Research Information Note 160

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THE STORAGE OF CARBON IN TREES AND TIMBER, by D.A. Thompson and R.W. Matthews

Summary

Trees have a positive role to play in countering the greenhouse effect. They absorb carbon dioxide by photosynthesis, some of which is stored as carbon compounds in wood, both during the growth of trees and, after felling, in various forms of wood products. This Note describes some preliminary calculations on the amounts of carbon likely to be involved for different tree species and end uses.

Introduction

1. Trees, while they are alive, absorb carbon dioxide from the atmosphere and store it in the form of timber. In natural forests trees mature, become senile, fall and decay. The process of decay by bacteria, fungi and insects results in wood being reconverted back to carbon dioxide. Foresters can intervene in this natural pattern in two ways. First, they can improve the rate at which carbon is absorbed by increasing the growth rate of the tree crop. Secondly, they can reduce the amount of carbon dioxide eventually returned to the atmosphere by removing wood in the form of timber. Furthermore, by ensuring that the timber is put into long-lived uses such as furniture or construction timber they can help to extend the time the carbon is stored well beyond the natural life of the tree crop.

2. Moving from natural forest management to plantations further increases carbon fixation since foresters can plant trees of a type and in a way so as to maximise the rate of timber production. They can also manipulate the competition between trees by removing thinnings at intervals during the life of a tree crop so as to concentrate timber production on the trees that are likely to produce the most valuable timber which should ensure that it is put to long-term rather than short-term uses.

The model

3. The Forestry Commission has developed a model which combines a tree production curve with an estimate of (and a curve for) the retention of carbon in 'waste' and wood products after harvesting. Using the latest versions of these, eg for Sitka spruce YC12, Corsican pine YC16 and other species, the rate of total above-ground biomass was accumulated for all the years up to the end of a normal rotation. Accumulation of carbon was estimated on the basis that the wet weight to wet volume ratio was 1:1; that multiplying the nominal specific gravity by the volume gave dry weight (DW) production and that there was 42% DW carbon in softwoods and 45% DW carbon in hardwoods. These estimates of carbon were based on the different proportions of cellulose, hemicelluloses and lignin reported for the two classes.

4. Carbon retention curves were constructed for the various timber products recognised in the market. For some classes of timber product the retention curve extends into and beyond the time taken for the next crop of trees to grow on the same site. This means that carbon accumulated is represented in part by the growing crop and in part by the timber products not yet returned to carbon dioxide from previous crops. After a number of rotations no further net increase in stored carbon occurs (graphs 1 and 2 show examples of Corsican pine YC16 and poplar coppice).

5. The number of combinations possible for species and timber products is infinite. However, those used here are as close as possible to realistic, presently found circumstances. The one exception to this is for short rotation coppice. Data for these estimates are based on experimental evidence and on one potential product outlet, medium density fibreboard.

Timber product retention

6. Some representative graphs for the longevity of Sitka spruce timber are given in Figure 1.

   a. The rate of deterioration of waste material on the forest floor was varied to allow for the differences between species in their durability in the face of decay organisms.

   b. Pulpwood is made into various paper and card products. The industries manufacturing these products use a considerable volume of recycled paper, however in the UK most of this is imported.

   c. The difference indicated between particleboard and medium density fibreboard (MDF) represents the differences observed between the end products made from those materials. MDF is seen in a greater number of long-lasting products.

   d. The apparent long life for fencing reflects the use of preservatives on these products.

   e. It is extremely difficult to estimate the retention time for timber in buildings. However, mortgage companies tend to view the life of dwellings as being about 100 years. On the other hand timber is also used by the building trade for temporary purposes.

Period and volume of carbon fixation

7. Table 1 summarises information on the period over which carbon is stored by a number of tree species growing in upland and lowland sites and on their products. Birch in the uplands is the species with lowest productivity at 1.0 tonne of C/ha/annum and poplar coppice for fibreboard use is the highest at 4 tonnes of C/ha/annum. The figures in column 5 represent the normal period of growth for these species before clear felling. The periods of years in the sixth column are those taken to reach maximum carbon storage. In this case oak takes 300 years to reach maximum carbon storage whereas poplar coppice used for medium density fibreboard takes 70 years. Column 7 gives the average amount of carbon in stored form, that is in trees and products, at the time when maximum storage is reached. This figure might be equated with the value for a 'normal' forest with all ages of crop equally represented.

Table 1 Carbon stored by British-grown trees and their timber products

Site type	Tree species	Yield class (m^3/hectare/ annum)	Equivalent carbon yield (tonnes/ hectare/annum)	Normal rotation (years)	Period to maximum carbon fixation (years)	Average amount of carbon in a fixed form at time of maximum (tonnes/hectare)
(1)	(2)	(3)	(4)	(5)	(6)	(7)
Upland	Sitka spruce	12	1.7	55	110	78
	Scots pine	8	1.4	70	140	74
	Birch	4	1.0	45	90	61
Lowland	Scots pine	10	1.7	65	130	91
	Corsican pine	16	2.7	50	100	135
	Oak	6	1.5	150	300	118
	Poplar coppice fibreboard	-	4.0	7	70	121

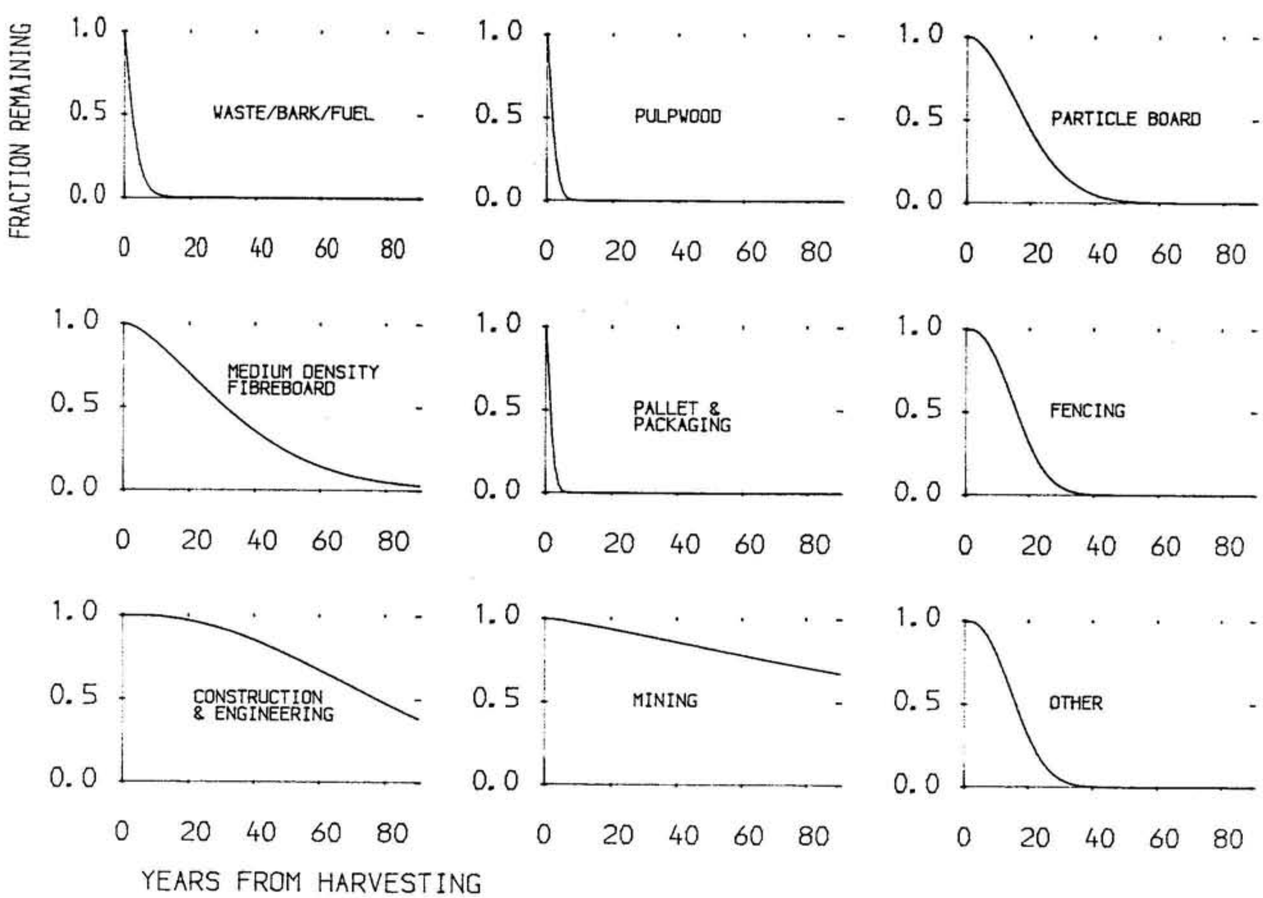
Conclusions

8. The calculations and estimates above demonstrate the way in which carbon from the atmosphere is apportioned between trees and wood products. The size and scale of differences resulting from various species and product combinations is shown. One general conclusion from the study is that a combination

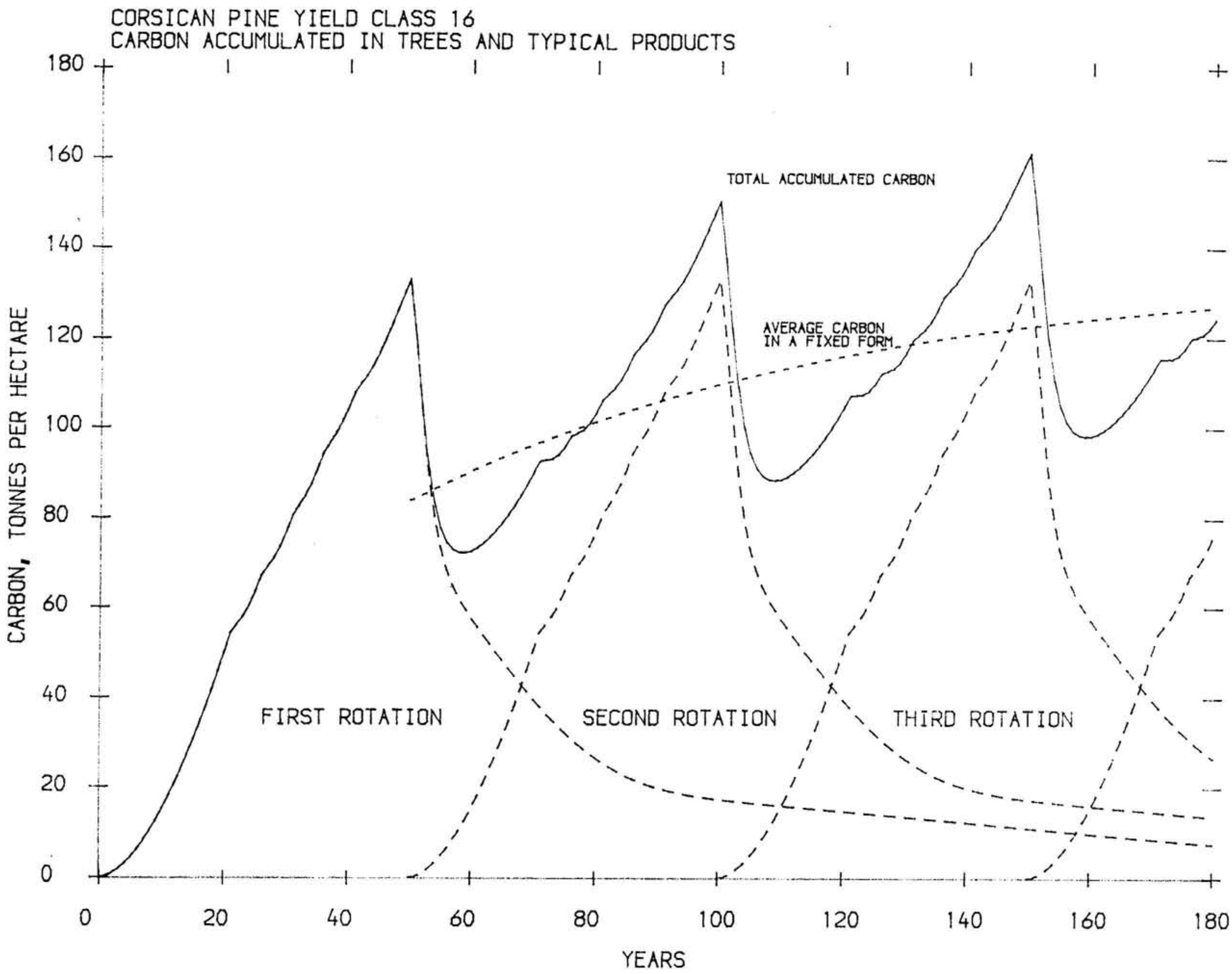
of a lowland site with a fast growing species converted to a long-lasting product, such as medium density fibreboard, can store substantially more carbon than even vigorous species grown on poorer upland sites. Traditional species, converted to conventional products, take longer to accumulate carbon.

FIGURE 1

LONGEVITY OF SITKA SPRUCE TIMBER WHEN PUT TO DIFFERENT USES



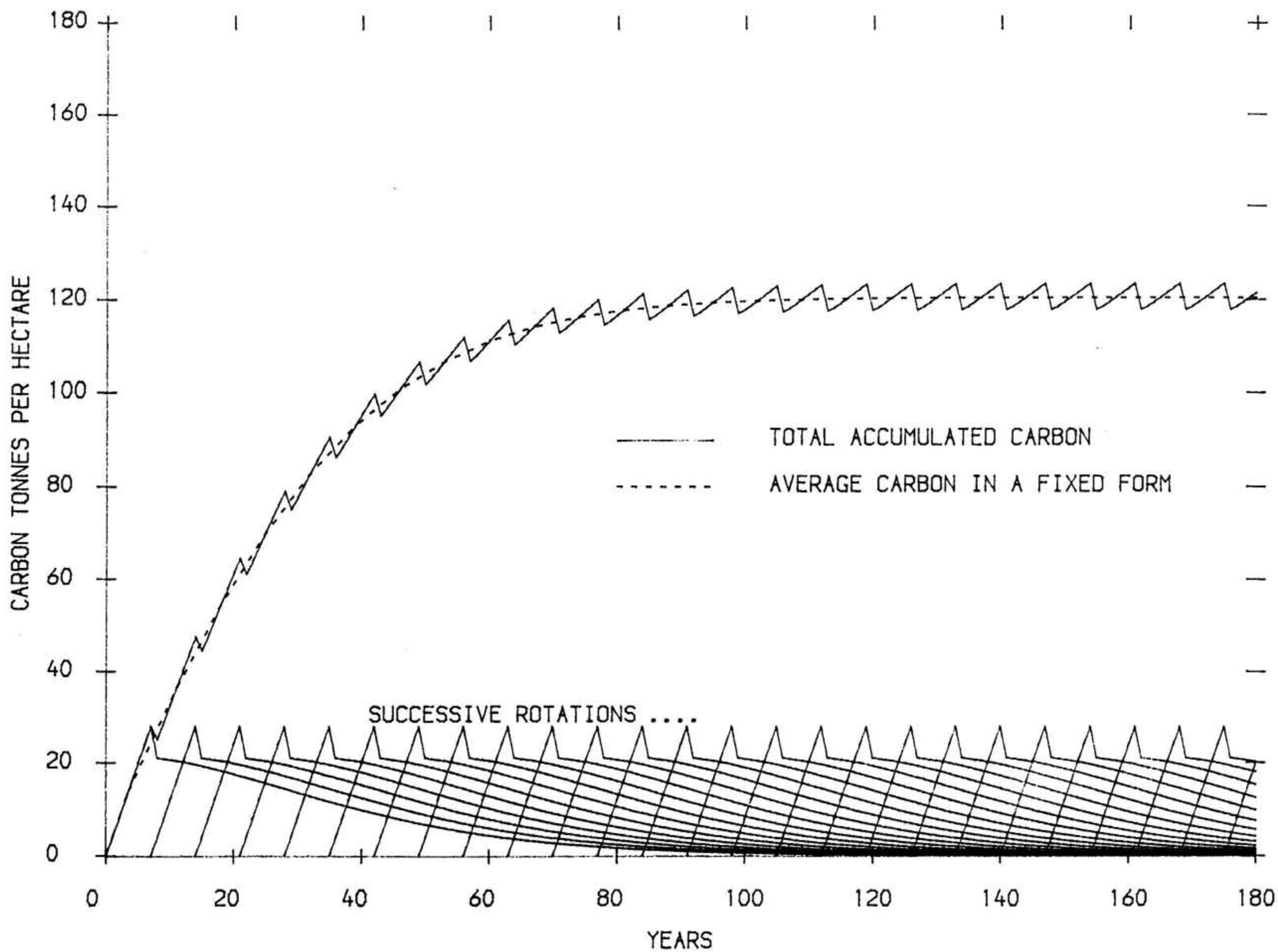
GRAPH 1



CORSICAN PINE YIELD CLASS 16
CARBON ACCUMULATED IN TREES AND TYPICAL PRODUCTS
TOTAL ACCUMULATED CARBON
AVERAGE CARBON
IN A FIXED FORM
FIRST ROTATION
SECOND ROTATION
THIRD ROTATION
CARBON, TONNES PER HECTARE
YEARS
0
20
40
60
80
100
120
140
160
180

GRAPH 2

POPLAR COPPICE CARBON ACCUMULATED IN TREES AND MDF



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