Scrap Tire Recovery and Recycling in Manitoba, 2018–2022

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

Scope 3 Consulting, LLC

for CATRA / TSM

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 Manitoba during the period from 2018–2022. 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 Tire Stewardship Manitoba (TSM). The MFA uses primary data provided by the agency 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 TSM which included province-specific results through the year 2020. The present report extends the study timeline through the year 2022 with updated data provided by TSM. 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.

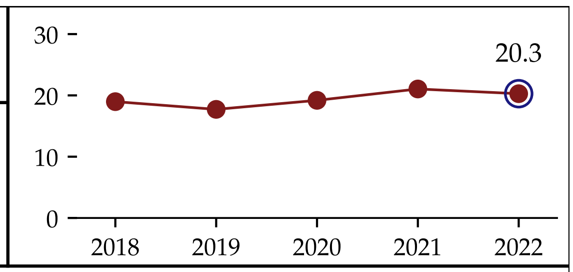
2 Key Performance Indicators

2.1 Total Processing

TIRES PROCESSED - MB

thousand metric tonnes (kt)

Value for 2022	20.3	kt
Change since 2021	-3.7	%
Change since 2018	+6.8	%
Cumulative Amount	97.2	kt



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

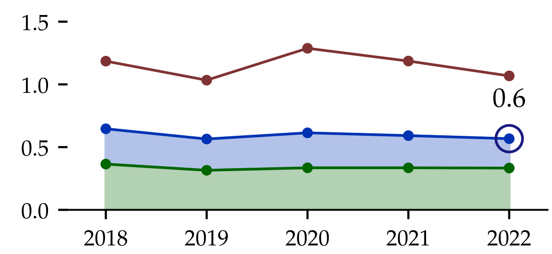
This chart shows the total amount of tires that were delivered to processors within the TSM program during the years 2018–2022. The quantity of tires processed annually has remained roughly constant over the study period with small fluctuations around a slight upward trend.

2.2 Incurred Impacts

INCURRED EMISSIONS - MB

Global Warming Intensity (kg CO2e/PLT)

Reverse Logistics, 2022	0.3	kg CO2e/PLT
add Processor emissions, 2022	0.6	kg CO2e/PLT
add downstream, 2022	1.1	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 Manitoba, and represent the environmental cost of operating the program.

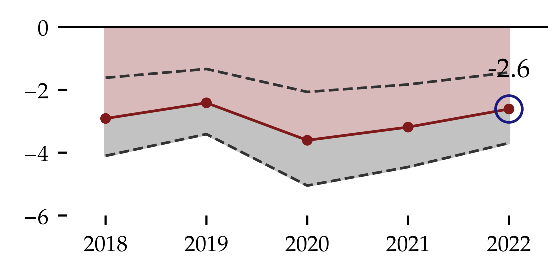
Incurred impacts in Manitoba are relatively small, because of three factors: low overall transport distance, low-carbon electricity grids, and a prevalence of tire-derived products that require minimal processing energy (aggregate, blast mats, sidewalls). Emissions per PLT-equivalent peaked in 2020 along with a maximum amount of tires processed into higher-value crumb.

2.3 Avoided Impacts

AVOIDED EMISSIONS - MB

Global Warming Intensity (kg CO2e/PLT)

Value for 2022	-2.6	kg CO2e/PLT
Change since 2021	-18.1	%
Change since 2018	-10.3	%
Weighted Average	-3.0	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.

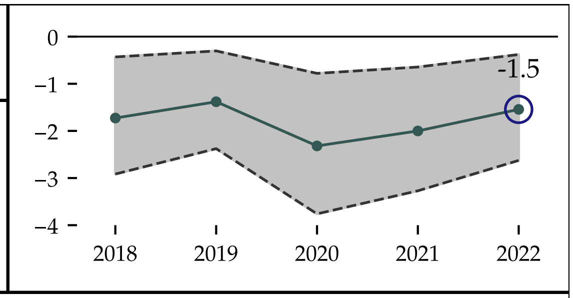
Potentially avoided emissions report the impact of producing goods and services that compete with tire-derived products in the marketplace. Under the assumption of displacement, some competing products were not produced because of the availability of tire-derived alternatives. Avoided impacts are shown as a negative score with an uncertainty range (see discussion of displacement uncertainty in Section 4.1). In Manitoba, avoided impacts are dominated by displaced primary rubber, molded rubber products, and steel blast mats. The avoided impacts per PLT equivalent trended down toward the later study years as an increasing share of tires were diverted to uses that displaced gravel, which has minimal environmental benefits.

2.4 Net Impacts

NET EMISSIONS - MB

Global Warming Intensity (kg CO2e/PLT)

Value for 2022	-1.5	kg CO2e/PLT
Change since 2021	-22.9	%
Change since 2018	-10.6	%
Weighted Average	-1.8	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 Manitoba, the modeling suggests that the operation of the program led to reduced GHG emissions in every year of the study, although the net score has been trending toward break-even as increasing shares of tires were used for low-value uses.

2.5 KPI Table

Table 1 on the next page reports impacts across all six indicators measured for the study, over the time period 2018–2022. 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 Manitoba.

Indicator	unit	2018	2019	2020	2021	2022
Global Warming Air						
Facility Impacts (per PLT eq)	kg CO2 eq	0.281	0.249	0.279	0.257	0.234
Total Incurred Impacts (per PLT eq)	kg CO2 eq	1.185	1.034	1.288	1.186	1.068
Net Impacts (per PLT eq)	kg CO2 eq	-1.727	-1.381	-2.318	-2.001	-1.543
Net Impacts (Provincial)	kt CO2 eq	-3.121	-2.331	-4.237	-4.010	-2.980
Equivalency (negative = avoided)						
Private vehicle travel	million km	-9.30	-6.95	-12.63	-11.95	-8.88
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	38.9	38.0	37.8	37.7	36.7
Total Incurred Impacts (per PLT eq)	g O3 eq	78.8	72.4	83.3	79.5	74.2
Net Impacts (per PLT eq)	g O3 eq	-85.2	-66.7	-126.0	-107.0	-77.4
Net Impacts (Provincial)	t O3 eq	-154.1	-112.5	-230.3	-214.4	-149.4
Equivalency (negative = avoided)						
Diesel loader operation	thousand hour	-84.8	-61.9	-126.7	-117.9	-82.2
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	0.227	0.211	0.225	0.210	0.188
Total Incurred Impacts (per PLT eq)	g PM2.5 eq	0.807	0.709	0.883	0.813	0.734
Net Impacts (per PLT eq)	g PM2.5 eq	-0.916	-0.717	-1.115	-0.906	-0.736
Net Impacts (Provincial)	t PM2.5 eq	-1.656	-1.209	-2.037	-1.817	-1.422
Equivalency (negative = avoided)						
Coal-fired electricity	million kg	-1.491	-1.088	-1.834	-1.635	-1.280
Burning 1 kg of coal in a typical coal power plant						
Acidification Air						
Facility Impacts (per PLT eq)	g SO2 eq	1.623	1.552	1.577	1.540	1.474
Total Incurred Impacts (per PLT eq)	g SO2 eq	4.180	3.764	4.566	4.283	3.871
Net Impacts (per PLT eq)	g SO2 eq	-5.593	-4.551	-7.840	-6.742	-5.027
Net Impacts (Provincial)	t SO2 eq	-10.11	-7.68	-14.33	-13.51	-9.71
Ozone Depletion Air						
Facility Impacts (per PLT eq)	mg CFC-11 eq	0.249	0.250	0.224	0.211	0.180
Total Incurred Impacts (per PLT eq)	mg CFC-11 eq	1.135	1.015	1.287	1.186	1.031
Net Impacts (per PLT eq)	mg CFC-11 eq	-0.031	0.280	0.183	0.278	0.257
Net Impacts (Provincial)	g CFC-11 eq	-56.3	472.4	334.2	556.8	495.4
Eutrophication Air + Water						
Facility Impacts (per PLT eq)	mg N eq	129.5	133.6	114.6	112.1	101.8
Total Incurred Impacts (per PLT eq)	mg N eq	371.3	341.3	434.6	404.8	345.3
Net Impacts (per PLT eq)	mg N eq	-151.3	-14.5	-135.4	-78.2	-51.9
Net Impacts (Provincial)	kg N eq	-273.5	-24.5	-247.5	-156.7	-100.1

3 Scrap Tire Material Flows

We obtained detailed data about the collection and processing of scrap tires from TSM, 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.

TSM provided documents that summarized the collection and processing claims received by the agency for 2021–2022. This information was added to data already collected for 2018–2020.

TSM supplied two forms of logistics data: collection claims, grouped monthly by provincial region and tire type; and collection records from retailers throughout the province, including a breakdown by tire type and transport distances. The retailer reports accounted for about two-thirds of reported collections. For the remainder, we assumed average distances for each provincial zone, based on population density.

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.

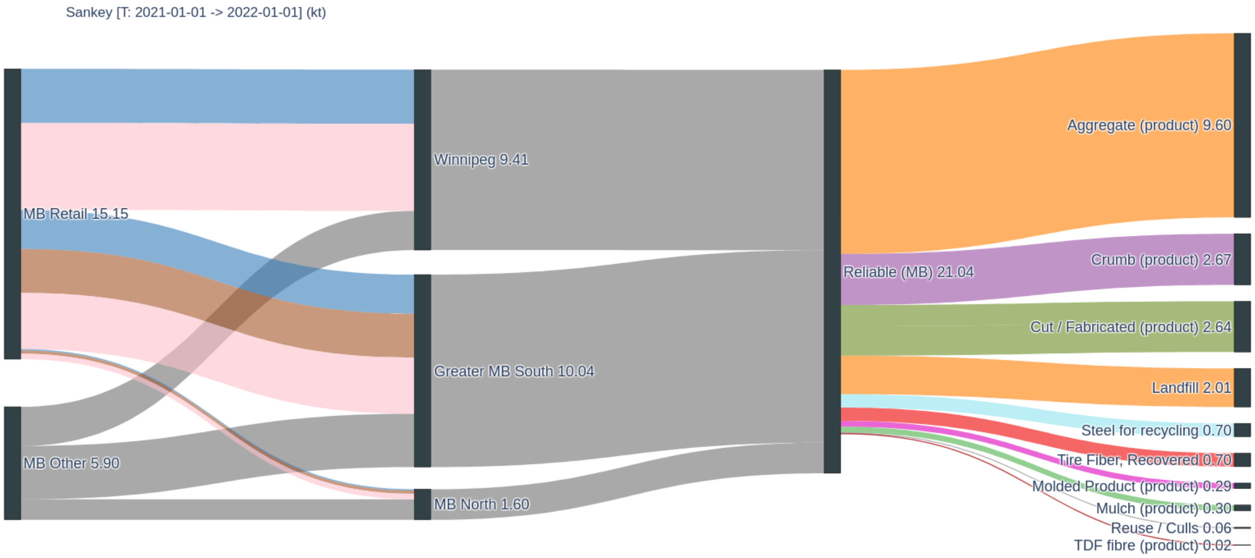
Overall, Manitoba has the lowest average freight distance of any province in the study. This is due to the high concentration of tires generated in Winnipeg, close to the processor. In 2022, around 1,300 t of tires were imported from Alberta and Ontario. We assumed Calgary and Thunder Bay, respectively, for the origins of these shipments. This accounts for the bump in average distance for 2022.

Freight modes (e.g. load and truck sizes) were not reported in the data provided by the agency. For these, we used records provided by Reliable Tire Recycling for phase 1 of the study, covering 2017. These records allowed us to estimate the distribution of tire deliveries by load size and zone.

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

	2018	2019	2020	2021	2022
Transport truck_20t	0.550	0.275	0.296	0.358	1.251
Transport truck_13t	1.420	1.046	1.299	1.470	1.051
Transport truck_8t	0.771	0.730	0.800	0.825	0.697
Transport truck_5t	0.088	0.085	0.089	0.098	0.095
Transport light_truck_1.5t	0.003	0.003	0.003	0.003	0.003
Total	2.832	2.138	2.486	2.755	3.097
Average Distance (km)	149.	121.	133.	131.	153.

2021 - 21.0 kt



2022 - 20.3 kt

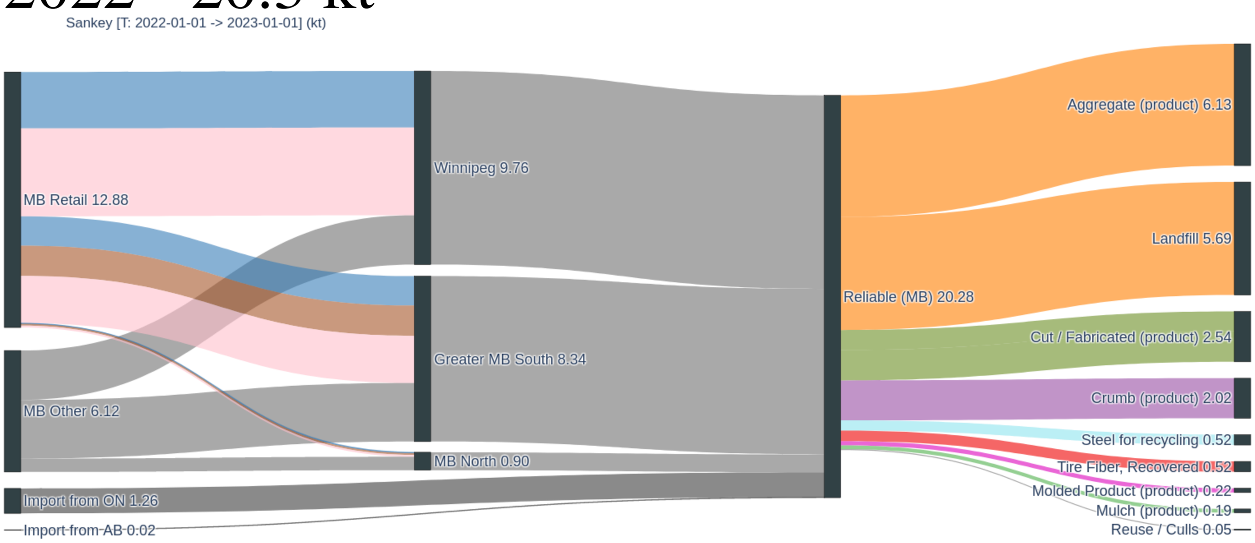


Figure 1: Scrap tire flows - 2021 (top) and 2022 (bottom).

3.2 Processing Outputs

Tire-derived products in Manitoba 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. Steel and fiber recovery were not directly reported by processors, so these amounts were estimated as 15% each of whole tire weight used for crumb and molded products. Cut and fabricated includes both sidewalls (55%) and blasting mats (45%).

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

	2018	2019	2020	2021	2022
Aggregate (product)	10,034	10,135	9,216	9,600	6,133
Cut / Fabricated (product)	2,739	2,033	3,105	2,643	2,536
Crumb (product)	1,769	1,411	2,669	2,670	2,016
Molded Product (product)	371	397	278	291	217
Steel for recycling	459	387	632	635	479
Tire Fiber, Recovered	459	387	632	635	479
Mulch (product)	847	344	356	303	188
Landfill Cover	346	324	2,150	2,011	5,695
Reuse / Culls	284	14	130	56	53
Tubes / other	33	0	0	0	0
TDF fibre (product)	0	0	25	24	0
Total Products	17,341	15,433	19,191	18,867	17,796
Net Facility Stock Change	1,637	2,286	-531	2,177	2,479
Total Collections	18,978	17,719	18,660	21,045	20,275

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).

Displaced products were dominated by gravel, sand, and concrete. However, higher value products were also displaced, including primary and molded rubber and blasting mats. Environmental benefits were also driven by higher-value products, including scrap steel recycling, displaced steel production from blasting mats, and displaced rubber and concrete.

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

		2018	2019	2020	2021	2022
Aggregate, gravel, displaced	kg	1.32e+07	1.33e+07	1.45e+07	1.48e+07	1.51e+07
Sand, displaced	kg	1.62e+06	6.58e+05	6.8e+05	5.79e+05	3.6e+05
Concrete product, displaced	kg	1.61e+06	1.4e+06	2.1e+06	2.11e+06	1.59e+06
Silage weight, displaced	kg	1.16e+06	8.39e+05	1.28e+06	1.09e+06	1.05e+06
Wood Chips, displaced	kg	7.63e+05	3.1e+05	3.2e+05	2.73e+05	1.7e+05
Primary rubber, polybutadiene	kg	5.97e+05	4.76e+05	9.01e+05	9.01e+05	6.8e+05
Primary rubber, in product, displaced	kg	4.7e+05	4.09e+05	6.14e+05	6.18e+05	4.66e+05
Steel, displaced	kg	3.44e+05	2.91e+05	4.74e+05	4.76e+05	3.59e+05
New tire, displaced	kg	7.1e+04	3.47e+03	3.26e+04	1.4e+04	1.34e+04
Blast Mat, steel cord, displaced	m2	4.73e+03	3.51e+03	5.37e+03	4.57e+03	4.38e+03
Heat, coal, in cement kiln, displaced	MJ	0	0	6.93e+05	6.7e+05	0

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

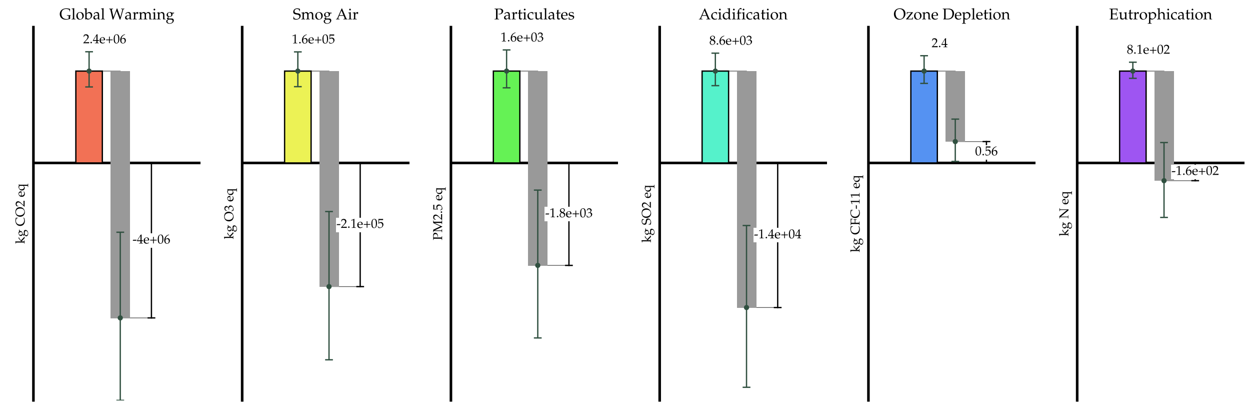
The LCA model includes uncertainty in the recycling process inventories, and in the market effects of tire-derived products. The charts in this section indicate uncertainty in the results by including error bars or "whiskers" that extend upward and downward from an indicated result or a net total. The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

2021



2022

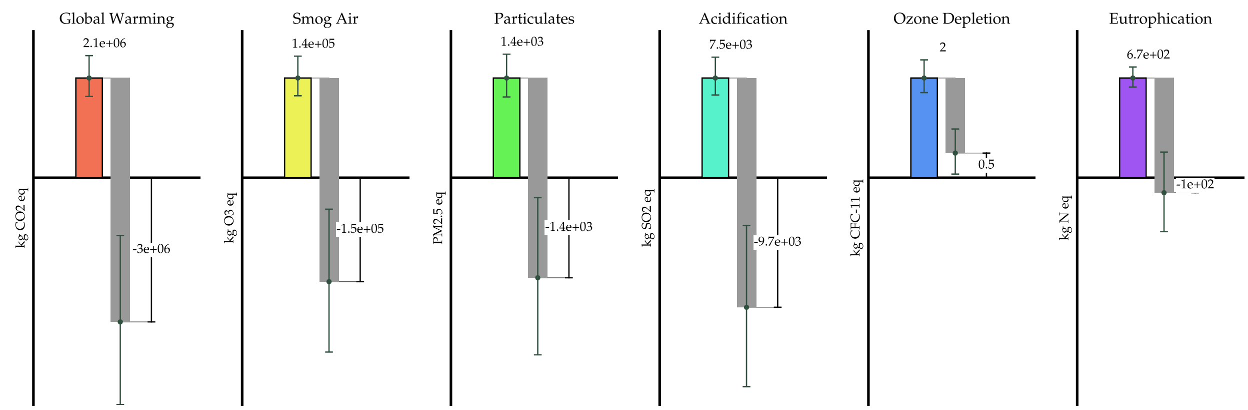


Figure 2: Total impacts incurred and avoided due to scrap tire management during 2021 (top) and 2022 (bottom). The colored bar in each panel indicates incurred emissions in the named category, while the gray bar indicates potentially avoided emissions in that category.

The results are shown graphically in Figure 2. 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).

In three categories (global warming, smog, and acidification), the favorable result is robust to modeled variations in the displacement rate and processing impacts. This means that even if the least-favorable assumptions were applied, the results would still show a net improvement. Particulate emissions are also favorable, with the break-even point just barely within the uncertainty. For eutrophication, incurred and avoided impacts are balanced, and for ozone depletion, incurred impacts modestly exceed avoided impacts.

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

	Unit	Incurred Impacts	Avoided Impacts	Net Total
Global Warming Air	kg CO2 eq	2.4e+06	-6.4e+06	-4e+06
Smog Air	kg O3 eq	1.6e+05	-3.7e+05	-2.1e+05
Human Health Particulates Air	PM2.5 eq	1.6e+03	-3.4e+03	-1.8e+03
Acidification Air	kg SO2 eq	8.6e+03	-2.2e+04	-1.4e+04
Ozone Depletion Air	kg CFC-11 eq	2.4	-1.8	0.56
Eutrophication Air + Water	kg N eq	8.1e+02	-9.7e+02	-1.6e+02

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

	Unit	Incurred Impacts	Avoided Impacts	Net Total
Global Warming Air	kg CO2 eq	2.1e+06	-5e+06	-3e+06
Smog Air	kg O3 eq	1.4e+05	-2.9e+05	-1.5e+05
Human Health Particulates Air	PM2.5 eq	1.4e+03	-2.8e+03	-1.4e+03
Acidification Air	kg SO2 eq	7.5e+03	-1.7e+04	-9.7e+03
Ozone Depletion Air	kg CFC-11 eq	2	-1.5	0.5
Eutrophication Air + Water	kg N eq	6.7e+02	-7.7e+02	-1e+02

4.2 Stage Contribution Analysis

The impact category scores are disaggregated into different stages in Figure 3. Thes chart enables a visual comparison of the relative contributions of different parts of the scrap tire management system in each impact category. Figure 4 shows the same information on a year-over-year basis for 2018–2022, providing a depiction of how the results changed over time.

"Displaced: Other", which includes aggregates, steel wire, cement, and others was the largest driver of improvements, along with molded rubber products and recycled scrap steel. Better performance in eutrophication and ozone depletion categories can be driven by increased culling and reuse of tires, as seen in the data for 2018 (Figure 4).

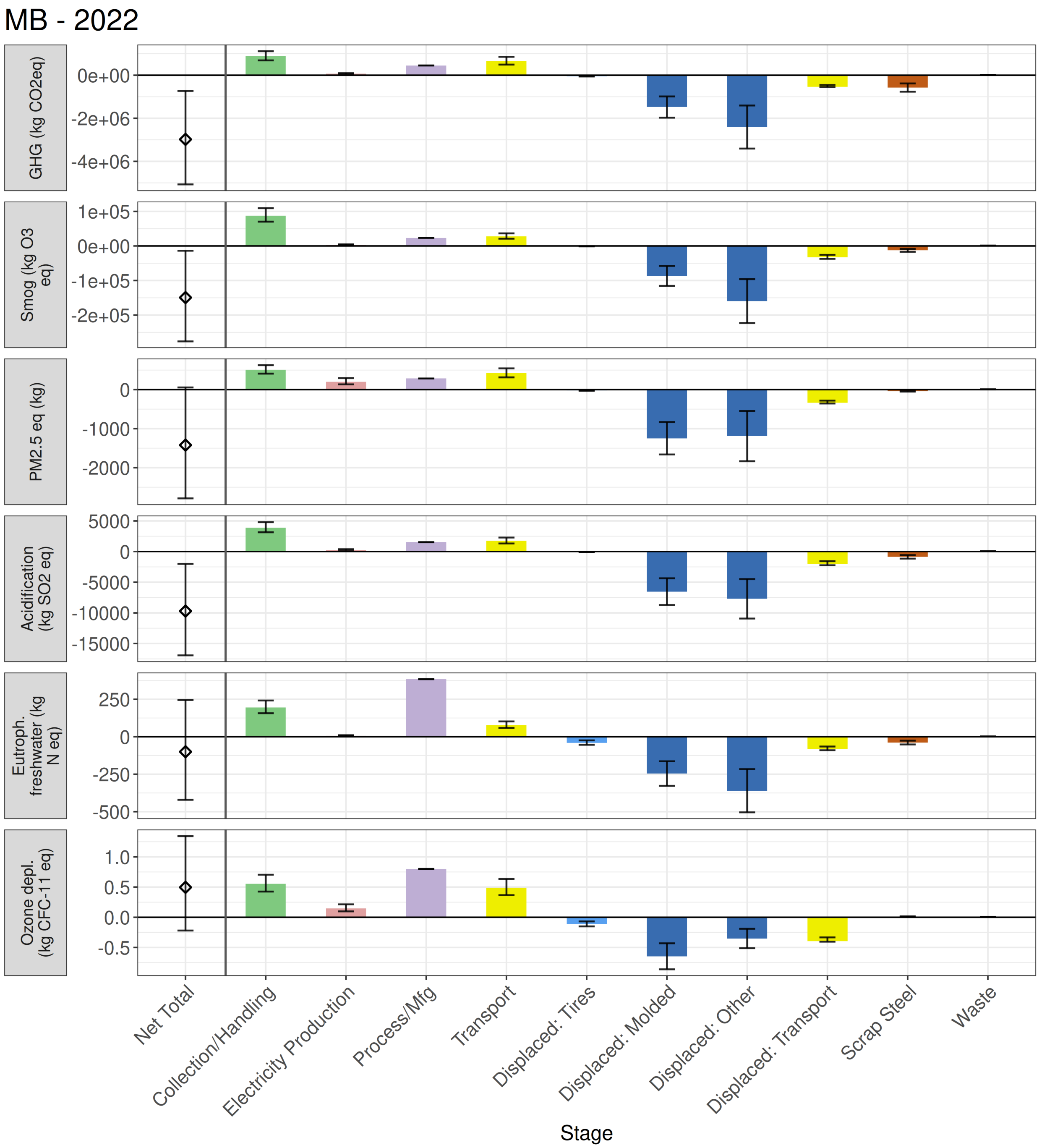


Figure 3: Province-wide environmental impacts of managing scrap tires in MB during 2022, stage contribution analysis. Net impacts, which take into account avoided production due to tire recycling, are indicated by the diamond symbol on the left. Colored bars show contributions by individual stages in the tire recycling system. Modeled uncertainty is indicated for each bar.

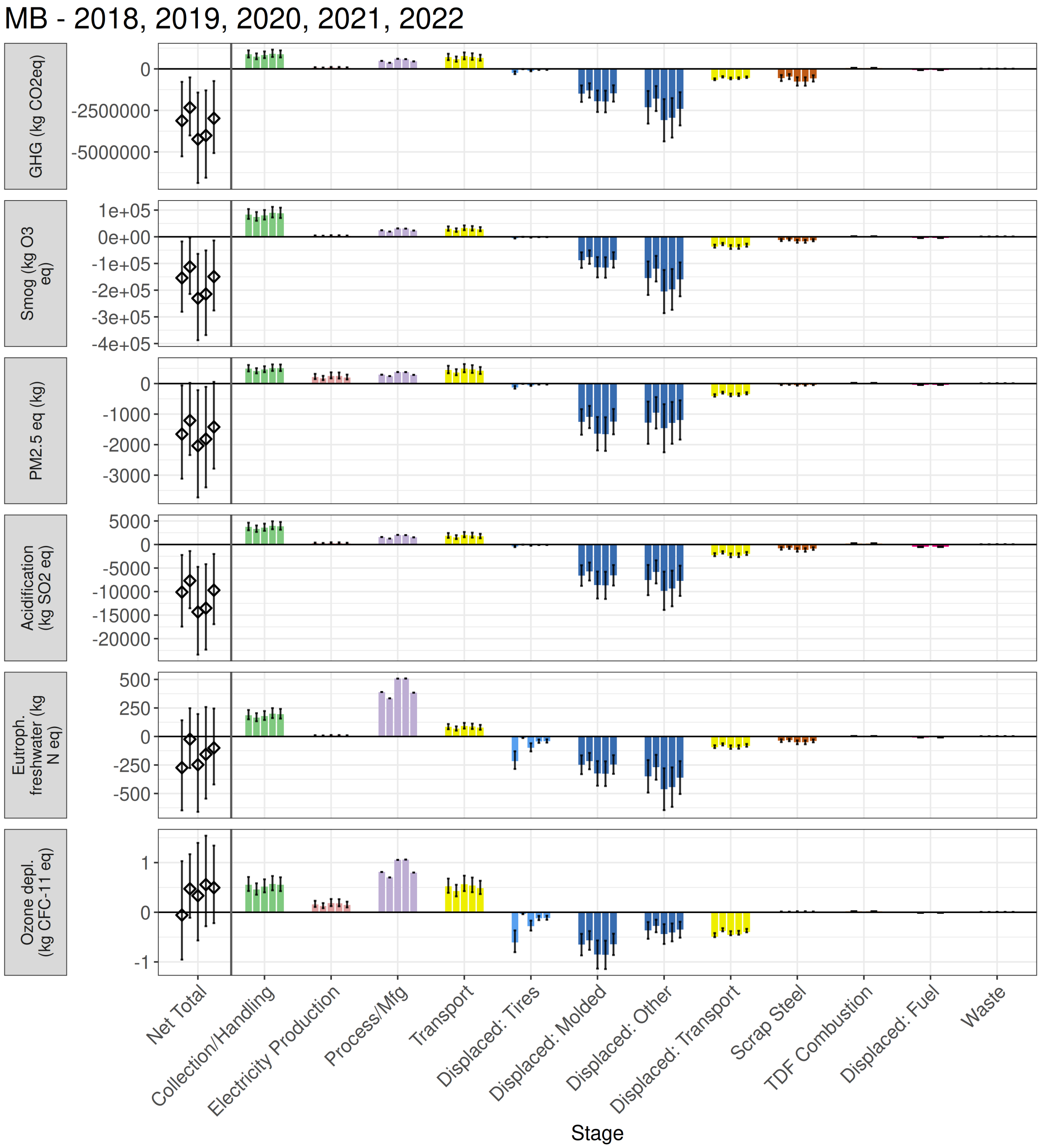


Figure 4: Province-wide environmental impacts of managing scrap tires in MB during 2018–2022, stage contribution analysis, by year. Net impacts, which take into account avoided production due to tire recycling, are indicated by the diamond symbol on the left. Colored bars show contributions by individual stages in the tire recycling system. Modeled uncertainty is indicated for each bar.