Life Cycle Analysis

Orientation Guide

landscapeforms®

Life-Cycle Analysis

In 2022, we worked with SCS Global Services, an international leader in third-party certification, to complete a comprehensive Life Cycle Analysis (LCA) of the embodied carbon impacts for top selling products within our family of brands. Following the requirements of ISO 14067, this project examined the carbon footprint of every product stage, including upstream materials, core manufacturing, packaging, transport, use, maintenance, and disposal at end of life (Carbon Footprint Report, p. 5). The report is critically reviewed, and followed guidelines set by vetted Product Category Rules for Seating and Furniture.

Goals

Our motivations for developing the LCA were twofold: First, we needed to better understand the embodied carbon impacts of the various materials and processes used in manufacturing our products; and second, our partners in the landscape architecture industry were voicing an unmet need for this data to better understand the overall impacts of their designs. This LCA provides a basis for understanding the carbon footprint of our products in the current state, while granting visibility of best practices and setting processes in motion for improvement.

Context and Considerations

In efforts to reduce emissions, understanding the impact of embodied carbon in our built environment is especially important. Today, embodied emissions from buildings, landscapes and infrastructure are responsible for 15% of global GHG emissions annually (Architecture 2030). Landscapes also have the potential to sequester carbon in plant material, and products made of biogenic materials can store carbon over their useful lifespan. In working towards rapid reduction in emissions, we're working to support the better understanding of (and accounting for) carbon impacts of whole projects.

Data for this report are based on primary data from Landscape Forms' materials, suppliers, transportation distances, and operations in its Michigan and Minnesota facilities. Where data was not able to be obtained or incomplete, data was modeled using representative secondary data. The LCA conforms to ISO 14067:2018 and Category Rules (PCR) for Seating and Furniture products developed by International EPD System PCRs are used as guidance (CF Report, p. 2). To date, no relevant PCR exists for Site Furniture and Amenities, so the study references more than one set of relevant PCRs developed for interior furnishings according to ISO requirements. More information on the production and sourcing of upstream materials could improve accuracy of the report, especially in the case of metals and woods (Carbon Footprint Report, p. 38).

Study Parameters are discussed in section two. Modeling and Analysis is covered in section 3, where data sources, limitations, assumptions, and data quality are detailed. Section 4 covers the Life Cycle Impact Assessment Results. In the case of disposal at end of life, pathways were modeled in line with the US EPA Facts and Figures report in the durable goods category (Carbon Footprint Report, p. 14). Materials we know to be commonly recycled in our manufacturing processes, such as aluminum, are recycled at lower rates in these data tables (zero percent in the case of aluminum). A sensitivity analysis for aluminum recycling is included on page 37, showing changes to the study outcomes if an 85% recycling rate is used per UL PCR Part A for Building Related Products.

Using the Report

This Life Cycle Analysis is being made publicly available as part of our commitment to transparency and furthering sustainable practices industry wide. This document could be utilized for entering our products into carbon calculations. It could be used to comparatively understand the carbon impacts of each of our products to each other. Internally, our teams are using this document to understand existing scenarios and prioritize areas for improvement. Due to the inherent unique circumstances of the data, and the parameters of the study, the results of this report are not intended to be utilized for public claims of the environmental superiority of one product over another (Carbon Footprint Report, p. 2). Regardless, we've heard a keen interest among our customers to be able to compare LCA data between products from various manufacturers. We would welcome the use of a PCR developed specifically for the site amenities industry to enable comparison.

On the Horizon

As we work towards a better understanding of the relationship between our business and products and the outdoor spaces we're committed to enhancing and the stakeholder groups we serve, the full picture will shape our path forward. Additional tools to measure comprehensive impacts and tradeoffs, especially concerning health and biodiversity are key to our next steps. Stay in touch to follow our journey towards better options, and a better future, together.

For More Information

Didn't find what you were looking for? Contact your Landscape Forms Business Development Representative to request additional information and documentation.

Carbon Footprint of Outdoor Furniture, According to ISO 14067:2018

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1. Executive Summary

1.1 Objectives of the Study

This report presents the findings of a carbon footprint study conducted by SCS Global Services (SCS) of seventeen outdoor furniture products manufactured by Landscape Forms and five outdoor furniture products manufactured by Loll Designs in North America. The assessment considered the single impact category of climate change for quantification of the Product Carbon Footprint (PCF).

The goals of the study include two primary objectives:

1. To assess the cradle-to-grave carbon footprint for twenty-two outdoor furniture products, including raw material extraction and processing, component production, upstream transportation and product manufacturing.
2. For the development of a Carbon Footprint (CF), conformant to ISO 14067:2018[1]. ISO 14067:2018 is used as the PCR for the study. The CF Report (this report) documents the carbon footprint analysis and is intended to serve as the documentation of the carbon footprint for client communication. The International EPD System PCRs for Seating and Furniture products[2] are used as guidance.

The Carbon Footprint is calculated using 100-year Global Warming Potentials (GWPs) from IPCC[3] AR6 (2021) and is reported in kg CO_2e. It should be noted that the results reported herein represent a single impact category, as required by ISO 14067:2018, and does not include all environmentally relevant impacts for the product system, such as acidification and eutrophication potential, smog creation potential, impacts to ecosystems, key species habitats, or water resources.

This report is provided to aid in understanding the potential greenhouse gas impacts for the twenty-two products produced by Landscape Forms and Loll Designs using a 100-year time horizon and IPCC 2021 metrics, as specified by ISO 14067:2018. The intended audience for this technical CF Study Report includes Landscape Forms, anyone Landscape Forms intends to share the report with, and the CF reviewer. Results presented are not intended for use in comparative assertions. This carbon footprint is to be verified by a carbon footprint expert, independent of the project, for conformance to ISO 14067:2018**.** This verification is considered an 'internal' verification.

[1] ISO 14067:2018. Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification.

[2] International EPD. PCR for Furniture, Except Seats and Mattresses , version 2.01

International EPD. PCR for Seats (Seating, Chairs), version 3.0.2.

[3] IPCC is the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/).

1.2 Product System Description

Twenty-two products are modeled in this study, seventeen of which are produced by Landscape Forms and the other five are manufactured by Loll Designs. The seventeen Landscape Forms products comprise the top selling products manufactured by Landscape Forms in 2021. Many, if not all, are available in slightly different configurations. The *Plainwell Bench* is modeled using two different configurations, one primarily aluminum and one primarily wood, because these have significantly different impacts.

1.3 Disclaimers and Limitations

There were several limitations of the study, which are provided below for users of this Product Carbon Footprint:

- Data for this product carbon footprint report are based on primary data from Landscape Forms' materials, suppliers, transportation distances, and operations in its three Michigan facilities and one manufacturing facility in Duluth, Minnesota. Data for additional third-party manufacturing operations were not able to be obtained but modeled using representative secondary data.

- Users of the carbon footprint information should keep in mind that this report only covers one issue (climate change). Other environmental, human health, material end-of-life and social issues are not addressed by this carbon footprint report. Users should use caution when making decisions based on a single issue. For these reasons, this Report should not be used for claims of environmental preferability.

- The carbon footprint calculations are based on IPCC 2021 Global Warming Potential (GWP) metric, calculated using a 100-year time horizon (GWP-100). The GWP-100 metric is based on a time horizon which assumes impacts from climate change will not occur for 100 years, ignoring thresholds for irreversible climate change which may be passed in as little as 20 years. This metric does not account for 60% of current radiative forcing caused by short-lived climate forcers including black carbon, tropospheric ozone precursors, and sulfur dioxide (forming sulfate aerosols), and underestimates the radiative effects of methane by over 30%. The GWP-100 has not been substantively revised since 1990, and results should be interpreted considering these limitations.

- This report is a product carbon footprint only and the results presented are not intended for use in comparative assertions.

2. Study Parameters

2.1 Scope of the Assessment

The scope of this product carbon footprint is "cradle-to-grave", including raw material extraction and processing, raw material transportation, product manufacturing, product distribution to customer, product use, and product and packaging end-of-life. Resource consumption, emissions and wastes, and their associated potential greenhouse gas emissions and removals, are calculated for the products manufactured at the Landscape Forms and Loll Designs facilities.

2.2 Functions of the Product System

The products fall into three primary categories: seating, table, or trash receptacle. Seating includes both chairs and benches, both of which have a primary function of providing a surface for sitting. The primary function of the tables is to provide a level surface on which objects are placed, however some additionally include the primary function of seating. The Chase Park Litter product provides the primary function of providing a bin for trash collection.

The products are warrantied for 3 years from the date of invoice but may be expected to perform their primary function longer than the warrantied period without need for repair. Landscape Forms notes that typically customers have kept the products in use between 7-10 years and replace for aesthetic purposes, whereas others have lasted 30 or more years. The reference service life (RSL) used for these products is assumed to be 15 years of use with no maintenance or replacement, per the International EPD PCRs.

The declared unit used is one unit of product. The reference flow for each of the products are the sum of the product and its packaging.

Table 1. Reference flows for each product modeled.

Product Name	Declared Unit	Reference flows (kg) Product	Packaging	Total
Chipman Chair	1 product	9.33	6.05	15.4
Carousel Table	1 product	124	59.1	183
Parc Centre Chair	1 product	11.5	5.68	17.2
Parc Centre Table	1 product	43.4	19.6	63.0
Scarborough Bench	1 product	101	66.0	167
MultipliCITY Bench	1 product	95.9	66.0	162
Chase Park Litter	1 product	60.4	27.1	87.5
Austin Bench	1 product	34.0	29.5	63.5
Catena Chair	1 product	6.88	5.86	12.7
Americana Chair	1 product	32.3	37.5	69.9
Harvest Table	1 product	123	40.3	164
Parc Vue Bench	1 product	79.6	29.5	109
FGP Bench	1 product	46.3	29.5	75.8
Plainwell Bench Aluminum	1 product	72.1	29.7	102
Plainwell Bench Wood	1 product	66.8	29.7	96.5
Strata Beam Bench	1 product	146	40.3	186
Strata Table	1 product	127	59.4	186
AD100 Strata Bench	1 product	216	99.7	316
Adirondack Chair	1 product	18.6	1.54	20.1
Alfresco Bench	1 product	20.8	2.04	22.9
Alfresco Table	1 product	39.1	3.21	42.3
Alfresco Chair	1 product	8.60	0.837	9.44
Satellite End Table	1 product	6.34	0.362	6.70

2.3 System Boundary

The product system under study is a cradle-to-grave study, as specified by the PCR and guidance documents, and includes three life cycle stages (modules):

- The upstream module including: production and processing of raw materials, components, ancillary materials and packaging;

- The core module, including: transportation of raw materials to the Landscape Forms and Loll Designs facilities; manufacturing, including electricity and fuel use related to production of each furniture product at the Landscape Forms facilities; waste disposal related to manufacturing.

- The downstream module, including: transportation to the customer; packaging disposal and transportation of packaging materials to disposal; product disposal at end-of-life and transportation of product to final disposal.

The system boundaries include all unit processes contributing measurably to category indicator results for the greenhouse gas indicators specified in ISO 14067:2018. In the present study, except where noted above, all known materials and processes were included in the life cycle inventory.

Under ISO 14067:2018 a sensitivity analysis to the system boundary must be performed to determine the significance of life cycle stages or units not included. Section 4.5 explores life cycle stages outside the system boundary further.

2.4 The Product Systems under Study

The product systems studied in this carbon footprint report include the cradle-to-grave greenhouse gas impacts of the outdoor furniture products. The product systems were modeled based on information provided by the manufacturer, including materials, suppliers, modes of transport and transportation distances, packaging materials and completed Data Request Forms for the Landscape Forms and Loll Designs facilities. The seventeen Landscape Forms products are manufactured primarily at three facilities in Michigan: two in Kalamazoo, Michigan and one in Richland, Michigan. Many of the products also undergo electrostatic painting at a third party which is included in the scope; however, primary data were not available for this process as it is performed at a third party. Loll Designs manufactures all of the five products included in the study within their Duluth, Minnesota facility.

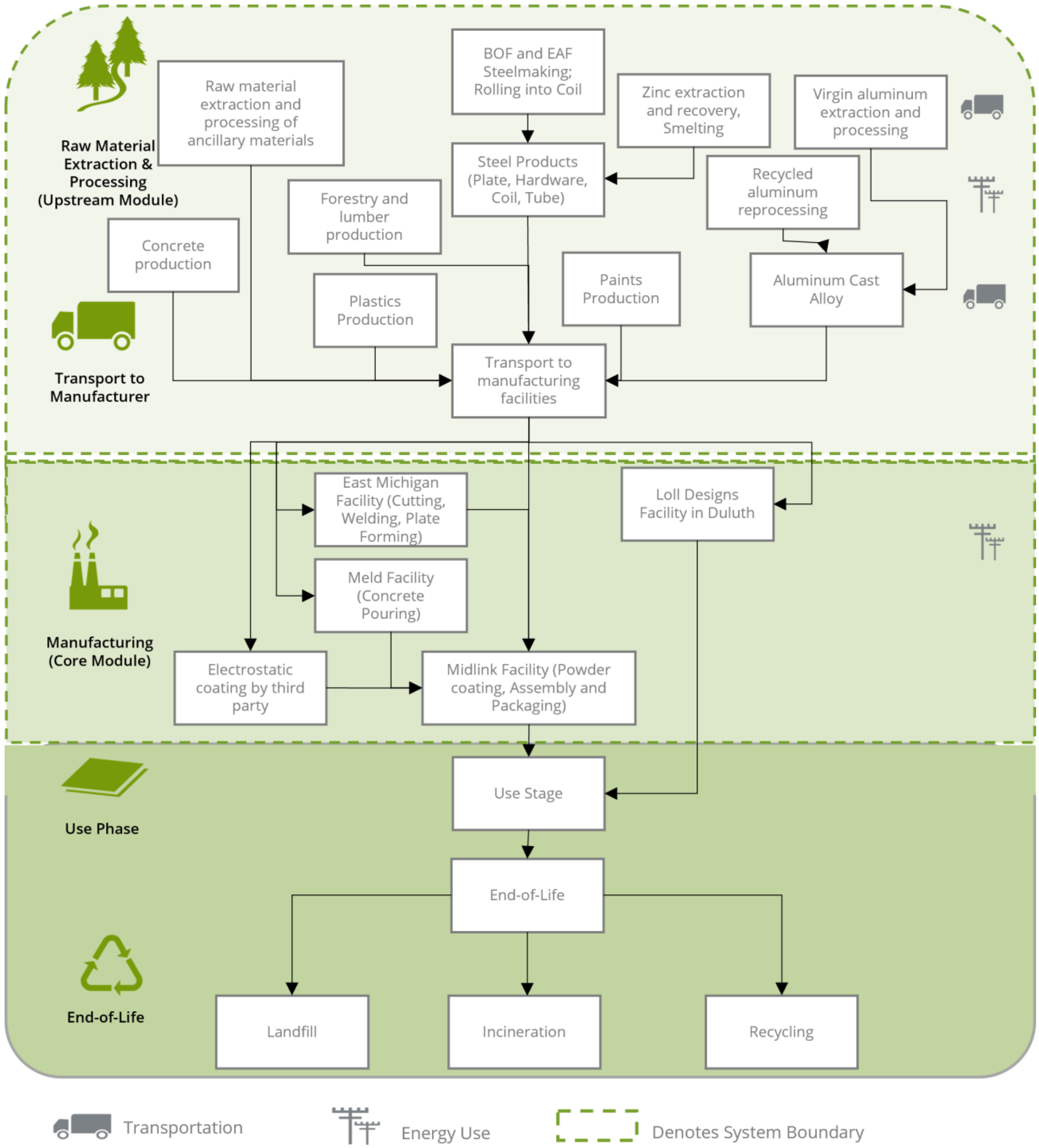

Figure 1. Process flow diagram to summarize processes and life cycle stages for the outdoor furniture products.

2.5 Allocation Procedures

The furniture products are manufactured at the Landscape Forms and Loll Designs facilities. All electricity and resources used at the manufacturing facilities are attributed to the products on a per unit basis, except for welding operations which are modeled on the basis of length of weld. Mass allocation was not possible due to data constraints. Ancillary materials related to powder coating at Midlink are estimated by surface area. Electrostatic coating processes at the third party facility are modeled based on the surface area of the coated portion of the product.

Impacts from transportation were allocated based on the mass of material and distance transported.

Per the PCR, the polluter pays principle is applied to the product systems in which the generator of the waste carries the environmental impact until the point in the product's life cycle at which the waste is transported to a scrapyard or gate of waste processing. Benefits from recovery operations at the end of life of these materials are not attributed to the product system.

2.6 LCIA Methodology and Interpretation Used

The Carbon Footprint is calculated using 100-year Global Warming Potentials (GWPs) from IPCC AR6[4] (2021), as mandated by the PCR, and is reported in kg CO_2e. Calculations are conducted using openLCA 1.11 using the IPCC AR6 GWP 100a impact method which includes all known greenhouse gas pollutants. Greenhouse gas indicators are calculated as the product of the 100-year GWP for all relevant greenhouse gases and the mass of greenhouse gas emission, summed over all contributing greenhouse gases and for all sources and sinks within the life cycle system boundary for the assessed product. Results are reported in units of kg CO_2 eq across the life cycle, as well as by contributing life cycle phase. Greenhouse gas emissions are also summarized separately for fossil and biogenic carbon sources and sinks. Biogenic carbon sources and sinks are those that are derived from biomass.

Following the requirements of ISO 14067, fossil GHG emissions are documented as net result, and biogenic GHG and direct land use change (dLUC) emissions are documented separately. There is a time delay for biogenic emissions in this study, such that not all biogenic carbon content within the products are released within the 100-year time horizon associated with the life cycle database and impact assessment methods. Assumptions related to end-of-life disposal pathways for product and packaging materials are explained within Section 2.14.

The interpretation phase conforms to ISO 14044 with further guidance from the ILCD General Guide for Life Cycle Assessment[5]. The interpretation included the use of evaluation and sensitivity checks to steer

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[4] IPCC is the Intergovernmental Panel on Climate Change (http://www.ipcc.ch/).

[5] European Joint Research Commission. International Reference Life Cycle Data System handbook. *General guide for Life Cycle Assessment – Detailed Guidance.* © European Union, 2010.

the iterative process during the assessment, and a final evaluation including completeness, sensitivity, and consistency checks, at the end of the study. Also included are discussion of study limitations, conclusions, and recommendations.

2.7 Data Requirements

This study included several key data requirements:

- Primary data on Landscape Forms' product materials, packaging materials, suppliers, transportation distances. Pre-consumer and post-consumer recycled content was additionally provided for aluminum, steel, concrete and cardboard components for Landscape Forms products.
- Number of units and mass of units produced at each of the facilities
- An SDS for the concrete pre-mix used at Meld and an SDS for the thread sealant used in Loll Designs products were provided.
- EPD information for the paper composite used in the Loll Designs product *the Alfresco Table* was obtained from the supplier's website.
- Surface area of the powder coated and electrostatic coated products, length of welding for each welded product. Type of welding process was additionally supplied for each product.
- Primary data for operations at each of the Landscape Forms facilities, including energy use, ancillary materials and waste generation.
- Product-specific datasheets and descriptions, retrieved from Landscape Forms' website, were used to verify product materials and dimensions
- Representative inventory data for many unit processes, using secondary data from the Ecoinvent[6] life cycle database, with a prioritization for data with the highest degree of representativeness of the actual material or process.
- The USDA Wood Handbook[7] was used to look up densities and moisture contents for Ipe and Jarrah woods, to match with Ecoinvent hardwood datasets based on the information.
- A material specifications sheet from Axalta[8] was used to look up the density of electrocoat to calculate the weight of electrocoat required, based on surface areas available from Landscape Forms.

[6] Ecoinvent 3.8 2021. Swiss Center for Life Cycle Inventories, 2021 http://www.ecoinvent.org

[7] Wood Handbook: Wood as an Engineering Material (2010). United States Department of Agriculture. https://www.fpl.fs.usda.gov/documnts/fplgtr/fpl_gtr190.pdf

[8] https://23433258.fs1.hubspotusercontent-na1.net/hubfs/23433258/Winona_Powder_Coating_December_2022/Pdf/Electrocoat-Aqua-EC-6100.pdf

2.8 Value Choices and Optional Elements

The study avoids the use of value choices in the assessment. Value choices, as described in ISO 14044, include normalization, weighting or grouping of indicator results. The study includes a data quality assessment, considered optional under ISO 14044.

2.9 Data Quality Requirements

One of the primary goals of the study is to prepare a carbon footprint for each of the twenty-two Landscape Forms and Loll Designs products; the overarching data quality requirements are to enable a reliable assessment of the indicator results, with data quality sufficient as to identify the key unit processes, differentiated by overall contribution to final results.

No data gaps were allowed which were expected to significantly affect the outcome of indicator results. Some individual parts were modeled using the ecoinvent datasets for representative materials and processing.

2.10 Type of Critical Review

This carbon footprint report has been critically reviewed by an internal independent GHG expert not involved with the execution of this study for conformance with ISO 14067:2018 following ISO 14064-3 standard. The carbon footprint critical review amended to this Report as an Appendix.

2.11 Product Composition

The product system examined in this study includes the cradle-to-grave greenhouse gas impacts of the twenty-two Landscape Forms products. The mass and a description of each component was provided by Landscape Forms, as well as a breakdown of the major components for each product as described in Table 2.

The primary materials used in Landscape Forms products include aluminum, various steel components, woods (namely Jarrah and Ipe), powder coating materials, various plastics and concrete. The packaging materials for each product was provided by Landscape Forms and includes wooden pallets, various plastics and corrugated cardboard.

Table 2. Material components for the Landscape Forms products (kg/product).

Product	Product Material							Packaging Materials			
	Aluminum	Steel	Plastics	Concrete	Wood	Coating	Total Product	Wood	Cardboard	Plastic	Total Packaging
Chipman Chair	8.76	0.0	0.0	0.0	0.0	0.545	**9.31**	2.18	3.84	0.0312	**6.05**
	94%	0%	0%	0%	0%	6%	**100%**	36%	63%	1%	**100%**
Carousel Table	0.00	118.7	0.0	0.0	0.0	4.404	**123**	24.3	33.8	0.960	**59.1**
	0%	96%	0%	0%	0%	4%	**100%**	41%	57%	2%	**100%**
Parc Centre Chair	0.00	11.0	0.0	0.0	0.0	0.409	**11.5**	2.18	3.47	0.0312	**5.68**
	0%	96%	0%	0%	0%	3%	**100%**	38%	61%	1%	**100%**
Parc Centre Table	0.00	42.6	0.0	0.0	0.0	0.863	**43.6**	10.9	8.53	0.163	**19.6**
	0%	98%	0%	0%	0%	2%	**100%**	56%	44%	1%	**100%**
Scarborough Bench	0.00	98.2	0.0	0.0	0.0	2.542	**101**	41.7	24.0	0.268	**66.0**
	0%	97%	0%	0%	0%	3%	**100%**	63%	36%	0%	**100%**
MultipliCITY Bench	41.2	1.0	0.4	0.0	52.3	1.27	**96.3**	41.7	24.0	0.268	**66.0**
	43%	1%	0%	0%	54%	1%	**100%**	63%	36%	0%	**100%**
Chase Park Litter	31.1	0.6	6.5	20.2	2.1	0.0	**60.4**	10.9	16.0	0.156	**27.1**
	51%	1%	11%	33%	3%	0%	**100%**	40%	59%	1%	**100%**
Austin Bench	30.8	0.5	0.0	0.0	0.0	2.72	**34.0**	10.9	18.3	0.268	**29.5**
	90%	2%	0%	0%	0%	8%	**100%**	37%	62%	1%	**100%**
Catena Chair	5.63	0.8	0.0	0.0	0.0	0.499	**6.90**	2.18	3.66	0.0312	**5.86**
	82%	11%	0%	0%	0%	7%	**100%**	37%	62%	1%	**100%**
Americana Chair	13.0	1.8	16.6	0.0	0.0	0.999	**32.4**	16.3	20.7	0.481	**37.5**
	40%	5%	51%	0%	0%	3%	**100%**	44%	55%	1%	**100%**
Harvest Table	23.9	27.7	67.5	0.0	0.0	4.31	**123**	28.1	11.4	0.754	**40.3**
	19%	22%	55%	0%	0%	3%	**100%**	70%	28%	2%	**100%**
Parc Vue Bench	0.00	78.2	0.0	0.0	0.0	1.498	**79.9**	10.9	18.3	0.268	**29.5**
	0%	98%	0%	0%	0%	2%	**100%**	37%	62%	1%	**100%**
FGP Bench	15.2	0.5	0.0	0.0	29.8	0.726	**46.3**	10.9	18.3	0.268	**29.5**
	33%	1%	0%	0%	64%	2%	**100%**	37%	62%	1%	**100%**
Plainwell Bench-Aluminum	62.7	8.2	0.0	0.0	0.0	1.498	**72.2**	10.9	18.5	0.293	**29.7**
	87%	11%	0%	0%	0%	2%	**100%**	37%	62%	1%	**100%**
Plainwell Bench	19.7	8.2	0.0	0.0	37.5	1.498	**66.7**	10.9	18.5	0.293	**29.7**
	5%	17%	0%	0%	76%	3%	**100%**	37%	62%	1%	**100%**
Strata Beam Bench	9.53	1.1	0.0	93.4	41.6	0.409	**146**	23.7	16.2	0.489	**40.3**
	7%	1%	0%	64%	28%	0%	**100%**	59%	40%	1%	**100%**
Strata Table	0.00	0.4	0.0	126.7	0.0	0.000	**127**	59.4	0.0	0.0	**59.4**
	0%	0%	0%	100%	0%	0%	**100%**	100%	0%	0%	**100%**
AD100 Strata Bench	0.00	45.3	0.0	170.3	0.0	0.590	**216**	99.7	0.0	0.0	**99.7**
	0%	21%	0%	79%	0%	0%	**100%**	100%	0%	0%	**100%**

Table 3. Material components for the Loll Designs products (kg/product).

Product	Product Material						Packaging Material	
	HDPE	Aluminum	Steel	Other	Paper Composite	Product Total	Corrugated	Packaging Total
Adirondack Chair	18.3	0.0434	0.281	0.00278	--	**18.6**	1.54	**1.54**
	98%	0%	2%	0%	--	**100%**	100%	**100%**
Alfresco Bench	20.6	0.0380	0.170	0.00262	--	**20.8**	2.04	**2.04**
	99%	0%	1%	0%	--	**100%**	100%	**100%**
Alfresco Table	32.6	0.0894	0.481	0.00414	5.90	**39.1**	3.21	**3.21**
	83%	0%	1%	0%	15%	**100%**	100%	**100%**
Alfresco Chair	8.35	0.0245	0.250	0.00222	--	**8.63**	0.837	**0.837**
	97%	0%	3%	0%	--	**100%**	100%	**100%**
Satellite End Table	6.31	0.00408	0.0165	0.00162	--	**6.36**	0.362	**0.362**
	100%	0%	0%	0%	--	**100%**	100%	**100%**

For more detail on data and assumptions, see Section 3.1

2.12 Manufacturing

Landscape Forms receives raw materials and components at their Kalamazoo facilities, referred to as East Michigan and Midlink, and the Richland, Michigan facility, herein referred to as Meld.

Each product undergoes different operations depending upon the form of the components received and the materials contained within. Operations within East Michigan include metal fabrication, including tube bending, welding, laser cutting and flat plate forming. Operations within Midlink include wood working, powder coating, product assembly and packaging. Packaging operations include the use of a box-on-demand machine located in the Midlink facility, and the production of custom cardboard packaging. Operations within Meld consist of concrete pouring into a mold, to which a mold release substance is applied, and packaging of some select products. Energy use at Landscape Forms facilities include electricity and natural gas for air compressors.

Some products undergo an electrostatic paint coating occurring at a third-party in Elkhart, Indiana. The following diagram summarizes the manufacturing processes for each facility and includes the list of the associated products for each process.

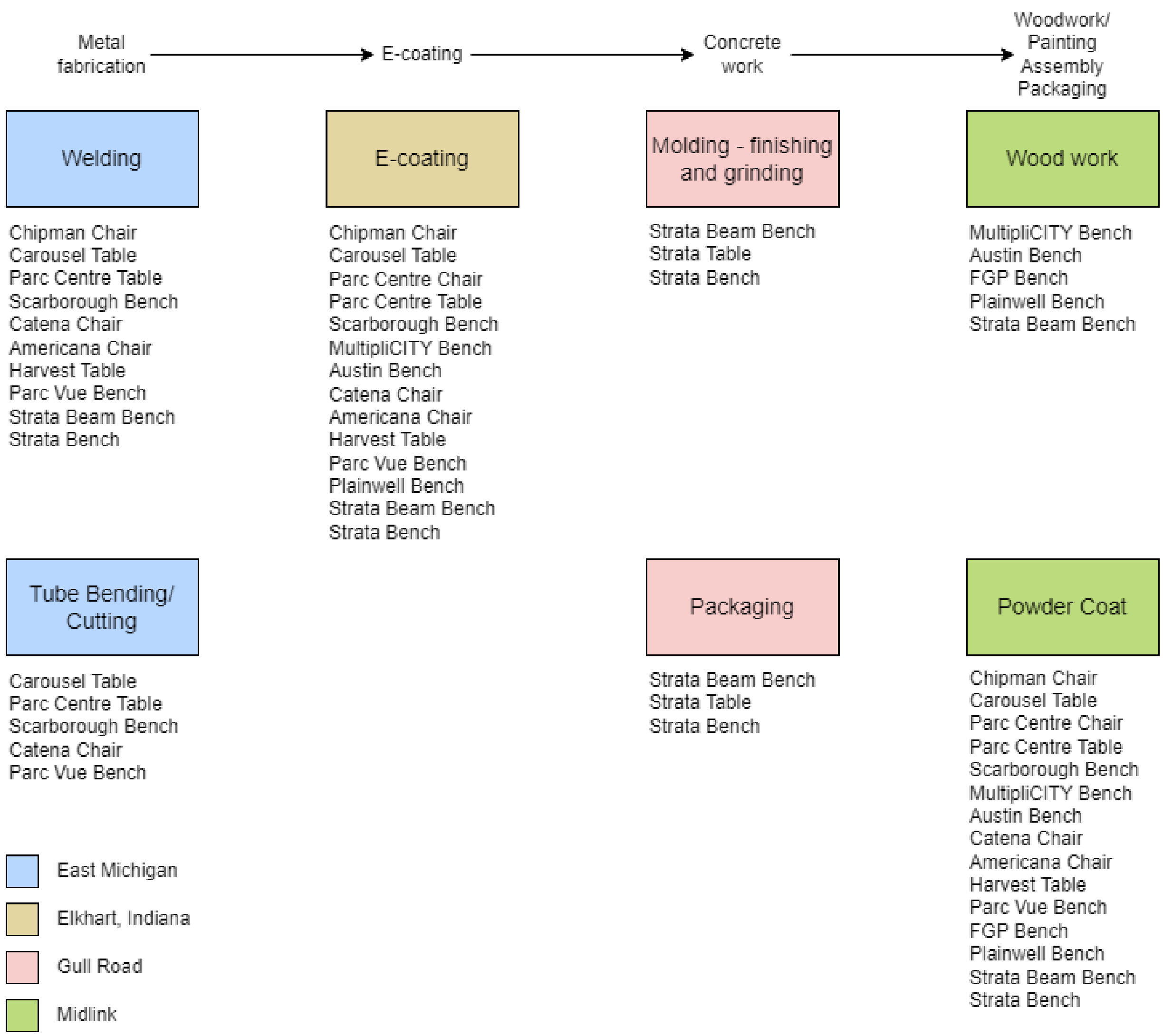

Figure 2. Summary of manufacturing processes occurring within each facility.

All of the Loll Designs products are manufactured at the Duluth, Minnesota facility. Duluth receives sheets of HDPE plastic, cut parts from them with large routing machines, installs threaded inserts, packages them and ships them direct to the consumer.

Disposal of manufacturing waste is modeled for solid waste generation and disposal in the United States. Data was provided on waste powder coating generated at Midlink, and waste concrete generated at Meld. Waste powder coating is treated as a nonhazardous waste. Waste concrete is sent for recycling at a third-party partner. Some plastic waste generated at Loll Designs is reprocessed and reused into other components for both Loll Designs and Landscape Forms products. Landscape Forms intends to recycle all plastics wastes generated in the near future.

Specifically, where the disposal was done by a third party, 80% of non-hazardous wastes are assumed to be disposed in landfill and 20% incinerated. Transportation for end-of-life scenarios was modeled using the EPA WARM model assumption of 20 miles (~32 km), from the point of product use to a landfill, material recovery center, or waste incinerator. Ecoinvent datasets are used to model the impacts associated with incineration and landfilling, which does not include energy recovery from landfill gas.

2.13 Transportation

Transportation of raw materials to the Landscape Forms facilities is based on primary data supplied by Landscape Forms. Data for transportation upstream of the 1st tier suppliers is included based on assumptions on supply chains embedded in the Ecoinvent datasets.

Transportation impacts will vary based on how far the final customer is from the Landscape Forms facility. As such, the transportation of the product and packaging to the final user is modeled based upon the guidance documents' prescription to model truck transport for 1,000 km in the absence of primary data.

Transportation for end-of-life scenarios was modeled using the US EPA WARM model assumption of 20 miles (~32 km), from the point of product use to a landfill, material recovery center, or waste incinerator.

2.14 End-of-Life

End-of-life disposal pathways are modeled by material in line with US statistics for waste disposal, as taken from the 2018 US EPA Facts and Figures report[9]. The disposal rates for the product materials are taken from the durable goods statistics, while the packaging disposal rates are taken from the packaging statistics by material. Concrete in the Landscape Forms products are modeled after the "other materials" category. The construction and demolition section of this report indicates over 80% of concrete materials are reused or recycled, and as such the remainder of concrete in the Landscape Forms products are modeled as recycled or reused.

Table 4. Disposal pathways by material for products and packaging materials at end-of-life.

Material	Product			Packaging		
	Landfill	Incineration	Recycling/ Reuse	Landfill	Incineration	Recycle
Aluminum	84.6%	15.4%	0.0%	--	--	--
Steel	59.2%	13.0%	27.8%	--	--	--
Plastics	80.5%	12.7%	6.8%	69.5%	16.9%	13.6%
Concrete	25%*	0.0%	75%	--	--	--
Wood	81.9%	18.1%	0.0%	58.8%	14.3%	26.9%
Corrugated	--	--	--	15.4%	3.7%	80.9%

[9] US EPA, 2020. Advancing Sustainable Materials Management: 2018 Fact Sheet. https://www.epa.gov/sites/default/files/2021-01/documents/2018_ff_fact_sheet_dec_2020_fnl_508.pdf

3. Life Cycle Modeling and Inventory Analysis

The life cycle inventory (LCI) of each unit process comprises energy inputs, material flows, emissions, wastes, and product outputs associated with the operation. Data sources for these inventories include data provided by the manufacturer, as well as representative data from the Ecoinvent LCI database.

Environmental flows from the LCI modeling are used to calculate greenhouse gas indicators in the Life Cycle Impact Assessment (LCIA) phase, discussed in Section 4 below.

3.1 Assumptions and Data Sources

The assessment relied on several assumptions related to production and end-of-life emissions. The major assumptions used in the study are described below.

- The Kalamazoo, Michigan production facility is located in the RFCM eGRID EPA subregion. The Duluth, Minnesota facility, in which Loll products are manufactured, is located in the MROW eGRID EPA subregion. Ecoinvent inventory datasets for the corresponding regions, RFC and MRO, were modified to reflect the eGRID[10] subregion energy mixes to estimate greenhouse gas emissions from electricity use at the facilities. All electricity datasets include upstream, use and downstream emissions.
- Electricity and natural gas use for the office space at East Michigan were accounted for using the area of office space at East Michigan and the average electricity and natural gas use per sq ft in the US[11].
- Additionally, electricity and natural gas use associated with welding at the facility were estimated by using the amount of welding required for one product, the allocation factor for the modeled products versus total production at East Michigan, and the energy consumption per length (m) from the ecoinvent datasets. In this way, welded products were modeled using the average electricity use per welding length and products which do not undergo welding were not assigned any of the electricity and natural gas use associated with welding.
- Powder coating ancillary resource requirements not provided by Landscape Forms were modeled based upon the area of the powder coated surface of each product using Ecoinvent datasets. Likewise welding resource requirements were modeled using the ecoinvent dataset and the actual length of welded surface. Electricity and natural gas from welding were allocated to the relevant products by length and removed from the overall resource requirements of the

[10] The Emissions & Generation Resource Integrated Database (eGRID). US EPA. http://www.epa.gov/cleanenergy/energy-resources/egrid/

[11] Commercial Buildings Energy Consumption Survey (CBECS) (2018). US Energy Information Administration. https://www.eia.gov/consumption/commercial/

facility.

- Landscape Forms provided primary data for the production facility operations based on representative 2021 production data. The source of secondary LCI data is the Ecoinvent databases[12].

- Per the PCR, each material dataset was modified to use the supplier's country-specific electricity dataset, and sub-national datasets were applied when available in ecoinvent.

- Much of the upstream raw materials extraction and processing could not be modeled with actual process information. Representative data from the Ecoinvent LCI databases were utilized as appropriate. Some individual pieces were modeled by their major materials and approximate masses using representative products. A conservative approach was used for modeling product mass in cases with less certainty.
- The recycled content of each aluminum component was provided by Landscape Forms. An existing Ecoinvent dataset for cast aluminum was modified to represent the secondary and primary aluminum content provided by Landscape Forms. Recycled content for HDPE was provided for Loll Designs products, but not for metals or packaging materials, which constitute a smaller proportion of the Loll Designs products.
- Steel datasets were developed using some representative secondary data sources for hot-dipped galvanized steel from the AISI report, "Life Cycle Inventories of North American Steel Products."[13] For some products, the length of steel tube purchased was based upon the dimensions of the product.
- Technology of steelmaking for steel components produced in China and the United States were based on the report "2022 World Steel in Figures.[14]"
- Zinc-coated materials were based on SDSs retrieved for the coating material, modeled with ecoinvent dataset for zinc coating and a conservative estimate of coating per mass. Surface area for various coated hardware materials were estimated based upon the hardware dimensions. A conservative estimate of 0.005 m^2 coating/kg of coated steel was used to model coated steel hardware. This assumption has a small impact on the results, wherein a 10% increase in m^2 coating per coated steel, yields a 0.18% increase in GWP.
- The SDS for the thread sealant used in the Duluth facility was used to model the chemical

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[12] Ecoinvent Centre (2021) Ecoinvent data from v3.8. Swiss Center for Life Cycle Inventories, Dübendorf, 2021 http://www.Ecoinvent.org

[13] Sphera on behalf of the American Iron and Steel Institute (AISI). (2020) Life Cycle Inventories of North American Steel Products.

[14] World Steel Association. (2022) 2022 World Steel in Figures.

components with ecoinvent datasets. The sealant is a small portion of each product.

- The metal components used in Landscape Forms' products are sent for e-coating to a facility in Elkhart, Indiana. Since the weight of electrostatic paint used was not known, primary data on the surface area of powder coated and e-coated components and secondary data on the thickness and density of electrocoat was used to calculate the amount of electrocoat used, and account for the impact of the electrostatic paint.
- For modeling concrete, supplier data was used to modify the Ecoinvent dataset for concrete ready-mix to account for a higher proportion of Portland cement used in the mix for Landscape Forms.
- The distance for distribution is taken from the International EPD PCRs, 1,000 km by lorry.
- No use-phase activities are included within the assessment, as no maintenance or energy use are expected within the lifespan of the products.

The datasets shown in Table 5 are used in the openLCA carbon footprint model to represent the manufacture of materials, transportation and end-of-life for the product system.

Table 5. LCI datasets and associated databases used to model the product carbon footprints.

Component	Material Dataset	Data Source	Publication Date
PRODUCTS			
Aluminum			
China/ aluminium, cast alloy	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U± - RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, post-consumer, prepared for recycling, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW	EI v3.8	2021
US/ aluminium, cast alloy	aluminium production, primary, cast alloy slab from continuous casting | aluminium, primary, cast alloy slab from continuous casting | Cutoff, U* - RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, post-consumer, prepared for recycling, at refiner | aluminium, cast alloy | Cutoff, U – RoW treatment of aluminium scrap, new, at refiner | aluminium, cast alloy | Cutoff, U – RoW	EI v3.8	2021
Hardware manufacturing	metal working, average for aluminium product manufacturing | metal working, average for aluminium product manufacturing | Cutoff, U – RoW	EI v3.8	2021
Extrusion	section bar extrusion, aluminium | section bar extrusion, aluminium | Cutoff, U * - RoW section bar extrusion, aluminium | section bar extrusion, aluminium | Cutoff, U ± - RoW	EI v3.8	2021
Sheet rolling	sheet rolling, aluminium | sheet rolling, aluminium | Cutoff, U* - RoW sheet rolling, aluminium | sheet rolling, aluminium | Cutoff, U± - RoW	EI v3.8	2021
Woods			

Component	Material Dataset	Data Source	Publication Date
hardwood	18olymeri, board, hardwood, u=10% | sawnwood, board, hardwood, dried (u=10%), planed | Cutoff, U – RoW	EI v3.8	2021
Steel datasets			
US Low-alloyed/ Carbon Steel	steel production, converter, low-alloyed | steel, low-alloyed | Cutoff, U RER* steel production, electric, low-alloyed | steel, low-alloyed | Cutoff, U – Europe without Switzerland and Austria*	EI v3.8	2021
China Low-alloyed/ Carbon Steel	steel production, converter, low-alloyed | steel, low-alloyed | Cutoff, U | - RoW ± steel production, electric, low-alloyed | steel, low-alloyed | Cutoff, U | China – RoW ±	EI v3.8	2021
Rolling	hot rolling, steel | hot rolling, steel | Cutoff, U | Europe without Austria* hot rolling, steel | hot rolling, steel | Cutoff, U – RoW	EI v3.8	2021
PO Steel, Galvanized Steel	Each modeled with life cycle inventory from "Life Cycle Inventories of North American Steel Products" From AISI modeled with ecoinvent data	AISI	2020
US Stainless Steel	steel production, chromium steel 18/8, hot rolled | steel, chromium steel 18/8, hot rolled | Cutoff, U – RER	EI v3.8	2021
Hardware mfg	metal working, average for steel product manufacturing | metal working, average for steel product manufacturing | Cutoff, U – RER	EI v3.8	2021
Channel and Bar mfg	section bar rolling, steel | section bar rolling, steel | Cutoff, U – RER* section bar rolling, steel | section bar rolling, steel | Cutoff, U – RoW±	EI v3.8	2021
Additional coating	zinc coating, pieces | zinc coat, pieces | Cutoff, U – RER	EI v3.8	2021
Plastics			
Packaging film	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U – RoW	EI v3.8	2021
US/ HDPE	polyethylene production, high density, granulate | polyethylene, high density, granulate | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	EI v3.8	2021
US/LDPE	polyethylene production, low density, granulate | polyethylene, low density, granulate | Cutoff, U – RoW injection moulding | injection moulding | Cutoff, U – RoW*	EI v3.8	2021
US/Microfoam	polypropylene production, granulate | polypropylene, granulate | Cutoff, U – RoW extrusion, plastic film | extrusion, plastic film | Cutoff, U – RoW*	EI v3.8	2021
US/Polypropylene	polypropylene production, granulate | polypropylene, granulate | Cutoff, U – RoW injection moulding | injection moulding | Cutoff, U – RoW*	EI v3.8	2021
US/Vinyl	polyvinylchloride production, bulk 18olymerization | polyvinylchloride, bulk 18olymerizat | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	EI v3.8	2021
US/ Nylon 6-6	nylon 6-6 production | nylon 6-6 | Cutoff, U – RoW* injection moulding | injection moulding | Cutoff, U – RoW*	EI v3.8	2021
China/ Nylon 6-6	nylon 6-6 production | nylon 6-6 | Cutoff, U – RoW± injection moulding | injection moulding | Cutoff, U – RoW±	EI v3.8	2021
Concrete			
US/ concrete	concrete production, 40Mpa, ready-mix, with Portland cement | concrete, 40Mpa | Cutoff, U – US*	EI v3.8	2021
Loll Products			
HDPE	polyethylene, high density, granulate, recycled to generic market for high density PE granulate | Cutoff, U – US	EI v3.8	2021

Component	Material Dataset	Data Source	Publication Date
	polyethylene production, high density, granulate, recycled | Cutoff, U – US		
Aluminum	market for aluminium, cast alloy | aluminium, cast alloy | Cutoff, U – GLO*, ±	EI v3.8	2021
Stainless Steel	steel production, chromium steel 18/8, hot rolled | steel, chromium steel 18/8, hot rolled | Cutoff, U – RER* metal working, average for steel product manufacturing | Cutoff, U*	EI v3.8	2021
ST3 Thread Sealant	Modeled using ecoinvent datasets and ST3 SDS: acrylic binder production, product in 34% solution state | acrylic binder, without water, in 34% solution state | Cutoff, U – RER kaolin production | kaolin | Cutoff, U – RER	EI v3.8 ST3 Sealant SDS provided by Landscape Forms	2021
Vinyl and Polyurethane	polyvinylchloride production, suspension 19olymerization | Cutoff, U – RER market for polyurethane, flexible foam | Cutoff, U – RER	EI v3.8	2021
Paper Composite	Richlite EPD	Richlite EPD	
PACKAGING			
Pallets/wood	EUR-flat pallet production | EUR-flat pallet | Cutoff, U – RoW	EI v3.8	2021
Corrugated cardboard	corrugated board box production | corrugated board box | Cutoff, U - RoW	EI v3.8	2021
Packaging film	packaging film production, low density polyethylene | packaging film, low density polyethylene | Cutoff, U – RoW	EI v3.8	2021
FACILITY			
US-RFC -Grid electricity	market for electricity, medium voltage | electricity, medium voltage | Cutoff, U – Custom RFCM – US-RFC	EI v3.8; EPA eGRID	2021; 2022
Natural gas	heat and power co-generation, natural gas, conventional power plant, 100MW electrical | heat, district or industrial, natural gas | Cutoff, U – US-RFC	EI v3.8	2021
Welding	welding, arc, aluminium | welding, arc, aluminium | Cutoff, U – RER	EI v3.8	2022
E-coating	market for electrostatic paint | electrostatic paint | Cutoff, U – GLO	EI v3.8	2021
WASTES			
Incineration	treatment of municipal solid waste, incineration | municipal solid waste | Cutoff, U – RoW	EI v3.8	2021
Landfill	treatment of inert waste, sanitary landfill | inert waste | Cutoff, U – RoW	EI v3.8	2021
TRANSPORTATION			
Road transport	transport, freight, lorry 16-32 metric ton, EURO4 | transport, freight, lorry 16-32 metric ton, EURO4 | Cutoff, U – RER	EI v3.8	2021
Ocean shipping	transport, freight, sea, container ship | transport, freight, sea, container ship | Cutoff, U – GLO	EI v3.8	2021
Train transport	market for transport, freight train | transport, freight train | Cutoff, U – US	EI v3.8	2021
END-OF-LIFE			
Corrugated landfill	treatment of waste paperboard, sanitary landfill | waste paperboard | Cutoff, U – CH	EI v3.8	2021
Corrugated incineration	treatment of waste paperboard, municipal incineration with fly ash extraction | waste paperboard | Cutoff, U – CH	EI v3.8	2021
Plastic landfilling	treatment of waste plastic, mixture, sanitary landfill | waste plastic, mixture | Cutoff, U – CH	EI v3.8	2021
Plastic incineration	treatment of waste plastic, mixture, municipal incineration with fly ash extraction | waste plastic, mixture | Cutoff, U – CH	EI v3.8	2021

Component	Material Dataset	Data Source	Publication Date
Wood landfill and incineration	treatment of waste wood, untreated, sanitary landfill | waste wood, untreated | Cutoff, U – CH	EI v3.8	2021
Wood incineration	treatment of waste wood, untreated, municipal incineration with fly ash extraction | waste wood, untreated | Cutoff, U – CH	EI v3.8	2021
Aluminum	treatment of waste aluminium, sanitary landfill | waste aluminium | Cutoff, U – CH	EI v3.8	2021
Steel	treatment of scrap steel, municipal incineration with fly ash extraction | scrap steel | Cutoff, U – CH treatment of waste concrete, inert material landfill | waste concrete | Cutoff, U – Europe without Switzerland	EI v3.8	2021
Concrete	treatment of waste concrete, inert material landfill | waste concrete | Cutoff, U – Europe without Switzerland	EI v3.8	2021

* modified for US electricity grid
± modified for State Grid Corp of China electricity grid

3.2 Data Quality Assessment

The data quality assessment addresses the following parameters: time-related coverage, geographical coverage, technological coverage, precision, completeness, representativeness, consistency, reproducibility, sources of data, and uncertainty. In accordance with the requirements of ISO 14067, a semi-quantitative assessment of data quality is also included, in the form of a data quality rating, on a scale of 1 to 5, with 1 considered to be the highest data quality.

Table 6. Data Quality Assessment

Data Quality Parameter	Data Quality Discussion	Data Quality Rating
Time-Related Coverage Age of data and the minimum length of time over which data should be collected	The most recent available data are used, based on other considerations such as data quality and similarity to the actual operations. Typically, these data are less than 10 years old (2015 or typically more recent). All of the secondary data used represents an average of at least one year's worth of data collection.	1
Geographical Coverage Geographical area from which data for unit processes should be collected to satisfy the goal of the study	The data used in the analysis provide the best possible representation available with current data. Actual processes for upstream operations are primarily North American or Chinese. Surrogate data used in the assessment for North American operations are representative of North American or European operations. Data representative of European operations are considered sufficiently similar to actual processes. Data for upstream processes in China are modeled with secondary data based on China, where available, of Rest-of-World operations. Electricity grids for secondary datasets are based on the country or sub-national grids, as available in ecoinvent.	1
Technology Coverage Specific technology or technology mix	Data are generally representative of the actual technologies used for energy generation, processing, transportation, and manufacturing operations.	1
Precision Measure of the variability of the data values for each data expressed (e.g. variance)	Precision of results are not quantified due to a lack of data on data variance. Precision on the allocating manufacturing resources is moderate, as subdividing electricity and fuel use by each manufacturing process was not possible. Data collected for most operations were typically averaged for one or more years and over multiple operations, which is expected to reduce the variability of results. Precision of the individual component materials could be improved with more primary data.	N/A

Data Quality Parameter	Data Quality Discussion	Data Quality Rating
Completeness Percentage of flow that is measured or estimated	The carbon footprint model includes all known mass and energy flows for production of the seventeen outdoor furniture products. In some instances, surrogate data are used to represent unit processes. No known processes or activities contributing to more than 1% of the total environmental impact for each indicator are excluded.	1
Representativeness Qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period, and technology coverage)	Data used in the assessment represent typical or average processes as currently reported from multiple data sources and are therefore generally representative of the range of actual processes and technologies for production of the outdoor furniture products.	2
Consistency Qualitative assessment of whether the study methodology is applied uniformly to the various components of the analysis	The consistency of the assessment is considered to be high. Data sources of similar quality and age are used; with a bias towards Ecoinvent data for secondary data. One exception is the paper composite in the Alfresco Table, modeled using results from the manufacturer's EPD.	1
Reproducibility Qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the study	Based on the description of data and assumptions used, the major contributing components and life cycle stages of the assessment would be reproducible by other practitioners with access to the primary data used in the study and the assumptions built into ecoinvent datasets. These major assumptions, models, and data sources are documented.	2
Sources of the Data Description of all primary and secondary data sources	Data sources used are documented and described in this report. For secondary LCI datasets, Ecoinvent v3.8 LCI data are used. Ecoinvent datasets are also used to underlie some assumptions on welding and coating processes. Other sources of data include the AISI report on steelmaking, and the supplier EPD for paper composite.	2
Uncertainty of the Information Uncertainty related to data, models, and assumptions	Uncertainty related to the manufacturing processes are low. Primary data for key unit operations are included. Uncertainty related to the IPCC 2021 metrics are high, given that these metrics assume impacts from climate change will not occur for 100 years and do not include short-lived climate forcers.	2

4. Life Cycle Impact Assessment (LCIA) Results

4.1 Life Cycle Inventory

Life cycle inventory were reviewed for completeness, consistency and representativeness. In addition, sensitivity analyses for several assumed generic processes were evaluated. Overall, with respect to those indicators assessed, the inventory was considered consistent and generally representative of the system processes as the same types of data sources are used throughout, primarily from the manufacturer as well as the Ecoinvent LCI database. As noted previously, all known processes and materials of the product system are included in the inventory.

4.1.1 Biogenic Carbon Content

For the global warming calculations, carbon uptake and biomass carbon dioxide emissions are included as part of the total carbon footprint. For some products, environmental impacts associated with biogenic carbon are relevant and impactful. The following table contains the biogenic content of the products containing wood. While the biogenic carbon content of the packaging materials are not strictly required, the large amounts of wood-based packaging are significant to the results in some cases, and as such the biogenic carbon content of the packaging materials are disclosed for all products.

Table 7. Biogenic carbon content (kg C) for the products containing wood.

Product	Biogenic Carbon Content (kg C/ product)
FGP Bench	14.9
Strata Beam Bench	20.8
Plainwell Bench, Wood	18.7
MultipliCITY Bench	26.1
Alfresco Table	2.66
Packaging	**Biogenic Carbon Content (kg C/ product)**
AD100 Strata Bench	181.4
Austin Bench	53.1
Carousel Table	105.7
Catena Chair	10.6
Chase Park Litter	49.0
Chipman Chair	10.9
FGP Bench	53.1
MultipliCITY Bench	119.6
Parc Centre Chair	10.3
Parc Centre Table	35.3
Parc Vue Bench	53.1
Plainwell Bench Aluminum	53.5
Plainwell Bench Wood	53.5
Scarborough Bench	119.6
Strata Beam Bench	72.5
Strata Table	108.0
Adirondack Chair	0.350
Alfresco Bench	0.463
Alfresco Chair	0.190
Alfresco Table	0.731
Satellite End Table	0.0824

4.2 Carbon Footprint Results

Life cycle modeling of the product systems was divided into the following distinct life cycle phases:

Upstream

- *Raw Materials and Processing (Sourcing/Extraction) stage* – This includes the resource use and emissions associated with the extraction of the raw materials used to produce materials and components as received by Landscape Forms prior to product manufacture.

- *Packaging Materials* – Resource use and emissions associated with the extraction of the packaging materials for each Landscape Forms' product.

Core

- *Transportation of Materials to Manufacturing* – The impacts associated with the transport of the materials and packaging to the manufacturing facilities are included in this stage.
- *Product Manufacture stage* – This stage includes the greenhouse gas emissions from energy use and emissions associated with the production of the outdoor furniture products. Both emissions and removals of carbon are considered. This stage also includes transportation between Landscape Forms facilities, as well as transportation between the third-party painter and Landscape Forms facilities.

Downstream

- *Product Distribution* – The impacts associated with the transport of the products to the customers.
- *Packaging Disposal* – This stage includes the greenhouse gas emissions from the transport of packaging waste to the waste treatment facility, and the treatment of the waste.
- *Product Disposal* **–** This stage includes the greenhouse gas emissions from the transport of product waste to the waste treatment facility, and the treatment of the waste.

The potential greenhouse gas impacts for the outdoor furniture products are reported by life cycle stage in Tables 8-11 below in kg CO_2e per unit.

It should be noted that the results reported below represent only a single impact category, as required ISO 14067:2018, and does not include all potentially relevant environmental and human health impacts for the product system, such as acidification and eutrophication potential, smog creation potential, impacts to ecosystems, key species habitats, or water resources.

Table 8. Carbon footprint results **(kg CO2e)** for the seating products per unit/chair.

	Carbon Footprint Total (kg CO2-eq)			
	Upstream	**Core**	**Downstream**	**Total**
Chipman Chair	157	62.1	4.68	**224**
	70%	28%	2%	**100%**
Parc Centre Chair	20.1	47.3	4.80	**72.1**
	28%	66%	7%	**100%**
Catena Chair	114	60.1	4.13	**179**
	64%	34%	2%	**100%**
Americana Chair	353	71.0	30.1	**454**
	78%	16%	7%	**100%**

Table 9. Carbon footprint results (kg CO2e) for the bench products, per unit/bench.

	Carbon Footprint Total (kg CO2-eq)			
	Upstream	Core	Downstream	Total
Scarborough Bench	158	73.6	48.5	**280**
	56%	26%	17%	**100%**
MultipliCITY Bench	780	76.9	65.4	**923**
	85%	8%	7%	**100%**
Austin Bench	649	57.8	20.7	**728**
	89%	8%	3%	**100%**
Park Vue bench	153	26.0	28.4	**207**
	74%	13%	14%	**100%**
FGP Bench	233	54.2	32.5	**320**
	73%	17%	10%	**100%**
Plainwell Bench – Wood	328	55.8	38.8	**423**
	78%	13%	9%	**100%**
Plainwell Bench – Aluminium	1,150	56.5	27.8	**1,240**
	93%	5%	2%	**100%**
Strata Beam Bench	137	80.9	58.0	**276**
	50%	29%	21%	**100%**
Strata Bench	17.2	105	80.3	**202**
	9%	52%	40%	**100%**

Table 10. Carbon footprint results for the tables per unit and Chase Park Litter per unit.

	Carbon Footprint Total (kg CO2-eq)			
	Upstream	Core	Downstream	Total
Carousel Table	276	73.7	50.3	**400**
	69%	18%	13%	**100%**
Parc Centre Table	104	60.8	16.9	**181**
	57%	34%	9%	**100%**
Harvest Table	786	77.9	65.5	**930**
	85%	8%	7%	**100%**
Strata Table	-16.9	35.1	47.4	**65.5**
	-26%	54%	72%	**100%**
Chase Park Litter	611	84.3	27.1	**722**
	85%	12%	4%	**100%**

Table 11. Carbon footprint results for Loll Products per unit.

	Carbon Footprint Total (kg CO2-eq)			
	Upstream	Core	Downstream	Total
Adirondack Chair	30.3	12.3	9.90	**52.5**
	58%	23%	19%	**100%**
Alfresco Bench	24.0	12.3	11.8	**48.0**
	50%	26%	25%	**100%**
Alfresco Dining Chair	17.0	12.3	4.80	**34.1**
	50%	36%	14%	**100%**
Alfresco Table	62.4	12.3	21.7	**96.3**
	65%	13%	22%	**100%**
Satellite End Table	6.14	12.3	3.54	**21.9**
	28%	56%	16%	**100%**

The carbon footprint is dominated by the upstream module for many of the Landscape Forms products, while the manufacturing module is also significant in some cases.

4.3 Contribution Analysis by Emission Type

The results are presented by emission type, fossil, biogenic or LULUC for each of the products and by module.

Table 12. Carbon footprint results by life cycle stage for the chair products (kg CO_2e/product).

	Carbon Footprint Fossil (kg CO2-eq)				Biogenic Carbon (kg CO2-eq)				Carbon Footprint LULUC (kg CO2-eq)			
	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total
Chipman Chair	162	61.5	2.77	**226**	-5.35	0.668	1.91	**-2.77**	0.127	6.35x10^{-3}	1.09x10^{-3}	**0.134**
	72%	27%	1%	**100%**	193%	-24%	-69%	**100%**	94%	5%	1%	**100%**
Parc Centre Chair	24.5	46.7	3.03	**74.3**	-4.62	0.506	1.77	**-2.34**	0.191	2.60x10^{-3}	1.21x10^{-3}	**0.195**
	33%	63%	4%	**100%**	197%	-22%	-76%	**100%**	98%	1%	1%	**100%**
Catena Chair	119	59.4	2.29	**181**	-5.00	0.652	1.84	**-2.51**	0.196	4.63x10^{-3}	9.02x10^{-4}	**0.202**
	66%	33%	1%	**100%**	199%	-26%	-73%	**100%**	97%	2%	0%	**100%**
Americana Chair	386	70.2	18.8	**475**	-33.5	0.776	11.3	**-21.4**	0.565	1.03x10^{-2}	4.93x10^{-3}	**0.581**
	81%	15%	4%	**100%**	157%	-4%	-53%	**100%**	97%	2%	1%	**100%**

Table 13. Carbon footprint results by life cycle stage for the benches (kg CO_2e/product).

	Carbon Footprint Fossil (kg CO2-eq)				Biogenic Carbon (kg CO2-eq)				Carbon Footprint LULUC (kg CO2-eq)			
	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total
Scarborough Bench	231	72.5	29.3	**333**	-74.3	1.13	19.1	**-54.1**	1.29	1.24x10^{-2}	1.18x10^{-2}	**1.31**
	69%	22%	9%	**100%**	137%	-2%	-35%	**100%**	98%	1%	1%	**100%**
MultipliCITY Bench	950	76.0	29.2	**1,050**	-170	60.5	36.2	**-73.4**	0.909	1.47x10^{-2}	1.14x10^{-2}	**0.935**
	90%	7%	3%	**100%**	232%	-82%	-49%	**100%**	97%	2%	1%	**100%**
Austin Bench	672	56.7	11.5	**740**	-24.0	1.04	9.21	**-13.7**	1.13	9.12x10^{-3}	4.50x10^{-3}	**1.14**
	91%	8%	2%	**100%**	175%	-8%	-67%	**100%**	99%	1%	0%	**100%**
Park Vue bench	175	25.5	19.1	**220**	-22.9	0.475	9.24	**-13.2**	0.692	9.82x10^{-3}	7.70x10^{-3}	**0.709**
	80%	12%	9%	**100%**	174%	-4%	-70%	**100%**	98%	1%	1%	**100%**
FGP Bench	306	53.6	13.6	**373**	-73.1	0.586	18.9	**-53.6**	0.457	6.97x10^{-3}	5.32x10^{-3}	**0.469**
	82%	14%	4%	**100%**	136%	-1%	-35%	**100%**	97%	1%	1%	**100%**
Plainwell Bench – Wood	413	55.0	17.3	**485**	-85.8	0.759	21.5	**-63.5**	0.767	7.81x10^{-3}	6.78x10^{-3}	**0.782**
	85%	11%	4%	**100%**	135%	-1%	-34%	**100%**	98%	1%	1%	**100%**
Plainwell Bench – Aluminum	1,180	55.7	27.8	**1,260**	-26.5	0.763	18.4	**-7.32**	0.880	8.36x10^{-3}	9.43	**10.3**
	93%	4%	2%	**100%**	362%	-10%	-251%	**100%**	9%	0%	91%	**100%**
Strata Beam Bench	261	80.2	32.6	**374**	-125	0.666	25.3	**-98.6**	0.396	1.36x10^{-2}	1.29x10^{-2}	**0.423**
	70%	21%	9%	**100%**	126%	-1%	-26%	**100%**	94%	3%	3%	**100%**
Strata Bench	177	104	54.8	**335**	-160	0.837	25.5	**-134**	0.342	1.78x10^{-2}	2.20x10^{-2}	**0.382**
	53%	31%	16%	**100%**	120%	-1%	-19%	**100%**	90%	5%	6%	**100%**

Table 14. Carbon footprint results by life cycle stage for the tables and litter receptacle (kg CO_2e/product).

	Carbon Footprint Fossil (kg CO2-eq)				Biogenic Carbon (kg CO2-eq)				Carbon Footprint LULUC (kg CO2-eq)			
	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total
Carousel Table	324	72.2	32.2	**428**	-49.6	1.55	18.1	**-30.0**	1.75	1.03×10^{-2}	1.28×10^{-2}	**1.77**
	76%	17%	8%	**100%**	165%	-5%	-60%	**100%**	99%	1%	1%	**100%**
Parc Centre Table	123	60.1	11.1	**194**	-19.9	0.742	5.79	**-13.4**	0.391	3.97×10^{-3}	4.45×10^{-3}	**0.400**
	63%	31%	6%	**100%**	149%	-6%	-43%	**100%**	98%	1%	1%	**100%**
Harvest Table	839	76.4	54.2	**969**	-53.9	1.52	11.3	**-41.1**	1.55	1.11×10^{-2}	1.16×10^{-2}	**1.57**
	87%	8%	6%	**100%**	131%	-4%	-27%	**100%**	99%	1%	1%	**100%**
Strata Table	78.3	34.9	32.2	**145**	-95.3	0.156	15.1	**-80.0**	8.36×10^{-2}	1.04×10^{-2}	1.29×10^{-2}	**0.107**
	54%	24%	22%	**100%**	119%	0%	-19%	**100%**	78%	10%	12%	**100%**
Chase Park Litter	635	83.5	18.0	**737**	-24.9	0.694	9.11	**-15.1**	0.883	1.35×10^{-2}	6.16×10^{-3}	**0.902**
	86%	11%	2%	**100%**	165%	-5%	-60%	**100%**	98%	1%	1%	**100%**

Table 15. Carbon footprint results by life cycle stage for the Loll Designs products (kg CO_2e/product).

	Carbon Footprint Fossil				Biogenic Carbon				Carbon Footprint LULUC			
	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total	Upstream	Core	Downstream	Total
Adirondack Chair	24.5	12.3	9.65	**46.4**	5.82	1.99×10^{-2}	0.246	**6.08**	2.54×10^{-2}	3.00×10^{-3}	1.30×10^{-3}	**2.97×10^{-2}**
	53%	26%	21%	**100%**	96%	0%	4%	**100%**	86%	10%	4%	**100%**
Alfresco Bench	19.7	12.2	11.5	**43.4**	4.27	1.99×10^{-2}	0.325	**4.62**	2.45×10^{-2}	3.00×10^{-3}	1.53×10^{-3}	**2.91×10^{-2}**
	45%	28%	26%	**100%**	93%	0%	7%	**100%**	84%	10%	5%	**100%**
Alfresco Dining Chair	13.9	12.2	4.67	**30.8**	3.14	1.99×10^{-2}	0.134	**3.29**	1.45×10^{-2}	2.99×10^{-3}	6.34×10^{-4}	**1.82×10^{-2}**
	45%	40%	15%	**100%**	95%	1%	4%	**100%**	80%	16%	3%	**100%**
Alfresco Table	55.6	12.3	19.2	**87.1**	6.68	1.99×10^{-2}	2.45	**9.15**	4.07×10^{-2}	3.00×10^{-3}	2.85×10^{-3}	**4.66×10^{-2}**
	64%	14%	22%	**100%**	73%	0%	27%	**100%**	87%	6%	6%	**100%**
Satellite End Table	4.92	12.2	3.49	**20.6**	1.22	1.99×10^{-2}	5.84×10^{-2}	**1.30**	5.19×10^{-3}	2.99×10^{-3}	4.59×10^{-4}	**8.64×10^{-3}**
	24%	59%	17%	**100%**	94%	2%	4%	**100%**	60%	35%	5%	**100%**

Across most of the products for the cradle-to-grave carbon footprint, the upstream life cycle stage is the predominant contributor to the greenhouse gas emissions, due primarily to the upstream production of raw materials. The *Chase Park Litter* product is made from waste concrete and therefore bears no burden associated with its primary material. The impact of different materials is explored further in section 4.4.

Detailed Contribution Analyses

In order to provide some additional detail on each of the lifecycle stages, each module is further broken out into its component processes for three example products provided in Tables 16-18. The upstream module is divided into upstream materials, and upstream packaging production. The core module is divided into transport of materials to the manufacturing facility and manufacturing processes. The downstream module is divided into the distribution to the customer, the packaging disposal and transport, and the product disposal and transport. Similar contribution tables are available for the other Landscape Forms products in Appendix A.

For the *Chipman Chair*, the *Carousel Table* and the *AD100 Strata Bench*, the carbon footprint results were broken down further to represent the upstream materials production, upstream packaging production, transport for upstream materials, transport for packaging, and manufacturing life cycle phases. While products like the *Chipman Chair* do not see a significant impact from the upstream packaging in the fossil category, the biogenic carbon in the packaging materials can be significant. Additionally, products like the *Carousel Table* and the *AD100 Strata Bench* do have significant greenhouse gas emissions from packaging production, at 10% of the total fossil carbon footprint.

Table 16: Carbon footprint contribution analysis for the Chipman Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	157	4.81	2.97	58.5	2.50	0.102	0.163	**226**
	69%	2%	1%	26%	1%	0%	0%	**100%**
Climate change – Biogenic	-0.603	-4.74	$1.48x10^{-3}$	0.666	$1.68x10^{-3}$	1.87	$3.72x10^{-2}$	**-2.77**
	22%	171%	0%	-24%	0%	-68%	-1%	**100%**
Climate change – Land use and LU change	$9.76x10^{-2}$	$2.93x10^{-2}$	$2.12x10^{-3}$	$4.23x10^{-3}$	$9.99x10^{-4}$	$3.18x10^{-5}$	$5.72x10^{-5}$	**0.134**
	73%	22%	2%	3%	1%	0%	0%	**100%**
Climate change (Total)	157	$9.89x10^{-2}$	2.97	59.2	2.51	1.98	0.200	**224**
	70%	0%	1%	26%	1%	1%	0%	**100%**

Table 17: Carbon footprint contribution analysis for the Carousel Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	279	44.8	6.66	65.5	29.7	1.31	1.22	**428**
	65%	10%	2%	15%	7%	0%	0%	**100%**
Climate change – Biogenic	0.207	-49.8	$4.79x10^{-3}$	1.55	$1.99x10^{-2}$	17.8	0.239	**-30.0**
	-1%	166%	0%	-5%	0%	-59%	-1%	**100%**
Climate change – Land use and LU change	1.48	0.263	$3.24x10^{-3}$	$7.07x10^{-3}$	$1.19x10^{-2}$	$3.15x10^{-4}$	$6.70x10^{-4}$	**1.77**
	84%	15%	0%	0%	1%	0%	0%	**100%**
Climate change (Total)	281	-4.81	6.66	67.1	29.8	19.1	1.46	**400**
	70%	-1%	2%	17%	7%	5%	0%	**100%**

Table 18: Carbon footprint contribution analysis for the AD100 Strata Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	142	34.5	33.0	70.7	51.5	1.69	1.58	**335**
	42%	10%	10%	21%	15%	1%	0%	**100%**
Climate change – Biogenic	0.180	-160	$2.65x10^{-2}$	0.810	$3.45x10^{-2}$	25.4	$9.20x10^{-2}$	**-134**
	0%	120%	0%	-1%	0%	-19%	0%	**100%**
Climate change – Land use and LU change	0.216	0.127	$1.32x10^{-2}$	$4.62x10^{-3}$	$2.06x10^{-2}$	$5.82x10^{-4}$	$8.15x10^{-4}$	**0.382**
	56%	33%	3%	1%	5%	0%	0%	**100%**
Climate change (Total)	143	-125	33.1	71.5	51.6	27.1	1.67	**202**
	71%	-62%	16%	35%	26%	13%	1%	**100%**

4.4 Contribution Analysis for Upstream Materials

As demonstrated by the previous results, the major contribution to the carbon footprint occurs within the upstream material production phase. To further evaluate which materials contribute significant impacts, the following contribution analyses provides the upstream production impacts by material. For reference, the product mass by material is presented in Figure 3. The carbon footprint by material for each Landscape Forms product and packaging materials is presented in Figure 3.

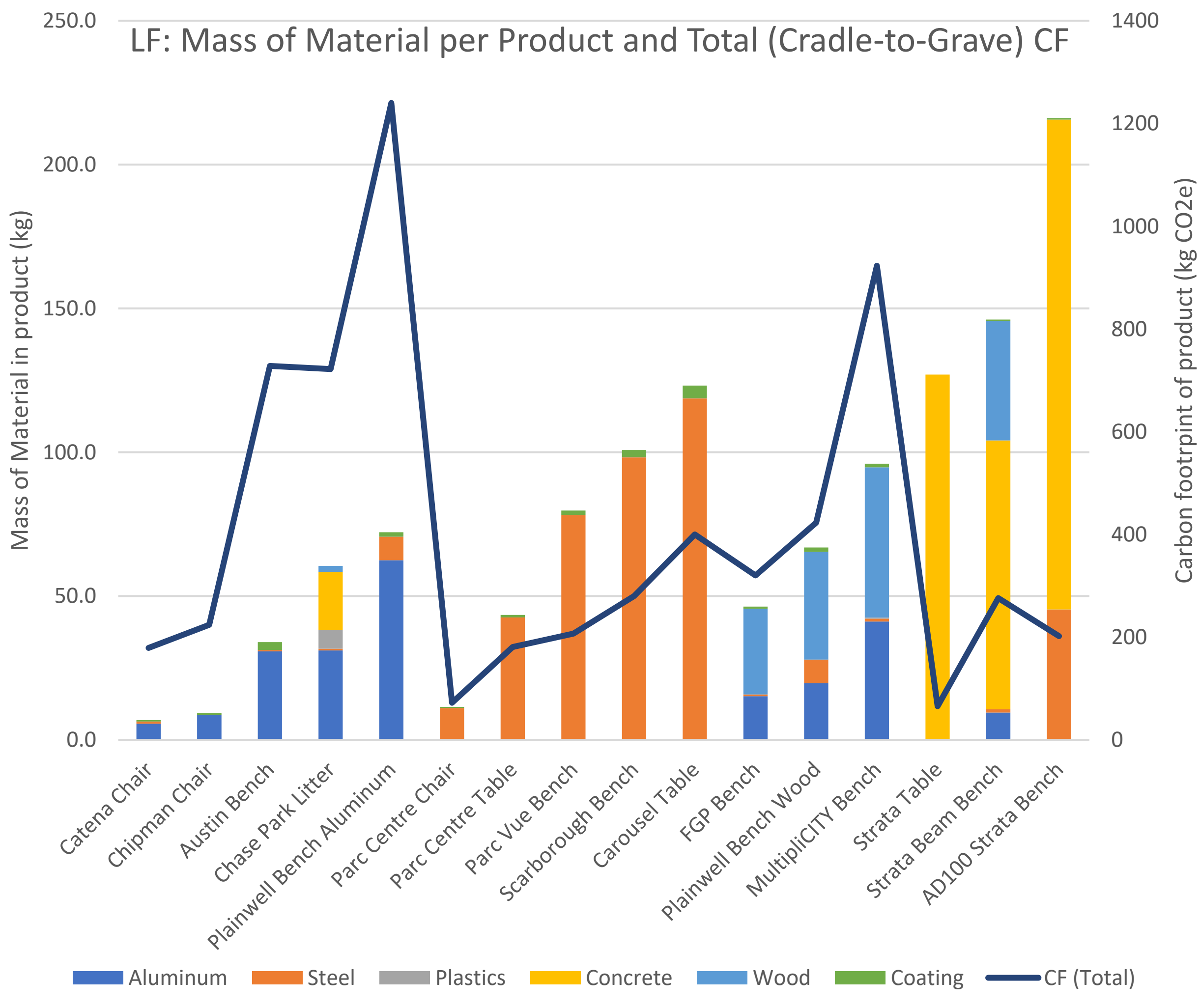


Figure 3. Comparison of the dominant material per product (lbs/product) and the total cradle-to-grave carbon footprint for each of the Landscape Forms products.

Figure 3 demonstrates the primary materials of each product (stacked bar graph) and their total cradle-to-grave carbon footprint (line) in order to identify trends among products with the same dominant material (i.e. aluminum, steel, concrete or wood). Plastics-based products (those products with plastic as >50% of their mass) are included in Figure 4. The total cradle-to-grave carbon footprint includes all carbon emissions from upstream (materials, packaging, transportation) and manufacturing (manufacturing and internal transportation), distribution and end of life.

Generally, the aluminum-based products have the highest product carbon footprint when compared to the overall mass of each product, while the carbon footprints of the steel-based products are concentrated within a small range that trends well with total mass of the product. The wood-based products, the *FGP Bench*, the *Plainwell Bench*, and the *MultipliCITY Bench*, have a higher carbon footprint than some other products because of the large percentage of aluminum in these products (see Figure 3). The concrete-based products have the lowest carbon footprint despite being the heaviest products overall, in part because of the large amounts of wood-based packaging for these products (see Figure 3).

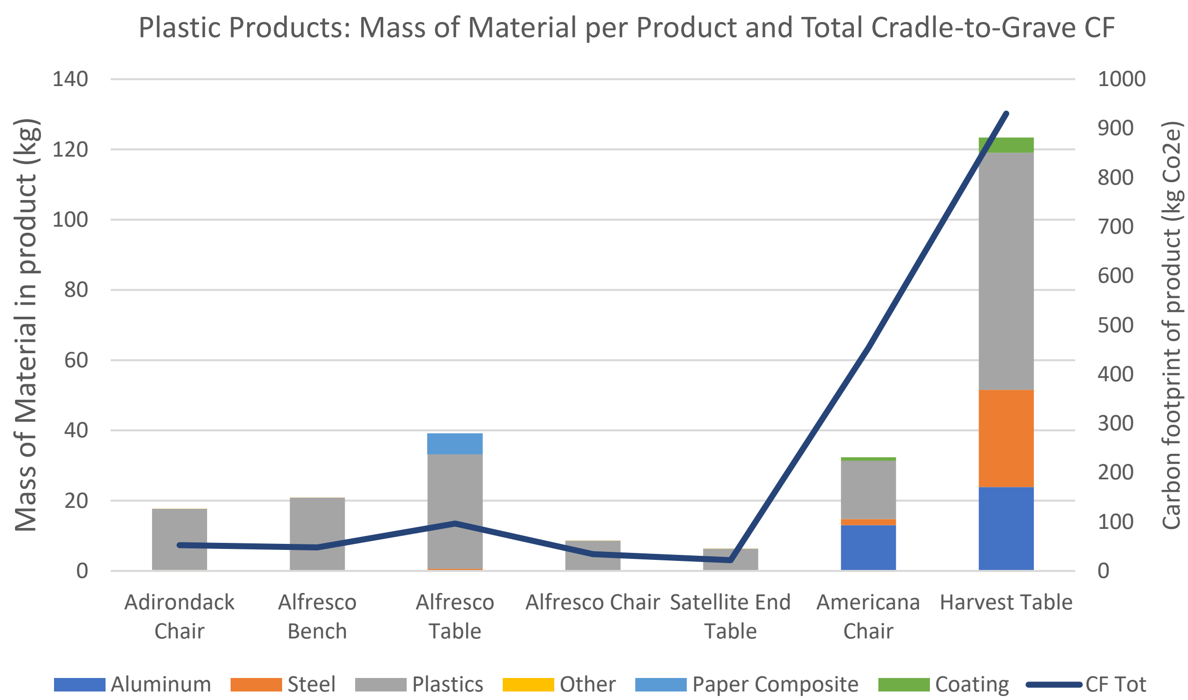
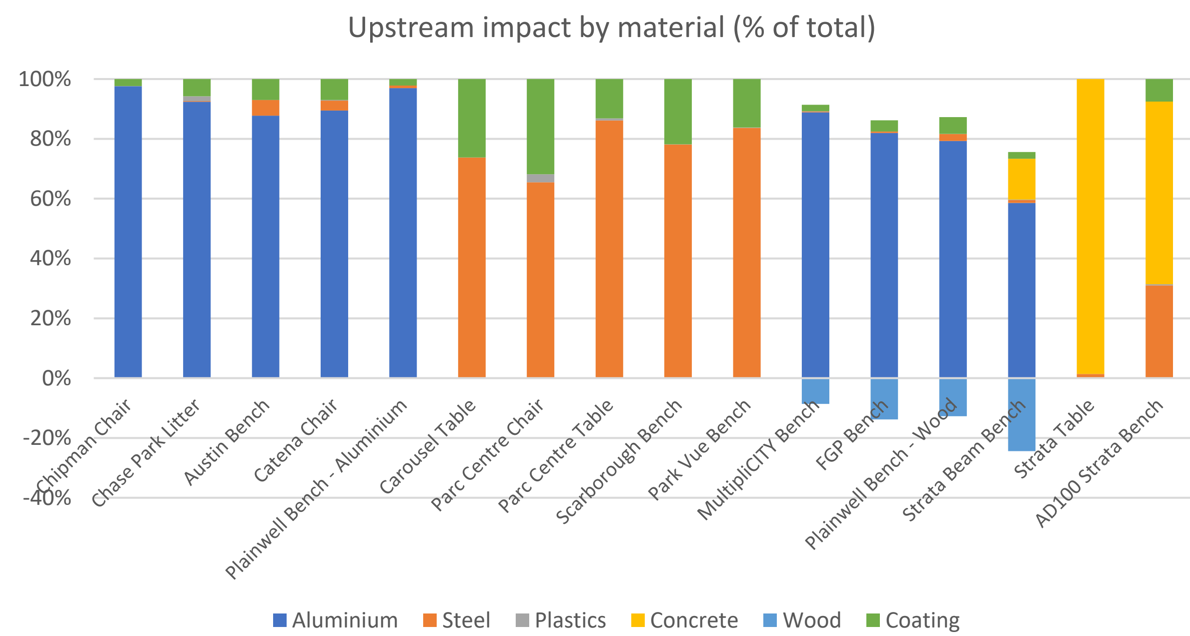


Figure 4: Comparison of the dominant materials per product (kg/product) and the total cradle-to-grave carbon footprint for each of the Landscape Forms products.

Figure 4 demonstrates the impacts of the plastic-based products, namely the Loll Designs products and the Landscape Forms *Americana Chair* and *Harvest Table*. Many of the Loll Designs products contain only plastics, and the total carbon footprint correlates generally with the amount of plastic in the product. Landscape Forms products which also contain aluminum and steel have a higher carbon footprint. The *Harvest Table*, while its overall weight is similar to the concrete-based *Strata Table*, has a much higher carbon footprint because it does not have as much wood-based packaging.

The following figures display the impact of upstream materials production (kg CO_2e) per material by product for the Landscape Forms products (Figure 5), the packaging materials of Landscape Forms products (Figure 6), the Loll Designs and Landscape Forms' plastics-based products (Figure 7), and the packaging for the Loll Designs and Landscape Forms' plastics-based products (Figure 8).

Figures 6 and 8 demonstrate that packaging materials also contribute to the upstream material impacts, especially plastics for the Landscape Forms products (Figure 6) and cardboard for the plastics-based and Loll products (Figure 8). Both figures indicate that wood-based packaging has a negative GHG impact in the upstream; however, some of this is released as biogenic carbon emissions at end-of-life of the packaging materials.



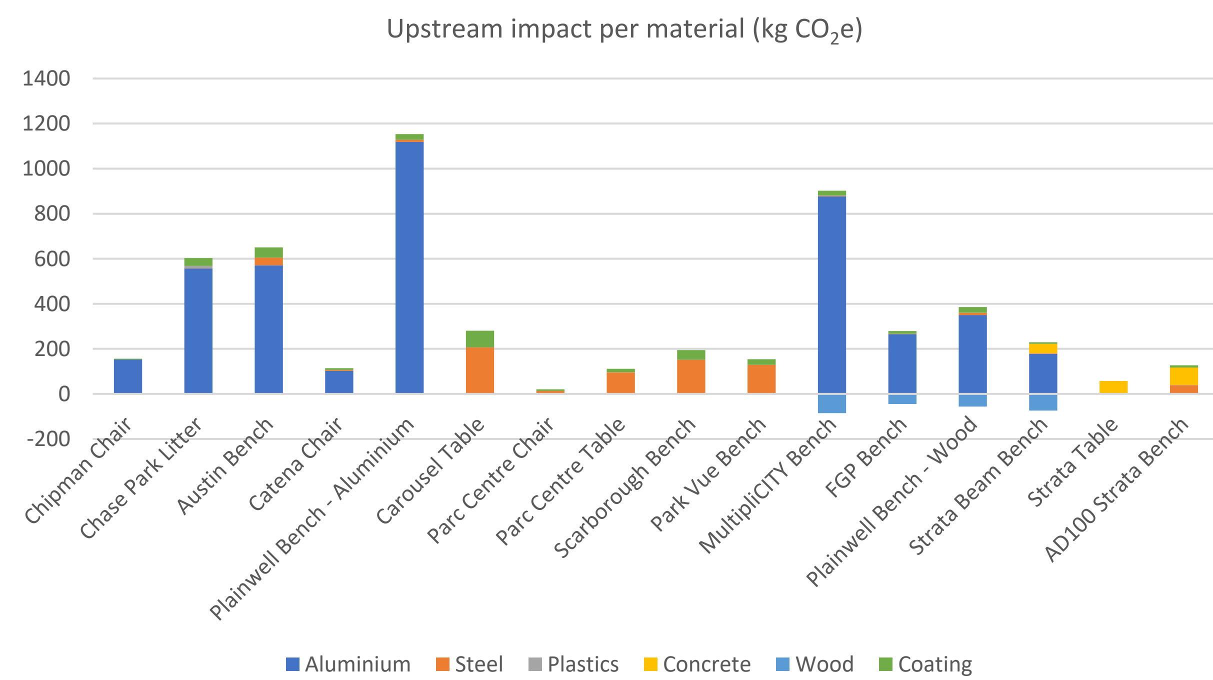
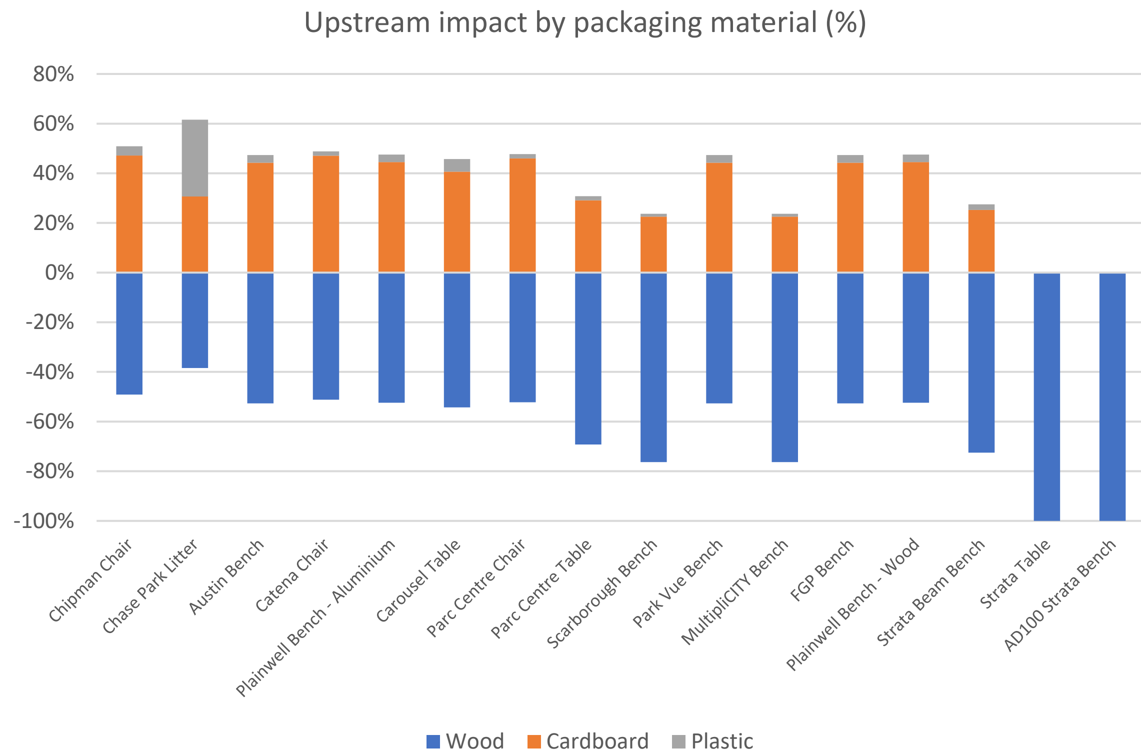


Figure 5. Impact of upstream material production, by material, for Landscape Forms products (excluding plastics-based) by percent (above) and by carbon footprint (kg CO_2e) (below).



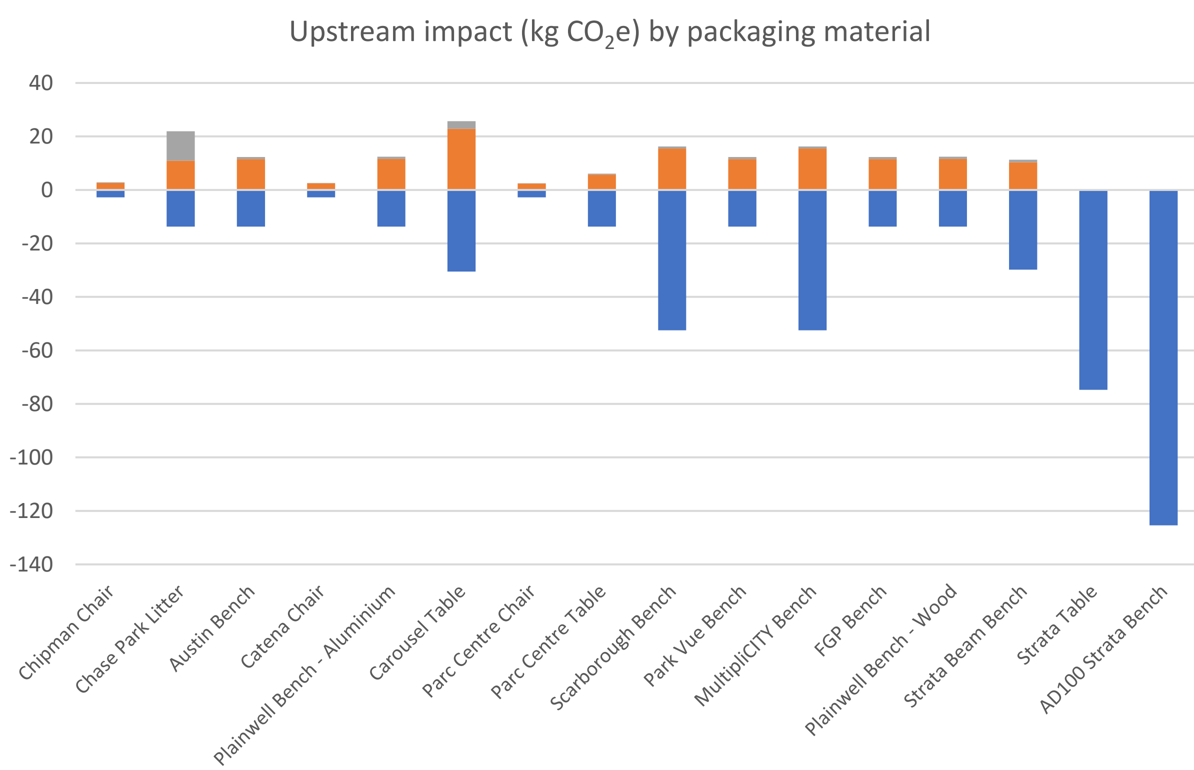
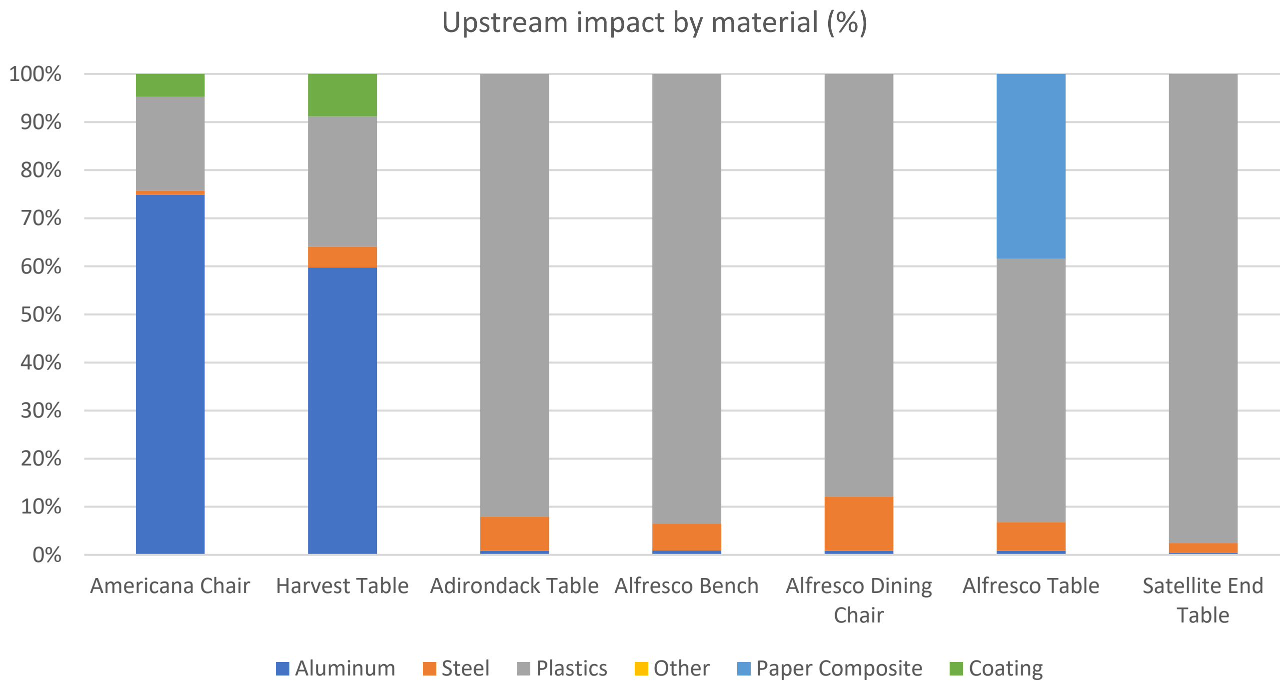


Figure 6. Impact of upstream material production, by material, for Landscape Forms products packaging by percent (above) and by carbon footprint (kg CO_2e) (below).



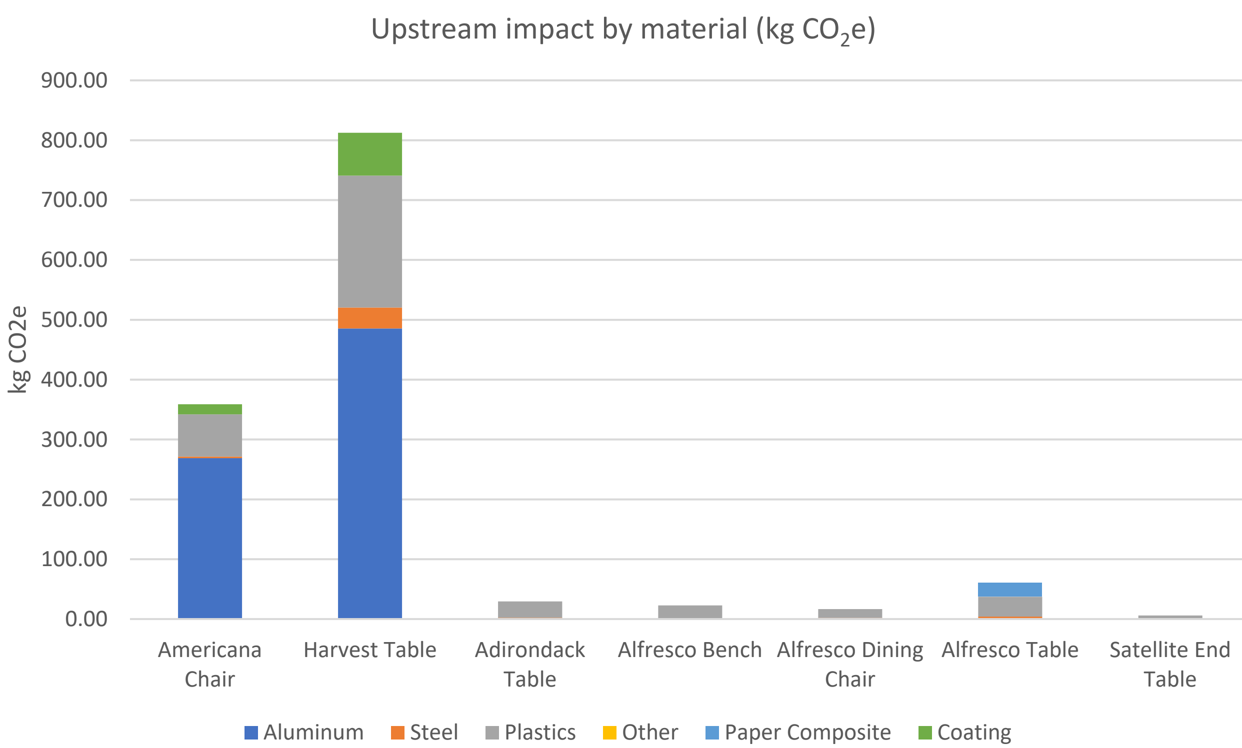
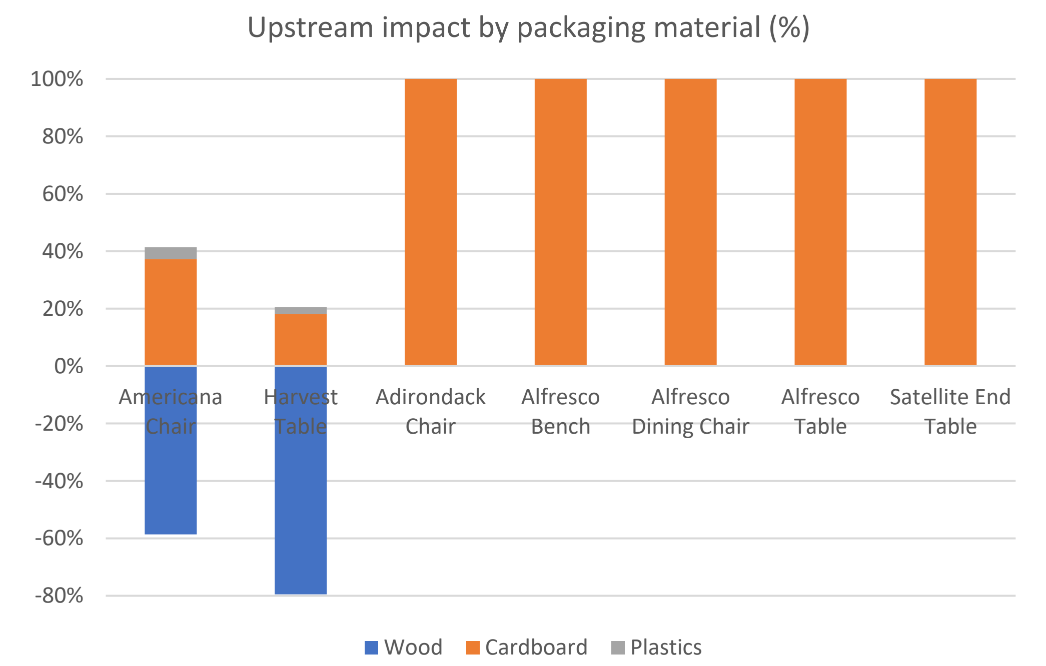


Figure 7. Impact of upstream material production, by material, for Loll Designs products and plastics-based Landscape Forms products by percent (above) and by carbon footprint for that material (kg CO_2e) (below)



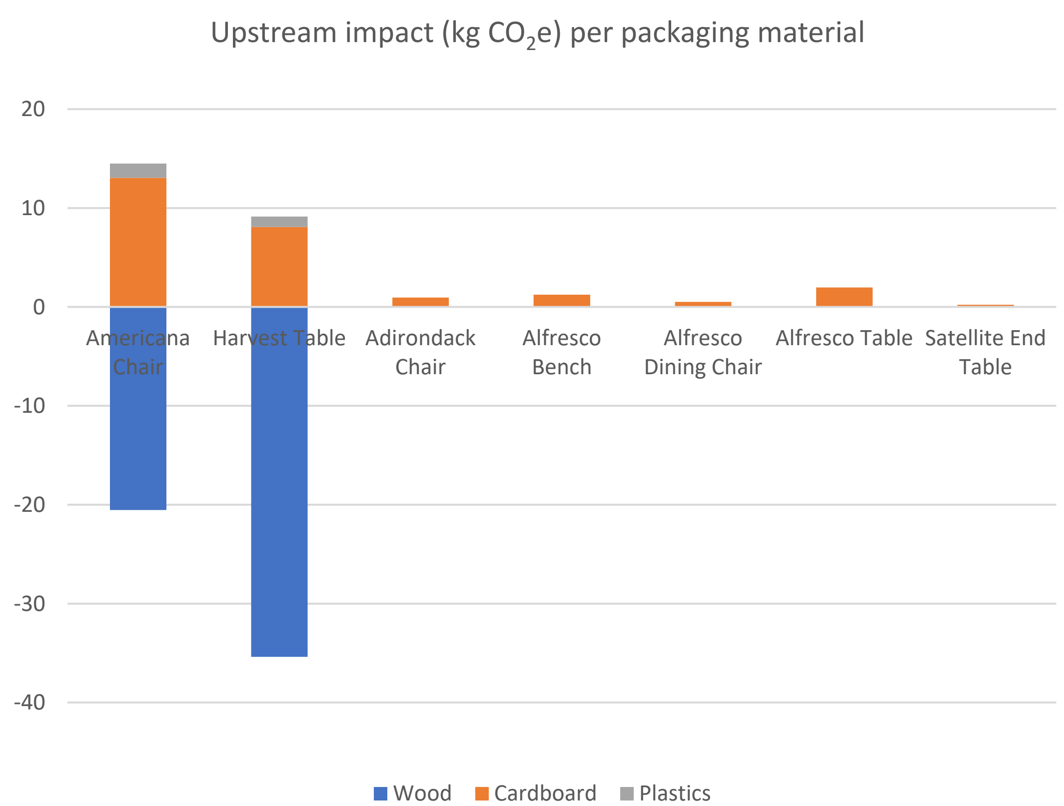


Figure 8. Impact of upstream material production, by packaging material, for Loll Designs products and plastics-based Landscape Forms products by percent (above) and by carbon footprint for that material (kg CO_2e) (below)

4.5 Sensitivity Analyses

Sensitivity 1

Section 4.4 demonstrated that upstream aluminum production is a significant contributor to a product's impact. The modeling revealed that total recycled content was an important variable for the carbon footprint of aluminum, due primarily to the reduced resource use associated with recycling aluminum, as compared to bauxite extraction and smelting required for primary aluminum production.

A sensitivity analysis is performed here to demonstrate the potential change to the carbon footprint were the recycled content in the aluminum used for the *Chipman Chair* is increased to 28.5% or decreased to 8.5%. The resulting percent change in the upstream aluminum impact is 12%, reflecting a total increase of 7.6%, or decrease of 7.1%, in the cradle-to-grave carbon footprint (upstream + manufacturing) of the *Chipman Chair*.

Table 19. Sensitivity Analysis for Recycled Content of the Chipman Chair.

	Base case	Scenario 1: Increased recycled content	Scenario 2: Decreased recycled content
Primary aluminum (%)	81.5%	71.5%	91.5%
Recycled aluminum (%)	18.5%	28.5%	8.5%
Impact of aluminum in kgCO2e	140	124	157
Percent change to aluminum impact from base case	--	-12%	+12%
Total carbon footprint for Chipman Chair (kgCO2e)	224	207	240
Percent change to total carbon footprint from base case	--	-7.6%	7.1%

Sensitivity 2

As discussed in section 2.14, the recycling rate for product materials were based on statistics from the US EPA Facts and Figures report and represent durable goods in Municipal Solid Waste. These recycling rates may not fully capture the recovery potential for the Landscape Forms products as they are often purchased by commercial customers whose disposal practices may be captured better by construction and demolition disposal practices. In the absence of specific aluminum recovery data within construction and demolition disposal, an assumption of 85% recovery was used for the aluminum, taken from the UL PCR Part A[15] and intended for use in the absence of actual statistical recovery data for metals in US C&D waste.

[15] UL Environment (2018). Product Category Rules for Building Related Products and Services. Part A: Life Cycle Assessment Calculation Rules and Report Requirements. (Version 3.2).

The results of the base case and sensitivity analysis impacts are displayed in Table 20. While the change to product disposal is significant, the change to the downstream modules between the base case and the sensitivity results is less than -3.9%. Moreover the impact to the overall cradle-to-grave carbon footprint for each product is negligible, less than -0.1%. Thes results are influenced by the use of the recycled content allocation method, which assumes that materials recycled at end of life leave the system boundary without additional burden (or credit).

Table 20. Sensitivity Analysis for increased aluminum recovery at end-of-life for the Landscape Forms products. All results represent the *climate change (total) indicator* in kilograms CO2e. Results are presented for each outdoor furniture product (per unit), and represent the climate change (total) indicator for the product disposal alone, the full cradle-to-grave climate change (total) impact for that product, and the percent difference between the two scenarios when comparing the downstream modules, and when comparing the total cradle-to-grave CF.

	Climate Change (Total) from Product Disposal (kg CO2e)		**Cradle-to-Grave Climate Change (Total)** (kg CO2e)		**Difference between results for Downstream Module**	**Difference between results for Cradle-to-grave**
	Base case	**Sensitivity**	**Base case**	**Sensitivity**		
Chipman Chair	0.151	6.560×10^{-3}	224	223	-3.19%	-0.06%
Catena Chair	0.10	1.09×10^{-2}	178.7	178.6	-2.31%	-0.05%
Americana Chair	6.48	6.27	454	454	-0.72%	-0.05%
MultipliCITY Bench	18.4	17.7	923	922	-1.05%	-0.07%
Austin Bench	0.530	2.11×10^{-2}	728	727	-2.52%	-0.07%
FGP Bench	10.3	10.0	319.8	319.6	-0.78%	-0.08%
Plainwell Bench - Wood	13	12.7	423	422	-0.85%	-0.08%
Plainwell Bench - Aluminium	1.11	7.67×10^{-2}	1,240	1,240	-3.86%	-0.08%
Strata Beam Bench	14.3	14.1	276	275	-0.27%	-0.06%
Harvest Table	26.1	25.7	930	929	-0.61%	-0.04%
Chase Park Litter	3.72	3.21	722.5	722.0	-1.94%	-0.07%

5. Recommendations and Limitations

The carbon footprint study of Landscape Forms products identified several opportunities for improvement, which are listed below as recommendations for future work.

- The impact of the upstream aluminum production was shown to have the greatest impact on the raw material stage and the overall carbon footprints for those materials containing large amounts of aluminum. The sensitivity analysis showed that the recycled content of aluminum has an important effect on the overall carbon footprint result of each product, yet collecting more information on the production or sources of metals would improve the accuracy of these results.

- The ecoinvent datasets used to represent each biomass-based material disposed within landfill and incineration assume that not all biogenic carbon dioxide is released within the end of 100 years. The emissions associated with disposal of biomass-based materials would be higher if the projected emissions after 100 years were included within the scope.

- While distribution did not have a significant impact on the results for many of the products, concrete products are among the heaviest of the Landscape Forms products and have a significant contribution to the carbon footprint from distribution. For these products the carbon footprint of the final product may change significantly depending on the location of the final customer.

- Energy use within the manufacturing facilities for the Landscape Forms products were a source of fossil emissions. Monitoring the energy and fuel use by process and product would improve the accuracy of the carbon footprint results by allocating facility resources more specifically to each product and pinpoint which manufacturing processes are having the greatest effect.

- The assessment relied on representative inventory data for much of the extraction and processing of component raw materials. Incorporation of primary data for the component materials of the products will result in a more representative and accurate carbon footprint.

- Several configurations or different options are available for many of the products. This product carbon footprint report assessed specific product configurations to the best of its ability taking into account the data provided, yet different configurations may have different carbon footprints.

6. Conclusions

A study on the cradle-to-grave product carbon footprints of 22 Landscape Forms products was conducted according to the ISO 14067:2018 and guided by EPD International PCRs for 1) Seating and 2) Non-Seating Furniture Products. The product carbon footprints were carried out to model raw material production, upstream transportation, and product manufacturing at the Landscape Forms facilities and by third parties, distribution to customer, product use, product disposal and packaging disposal. Results of the study demonstrate for the outdoor furniture products that the upstream phase contributes the largest impact over the lifecycle of many of the products, due to the primary content in aluminum, whereas some products saw relatively small impacts from upstream materials due to the ability of wood-based packaging to sequester carbon. Sensitivity analyses demonstrated the importance of the assumptions regarding recycled content in aluminum-containing products.

Further primary data on energy consumption by manufacturing processes would improve the precision of the manufacturing module. Additionally, primary or supplier data on upstream materials could improve the precision of the upstream module.

Appendix A

This appendix provides a detailed contribution analysis of the carbon footprint of all Landscape Forms products.

Table 21: Carbon footprint results for the Parc Centre Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	24.5 33%	0.224 0%	46.5 63%	2.80 4%	9.72×10^{-2} 0%	0.132 0%	74.3 100%
Climate change - Biogenic	-4.62 197%	1.80×10^{-4} 0%	0.506 -22%	1.88×10^{-3} 0%	1.75 -75%	2.22×10^{-2} -1%	-2.34 100%
Climate change - Land use and LU change	0.191 98%	8.97×10^{-5} 0%	2.51×10^{-3} 1%	1.12×10^{-3} 1%	3.00×10^{-5} 0%	6.26×10^{-5} 0%	0.195 100%
Climate change (Total)	20.1 28%	0.224 0%	47.0 65%	2.80 4%	1.85 3%	0.154 0%	72.1 100%

Table 22: Carbon footprint results for the Catena Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	119 66%	1.15 1%	58.3 32%	2.08 1%	9.96×10^{-2} 0%	0.115 0%	181 100%
Climate change - Biogenic	-5.00 199%	5.90×10^{-4} 0%	0.652 -26%	1.39×10^{-3} 0%	1.81 -72%	2.55×10^{-2} -1%	-2.51 100%
Climate change - Land use and LU change	0.196 97%	8.00×10^{-4} 0%	3.83×10^{-3} 2%	8.30×10^{-4} 0%	3.09×10^{-5} 0%	4.14×10^{-5} 0%	0.202 100%
Climate change (Total)	114 64%	1.15 1%	59.0 33%	2.08 1%	1.91 1%	0.140 0%	179 100%

Table 23: Carbon footprint results for the Americana Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	386 81%	7.54 2%	62.7 13%	11.4 2%	0.777 0%	6.59 1%	475 100%
Climate change - Biogenic	-33.5 157%	4.90×10^{-3} 0%	0.772 -4%	7.64×10^{-3} 0%	11.3 -53%	6.15×10^{-2} 0%	-21.4 100%
Climate change - Land use and LU change	0.565 97%	4.22×10^{-3} 1%	6.05×10^{-3} 1%	4.55×10^{-3} 1%	2.01×10^{-4} 0%	1.83×10^{-4} 0%	0.581 100%
Climate change (Total)	353 78%	7.55 2%	63.5 14%	11.4 3%	12.1 3%	6.65 1%	454 100%

Table 24: Carbon footprint results for the Scarborough Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	231 69%	9.99 3%	62.5 19%	27.2 8%	1.15 0%	0.984 0%	333 100%
Climate change - Biogenic	-74.3 137%	5.27×10^{-3} 0%	1.12 -2%	1.82×10^{-2} 0%	18.9 -35%	0.198 0%	-54.1 100%
Climate change - Land use and LU change	1.29 98%	6.85×10^{-3} 1%	5.51×10^{-3} 0%	1.09×10^{-2} 1%	3.64×10^{-4} 0%	5.52×10^{-4} 0%	1.31 100%
Climate change (Total)	158 56%	10.0 4%	63.6 23%	27.2 10%	20.0 7%	1.18 0%	280 100%

Table 25: Carbon footprint results for the MultipliCITY Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	950 90%	14.7 1%	61.3 6%	26.4 3%	1.15 0%	1.63 0%	1,050 100%
Climate change - Biogenic	-170 128%	7.63×10^{-3} 0%	0.828 -1%	1.77×10^{-2} 0%	18.9 -14%	17.3 -13%	-133 100%
Climate change - Land use and LU change	0.909 97%	1.03×10^{-2} 1%	4.43×10^{-3} 0%	1.05×10^{-2} 1%	3.64×10^{-4} 0%	4.99×10^{-4} 0%	0.935 100%
Climate change (Total)	780 85%	14.8 2%	62.1 7%	26.5 3%	20.0 2%	18.9 2%	923 100%

Table 26: Carbon footprint results for the Austin Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	672 91%	7.86 1%	48.9 7%	10.4 1%	0.552 0%	0.578 0%	740 100%
Climate change - Biogenic	-24.0 175%	4.07×10^{-3} 0%	1.03 -8%	6.94×10^{-3} 0%	9.07 -66%	0.132 -1%	-13.7 100%
Climate change - Land use and LU change	1.13 99%	5.47×10^{-3} 0%	3.65×10^{-3} 0%	4.13×10^{-3} 0%	1.56×10^{-4} 0%	2.06×10^{-4} 0%	1.14 100%
Climate change (Total)	649 89%	7.86 1%	49.9 7%	10.4 1%	9.63 1%	0.709 0%	728 100%

Table 27: Carbon footprint results for the Park Vue Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	175 80%	10.2 5%	15.3 7%	17.8 8%	0.552 0%	0.784 0%	220 100%
Climate change - Biogenic	-22.9 174%	5.25×10^{-3} 0%	0.469 -4%	1.19×10^{-2} 0%	9.07 -69%	0.157 -1%	-13.2 100%
Climate change - Land use and LU change	0.692 98%	7.14×10^{-3} 1%	2.68×10^{-3} 0%	7.11×10^{-3} 1%	1.56×10^{-4} 0%	4.38×10^{-4} 0%	0.709 100%
Climate change (Total)	153 74%	10.2 5%	15.8 8%	17.8 9%	9.63 5%	0.941 0%	207 100%

Table 28: Carbon footprint results for the FGP Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	306 82%	5.74 2%	47.8 13%	12.4 3%	0.552 0%	0.700 0%	373 100%
Climate change - Biogenic	-73.1 136%	3.03×10^{-3} 0%	0.583 -1%	8.29×10^{-3} 0%	9.07 -17%	9.84 -18%	-53.6 100%
Climate change - Land use and LU change	0.692 98%	3.93×10^{-3} 1%	3.04×10^{-3} 0%	4.93×10^{-3} 1%	1.56×10^{-4} 0%	2.31×10^{-4} 0%	0.704 100%
Climate change (Total)	233 73%	5.74 2%	48.4 15%	12.4 4%	9.63 3%	10.5 3%	320 100%

Table 29: Carbon footprint results for the Plainwell Bench Wood in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	413 85%	6.88 1%	48.2 10%	15.7 3%	0.566 0%	0.971 0%	485 100%
Climate change - Biogenic	-85.8 135%	3.73×10^{-3} 0%	0.755 -1%	1.06×10^{-2} 0%	9.13 -14%	12.4 -19%	-63.5 100%
Climate change - Land use and LU change	0.767 98%	4.63×10^{-3} 1%	3.18×10^{-3} 0%	6.28×10^{-3} 1%	1.57×10^{-4} 0%	3.37×10^{-4} 0%	0.782 100%
Climate change (Total)	328 78%	6.89 2%	48.9 12%	15.8 4%	9.70 2%	13.3 3%	423 100%

Table 30: Carbon footprint results for the Plainwell Bench Aluminum in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	1,180 94%	6.28 1%	49.4 4%	16.6 1%	0.566 0%	1.21 0%	1,250 100%
Climate change - Biogenic	-26.5 163%	3.25×10^{-3} 0%	0.760 -5%	1.11×10^{-2} 0%	9.13 -56%	0.282 -2%	-16.3 100%
Climate change - Land use and LU change	0.880 98%	4.39×10^{-3} 0%	3.97×10^{-3} 0%	6.63×10^{-3} 1%	1.57×10^{-4} 0%	4.48×10^{-4} 0%	0.896 100%
Climate change (Total)	1,150 93%	6.29 1%	50.2 4%	16.6 1%	9.70 1%	1.49 0%	1,240 100%

Table 31: Carbon footprint results for the Strata Beam Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	261 70%	21.3 6%	58.9 16%	30.4 8%	0.846 0%	1.39 0%	374 100%
Climate change - Biogenic	-125 126%	1.60×10^{-2} 0%	0.650 -1%	2.04×10^{-2} 0%	11.6 -12%	13.7 -14%	-98.6 100%
Climate change - Land use and LU change	0.396 94%	9.70×10^{-3} 2%	3.90×10^{-3} 1%	1.21×10^{-2} 3%	2.22×10^{-4} 0%	5.57×10^{-4} 0%	0.423 100%
Climate change (Total)	137 50%	21.3 8%	59.6 22%	30.4 11%	12.5 5%	15.1 5%	276 100%

Table 32: Carbon footprint results for the Parc Centre Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	123 63%	0.480 0%	59.6 31%	10.3 5%	0.374 0%	0.425 0%	194 100%
Climate change - Biogenic	-19.9 149%	3.80×10^{-4} 0%	0.742 -6%	6.89×10^{-3} 0%	5.70 -43%	8.57×10^{-2} -1%	-13.4 100%
Climate change - Land use and LU change	0.391 98%	1.90×10^{-4} 0%	3.78×10^{-3} 1%	4.10×10^{-3} 1%	1.07×10^{-4} 0%	2.39×10^{-4} 0%	0.400 100%
Climate change (Total)	104 57%	0.481 0%	60.4 33%	10.3 6%	6.07 3%	0.511 0%	181 100%

Table 33: Carbon footprint results for the Harvest Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	839 87%	12.3 1%	64.1 7%	26.7 3%	0.985 0%	26.5 3%	969 100%
Climate change - Biogenic	-53.9 131%	9.87×10^{-3} 0%	1.51 -4%	1.79×10^{-2} 0%	11.1 -27%	0.168 0%	-41.1 100%
Climate change - Land use and LU change	1.55 99%	4.93×10^{-3} 0%	6.18×10^{-3} 0%	1.07×10^{-2} 1%	2.26×10^{-4} 0%	6.75×10^{-4} 0%	1.57 100%
Climate change (Total)	786 85%	12.3 1%	65.6 7%	26.7 3%	12.1 1%	26.7 3%	930 100%

Table 34: Carbon footprint results for the Strata Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	78.3 54%	23.9 16%	11.0 8%	30.4 21%	1.01 1%	0.832 1%	145 100%
Climate change - Biogenic	-95.3 119%	1.91×10^{-2} 0%	0.136 0%	2.04×10^{-2} 0%	15.1 -19%	1.29×10^{-3} 0%	-80.0 100%
Climate change - LULUC	8.36×10^{-2} 78%	9.60×10^{-3} 9%	7.89×10^{-4} 1%	1.21×10^{-2} 11%	3.47×10^{-4} 0%	4.20×10^{-4} 0%	0.107 100%
Climate change (Total)	-16.9 -26%	23.9 36%	11.2 17%	30.4 46%	16.1 25%	0.834 1%	65.5 100%

Table 35: Carbon footprint results for the Chase Park Litter in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	635 86%	12.1 2%	71.4 10%	14.3 2%	0.469 0%	3.23 0%	737 100%
Climate change - Biogenic	-24.9 165%	7.22×10^{-3} 0%	0.687 -5%	9.57×10^{-3} 0%	8.29 -55%	0.815 -5%	-15.1 100%
Climate change - LULUC	0.883 98%	7.44×10^{-3} 1%	6.05×10^{-3} 1%	5.70×10^{-3} 1%	1.44×10^{-4} 0%	3.12×10^{-4} 0%	0.902 100%
Climate change (Total)	611 85%	12.1 2%	72.1 10%	14.3 2%	8.75 1%	4.04 1%	722 100%

Table 36: Carbon footprint results for the Adirondack Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	24.5 53%	0.0375 0%	12.2 26%	3.00 6%	9.14×10^{-3} 0%	6.64 14%	46.4 100%
Climate change - Biogenic	5.82 96%	1.86×10^{-5} 0%	1.99×10^{-2} 0%	2.01×10^{-3} 0%	0.241 4%	3.50×10^{-3} 0%	6.08 100%
Climate change - LULUC	2.54×10^{-2} 86%	1.66×10^{-5} 0%	2.99×10^{-3} 10%	1.20×10^{-3} 4%	3.43×10^{-6} 0%	9.40×10^{-5} 0%	2.97×10^{-2} 100%
Climate change (Total)	3.03×10^{1} 58%	3.76×10^{-2} 0%	12.3 23%	3.00 6%	0.250 0%	6.65 13%	52.5 100%

Table 37: Carbon footprint results for the Alfresco Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	19.7 45%	0.0189 0%	12.2 28%	3.56 8%	1.21×10^{-2} 0%	7.90 18%	43.4 100%
Climate change - Biogenic	4.27 93%	9.38×10^{-6} 0%	1.99×10^{-2} 0%	0.00238 0%	0.318 7%	3.77×10^{-3} 0%	4.62 100%
Climate change - LULUC	2.45×10^{-2} 84%	1.66×10^{-5} 0%	2.99×10^{-3} 10%	1.42×10^{-3} 5%	4.55×10^{-6} 0%	1.11×10^{-4} 0%	2.91×10^{-2} 100%
Climate change (Total)	24.0 50%	1.90×10^{-2} 0%	12.3 26%	3.56 7%	0.330 1%	7.91 16%	48.0 100%

Table 38: Carbon footprint results for the Alfresco Dining Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	13.9 45%	0.0129 0%	12.2 40%	1.47 5%	4.97×10^{-3} 0%	3.19 10%	30.8 100%
Climate change - Biogenic	3.14 95%	6.41×10^{-6} 0%	1.99×10^{-2} 1%	0.00098 0%	0.131 4%	1.93×10^{-3} 0%	3.29 100%
Climate change - LULUC	1.45×10^{-2} 80%	5.73×10^{-6} 0%	2.99×10^{-3} 16%	5.86×10^{-4} 3%	1.87×10^{-6} 0%	4.58×10^{-5} 0%	1.82×10^{-2} 100%
Climate change (Total)	17.0 50%	1.30×10^{-2} 0%	12.3 36%	1.47 4%	0.136 0%	3.20 9%	34.1 100%

Table 39: Carbon footprint results for the Alfresco Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	55.6 64%	0.0354 0%	12.2 14%	6.62 8%	1.91×10^{-2} 0%	12.6 14%	87.1 100%
Climate change - Biogenic	6.68 73%	1.75×10^{-5} 0%	1.99×10^{-2} 0%	0.00444 0%	0.502 5%	1.94 21%	9.15 100%
Climate change - LULUC	4.07×10^{-2} 87%	1.57×10^{-5} 0%	2.99×10^{-3} 6%	2.64×10^{-3} 6%	7.17×10^{-6} 0%	2.02×10^{-4} 0%	4.66×10^{-2} 100%
Climate change (Total)	62.4 65%	3.54×10^{-2} 0%	12.3 13%	6.63 7%	0.521 1%	14.5 15%	96.3 100%

Table 40: Carbon footprint results for the Satellite End Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change - Fossil	4.92 24%	0.0051 0%	12.2 59%	1.06 5%	2.15×10^{-3} 0%	2.42 12%	20.6 100%
Climate change - Biogenic	1.22 94%	2.54×10^{-6} 0%	1.99×10^{-2} 2%	0.00071 0%	5.66×10^{-2} 4%	1.05×10^{-3} 0%	1.30 100%
Climate change - LULUC	5.19×10^{-3} 60%	2.28×10^{-6} 0%	2.99×10^{-3} 35%	4.24×10^{-4} 5%	8.08×10^{-7} 0%	3.37×10^{-5} 0%	8.64×10^{-3} 100%
Climate change (Total)	6.14 28%	5.14×10^{-3} 0%	12.3 56%	1.06 5%	5.88×10^{-2} 0%	2.42 11%	21.9 100%

Table 41: Carbon footprint contribution analysis for the Chipman Chair in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	157	4.81	2.97	58.5	2.50	0.102	0.163	**226**
	69%	2%	1%	26%	1%	0%	0%	**100%**
Climate change – Biogenic	-0.603	-4.74	$1.48x10^{-3}$	0.666	$1.68x10^{-3}$	1.87	$3.72x10^{-2}$	**-2.77**
	22%	171%	0%	-24%	0%	-68%	-1%	**100%**
Climate change – Land use and LU change	$9.76x10^{-2}$	$2.93x10^{-2}$	$2.12x10^{-3}$	$4.23x10^{-3}$	$9.99x10^{-4}$	$3.18x10^{-5}$	$5.72x10^{-5}$	**0.134**
	73%	22%	2%	3%	1%	0%	0%	**100%**
Climate change (Total)	157	$9.89x10^{-2}$	2.97	59.2	2.51	1.98	0.200	**224**
	70%	0%	1%	26%	1%	1%	0%	**100%**

Table 42: Carbon footprint contribution analysis for the Carousel Table in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	279	44.8	6.66	65.5	29.7	1.31	1.22	**428**
	65%	10%	2%	15%	7%	0%	0%	**100%**
Climate change – Biogenic	0.207	-49.8	$4.79x10^{-3}$	1.55	$1.99x10^{-2}$	17.8	0.239	**-30.0**
	-1%	166%	0%	-5%	0%	-59%	-1%	**100%**
Climate change – Land use and LU change	1.48	0.263	$3.24x10^{-3}$	$7.07x10^{-3}$	$1.19x10^{-2}$	$3.15x10^{-4}$	$6.70x10^{-4}$	**1.77**
	84%	15%	0%	0%	1%	0%	0%	**100%**
Climate change (Total)	281	-4.81	6.66	67.1	29.8	19.1	1.46	**400**
	70%	-1%	2%	17%	7%	5%	0%	**100%**

Table 43: Carbon footprint contribution analysis for the AD100 Strata Bench in kg CO2e, by life cycle phase.

Indicator	Upstream Materials	Upstream Materials Packaging	Materials Transport to Landscape Forms	Manufacturing	Distribution to Customer	Packaging Disposal	Product Disposal	Total
Climate change – Fossil	142	34.5	33.0	70.7	51.5	1.69	1.58	**335**
	42%	10%	10%	21%	15%	1%	0%	**100%**
Climate change – Biogenic	0.180	-160	$2.65x10^{-2}$	0.810	$3.45x10^{-2}$	25.4	$9.20x10^{-2}$	**-134**
	0%	120%	0%	-1%	0%	-19%	0%	**100%**
Climate change – Land use and LU change	0.216	0.127	$1.32x10^{-2}$	$4.62x10^{-3}$	$2.06x10^{-2}$	$5.82x10^{-4}$	$8.15x10^{-4}$	**0.382**
	56%	33%	3%	1%	5%	0%	0%	**100%**
Climate change (Total)	143	-125	33.1	71.5	51.6	27.1	1.67	**202**
	71%	-62%	16%	35%	26%	13%	1%	**100%**

Appendix B: Critical Review Report

Critical Review of *Carbon Footprint of Outdoor Furniture*, According to ISO 14067

Prepared for:
Landscape Forms

Date Completed:
6/29/2023

Reviewer:
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Table of Contents

1.0 Introduction

This report contains a summary of the critical review, according to the ISO 14067[16] standard, of the report titled *Carbon Footprint of Outdoor Furniture*, completed in June 2023 completed by Tess Garvey and Urvi Talaty. The carbon footprint of products (CFP) study was commissioned by *Landscape Forms*.

The critical review was conducted by an independent life cycle practitioner with no involvement with the execution of the carbon footprint of products study. The critical review assessed the CFP report for conformance to the ISO 14067:2018 standard and conforms with the ISO 14071:2014 standard[17]. The self-declaration of reviewer independence and competencies has been provided to the relevant parties in a separate document. This critical review is considered an 'internal expert review' under ISO 14071. The review includes an assessment of the life cycle inventory (LCI) model and excludes an assessment of individual data sets.

When compared to the requirements of ISO 14067, the product carbon footprint report is consistent with requirements. All non-conformities and opportunities for improvement have been addressed and closed.

[16] ISO 14067:2018 Environmental management – Greenhouse gases — Carbon footprint of products — Requirements and guidelines for quantification

[17] ISO/TS 14071:2014 Environmental management — Life cycle assessment — Critical review processes and reviewer competencies: Additional requirements and guidelines to ISO 14044:2006

2.0 Editorial Comments

The following editorial comments are provided:

- Table 1 lists "*Carousel Bench"*; it is referred to as "*Carousel Table*" elsewhere within the report.
- Section headings beyond Section 2.4 are missing/corrupted.
- Table 4 is missing data for corrugated packaging (last row).
- Section 3 heading is missing "3." (pg. 14).
- Section 4.5 appears to include a section heading "Sensitivity 2" but there is no corresponding "Sensitivity 1" heading.
- Table 37 and Table 38 are duplicated.

Critical Review Checklist

ISO 14067:2018 Critical Review Checklist				
Report Title:	Carbon Footprint of Outdoor Furniture, According to ISO 14067:2018		**Finding Type**	**Acronym**
Version of Report (e.g. Report Date, Version Number, etc.):	June 9, 2023; Revised June 29, 2023		Verified (Conforms with requirement)	V
Report Author:	Tess Garvey., Ph.D. and Urvi Talaty; SCS Global Services	**Original (06/28/23)**	102	
		Final (06/29/23)	108	
Reviewer Name:	Gerard Mansell		Opportunity for improvement	OFI
Reviewer Organization:	SCS Global Services	**Original (06/28/23)**	3	
		Final (06/29/23)	0	
Date of Review Completed:	June 28, 2023; Revised June 29,2023		Non-conformity with requirement	NCR
Review performed concurrently or at the end of study?	End of study			
Internal Expert?	Yes	**Original (06/28/23)**	3	
		Final (06/29/23)	0	
External Expert?	No	**Color Key**		
Review Panel?	No		PRACTITIONER COMMENT	V COMMENT
				NCR/OFI COMMENT
				Should Statement

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
1	**Scope of ISO 14067** This document addresses only a single impact category: climate change. Carbon offsetting and communication of CFP or partial CFP information are outside the scope of this document. This document does not assess any social or economic aspects or impacts, or any other environmental aspects and related impacts potentially arising from the life cycle of a product.	V	V	
6.1	**General** A CFP study in accordance with this document shall include the four phases of LCA, i.e. goal and scope definition (see 6.3), LCI (see 6.4), LCIA (see 6.5) and life cycle interpretation (see 6.6), for CFP or partial CFP. The unit processes comprising the product system shall be grouped into life cycle stages, e.g. acquisition of raw material, design, production, transportation/delivery, use (see 6.3.7) and end-of-life (see 6.3.8). GHG emissions and removals from the product's life cycle shall be assigned to the life cycle stage in which the GHG emissions and removals occur. Partial CFPs may be added together to quantify the CFP, provided that they are performed according to the same methodology for the same timeframe and that no gaps or overlaps exist.	V	V	
6.2	**Use of CFP-PCR** Where relevant PCR or CFP–PCR exist, they shall be adopted. PCR or CFP–PCR are relevant provided: — they have been developed in accordance with ISO/TS 14027, or a relevant sector-specific International Standard that applies the requirements of ISO 14044; — they conform to the requirements of this clause, 6.3, 6.4 and 6.5; — they are considered proper (e.g. for system boundaries, modularity, allocation and data quality) by the organization applying this document and are in accordance with the principles in Clause 5.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	NOTE Examples of organizations that apply this document are providers of goods and services, practitioners and commissioners of the CFP study. If more than one set of relevant PCR or CFP–PCR exist, the relevant PCR or CFP–PCR shall be reviewed by the organization applying this document (e.g. for system boundaries, modularity, allocation, data quality). The choice of the PCR or CFP–PCR adopted shall be justified. When all requirements in this subclause are met by PCR, those PCR are equivalent to the CFP–PCR. If CFP–PCR are adopted for the CFP study, the quantification shall be conducted according to the requirements in these CFP–PCR. Where no relevant CFP–PCR exist, the requirements and guidance of other internationally agreed sector-specific documents, related to specific product or material categories, should be adopted if they conform to the requirements of this document and are considered appropriate by the organization applying this document.			
6.3.1	**Goal of a CFP study** In defining the goal of a CFP study, the following items shall be unambiguously stated:			
	— the intended application;	V	V	
	— the reasons for carrying out the CFP study;	V	V	
	— the intended audience;	V	V	
	— the intended communication, if any, of the CFP or partial CFP information, in accordance with ISO 14026.	V	V	
6.3.2	**Scope of a CFP study** In defining the scope of the CFP study, the following items shall be considered and clearly described, taking into account the requirements and guidance given in the relevant subclauses of this document:			
	the system under study and its functions;			
6.3.3	**The functional or declared unit:**			

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	A CFP study shall clearly specify the functional or declared unit of the system under study. The functional or declared unit shall be consistent with the goal and scope of the CFP study. The primary purpose of a functional or declared unit is to provide a reference to which the inputs and outputs are related. Therefore, the functional or declared unit shall be clearly defined and measurable. The declared unit shall only be used in a partial CFP. When CFP–PCR are adopted, the functional or declared unit used shall be that defined in the CFP–PCR.	V	V	
	Having chosen the functional or declared unit, the associated reference flow shall be defined.	NCR	V	Packaging materials and weights for each product are not included. The total mass of packaging and product should be included in Table 1 to define the reference flows. Packaging and product are already included in the reference flow table (total). Now includes product and packaging separately as well. Include packaging material weights per product in Table 2 & Table 3 (or as separate table) Included in update Requirement satisfied

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	When a comparison is done between product systems, it shall be made on the basis of the same functional unit(s). Comparisons based on partial carbon footprint (declared unit) are permitted if the omitted life cycle stages are identical (see Annex B). Comparison based on the declared unit may only be used for business-to-business purposes. If additional functions of any of the product systems are not taken into account in the comparison of functional units, then these omissions shall be explained and documented. As an alternative to this approach, systems associated with the delivery of these functions may be added to the boundary of the other product system to make the product systems more comparable. In these cases, the processes selected shall be explained and documented	NA	NA	
6.3.4	**System boundary**			
	Where CFP–PCR are used (see 6.2), their requirements on the processes to be included shall also apply	V	V	
6.3.4.1	The selection of the system boundary shall be consistent with the goal of the CFP study.	V	V	
	The criteria, e.g. cut-off criteria used in establishing the system boundary shall be identified and explained.	V	V	
	The exclusion of life cycle stages, processes, inputs or outputs within the system under study is only permitted if they do not significantly change the overall conclusions of the CFP study. Any decisions to exclude life cycle stages, processes, inputs or outputs shall be clearly stated and the reasons and implications for their exclusion shall be explained. The threshold for significance shall be stated, e.g. as cut-off criteria (see), and justified.	V	V	
	Decisions made regarding which unit processes, inputs and outputs shall be included and the level of detail of the quantification of the CFP shall be clearly stated.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	The CFP and the partial CFP shall not include carbon offsetting. GHG removals that are not linked to carbon offsetting can occur within the system boundary of the product system.	V	V	
	Quantification carried out in accordance with this document shall include all GHG emissions and removals of those unit processes that are part of the product system that have the potential to make a significant contribution to the CFP or the partial CFP	V	V	
6.3.4.2	**Setting the system boundary**: Within the goal and scope definition phase, consistent criteria shall be defined:			
	for which unit processes a detailed assessment is needed due to an expected significant contribution to the CFP or the partial CFP;	V	V	
	or which unit processes the quantification of GHG emissions may be based on secondary data if the collection of primary data are not possible or practicable	V	V	
	which unit processes may be merged, e.g. all transport processes within a plant.	V	V	
6.3.4.3	**Cut-off Criteria** In general, all processes and flows that are attributable to the analyzed system shall be included. If individual material or energy flows are found to be insignificant for the carbon footprint of a particular unit process, these may be excluded for practical reasons and shall be reported as data exclusions	V	V	
	Consistent cut-off criteria that allow the exclusion of certain processes of minor importance shall be defined within the goal and scope definition phase			
6.3.5	**Data and data quality**	V	V	
	Site-specific data shall be collected for individual processes where the organization undertaking the CFP study has financial or operational control.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	Site-specific data refer to either direct GHG emissions (determined through direct monitoring, stoichiometry, mass balance or similar methods), activity data (inputs and outputs of processes that result in GHG emissions or removals) or emission factors. Site-specific data can be collected from a specific site, or can be averaged across all sites that contain the process within the system under study. They can be measured or modelled, as long as the result is specific to the process in the product's life cycle			
	The data shall be representative of the processes for which they are collected	V	V	
	Site-specific data should also be used for those unit processes that are most important and not under financial or operational control. The most important processes are those which together contribute at least 80% to the CFP, starting from the largest to the smallest contributions after cut-off. Primary data that are not site-specific data, and which have undergone third-party review, should be used when the collection of site-specific data is not practicable Secondary data shall only be used for inputs and outputs where the collection of primary data is not practicable, or for processes of minor importance. Secondary data shall be justified and documented with references in the CFP study report.	V	V	
	A CFP study should use data that reduce bias and uncertainty as far as practical by using the best quality data available	V	V	
	Data quality shall be characterized by both quantitative and qualitative aspects	V	V	
	Characterization of data quality shall address the following:			

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	time-related coverage: age of data and the minimum length of time over which data should be collected	OFI	V	The statement "Typically, these data are less than 10 years old (2008 or typically more recent)." should be revised to "Typically, these data are less than 10 years old." if appropriate (i.e., are the data 10 years or 15 years old ?)**Updated** Acknowledged
	geographical coverage: geographical area from which data for unit processes should be collected to satisfy the goal of the CFP study	V	V	
	technology coverage: specific technology or technology mix	V	V	
	precision: measure of the variability of each data value expressed (e.g. variance);	V	V	
	Characterization of data quality should address the following:			
	completeness: percentage of total flow that is measured or estimated	V	V	
	representativeness: qualitative assessment of the degree to which the data set reflects the true population of interest (i.e. geographical coverage, time period and technology coverage);	V	V	
	consistency: qualitative assessment of whether or not the study methodology is applied uniformly to the various components of the sensitivity analysis;	V	V	
	reproducibility: qualitative assessment of the extent to which information about the methodology and data values would allow an independent practitioner to reproduce the results reported in the CFP study;	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	sources of the data;	OFI	V	Secondary LCI data is from Ecoinvent v3.8. Most recent version is v3.9. Recommend updating to v3.9, if feasible **Modeling began before ecoinvent 3.9 was available and is not feasible at this point.** End-of-Life process datasets listed in Table 5 are for Switzerland (CH).The available Rest-of-World (RoW) datasets may be more appropriate for the modeling system assessed. **Noted. Used as a proxy for european operations**. Acknowledged
	uncertainty of the information	V	V	
6.3.6	**Time boundary for data** The time period for which the CFP is representative shall be specified and justified.	V	V	
	The choice of the time period for data collection should consider intra- and inter-annual variability and, when possible, use values representing the trend over the selected period	V	V	
	Where the GHG emissions and removals associated with specific unit processes within the life cycle of a product vary over time, data shall be collected over a time period appropriate to establish the average GHG emissions and removals associated with the life cycle of the product.	NA	NA	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	If a process within the system boundary is linked to a specific time period (e.g. seasonal products such as fruit and vegetables), the assessment of GHG emissions and removals shall cover that particular period in the life cycle of the product	NA	NA	
	Any activity (or activities) occurring outside that period shall also be included provided that it is within the product system (e.g. GHG emissions related to a tree nursery).	NA	NA	
	These data on GHG emissions and removals shall be related to the functional or declared unit.	V	V	
6.3.7	**Use stage and use profile** The use stage starts when the specified user takes possession of the finished product and ends when the product is ready for disposal, reuse for a different function, recycling or energy recovery.			
	When the use stage is included within the scope of the CFP study (see 6.3.2), GHG emissions and removals arising from the use stage of the product shall be included.	NA	NA	
	The user of the product and the use profile of the product shall be specified in the CFP study.	NA	NA	
	Service life information shall be verifiable. It shall refer to the intended use conditions and to the related functions of the product.	NA	NA	
	The use profile should seek to represent the actual usage pattern in the selected market.	NA	NA	
	Where not otherwise justified, the determination of the use profile (i.e. scenarios for service life and the selected market) shall be based on published technical information	NA	NA	
	Where no method for determining the use profile of products has been established in accordance with a) to e) above, the assumptions made in determining the use profile of products shall be established by the organization carrying out the CFP study	NA	NA	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	A sensitivity analysis shall be undertaken if the use stage assumption is shown to be significant for the conclusions of the CFP study.	NA	NA	
	All relevant assumptions for the use stage shall be documented in the CFP study report.	NA	NA	
6.3.8	**End-of-life Stage** The end-of-life stage begins when the used product under study is ready for disposal, recycling, reuse for different purposes or energy recovery.			
	All the GHG emissions and removals arising from the end-of-life stage of a product shall be included in a CFP study, if this stage is included in the scope	V	V	
	End-of-life scenarios shall reflect the current market and be representative of one of the most likely alternatives, or more than one scenario (including future scenarios) may be assessed	V	V	
6.4.1	**Life cycle inventory analysis for the CFP** LCI is the phase of LCA involving the compilation and quantification of inputs and outputs for a product throughout its life cycle.			
	If CFP–PCR are adopted for the CFP study, the LCI shall be conducted according to the requirements in the CFP–PCR.	V	V	
6.4.2	**Data Collection** The qualitative and quantitative data for inclusion in the life cycle inventory shall be collected for all unit processes that are included in the system under study	V	V	
	Significant unit processes shall be documented in the CFP study report.	V	V	
	For those data that might be significant for the conclusions of the CFP study, details about the relevant data collection process, the time when data have been collected, and further information about data quality shall be referenced.	V	V	
	If such data do not meet the data quality requirements, this shall be stated	V	V	
	Since data collection can span several locations and published references, a representative and consistent data set for the system under study should be used.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
6.4.3	**Validation of data** Validation should involve establishing mass balances, energy balances and/or comparative analyses of emission factors or other appropriate methods	V	V	
6.4.4	**Relating data to unit process and functional or declared unit** An appropriate flow shall be determined for each unit process. The quantitative input and output data of the unit process shall be calculated in relation to this flow.	V	V	
	The calculation shall relate system input and output data to the functional or declared unit.	V	V	
	The level of aggregation shall be consistent with the goal of the CFP study.	V	V	
	If more detailed aggregation rules are required, they should be explained in the goal and scope definition phase of the CFP study or should be left to a subsequent LCIA phase.	NA	NA	
6.4.5	**Refining the system boundary** Reflecting the iterative nature of the quantification of the CFP, if no CFP–PCR are used, decisions regarding the data to be included or excluded shall be based on a sensitivity analysis to determine the significance.	V	V	
	The initial system boundary shall be revised, as appropriate, in accordance with the cut-off criteria established in the goal and scope definition phase	V	V	
	The results of this refining process and the sensitivity analysis shall be documented in the CFP study report.	V	V	
6.4.6				
6.4.6.1	**General** The inputs and outputs shall be allocated to the different products according to the clearly stated and justified allocation procedure	V	V	
	The sum of the allocated inputs and outputs of a unit process shall be equal to the inputs and outputs of the unit process before allocation.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	Whenever several alternative allocation procedures are applicable, a sensitivity analysis shall be conducted to illustrate the consequences of the departure from the selected approach.	NA	NA	
	When PCR or CFP–PCR are developed in accordance with ISO/TS 14027, no further sensitivity analysis shall be required.	V	V	
6.4.6.2	**Allocation Procedure**			
	The CFP study shall include the identification of the processes shared with other product systems and deal with them in accordance with the stepwise procedure presented below: Step 1: Wherever possible, allocation should be avoided by 1) dividing the unit process to be allocated into two or more sub-processes separately and collecting the input and output data related to these sub-processes, or 2) expanding the product system to include the additional functions related to the co-products. Step 2: Where allocation cannot be avoided, the inputs and outputs of the system should be partitioned between its different products or functions in a way that reflects the underlying physical relationships between them. Step 3: Where physical relationship alone cannot be established or used as the basis for allocation, the inputs should be allocated between the products and the functions in a way that reflects other relationships between them. For example, input and output data might be allocated between co-products in proportion to the economic value of the products.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	When outputs include both co-products and waste, the ratio between co-products and waste shall be identified and the inputs and outputs shall be allocated to the co-products only.	NA	NA	
	Allocation procedures shall be uniformly applied to similar inputs and outputs of the product under study	V	V	
	Allocation procedures should therefore approximate, as much as possible, such fundamental input/output relationships and characteristics.	V	V	
6.4.6.3	**Allocation procedure for reuse and recycling**			
	Changes in the inherent properties of materials shall be taken into account. In addition, particularly for the recovery processes between the original and subsequent product system, the system boundary shall be identified and explained, ensuring that the allocation principles are observed as described in 6.4.6.2.	V	V	
	The allocation procedures for the shared unit processes should use, as the basis for allocation, the following order, if feasible: — physical properties (e.g. mass); — economic value (e.g. market value of the scrap material or recycled material in relation to market value of primary material); or — the number of subsequent uses of the recycled material	V	V	
6.4.7	**CFP performance tracking** When the CFP is intended to be used for CFP performance tracking, the following additional requirements for the quantification of the CFP shall be met:			
	a) the assessments shall be carried out for different points in time;	NA	NA	
	b) the change to the CFP over time shall be calculated for products with an identical functional or declared unit;	NA	NA	
	c) the change to the CFP over time shall be calculated using the same method and, if used, the same PCR, for all subsequent assessments (e.g. systems for selecting and managing data, system boundaries, allocation, identical characterization factors).	NA	NA	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	The time period between the points in time for which the CFP performance tracking is undertaken shall not be shorter than the time boundary for data as described in 6.3.6. It shall be described in the goal and scope of the CFP study.	NA	NA	
6.4.8	**Assessing the effect of the timing of GHG emissions and removals**			
	All GHG emissions and removals shall be calculated as if released or removed at the beginning of the assessment period without taking into account an effect of delayed GHG emissions and removals	V	V	
	Where GHG emissions and removals arising from the use stage (see 6.3.7) and/or from the end-of-life stage (see 6.3.8) occur over more than 10 years (if not otherwise specified in the relevant PCR) after the product has been brought into use, the timing of GHG emissions and removals relative to the year of production of the product shall be specified in the life cycle inventory	NA	NA	
	The effect of timing of the GHG emissions and removals from the product system (as CO2e), if calculated, shall be documented separately in the CFP study report.	NA	NA	
	The method used to calculate the effect of timing shall be stated and justified in the CFP study report.	NA	NA	
6.4.9	**Treatment of specific GHG emissions and removals**			
6.4.9.2	**Fossil and biogenic carbon**			
	Fossil GHG emissions and removals shall be included in the CFP or the partial CFP and documented separately as a net result	V	V	
	Biogenic GHG emissions and removals shall be included in the CFP or the partial CFP and should each be expressed separately	V	V	
	All relevant unit processes of the life cycle of biomass-derived products shall be included in the system under study, including, but not limited to, cultivation, production and harvesting of biomass	V	V	
6.4.9.3	**Biogenic carbon in products**			

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	When biogenic carbon is stored in a product for a specified time, this carbon shall be treated in accordance with the provisions in 6.4.8.	V	V	
	If a product's biogenic carbon content is calculated, it shall be documented separately in the CFP study report but it shall not be included in the result of CFP or partial CFP.	V	V	
	Information on biogenic carbon content shall be provided when performing cradle to gate studies, as this information may be relevant for the remaining value chain.	V	V	
6.4.9.4	**Electricity** The GHG emissions associated with the use of electricity shall include: — downstream emissions (e.g. the treatment of waste arising from the operation of nuclear electricity generators or treatment of ashes from coal fired electricity plants). — GHG emissions during generation of electricity, including losses during transmission and distribution; — GHG emissions arising from the life cycle of the electricity supply system, such as upstream emissions (e.g. the mining and transport of fuel to the electricity generator or the growing and processing of biomass for use as a fuel);	V	V	
6.4.9.4.2	**Internally generated electricity** When electricity is internally generated (e.g. on-site generated electricity) and consumed for a product under study and no contractual instruments have been sold to a third party, then the life cycle data for that electricity shall be used for that product.	NA	NA	
6.4.9.4.4	**Electricity from the grid** Life cycle data from a supplier-specific electricity product shall be used when the supplier is able to guarantee through a contractual instrument that the electricity product: — is tracked and redeemed, retired or cancelled by or on behalf of the reporting entity — is assured with a unique claim (see 5.12);	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	conveys the information associated with the unit of electricity delivered together with the characteristics of the generator; — is produced within the country, or within the market boundaries where consumption occurs if the grid is interconnected. — is as close as possible to the period to which the contractual instrument is applied and comprises a corresponding timespan;			
	When information on supplier specific electricity is not available, GHG emissions associated with the relevant electricity grid from which the electricity is obtained shall be used. The relevant grid shall reflect the electricity consumption of the related region, excluding any previously claimed attributed electricity. In case no electricity tracking system is in place, the selected grid shall reflect the electricity consumption of the region.	V	V	
	Some electricity attributes, such as green certificates are sold without direct coupling to the electricity itself. In some countries, parts of the electricity from renewable energy sources might be sold/exported as renewable electricity without being excluded from the supplied mix. For this reason, in such cases a sensitivity analysis applying the relevant consumption grid mix shall be conducted and reported in the CFP study report to demonstrate the difference in results of the electricity tracking instruments.	NA	NA	
6.4.9.5	**Land use change**			
	The GHG emissions and removals occurring as a result of direct land use change (dLUC) within the last 20 years shall be assessed in accordance with internationally recognized methods, such as the IPCC Guidelines for National Greenhouse Gas Inventories and included in the CFP	NA	NA	
	The net dLUC GHG emissions and removals shall be documented separately in the CFP study report.	NA	NA	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	If site-specific data are applied, they shall be transparently documented in the CFP study report. If a national approach is used, the data shall be based on a verified study, a peer reviewed study or similar scientific evidence and shall be documented in the CFP study report.	NA	NA	
	When the process under assessment causes changes in carbon stocks compared to the reference land use, the GHG emissions and removals associated with these changes shall be documented and assigned to the system under study. "Changes in carbon stocks" refers to changes in soil carbon and changes in above- and below-ground biomass over time.	NA	NA	
	The net changes shall be assigned to the system under study across the selected time period. The time period selected for analysis shall be documented and justified. At a minimum, it shall include at least one full rotation period for processes that involve growing crops or trees.	NA	NA	
	All choices and assumptions, including applied methodologies, shall be justified and documented in the CFP study report.	NA	NA	
6.4.9.6	**Land Use**			
	GHG emissions and removals occurring as a result of land use through changes in soil and biomass carbon stocks that are not the result of changes to management of land should be assessed and included in the CFP. If changes in soil and biomass carbon stocks are not assessed, this decision shall be justified in the CFP study report.	NA	NA	
	Where included, these emissions and removals shall be assessed in accordance with internationally recognized methods, such as the IPCC Guidelines for National Greenhouse Gas Inventories[17] and shall be documented separately in the CFP study report	NA	NA	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	When changes in management of land cause changes in soil and biomass carbon stocks, compared with the reference land use, the GHG emissions and removals shall be documented and assigned to the system under study.	NA	NA	
	The net changes in soil and biomass carbon stocks shall be assigned to the system under study across the selected time period. The time period selected for analysis shall be documented and justified. At a minimum, it shall include at least one full rotation period for processes that involve growing crops or trees.	NA	NA	
	If there is a net increase of soil or biomass carbon due to modified land use practices, the net increase shall be included in the CFP and the partial CFP only if measures are in place to address its permanence. If a national approach is used, the data shall be based on a verified study, a peer reviewed study or similar scientific evidence and shall be documented in the CFP study report.	NA	NA	
6.4.9.7	**Aircraft GHG emissions**			
	Aircraft transportation GHG emissions shall be included in the CFP and documented separately in the CFP study report. Where an aviation multiplier is used, the effect of this multiplier shall not be included in the CFP and shall be reported separately together with the source.	NA	NA	
6.5	**Impact Assessment**			
	In the LCIA phase of a CFP study, the potential climate change impact of each GHG emitted and removed by the product system shall be calculated by multiplying the mass of GHG released or removed by the 100-year GWP given by the IPCC in units of kg CO2e per kg emission (with carbon feedbacks, according to IPCC). Where GWP values are amended by the IPCC, the latest values shall be used in the CFP calculations if not otherwise stated and justified.	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	GWP for other time horizons and GTP, as given by the IPCC, may be used in addition to GWP 100 but should be reported separately.	NA	NA	
6.5.2	**Impact assessment of biogenic carbon**			
	Removals of CO2 into biomass shall be characterized in the LCIA as −1 kg CO2e/kg CO2 in the calculation of the CFP when entering the product system. Emissions of biogenic CO2 shall be characterized as +1 kg CO2e/kg CO2 of biogenic carbon in the calculation of the CFP. For fossil and biogenic methane, the characterization factors in accordance with the most recent IPCC report shall be used.	V	V	
6.6	**Interpretation of CFP or partial CFP**			
	The life cycle interpretation phase of a CFP study shall comprise the following steps: a) identification of the significant issues based on the results of the quantification of the CFP and partial CFP in accordance with LCI and LCIA phases; b) an evaluation that considers completeness, consistency and sensitivity analysis; c) the formulation of conclusions, limitations and recommendations	V	V	
	The interpretation shall:			
	include an assessment of uncertainty, including the application of rounding rules or ranges	V	V	
	identify and document the selected allocation procedures in the CFP study report in detail	V	V	
	identify the limitations of the CFP study (in accordance with, but not limited to, Annex A).	V	V	
	The interpretation should include:			

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	a sensitivity analysis of the significant inputs, outputs and methodological choices, including allocation procedures, in order to understand the sensitivity and uncertainty of the results	V	V	
	an assessment of the influence of alternative use profiles on the final result	V	V	
	an assessment of the influence of different end-of-life scenarios on the final result	V	V	
	an assessment of the consequences of recommendations [see 6.6 c)] on the final result	V	V	
7	**CFP study report**			
	The results and conclusions of the CFP study shall be documented in the CFP study report without bias. The results, data, methods, assumptions and the life cycle interpretation (see 6.6) shall be transparent and presented in sufficient detail to allow the reader to comprehend the complexities and trade-offs inherent in the CFP study.	OFI	V	The description of the life cycle stages in Sec. 4.3 should precede the presentation of results in Sec 4.2 - results in Tables 8-11 are presented by stages which have not been identified. **Text has been rearranged** Appendix 1 should include results for all products, including the 3 products evaluated in detail in Sec. 4.3. Also Table 37 and Table 38 are duplicate. **Updated** The discussion and interpretation of results recognizes the impacts associated with the packaging materials, and their relation to the overall product carbon footprints, however lacking a summary of the packaging materials for each product, it is somewhat confusing to follow **Some text is added to describe their impacts on page 30.** Revisions acknowledged

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	The type and format of the CFP study report shall be defined in the goal and scope definition phase of the CFP study. The CFP study report shall also allow the results and life cycle interpretation to be used in a manner consistent with the goals of the CFP study.	V	V	
7.2	**GHG values in the CFP study report**			
	Results of the quantification of the CFP or the partial CFP shall be documented in the CFP study report in mass of CO2e per functional or declared unit.	V	V	
	The following GHG values shall be documented separately in the CFP study report:			
	GHG emissions and removals linked to the main life cycle stages in which they occur, including the absolute and the relative contribution of each life cycle stage;	V	V	
	net fossil GHG emissions and removals;	V	V	
	biogenic GHG emissions and removals;	V	V	
	GHG emissions and removals resulting from dLUC;	V	V	
	GHG emissions resulting from aircraft transportation.	NA	NA	
	The following GHG values shall be documented separately in the CFP study report, if calculated:			
	GHG emissions and removals occurring as a result of iLUC	NA	NA	
	GHG emissions and removals occurring as a result of land use	NA	NA	
	results of the sensitivity analysis applying the relevant consumption grid mix, when applicable	NA	NA	
	biogenic carbon content of products	V	V	
	CFP calculated using GTP 100	NA	NA	
7.3	**Required information for the CFP study report**			
	functional or declared unit and reference flow (see 6.3.3);	V	V	
	system boundary, including — decision criteria concerning treatment of unit processes, considering their importance for the conclusions of the CFP study;	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	— the type of inputs and outputs of the system as elementary flows, and			
	list of important unit processes	V	V	
	data collection information, including data sources	V	V	
	the list of GHGs taken into account	NCR	V	List of GHGs included in assessment is missing- would be difficult to include all as we are using the openlca GWP method which includes all available flows. A note is made under section 2.6 Acknowledged. Considered included by reference
	the selected characterization factors	NCR	V	List of GWPs used is missing. Should be from IPCC AR6.Noted in section 2.6 Acknowledged. Considered included by reference
	the selected cut-off criteria and cut-offs	V	V	
	the selected allocation procedures	V	V	
	timing of GHG emission and removals (see 6.4.8 and 6.4.9.6), if applicable	NA	NA	
	description of data (see 6.3.5), including — assessment of data quality; — decisions concerning data, and	V	V	
	results of sensitivity analyses and uncertainty assessments	V	V	
	treatment of electricity (see 6.4.9.4), which should include information on the grid emission factor calculation and relevant grid specific constraints	V	V	
	results of the life cycle interpretation (see 6.6), including conclusions and limitations (see Annex A);	V	V	
	disclosure and justification of value choices that have been made in the context of decisions within the CFP study;	V	V	

Section	Specific requirements	Original finding (06/28/23)	Final finding (06/29/23)	Comments
	scope, and modified scope, if applicable, along with justifications and exclusions (see 6.3.2);	V	V	
	description of the stages of the life cycle, including a description of the selected use profiles and end-of-life scenarios, when applicable;	V	V	
	the assessment of influence of alternative use profiles and end-of-life scenarios on the final results;	V	V	
	time period for which the CFP is representative (see 6.3.6);	V	V	
	reference of the PCR applied or other supplementary requirements used in the study;	V	V	
	description of performance tracking (see 6.4.7), when applicable.	NA	NA	
7.4	**Optional information for the CFP study report** In addition to the items above, the following items should be considered for inclusion in the CFP study report:			
	conformity with Annex B;	NA	NA	
	graphical presentation of results of the CFP study.	NA	NA	