Does the world need planted forests?*

by

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Summary

Wood has been one of human civilisation's most important raw materials. The continued use of wood is not assured because there are suitable (and increasingly cost competitive) substitutes for every wood use. Most wood substitutes require fossil fuels or the energy from fossil fuels.

The major advantage of wood is its environmental friendliness. Although it involves forest felling (which may increase atmospheric emissions of carbon dioxide) wood differs greatly from wood substitutes made from fossil fuels. The carbon dioxide from the use of wood is, within a few decades, recycled back into more wood by the regenerating forests. In contrast, the carbon dioxide from fossil fuels remains a permanent addition to the atmosphere.

Wood is very energy efficient. Wood requires a tenth or less of the energy needed to make wood substitutes such as steel and concrete. Further substitution of wood is unlikely because of the huge energy requirements and because of concerns about further increases in atmospheric carbon dioxide (from the use of fossil fuels). The future world will require more wood than is used now if it wishes to reduce fossil fuel use while improving average standards of living.

However let us assume that there is no future increase in the per capita use of wood and that it remains at 0.6 m3 per person per year. The increase in the global population alone (expected to be 10 billion by the middle of the twenty-first century) will require at least 2 billion m^3 more wood each year than can be supplied from those forests existing at the end of the twentieth century. An additional 100 million hectares of managed planted forests will be required to meet even this conservative wood demand.

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The importance of wood

In 1996 approximately 55% of the 3.36 billion m^3 annual wood harvest was used as fuelwood (wood is probably the primary energy source for most of the world's population). The other 45% was used industrially, mostly as sawlogs.

Wood is very versatile. Industrial wood has at least 10,000 different uses. Probably no other raw material has been so useful throughout human civilisation.

An effective way of illustrating the importance of wood is to express the consumption of the major products in terms of average use per person per day. Even then there are problems because it can be difficult to compare wood (which is usually measured by volume) with food and materials (which are usually measured by weight). Table 1 compares the global average daily per capita consumption wood (the combined total of fuelwood and industrial wood) with the consumptions of major foods and construction/industrial products.

TABLE 1

World per capita daily consumption of wood, major foods and materials (in litres or grams)

Wood	Food		Materials	
Daily use	Item	Daily use	Product	Daily use
1.7 litres	Wheat	290	Cement	710
	Maize	270	Steel	330
or	Rice	180	Plastic	60
approximately	Potatoes	135	Aluminium	9
	Barley	75		
900 grams	Soybeen	70		
	Sugar	60		

Table footnotes:

1) the global estimates of wood use are almost certainly under-estimates because of a very likely understatement for the total Russian wood harvest and because many countries have poor records of actual fuelwood use.
2) Sources are from various yearbooks and trade associations. Values for 1997, except wood and potatoes which are for 1996.
3) Rice, potatoes and sugar excepted, much of these food products are not consumed directly, they are feed for our chicken (including eggs) and pig meat production

The values in Table 1 are global averages. There are however, major differences between countries. The poorer countries of the world use most of their wood as fuelwood : the wealthier countries use wood mainly for industrial purposes. In general, the wealthier a country, the more wood it consumes. For example, Bowyer (1992) quotes an average per capita use of wood in the USA (2.3 m^3 per person per year) which is nearly four times the 1996 global average of 0.58 m^3 per person per year.

Traditionally, wood has been very important to the world. Wood has been far more important than most realise.

Past trends in wood use

To better understand past trends we need more than just the total annual consumptions. We must remove the complication created by an expanding global population. The solution is to convert global totals to average per capita consumptions. In Table 2 the average consumptions, in m^3 per person per year, are given for representative years since 1960. For each year, three values have been calculated - first, the total volume of wood consumed, and then, the values for industrial wood and fuelwood.

Table 2

Trends in the per capita annual consumptions of both all wood and industrial wood only (in m3 per person per year)

Year	Per capita annual wood consumption		
	All wood	Industrial wood only	Fuelwood only
1960	0.60	0.34	0.26
1970	0.65	0.35	0.30
1980	0.65	0.32	0.33
1990	0.65	0.31	0.34
1992	0.61	0.28	0.33
1994	0.60	0.27	0.33
1996	0.58	0.26	0.32

Table footnotes: the per capita consumptions calculated from:
1) the annual wood harvests given in FAO yearbooks, and,
2) populations (based on mid year totals) from various yearbooks.

If we assume that the FAO estimates of the total global wood consumption are reasonably accurate, then the per capita wood use rose slightly through the 1960's. From 1970 to 1990 total wood consumption was constant at 0.65 m^3

per person per year. Since 1990 the average per capita wood use has declined each year. By 1996 the per capita use of wood had fallen to only 0.58 m^3 per person per year.

From 1970 to 1996 the global per capita wood use for fuelwood was remarkably constant - being in the range 0.30 to 0.34 m^3 per person per year.

The fall in total wood consumption in the 1990's is explained almost entirely by the reduction in the per capita use of industrial wood. From 1960 to 1990 the use of industrial wood was very similar to, and just as constant as, that of fuelwood - the average industrial wood consumption varying between 0.31 and 0.34 m^3 per person per year. From 1990 onwards, however, there has been a significant decrease in the amount of industrial wood consumed. Industrial wood use in 1990 was 0.31 m^3 per person per year but by 1996 it had decreased to only 0.26 m^3 per person per year. Some of that decline may be explained by the problem of understatements in country returns (especially Russia - see footnotes to Table 1). But some of the decline is almost certainly because wood has been replaced by wood substitutes. Substitutes such as metals, cement, plastic, etc. Although it may not affect the total wood use, solid wood uses have also been replaced with reconstituted wood products such as particleboard and fibreboard.

The substitution of wood has been so successful that there is probably no longer a **single** wood use for which wood is essential. Every wood use now has a suitable (and increasingly price competitive) wood substitute. It could be argued that because of wood substitution, especially of industrial uses, wood could become less and less important and may eventually be totally replaced by substitutes.

Before we consider the future of wood we need to evaluate the prospects for further wood substitution. Because most wood substitutes:

1) are either made from fossil fuels or energy that is produced by fossil fuels, and,

2) often involves processes which are polluting and/or result in the addition to the atmosphere of significant amounts of carbon dioxide from fossil sources (such as cement making which involves the atmospheric release of fossil carbon from limestone)

a comparison between wood and wood substitutes could be insightful. Because most wood substitutes are made by using fossil fuels the comparison should be between wood and fossil fuels.

A comparison between wood and fossil fuels.

The end result of using either fossil fuels or wood is essentially the same. The processes may differ, but ultimately most fossil fuels and most wood are converted to carbon dioxide and water. When used as a fuel both fossil fuels and wood are immediately converted to their byproducts. Some wood products (such as solid wood used in buildings or furniture) and some fossil fuel products (such as synthetic rubber or plastics) may last for decades, or even centuries, but their eventual decay generally reduces them to carbon dioxide and water. (Note - for the sake of simplicity I have largely ignored the fact that in anaerobic conditions (such as in land fills) the decay of some wood products, such as paper, also produce methane. This does not however invalidate the following general comparison).

Although both carbon dioxide and water enter the atmosphere as chemical byproducts of the use of both fossil fuels and wood, only the carbon dioxide is important.

This is because there are growing concerns about the long term global effects of the continuing increase of greenhouse gases in the atmosphere of the earth. Of the greenhouse gases, the atmospheric concentration of carbon dioxide has the greatest total effect. There are fears of unfavourable climate changes (especially global warming), rises in sea level, increased incidence and severity of storms , etc. The concern has resulted in an International agreement - The Framework Convention on Climate Change - with the stated objective of stabilising greenhouse gases (which includes carbon dioxide).

What is most relevant to this comparison is the relative fates of the atmospheric carbon dioxide that comes from each source. First, let us consider fossil fuels. Over hundreds of millions of years fossil fuels slowly accumulated in the crust of the earth. When the carbon in fossil fuels is released back into the atmosphere that carbon dioxide will effectively stay there for tens, and possibly hundreds of millions of years. It will be very slowly removed to create new fossil fuels.

The fate of carbon dioxide from wood is very different. Unlike the carbon dioxide released by the use of fossil fuels, the carbon dioxide released by the use of wood (or from forest clearance for agriculture, urban development, etc) need not permanently remain in the atmosphere. As forests regenerate, or as new forests are created, the carbon dioxide in the atmosphere is removed to make more wood. Within a few decades the carbon released into the atmosphere by the use of wood can be transformed back into wood again. Even if the carbon in wood is converted to methane instead of carbon dioxide, that methane eventually converts to carbon dioxide. The only reason the carbon dioxide might not be removed from the atmosphere would be because the forest was prevented from regenerating.

This highlights the crucial difference between fossil fuels and wood. Carbon dioxide from fossil fuels is a permanent addition to the earth's atmosphere : Carbon dioxide from the use of wood need only be temporary. As we continue to harvest forests the carbon dioxide produced by the use of wood will, within a few decades, be converted back into more wood.

The use of wood **recycles** atmospheric carbon dioxide : the use fossil fuels makes a **permanent addition** to atmospheric carbon dioxide.

If the world increases the area of forest cleared for either agriculture or urban development, then carbon dioxide in the atmosphere will increase. This increase can be reversed by allowing marginal farmland to revert back into forest (including planted forests).

The advantages of wood over fossil fuels are greater than simply the effect on atmospheric carbon dioxide. Wood is formed from sugar that is "manufactured" by the photosynthesis process in the trees needles or leaves. In this process, carbon dioxide from the atmosphere is combined with water from the soil (and solar energy) to form sugar (and oxygen). The tree later transforms that sugar into wood. When we use wood as a fuel we are essentially releasing the solar energy that the tree used to make the sugar in the first place.

Wood is much much more than simply an energy source. Wood has a very complex structure. Wood is very strong for its weight (which is why wood is ideal for use in buildings) and can be easily processed into products such as joinery, furniture, containers, etc. When made into useful solid wood products (as opposed to reconstituted wood products such as fibreboard, pulp, etc) processing begins with the wood already in a form that requires the minimum of conversion. This suggests that the manufacture of wooden (and especially solid wood - sawntimber or plywood) products is energy efficient, especially compared with similar products made from fossil fuels. Many studies of energy use have confirmed this. One of these was by Dr. Peter Koch (Koch 1992) who compared the energy required in the manufacture of several similar building systems. A sample of his findings are given in Table 3

TABLE 3

Relative increase in energy use resulting from replacing wood by non-wood substitutes

(wood use is assumed to be one)
From Koch 1992

Substitution process and product	Relative increase in energy use
Wood studs being replaced by steel	**9**
Wooden floors being replaced by concrete	**21**
Plywood siding being replaced by brick veneer	**30**

In this comparison of major wood uses, the solid wood products are ten to thirty times as energy efficient as the fossil fuel substitutes.   Wood is a very energy efficient raw material.

Other (especially environmental) advantages of wood

The ability of forests and trees to re-absorb from the atmosphere any carbon dioxide which results from the use of wood demonstrates why wood is a renewable resource.   Wood may be only one of the world's many renewable commodities but compares favourably with fossil fuels.   Fossil fuels are definitely not renewable.   Once used, fossil fuels will take millions of years to be renewed.

Most renewable commodities are energy products (solar, water, wind, etc). Wood is one of the few raw material products that are renewable.

Wood is a very benign material. Wood use, especially as solid wood (sawntimber or plywood), poses few health risks in either manufacturing or use.

Wood does require forest harvesting (there is no other way of extracting wood). But harvested forest are rarely 'destroyed'. Even if left, harvested forests almost always regenerate naturally. Sound forest management can hasten the recovery of the forest.

Further wood substitution is most unlikely

Taking a long term view, which we must because trees need decades to mature, further substitution of wood is most unlikely. The main reasons are:

Constraints on the supply of energy
As most substitutes for wood require at least ten times as much energy as wood itself, a major substitution is not possible. Unless the world soon develops a massive new energy source that is cheap, renewable, and environmentally friendly (i. e. is non-polluting and especially does not produce atmospheric carbon dioxide from fossil carbon sources) there is not enough energy available in the world to permit major wood substitution Although comparisons are difficult, as Table 1 showed, the world uses an enormous amount of wood. The problem for wood substitution is the sheer size of the wood using sector. Any constraint on the world energy supply is going to make further substitution of wood increasingly difficult. Because substitutes for wood require so much energy, any increase in energy prices will result in proportionally large price increases for wood substitutes.

The need for restraint on the further emissions of atmospheric carbon dioxide
If the world is serious about preventing the continuing and permanent increase in atmospheric carbon dioxide then the use of wood offers a realistic solution. While carbon dioxide from fossil fuels remains permanently in the atmosphere, the carbon dioxide from the use of wood is mostly only temporary. The carbon dioxide is soon recycled back into more wood.

The use of wood is easier on the environment
Wood use does involve the harvesting of forests but need not require the use of non-renewable resources. Wood is one of the least polluting of all products used by human civilisation. Wood (and forests) are one of the few renewable raw materials of the world that are more than just a source of energy.

There are also major pressures on demand.

The future demand for wood

Cost competitiveness is a major demand driver. As we demonstrated above, the relative cost of wood and wood substitutes will be largely determined by energy costs. Fossil fuels and energy costs are expected to rise because of the increasing awareness that resources (especially oil) are finite and because of the strong likelihood of carbon taxes. Any energy price increase will improve the cost competitiveness of wood and very likely increase the demand for wood.

The other two major drivers of wood demand are the increase in the global population and the rise in the standard of living. Others drivers, which are not considered, are factors such as trade liberalisation, personal preferences, fashion, etc.

By the end of 1999 the global population will exceed 6 billion . For the year ended December 1998, the world population increased by 84 million (PRB 1999).

Most agree that the increase in global population must slow down. Current expectations are that the global population will stabilise at around 10 billion by the middle of the twenty-first century. The problem will be how to actually slow down the population growth.

The developed (wealthier) countries have almost no population increase. All the growth in population is in the poorer countries. There is circumstantial evidence that improving living standards decreases population growth. South Korea is a good example. In the period 1985 to 1990 the average real wealth of the South Korean citizens doubled in real terms. That increase in wealth resulted in a slower rate of population increase but it also resulted in increased average consumption (including a nearly 50% increase in the per capita consumption of industrial wood - Sutton 1993 - and that was in a country which was not a traditional wood user).

One way that the world can slow down the population growth is by improving living standards. Wealthier people have fewer children than people who are poor. However, wealthier people consume more. If consumption increases so does energy use. Unless there is a major breakthrough in energy production an increase in energy consumption means an increased use of fossil fuels.

The dilemma for the world is how to satisfy increased consumption without an increase in the use of fossil fuels. Wood has an important contribution to make. Because it is so energy efficient a far greater use of wood in the global economy would permit greater consumption without the need for more fossil fuels (and therefore without any increase in permanent atmospheric emissions of carbon dioxide).

Because wood has so many environmental and social advantages a strong case can be made for a greater use of wood in the world.

The global human population is expected to stabilise at about 10 billion by about the middle of the twenty-first century.   Although there is a very strong case for greater wood consumption we are safe to assume that in the longer term the per capita use of wood will not decrease.   Let us assume therefore that by the middle of the next millennium the global average per capita wood consumption will be as it was in the mid 1990s - 0.6 m^3 per person per year.   At a per capita consumption of 0.6 m3 we are being very conservative.   This consumption is lower than the average global consumption of 0.65 m3 per person per year in the 1970s and 1980s.   It is also less than a third of the per capita wood consumption of several advanced economies and nearly a quarter of the per capita wood consumption of the USA in the early 1990's - 2.3 m^3 per person per year (as reported in Bowyer, 1992).

A global population of 10 billion using an average of 0.6 m^3 of wood per person per year would require an annual global wood harvest of 6 billion m^3 per year. That harvest is 2.5 billion m^3 more than the 3.5 billion m^3 annual global wood harvest of the mid 1990s.

The question then becomes:

How can we satisfy an increased demand for wood?

Wood has traditionally come from natural forests.   My own research estimates that in the mid 1990's more than 80% of the world's industrial wood harvest came from natural forests.   Based on country returns my estimate is that less than 20% of the industrial wood of the world came from planted forests (definitions of planted forests vary between countries but they are essentially forests that are deliberately planted and managed for the production of industrial wood).

In theory, the natural forests of the world may be able to support some increase in the future wood harvest.   There are, however, two pressures on natural forests that will make this difficult ***viz:***

> 1)The on going conversion of natural forests to both farm and urban development land.   FAO estimates that currently there is a net loss of

over 16 million hectares of forests which are deforested each year (FAO 1997).

2) Environmental concerns over issues such as the preservation of old growth, a general dislike of clearcuts, as well as the loss of wilderness, biodiversity, species habitat, recreation, tourism, etc. While some of these concerns can and are being addressed, there is no doubt that public pressures will increase for natural forests to satisfy demands other than wood production.

These pressures are likely to limit further increases in the wood harvest from natural forests. The pressures could even reduce future wood harvests. The pressures will almost certainly increase wood costs. However, let us be optimistic and assume that the future wood harvest from natural forests will actually increase. An extra 0.3 billion m^3 of harvested wood will most likely be the upper limit of the supply from natural forest, especially if the natural forests are to continue to provide nonwood benefits (such as natural reserves and parks, wilderness areas, biodiversity, habitats for animals, birds and invertebrates, etc).

Assuming that the current annual harvest of 3.5 billion m^3 (which comes from both natural forests and mature planted forests) can be maintained, then an extra 0.3 billion m^3 from natural forests takes the total annual supply to 3.8 billion m^3. The deficit between potential future demand and potential future supply is therefore 2.2 billion m^3.

There are already established planted forests (in regions such as Africa, Australasia and South America) which have not yet reached maturity. The total annual global supply of these planted forests at maturity will almost certainly supply no more than 0.2 billion m^3 annually· This leaves a minimum potential annual supply deficit of (2.2 minus 0.2 or) 2 billion m^3.

How then can we supply that additional world demand of 2 billion m^3 of environmentally friendly wood? As we have just discussed, this wood cannot come from further increases in the harvest from the world's natural forests. Nor can it come from already established planted forests - the expected harvest levels of both natural forests and existing planted forests have already been included. The only solution is to get the extra wood from planted forests which have yet to be established. These planted forests can be with tree species that are indigenous to the region or which have been introduced.

Planted forests have some major advantages:

1) for the supply of fuelwood, planted forests can be established near to where the fuelwood is required - thereby reducing the time required to harvest the wood. This could be a major social advantage, especially for rural women.

2) for the supply of industrial wood, planted forest management can ensure trees are grown for the expected market (pulpwood, structural and finishing sawntimber, plywood, etc).

3) yields per hectare are often higher than in natural forest (this reduces the area that needs to be felled each year to satisfy a given wood demand),

4) planted forests, especially established with fast growing trees and responsibly managed, can be profitable. As planted forests are increasingly attractive economically, financing could be left almost entirely to the private sector. This would relieve Governments of the need to invest in forestry for the provision of wood.

5) planted forests can sometimes be established on land that should never have been cleared of its forest in the first place.
In some cases, planted forests offer a profitable and practical way of getting degraded and erosion prone farm land back into forest.

6) planted forests, while still commercially focused, can also satisfy many nonwood demands (hunting, recreation, minor forest products, etc) and also provide many environmental benefits (wildlife habitat, reduced soil erosion, etc).

7) planted forest, like natural forests, are carbon sinks while they are maturing, and, provided they are sustainably managed , will remain carbon reservoirs after the start of harvesting.

There have been environmental concerns expressed about planted forests. Issues such as the renewability of planted forests sites, biodiversity and monocultures, etc. Foresters have addressed these issues but there has been poor public communication of the findings. For example the renewability of planted forests sites was addressed in a paper by Will and Ballard (1976). This research showed that the annual uptake of the major nutrients by radiata pine plantations was only a thirtieth to a hundredth of the nutrient uptake of major agricultural crops. Biodiversity within planted forests is also a concern. Planted forests probably do have less biodiversity than natural forests, but planted forests would certainly have more biodiversity than farmland. The greatest contribution that planted forests make to biodiversity is probably indirect. By providing an alternative source of environmentally friendly wood, planted forests reduce the need for wood harvesting in natural forests (Sutton, 1995).

An excellent summary of the environmental aspects of planted forests is given in Maclaren, 1996.

What area of planted forest might the world require?

Assuming that the extra wood which the world will need for its future must come from newly created planted forests, what area of planted forest would be required to supply an extra 2 billion m^3 annually? Assuming planted forests with an average yield of 20 m^3 per hectare per year (an average for the fast growing planted forests of the tropics and the Southern Hemisphere), then we will need an extra 100 million hectares of additional planted forest. This is an area equal to that of Nigeria or the Canadian province of British Columbia. This is assuming the land is very productive forest land. If the land is of lower productivity the required area of planted forest will be greater. Such a planting would require a huge global effort. It would require most of the world's land that is suitable for planted forests and which is currently surplus to food production, but which is not already in forest.

The reason for urgency is because of the time required between initial establishment and final harvest. Fuelwood and some pulpwood planted forests can be grown in under 10 years but most industrial planted forests require at least 2 to 3 decades to mature.

In calculating this requirement for planted forests we have not allowed for either any major wood substitution for wood substitutes, or for an increasing per capita wood use of a global population which many hope and expect will have increasingly higher average standards of living. The estimate of 100 million hectares of additional planted forest is therefore a minimum requirement.

In this very simplistic analysis I have ignored the different requirements for fuelwood and industrial wood. I have also ignored the very important questions of wood quality and stand management within planted forests.

Planted forests in this paper are considered to be primarily for wood production. However, some of those planted forests may be established with multi-purpose objectives. These could extend the non-wood benefits of managed planted forests.

The answer to the question posed by the title of this paper "Does the world need planted forests?" is, "yes, it most certainly does".

Conclusions

If the world is to provide its future inhabitants with a reasonable standard of living, and if fossil fuels are either damaging to the global environment (because of permanent emissions of atmospheric carbon dioxide), or the supply is in any way limited, then a much greater use of wood offers a viable alternative. A wood consuming world would not solve all the world's concerns over the continuing use of fossil fuels but the wood solution would make a significant contribution. A wood based society would use less fossil fuel and produce less atmospheric carbon dioxide while permitting its population to still enjoy a high material standard of living.

Of the world's raw materials, wood is one of the very few that is renewable, sustainable and environmentally friendly There is probably no other raw material which is so versatile.

One way the world could satisfy the potential future demand for wood, without significantly increasing the wood harvest from natural forests, is by the creation of a large area of planted forests. These planted forests would have the specific objective of supplying future wood demand. With sustainable forest management these planted forests will supply environmentally friendly wood for centuries to come.

For the global population of the middle of the twenty-first century this paper estimates that the world would need another 100 million hectares of additional managed planted forests. This is a minimum as these additional forests essentially only maintain the present (1990s) position . If the world is to become more pro-wood considerably more planted forests will be required.

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