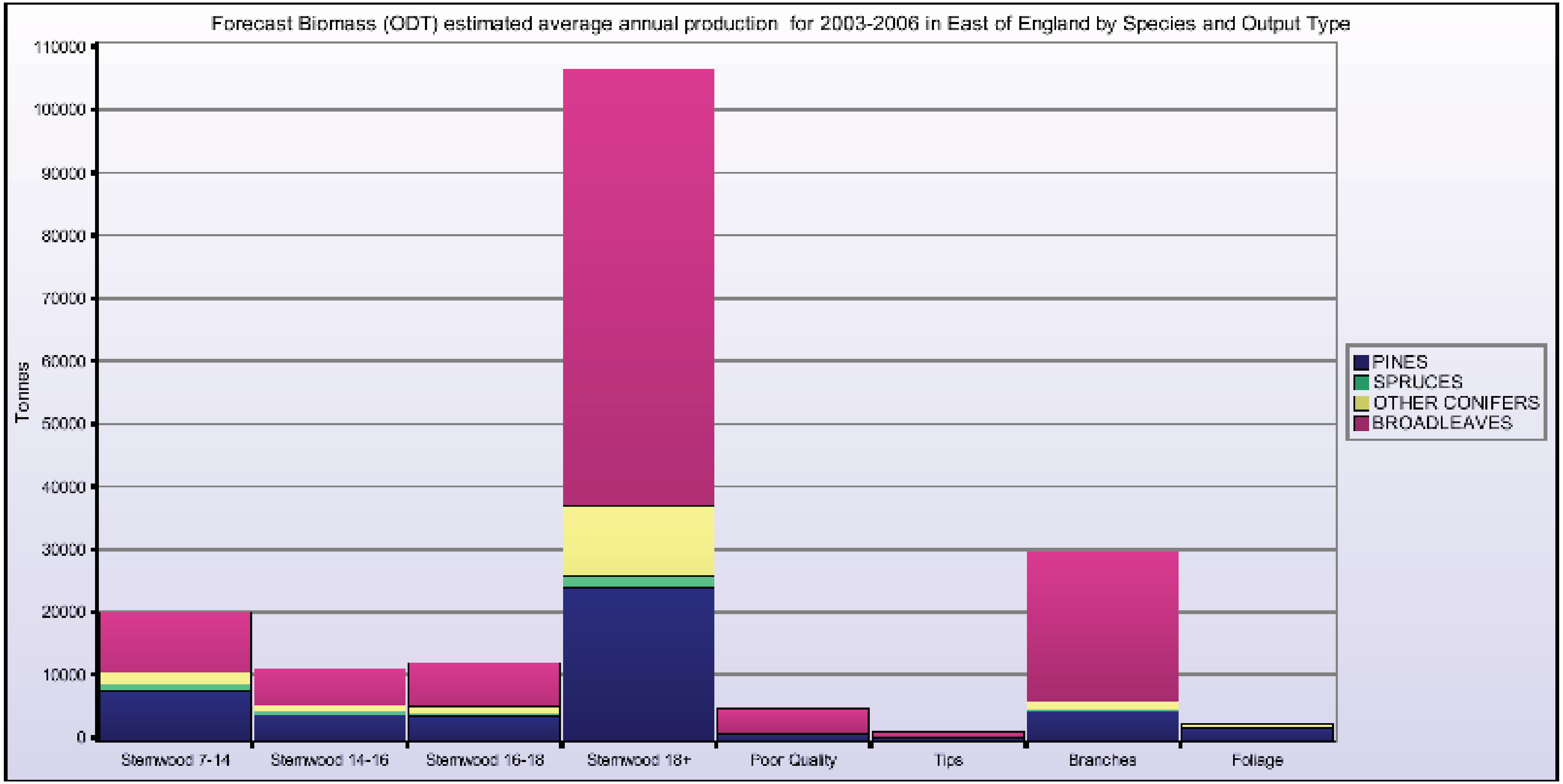
Figures are estimates of the annual sustainable production that can be made available taking account of technical and environmental constraints. They do not take account of economic or market constraints.

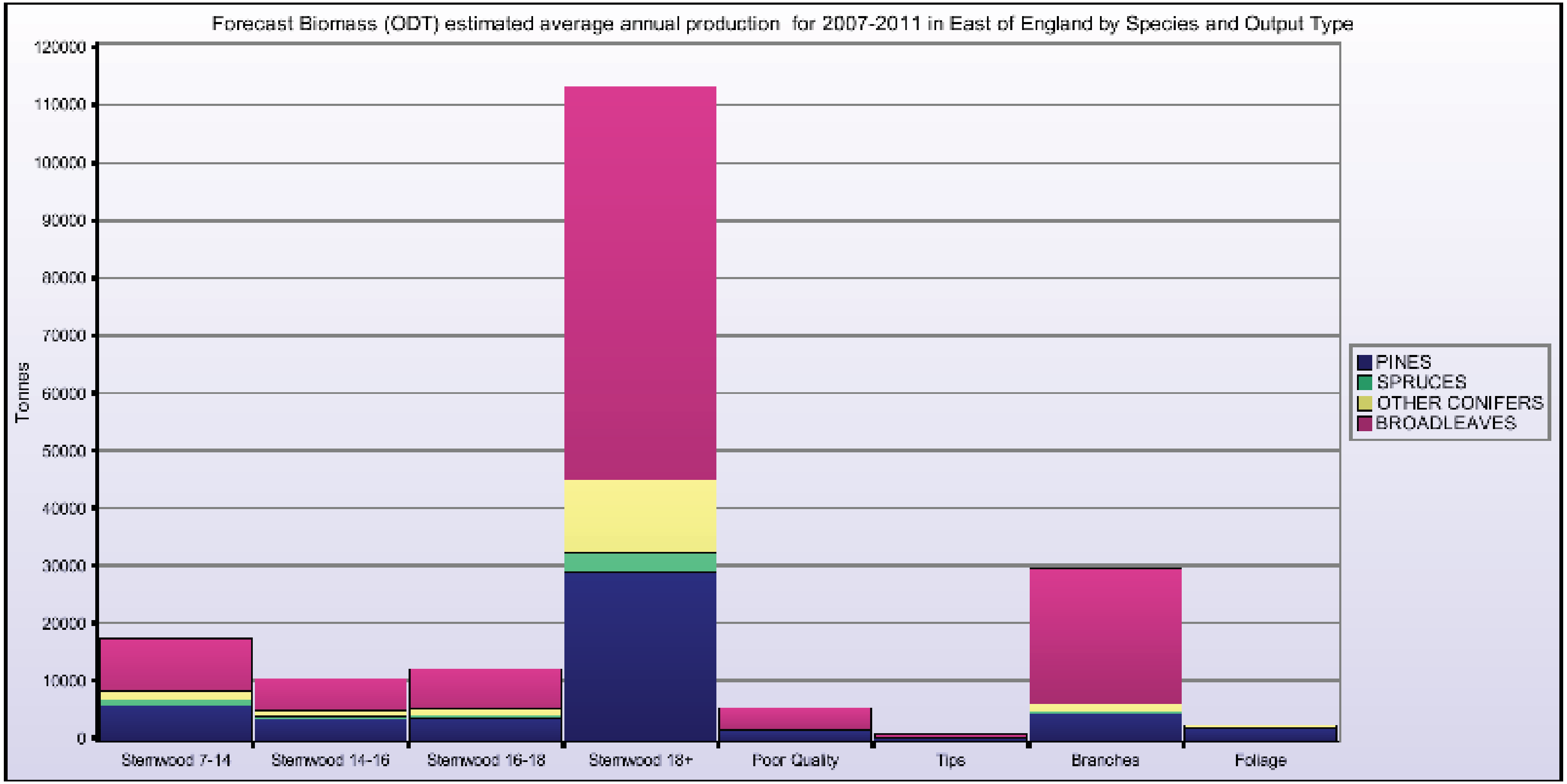
i) It is unlikely that energy-end markets will be sufficiently profitable to allow stemwood greater than 14cm diameter and of good form to be diverted from their existing markets of sawn timber to new energy markets.

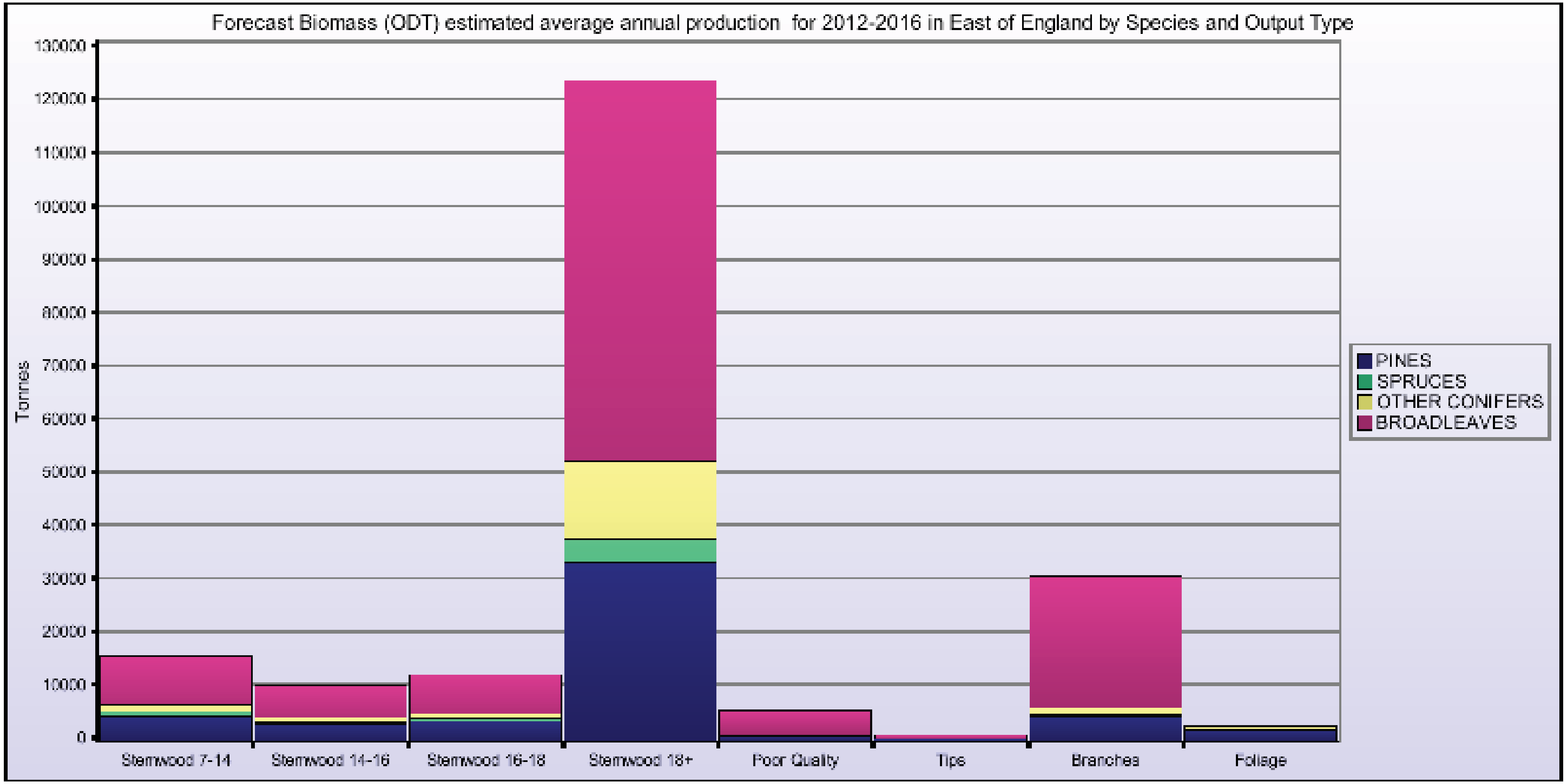
ii) Figures for stemwood greater than 7cm top diameter may differ from the standard production forecasts. An explanation of any differences compared to the standard production forecast of stem volume for the Forest Enterprise estate given in Appendix 6 Final Report B/W3/00787/REP, URN 03/1436. The Private Sector Forecasting Model is described in Appendix 7.

Figures do not include production from woodlands <2ha in area. These can be a significant resource in particular locations, e.g. Norfolk, Powys, Scottish Borders, Tayside, Cambridgeshire, and Hereford and Worcester (all more than 5000ha). For more information see Appendix 22 of Final Report B/W3/00787/REP, URN 03/1436

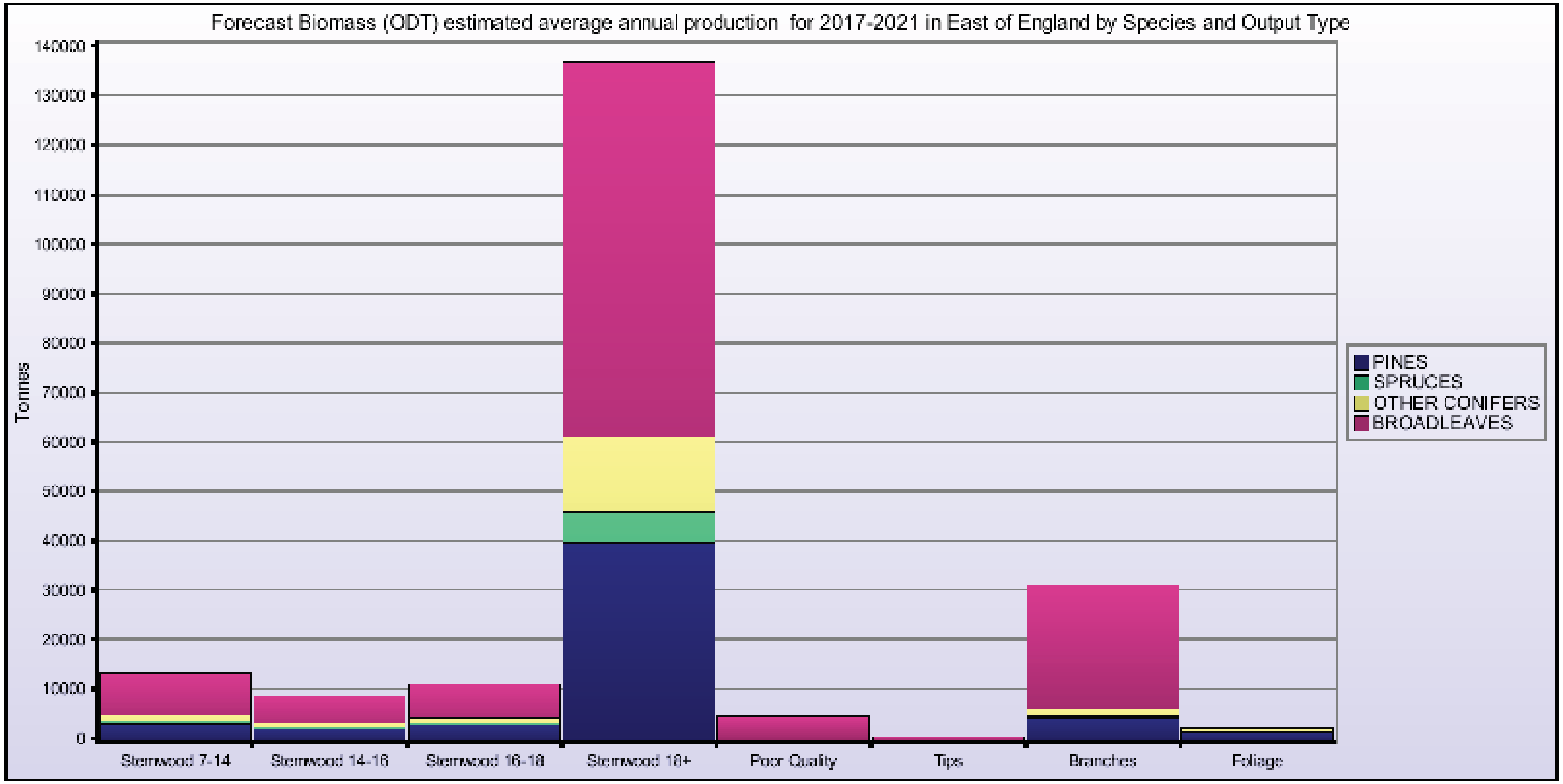
Private Sector Thinning and Felling Biomass Forecast(Oven Dried Tonnes) estimated average annual production




Forecast Biomass (ODT) estimated average annual production for 2007-2011 in East of England by Species and Output Type
Tonnes
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES



Forecast Biomass (ODT) estimated average annual production for 2012-2016 in East of England by Species and Output Type
Tonnes
130000
120000
110000
100000
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES


Forecast Biomass (ODT) estimated average annual production for 2017-2021 in East of England by Species and Output Type
Tonnes
0
10000
20000
30000
40000
50000
60000
70000
80000
90000
100000
110000
120000
130000
140000
Stemwood 7-14
Stemwood 14-16
Stemwood 16-18
Stemwood 18+
Poor Quality
Tips
Branches
Foliage
PINES
SPRUCES
OTHER CONIFERS
BROADLEAVES

Standing Biomass

Privately Owned Standing Biomass (Oven Dried Tonnes) estimated average annual production

	Species	Stemwood 7-14 (Oven Dried Tonnes)	Stemwood 14-16 (Oven Dried Tonnes)	Stemwood 16-18 (Oven Dried Tonnes)	Stemwood 18+ (Oven Dried Tonnes)	Poor Quality (Oven Dried Tonnes)	Tips (Oven Dried Tonnes)	Branches (Oven Dried Tonnes)	Foliage (Oven Dried Tonnes)	Roots (Oven Dried Tonnes)	Stumps (Oven Dried Tonnes)	Total (Oven Dried Tonnes)
East of England	PINES	220,240	122,604	125,600	776,155	29,628	24,095	235,066	102,905	318,872	25,515	1,980,680
	SPRUCES	27,759	13,774	12,698	62,513	0	3,071	30,619	13,663	33,709	2,744	200,549
	OTHER CONIFERS	45,534	26,412	30,662	306,900	15,498	5,421	66,343	28,827	118,970	7,467	652,035
	BROADLEAVES	745,236	354,889	372,852	2,956,864	333,956	112,687	2,216,225	0	3,826,217	113,906	10,832,833
Total (Oven Dried Tonnes)		1,038,769	517,679	541,812	4,102,432	379,082	145,274	2,548,253	145,395	4,097,768	149,633	13,666,096

Figures are given in oven-dry tonnes. Woodfuel will never be delivered at this moisture content. Typical moisture contents will vary from 50-60% (measured on a fresh weight basis) for harvesting brash to 25-30% for conditioned woodchips.

Figures are estimates of the annual sustainable production that can be made available taking account of technical and environmental constraints. They do not take account of economic or market constraints.

Figures do not include production from woodlands <2ha in area. These can be a significant resource in particular locations, e.g. Norfolk, Powys, Scottish Borders, Tayside, Cambridgeshire, and Hereford and Worcester (all more than 5000ha). For more information see Appendix 22 of Final Report B/W3/00787/REP, URN 03/1436

Privately Owned Standing Biomass (Oven Dried Tonnes) estimated average annual production

8.7. Appendix G: Full WP4 technical report

The influence of Red band needle blight on the strength of Corsican pine

Prepared for: InCrops – East of England

29 July 2010

Client report number 261-716

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The investigation in to the influence that Red band needle blight has upon the material strength of Corsican pine has shown that the disease has little overall affect on the measured parameters. The key conclusions are:

1. Corsican pine infected with Red band needle blight has been shown to be as strong if not stronger that timber from un-infected trees and is comparable to data for the national supply dating from the 1970's.

2. The density of Corsican pine infected with Red band needle blight is as high if not higher than that of un-infected timber and is comparable to data for the national supply dating from the 1970's.

3. The disease slows the rate of growth of the timber but maintains the ratio of latewood to earlywood, which is reflected in the density results. The rate of growth for the material infected with Red band needle blight was considerably slower that for un-infected material. Normally a slower rate of growth suggests better quality of timber but this may not always be the case. Investigations showed that the growth rings maintained a good ratio of latewood to earlywood meaning the density remained high and this translated in to good values for strength and stiffness as these properties are density related in clear timber.

4. Two of the sites investigated (Thetford and the New Forest) showed very similar results, whilst the third site Cannock and the National Forest (central England) showed a similar general trend but the values were significantly lower. This suggests that geographical region and local growing conditions have an impact on the overall quality of the material produced regardless of the affects of Red band needle blight.

5. The structural strength of Corsican pine infected with Red band needle blight should remain unaffected as it is the size and distribution of the knot whorls that controls structural strength. The size and frequency of the knot whorls are not influenced by the disease.

Taken overall the results indicate that infected Corsican pine remains fit for use, without a loss of performance from the finished product, this should maintain current markets into which the material is sold. Additionally the disease has little influence on the structural strength of the timber, which is significantly influenced by the size and frequency of the knot whorls, but as no UK grown pines appear to be strength graded in the east of England this should be regarded as an opportunity to produce material that can meet the requirements of the construction market.

Introduction

Corsican pine is a commercially important timber species for the UK and England in particular, along with Scots pine it is grown in many English regions. Unfortunately it has proved susceptible to a fungal disease – Red band needle blight. This disease now affects the majority of all Corsican pine stands in central and southern England with a high proportion of the trees within these stands being affected. The question that has been raised and this report aims to clarify is;

"what influence does the disease have on the quality of the timber and in particular can it still be used for the end uses it is currently put to without a reduction in the performance of the product"?

Quality can mean many things and to determine the influence of Red band needle blight upon quality, the term quality has to be defined and be measurable. The most readily understood concept of quality for timber is strength along with the associated properties of stiffness and density as these are the significant properties that control many of the end uses the timber can be put to.

Strength can refer to either material strength as determined by small clear testing or structural strength. It has been noted that the diseases most noticeable influence was to slow the rate of growth once the disease had become established. Normally a slow rate of growth would be considered a good thing for the quality of the timber but this in not always the case. The most useful indicator for the influence of the disease on the quality of the timber would be small clear strength rather than in the structural strength. The largest influence on structural is the size and frequency of the knot whorls prevalent in species such as Corsican. The influence of the knot whorls on structural strength is far greater than any changes that resulted from a slowing of the rate of growth. Therefore the quality marker chosen to investigate the affect the disease has on the timber was small clear (material) strength of the portion of the log between the knot whorls.

The investigation was being carried out on behalf of a consortium of interested parties and was funded through InCrops based at the University of East Anglia (UEA) supported by The East of England Development Association (EEDA). The main focus of the work was on Corsican pine grown within the east of England. However, experience has shown that investigating timber from one isolated growth region can produce anomalous results; therefore, the decision was taken to put the results for the east of England into a wider context by additionally testing material from central and southwest England. If the same overall trend could be established for the three geographical locations then greater confidence could be placed in the result.

Description of the project

To understand and determine the influence that Red band needle blight has upon the strength of Corsican pine, logs have been selected from three geographical locations in Central and Southern England, these being Cannock (Central England), Thetford Forest (South East) and the New Forest (South West).

From each of these regions logs that were affected with the disease and logs that were clear of the disease were taken in sufficient numbers so that each region supplied a third of the total specimens for each condition (approximately 35 logs per location per condition, with some over supply).

The individual sites were as follows:

Central: - Cannock

Cannock Chase, Rugeley (Colour code - Orange)

National Forest (Colour code - Pink)

South East - Thetford

Kings Forest (Colour code - Red)

Croxton (Colour code - Clear)

South West – New Forest

Highland Water plantation (Colour code - Red)

Udds Forest (Colour code - Green)

Material for test was derived from the logs supplied and kiln dried before final conditioning at 20°C and 65% RH to attain a moisture content of around 12%. After conditioning the specimens were tested in accordance with BS373:1957[1] to determine the small clear strength, stiffness and density.

The results obtained from the testing of the infected and un-infected material was used to determine the influence the disease had up on the timber. The different geographical locations was used to ensure that the trends noted for the Thetford site were replicated in other regions, if the trends were replicated in the other regions it will give confidence that the Thetford results are a true reflection of the influence of the disease.

A final validity check on the results obtained has been carried out by comparing them to data from the 1970's for the national supply of Corsican pine. By using this approach it was possible to determine the affect of Red band needle blight on the timber quality and have a high degree of confidence in the outcome.

Findings

Initial processing

The aim of the initial processing was to break down the logs so that rapid kiln drying could be achieved, targeting the outer boundary of the sapwood, the most recently produced timber of the tree, where most of the timber that was affected by the Red band needle blight was expected to be found.

Each log needed to be no longer than 1 metre in length to allow for the cutting of the small clear sample but having sufficient material around the area were the sample were to be taken from so that the grain was straight, the influence of knots was eliminated and drying degrade could be reduced, Figure 1 shows typical samples of logs.

Figure 1. Typical logs (Pink indicates the National Forest)

The knot whorls where spaced between 400 mm and 800 mm and the saw cuts were made to extract the clear timber between the whorls, Figure 2 shows the typical cutting points (between the sticks) for the logs.

Figure 2. Showing the cut points to remove the knots whorls.

The logs were then sawn in half length wise to open a wide face for drying, for the Cannock and New Forest material the end grain was sealed and the material kiln dried. This material took longer to dry than originally expected so for the remaining material after sawing length wise the edges were removed to open addition drying pathways, before the end grain was sealed. This difference is shown in Figure 3; the aim was to reduce the drying time for the second and third locations compared to the first. Each portion of the log for further processing was marked with an identification number so that the identity of each piece could be traced. The target moisture content for the drying of the logs was just above 12% with the final reduction to the test condition of 12% being carried out by conditioning at 20°C and 65%RH when the specimens have been fully machined.

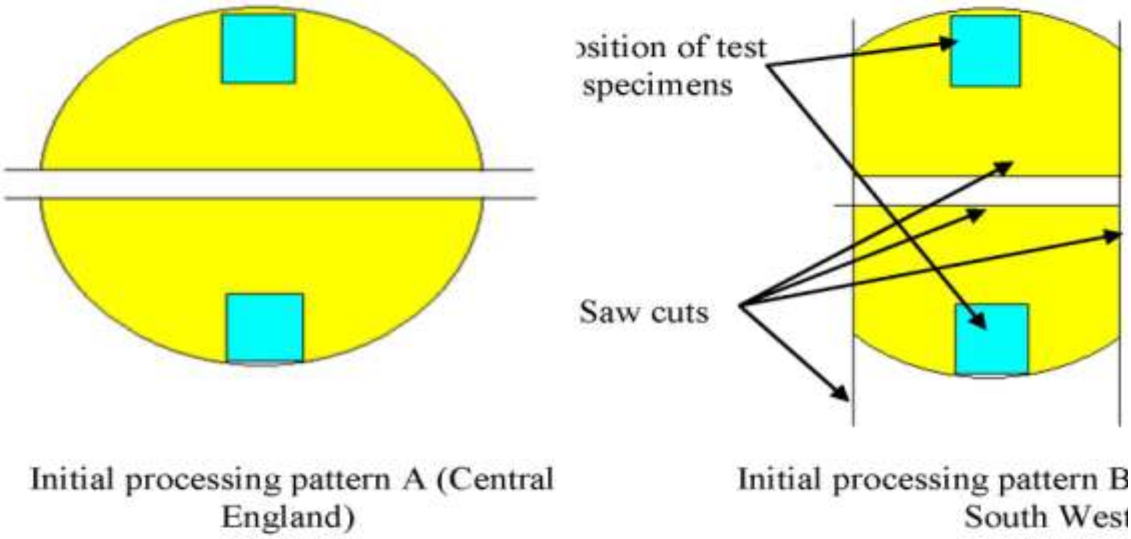


Figure 3. Showing the difference in the initial processing patterns between the material f
England and material from the Southwest and Southeast.

Figure 4 shows the Thetford material being loaded in to the kiln, the logs during stacking
determination probes fitted to constantly monitor moisture content throughout the drying

Figure 4 . The Thetford material being loaded in to the kiln for drying to 12% moisture cc

Testing rational

Testing to BS373 gives the best indication of the innate strength for the timber by excluding, as far as is possible, all other strength reducing characteristics present in the timber. This method allows for a relatively large portion of the test specimens cross sectional area to include material that will have been laid down during the period of the infection, thereby reducing the influence of timber laid down before the infection took hold. This was compared directly to timber that is known to be unaffected by the disease taken from a similar region within the control log to reduce the variation in strength that is noted between locations within the tree.

To increase the sensitivity of the testing the normal arrangement for testing, with the growth rings arranged vertically (parallel to the direction of loading), left hand image in Figure 5, be changed so that the portion of the test specimen that contains the greatest amount of timber that results from the period of the infection is placed on the compression face of the test specimen, right hand image in Figure 4. During testing the maximum fibre stress occurs on the compression face of the test specimen, thereby making it more likely that any difference in strength between timber that results from infected trees and that from un-infected trees will be detected.

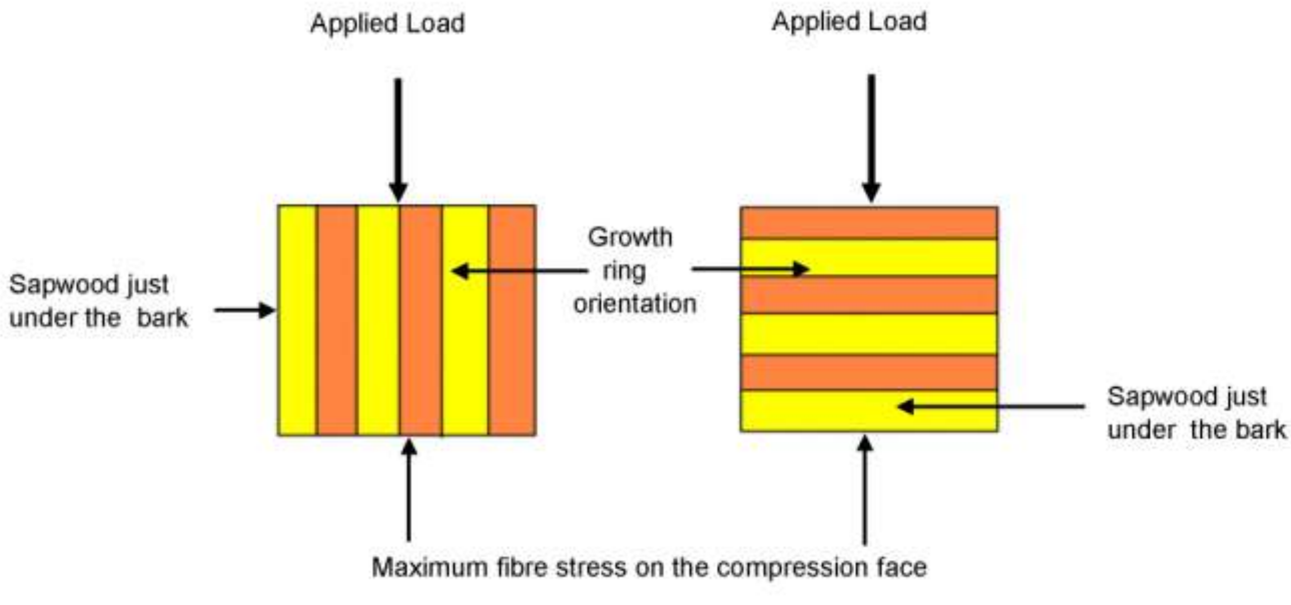
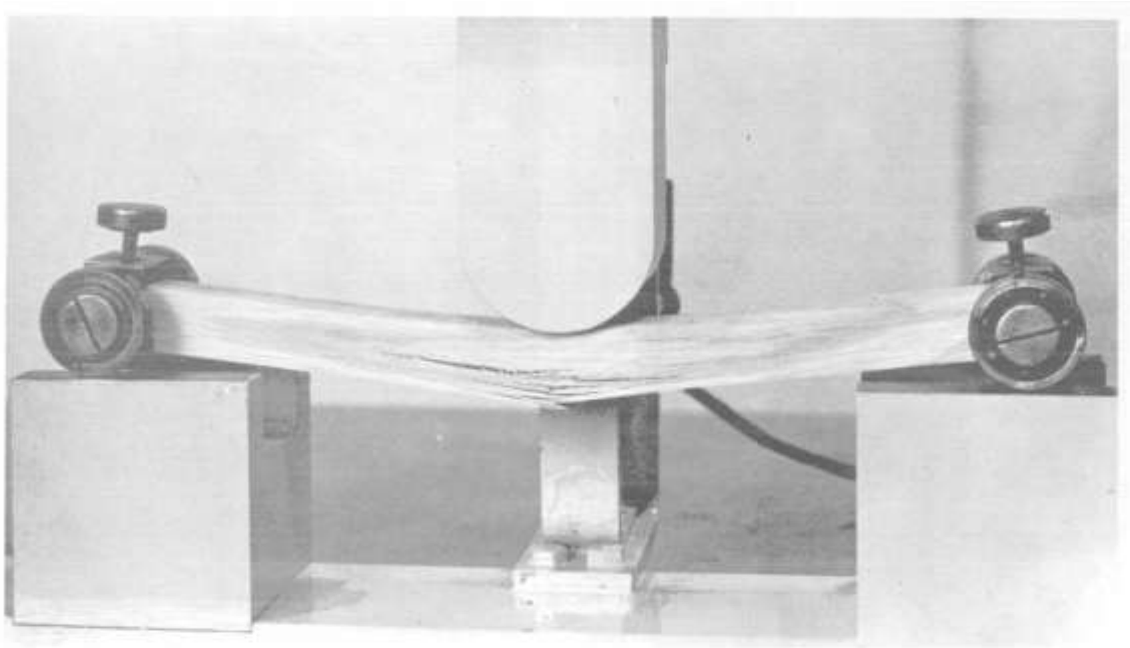


Figure 5. Showing change to growth ring orientation for testing

Testing results

All material tested to determine strength, stiffness and density complied with the requirements of BS 373



being nominally 20mm x 20mm x 300mm giving an effective span of 280mm. The testing arrangement was as shown in Figure 6.

Figure 6. Showing the testing arrangement for the specimens.

The specimens are fitted to self centring roller bearings allowing the specimen to adjust to dimensional changes that result from the accumulative increase in deflection throughout the test. This ensures that the loading point is always acting through the centre of the specimen. The orientation of the specimen was as described in the “Testing Rational”.

Testing commenced with the material from Cannock as this was first to be acquired and processed, followed by material from Thetford and finally material from the New Forest. In addition there was data for comparison that dated from the 1970’s for Corsican pine drawn from the national supply. Therefore, with the three sites regional variations within the resource could be studied and compared to the national data, this should give a clear indication of the overall affect that Red band needle blight has upon the material strength of the timber.

At the stakeholders meeting held on the 27th May 2010 at Santon Downham the results for Cannock and a subset of the Thetford sample was given. Since that time the full set Thetford specimens have been completed and work on the New Forest material completed. Each set of regional samples contains 66 specimens from infected trees and 66 specimens from un-infected tress. “Un-infected” is a relative term as in some regions it was hard to completely exclude infected trees from the sampling, though the extent of infection was not comparable with the material described as being from “infected” trees. This was certainly true of the Thetford sample.

Source Geographical regions	Number of specimens	Strength (N/mm^2)	Stiffness (N/mm^2)	Density (kg/m^3)
Cannock	66	76.68	8302	483
	66	59.2	6136	396
Thetford	66	84.72	9780	508
	66	83.41	8920	498
New Forest	66	80.39	9125	539
	66	78.2	9003	521
National data (1970's)	38 whole trees and 20 joists	81	9200	481
	Infected material		Un-infected	

The influence of red needle blight on the strength of Corsican pine

Table 1. Showing the results obtains for the three geographical regions.

It can be seen that there is a general trend for the infected material to perform slight better than the un-infected material across of the measured parameters. For Thetford and the New Forest the results for the infected material and un-infected material are not that dissimilar, however, there is the question of the purity of the un-infected material to take into account. The results are generally in line with the values obtained from the national data gathered in the 1970's. It may be considered surprising that the results are so similar as usually when data from current sources is compared to historical data a deterioration in overall quality is invariably noted, this does not seem to be the case with Corsican pine.

However, there is the question of the Cannock material; though the trend between infected and un-infected follows a similar pattern to the other two sites the values obtained for the three key indicating parameters are well below those obtained for Thetford and the New Forest. At this time it is not known why there is such a striking difference between Cannock and the remaining sites but it is likely that it is not attributable to Red band needle blight. It is important to be aware of these results as some saw millers in the east of England import Scots and Corsican pine logs from Cannock.

Taken collectively and with the caveat with regards to the Cannock data the results for the infected and the un-infected material is shown in Table 2.

Condition	Strength (N/mm^2)	Stiffness (N/mm^2)	Density (kg/m^3)
Infected	80.6	9069	510
Un-infected	73.6	8019	471
nation data for the 1970's	81	9200	481

Table 2. The collective results for the 3 sites by condition compared to data for the national supply from the 1970's.

The results suggest that the timber from infected trees can continue to be used for the uses it is current put to without a deterioration in the performance of the product due to the presence of Red band needle blight. In fact it could be argued that there is a slight improvement in the mechanical properties of the timber from trees infected with the disease.

Other strength related properties

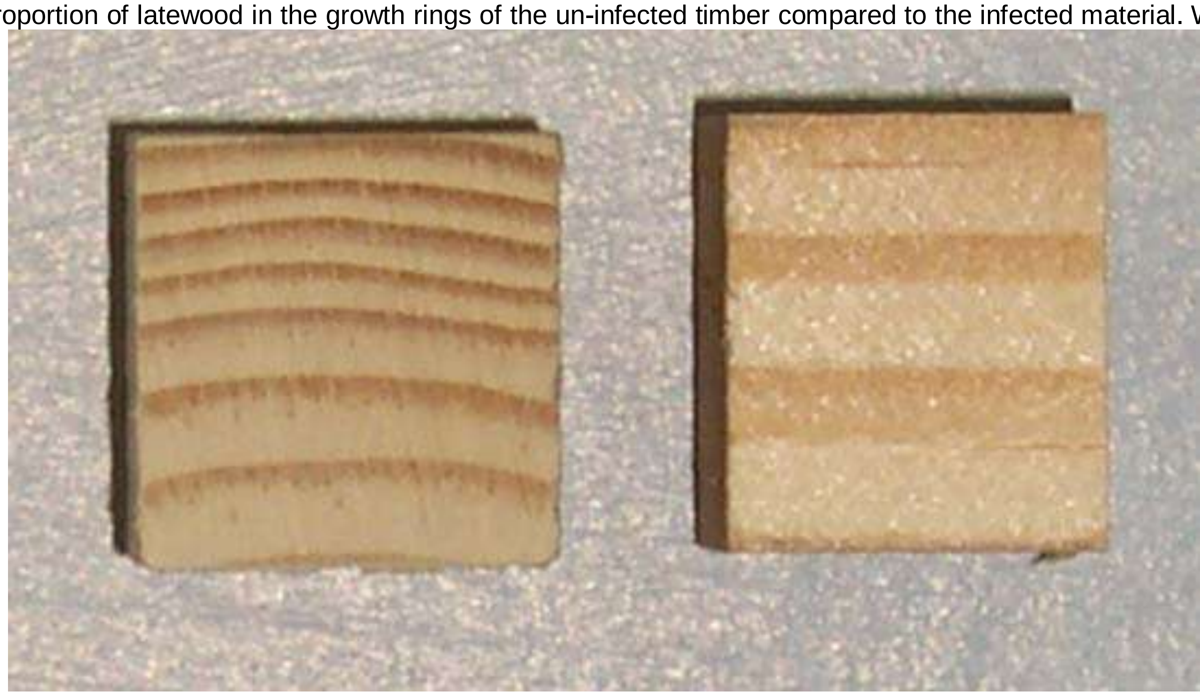
This investigation has focussed on the influence that Red band needle blight has upon the mechanical properties of the clear timber and has not addressed the issue of structural strength. Structural strength is of importance if there is a desire to increase the amount of East of England grown timber going in to local construction.

The structural strength and related properties of Corsican pine are in the main influenced by the presence of knots and knot whorls typical for this species. In Corsican pine the knot whorls are spaced at between 400mm and 800mm intervals along the length of the log, with clear timber in between. The presence of knots is the most significant strength reducing characteristic and along the knot whorls there is servere local slope of grain, another significant strength reducing characteristic. Taken together knots and slope of grain have a far greater influence on the overall structural strength than the strength of the timber between the knot whorls does. Therefore for the Red band needle blight to have any influence on structural strength it would have to lead to a major change in strength of the clear wood and this has not been noted. It is therefore considered that the disease will not adversely affect structural strength.

Corsican pine can be machine graded using bending type machines to C16 and C24 strength classes, though the yield of C24 is relatively modest. C16 is the commonly specified strength class for timber frame stud and timber floor joists. It can also be visually strength graded to the GS and SS visual grades in BS4978[2]. These visual grades are then attributed to the C14 and C22 strength classes in BS 5268: Part 2[3]. Whilst C14 is a virtually a non-commercial strength class timber meeting the C22 strength class can be sold C16 and better.

Influence on rate of growth

It had been noted that the rate of growth of infected trees was considerably slower than the rate observed in un-infected trees. Whilst it is normally considered that a slow rate of growth is good for timber quality this is true only where there is a good ratio of latewood to earlywood. Where there is a poor ratio of latewood to earlywood and earlywood predominates the timber is low in density, tends to lack strength and is prone to compression crease formation. It was considered important to understand if as a result of the disease the growth rings still contained an appropriate ratio of latewood to earlywood. The density values taken from the test data suggests that this was the case. Though on visual inspection there appeared to be a greater proportion of latewood in the growth rings of the un-infected timber compared to the infected material. Whilst



the rate of growth was higher in the un-infected material, being 3 to 5 growth rings per 20mm section compared to 5 to 7 growth rings in the infected material there was in general a ratio of 50/ 50 latewood to earlywood compared to a ratio 40/ 60 latewood to earlywood in the infected timber (Figure 7).

Figure 7. Showing the difference between infected (left) and un-infected (right) timber with relation to rate of growth.

Under microscopic examination though there appeared a greater proportion of latewood in the growth rings of the un-infected timber there was a wide transition zone from earlywood to latewood which appeared to the naked eye as latewood, hence making the total amount of latewood appear large. By contrast the infected material, when viewed under the microscope, showed an abrupt point at which earlywood stopped and the latewood started with no transitional zone. The overall effect was that when the effect of the transitional zone in the un-infected material is taken in to account there is probably more latewood in the infected timber than the un-infected material.

Conclusion and recommendations

1. Corsican pine infected with Red band needle blight has been shown to be as strong if not stronger that timber from un-infected trees and is comparable to data for the national supply dating from the 1970's.
2. The density of Corsican pine infected with Red band needle blight is as high if not higher than that of un-infected timber and is comparable to data for the national supply dating from the 1970's.
3. The disease slows the rate of growth of the timber but maintains the ratio of latewood to earlywood, which is reflected in the density results.
4. The results for Thetford and the New Forest are similar and significantly different to those from central England but the general trend is similar. This suggests that Corsican pine is site dependent for the quality of the timber it produces.
5. It has been discovered that some material is imported in to the Thetford region from central England; material from the New Forest would be a better choice as it is almost identical to material from Thetford and of overall better quality than from Central England.
6. The results show that Corsican pine infected with Red band needle blight remains suitable for the current uses it is being put to without a loss of performance.
7. The structural strength of Corsican pine infected with Red band needle blight should remain unaffected as it is the size and distribution of the knot whorls that controls structural strength. The size and frequency of the knot whorls are not influenced by the disease.
8. The material can be machine and visually strength graded to meet the requirements for use in the construction industry,

References

1. British Standards Institution 1957, Small clear testing of timber, BS 373 1957, London.
2. British Standards Institution 2007, Visual strength grading of softwood - Specification, BS 4978: 2007. London
3. British Standards Institution 2002, Structural use of timber. Part 2. Code for practice for permissible stress design, materials and workmanship, BS 5268: 2002. London

InCrops Enterprise Hub

InCrops Project

Modeling the supply chain for new low carbon forestry products

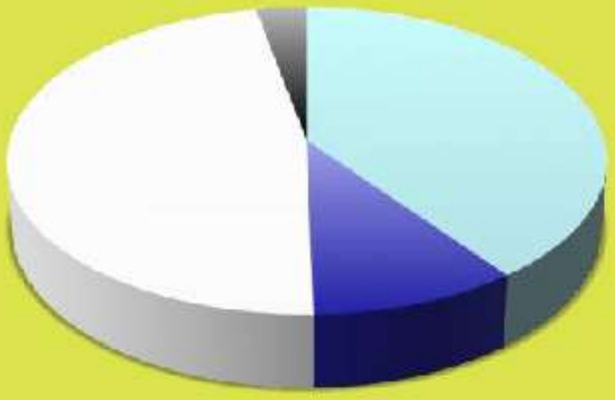
Mark Coleman

Presentation for EcoBuild March 2010

UK Woodland Cover

InCrops Project

Total woodland cover



***Total:* 2841 kha**

Forestry Facts & Figures 2009, Forestry Commission

UK Woodland Cover

Broadleaves

***Total:* 1213 kha**

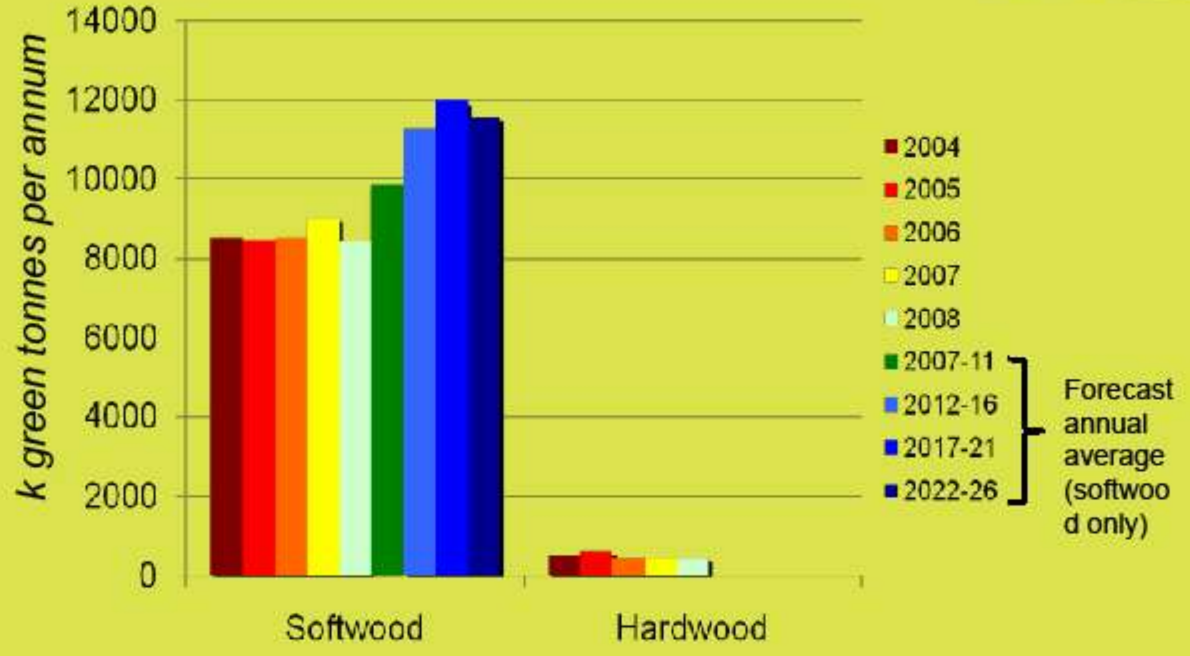
Conifers

***Total:* 1628 kha**

Forestry Facts & Figures 2009, Forestry Commission

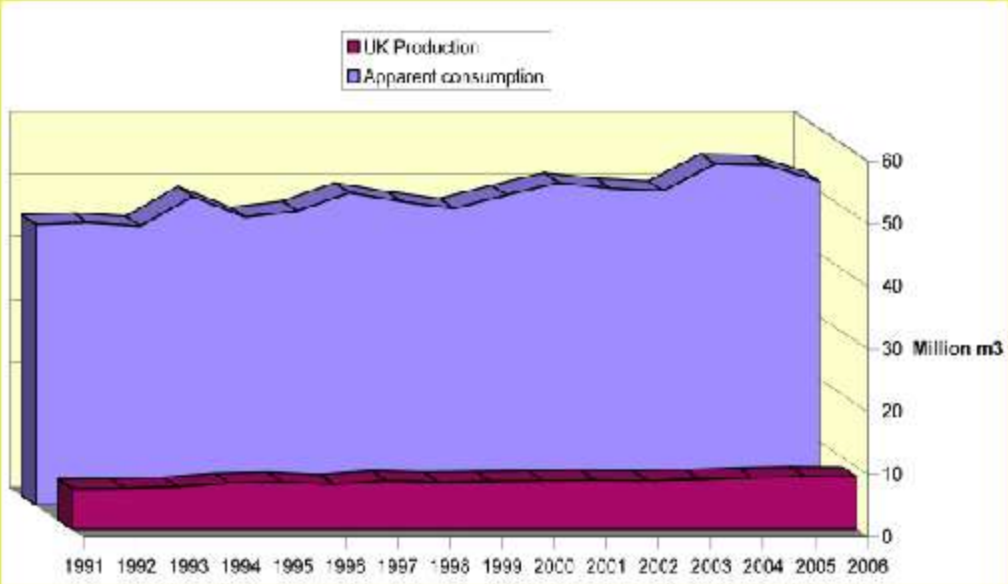
UK Wood Production

InCrops Project



Forestry Facts & Figures 2009, Forestry Commission

Production and consumption



Forestry Commission

Major import sources

InCrops Project

	Sawn softwood	Sawn hardwood	Plywood	Particle-board	Fibre-board	Total
Sweden	2443	6	0	0	8	2457
Finland	1222	0	218	50	17	1507
Latvia	1150	101	16	0	0	1267
Russia	1008	6	78	0	0	1090
Germany	359	34	16	249	117	775

Thousands m^3

Forestry Commission

Corsican pine

Species: *Pinus nigra* subsp. *laricio*
Size: 18-45 m (h) x 1+ m (dia)
Introduced: 1759
Area: 30,575 ha (Forestry Commission)
14,774 ha (other)
45,350 ha (total)

Density (dry): 510 kg/m^3
Price: low
Uses: heavy structural uses, exterior and interior joinery

National Inventory of Woodland and Trees. Forestry Commission, 2003;
TRADA; Kew

Corsican pine

	Area (ha)	Area (%)
Scots pine	219,438	16
Corsican pine	**45,350**	**3**
Lodgepole pine	134,076	10
Sitka spruce	683,656	49
Norway spruce	76,206	6
European larch	22,485	2
Japanese/hybrid larch	107,677	8
Douglas Fir	45,224	3
Other conifer	29,209	2
Mixed conifers	16,188	1
Total conifers	**1,379,510**	**100**

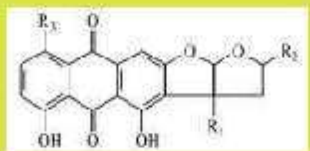
National Inventory of Woodland and Trees. Forestry Commission, 2003

Corsican pine

• Thetford Forest: ~65% Corsican pine

National Inventory of Woodland and Trees. Forestry Commission, 2003

Red Band Needle Blight



Species: *Mycosphaerella pini* (anamorph *Dothistroma pini*)

Hosts: many species of Pinaceae (pine, spruce, larch, fir)

Disease type: necrotrophic

Symptoms: needle mortality, defoliation, deceased yield, tree mortality

UK Prevalence: appeared 1954; became widespread 1990s; estimated >80% of the East Anglia Forest District Corsican pine crop infected 2007

Factors affecting severity: plant age, wetness, temperature, shading, genetic resistance

Control: fungicide, genetic resistance, removal of infected branches

Red Band Needle Blight of Pine Forestry Commission, 2003; Bradshaw RE, 2004, For. Path. 34: 163–185

Corsican pine

InCrops Project

- Thetford Forest: ~65% Corsican pine
- ~60% is infected with red band needle blight
- Infected trees will be felled and replaced over next 20-25 years

National Inventory of Woodland and Trees. Forestry Commission, 2003

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Aims

- Catalyse change in supply, value adding and use of wood in the East of England
- Boost the delivery of low carbon housing in the region
- Link expertise and knowledge around wood resource in the region

InCrops Project

Forestry Commission England

bre

UEA University of East Anglia

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Work programme

- Task 1: Mapping exercise
- Task 2: Forest characterisation
- Task 3: Supply chain modelling
- Task 4: Corsican pine strength assessment
- Task 5: Drafting Phase II proposal

InCrops Project

Forestry Commission England

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UEA University of East Anglia

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Task 1: Mapping exercise

- Capture structure and form of existing supply chain and potential end users including:
  - Businesses in supply chain
  - Local communities
  - House builders
  - Manufacturers
  - Regulators

Image: Forestry Commission

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Task 2: Forest characterisation

- Potential for production and mensuration of low carbon end products. Data on:
  - Harvest volumes
  - Projected future harvest volumes
  - Yield volumes of sawn timber and other products (per hectare)
  - Volume of carbon stored

Image: Forestry Commission

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Task 3: Supply chain modelling

• Focus areas: structural, joinery and flooring wood products, e.g.:

Window (oak, chestnut)

Twin laminate beam (pine)

Flooring (ash, hornbeam)

Interior joinery (hornbeam)

Structural post and beam (pine)

• A series of supply chain scenarios will be developed for presentation at the stakeholders event in week 10.

Image: Forestry Commission

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Task 4. Corsican pine strength assessment

- Construct sample of ~200 pieces of Corsican pine reflecting incidence of red band needle blight in the East of England
- Test to destruction following procedures in BS EN 408 to determine strength, modulus of elasticity and density
- Compare to data for "British pine" (Scots pine and Corsican pine) in BRE database

Image:
www.worldculturepictorial.com

Low Carbon Supply Chains For Forest Products in the East of England

InCrops Project

Task 5: Drafting Phase II proposal

- Draft proposal.
  - Three priority supply chains will be identified at Event 1.
  - Activity to move these supply chains forward will be proposed.
- Establish advocacy group

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