ENVIRONMENTAL LIFE - CYCLE ASSESSMENT

A STOOL FOR THE KITCHEN

STOOL BY FELIX DE PASS WITH ALISON BROOKS

MADE IN AMERICAN CHERRY

SUMMARY

Felix de Pass created two stools for the Wish List, one tall and the other short. This commentary refers only to the tall stool. In practice, the impact of the two stools is almost exactly equivalent with just a marginal saving for the small stool due to lower material usage. American cherry is a positive environmental choice for the stool, being a highly desirable timber which is readily available in the US forest but which has been under-utilised in recent years.

The stool is carbon neutral on a cradle to grave basis. Very few non-wood materials are used and the carbon emissions from supply of wood are offset by energy recovery from wood waste which substitutes for fossil fuels.

The small amount of plywood used to create the jig for the stool has a relatively minor effect across all environmental impact categories. For this analysis, the full impact of the plywood is allocated to the first stool. However, if the stool were produced commercially, the plywood jig would be reused and this impact would be allocated among multiple products.

WOOD RESOURCE

U.S. government forest inventory data[1] shows that American cherry growing stock is 306 million m^3, 2.7% of total U.S. hardwood growing stock. American cherry is growing 8.6 million m^3 per year while the harvest is 3.5 million m^3 per year. After harvesting, an additional 5.1 million m^3 of cherry accumulate in U.S. forests every year. American cherry growth exceeds harvest in all states. It takes just over a second for new growth in the U.S. forest to replace the cherry logs harvested to manufacture each stool.

CARBON FOOTPRINT

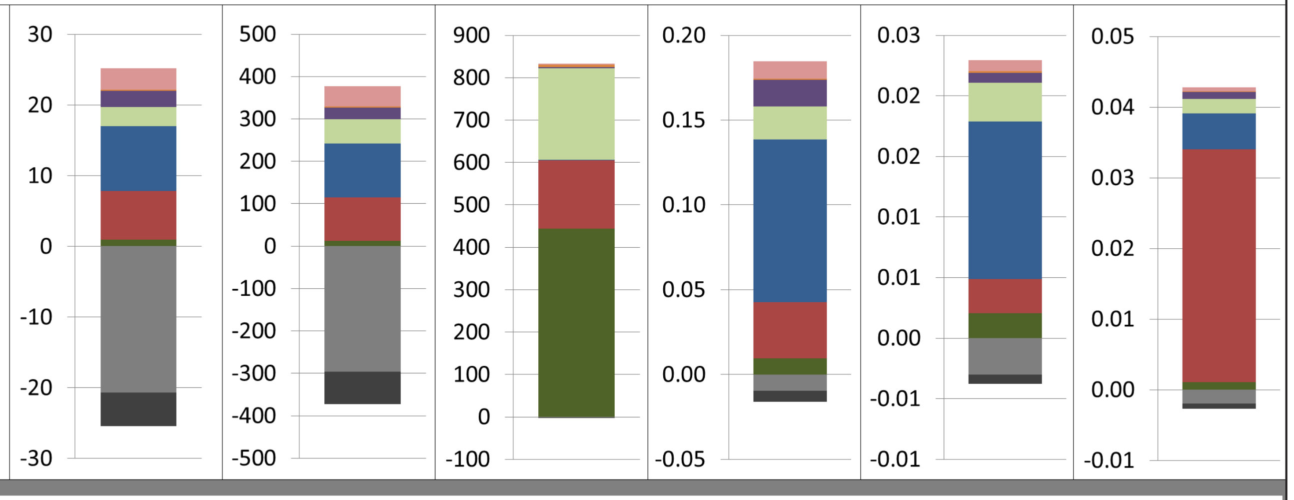
The stool's carbon footprint is -0.2 kilograms of CO_2 equivalent on a cradle to grave basis. Carbon emissions during all stages of material extraction and processing, product manufacturing, and transport are 25.2 kilograms of CO_2 equivalent. These emissions are offset by 25.4 kilograms of avoided emissions from energy recovery.

A large proportion of the wood required to manufacture the stool did not end up in the finished product. This reduces the long-term carbon storage potential but it also means that there is a significant volume of

CRADLE TO GRAVE ENVIRONMENTAL IMPACT OF THE TALL STOOL

Impact category	Global Warming Potential	Primary energy demand (resources)	Primary energy demand (renewable)	Acidification Potential	Eutrophication Potential	Photochemical Ozone Creation Potential
Unit	kg CO2-Equiv.	MJ	MJ	kg SO2-Equiv.	kg Phosphate-Equiv.	kg Ethene-Equiv.
Total	0	5	831	0.17	0.02	0.04

Data by process steps



Key ■ Forestry ■ US processing ■ Transport ■ Other wood ■ Other Materials ■ Glues & Coatings ■ UK processing ■ Process waste ■ End of Life

waste wood diverted to energy production. The overall mass of wood waste arising from the processing is much greater than the final mass of the product, so the credits from processing are greater than those from end of life.

OTHER IMPACTS

The total eutrophication potential of the stool is 0.02 kg of phosphate equivalent, about the same as caused each year by conventional farming of 9 square meters of land for wheat in the UK[2]. Nearly all eutrophication potential of the stool is due to nitrate emissions during burning of fuels for transport and processing of materials. Hardly any eutrophication potential is linked to growth of U.S. hardwoods which thrive under natural conditions and very rarely require fertilisers.

The stool's acidification potential of 0.17 kg of SO_2 equivalent is mainly caused by the emissions during shipping of hardwoods from the U.S. to the UK and is due to the relatively high sulphur content of marine fuels.

The stool's POCP is 0.04 kg of Ethene equivalent. The processing of U.S. hardwoods makes a significant contribution to POCP due to the presence of terpenes, naturally occurring VOCs, in wood resin. Although terpenes are released naturally as trees grow, processes in which wood is heated lead to more significant emissions.

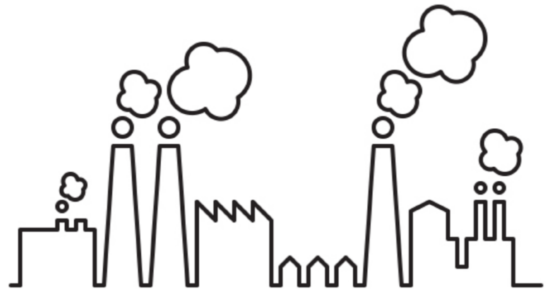
The input of renewable energy – 831 megajoules – is due partly to the high proportion of thermal energy derived from burning of wood waste during manufacture of plywood and the hardwood kiln drying process. At least 90% of all thermal energy used for kiln drying in the U.S. hardwood sector is derived from biomass. The high proportion of renewable energy attributed to the forestry stage is a peculiarity of life cycle inventory rules for wood products and has nothing to do with the energy used during forestry operations. It is the solar energy that is absorbed by the tree during growth and converted into chemical energy within the wood itself. In other words it is the energy that would have been released if the wood were burnt immediately after harvest.

The use of a small amount of stainless steel for the foot bar of the stool has negligible environmental impact.

MATERIALS USED FOR THE TALL STOOL

Wood materials	Use	Volume (m^3)
American cherry sawn 2"	Main structure	0.1474
Birch plywood	Moulding jig	0.069
Other materials	**Use**	**Weight (g)**
Titebond III Glue	Bonding	5g
Stainless steel (tall stool only)	Foot bar	650g
Epoxy	Glue seat to legs	5g
Osmo clear oil	Finishing	100g

ENVIRONMENTAL IMPACT CATEGORIES

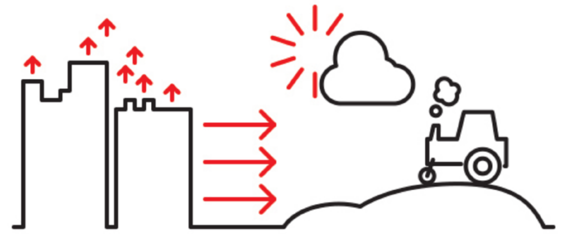


1 PRIMARY ENERGY DEMAND (NON-RENEWABLE RESOURCES)

This is a measure of the total demand of primary energy that comes from non-renewable resources, such as oil and natural gas. Measured in gigajoules (GJ), the primary energy demand takes into account the conversion efficiencies from the primary energy to, for example, electricity. The generation of carbon dioxide from the production of energy is one of the major causes of global warming.

2 PRIMARY ENERGY DEMAND (RENEWABLE RESOURCES)

Like the primary energy demand from non-renewable resources, this is a measure of the total amount of primary energy, but in this case, derived from renewable sources such as hydropower and wind energy. Again, it takes conversion efficiencies into account where appropriate. Total primary energy demand can be measured by adding the figures for energy from non-renewable and renewable resources

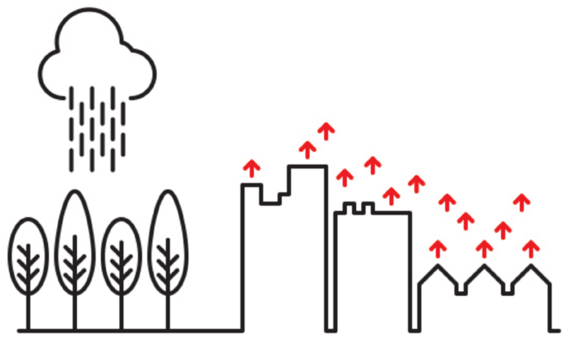


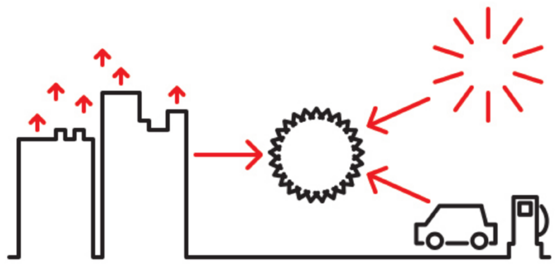
3 GLOBAL WARMING POTENTIAL (GWP)

Global warming is usually regarded as one of the most significant environmental issues. Global Warming Potential, measured in kg CO2 equivalent, is also a good marker for other environmental impacts. It is calculated from the volumes of greenhouse gases, such as carbon dioxide and methane, emitted during a process.

4 ACIDIFICATION POTENTIAL (AP)

This is a measure of the emissions that cause acidifying effects to the environment, which can cause imbalances and the death of species. Emissions of sulphur dioxide and nitrous oxide result in acid rain which can fall some way from the place where the emissions occur. Acidification potential is measured in kg of sulphur dioxide equivalent.





5 EUTROPHICATION POTENTIAL (EP)

Eutrophication is the process by which water receives an excessive amount of nutrients, particularly phosphates and nitrates. These nutrients, which typically come from run-off from fertilisers, lead to algal blooms which, in turn, deprive the water of oxygen and lead to imbalances and deaths in the aquatic populations. Eutrophication is measured in terms of kg of phosphate equivalent, and kg of nitrogen equivalent.

6 PHOTOCHEMICAL OZONE CREATION POTENTIAL (POCP)

This is a measure of emissions or precursors that contribute to low-level smog. It is measured in kg of ethene equivalent. Ozone layer depletion potential (ODP) is also part of the i-report but is not included in the charts because the effect is negligible. There may seem to be a contradiction between these two impacts but, put simply, high-level ozone is good and should be protected, whereas ozone at ground level is a pollutant.

NOTES

1. Figures based on 2011/2012 data from the U.S. Forest Service Forest Inventory and Analysis (FIA) program at http://www.fia.fs.fed.us/
2. Based on Williams *et al* 2010 at Cranfield Natural Resources Management Institute who for 1 tonne of bread wheat from conventional farming in the UK assessed Eutrophication Potential of 3.1 kg of phosphate equivalent and average occupation of 0.14 hectares of Grade 3a agricultural land.

ENVIRONMENTAL LIFE-CYCLE ASSESSMENT

Environmental life-cycle assessment (LCA) involves the collection and evaluation of quantitative data on all the inputs and outputs of material, energy and waste flows associated with a product over its entire life cycle so that the environmental impacts can be determined. LCA quantifies environmental effects against a range of impact categories (see page 3). LCA may also provide qualitative assessment of other environmental impacts such as on biodiversity and land-use that are less easy to quantify.

The LCA of The Wish List builds on a two-year study, commissioned by AHEC and undertaken by PE International, to assess environmental impacts associated with delivery of US hardwood material into world markets[a]. This involved a wide-ranging independent assessment of hardwood forestry practices and a survey of the hundreds of US companies engaged in the processing and export of hardwood products.

Life cycle inventory data from the LCA of US hardwoods was combined with data gathered during product manufacture at Benchmark in the UK. It was also combined with PE's existing life-cycle inventory database which covers an expanding range of non-wood materials and product groups. Using PE's Gabi software for LCA, the data was analysed to quantify environmental impacts.

To model the cradle-to-grave impact of the stools, the following assumptions are made about waste disposal during manufacture at Benchmark and at the end of the product's life.

- 80% of hardwood waste is used as a fuel for biomass boilers, substituting for light fuel oil.
- The remaining 20% of hardwood waste is reused on other products (no benefits have been modelled for this option).
- 50% of the plywood for the jig is discarded and sent for waste incineration with electricity and thermal energy recovery. This is reported at the 'process waste' stage.
- The final disposal of the plywood jig (the remaining 50%) occurs in the same way but is reported in the 'End of Life' stage
- Other parts (including glues, coatings, fittings, etc.) are incinerated with electricity and thermal energy recovery using appropriate datasets.

These assumptions are based on information gathered from Benchmark about its standard procedures for use of waste and from secondary sources about waste-disposal practices in the UK.

a. The PE LCA study of US sawn hardwood is available at http://www.americanhardwood.org/fileadmin/docs/sustainability/Final_LCA_Lumber_report.pdf