Climate Change Research: Evaluation and Policy Implications
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Forests and wood consumption on the carbon balance.

Carbon emission reduction by use of wood products

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Abstract

Until now studies on the greenhouse effect paid much attention to carbon fixation by forests, while the entire CO_2 cycle of forests and forest products remained underexposed. Utilization of wood products instead of energy-intensive materials (plastics/steel) and fossil fuels (coal) proves to play an important role as well. The effect of utilization is even greater than that of fixation. In all, additional forests together with the multiple use of trees can contribute substantially to the reduction of CO_2 emissions. The contribution can run from 5.3 ton CO_2/ha/yr for a mixed forest of oak/beech to 18.9 ton CO_2/ha/yr for energy plantations (poplar).

INTRODUCTION

The greenhouse effect is a problem acknowledged worldwide. The increasing concentration of greenhouse gasses in the atmosphere (carbon dioxide, methane, nitrogen oxide and others) may in time lead to an unwanted temperature rise. Forests and the use of wood contribute to the fight against the greenhouse effect in three ways:

1. Carbon fixation (during their growth trees convert CO_2 into timber)
2. CO_2 avoidance through substitution by wood of energy-intensive materials such as plastics, aluminium and steel. Processing timber uses relatively little energy (fossil fuels). After use it can easily be reused, e.g. as particle board.
3. CO_2 avoidance by using timber instead of fossil fuels for generating energy. When recycling has become technically or economically impractical, wood may be used for energy purposes. The same is valid for timber from special energy plantations. Only the previously sequestered CO_2 will be released when burning the woody material. This makes the use of timber 'CO_2 neutral'.

In 1989 the CO_2-emissions in the Netherlands amounted to 183 million tons. These increase by 3.5 million tons annually. The Dutch government is striving for stabilization with respect to the 1989 emissions level. This corresponds to a reduction of 21 million tons CO_2 by 1995.

FIXATION OR AVOIDING?

Recently a number of reports are published concerning the carbon sequestering potential of various forest types. These studies primarily examine carbon sequestration in biomass (the tree), soil and timber products. Findings suggest that long rotation forests provide a greater contribution than short rotation forests (Table A, No.1).

Besides the average carbon sequestration by trees and in timber products, an important CO_2 reduction effect is created through substitution for nonwood products (product substitution) and fossil fuels (fuel substitution). This CO_2 avoidance was included in the NOVEM[c]-report 'Bossen en hout op de koolstofbalans'.

Table A Potential contribution to CO_2 reduction (in tons CO_2/ha) of several forest types

	Oak/Beech	Spruce	Poplar 15 year	Poplar 5 year
1. CO_2 fixation in biomass, humus and products (average)	432	394	104	-106 *)
2. CO_2 avoidance through replacement of non-timber materials	182	784	653	0
3. CO_2 avoidance through replacement of fossil fuels	966	1289	1560	5788
Total CO_2 reduction in 300 years	1580	2467	2317	5682

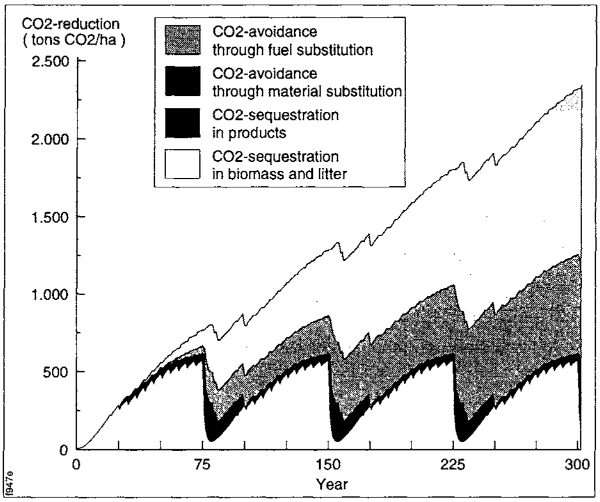
*)Including processing energy of fertilization (0.44 ton CO_2/ha/yr)

Substituting wood for plastic, aluminium and steel leads to an important reduction in emissions. This is because the production of wood materials uses far less fossil energy than the mentioned alternatives. The effect is most evident in saw and packing timber products, such as frames, construction timber and pallets. Norway spruce is a forest type that produces relatively many saw logs and packaging timber products (Table A, No.2).

The greatest contribution to CO_2 reduction, however, results from substituting wood for coal in energy production. This is especially true for energy wood plantations (short rotation poplar), from which all wood produced, such as increment, is used as fuel (Table A, No.3).

The effects of both product and fuel substitution are repeatable. During cultivation, harvest, use and renewed cultivation, no additional CO_2 is released into the atmosphere. The average sequestration clearly has a once-time effect, because in time the CO_2 is released again, either through decay or through combustion (Figure A)

Figure A Total CO_2 reduction effect* of Norway spruce stand having a rotation of 75 years (tons CO_2/ha)



Source: Stichting Bos en Hout, Wageningen, The Netherlands

*) Carbon sequestration in biomass, litter and products is subject to fluctuations during every rotation. An average sequestration, which reaches a constant value of 394 tons CO_2/ha after several rotations, was used for calculations in the text.

Table B Contribution by forest type to 1995* goal for national CO_2-emission reduction

	Oak/Beech	Spruce	Poplar 15 year	Poplar 5 year
Annual reduction (in tons CO_2/ha)	5	8	8	19
Reduction per 100,000 ha (in 1000 tons CO_2)	530	820	770	1890
Contribution to policy '95	2.5	3.9	3.7	9.0

*)National CO_2-emissions were 183 million tons in 1989. Emissions increase 3.5 million tons annually. 1995 goal: Stabilization with respect to 1989 correspondends to a reduction of 21 million tons CO_2.

In the study CO_2 balances of long rotation forests (oak/beech, 150 years) were compared with those of short rotation forests (poplar, 5 and 15 years), and supplemented with those of Norway Spruce, a wood species ideal for recycling. The contribution to CO_2 emissions reduction (see Table B) proves to be substantial: 5 to 19 tonnes CO_2/ha/yr. The contribution to the Dutch reduction goal can run from 2.5% for a mixed forest of oak/beech to 9% for energy plantations of poplar.

FOREST TYPES

Calculations were made for four forest types (see Table C). An average tree-species specific increment was assumed. The average CO_2 sequestration in the tree itself and in the upper soil layer (litter) of each forest type over a 300 year period was modelled. Sequestration in the stable humus was not considered, because this factor is greatly dependent on soil types and previous use of soil (e.g. agriculture). In the Netherlands the extra fixation by afforestation amounts to a small quantity.

Table C Important characteristic figures of considered forest types

	Oak/Beech	Spruce	Poplar 15 year	Poplar 5 year
Rotation time (yr)	150	75	15	5
Number of rotations in 300 yr	2	4	20	60
Mean increment (m^3/ha/yr)	5.4	11.5	15.9	29.5
Density air dry (kg/m^3)	700	460	450	450
Amount of carbon in dry matter weight (%)	50	50	50	50

FIXATION OF CO_2 IN TREE AND SOIL

With each rotation, forests 'produce' wood that becomes available during thinning and during the final felling at the end of the cycle.
Most of the wood ends up being used outside the forest as industrial wood. Another part of the felled trees remains in the forest as dead wood. This wood ends up in the litter layer and breaks down during decomposition to CO_2 and water. Thus the fixed CO_2 in wood is gradually released into the atmosphere.

No wood is left behind in short rotation poplar forests. The entire above-ground biomass (the trunk including the branches, but excluding the leaves) of this forest is destined to serve as fuel for energy production. Thus, hardly any sequestration occurs in the litter layer. Removal of the trunk and branches also means the disappearance of nutrients. Fertilizing compensates for this effect. The processing energy of the fertilizer (0.44 ton CO_2/ha/yr) such as lime and K_2O is subtracted from the net sequestration. Total sequestration as a result has a negative value.

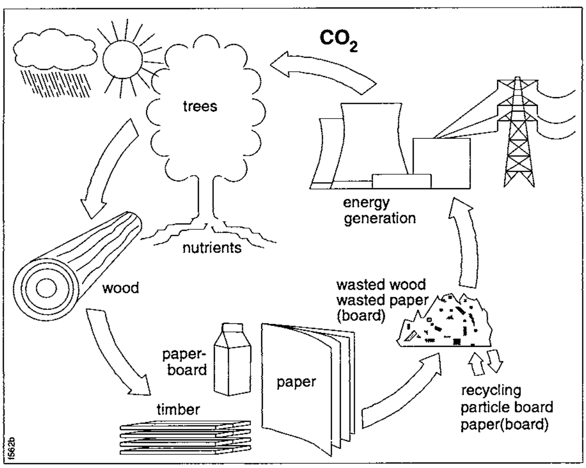
FIXATION OF CO_2 IN PRODUCTS

Depending on the diameter and tree species, harvested forest products are assigned to be used as fuel wood, pulp wood, wood based panels, packing or sawn timber. The research model assumes optimal utilization of the available amount of raw material. This means sawing residues (bark, sawdust, chips, etc.) are assigned to the most durable uses, like chipboard and paper, or when not possible, to fuel.

Fuel wood is delivered to the power station in chipped and dried form. Assumed is the possibility to allow the wind to dry the wood in the forest naturally (to a maximum moisture content of 15%).

All timber products run through a so-called 'cascade model' (figure B). Where possible this calls for wood to be reused at the end of its technical life span. In this model packaging material and other timber products will be reused for chipboard or paper. Ultimately, when written off or replaced, particle board and waste paper are used for energy generation. Thus all sequestered carbon will again be released to the atmosphere as CO_2.

Figure B All wood and timberproducts end at the stage of energy-generation



CO_2 AVOIDANCE THROUGH MATERIAL SUBSTITUTION

The first reduction of CO_2-emission occurs when wood replaces non timber products. Consideration is made of the use of fossile fuels. An important factor is the energy applied during production and transportation of raw materials, semifinished products and finished products. Net energy applied is calculated in the model. This means that remnant wood is utilized for drying other wood. Some production processes are therefore CO_2/energy neutral. It is assumed that mineral oil is the only fossil fuel used in this application.

CO_2 AVOIDANCE THROUGH FUEL SUBSTITUTION

Secondly, the application of energy wood, remnant wood, waste wood and waste paper for energy purposes is considered. Timber products (in contrast to fossil fuels) are CO_2 neutral. Fuel wood does produce carbon dioxide emissions, but the emissions occur within a closed cycle. After all, wood originates and grows by extracting an equal amount of CO_2 from the atmosphere. In this study, a comparison was made with coal, one of the most used fossil fuels for generating electricity in the Netherlands. This comparison is the most realistic, because electricity producers have serious plans to use wood in coal-fired power stations in the short term.

CONCLUSIONS

* Studies on CO_2 reduction pay too much attention to sequestering of CO_2 in biomass, soil and products. Thus, the total CO_2 cycle of forests and forest products remains underexposed. Utilization of wood (multiple use of products and energy-generation) proves to play an important role. The influence on the CO_2 balance (avoidance through product substitution and fuel substitution) is even greater than carbon sequestration by trees.
* Forests and the multiple use of wood (including energy-generation) can contribute substantially to the reduction of C02 emissions. The contribution to the Dutch government's policy (reduction of the annual emission by 21 million tons) can run from 2.5% for a mixed forest of oak and beech, to 9% for short cycle (5 years) poplar. These percentages are based upon an additional 100,000 ha of forest.

Notes

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