Scrap Tire Recovery and Recycling in Ontario, 2019–2022

CATRA 2021 Scrap Tire Life Cycle Assessment
Year-over-year update

Scope 3 Consulting, LLC

for CATRA / eTracks

scope3@scope3consulting.com

July 11, 2023

Contents

1 Introduction

This document reports the results of a life cycle assessment (LCA) of scrap tire management in the province of Ontario during the period from 2019–2022. The results are a continuation of an LCA study commissioned by the Canadian Association of Tire Recycling Agencies (CATRA) and conducted by Scope 3 Consulting LLC, based in Santa Barbara, CA, USA.

1.1 Study Basis

The study is based on a *material flow analysis* (MFA) of scrap tires and tire-derived products collected and managed under the scrap tire management program operated by eTracks. The MFA uses primary data provided by the agency, as well as statistics published by the Resource Productivity & Recovery Authority (RPRA), to estimate the quantity of scrap tires under management, their origins, processing locations, and ultimate fates. The MFA results are coupled to a *life cycle model* that is used to generate estimates of environmental impact. The life cycle model was used to author an ISO 14044-compliant *study report* which underwent critical panel review during 2021–2022. A public version of the critically reviewed report is available from CATRA.

A previous *provincial report* was prepared for eTracks which included provincial statistics through 2019 and eTracks data for 2020. The present report extends the study timeline through the year 2022 with updated data provided by eTracks. For further details and documentation of the study background and methodology, please consult the study report. For prior year provincial results, please consult the provincial report.

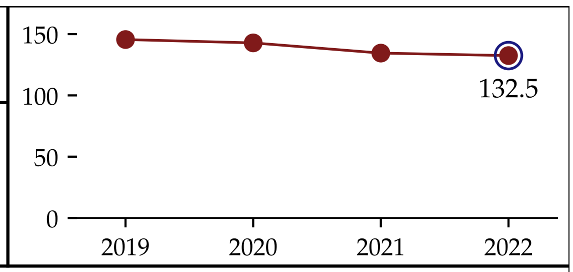
2 Key Performance Indicators

2.1 Total Processing

TIRES PROCESSED - ON

thousand metric tonnes (kt)

Value for 2022	132.5	kt
Change since 2021	-1.5	%
Change since 2019	-9.0	%
Cumulative Amount	555.3	kt



This is the amount of tires that enter processing in the province in a given year

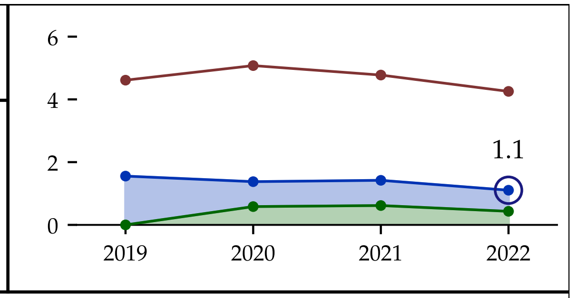
This chart shows the total amount of tires that were delivered to processors within the eTracks program during the years 2019–2022. 2019 data was based on reporting from RPRA. 2020–2022 data are based on collection and hauling data from eTracks.

2.2 Incurred Impacts

INCURRED EMISSIONS - ON

Global Warming Intensity (kg CO2e/PLT)

Reverse Logistics, 2022	0.4	kg CO2e/PLT
add Processor emissions, 2022	1.1	kg CO2e/PLT
add downstream, 2022	4.3	kg CO2e/PLT



Emissions intensity of all activities that occur during scrap tire collection (shaded green), processing (shaded blue), and downstream production (unshaded, includes further processing and transport to market). Values are reported per PLT-equivalent (10.5 kg) processed. Reported values include both direct and indirect emissions.

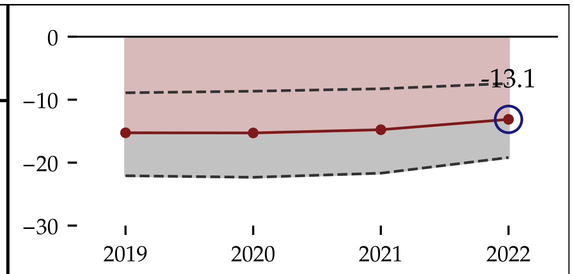
Incurred emissions are generated during collection and processing of scrap tires, as well as during further processing of tire-derived materials to make them into products. This chart shows global warming potential (GWP) impacts on a per-tire basis. These emissions can be attributed to the operation of the scrap tire management program in Ontario, and represent the environmental cost of operating the program. For 2019, no logistics data were available. The previous provincial report had used Quebec logistics as a proxy, but that was omitted for this study. Processor emissions include only up to crumb production, while downstream emissions include conversion of crumb into products.

2.3 Avoided Impacts

AVOIDED EMISSIONS - ON

Global Warming Intensity (kg CO2e/PLT)

Value for 2022	-13.1	kg CO2e/PLT
Change since 2021	-11.1	%
Change since 2019	-14.0	%
Weighted Average	-14.6	kg CO2e/PLT



Emissions intensity of all activities expected to be displaced through the marketing of scrap tire-derived products. Red shaded area indicates median range; dashed lines indicate uncertainty with respect to modeled displacement rate.

Potentially avoided emissions report the impact of producing goods and services that compete with tire-derived products in the marketplace. Under the assumption of displacement, some competing products were not produced because of the availability of tire-derived alternatives. Avoided impacts are shown as a negative score with an uncertainty range (see discussion of displacement uncertainty in Section 4.1). The producer responsibility framework in Ontario disincentivizes the use of tires for low-value dispositions such as TDA. Consequently, the displacement of primary products by tire-derived products leads to large avoided impacts. While collection was steady in

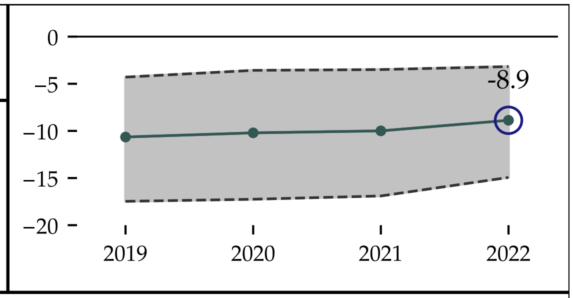
2022, reported crumb production was down compared to 2021, leading to a year-over-year reduction in both incurred and potentially avoided impacts per tire delivered to processing.

2.4 Net Impacts

NET EMISSIONS - ON

Global Warming Intensity (kg CO2e/PLT)

Value for 2022	-8.9	kg CO2e/PLT
Change since 2021	-11.2	%
Change since 2019	-16.7	%
Weighted Average	-10.0	kg CO2e/PLT



Estimated net environmental impact resulting from incurred and potentially avoided activities. A negative value indicates a potential environmental benefit. The net total is shown as the blue line, with the uncertainty due to modeled displacement rate shown by the dashed lines and shaded region.

Net emissions report the combination of (positive) incurred and (negative) avoided emissions. For Ontario, the modeling suggests that the operation of the program led to robust reductions in GHG emissions through the displacement of primary products. The net-negative score reduced in magnitude in 2022 because of reductions in reported crumb production.

2.5 KPI Table

Table 1 on the next page reports impacts across all six indicators measured for the study, over the time period 2019–2022. Impacts are reported on both per-PLT and Provincial basis. The net impact scores in three categories are also reported in terms of *equivalency factors*, which are meant to be more tangible and easy to understand:

- **Private vehicle travel**– net global warming impacts are compared to the use of a private vehicle weighing approximately 1,600 kg and having a fuel economy of 28.5 miles per gallon / 46 km per gallon / 8.2 liters per 100 km.
- **Diesel loader operation**– net smog impacts are compared to the operation of a 100 hp diesel loader for one hour at a low duty cycle (1.8-2 gal/hr).
- **Coal-fired electricity**– net particulate impacts are compared to the combustion of one kg of coal in a power plant to generate electricity.

For each of these impact categories, the net total impact scores (under the median displacement assumption) for scrap tire management are described in terms of the equivalency. If the net impacts are negative, the effect of the program is comparable to *avoiding* the reported amounts of each activity. *(Note: these different equivalencies are for comparison purposes only, and are not cumulative with each other.)*

Table 1: Tabulated KPI Scores for Ontario.

Indicator	unit	2019	2020	2021	2022
Global Warming Air					
Facility Impacts (per PLT eq)	kg CO2 eq	1.55	0.79	0.80	0.67
Total Incurred Impacts (per PLT eq)	kg CO2 eq	4.61	5.08	4.78	4.26
Net Impacts (per PLT eq)	kg CO2 eq	-10.65	-10.21	-10.00	-8.87
Net Impacts (Provincial)	kt CO2 eq	-147.6	-138.8	-128.0	-111.9
Equivalency (negative = avoided)					
Private vehicle travel	million km	-439.8	-413.7	-381.5	-333.5
1600 kg vehicle; Equivalent to 28.5 mpg | 46 kpg | 8.2 l/100km fuel economy					
Smog Air					
Facility Impacts (per PLT eq)	g O3 eq	108.6	62.4	63.6	57.7
Total Incurred Impacts (per PLT eq)	g O3 eq	354.8	375.1	362.1	325.0
Net Impacts (per PLT eq)	g O3 eq	-570.9	-645.3	-620.3	-556.8
Net Impacts (Provincial)	kt O3 eq	-7.914	-8.776	-7.946	-7.025
Equivalency (negative = avoided)					
Diesel loader operation	million hour	-4.354	-4.828	-4.371	-3.864
100 hp diesel engine with low load factor, 1.8-2 gallons per hour					
Human Health Particulates Air					
Facility Impacts (per PLT eq)	g PM2.5 eq	1.209	0.516	0.527	0.429
Total Incurred Impacts (per PLT eq)	g PM2.5 eq	2.888	2.836	2.731	2.394
Net Impacts (per PLT eq)	g PM2.5 eq	-8.211	-8.621	-8.325	-7.411
Net Impacts (Provincial)	t PM2.5 eq	-113.8	-117.3	-106.6	-93.5
Equivalency (negative = avoided)					
Coal-fired electricity	million kg	-102.4	-105.5	-96.0	-84.2
Burning 1 kg of coal in a typical coal power plant					
Acidification Air					
Facility Impacts (per PLT eq)	g SO2 eq	7.10	3.50	3.57	3.07
Total Incurred Impacts (per PLT eq)	g SO2 eq	21.15	22.03	20.63	18.69
Net Impacts (per PLT eq)	g SO2 eq	-45.83	-51.81	-49.61	-44.80
Net Impacts (Provincial)	t SO2 eq	-635.3	-704.7	-635.5	-565.2
Ozone Depletion Air					
Facility Impacts (per PLT eq)	mg CFC-11 eq	0.903	0.500	0.505	0.424
Total Incurred Impacts (per PLT eq)	mg CFC-11 eq	3.731	4.199	4.072	3.581
Net Impacts (per PLT eq)	mg CFC-11 eq	-7.899	-3.138	-3.259	-2.357
Net Impacts (Provincial)	kg CFC-11 eq	-109.5	-42.7	-41.7	-29.7
Eutrophication Air + Water					
Facility Impacts (per PLT eq)	g N eq	0.285	0.151	0.154	0.136
Total Incurred Impacts (per PLT eq)	g N eq	1.477	1.592	1.554	1.382
Net Impacts (per PLT eq)	g N eq	-3.226	-1.690	-1.692	-1.316
Net Impacts (Provincial)	t N eq	-44.72	-22.99	-21.67	-16.60

3 Scrap Tire Material Flows

We obtained detailed data about the collection and processing of scrap tires from eTracks, which we used to calculate the flow of scrap tires and tire-derived materials from the points of collection, through processing, to final products. Sankey diagrams showing reported scrap flows for 2021 and 2022 are found in Figure 1.

Data from 2020–2022 described collection, deliveries, and disposition of tires and tire-derived materials, culled tires, and retreading activities under the administration of eTracks. Changes in reporting may lead to differences in material flow results between 2021 and 2022.

3.1 Collection and Freight

Estimated freight requirements for scrap tire collections by year are shown in Table 2. The average shipping distance for each tire is also reported, and is calculated by dividing total freight requirements by total collections.

For 2019, no freight data was available. For 2020–2021, origin municipalities were not directly linked to processor deliveries, so an average transport distance was calculated for each hauler and applied to all trips by that hauler. For 2022, origin municipality was specified for each delivery, so freight requirements are more accurate. Vehicle size was estimated from delivery size for each reported processor delivery. A histogram for load sizes in 2022 is shown in Figure 2.

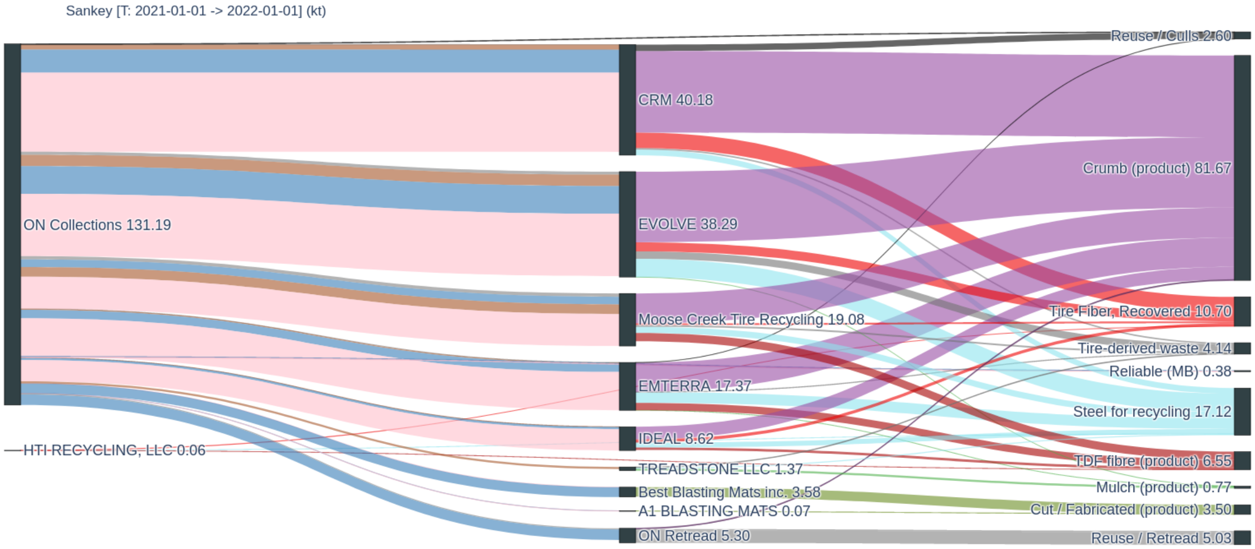
Table 2: Logistics requirements for scrap tire collection in Ontario (million tonne*km).

	2019	2020	2021	2022
Transport truck_20t	–	16.337	19.106	17.348
Transport truck_13t	–	4.481	3.883	3.085
Transport truck_5t	–	4.822	5.172	3.019
Transport truck_8t	–	5.596	4.113	2.234
Transport light_truck_1.5t	–	0.089	0.056	0.035
Total	0.000	31.325	32.331	25.720
Average Distance (km)	0.	238.	254.	196.

3.2 Processing Outputs

Tire-derived products in Ontario reported from all processing sites are shown in Table 3, and compared to total collections. Any tire-derived wastes reported are shown as well. Differences between tires collected and products generated are assumed to reflect changes in stock-on-hand at the processors. The reporting system for eTracks distinguishes between five different grades of tire-derived products, as well as wastes for resale, recycling, landfill, and energy recovery. TDP2 designated “from feedstock”, as well as TDP3, was assumed to be directed to tire-derived mulch

2021 - 134.5 kt



2022 - 132.5 kt

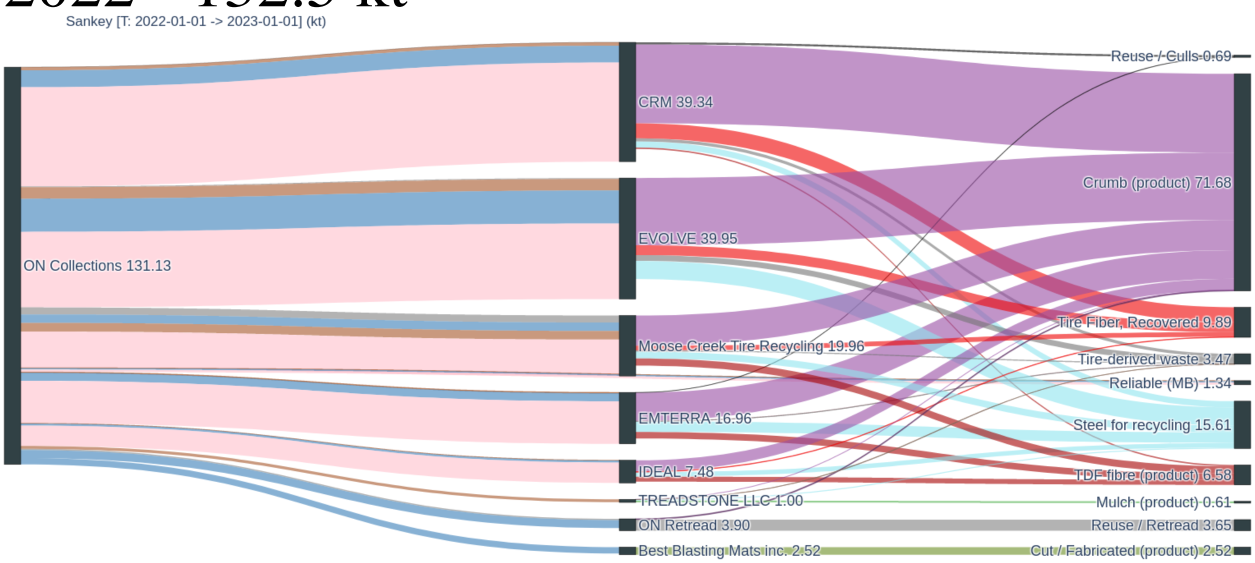


Figure 1: Scrap tire flows - 2021 (top) and 2022 (bottom). On the collection side, pink stripes correspond to PLT, blue stripes indicate MT, brown stripes indicate all types of smaller OTR, and grey strips indicate large and giant OTR.

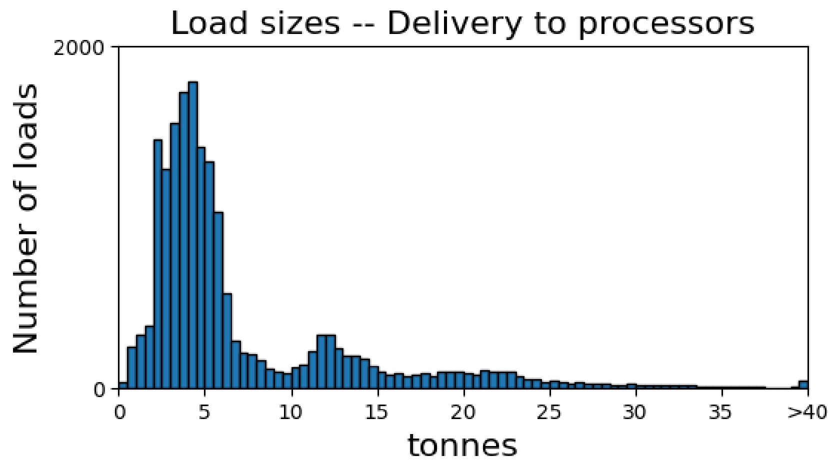


Figure 2: Histogram of load sizes delivered to processors in 2022.

based on the downstream customer. TDP4 was assumed to indicate blasting mats. No TDP5 was reported from in-province processors in 2021 or 2022 (TDA production from Reliable Tire Recycling in Manitoba was excluded from reporting). The results show that processors built up stocks-on-hand in 2022 by considerable amounts (16 kt), after drawing down these stocks substantially in 2020–2021.

Table 3: Tire-derived products in Ontario (tonnes).

	2019	2020	2021	2022
Crumb (product)	78,958	88,436	81,670	71,685
Retread / Remolding	17,215	5,158	5,032	3,648
Steel for recycling	15,350	18,125	17,125	15,608
Tire Fiber, Recovered	8,747	10,660	10,699	9,885
TDF fibre (product)	6,672	8,671	6,552	6,580
Cut / Fabricated (product)	6,111	4,489	3,499	2,520
Tire-derived waste	3,428	4,851	4,141	3,466
Reuse / Culls	2,536	2,409	2,595	693
Mulch (product)	126	14	771	611
Aggregate (product)	42	0	0	0
Total Products	139,184	142,814	132,083	114,696
Net Facility Stock Change	6,365	-10,959	-4,716	16,435
Total Collections	145,549	131,854	127,367	131,132

3.3 Displaced Products

The products potentially displaced by tire-derived products are shown in Table 4. The amounts of potentially displaced products were calculated according to the displacement methodology described in the study report (Section 3.5) and in the provincial report (Appendix B).

Downstream processing of tire-derived crumb was determined based on a matrix of information provided by eTracks about crumb buyers in 2020. According to the data provided, just over 45 percent was used to make molded products (displacing 80 percent synthetic rubber / 20 percent concrete), 40 percent of crumb was destined for use as athletic infill (displacing both primary crumb and acrylic-coated sand), and most of the rest was used for rubberized asphalt production. This market split was applied for all years of the study. Recovered fibres were not assumed to displace any primary production.

Table 4: Primary products displaced by tire-derived products in Ontario, as modeled.

		2019	2020	2021	2022
Heat, coal, in cement kiln, displaced	MJ	1.85e+08	2.4e+08	1.81e+08	1.82e+08
Primary rubber, in product, displaced	kg	2.15e+07	2.41e+07	2.23e+07	1.95e+07
Concrete product, displaced	kg	1.57e+07	1.76e+07	1.63e+07	1.43e+07
Acrylic coated sand, displaced	kg	1.38e+07	1.55e+07	1.43e+07	1.25e+07
New tire, displaced	kg	1.2e+07	4.01e+06	3.97e+06	2.58e+06
Steel, displaced	kg	1.15e+07	1.36e+07	1.28e+07	1.17e+07
Sand, displaced	kg	3.37e+06	3.53e+06	4.71e+06	4.01e+06
Primary rubber, polybutadiene	kg	1.78e+06	1.99e+06	1.84e+06	1.61e+06
Wood Chips, displaced	kg	1.58e+06	1.66e+06	2.21e+06	1.88e+06
Roadway mix and service lifetime	m	1.11e+06	1.24e+06	1.15e+06	1.01e+06
Silage weight, displaced	kg	2.29e+05	1.68e+05	1.31e+05	9.45e+04
Aggregate, gravel, displaced	kg	5.36e+04	0	0	0
Blast Mat, steel cord, displaced	m2	2.23e+04	1.64e+04	1.28e+04	9.19e+03

4 Results and Interpretation

This section reports quantitative results of the life cycle impact assessment for the recent years. Results have two types of contributions: positive-valued (incurred) contributions and negative-valued (displaced) contributions.

- Positive-valued contributions result from direct actions taken within the scrap tire management system that have environmental impacts. These include emissions from transportation of tires from collection centers to processors, direct emissions from facility operations, upstream emissions from materials used by processors, and emissions from electricity generation.
- Negative-valued contributions represent emissions associated with the production of products that compete with tire-derived products in the marketplace, and so are potentially avoided by the use of scrap tires.

The sum of these positive and negative impacts indicates the potential net environmental impacts that could occur if tire-derived products are displacing primary products.

4.1 Uncertainty

The LCA model includes uncertainty in the recycling process inventories, and in the market effects of tire-derived products. The charts in this section indicate uncertainty in the results by including error bars or "whiskers" that extend upward and downward from an indicated result or a net total. The size of the error bar indicates the uncertainty in the estimate.

Uncertainty is applied to the following parameters (please consult the study report, Section 4.2, for details):

- In the displacement relationship between tire-derived products and the products with which they compete, we apply uncertainty to the amount of displacement according to the type of product being displaced;
- Inventory parameters that describe scrap tire processing, such as electricity and diesel
- Freight requirements for scrap tire collection;
- Aspects of tire composition, including biogenic carbon and zinc content.

Each unit of tire-derived product is considered to replace anywhere between 0.2–1 equivalent unit of displaced product, depending on the nature of the product. This is called the displacement rate. Error bars on the negative-valued contributions reflect this uncertainty only, while error bars on net results reflect all uncertainties. Displacement relationships are reported in Appendix B of the provincial report.

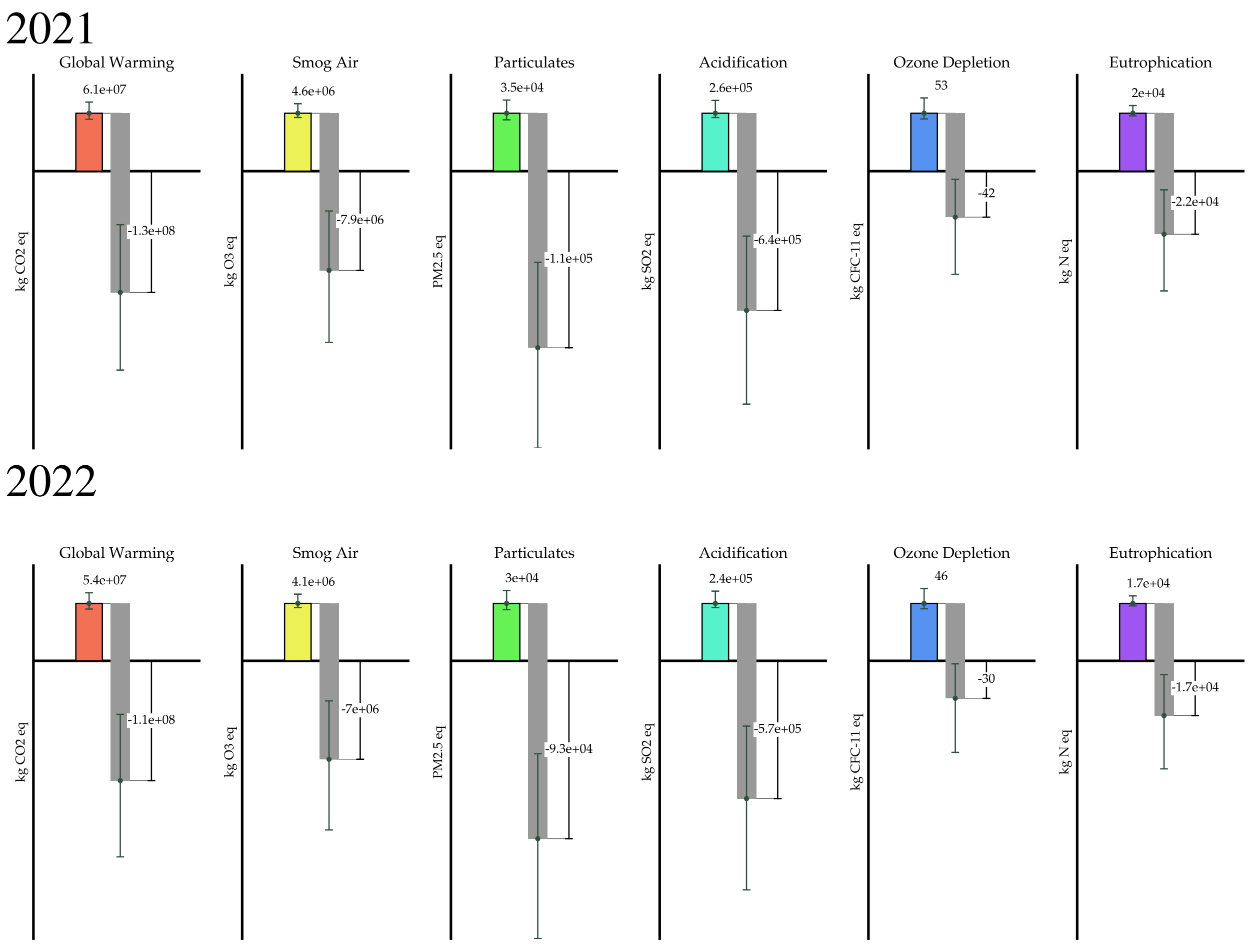


Figure 3: Total impacts incurred and avoided due to scrap tire management during 2021 (top) and 2022 (bottom). The colored bar in each panel indicates incurred emissions in the named category, while the gray bar indicates potentially avoided emissions in that category.

The results are shown graphically in Figure 3. The same data can be found in tabular form in Tables 5 and 6. The most-negative point on each bar indicates the most favorable displacement assumption (i.e. a tonne of tires displaces nearly a tonne of primary product).

Due to Ontario's program design, most tires were recycled into high-value uses, particularly crumb, which have the highest potential to lead to avoided burdents. As a consequence, the environmental performance of eTracks' activites showed large net improvements were likely in four out of six indicators (global warming, smog, particulates, and acidification) and modest improvements likely in eutrophication and ozone depletion. These improvements were robust to uncertainty in the displacement rate and in processing impacts.

Table 5: Total impacts incurred, total impacts avoided, and net total impacts due to tire recycling in Ontario during 2021.

	Unit	Incurred Impacts	Avoided Impacts	Net Total
Global Warming Air	kg CO2 eq	6.1e+07	-1.9e+08	-1.3e+08
Smog Air	kg O3 eq	4.6e+06	-1.3e+07	-7.9e+06
Human Health Particulates Air	PM2.5 eq	3.5e+04	-1.4e+05	-1.1e+05
Acidification Air	kg SO2 eq	2.6e+05	-9e+05	-6.4e+05
Ozone Depletion Air	kg CFC-11 eq	53	-94	-42
Eutrophication Air + Water	kg N eq	2e+04	-4.2e+04	-2.2e+04

Table 6: Total impacts incurred, total impacts avoided, and net total impacts due to tire recycling in Ontario during 2022.

	Unit	Incurred Impacts	Avoided Impacts	Net Total
Global Warming Air	kg CO2 eq	5.4e+07	-1.7e+08	-1.1e+08
Smog Air	kg O3 eq	4.1e+06	-1.1e+07	-7e+06
Human Health Particulates Air	PM2.5 eq	3e+04	-1.2e+05	-9.3e+04
Acidification Air	kg SO2 eq	2.4e+05	-8e+05	-5.7e+05
Ozone Depletion Air	kg CFC-11 eq	46	-75	-30
Eutrophication Air + Water	kg N eq	1.7e+04	-3.4e+04	-1.7e+04

4.2 Stage Contribution Analysis

The impact category scores are disaggregated into different stages in Figure 4. Thes chart enables a visual comparison of the relative contributions of different parts of the scrap tire management system in each impact category. Figure 5 shows the same information on a year-over-year basis for 2019–2022, providing a depiction of how the results changed over time.

The results show that molded products, reduced road maintenance impacts, and displaced tires through reuse and retreading are the most substantial contributors to the avoided burdens, while processing impacts are the largest contributors to incurred burdens.

Avoided burdens are somewhat smaller in 2022, resulting from processors shipping less material. The 2019 year is somewhat anomalous because it is based on RPRA reporting, but it shows the largest savings due to displaced tire production because of higher volumes of retreading (17 kt).

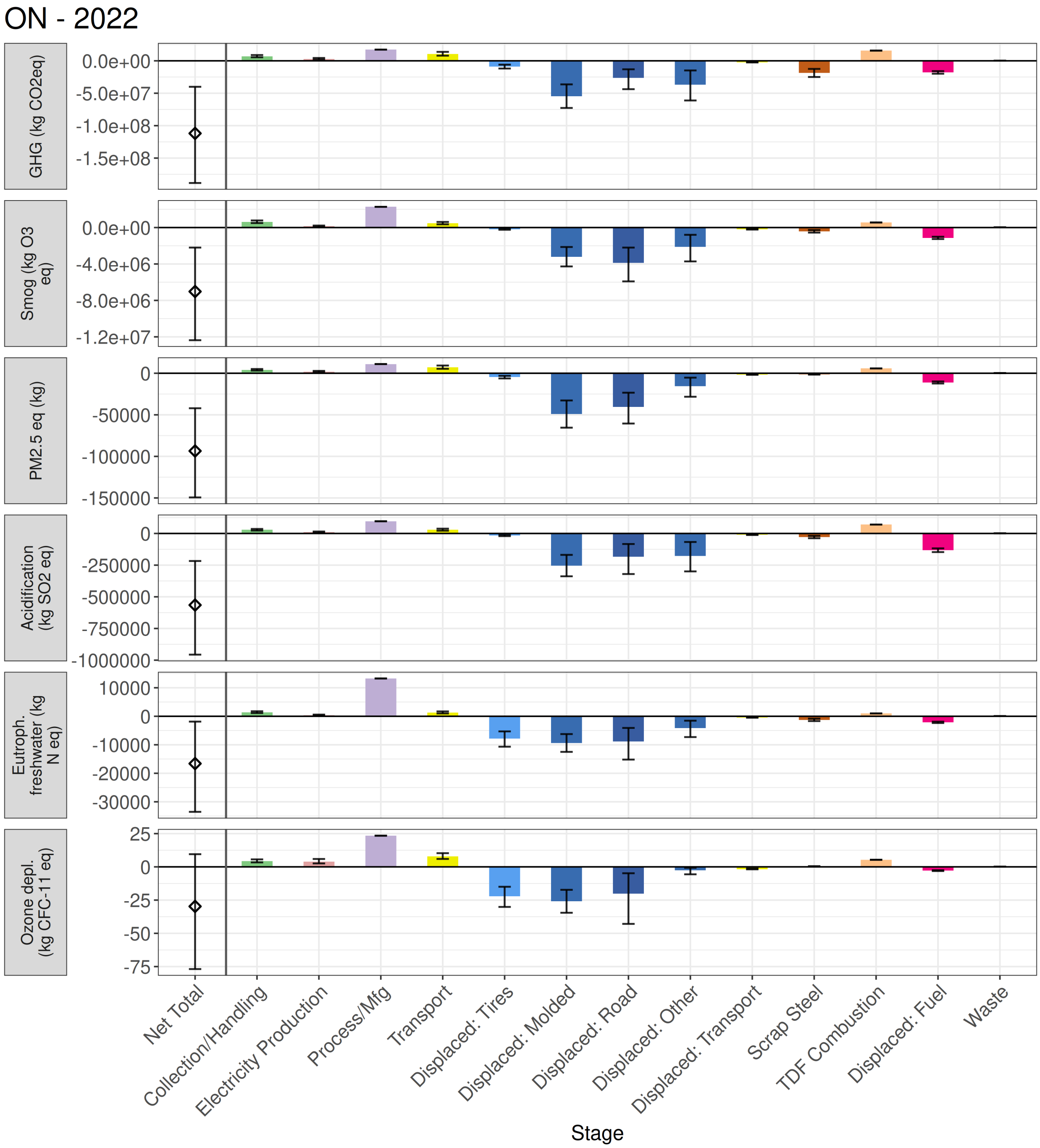


Figure 4: Province-wide environmental impacts of managing scrap tires in ON during 2022, stage contribution analysis. Net impacts, which take into account avoided production due to tire recycling, are indicated by the diamond symbol on the left. Colored bars show contributions by individual stages in the tire recycling system. Modeled uncertainty is indicated for each bar.

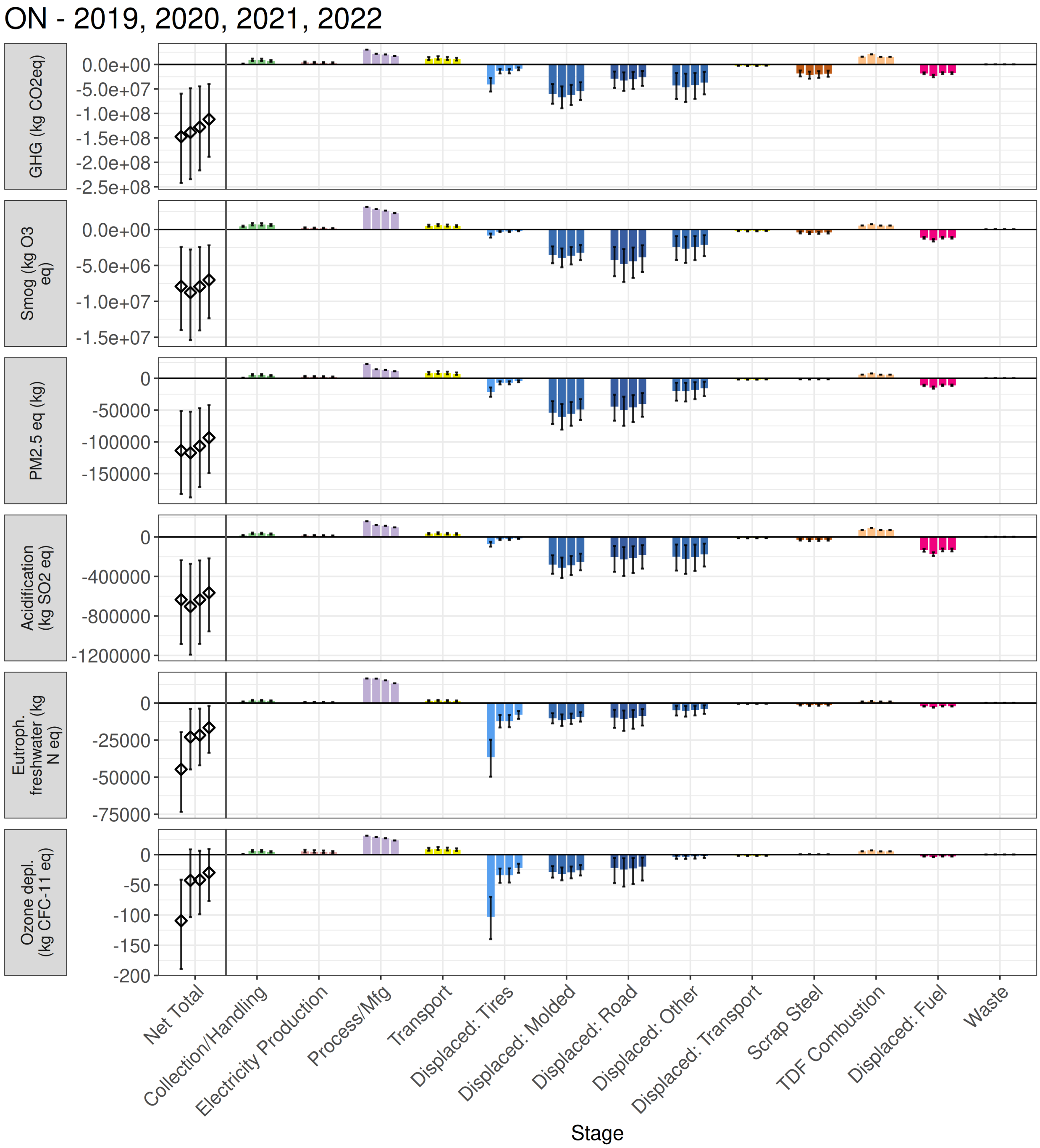


Figure 5: Province-wide environmental impacts of managing scrap tires in ON during 2019–2022, stage contribution analysis, by year. Net impacts, which take into account avoided production due to tire recycling, are indicated by the diamond symbol on the left. Colored bars show contributions by individual stages in the tire recycling system. Modeled uncertainty is indicated for each bar.