Carbon footprints of Ipê vs. Kebony Southern Yellowpine

A comparative study

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CARBON FOOTPRINTS OF IPÊ VS. KEBONY SOUTHERN YELLOWPINE – A COMPARATIVE STUDY
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Summary

The results of this study show that the carbon footprint for average Brazilian Ipê is in the range of 7,500–15,000 kilograms per cubic meter, whilst the carbon footprint of modified Southern Yellow Pine is approximately 459 kilograms per cubic meter. Both figures include treatment and transportation to Northern Europe.

The carbon footprint from selective cutting of Ipê from the Brazilian rainforest is in the order of 300 kg CO_2/m^3 Ipê, including transportation and cutting into saleable product. However when the Ipê harvesting takes place through clear cutting of rainforest the carbon footprint rockets up to approx 15,000 kg CO_2/m^3 Ipê. This is caused by selective cutting being sustainable in the sense that within a few years of cutting, an almost equal amount of biomass grows to take its place. Clear cutting on the other hand entails a large loss of living biomass which is not replaced by new growth. Southern Yellow Pine, SYP, is grown in managed forests in the US southeast. These forests have a net gain in biomass and from a carbon footprint point of view are sustainable, ie no emissions of greenhouse gases. However the subsequent transportation and modification of the wood has a carbon footprint which has been found to be 459 kg CO_2/m^3 of SYP. Examination of sales records and known occurrences of Ipê indicates that the majority of Ipê for sale originates from clear cutting.

Introduction

Ipê is prized for its dense, rot resistant wood, its use in herbal medicine, beautiful flowering and known for its high price. Even though the tree grows at low densities the high price ensures that profitable extraction is possible from all but 36% of the Brazilian Amazon.

In the Amazon basin Ipê has partly filled the gap caused by restrictions on the trade in mahogany instigated through CITES in 2003. Ipê has a critical role in the formation of new logging areas through the high profitability of the timber. This allows logging to occur in remote regions and at very low tree densities. The initial logging is often the precursor to more intense logging and possibly to conversion to farmland, although this practice is becoming less common as Brazil is tightening its conservation laws and practices.

Kebony Southern Yellowpine.

Its resistance to decay has made Ipê a prized material for outdoor construction and it is the dominant species on the US decking market. The conversion of forest to agricultural land carries a penalty in the form of loss of organically and inorganically bound carbon from the living biomass, litter and soil.

Alternatives to Ipê use include the chemically modified Southern yellow pine, SYP, grown in the south- eastern parts of the US. SYP production is based primarily on managed forests; the cut wood is transported for treatment with chemicals derived from production of sugar in the Caribbean. The modified wood has excellent resistance towards environmental degradation and is suitable also for decking and other outdoor applications.

The current study will calculate the carbon footprints of Ipê harvesting in Brazil, SYP harvesting in US and the subsequent transportation and treatment. The end result will be to compare the carbon footprints of Ipê and modified SYP.

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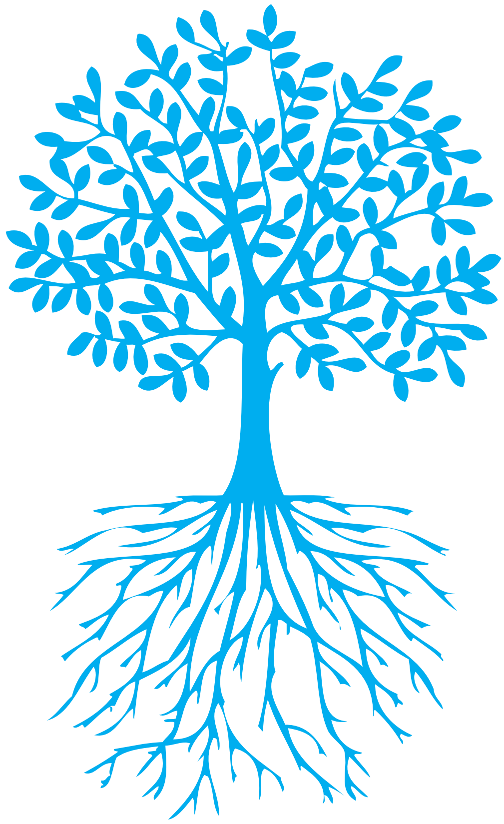


Bergfald Miljørådgivere is an environmental consultancy with long experience in guiding the private and public sectors and is involved with both the technical as well as the strategic aspects related to environmental performance. Bergfald has specialised competencies in the different fields of environmental engineering offering a broad range of specialized services; from eco- labeling, ensuring compliance with environmental legislation, environmental risk management or cleanup of chemical spills and contaminated sites.

The company has long experience with eco management systems as well as the different carbon/climate footprint calculation tools.

Part 1: Calculation tools

1.1. Land use, land-use change and forestry (LULUCF)

Changing use of land can have major environmental impacts. The conversion of woodland to agricultural land in particular is associated with a loss of biomass both above ground and in the soil. The lost biomass is converted to carbon dioxide, CO_2, and released to the atmosphere where it contributes to the greenhouse effect.

Large tracts of woodland are lost each year. The present loss rate is 112,600 km^2/year,[1] only slightly less than the area of England (130,000 km^2).

The IPCC estimates that land use change (conversion of forest to agriculture) leads to emissions of 5,9 billion ± 50% tons of CO_2 equivalents (CO_2 eq.) yearly. Emissions from fossil fuel combustion and cement production add up to 23 billion tons yearly. Clearly land use is a significant factor in the Greenhouse effect, and in the future land use may play a pivotal part in the mitigation of global warming.

However an increasing population puts many forested areas under pressure. The prime motives for deforestation are the creation of farmland, removal of valuable timber/minerals and production of fuel.

In order to measure the effects of land use change the UN climate change secretariat have developed a set of rules for calculation and reporting. These are named LULUCF; "A greenhouse gas inventory sector that covers emissions and removals of greenhouse gases resulting from direct human-induced land use, land-use change and forestry activities."

Carbon footprint

=

Emissions caused by lost biomass from plants and soil in forests

-

Emissions absorbed by the remaining forest and newly established agricultural land (converted from forest)

1.2. Good practice guidance for LULUCF

The carbon footprinting of Kebony's Southern Yellow Pine (SYP) was carried out based on the IPCC's Good Practice Guidance for Land Use, Land-Use Change and Forestry.[2] The fundamental basis for the methodology rests upon two linked themes:

- the flux of CO_2 to or from the atmosphere is assumed to be equal to changes in carbon stocks in existing biomass and soils,
- changes in carbon stocks can be estimated by first establishing rates of change in land use and the practice used to bring about the change (e.g., burning, clear-cutting, selective cut, etc.).

The LULUCF document covers the following aspects:

- Choice of estimation method within the context of the IPCC Guidelines;
- Quality assurance and quality control procedures to provide cross-checks during inventory compilation;
- Data and information to be documented, archived and reported to facilitate review and assessment of inventory estimates; and
- Quantification of uncertainties at the source or sink category level and for the inventory as a whole, so that resources available can be directed toward reducing uncertainties over time, and the improvement can be tracked.

Calculation of forest loss and of the biomass therein is difficult. LULUCF is a guideline for authorities whose task is to compile national inventories over land use and the attendant biomass. The guidelines cover three basic calculation choices called tiers. Tier 1 applies when little actual data is known and default values are chosen, tier 2 applies when country specific data is used for the calculations, and tier 3 applies when more advanced specific data is used.

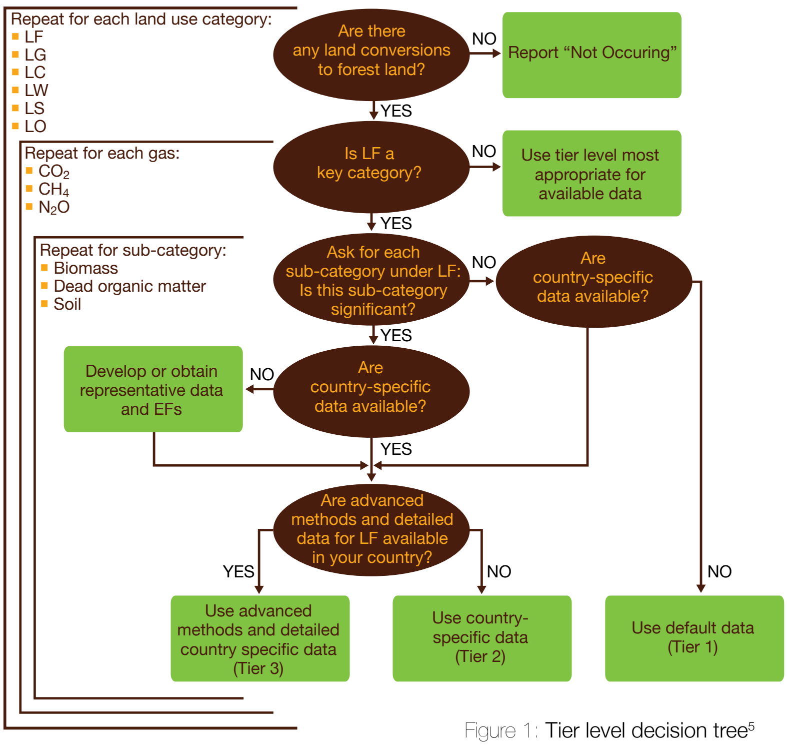


Figure 1: Tier level decision tree[5]

To assist in choice of tier level decision trees are included. An example is attached in figure 1.

1.3. The GHG Protocol

The Greenhouse Gas Protocol (GHG Protocol) is the most widely used international accounting tool for government and business leaders to understand, quantify, and manage greenhouse gas emissions. The GHG Protocol is the result of a partnership between the World Resources Institute and the World Council for Sustainable Development. Businesses, governments and environmental NGOs have all been involved in the development of an accounting tool for carbon footprints for manufacturers of goods as well as of services. It contains a series of calculation tolls and default values for a number of specific processes and purposes, as well as principles for calculation, reporting and transparency. In this study, the calculation of the carbon footprint associated with the modification of SYP will be carried out according to the GHG Protocol. However deforestation and conversion to agricultural land is not covered by the Protocol and for these calculations the Good Practice Guidance LULUCF will be chosen instead.

1.4. Forest management certification

The Forest Stewardship Council (FSC) is an independent, non-governmental, non profit organization established to promote the responsible management of the world's forests. Established in 1993 it is regarded as one of the dominant forest management schemes.

The FSC develops forest management standards based on its 10 guiding principles. The standards are designed to apply to different forest management issues such as harvesting of non-wood products. National FSC standards are encouraged so that local issues can be included. The standards always rest on the ten guiding principles. The principles are:

1. Compliance with all applicable laws and international treaties.
2. Demonstrated and uncontested, clearly defined, long–term land tenure and use rights.
3. Recognition and respect of indigenous people's rights.
4. Maintenance or enhancement of long-term social and economic well-being of forest workers and local communities and respect of worker's rights in compliance with International Labour Organisation (ILO) conventions.
5. Equitable use and sharing of benefits derived from the forest.
6. Reduction of environmental impact of logging activities and maintenance of the ecological functions and integrity of the forest.
7. Appropriate and continuously updated management plan.
8. Appropriate monitoring and assessment activities to assess the condition of the forest, management activities and their social and environmental impacts.
9. Maintenance of High Conservation Value forests defined as forests containing environmental and social values that are considered to be of outstanding significance or critical importance.
10. In addition to compliance with all of the above, plantations must contribute to reduce the pressures on and promote the restoration and conservation of natural forests.

Part 2: Ipê

Tabebuia impetignosa and Tabebuia serratifolia are two of the commercially most important species of the Amazonian tropical tree known in the vernacular as Ipê. Other common names used for the Tabebuia species include poui, trumpet trees, lapacho, brazilian walnut,ironwood and pau d'arco. Its use is based on the durability of the wood and as such, it is the dominant "tropical"species on the $ 3 billion residential US decking market. Ipê is a comparatively rare species with densities usually in the order of less than one commercially harvestable tree/ hectare. Since restrictions have been imposed on harvesting and export of mahogany, Ipê now has one of the highest prices and accounts for ca. 9% of value of Brazilian wood exports.[3] Logging has been a major catalyst for settlement in the Brazilian Amazon because loggers open roads and make watercourses navigable to reach pristine forests. 24.5 million m^3 of logs were processed by sawmills in 2004, 36% of this total was exported.[4] When calculating the carbon footprint from Ipê harvesting two basic approaches can be made;

a) Direct consequences, calculating the climate impact of the wood removal itself including roads and damage to neighbouring trees etc.

b) Direct and indirect consequences, calculating the emissions in point a) and then adding the further degradation of the forest and conversion to farmland following the establishment of roads and infrastructure.

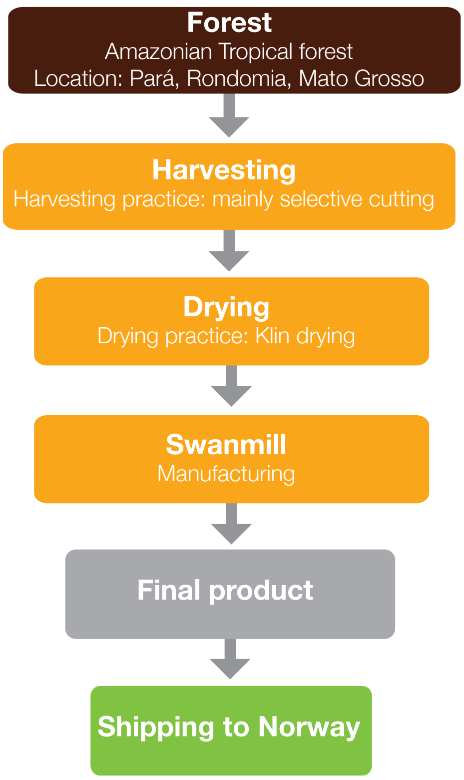


Figure 2: Production stages of Ipê wood products

2.2. Geography, volumes and values

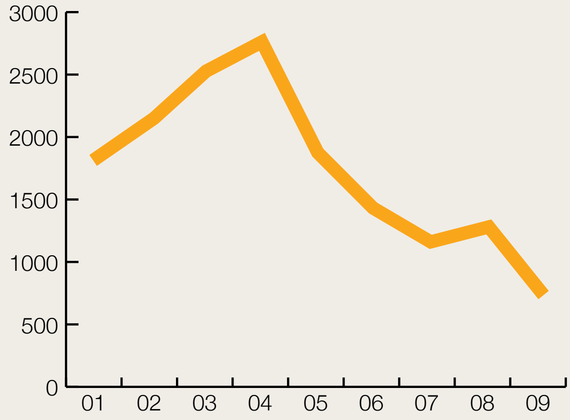
2.2.1. Deforestation

Deforestation rates in the Brazilian Amazon have seen a gradual increase to 27,400 km^2 per year in 2004. The average deforestation value for the period 2000–2005 was 22,392 km^2.[5] The 4,900 km Transamazonica highway was completed in 1970 and has provided the main artery for logging activities. This highway crosses the southern part of the Amazon basin, and the greatest logging activity takes place from the road and northward in what has been called the "ring of fire". However, Brazilian authorities are implementing increasingly effective measures to control the deforestation and these measures include increasing the area landowners are not allowed to cut to 80% (implemented 2001), increasing fines for illegal logging (implemented 1998), the creation of larger nature reserves (32% protected in 2004[6]) and the introduction of RIL, Reduced Impact Logging techniques. The results have been good, with a sharp decrease in deforestation rates, as illustrated in figure 3 and table 1. Satellite observation by the Brazilian Space Agency confirms deforestation for 2009 at 7,464 km^2.[7]

Land use after deforestation:[10]

- for 58% by cattle ranches;
- for 29% by subsistence farming;
- for 4% by logging;
- for 3% large scale agriculture;
- the remainder to fire.

Figure 3: Annual deforestation rates Brazilian Amazon, km^2.



Some loss is also due to mining and from building hydroelectric dams.

However, the greatest land users are the cattle ranchers. Conversion of forest to grazing leads to loss of biomass from the forest and in addition to possible loss of bound carbon from the soil. The carbon footprint associated with this kind of land use change is large. Based on the establishment and location of slaughterhouses, the areas of expanding ranching in Brazil are Eastern Pará, Mato Grosso, Tocantins and Rondônia.[11]

Year	Deforestation (km^2)
2001	18,165
2002	21,393
2003	25,247
2004	27,423
2005	18,846
2006	14,109
2007	11,532
2008	12,911
2009	7,464

Table 1: Deforestation rates in the Brazilian Amazon.[8]

State	Annual Deforestation 2004 (km^2)	Annual Deforestation 2009 (km^2)
Acre	728	167
Amazonas	1,232	405
Amapá	46	70
Maranhão	755	828
Mato Grosso	11,814	1,049
Pará	8,521	4,281
Rondônia	3,858	482
Roraima	311	121
Tocantins	158	61
Total Legal (Amazon)	**27,423**	**7,464**

Table 2: Annual Deforestation in 2004 versus 2009, by state.[9]

State	Export value (USD)	Harvested Ipê roundwood 2004 (m³)	Harvested Ipê from clear cut forests 2009 (m³)*
Acre	124,316	1,827	NA
Amazonas	314,467	4,621	NA
Maranhão	208,458	3,063	NA
Mato Grosso	30,857,124	453,781	233,927
Pará	31,811,577	467,817	954,663
Rondônia	19,496,032	286,706	107,486
Roraima	45,618	670	NA
Legal Amazon (total)	**82,857,592**	**1,218,494**	**1,296,076 (in the 3 states)**

* Calculation based on areas in table 2, tree densities and volumes per harvestable tree. These are taken from Mark Schulze et. Al. Evaluating Ipê logging in Amazonia: Biological Conservation 2071-2086. 2008.

Table 3: Ipê export values and estimated harvest volumes per state 2004.[13]

2.2.2. Harvesting volumes of Ipê

The total annual Brazilian Ipê roundwood harvest has been estimated at 158,628 tonnes (approx. 150,000m³) in 2004.[12] This estimate is based on export values and conversion for 42% processing efficiency and 36% of wood meeting export standards. SECEX also publish Ipê export values from the individual states. The export values and the conversion factors above have been used to calculate estimated volumes of Ipê harvested from the different Brazilian states. The results are presented in Table 3.

As indicated in Table 3, it is evident that the greater part (99%) of the Ipê harvest takes place in the states of Pará, Mato Grosso, and Rondônia, the same states where cattle ranching is on the increase.

The table shows that calculation of Ipê harvest volumes based on economic data and from tree density and size data both give the same result. This lends credence to the result.

The data in table 3 corresponds well with the deforestation rates of the different states. Indeed, as indicated in Table 2, the three states of Pará, Mato Grosso and Rondônia together represented 88% of all deforestation in 2004 and 78% in 2009. The reduction in the annual deforestation in these three states has significantly decreased between 2004 and 2009. The reduction in total forest loss is almost entirely due to reductions in these three states.

2.3. Calculation method

It is clear that although deforestation and conversion to pasture has been a large and damaging activity, the importance of this has been sharply reduced. Where forest is converted to farmland or pasture, the primary intention is not to market the timber, but to create larger areas of arable land. Nonetheless, the Ipê harvested in this fashion will represent a significant amount of the annual export of Ipê and therefore will contribute to the GHG emissions related to Ipê in addition to the emissions related to selective logging of Ipê.

The following parameters have been taken into consideration in the estimation of the carbon footprint of Ipê:

- GHG emissions related to selective logging of Ipê, in accordance with the IPCC LULUCF guidelines.
- GHG emissions related to the logging of Ipê through clear cutting and conversion from forest land to grazing land, in accordance with the IPCC LULUCF guidelines.
- The drying of Ipê, based on the energy consumption and in accordance with the GHG protocol guidance
- Transport, based on the energy consumption and in accordance with the GHG protocol guidance

2.4. Carbon footprint of Ipê from selective logging

2.4.1. Selective logging in practice

Selective logging involves establishing road or water communications into an area, skid trails are made along which logs are dragged to the staging area. Log decks are built for temporary storage. The actual felling is mostly mechanical and increasingly commonly carried out so as to minimize damage to neighboring trees. However, damage to the forest is still extensive, a 1989 study from Pará[14] shows that after 30–50 m³/ha (4–8 trees) are removed, 26 % of immature commercial trees are killed or damaged and that total canopy cover is reduced from 80% to 45%.[15]

The majority of areas selectively logged are allowed to re-grow. A study from Eastern Pará[16] shows that 5 years after selective logging the area of undisturbed forest was reduced by only 1.5%.[17]

A 2002 study[18] in the Paragominas area of Pará state shows that 6 years following moderate intensity logging the canopy openings and reductions in tree densities had largely disappeared.[19] The study also shows that in moderately logged stands 35 m^3/ ha are removed, which results in a loss of commercial species of 43 m^3/ha and a 20% reduction in total aboveground live biomass (AGLB). The biomass concentration in the Amazon varies, but an average value of 254.8 tons/ha (standard deviation 103.2) has been established on the basis of measurements from 216 different plots.[20] This represents a average loss of 50.96 tons AGLB for 35 m^3 roundwood for sale, i.e. 1.46 tons AGLB/m^3 roundwood.

2.4.2. LULUCF: selective cutting of Ipê

The emissions related to the selective logging of Ipê will be estimated in accordance with the IPCC guidelines for forest land remaining forest land. The equation below highlights the parameters that should be assessed.

$$\left[\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{soils}})\right]$$

ΔC_{FF} : annual change in carbon stocks from forest land remaining forest land (FF).

$\Delta C_{FF_{LB}}$: annual change in carbon stocks in living biomass (LB) in forest land remaining forest land.

$\Delta C_{FF_{DOM}}$: annual change in carbon stocks in dead organic matter (DOM) in forest land remaining forest land.

$\Delta C_{FF_{soils}}$: annual change in carbon stocks soils in forest land remaining forest land.

As the harvesting of Ipê is selective, the disturbance of harvesting one tree on the carbon stocks in dead organic matter and in soil is expected to be very low. Accordingly, both of these parameters will be considered as negligible and hence not estimated in the following calculations. Consequently, only the change in living biomass will be considered.

$$\Delta C_{FF_{LB}} = \Delta C_{FF_{growth}} - \Delta C_{FF_{loss}}$$

$\Delta C_{FF_{growth}}$: annual increase in carbon stocks in living biomass due to growth.

$\Delta C_{FF_{loss}}$: annual decrease in carbon stocks in living biomass due to losses.

As reflected in the equation above, the variation in carbon stocks in living biomass is a reflection of the biomass increment due to forest growth and the loss in this case due to harvesting.

Biomass includes the aboveground biomass (branches, leaves, etc) and the underground biomass (roots).

As mentioned earlier, where Ipê has been selective cut, other vegetation will be allowed to grow (98,5%).[21] However the carbon content of the regrowth is slightly lower than Ipê.

Data used

- Aboveground live biomass lost from selective cutting: 1.46 tons biomass/m^3 roundwood sold. (see 1.4.1)
- IPCC default values:
  - Density of non-coniferous woods[22]: 0.56 tonnes d.m./m^3
  - Above ground biomass carbon content of non-coniferous wood[25]: 0.5 tonnes C/ tonnes d.m.
  - Root-shoot ratio for primary tropical moist forest[24]= 0.24 (Root to shoot ratio is the underground to aboveground biomass ratio.)
- C to CO_2 conversion factor = 3.76
- Above ground biomass carbon content of regrowth non-coniferous wood = 0.45 tonnes C/ tonnes d.m.

Calculations

Note: The loss is directly associated to the tonnage of sold roundwood.

$\left[\Delta C_{FF_{loss}}\right]_{aboveground}$ = 1.46 tonnes/m^3 x 0.5 tonnes C/tonnnes d.m x 3.67 CO_2/C = –1,500 tonnes CO_2/m^3

$\Delta C_{FF_{loss}\ underground}$ = 24% of $\Delta C_{FF_{loss}\ aboveground}$ = –0.360 tonnes CO_2/m^3

$\Delta C_{FF_{loss}\ total}$ = –1.86 tonnes CO_2/m^3

$\Delta C_{FF_{growth}\ aboveground}$ = $\Delta C_{FF_{loss}\ aboveground}$ x 0.45 tonnes C/tonnes d.m. x 3.67 CO_2/C = +1.35 tonnes CO_2/m^3

$\Delta C_{FF_{growth}\ underground}$ = 24% of $\Delta C_{FF_{growth}\ aboveground}$ = +0.324 tonnes CO_2/m^3

$\Delta C_{FF_{growth}\ total}$ = +1.674 tonnes CO_2/m^3

Parameter	Tonnes CO_2/m³ of Ipê
$\Delta C_{FF_{growth\ total}}$	+1.674
$\Delta C_{FF_{loss\ total}}$	−1.86
$\Delta C_{FF_{LB}}$	**−0.203**

Table 4: Change in carbon stock from selective cutting of Ipê.

2.5. Carbon footprint from conversion of forest land to grazing land

2.5.1. Deforestation attributed to Ipê via economic assessment

Deforestation, such as in the Amazonia is driven by a complex set of drivers. The market for high value timber, cheap construction materials, firewood and charcoal material, as well as pasture and cropland are all important reasons. Therefore it is debatable to what extent any one factor has prime responsibility for driving deforestation, rather it is the combination of economic pressure represented by all the factors above which must pay the "burden" of climate emissions resulting from the removal of forest. We propose to divide the burden according to the "follow the money"-principle.

According to this, the relative influence on deforestation should be estimated from the gross value of land for different drivers.

1. Value from Ipê.

- Logging of average areas in Para, Rondovia and Mato Grasso = 0.34 commercial sized trees/ha, average gross yield = 6.55 m³.[26]
- Logwood wood prices for Ipê = USD 29–73/m³, average value = USD 42.5/m³ in 2004.[27]
- Average Ipê value = USD 95/ha.

2. Value from other construction timber.
Value of other commercial species for construction wood exported from Pará, Rondovia and Mato Grasso = approx. 90%[28] of the total value exported giving an approximate value of the other construction species of USD 855/ha.

3. Value from biomass for energy.
Value deriving from firewood and raw material for charcoal production from the remaining third grade wood species is difficult to estimate, partly because much of it is part of "private" economies. A simple estimate of 100 m³ of charcoal raw material /ha and average 15 % efficiency in charcoal conversion, gives approx. 300 sacks of 50 liters/ha. With an average profit of USD 1/sack, that gives an area value of USD 300/ha.

All of the points 1, 2 and 3 above can only be harvested once.

4. Value from cattle ranching.
Ranching is often portrayed as the single most important driver in deforestation. Cattle ranching however is not a very lucrative industry. Low density cattle ranching as it is practiced in former forest in the Amazon may hold only 1.5 cattle/ha, with a beef weight gain of approx. 40 kg/ha/yr. Cattle ranching gives an annual return on the land used, in contrast to the "mining" of the forest but overhead costs are high, related to raising of calves, transport of live animals, veterinary costs and slaughter costs, combined with low global beef prices and difficult market accesses in several areas. In this case we estimate the net profit at USD 1/kg beef. This gives an estimated profit of USD 40/ha/y. Over a 10 year amortization period this gives the land the value from ranching of USD 400/ha.

Based on these estimates, IPE represent 5.75% of the economic driver for land use changes in the states of Para, Rondovia and Mato Grosso.

Source	Value USD/ha
Primary harvest Ipê	95
Primary harvest other construction woods	855
Production of wood fuel/charcoal	300
Use of former forest for cattle ranching	400
Total	1,650
Share of Ipê	5.75%

Table 5: Economic attribution of deforestation to the different drivers (incl. Ipê)

2.5.2. LULUCF: logging of Ipê and land converted to grassland

The conversion of land from other uses and from natural states to grassland can result in net emissions (or net uptake) of CO_2 from both, biomass and soil, as summarized in the equation below. Consequently, both of these parameters will be assessed.

In the following we will consider that when clear cutting forest the land is converted to grazing or other similar use where the previous high density of live biomass is severely reduced.

$$\Delta C_{LG} = \Delta C_{LG\ LB} + \Delta C_{LG\ soils}$$

ΔC_{LG} : total change in carbon stocks in land converted to grassland.

$\Delta C_{LG\ LB}$: change in carbon stocks in living biomass in land converted to grassland.

$\Delta C_{LG\ soils}$: change in carbon stocks soils in land converted to grassland.

2.5.3. Change in carbon stocks in living biomass: $\Delta C_{LG\ LB}$

$$\Delta C_{LG\ LB} = A_{conversion} \times (L_{conversion} + \Delta C_{growth})$$

$A_{conversion}$: annual area of land converted to grassland from another use.

$L_{conversion}$: carbon stock change per area for that type of conversion when land is converted to grassland ($L_{conversion} = C_{after} - C_{before}$).

ΔC_{growth} : carbon stocks from one year of growth of grassland vegetation after conversion.

Data used

Data	
Conversion factor C/CO_2	3.67
2009 deforestation in Mato Grosso[29]	1,049 km^2
2009 deforestation in Pará[30]	4,281 km^2
2009 deforestation in Rondônia[31]	482 km^2
Attributed deforestation to Ipê	5.75%
$A_{conversion}$	33,419 ha
Mean biomass of deforested areas in Brazilian Amazon:[32] C_{before}	156 Mg C/ha
C after*	0
$L_{conversion}$	156 tonnes C/ha
Biomass carbon stocks present on land converted to grassland (tropical wet)[33]:	16.1 tonnes d.m./ha
Carbon density in grass	40%
Grass growth in 1 year: ΔC_{growth}	6.44 tonnes C/ha

** we will consider that the area is totally cleared and thereby no aboveground biomass is present.*

Table 6: Data used for calculations for Ipê, change in carbon stocks in living biomass.

Calculations

In 2009: $\Delta C_{LG\ LB}$ = - 18.3 million tonnes CO_2

2.5.4. Change in carbon stocks in soils: $\Delta C_{LG\ soils}$

$$\Delta C_{LG\ soils} = \Delta C_{LG\ mineral} - \Delta C_{LG\ organic} - \Delta C_{LG\ lime}$$

$\Delta C_{LG\ soils}$: annual change in stocks in soils in land converted to grassland.

$\Delta C_{LG\ mineral}$: change in carbon stocks in mineral soils in land converted to grassland.

$\Delta C_{LG\ organic}$: annual C emissions from organic soils converted to grassland (estimated as net annual flux).

$\Delta C_{LG\ lime}$: annual C emissions from agricultural lime application on land converted to grassland, this is not done in cattle grazing and therefore will not be considered here.

$$\Delta C_{LG\ mineral} = SOC_0 - SOC_{(0-T)} \times A/T$$

$$SOC = SOC_{ref} \times F_{LU} \times F_{MG}$$

$$\Delta C_{LG\ organic} = A \times \Delta EF$$

SOC_0 : soil organic carbon stock in the inventory year.

$SOC_{(0-T)}$: soil organic carbon stock T years prior to the inventory.

T : inventory time period, yr (default is 20 yr).

A : land area.

SOC_{ref} : the reference carbon stock.

F_{LU}: stock change factor for land use or land-use change type.

F_{MG} : stock change factor for management regime.

ΔEF: emission factor for climate type.

Data used

Data	
Conversion factor C/CO_2	3.67
Tropical moist, low clay density : SOC_{ref}	7.4 tonnes C/ha
Severally degraded: F_{MG}	0.7
Default value: F_{LU}	1
Default time: T	20 years
$SOC_{(0-T)}$	7.4 tonnes C/ha
SOC_0	5.18 tonnes C/ha
Annual emission factor tropical/ subtropical: $EF_{grassland}$	5 tonnes C/ha/year
Annual emission factor tropical forest: EF_{forest}	1.36 tonnes C/ha/year
ΔEF	3.64 tonnes C/ha/year

Table 7: Data used for calculations for Ipê, changes in carbon stocks in soils.

LULUCF parameter	Change in carbon stocks related to deforestation and Ipê logging (million tonnes CO_2/year)	Tonnes CO_2/m^3 of Ipê
$\Delta C_{LG\ LB}$	– 18.3	
$\Delta C_{LG\ soils}$	– 0.46	
ΔC_{LG}	**–18.8**	**–15.7**

Table 8: Change in carbon stocks from Ipê logging.

Calculations

$\Delta C_{LG\ mineral}$ = – 2.2 tonnes C/ha over T = – 13,613.9 tonnes CO_2/year

$\Delta C_{LG\ organic}$ = – 446,437 tonnes CO_2/year

$\Delta C_{LG\ soils}$ = – 0.46 million tonnes CO_2/year

2.6. Transport

GHG protocol[34] was used for all the emission factors and Google Maps[35] and World Shipping Register[36] were used as references for the distances used in the calculations.

CO_2 Emissions = Distance Traveled x Emission factor.

The emission factors are default values provided from the GHG protocol.[37]

Route	Mode of transport	Distance	Emission factor (kg CO_2/ ton.km)*	Total emission kg CO_2/ ton of goods transported	Emission kg CO_2 / m^3 finished product
Novo Progresso – Belém Parà, Brazil	Heavy diesel truck	1,702	0.029	49.4	27.6
(Ipê density ca. 0.56 tonnes/m^3)					855
Belém, Brazil – Oslo, Norway	Large Ro-Ro ship	4,685	0.02	93.7	52.5
(Ipê density ca. 0.56 tonnes/m^3)					400
Total transport		80.1			1,650
Share of Ipê					5.75%

**Assuming 30 ton payload for road transport.*

Table 9: Transport related emissions.

2.7. Results

Ipê production stages	Emissions (tonnes CO_2/m^3)
Selective logging of Ipê	0.203
Clear cutting of Ipê	15.7
Transport	0.0801
Total GHG emission	**15.98**

Table 10: Total GHG emission related to the import of Ipê.

Part 3: Kebony Southern Yellow Pine

Southern Yellow Pine (SYP) consists of four main pine species: shortleaf, longleaf, loblolly, and slash. Commercially all species are used, and deliveries are often mixes of the species, which are not distinguished.

Kebony SYP is produced from sustainably managed forests and treated with bio-based, renewable chemicals. The process gives a unique wood material with outstanding durability and an exclusive appearance. Kebony SYP can be machined in the same way as ordinary hardwood.

This section consists of the carbon footprint estimation for Kebony SYP. This section highlights the specific practices related to each stage of the production of Kebony SYP (summarized in Figure 4) and presents the assumptions considered and the calculations realized to determine the carbon footprint related to the production of Kebony SYP.

Kebony purchases its SYP from several suppliers and each supplier has their own specificities and practices related to the production of the raw material. However, in order to be as specific as possible, the following carbon footprint will be based on the practices of one major supplier, McShan Lumber (please see Box 1) and then generalized to the whole of Kebony's SYP production.

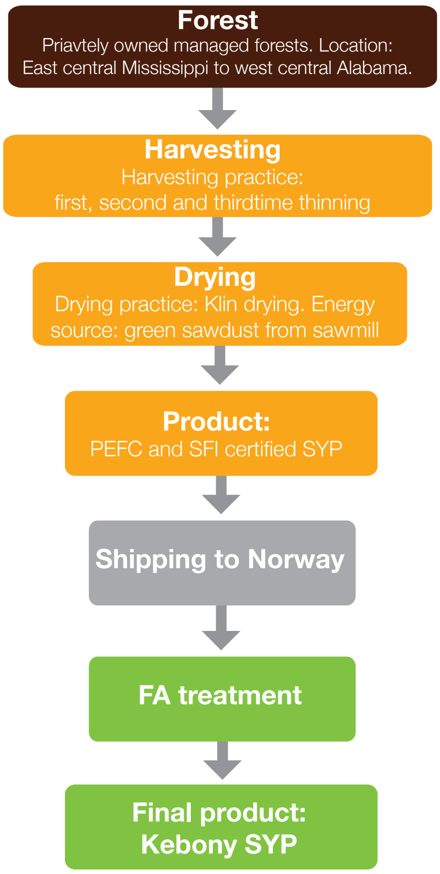


Figure 4: Production stages of Kebony SYP

McShan Lumber Company

- Website: www.mcshanlumber.com
- Location: McShan, Alabama, USA
- Activity: Sawmill
- Certifications:
  - Sustainable Forestry Initiative
  - PEFC (chain of custody)

Box 1: McShan Lumber Company

3.1. Calculation methodology

The carbon footprint calculation of Kebony SYP aims to estimate the change in carbon stocks and green house gas (GHG) emissions and removal associated with the production of Kebony SYP. The main estimations have been done in accordance with the IPCC Guidance for Land Use, Land-Use Change and Forestry (LULUCF).[38]

Figure 5 illustrates the carbon cycle within a forest area, highlighting the transfers of GHG emissions from the different carbon pools available in a forest, that will be considered in this section.

This report aims to be rigorous and precise and thereby refers to specific regional and specie specific data as much as possible. In terms of regional data we have referred to data from Alabama, which according to the supplier is their main region of SYP supply. Regarding specie specific data, we took into account data for all four species of SYP, however, where data was missing, Loblolly was used as a reference.

GHG emissions other than those related to the logging of SYP were addressed in accordance to GHG protocol for mobile and stationary combustion.

3.2. LULUCF: Forest land remaining forest land

3.2.1. Forest of origin

The SYP purchased via McShan originates from privately owned managed forests located between East central Mississippi and West central Alabama,[40] however the majority of SYP supplies are from Alabama. Therefore, in order to use the most specific data available we will only refer to data relative to Alabama forests. The forests of Alabama are managed in order to maintain the harvest rate lower than the growth rate, thereby guarantying a net annual growth of the forests (please refer to Box 2).

- Alabama timberland covers 9,586,930 ha
- It is the third largest commercial forestland in the United States.
- Ownership of Alabama's timberland:
  - 94% is privately owned (14% by forest industry and 80% by private individuals).
  - 6% is publicly owned.
- Alabama forests are comprised of:
  - 44% hardwood stands
  - 41% pine stands
  - 15% mixed pine/hardwood stands.
- Net annual area change to forest in Alabama: + 4,700 ha/year (U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005)

Box 2: Alabama forests facts (Alabama Forest Resource Report 2008)

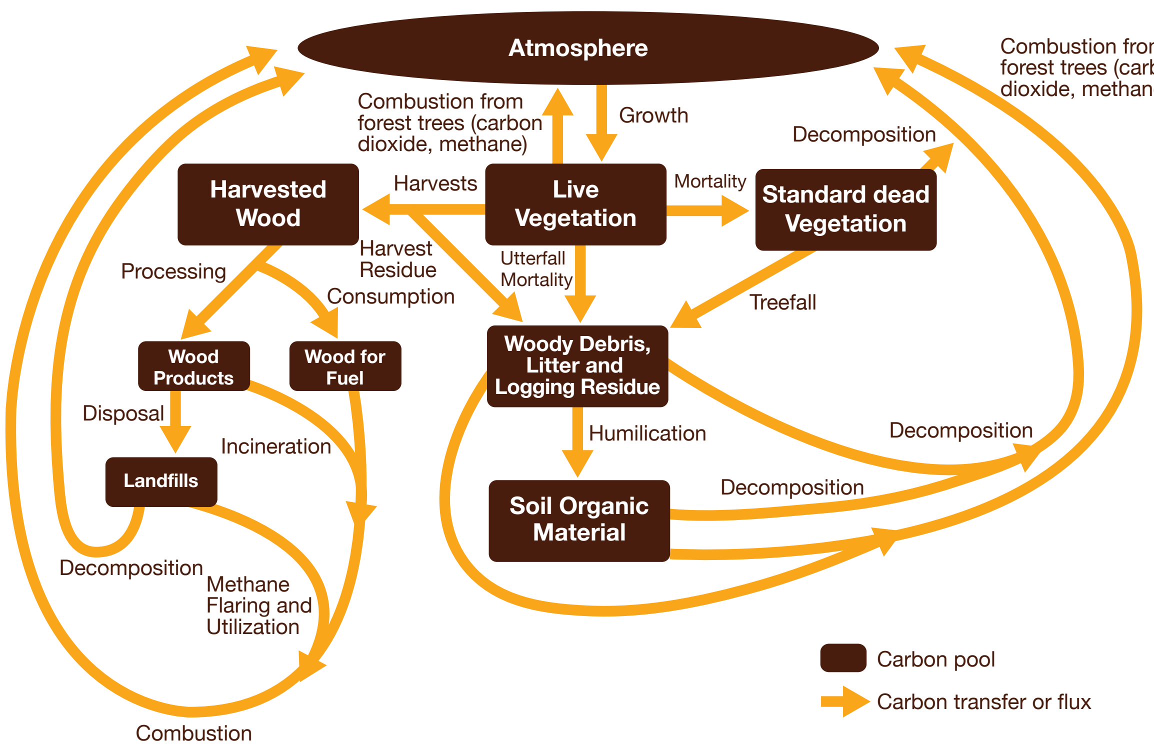


Figure 5: Summary of Forest Carbon Stocks and Carbon transfer among stocks[39]

3.2.2. Harvesting practices

The harvesting is carried out mainly by the forest owners and done in accordance to their individual forest management priorities. In this manner not all harvesting practices are homogenous, however according to Mc Shan first, second and third time thinning are the most widely used harvesting practices.

According to MC Shan who monitors the reforestation of the timber they cut every year, their three year average reforestation rate is over 98%. Furthermore, the suppliers state they have seen no conversion from forest to cropland. Consequently, forest land is maintained forest land, and thereby the following calculations will focus on Chapter 3.2.1 “Forest land remaining forest land” of the IPCC LULUCF guidelines. In accordance to these guidelines, the annual emissions or removals from forest land remaining forest land:

$$\Delta C_{FF} = (\Delta C_{FF_{LB}} + \Delta C_{FF_{DOM}} + \Delta C_{FF_{soils}})$$

ΔC_{FF} : annual change in carbon stocks from forest land remaining forest land (FF).

$\Delta C_{FF_{LB}}$: annual change in carbon stocks in living biomass (LB) in forest land remaining forest land.

$\Delta C_{FF_{DOM}}$: annual change in carbon stocks in dead organic matter (DOM) in forest land remaining forest land.

$\Delta C_{FF_{soils}}$: annual change in carbon stocks soils in forest land remaining forest land.

Each of these parameters will be taken into consideration and assessed. Most of the data used for the calculations are summarized in Table 11.

3.2.3. Living biomass $\Delta C_{FF_{LB}}$

Equation

$$\Delta C_{FF_{LB}} = \Delta C_{FF_{growth}} - \Delta C_{FF_{loss}}$$

$\Delta C_{FF_{growth}}$: annual increase in carbon stocks in living biomass due to growth.

$\Delta C_{FF_{loss}}$: annual decrease in carbon stocks in living biomass due to losses.

As reflected in the equation above, the variation in carbon stocks in living biomass is a reflection of the biomass increment due to forest growth and the loss in this case due to harvesting.

Biomass includes the aboveground biomass (branches, leaves, etc) and the underground biomass (roots).

Data used

Please refer to Table 11.

Note: “Biomass” mentioned in the US inventory corresponds to what is named as ”living biomass” in the IPCC guidelines. Biomass includes above and underground living biomass.

Calculations

Annual change in carbon stocks in biomass in the state of Alabama, relative to SYP production:

average $\Delta C_{FF_{LB\ SYP}}$ = +2.13 tonnes CO_2 /year/ha

$\Delta C_{FF_{LB}}$ total = *average* $\Delta C_{FF_{LB\ SYP}} \times F_{alabama\ pine}$ = +9.6 million tonnes CO_2 /year

Source	Section	Data	
Forest Resource Report 2008[41]	General	Alabama forests pine stands	41%
		Alabama forests mixed pine/hardwood stands	15%
		Alabama forests total pine stands (considering that the mixed stands are composed half pine – half hardwood)	48.5 %
		Total pine forest in Alabama: $F_{alabama_{pine}}$	4,503,710 ha
U.S. Agriculture and Forestry Greenhouse Gas Inventory: 1990-2005[42]	General	Loblolly/Shortleaf Pine forest area in the US	21,955,000 ha
		Longleaf/Slash Pine forest area in the US	5,383,000 ha
	Living biomass	Net Annual Stock Change biomass for Loblolly/Shortleaf Pine	53.5 million tonnes CO_2 /yr
		Net Annual Stock Change biomass for Longleaf/Slash Pine	9.8 million tonnes CO_2 /yr
		Net Annual Stock Change biomass for Loblolly/Shortleaf Pine per hectare $\Delta C_{FF_{LB\ loblo\ \&\ short}}$	2.44 tonnes CO_2 /ha/yr
		Net Annual Stock Change biomass for Longleaf/Slash Pine per hectare: $\Delta C_{FF_{LB\ long\ \&\ slash}}$	1.82 tonnes CO_2 /ha/yr
	DOM	Net Annual Stock Change Dead matter for Loblolly/Shortleaf Pine	10.4 million tonnes CO_2 /yr
		Net Annual Stock Change Dead matter for Longleaf/Slash Pine	1.0 million tonnes CO_2 /yr
		Net Annual Stock Change dead matter for Loblolly/Shortleaf Pine per hectare: $\Delta C_{FF_{DOM\ loblo\ \&\ short}}$	0.47 tonnes CO_2 /yr/ha
		Net Annual Stock Change dead matter for Longleaf/Slash Pine per hectare: $\Delta C_{FF_{DOM\ long\ \&\ slash}}$	0.19 tonnes CO_2 /yr/ha
	SOC	Carbon Stock in SOC for Loblolly/Shortleaf Pine	4,449 million tonnes CO_2
		Carbon Stock in SOC for Longleaf/Slash Pine	1,909 million tonnes CO_2
		Carbon Stock in SOC in US, 2005	57,001 million tonnes CO_2
		Proportion of US carbon stock in SOC related to SYP	11.15 %
		Annual Stock Change SOC change in US, 2005: $FF_{SOC\ US}$	35 million tonnes CO_2 /yr
Other		C to CO_2 conversion factor	3.67

Table 11: SYP in Alabama.

3.2.4. Dead organic matter $\Delta C_{FF_{DOM}}$

Equation

$$\Delta C_{FF_{DOM}} = \Delta C_{FF_{DW}} + \Delta C_{FF_{LT}}$$

$\Delta C_{FF_{DW}}$: annual change in carbon stocks in dead wood.

$\Delta C_{FF_{LT}}$: annual change in carbon stocks in litter.

Dead organic matter is considered to be dead wood and litter.

Data used

Please refer to Table 11.

Note: “Dead matter” mentioned in the US inventory corresponds to what is named as ”dead organic matter” in the IPCC guidelines. Dead matter includes dead wood and litter as defined below:
Dead wood: all non-living woody biomass either standing, lying on the ground (but not including litter), or in the soil.

Litter: the litter, fumic, and humic layers, and all non-living biomass with a diameter less than 7.5 cm at transect intersection, lying on the ground.

Calculations

Annual change in carbon stocks in dead organic matter in the state of Alabama, relative to SYP production:

average $\Delta C_{FF_{DOM\ SYP}}$ = +0.33 tonnes CO_2 /year/ha

$\Delta C_{FF_{DOM}}$ = *average* $\Delta C_{FF_{DOM\ SYP}} \times F_{alabama\ pine}$ = +1.48 million tonnes CO_2 /ha/year

3.2.5. Soil $\Delta C_{FF_{SOC}}$

The carbon stocks in soil refer to the sum of the soil organic carbon (SOC) and the soil inorganic carbon (SIC). However, SIC is not addressed in the IPCC guidelines.

SOC is a complex of large and amorphous organic molecules and particles derived from the humification of aboveground and underground litter, and incorporated into the soil either as free particles or bound to mineral particles. It also includes organic acids, dead and living microorganisms and the substances synthesized from their breakdown.

Data used

Please refer to Table 11.

Calculations

Annual Stock Change SOC change related to SYP:

$\Delta C_{FF_{SOC}\ SYP\ US} = \Delta C_{FF_{SOC}\ US} \times 11.15\%$ = +15.3 tonnes CO_2 /year = +0.56 tonnes CO_2 /ha/year

Annual Stock Change SOC change related to SYP in Alabama:

$\Delta C_{FF_{SOC}} = \Delta C_{FF_{SOC}\ SYP\ US} \times F_{alabama\ pine}$ = +2.52 million tonnes CO_2 /year

3.2.6. Non-CO_2 greenhouse gas emissions

The non-CO_2 GHG emissions as defined in the IPCC guidelines, reflects the nitrous oxide emissions related mainly to nitrogen fertilizations and burning within forest management.

Direct N2O emissions from forest fertilization:
As mentioned previously, 80% of Alabama's forests are owned by private individuals and in this manner the management practices will vary greatly.

Defining the fertilization of SYP in Alabama is complex. In order to carry out the following calculations we have referred to values recommended in a management guide for Loblolly Pine issued by the US department of agriculture and forest services.[43]

$$N_2O \text{ direct} = (FSN + FON) \times EF$$

FSN: annual amount of synthetic fertilizer nitrogen applied to forest soils adjusted for volatilization as NH_3, NO_x.

FON: annual amount of organic fertilizer nitrogen applied to forest soils adjusted for volatilization as NH_3, NO_x.

EF: emission factor for N_2O emissions from N inputs.

Estimation of GHGs directly released in fires:

$$L_{fire} = A \times B \times C \times D \times 10^{-6}$$

A: area burnt
B: mass of "available" fuel
C: combustion efficiency
D: emission factor

Data used

Fertilization:

- Recommended application rate of nitrogen for Loblolly (once every 5 years)[44] = 100 – 150 lbs/acre

Data		IPCC Default Values
Mass of "available" fuel ("other temperate forests", felled and burned (land clearing fire))	B[47]	44.80 tonnes d.m./ha
Combustion efficiency	C[48]	0.5
Emission factor	D[49] CO_2	1,531 g/kg d.m.
	D[50] CO	112 g/kg d.m.
	D[51] CH4	7.1 g/kg d.m.
	D[52] NO_x	0.7 g/kg d.m.
	D[53] N25O	0.11 g/kg d.m.
	N/C ratio[54]	0.01

Table 12: IPCC default values for fires.

Annual mean application rate of nitrogen = 28 kg/ha

Annual mean application rate of nitrogen for SYP forests in Alabama: (FSN + FON) = 126,199.71 tonnes/yr

- Urea is 46 % nitrogen

Application rate of urea = 60.9 kg/ha

- EF for urea[45] = 0.20 kg C/ kg urea

Permitted fires for forest management:

- 2004 Annual permitted burning objective in Alabama[46] = 55,000 acres = 22,257.71 ha

Considering that 48.8% of all permitted burning is related directly to the production of SYP in Alabama:

Annual permitted burning related to SYP in Alabama: A = 10,794 ha

Calculations

Fertilization:
No data was found regarding nitrogen fertilizer use other than urea and thereby will not be considered.
By considering the worst case scenario, where the total SYP production in Alabama is fertilized:

Annual non-CO_2 emissions related to SYP fertilization in Alabama = 0.05 million tonnes C/yr = 0.2 million tonnes CO_2 /yr.

Permitted fires for forest management:

Results	Emissions
$L_{fire\ CO_2}$	370,207 tonnes/yr
$L_{fire\ CO}$	27,082 tonnes/yr
$L_{fire\ CH_4}$	1,717 tonnes/yr
$L_{fire\ NOx}$	169 tonnes/yr
$L_{fire\ N_2O}$	26.5 tonnes/yr
Total L_{fire}	**0.4 million tonnes CO_2 /yr**

Table 13: Emissions from permitted fires.

Total non-CO_2 emissions = 0.62 million tonnes CO_2 /yr.

3.2.7. Additional emissions not included in the IPCC guidelines

Emissions related to the production of fertilizer:

- US CO_2 emissions from nitrogen fertilizer making[55] = 9,070,000 tonnes C = 33,600,000 tonnes CO_2
- US production ammonia[56] = 16,300,000 tonnes = 13,300,000 tonnes nitrogen

CO_2 emission from nitrogen fertilizer = 2.52 kg CO_2/kg nitrogen

CO_2 emission from nitrogen fertilizer in SYP Alabama forests = 318,820.33 tonnes CO_2 /yr

Emissions related to the use of machinery for harvesting:

No data regarding the use of machinery used for harvesting was found in order to calculate this parameter's GHG emissions.

3.2.8. Results

A recapitulative of the calculations carried out can be found in table 15.

Since the total annual change in carbon stocks related to the logging of SYP in Alabama is positive we can consider the harvesting as sustainable with no net additional emission of GHG. Consequently in the following calculations we will consider southern yellow pine timber as carbon neutral.

3.3. Drying

McShan's kilns hold about 80,000 board feet, at 185 degrees F. for about 48 hours.

The kilns are heated by steam that is produced in a boiler which burns green sawdust from the sawmill, with an estimated average of 4 pounds of steam to dry 1 board foot of lumber.

Change in carbon stocks in the state of Alabama for softwoods/SYP	Million tonnes CO_2 / year
$\Delta C_{FF\ LB}$	+ 9.2
$\Delta C_{FF\ DOM}$	+1.48
$\Delta C_{FF\ soils}$	+2.52
Non-CO_2 emissions	-0.62
Additional emissions	-0.32
ΔC_{FF}	**+7.93**

Table 14: Recapitulative on the GHG emission/removal related to SYP logging in Alabama.

As demonstrated in the previous section, the timber from Alabama can be considered as carbon neutral. Consequently, as sawdust from Alabama timber is used as the carburant for the kiln, we will consider the net emissions from the drying process as carbon neutral.

3.4. Kebonisation

The Kebony process consists of treating timber with chemicals in a curing chamber under high temperature. The primary chemical is furfuryl alcohol (FA), which is a by-product from sugarcane production. Smaller quantities of proprietary additives are also used.

The main production stages:

1. Manufacture of furfural from crushed sugarcane (bagasse) in the Caribbean, utilising bio fuel as energy source.
2. Conversion of furfural to furfuryl alcohol in Belgium, utilising electricity and natural gas as energy sources.
3. Curing SYP with chemicals and heat in Norway, utilising electricity and propane gas.

3.4.1. Manufacturing of furfural

The production is based on bagasse, the crushed sugarcane after the juice has been extracted. The bagasse is also burned as fuel for the process. Since an equivalent amount of sugarcane to that harvested will grow back in the following year the net emission of CO_2 is set at zero.

3.4.2. Conversion of furfural to furfurylalcohol

The conversion takes place in Belgium using natural gas and electricity from the grid. The emissions from this power production will be chosen according to the principles in the GHG Protocol which state that if site-specific data are not available then national production and emission figures

Energy requirement per kg FA	Conversion factors[57]	GHG emission (kg CO_2/kg FA)
0.14 +/- 0.02 kWh electricity	0.267 kg CO_2/kWh	0.037 +/- 0.005
2.80 +/- 0.03 MJ methane	50 MJ/kg heat of combustion The combustion of 1kg methane is equivalent to 2.77kg of CO_2	0.186 +/- 0.002 (assuming 80% efficiency)
Total		**0.223 +/- 0.007**

Table 15: Carbon emissions from energy use in Belgium for the conversion of furfural to furfurylalcohol.

can be utilised. In this case national emission data are available from the International Energy Agency, IEA for the year 2005. The emission data cover all emissions associated with Belgian electricity production, but do not include emissions from any electricity imported into Belgium from abroad. However, Belgium is broadly self sufficient in electricity basing its production on nuclear power, gas and coal. Any imports of electricity will only slightly modify the carbon footprint.

Approximately 200 kg FA is used to treat 1 m^3 of SYP. Consequently, the CO_2 emission related to furfural to furfurylalcohol conversion is 44.6 kg CO_2 /m^3 of Kebony SYP.

3.4.3. Emissions from manufacture of other chemicals

In addition to FA the production of modified wood requires low concentrations of additives. The carbon emissions related to the production of these chemicals depend heavily on where and how they are manufactured. According to a previous environmental assessment of Kebony (Lum, 2009), the CO_2 emissions related to the manufacture of a "treatment package" of these chemicals have been estimated at 110 +/- 50 kg CO_2 per cubic meter of wood.

3.4.4 Curing in Norway

The amount of propane used per m^3 wood under normal operations and production is 75 kg. This amount will vary a lot based on the production. Since the amount of propane used is constant, the amount of propane per m^3 wood will decrease when production is higher and it will increase when production is lower than normal. Empirical evidence shows that the amount of propane used varies between 50 and 100 kg per m3 wood with an average value of 75 kg.

Total emissions related to the Kebonisation of SYP
= 381.3 kg CO_2 /m^3 of Kebony SYP

Energy requirement per m^3 wood	Conversion factors	Kg CO_2 emissions pr m^3 wood
120 +/- 20 kWh electricity	0.0055 kg CO_2/kWh	0.66 +/- 0.11
75 +/- 25 kg propane	3 kg CO_2/kg propane	225 +/- 75
Total		**225.66 +/- 75.11**

Table 16: Energy requirement per m^3 wood.

3.5. Transport

GHG protocol[58] was used for all the emission factors and Google Maps[59] and World Shipping Register[60] were used as references for the distances used in the calculations.

$$\text{CO}_2 \text{ Emissions} = \text{Distance Traveled} \times \text{Emission factor}$$

The emission factors are default values provided from the GHG protocol.[61]

Route	Mode of transport	Distance (km)	Emission factor (kg CO_2/ton.km)*	Total emission kg CO_2/ton of goods transported	Emission kg CO_2/m^3 finished product
Alabama - Norway	Large Ro-Ro ship	3,554	0.02	71.08	39.1 (SYP density 0.55 tonnes/m^3)
Caribbean-Belgium	Large Ro-Ro ship	7,400	0.02	148	29.6 (200 kg FA/m^3 SYP)
Belgium-Norway	Heavy diesel truck	1,510	0.029	44	8.8 (200 kg FA /m^3 SYP)
Total transport					**77.5**

**Assuming 30 ton payload for road transport*

Table 17: GHG emissions relative to transport.

3.6. Conclusion

Kebony SYP stages of production	GHG emission: kg CO_2 /m^3 Kebony SYP
SYP logging	0
Drying	0
Kebonisation	381.3
Transport (total)	77.5
Total GHG emission	**458.8**

Table 18: Total GHG emissions related to the production of Kebony SYP.

Part 4: Results, discussion and conclusion

The results of this study show that the harvesting method used for Ipê and SYP is all important for the carbon footprint of the finished product. Harvesting methods that result in the permanent loss of forest biomass also result in very high carbon footprints. Harvesting methods that allow regrowth of biomass have small carbon footprints. The carbon footprints associated with treatment and transportation is small compared to the effects from harvesting methods.

Carbon footprint SYP vs Ipê

The carbon footprint from production of **modified SYP** has been calculated to **459 kg CO_2/m^3.**

The carbon footprint from **selective cutting of Brazilian Ipê** has been calculated to **300 kg CO_2/m^3.**

The carbon footprint from **clear cutting of Brazilian Ipê** has been calculated to **15,000 kg CO_2/m^3.**

The production of SYP in the south eastern part of the US is based on managed forests. Some of the production is certified by PEFC or SFI. All forestry statistics document that there is a net increase in forest biomass in the region. The carbon footprint from harvesting of SYP is therefore set at zero. The emissions from the subsequent transportation and modification of the wood result in a small carbon footprint for modified SYP.

The production of Ipê from selective harvesting in Brazil also has a small carbon footprint. The main carbon contribution is due to regrowth having a lower carbon content than the original forest. Ipê is a wood that requires no modification or other treatment in order to become durable for outdoor use. The carbon footprint associated with treatment and transportation is relatively small. Selective cutting of valuable timber such as mahogany has traditionally been seen as damaging to the forest because the necessary roads open the forest to subsequent exploitation. Harvesting techniques in Brazil have improved over the past years and this is no longer a major concern.

The production of Ipê from clear cutting of forest is associated with a large carbon footprint. The dominant source of the footprint is the loss of the large standing live biomass in the forest. The loss of carbon from dead biomass and from inorganic carbon bound in the soil is small. The method used in this report to apportion the share of biomass loss to be attributed to Ipê harvesting is based on a calculation of the economic value of different aspects of deforestation and attributes 5,75% of the biomass loss to Ipê harvesting. This attribution is necessarily somewhat rough and will fluctuate depending on changing world market prices for Ipê, beef, soymeal, construction timber and so on.

However it is clear that with the current low market prices for beef and with the removal of Brazilian economic inducements for forest clearing the beef industry itself cannot finance the current 7000 km^2 /year deforestation. The largest economic value of the forest is represented by construction timber including Ipê. Deforestation for creation of grazing for cattle would be uneconomical without the value of the standing timber. Therefore, attributing a share of the biomass loss to Ipê harvesting is valid. Deforestation in Brazil is now concentrated in three states along the Transamazonica highway, these states producing 99% of all Ipê. Clearly selective logging from other parts of the Amazon contribute little to the total Ipê production, and conversely the clear cutting still being practiced in these three states contribute massively to the total Ipê volume. The carbon footprint share attributed to Ipê production depends on the actual volume of trees in the forest being clear cut. Since this forest is located in the "ring of fire" it is reasonable to assume that it is degraded and some Ipê has already been removed. Assuming that half the marketable trees have already been harvested the climate footprint from clear cut Ipê will also be halved to 7,500 kg CO_2/m^3, which still is very high. It is not reasonable to assume that the carbon footprint is significantly higher than 15,000 kg CO_2/m^3. The reasons for this are that biomass density data for the region are reasonably accurate and that Ipê volumes and values from the three states are very unlikely to be higher than the Brazilian average. The proximity to the Transamazonia highway makes it much more likely that the forest in question has been degraded to some extent.

Conclusion

The production of modified SYP and Ipê from selective logging both carry very small carbon footprints in the region of 300–500 kg CO_2/m^3. However the volume of Ipê harvested in this manner is very small.

The production of Ipê from clear cutting carries a very large carbon footprint. The size of the footprint is in the range of 7,500-15,000 kg CO_2/m^3.

From the point of view of carbon footprints Brazilian Ipê carries a large burden unless it can be documented that the Ipê originates in the small volumes produced from selective cutting or from certified forestry.

Notes

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