Analysis of Carpet Discards Formula

Interim Report to CalRecycle

June 2021

California Carpet Stewardship Program

An initiative of CARE: Carpet America Recovery Effort

CASCADIA CONSULTING GROUP

ACKNOWLEDGMENTS

Cascadia Consulting Group, the California Carpet Stewardship Program, and CARE gratefully acknowledge the many contributors to this analysis of carpet Discards in California. We appreciate and thank you for your ideas, insights, and energy in assessing the many data complexities and helping map an effective path forward.

- CalRecycle agency members
- California Carpet Advisory Committee
- Santo Torcivia, Market Insights, LLC
- CARE Stewardship Planning Committee (SPC)

EXECUTIVE SUMMARY

California's Carpet Stewardship Law establishes statewide goals for increasing post-consumer carpet recycling rates. The Carpet America Recovery Effort (CARE) serves as the carpet stewardship organization and manages the California Carpet Stewardship Program (the Program). The law calls for "continuous meaningful improvement in the rates of recycling and diversion," and a 2017 amendment establishes a goal to "Achieve a 24-percent recycling rate for post-consumer carpet by January 1, 2020."[1]

To track progress toward these goals, the Program reports to the California Department of Resources Recycling and Recovery (CalRecycle) on quantities of carpet recycled, reused, and discarded. The **Recycling Rate** is based on the known quantity of carpet Recycled Output (the numerator) divided by the estimated amount of total carpet Discards (the denominator). **Recycled Output** includes carpet reuse, tile recycled, fiber, depolymerized material (depoly), calcium carbonate, filler, and carcass.

Discards are defined as carpet that has completed its lifecycle as a consumer item or is no longer used for its manufactured purpose. Discards are also referred to as post-consumer carpet (PCC) materials. To estimate Discards, the Program uses a formula based on carpet sales, replacement, weight, demolition, and deselection from carpet to other flooring materials.

$$\text{Discards} = (S * R * P) * (1 + D + DS)$$

Where:

S = Sales of carpet (in square yards) in California for the reporting period.

R = Replacement, the percentage of carpet sales that is replacing existing carpet.

P = Density, the average weight of carpet in pounds per square yard.

D = Demolition, pounds of carpet from demolition projects.

DS = Deselection, pounds of carpet removed from existing buildings but not replaced by new carpet.

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[1] California Assembly Bill 2398, Bill Text - AB-2398 Product stewardship: carpet. Public Resources Code, Division 30, Part 3, Section 42972, Bill Text - AB-1158.

In 2019, the Program reported Recycled Output of 58 million pounds and estimated Discards of 304 million pounds. These quantities resulted in a recycling rate of 19%. In 2014 and 2018, CalRecycle conducted studies of waste disposal around the state, which estimated carpet discards at 1.6% and 1.8% of the waste stream, respectively.

As part of its commitment to providing accurate data and analyses, the Program commissioned Cascadia Consulting Group to conduct a review of the Discards formula, its variables and data, and relevant waste characterization studies. This report presents the findings to date. Due to the complexities of accurately calculating the amount of carpet Discards in the waste stream, the need for additional data, and the requirements for additional stakeholder engagement with the Advisory Committee, CalRecycle, and CARE, follow-up work is needed to finalize recommendations, update the Discards parameters, and address implications for the Program's recycling rate, targets, and goals.

Findings to date include the following:

1. Overall, the individual variables used in the Discards formula appear conceptually reasonable. Cascadia suggests that further analysis of the data inputs and calculation approach is warranted. This includes decoupling the *Demolition* and *Deselection* rates from current carpet *Replacement* and considering options for reflecting changes in *Sales* from higher historical levels.

2. *Sales* data are compiled by an accounting firm and appear sound. *Sales* were higher in the past, however, and have decreased since the start of the Program. These past sales are the source of current and future Discards, at the end of the carpet's lifespan.

3. Supplemental measurements conducted during 2018 waste sampling field studies validate the Program's *Density* estimates of carpet weight per square yard. Considering variations in carpet weight by type (e.g., broadloom versus carpet tile) may be a useful refinement but requires robust market share data, which are not readily available.

4. Data for the *Replacement*, *Demolition*, and *Deselection* variables are not verified with existing public data sources. The current estimates for *Demolition* and *Deselection* appear too low and warrant adjustments, to avoid underestimation of Discards.

5. *Deselection* of carpet replaced by other flooring materials is currently underestimated. Cascadia is considering several approaches for estimating *Deselection*, which raise additional questions, data requirements, and needs for external validation.

6. While waste characterization studies provide an overall view of waste flows, they are not intended to track annual changes in a relatively small, non-normally distributed single material like carpet.

7. Due to carpet's non-normal distribution, use of a modified Discards formula is the recommended method for estimating carpet discards.

8. This report considers a historical sales approach that reflects a mass balance of material flows over time, where carpet Discards are approximately equal to carpet Sales over time. Additional data and/or consensus assumptions would be needed to validate this approach.

9. Data and calculation adjustments are needed to the current Discards formula, which will result in a higher estimate of carpet Discards (and thus a lower recycling rate).

10. A modified formula as shown below uses *Sales* data and an updated *Deselection* parameter, based on non-carpet sales, which will result in higher estimated Discards than the current reporting. Additional review is needed to determine the viability and need for a *Demolition* variable. Further refinements of the data, calculations, and continued discussions with CARE, the Advisory Committee, and CalRecycle are still needed to reach agreement, finalize the Discards calculations, implement the updates, and address implications for the recycling rate and Program goals.

Discards = (Sales * Density) + $\text{Deselection}_{\text{Non-Carpet}}$ + *Demolition*

1 OVERVIEW

1.1 Background and Purpose

California's Carpet Stewardship Law establishes statewide goals for increasing post-consumer carpet recycling rates. The Carpet America Recovery Effort (CARE) serves as the carpet stewardship organization and manages the California Carpet Stewardship Program (the Program).

Carpet Recycling Goals

The original statute passed in 2010 called for "continuous meaningful improvement in the rates of recycling and diversion."[2] In 2017, the state amended the law to establish a goal to "Achieve a 24-percent recycling rate for post-consumer carpet by January 1, 2020, and any other recycling rate established by the Department."[3] To track progress toward these goals, the Program reports to the California Department of Resources Recycling and Recovery (CalRecycle) on quantities of carpet recycled, reused, and discarded.

[2] California Assembly Bill 2398, Bill Text - AB-2398 Product stewardship: carpet.

[3] California Public Resources Code (PRC), Division 30, Part 3, Section 42972, Bill Text - AB-1158 Carpet recycling.

Recycled Output, Discards, and Recycling Rate

The Program provides incentives to increase **Recycled Output (RO)**—including carpet reuse, tile recycled, fiber, depolymerized material (depoly), calcium carbonate, filler, and carcass. The Program measures and tracks the quantities of Recycled Output and **Gross Collections (GC)** of material recovered through the Program on a monthly, quarterly, and annual basis. **Yield** is the percentage of Gross Collections (GC) that are converted into Recycled Output (RO/GC).[4]

Recycled Output = Type 1 + Type 2 + PC4 Recycled Outputs + Reuse

Discards are defined as carpet that has completed its lifecycle as a consumer item or is no longer used for its manufactured purpose. Discards are also referred to as post-consumer carpet (PCC) materials. To estimate Discards, the Program uses a formula based on carpet sales, replacement, weight, demolition, and deselection from carpet to other flooring materials. The variables and data sources are explained further in the *Discards Formula History* section beginning on page 8.

Discards = (S * R * P) * (1 + D + DS)

Where:

S = Sales of carpet (in square yards) in California for the reporting period.

R = Replacement, the percentage of carpet sales that is replacing existing carpet.

P = Density, the average weight of carpet in pounds per square yard.

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[4] *Type 1 Recycled Output Material*: Higher-value recycled output with the most benefits to manufacturers of finished products and which generally takes more processing to achieve; examples include PCC fiber, PCC backing, engineered resins, and material for carpet cushion. *Type 2 Recycled Output Material*: Lower-valued recycled output with generally lower benefit to manufacturers of finished products and a lower value than Type 1 recycled materials; examples of Type 2 recycled materials include carpet filler and non-functional filler. *PC4*: Post-Consumer Carpet Calcium Carbonate is the residual, non-fiber content that is collected by a Type 1 processor when a carpet is separated.

D = Demolition, pounds of carpet from demolition projects that were not replaced with new carpet.

DS = Deselection, pounds of carpet removed from existing buildings (not demolished) but not replaced by new carpet.

The Program uses Recycled Output and Discards to calculate the carpet **Recycling Rate**. The recycling rate is based on the known quantity of Recycled Output (the numerator) divided by the estimated amount of total carpet Discards (the denominator).

$$\text{Recycling Rate} = \frac{\text{Recycled Output}}{\text{Discards}}$$

In 2019, the Program reported Recycled Output of 58 million pounds, Gross Collections of 82 million pounds, and estimated Discards of 304 million pounds. These quantities resulted in a Yield of 71% and a recycling rate of 19%. (Note that some stewardship programs define their recycling rate as the recycled output percentage of the total material they collect, which is what the Carpet Stewardship Program reports as Yield).

Statewide Waste Characterization Studies

In 2014 and 2018, CalRecycle conducted random sampling of waste disposal around the state, including 754 samples at 26 solid waste facilities in 2014 and 892 samples at 34 facilities in 2018. These samples covered 82 different material types in 2014 and 94 types in 2018. These waste characterization studies provide data on waste disposal in the state overall, by sector (residential, commercial, and self-hauled), subsector (such as single-family residential and multifamily residential), and geographic region.

These statewide waste characterization studies estimate substantially higher figures for carpet disposal than are calculated using the Discards formula. The 2014 waste characterization study estimated carpet discards at 1.8% ±0.6% of the waste stream,

or 1.1 billion pounds (570,212 tons).[5] The 2018 study is expected to be revised; the version published in May 2020 reports that carpet composed 1.6% ±0.2% of waste, or 1.3 billion pounds (627,926 tons).[6]

In its Annual Reports, the Program estimated annual carpet discards in California at 350.7 million pounds in 2014 and 322 million pounds in 2018. These annual figures have declined over time, as annual carpet sales have decreased.

Purpose of this Study

The waste characterization estimates exceed the estimated Discards calculated using the formula. These differences have raised questions about the appropriate method for estimating carpet discards and calculating the carpet recycling rate in California.

As part of its commitment to providing accurate data and analyses, the Program commissioned Cascadia Consulting Group to conduct a review of the Discards formula, its variables and data, and relevant waste characterization studies. This work is referred to interchangeably as the Discards Formula study, the Discards study, and the Denominator study. This report presents the findings of that study. Due to the complexities of accurately calculating the amount of carpet Discards in the waste stream, the need for additional data, and the requirements for additional stakeholder engagement with the Advisory Committee, CalRecycle, and CARE, follow-up work is needed to finalize recommendations, update the Discards formula, and address implications for the Program's recycling rate, targets, and goals.

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[5] CalRecycle, *2014 Disposal-Facility-Based Characterization of Solid Waste in California*, October 2015, Publication Summary. Carpet is defined as "flooring applications consisting of various natural or synthetic fibers bonded to some type of backing material. This type does not include carpet padding or woven rugs with no backing." The study reports results in tons, which are converted to pounds here for comparability with other Carpet Stewardship Program reporting.

[6] CalRecycle, *2018 Disposal-Facility-Based Characterization of Solid Waste in California*, May 2020, Publication Summary.

1.2 Discards Formula History

With input and review from CalRecycle, the Program has modified its approach to estimating carpet Discards over time. The Program originally used a formula based on carpet sales, replacement, weight per square yard, and quantity of carpet from demolition projects. The Deselection variable was added later to account for carpet that is removed from existing buildings but not replaced by new carpet, primarily from switching to hard-surface flooring.

From its early days, the Program has used a **Discards formula** to estimate the amount of carpet discarded and therefore available for potential collection and recovery. The Discards formula has been modified over time from the version included in the original California Carpet Stewardship Plan. In mid-2016, the Program updated the Discards formula, adding a new variable for Deselection, to the version currently in use:

Discards = (S * R * P) * (1 + D + DS)

Where (the variables and data sources are explained further in Chapter 2 beginning on page 10):

S = Sales of carpet (in square yards) in California for the reporting period.

R = Replacement, the percentage of carpet sales that is replacing existing carpet.

P = Density, the average weight of carpet in pounds per square yard.

D = Demolition, pounds of carpet from demolition projects that were not replaced with new carpet.

DS = Deselection, pounds of carpet removed from existing buildings (not demolished) but not replaced by new carpet.

The Discards formula is used to estimate total carpet discards in California. Recycled Output (RO, the numerator) is divided by the Discards estimate (the denominator) to calculate the Program's recycling rate. While working to ensure a more accurate discards number, CARE has been consistent in its use of the current formula and calculation of the Recycling Rate, which has shown steady annual growth over time.

1.3 Report Organization

The remainder of this report is organized into the following chapters:

- **Chapter 2: Review of Existing Discards Formula.** This chapter addresses the variables in the existing Discards formula and their data sources.
- **Chapter 3: Review of Statewide Waste Characterization Data.** This chapter addresses the 2014 statewide waste characterization study, the 2018 update, additional statistical analysis, and differences between the resulting Discards estimates.
- **Chapter 4: Modified Approaches for Estimating Discards.** This chapter considers alternative ways to estimate annual carpet discards in California, including consideration of a mass-balance or historical sales approach and new methods for estimating Deselection in a modified Discards formula.
- **Chapter 5: Conclusions and Next Steps.** This chapter summarizes findings to date and proposed next steps recommended to update the Discards formula and its parameters. Further refinements of the calculations, data inputs, and continued discussions with CARE, the Advisory Committee, and CalRecycle are still needed.

2 REVIEW OF EXISTING DISCARDS FORMULA

Cascadia conducted an analysis of the overall Discards formula, including data inputs and how it has been calculated and modified over time. This research and analysis included multiple iterations of collecting additional information to address data gaps including historical sales of carpet and non-carpet materials, Deselection, Demolition, Density, market share, and carpet lifespan. This chapter analyzes the existing formula for estimating carpet Discards in California, including its data sources, calculations, and results. It identifies strengths and limitations of the current approach and identifies areas for improvement.

2.1 Discards Formula and Results

The Program has used the existing version of the Discards formula since mid-2016. The formula is as follows:

$$\text{Discards} = (S * R * P) * (1 + D + DS)$$

Where:

S = Sales of carpet (in square yards) in California for the reporting period. Sales data comes from Aprio, the independent accounting firm that collects confidential sales data from the carpet manufacturers registered with CARE.

R = Replacement, the percentage of carpet sales that is replacing existing carpet. Market Insights, LLC, calculates this percentage as the weighted average of the residential and commercial sectors and then reports the results to CARE.

P = Density, the average weight of carpet in pounds per square yard. CARE collects raw industry data and calculates the weighted averages of commercial broadloom carpet, residential broadloom, and carpet tile.

D = Demolition, pounds of carpet from demolition projects that were not replaced with new carpet. Market Insights, LLC, collects and reports the weighted demolition rate (based on 75% residential broadloom, 15% commercial broadloom, and 10% commercial carpet tile). The resulting percentage is converted to pounds by multiplying it by the product of S * R * P (that is, the weight of Replacement carpet).

DS = Deselection, pounds of carpet removed from existing buildings (not demolished) but not replaced by new carpet; this variable reflects choices to remove existing carpet and not replace it with new carpet, such as switching to hardwoods, vinyl, tile, or other hard surfaces. Deselection is estimated based on reviewing historical trend data for carpet sales. The percentage is multiplied by the product of S * R * P.

The following table, reproduced from the Program's 2019 Annual Report, shows the values used for each formula variable in the most recent published annual report.

Table 1. Discards Formula Variables and Values, as Reported in 2019 Annual Report *(Table 5-8, page 126)*

Variable	Description	Value	Source
S	Sales (square yards)	80,583,382	Accounting firm (Aprio, LLP)
R	Replacement rate (%)	0.83	Market Insights, LLC
P	Average weight of carpet per square yard (pounds)	4.48	CARE and corroborated by Cascadia Consulting
D	Pounds of carpet from demolition projects not replaced (%)	0.006	Market Insights, LLC
DS	Deselection: Pounds of carpet removed but not replaced by carpet (%)	0.008	Market Insights, LLC

2.2 Analyses of Formula Variables and Data Sources

Cascadia investigated each element of this formula and its data sources. The following sections provide the definitions, describe data sources and assessment methods, summarize the findings.

Sales (S)

Definition

According to the Program's 2019 Annual Report (and prior reports), **Sales** is defined as "Carpet sales (square yards) in California for the reporting period. Sales data comes from the independent accounting firm Aprio, which collects the confidential sales data from the carpet manufacturers registered with CARE."[7]

Data Sources and Assessment Methods

The actual *Sales* data reported for California in the Program's Annual Reports are shown in Table 2 below.

Table 2. Annual Carpet Sales in California, as Reported in Program Annual Reports (million square yards)

Sales	2012	2013	2014	2015	2016	2017	2018	2019
Million square yards	98	100	98.9	97	94	90	86	81

To support the analysis, CARE provided an anonymized version of the confidential data that carpet mills report to Aprio, the independent accounting firm, on carpet sales in California. The confidential mill data for the period from Quarter 1 of 2012 through Quarter 1 of 2018 included quarterly reporting for more than 100 mills (the number of mills has changed over time due to industry consolidation and other business changes).

[7] CARE California Carpet Stewardship Program, *2019 Annual Report* (September 2020), page 127.

CARE and Market Insights, LLC, also provided a copy of the confidential report that Market Insights produces annually for CARE, *U.S. Carpet Market Size for Recycling Program Tracking with California, Maine, and Minnesota Markets Detailed* (March 14, 2018). Market Insights uses proprietary algorithms to generate their report, drawing on data from public and private sources.

National data in the U.S. FLOOReport are calculated and then adjusted to estimate California residential sales according to the following: housing starts, population change and household growth, propensity to buy carpet, income, and economic activity. According to Market Insights, retail and hotel construction generally tracks with residential growth, and office construction tracks with employment growth indicators. National data on commercial sales from the U.S. FLOOReport are adjusted to produce estimates for California based on propensity to buy product, economic activity, changes in employment, and other factors.

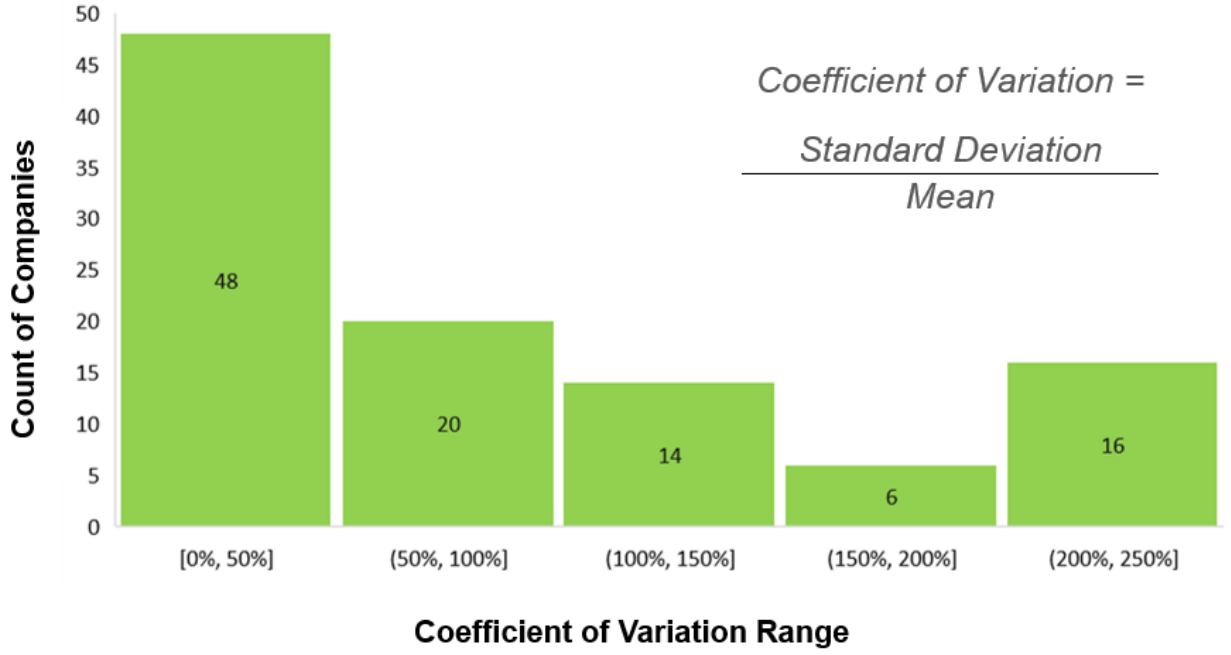
Cascadia reviewed and compared these two confidential and proprietary data sources, including evaluating the potential impacts of non-reporting (missing data) in the confidential mill reporting.

Results

Based on this assessment, the data on current sales appear sound. The difference in total sales quantities between the confidential mill data reported to the Program's accounting firm and the Market Insights report was less than 0.5% for 2012–2017.

The confidential mill data shows substantial variation across the quarterly reporting periods. For each mill, Cascadia derived the *coefficient of variation*, a standard statistical measure of variability or dispersion of values, calculated as the *standard deviation* divided by the *mean* (average). About a third of the mills (34%, 36 of 105 firms) showed coefficients of variation greater than 100%, indicating substantial variability across reporting periods, as shown in Figure 1.

Figure 1. Variation in Mill Data across Reporting Periods, 2012–2017



Some of this variation is due to seasonal effects, with carpet sales typically being higher in the second and third quarters of each year. Non-reporting, or blank records, in the quarterly reporting also contributes to the observed variation. Most of the non-reporting is from mills that produce relatively small quantities of carpet, and 17 of these mills show blank records in more than 20 of the 25 reporting periods, as shown in Table 3. The blank records are assumed to mean zero quantities in that quarterly reporting period.

Table 3. Count of Blank Records in Quarterly Mill Reporting

Count of Zero Reports	0	1-5	6-10	11-15	16-20	21-25	Total
Count of mills	33	25	10	10	10	17	105

Even if the blank records were assumed to have the average quarterly quantity for the periods when that mill reported, the total quantity of carpet sales would increase by less than 3%. Accordingly, non-reporting or blank records do not appear to have a notable effect on the overall sales figures, and the review did not identify underreporting.

Data sources for current *Sales* used in the formula appear sound.

However, current carpet discards come from carpet that was purchased and installed in the past, and **current sales are not equivalent to historical sales**, which were higher, as addressed further in Chapters 4 and 5. In response to a follow-up request, Market Insights provided national carpet sales data dating back to 1996. Applying historical sales data in the Discards formula would yield higher estimates of discarded carpet.

Replacement (R)

Definition

As stated in the 2019 (and prior) Annual Report, **Replacement** is defined as the "Percentage of carpet that is replacement—that is, carpet replacing existing carpet. The rate is derived as the weighted average from the residential and commercial sectors and is reported by Market Insights, LLC."[8] In the Market Insights report, **Replacement** is further defined as follows for the residential and commercial sectors:[9]

- **Residential replacement**: "All dollar-value purchases of tufted carpet rollgoods & tile by consumers for use in existing homes (includes vacation & rental properties)."
- **Commercial replacement**: "Quantity of Total U.S. consumption of commercial broadloom and carpet tile installed in… existing commercial/ non-residential buildings such as stores, hospitals, dormitories, etc. in California."

Data Sources and Assessment Methods

The estimates for carpet *Replacement* are proprietary findings compiled by Market Insights, LLC. From discussions with Market Insights, Cascadia understands that the Replacement rate is first developed at national level as part of Market Insights' *U.S. FLOOReport* (the 2017 version, published in May 2018, was approximately 400 pages in length). Cascadia was not able to review a copy of this proprietary report.

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[8] CARE California Carpet Stewardship Program, *2019 Annual Report* (September 2020), page 127.

[9] Market Insights, LLC, *U.S. Carpet Market Size for Recycling Program Tracking with California, Maine, and Minnesota Markets Detailed* (March 14, 2018).

Replacement was reported as 83% in the 2019 Annual Report and has had similar values close to 85% in prior years. The remaining portion of carpet *Sales* is assumed to go to new construction.

The national carpet production and sales figures represent domestic production (shipments from U.S. mills), minus exports and plus imports (from the U.S. International Trade Commission). California data in the Market Insights report for CARE (Tables 9A and 9B) are developed from national figures, applying demographic, economic data, consumer preferences, and other factors. Part of this translation involves use of a Region Purchase Index for the “Pacific” region, which includes multiple West Coast states in addition to California.

According to Market Insights, the highest replacement of residential carpet occurs in the first 2 years of tenancy, after someone buys a home. National residential replacement in the U.S. FLOOReport (2018) is calculated from consumer spending, floor-covering spending, and other factors. National data are then adjusted for California based on the share of households in each county, economic activity (based on changes in home furnishings sales), average income, and other factors.

For commercial replacement, national data from the U.S. FLOOReport are adjusted for California based on regional propensity-to-buy models, adjustments for economic activity, number of employed persons, and other factors.

Public data sources to support independent verification of these source data and calculations are not available.

Results

The *Replacement* rate data are proprietary, and published data sources are not currently available for independent validation of this variable.

The approximately 15% of *Sales* that is not *Replacement* and goes to new construction eventually becomes Discards but is not sufficiently accounted for in the current formula. In addition, the current *Deselection* and *Demolition* variables (which are also calculated as percentage of carpet *Replacement*) do not sufficiently account for these carpet discards at any given time period or over time. Using *Replacement* as the basis for Discards results in the Discards estimates always being lower than *Sales* over time, rather than achieving an approximate “mass balance” as discussed in Chapter 4.

Density (P)

Definition

As noted in the 2019 (and prior) Annual Report, **Density** is defined as the "Average weight of carpet per square yard. CARE gathers and analyzes raw industry data (via a confidential mill survey) [since 2016] to calculate the weighted averages of carpet weights of broadloom and tile used in the commercial and residential sectors."[10]

Data Sources and Assessment Methods

In the Discards formula, *Density* has a major effect on the total quantity estimates.

CARE obtains data from carpet mills through an annual survey regarding the reported density of current carpet sales by type: commercial broadloom, residential broadloom, and commercial tile. These estimates for carpet density over time range from approximately 4.2 to 4.5 pounds per square yard. The data are currently weighted by type (residential broadloom, commercial broadloom, and loom); they should also be weighted by volume produced by manufacturer within each carpet type.

To evaluate the *Density* variable, Cascadia reviewed CARE's data workbook and also conducted new data collection in the field to independently assess carpet density. This work was conducted as an addition to CalRecycle's waste characterization study conducted in 2018.

Results

Cascadia notes that the Density variable, as calculated from annual reporting from carpet mills, is based on densities of current carpet sales. Historical carpet density may be different due to changes over time in carpet composition, manufacturing methods, and other factors. When carpet reaches the point of disposal, its density may also be different, as a result of wear, soil or other contamination over its lifetime as well as during the disposal process, moisture (e.g., discarded carpet is left outside and rained on), and other factors.

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[10] CARE California Carpet Stewardship Program, *2019 Annual Report* (September 2020), page 127.

During the field work for CalRecycle's 2018 statewide waste characterization study, CARE commissioned the field crews to collect and analyze additional samples of carpet, where it was observed in disposed materials. This work collected samples from disposed carpet and measured its area and weight.

The resulting estimate from the field data measurements was approximately 4.5 pounds per square yard of disposed carpet. This figure is very similar to the density estimates that the Program has been using in the existing Discards formula. Accordingly, Cascadia does not consider that carpet density estimates are likely to be a major driver of differences in overall estimates of discarded carpet quantities.

Demolition (D)

Definition

According to the 2018 Annual Report, **Demolition** is defined as the "Pounds of carpet from demolition projects that were not replaced. This includes the weighted demolition rate (75% residential broadloom, 15% commercial broadloom, and 10% commercial carpet tile). D is converted to pounds by multiplying the percentage by the product of S * R * P. The demolition data is gathered by Market Insights, LCC. Note that demolition represents the teardown of a building. The actual volume of carpet resulting from this process cannot be accurately calculated. By using the actual demolition rate obtained from Market Insights, LLC., the total volume of carpet sent to landfill is likely being overestimated. However, this is a small fraction (<1%) of the overall amount and does not significantly alter the calculations because it is well within acceptable error limits."[11] The 2019 Annual Report ended the definition with "The actual volume of carpet resulting from this process is estimated" and did not speculate on whether it is likely overestimated.[12]

According to Market Insights, the residential demolition rate is defined as the "share of total housing floor area lost each year," with the demolition rate based on a national figure from the U.S. Census of Housing from the year 2000. The commercial demolition rate is the "share of total commercial building stock floor area lost each year," based an estimate from the National Association of Home Builders.

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[11] CARE California Carpet Stewardship Program, *2018 Annual Report* (September 2019), page 101.

[12] CARE California Carpet Stewardship Program, *2019 Annual Report* (September 2020), page 127.

The total demolition rate is calculated from the combined estimates of residential and commercial building stock lost each year in California to demolition.

Data Sources and Assessment Methods

The Demolition data sources are nearly two decades old. Despite efforts by Cascadia and CARE, with support from CalRecycle, updated Demolition data do not appear to be available, either nationally or for California. California's Construction Industry Research Board (CIRB) does not track demolition data at the state level, and the federal government no longer tracks demolition at the national level.

The Discards formula calculates carpet discards from *Demolition* as a percentage of carpet *Replacement* sales.

Results

The Demolition data sources are older, and Cascadia has not been able to verify the results independently. Improved data needed to update the Demolition rate are not available at the state or national level.

The Discards formula calculates carpet discards from *Demolition* as a percentage of carpet *Replacement*, which in turn is a percentage of carpet *Sales*. However, demolition is not a function of carpet sales; demolition carpet comes from the portion of floor area in demolished buildings that were carpeted. Demolition is correlated with other economic indicators, such as housing starts and employment.

Estimating carpet discards from demolition based on existing building floor area in California, the portion that is carpeted, and the percentage of existing building stock that is demolished would better represent real-world carpet discards from demolition. However, such a calculation requires multiple data inputs that are neither readily available for California, nor are they included in data that the carpet industry tracks.

The quantities of carpet discards derived from demolition would have to be several times larger to change the overall Discards estimates substantially. Considering the limited expected impact of Demolition on the Discards estimates, along with the high data requirements and major data gaps, we do not currently anticipate that an accurate estimate can be calculated with a sufficient degree of confidence.

Deselection (DS)

Definition

According to the 2017 Annual Report, **Deselection** is defined as the "Pounds of carpet removed (deselection) but not replaced by carpet. The estimate is based on reviewing historical trend data is 0.75% (DS = Sales in pounds x rate)."[13]

The 2017 Annual Report further states: "Deselection, or the removal of carpet for the replacement by another flooring material, is estimated to be approximately 0.75%, based on analysis of historical trend data [in carpet sales]. It has a minimal impact on the flow to landfill and is well within the error limits of current estimates." Flooring materials used in place of carpet can include hardwoods, vinyl, ceramic tile, stone, and other hard-surface flooring types. Luxury vinyl tile (LVT) has become a popular and growing replacement in recent years.

The 2019 Annual Report notes that "recent work suggests this source of PCC may be more significant that previously assumed. Further refinement is underway in 2020."[14]

Data Sources and Assessment Results

The existing estimation is based on a percentage of flooring market share, in terms of the dollar value of sales, rather than quantities sold, by area or weight.

The Discards formula calculates carpet discards from *Deselection* as a percentage of current carpet *Replacement*.

These estimates do not appear to adequately reflect changes in the prices of different flooring types and total sales quantities (in square yards, square feet, or pounds) of carpet and other flooring types.

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[13] CARE California Carpet Stewardship Program, *Annual Report January 2017 – December 2017* (September 2018), page 80.

[14] CARE California Carpet Stewardship Program, *2019 Annual Report* (September 2020), page 127.

Results

Based on national carpet sales dating back to 1996, the estimate of 0.75% appears too low to account for the observed decreases in carpet sales over time.

Quantity data, rather than cost/price data, on carpet sales and on competing flooring materials are needed to better estimate *Deselection*.

Deselection appears to be substantially underestimated. It should also be a function of non-carpet flooring sales, rather than carpet sales. Improved methods are still being refined, as discussed in Chapter 4.

2.3 Conclusions on Discards Formula Variables and Data

The current Discards formula places the greatest emphasis on *Sales*, *Replacement*, and *Density*. *Sales* and *Density* drive the results. The *Replacement* rate reduces discards estimates from the amount of carpet currently sold. *Demolition* and *Deselection* are small increments added back to the Discards estimate and are based on a function of current carpet *Replacement* sales quantities.

Overall, the individual variables included in the Discards formula appear conceptually reasonable. To refine this approach, however, Cascadia recommends adjustments in the data inputs and calculations, including considering ways to apply historical sales data rather than current *Sales* and decoupling the *Demolition* and *Deselection* rates from current carpet Replacement. These topics are discussed further in Chapter 4 on *Modified Approaches for Estimating Discards* and Chapter 5 on *Conclusions and Next Steps*.

For *Sales*, the current-year data appear sound. However, discards today come from carpet sold in the past, and the formula does not address the lag time between historical sales and current discards. Using current sales underestimates the historical quantities that drive carpet discards. Because calculations for *Replacement*, *Demolition*, and *Deselection* also tied to *Sales* and *Replacement* figures, using current rather than historical sales leads to lower estimates for all of these factors. It would also be valuable to have carpet lifespan data to determine the appropriate time period (number of years) to use for historical data, but carpet lifespans have been elusive information.

Density is a primary driver of the resulting discards estimates, along with *Sales*. Data from new field research suggest that the current estimates are reasonable. Cascadia notes that the carpet density shows high variation across carpet types (with carpet tile being denser/heavier than broadloom carpet per square yard), and the market share of these carpet types is changing. CARE should continue to collect density data by carpet type and could consider using historical density data once more years of data are available.

For the other formula variables, the data are older, proprietary, and from unpublished sources that cannot be independently verified or updated with public sources. The Replacement data are proprietary and not independently verified. Demolition rates are older (year 2000), based on personal communication or unpublished sources, and not independently verified. Cascadia recommends decoupling Demolition estimates from current carpet Replacement sales. Deselection was calculated based on sales in dollars, not actual quantities, and the 0.75% figure appears lower than observed declines in sales over time. More recent revisions to the Deselection variable seek to address these concerns and are explored further in Chapter 4. Incorporating historical sales data could help account for Deselection, as Deselection is observed as decreased carpet Sales over time along with increases in other flooring types.

3 REVIEW OF STATEWIDE WASTE CHARACTERIZATION DATA

The Program's approach to estimating carpet discards, as discussed in Chapter 2, results in a different estimation than CalRecycle's statewide waste characterization, *2014 Disposal-Facility-Based Characterization of Solid Waste in California*. The estimates of carpet discards derived from the waste characterization study are substantially higher. The waste characterization study estimated carpet discards at 1.8% ±0.6% of the waste stream, or 570,212 tons (1,140,424,000 pounds). The 2018 waste characterization study shows similar figures.

This chapter explores the waste characterization data with a focus on carpet discards. Waste characterization studies provide a valuable overall view of waste flows statewide and by substream. Considering carpet's particular attributes and distribution, however, waste characterization studies are not intended to track annual changes in a relatively small, non-normally distributed single material like carpet.

3.1 Data Sources

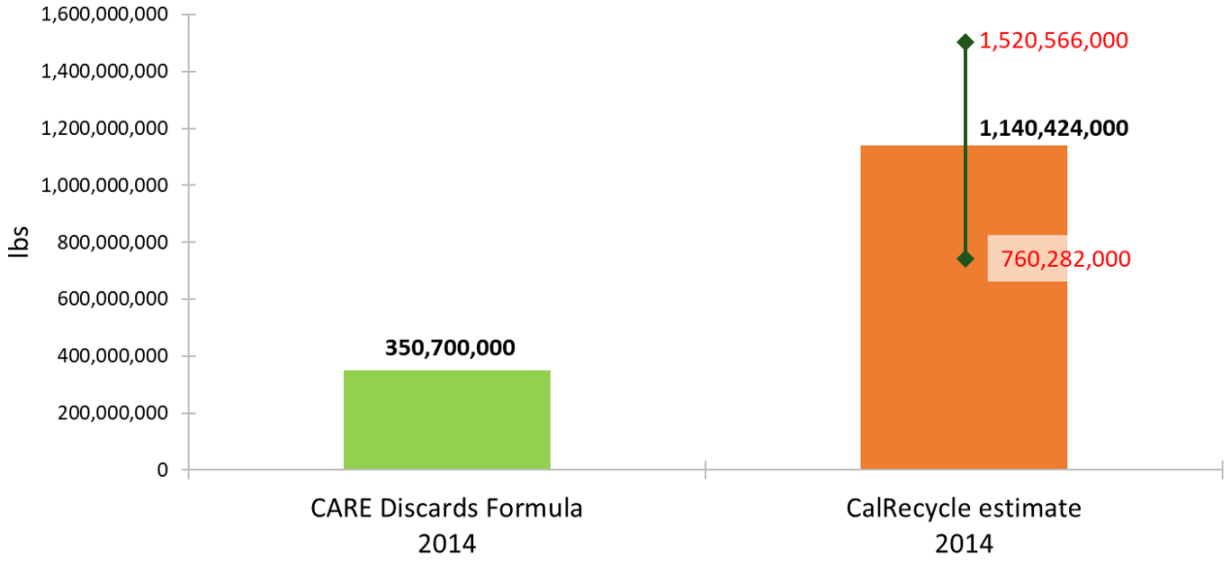
CalRecycle regularly conducts waste characterization studies to monitor California's waste stream and changes over time. These studies also gather new information on emerging materials of concern as they are identified.

CalRecycle uses up-to-date information on the types and amounts of materials disposed in the state's waste stream to identify opportunities for expanding recycling to achieve California's 75 percent recycling goal. These resulting data support solid waste management planning, assessment of waste diversion activities, market development for recovered materials, as well as tracking progress toward the state's climate impact goals.

In 2014, CalRecycle contracted with Cascadia Consulting Group to characterize and quantify the statewide disposed waste stream. As noted in the report, "This study followed standards and protocols similar to those used in the statewide waste characterization studies conducted in 2008 and 2004. The first statewide study was done in 1999 and used a different methodology. As with the 2004 and 2008 studies, the 2014 study estimates the quantity and composition of the commercial, residential, and self-hauled waste streams in California and aggregates this data to estimate the overall composition."

As shown in Figure 2 below, estimated annual carpet discards in California based on CalRecycle's 2014 waste characterization study are more than three times higher than the Program's estimate using its Discards formula.

Figure 2. Estimated 2014 Carpet Discards in California: Discards Formula and CalRecycle Waste Characterization Study



3.2 Overview of Study Methodology

The 2014 waste characterization study applied a stratified random sampling methodology to sample waste from numerous subgroups (strata) to develop a waste composition profile for each stratum. The strata considered in this study included the geographical region, the waste sector (franchised residential, franchised commercial, or self-hauled), and the waste subsector (single-family residential, multi-family residential, residential self-hauled, and commercial self-hauled). Strata were then weighted to reflect each stratum's relative contribution to the overall waste stream and to produce information on overall waste composition in California.

For the study, California was divided into five regions defined by similarities in demographic, climatic, geographic, and economic characteristics. Waste composition data were gathered from **754 waste samples** that the field crew sorted at 26 solid waste facilities (landfills and transfer stations) during four seasons. The samples included loads from residential, commercial, and self-haul sources. A randomized process was used in most cases to select participating solid waste facilities, dates for fieldwork, vehicles carrying waste, and samples from loads.

The sampled waste was sorted into 82 material types. As part of the study, drivers bringing loads to participating solid waste facilities were surveyed to determine the waste-generating sector and the net weight of each load, among other data. Survey results were used to estimate the portion of California's disposed waste derived from each waste sector and subsector. Surveys were conducted on the same days at the same sites that waste was sampled, with an additional survey-only days at additional sites. During the study period, a total of **7,245 vehicle surveys** were completed.

The resulting data were compiled, and statistical analyses were performed to translate the findings to statewide waste composition estimates. The resulting report addresses disposed waste composition and tonnage for the California's overall waste stream and for the commercial, residential, and self-hauled sectors.

3.3 Analysis of Study Methodology

CalRecycle has standard methods for waste characterization studies, which were followed for this work. Regarding the application of the study results to estimate carpet discards, Cascadia considered four main factors regarding the study methodology:

- Number of samples
- Weight (size) of samples
- Allocation of samples by generator types
- Statistical methods

The following sections address each of those topics.

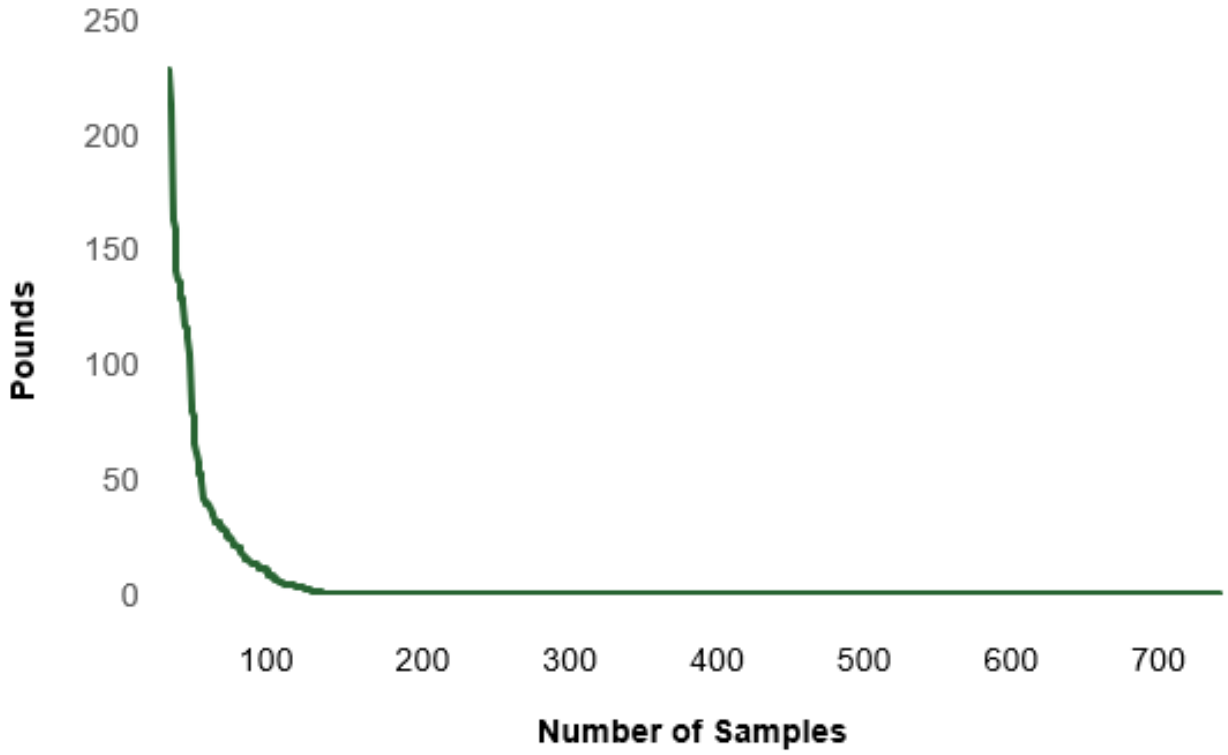
Number and Weight (Size) of Samples

The 2014 study included 754 waste samples, which meets or exceeds CalRecycle and industry standards for waste characterization studies. These samples are sufficient to produce statistically significant results regarding the overall waste stream and the covered generator categories of commercial, residential, and self-haul.

The average sample weight was approximately 220 pounds, which meets or exceeds industry standards.

Of these 754 samples, further examination revealed that 114 samples (15%) contained some amount of carpet. The majority of samples (85%) did not include any carpet (0 pounds). Figure 3 shows the distribution of waste samples by carpet quantity, indicating that a small number of samples are nearly all carpet (more than 200 pounds), while the large majority of samples contain no carpet (0 pounds)

Figure 3. Distribution of Samples by Carpet Quantity



Allocation of Samples by Generator Type

Cascadia also reviewed how the 754 samples were allocated across waste streams, as shown in Table 4.

Table 4. Allocation of Samples by Generator Type in 2014 CalRecycle Waste Characterization Study

Stream	Total Tons	Number of Samples
Commercial (franchised haulers)	**11,909,937**	**251**
Residential (franchised haulers)	**14,516,212**	**253**
Single-family residential	10,924,313	201
Multifamily residential	3,591,900	52
Self-hauled	**4,438,130**	**250**
Commercial self-hauled	3,486,297	134
Residential self-hauled	951,833	116
OVERALL disposed	**30,864,279**	**754**

The sample allocations meet or exceed CalRecycle's standards of 30 residential or 40 non-residential samples per stratum (region and waste sector) for disposal facility waste characterization studies.

Statistical Methods

The statistical analyses included in the CalRecycle 2014 meet or exceed industry standards. The results, however, are intended to present a representative picture of the overall waste stream, but they are not designed to present precise quantities or comparisons over time for *small-quantity, infrequent material types that are highly variable*, such as carpet. The statistical methods are also based on assumptions of normality, as discussed further below.

Table 5 shows the estimated percentage in the overall waste stream for selected materials, along with their absolute plus-or-minus (±) error ranges as well as relative error ranges. Carpet is estimated at 1.8%, with an error range of ±0.6, meaning that the actual percentage of carpet is expected to be between 1.2% and 2.4%, at a 90% confidence level. The relative error range is much higher, recognizing that 0.6 is one-third of 1.8—for a relative error range of 33%. As shown in Table 5, this relative error range is substantially larger than for other example materials.

Table 5. Percentage Estimates for Selected Material Types, with Absolute and Relative Error Ranges

Component	Est. %	Absolute +/-	Ratio of Absolute +/- to Est. %
Carpet	1.8%	0.6	33%
PETE containers	0.6%	0.1	17%
Tin/steel cans	0.7%	0.1	14%
Clear glass bottles and containers	0.9%	0.1	11%
Other miscellaneous paper	3.9%	0.4	10%
Food waste	18.1%	1.6	9%

Source: Data from 2014 CalRecycle Waste Characterization Study

Contributors to this large range include the incidence of in carpet loads—that is, 15% of samples contained carpet, while 85% had none. Carpet is considered a bulky or “lumpy” material, occurring less frequently but often in larger, highly variable quantities than a commonly occurring material such as paper, which is found in most waste samples. Carpet is generated infrequently—for a given location, carpet is likely to be discarded only once every several years (potentially 5 to 10 years or more), if at all.

While many waste materials follow a bell-shaped *normal distribution* curve, carpet is not normally distributed in the waste stream.

Instead, the distribution of carpet in the waste stream shows a small number of samples with large carpet quantities, and a large number of samples with zero carpet. Figure 3 illustrates this non-normal distribution of carpet.

3.4 Description of Non-Normal Statistical Methodology for Carpet Estimation

The statistical analysis used the 2014 CalRecycle study is appropriate for the overall waste stream. For carpet as an individual material that is not normally distributed, however, an alternative statistical approach may be more appropriate for estimating this single, low-incidence material.

Accordingly, Cascadia engaged a University of Washington Ph.D. statistician to conduct a specialized statistical analysis. This methodology involved using a “bootstrap” method to estimate the mean (average) proportion of carpet in the waste stream, including 90% and 95% confidence intervals.

As noted previously, the data contained a large percentage of zeroes (84.9% overall), meaning no carpet in the samples. In contrast, two self-haul commercial samples in the Mountain region were 100% carpet. Across all the samples, the first quartile, the median, and the third quartile were all 0.00% carpet. The counts and percentage of zeroes, by strata, are summarized in Table 6.

Table 6. Total Number of Samples (with Percentage of Zeroes), By Strata

Sector	Bay Area	Coastal	Mountain	South	Valley
Commercial Large	23 (91.3%)	23 (87.0%)	36 (86.1%)	23 (87.0%)	26 (84.6%)
Commercial Small	27 (96.3%)	27 (88.9%)	15 (100%)	27 (100%)	24 (100%)
Multifamily	12 (91.7%)	10 (80.0%)	10 (90.0%)	10 (80.0%)	10 (90.0%)
Self-Haul Commercial	24 (79.2%)	29 (86.2%)	19 (84.2%)	31 (83.9%)	31 (74.2%)
Self-Haul Residential	26 (84.6%)	21 (85.7%)	31 (80.6%)	19 (68.4%)	19 (78.9%)
Single-Family	40 (80.0%)	41 (85.4%)	40 (87.5%)	40 (75.0%)	40 (77.5%)

Methods

According to the statistician, the distributions for proportion carpet are generally unimodal and strongly skewed to one side of the distribution. Based on review of the data, the statistician concluded that a *beta* distribution or zero-one inflated *beta* regression would not be suitable and determined that *bootstrap* methods would be most appropriate.

Bootstrap estimation was the method of choice for this analysis, in which large numbers of smaller samples are repeatedly drawn, with replacement, from the original sample. The bootstrap estimation was conducted as follows:

- Step 1. Stratify the waste characterization data (754 samples) by source and region. This step used the study's 6 generator types and 5 geographic regions, resulting in 30 separate strata.
- Step 2. Select a random sample, with replacement, from each stratum using sample sizes corresponding to the observed sample sizes within each stratum.
- Step 3. Calculate the mean (average) of the random sample.

- Step 4. Repeat steps 2 and 3 above 9,999 more times for a total of 10,000 bootstrap samples from each stratum.
- Step 5. Calculate the mean of each set of 10,000 samples to determine a point estimate for the proportion of carpet in each stratum.
- Step 6. Sort the 10,000 bootstrap samples within each stratum and select the 500th and 9,500th means for the 90% confidence interval bounds for the proportion of carpet. Also, select the 250th and 9,750th means for the 95% confidence interval bounds for each stratum.
- Step 7. Combine the stratum estimates by applying the weights for each combination of region and generator sector.

3.5 Results of Alternative Analysis: Custom Statistical Analysis

The bootstrap estimates resulted in an overall weighted mean of 1.9% carpet, which was similar to the 1.8% indicated in the 2014 waste characterization study, a difference of +0.1 percentage point.

The resulting confidence intervals are as follows, substantially wider than those in the CalRecycle 2014 Waste Characterization study:

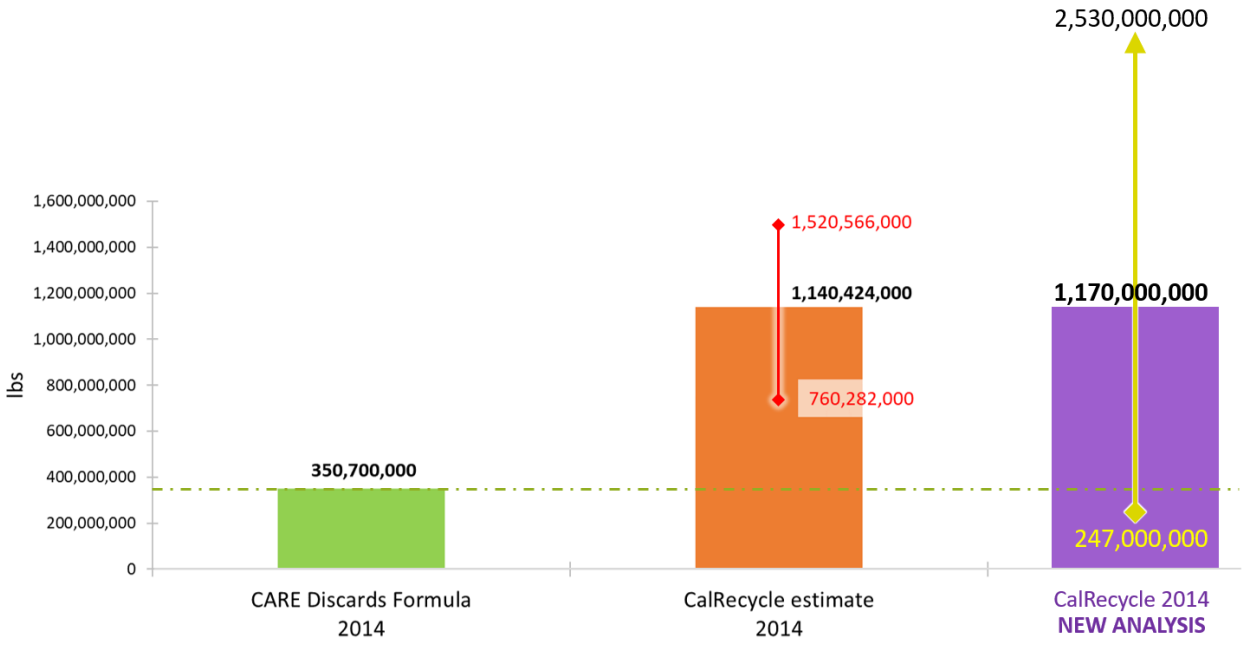
- 90% confidence interval: (0.4%, 4.1%)

Note that the confidence intervals are not symmetric. This is due to the generally skewed distribution of carpet in the waste stream. The 90% confidence interval identified in the new statistical analysis is dramatically larger, more than three times wider than the 2014 study. Table 7 summarizes these results, and Figure 4 presents them graphically.

Table 7. Comparison of Statistical Results from CalRecycle 2014 Study and Non-Normal Statistical Analysis

Statistical Measure	CalRecycle 2014 Estimate	Statistical Analysis for Non-Normal Distribution
Mean (average)	1.8%	1.9%
± Absolute %	±0.6%	-1.5%, +2.2% (non-symmetrical)
90% confidence interval (upper & lower bound)	1.2% to 2.4%	0.4% to 4.1%

Figure 4. Estimated Carpet Discards: Discards Formula and CalRecycle 2014 Study



3.6 2018 Waste Characterization Study Update

In May 2020, CalRecycle published its 2018 statewide waste characterization study, *2018 Facility-Based Characterization of Solid Waste in California*. Cascadia conducted a similar statistical analysis, using the 2018 data, for non-normally distributed data for carpet. This analysis involved the following steps:

- Stratifying the data (n=896 samples) by generator type (6 types) and geographic region (5 regions), for a total of 30 strata.
- Selecting 10,00 random samples, with replacement, from each of the 30 strata.
- Replicating the non-normal statistical analysis using the 2014 weighting data.

The non-normal statistics yielded similar results to the 2014 study analysis. The **mean (non-normal) was 1.7%, with a range from 0.3% to 3.3%** (-1.4%, +1.6%). Findings included the following:

- Carpet is not normally distributed; 85% of 2014 samples and 90% of 2018 samples have no carpet, and the percentage of carpet in samples ranges from zero (0%) to 100% carpet.
- Confidence intervals for carpet are large.
- CARE's 2014 and 2018 estimates of carpet quantities fall within the large confidence interval calculated using statistical methods for non-normal distribution.

Using the statistical methods for non-normal distribution described above, the Program's existing Discards formula estimate is on the low end, but it does fall within the recalculated 90% confidence interval of the statewide waste characterization study. With the recalculated confidence interval, the quantity of carpet ranges from approximately 247 million pounds to more than 2.5 billion pounds—approximately one order of magnitude.

Due to carpet's wide variability in the waste stream, statistical methods based on assumptions of normality and industry-standard waste characterization approaches are not well-suited for tracking trends over time for a single, low-incidence, non-normally distributed material like carpet. A formula-based approach for estimating Discards is recommended instead.

3.7 Conclusions on Waste Characterization Data

Based on its review of the 2014 CalRecycle waste characterization study and the alternative statistical approach applied to evaluate non-normally distributed data, Cascadia finds the following:

- The number and size (weight) of waste samples in the 2014 study exceeds industry standards.
- The 754 samples are allocated appropriately across generator types and regions.
- The statewide estimate (mean) for carpet percentage in the waste stream is 1.8%.
- Carpet is not normally distributed: 85% of samples have no (zero) carpet, and 15% of samples contain carpet, ranging from 1% to 100%.
- Confidence intervals for carpet are large compared to other materials (±0.6% absolute, or 33% relative).
- Industry-standard waste characterization approaches for statewide waste studies are not well-suited for tracking trends for small-quantity, infrequent, non-normally distributed materials like carpet.
- Specialized statistical analysis is recommended for carpet composition estimates and confidence intervals due to its non-normal distribution.
- The Program's estimates of carpet quantities for 2014 and 2018 fall within the waste characterization studies' wider confidence interval calculated using statistical methods for non-normal distribution.
- Reducing uncertainty requires many more samples and is costly. The Program needs estimated Discards on an annual basis, and California's statewide studies are conducted approximately every four years.
- Due to carpet's low incidence, highly variable quantities, and resulting non-normal distribution, waste characterization studies are not well-suited for tracking precise amounts of carpet each year.
- Accordingly, a formula-based approach is recommended for calculating Discards over time for the California Carpet Stewardship Program.

4 MODIFIED APPROACHES FOR ESTIMATING DISCARDS

As described previously in this report, primarily in Chapter 2, Cascadia's review of the existing Discards formula identified several considerations:

- **Deselection**, the selection of other flooring types in place of carpet, appears to be underestimated.
- **Demolition** discards are not calculated as a portion of building or floor area demolition.
- **Discards** estimates remain lower than carpet Sales over time, including when considering the lifespan of carpet.

To determine how best to modify the Discards estimates, Cascadia conducted research, analyzed data, and tested modified approaches to calculating different variables in the Discards formula as well as adjustments to the formula itself. Multiple approaches were considered and dismissed due to major data gaps or other limitations. This chapter describes the more promising approaches which fit into two main categories:

- A "mass balance" or historical sales approach where new carpet sold moves to Discards after a time period, based on estimated carpet lifespans.
- Modifications to the existing Discards formula focused on the Sales and Deselection variables.

Even the preferred options have substantial remaining data challenges and limitations, which this chapter explores before the final report chapter summarizes findings to date and proposed next steps for moving forward to reach agreement, finalize, and implement a modified approach for estimating Discards and calculating the carpet recycling rate in California.

4.1 Historical Sales or Mass Balance over Time

In a mass-balance or material flow framework, we expect that the quantity of carpet sold in California should be approximately equal to the amount of carpet discarded over time. That is, more carpet should not be discarded than was sold, nor should discards be consistently less than total carpet sales. Over time, we expect the flows "in" and "out" of the system to roughly balance. Considering the principle of mass balance over time, all carpet sales eventually become Discards—ideally after a long and useful life.

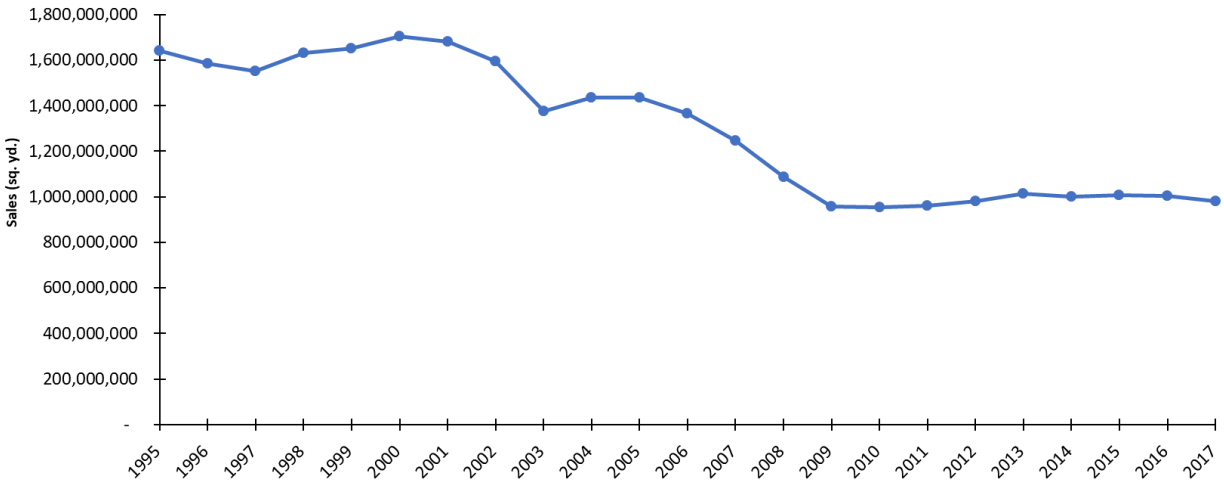
Carpet has a relatively long lifespan compared to other recyclable materials that may be produced, used, and discarded within the same year, such as aluminum cans, newspapers, or food. A portion of carpet in California's houses, apartments, and businesses was purchased and installed prior to the Program's start in 2011. Different types of carpet installed in different settings have highly variable replacement cycles, ranging from sometimes as short as one year in apartments, to 20 years or longer for high-quality, long-lasting carpet that some homeowners install.

Carpet mills report their Sales in California directly to an auditor for compilation. These data are considered highly reliable. Carpet sales have declined over the history of the Program. National sales data show a similar pattern of relative decreases since their peak sales around the year 2000, as shown in Figure 5.

Current carpet sales are not equivalent to current carpet discards. Today's Discards come from carpet that was sold in the past, when Sales were higher. Similarly, carpet sold today will likely not be disposed until several years into the future, potentially 5 to 10 years or more.

Because current sales have declined from historical levels, using current Sales leads to underestimation of carpet Discards.

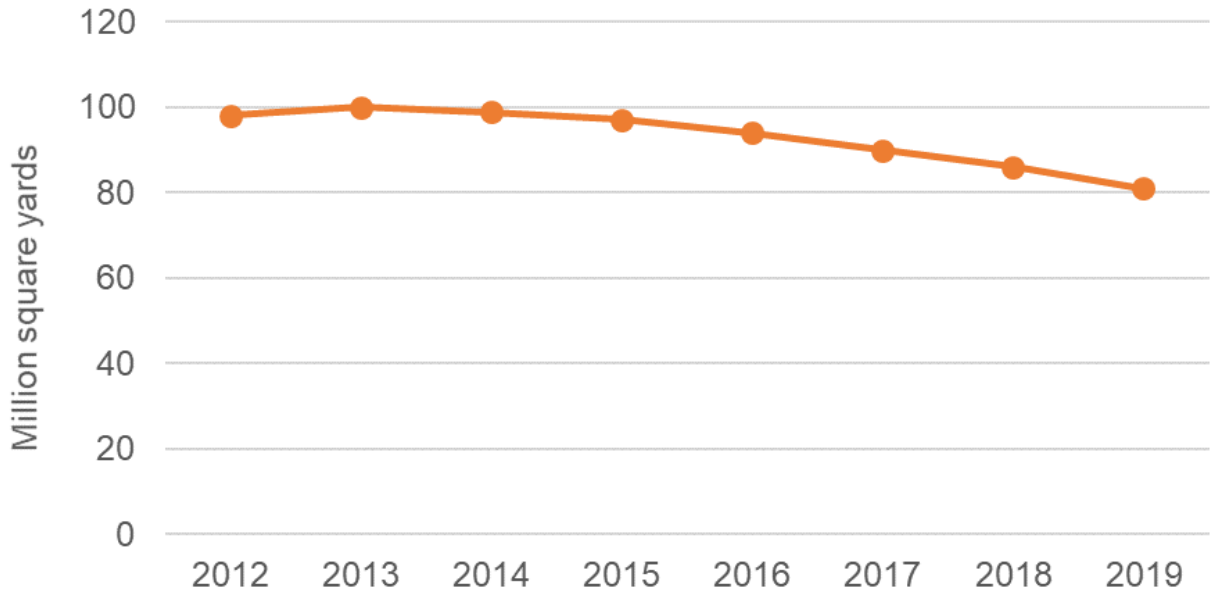
Figure 5. U.S. Carpet Sales, 1995–2017 *(in square yards)*



Source: Data from Market Insights

For California, statewide sales data are available starting in 2012, the first full year of the Carpet Stewardship Program. As shown in Figure 6, California sales have declined since tracking began in 2012.

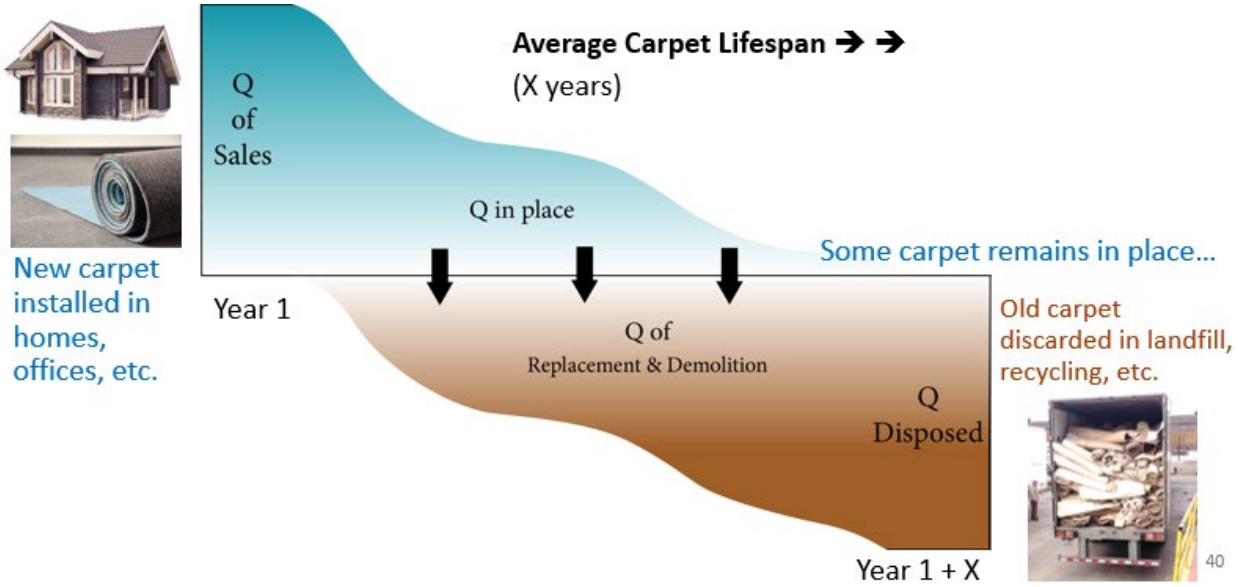
Figure 6. California Carpet Sales, 2012–2019 *(in square yards)*



Source: CARE/Aprio

To account for these changes over time, Cascadia considered using historical sales instead of current sales to estimate Discards. Figure 7 provides a conceptual illustration of how new carpet (Sales) shifts over time from installation in homes and offices to eventual discards for recycling or disposal. Over the typical lifespan of carpet, we expect that most of the carpet moves from installation to discards, though some is removed sooner, while other carpet may remain in place well past its average lifespan.

Figure 7. Conceptual View of How Carpet Shifts from Use to Discards Over Time



The change in *Sales* over time also reflects *Deselection* over this time period and avoids the needs for a separate *Deselection* variable to account for changes in carpet sales. Such an approach can also avoid the need for updating *Demolition* estimates because demolition comes from previously installed carpet, as reflected in historical sales figures. Using historical sales data can simplify the formula and calculations by avoiding the need for data on *Deselection*, *Demolition*, and *Replacement*.

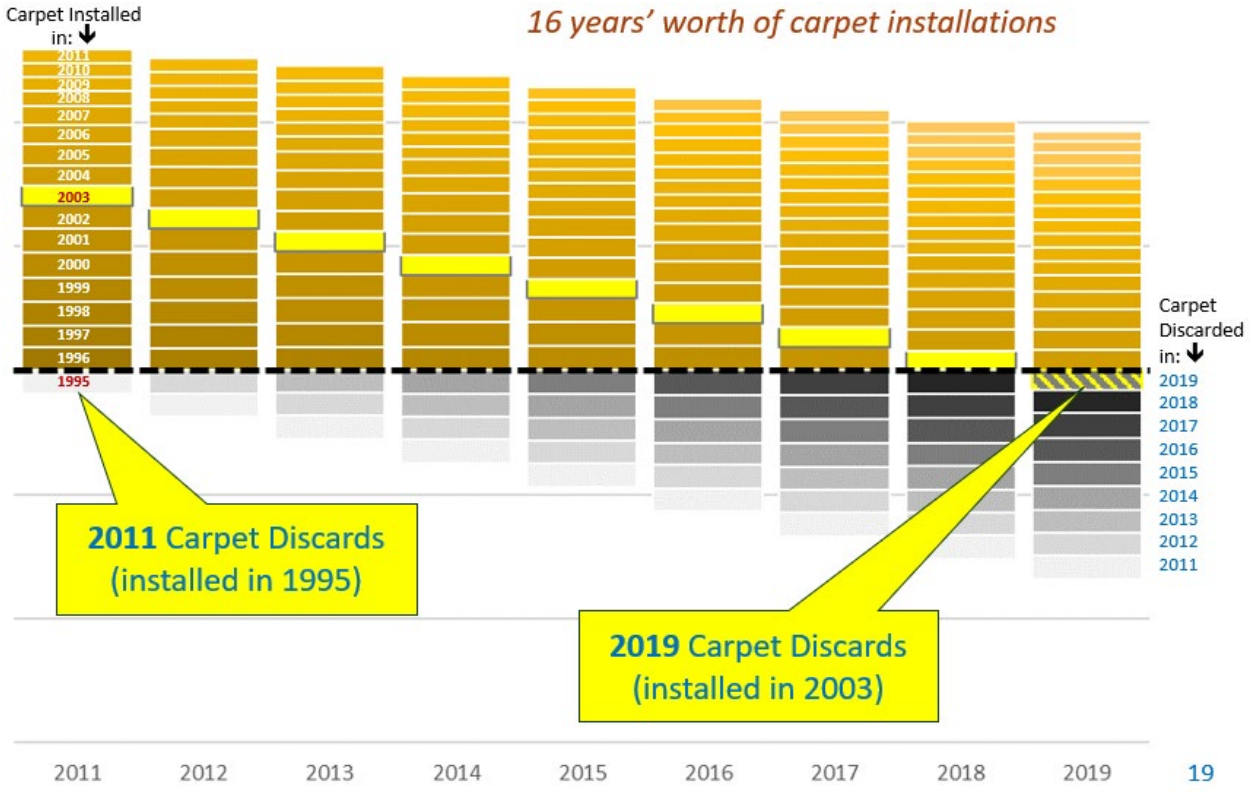
In their place, however, other data are needed regarding the replacement cycles, weights, and quantities of different types of carpet installed in homes, apartments, and businesses. Industry leaders report that lower-grade carpet installed in apartments (multifamily housing) is frequently replaced on a short cycle of less than five years, while high-grade carpet in single-family homes can remain installed for 15 to 20 years or more. Commercial spaces typically replace carpet on a timeline in between the two types of housing.

In a simplified conceptual model, one unit of carpet is sold and remains installed until it reaches its expected lifespan or replacement schedule, at which point it is discarded. For example, if carpet is replaced after 16 years, the carpet that is removed this year was installed 16 years earlier. The carpet that is installed today will be removed 16 years from now. The total "stocks" of all carpet installed in homes and commercial spaces is the sum of carpet installed this year, last year, the year before, and each year back to 16 years ago (or a different assumed lifespan or replacement cycle).

For example, in 2011, the total carpet "in place" would be the sum of each year's sales of carpet from 1996 through 2011. Each year, the carpet from 16 years prior would become discards in that year. Accordingly, the carpet discarded in 2011 would be from carpet that was installed in 1995. In any given year, the total carpet "stocks" (all carpet) were installed over multiple prior years.

Figure 8 below highlights in yellow the "slice" of carpet sold in 2003 moving closer to discards each year as it ages, until it is assumed to be discarded in 2019, at the end of its theoretical 16-year lifespan. After the carpet is discarded, it could be replaced with non-carpet flooring or with new carpet—which would begin a new 16-year life cycle resulting in eventual carpet discards in the future.

Figure 8. Illustrative Example of Carpet Installed and Shift to Discards over Time



Conceptually, this approach makes sense and offers some benefits. But the realities of the data limitations regarding market share of different carpet types, along with their lifespans and weights, render it currently impractical without further research and substantial additional data collection. Data needs include the following:

- **Weight per square yard** of carpet by type (e.g., broadloom, tile, builders' grade, high-end). Currently, the Density variable is collected from carpet mills in an annual survey and calculated for residential broadloom, commercial broadloom, and commercial carpet tile, but additional categories may be needed to align with different grades and lifespans of single-family versus multifamily carpet, for example. Detailed data are not available prior to 2016.
- **Market share** of carpet by sector (e.g., single-family, multifamily, commercial). Carpet mills have proprietary data on their own product sales, but industry-wide market share data, including by single-family versus multifamily sectors, are limited and not readily available.

- **Lifespan** of carpet by type and sector. Carpet mills generally do not track the lifecycle and disposition of their products over time; further research or assumptions would be needed.

To gather data that could support a historical sales approach at some point in the future, CARE could request that carpet mills report carpet sales by type and weight. Back-stamping of carpet with dates of manufacture, along with recording of these dates when carpet is collected, could support improved estimates of carpet lifespans by type. However, it would take an extended period of time (the length of the carpet replacement cycle) before data become available, and such an approach would not begin until mills implement back-stamping including year of manufacture.

If consensus assumptions on replacement cycles for different carpet types can be agreed upon, they could be used in a modeled approach. The core principle is that over time carpet Sales will eventually become Discards; the replacement cycle or lifespan determines the timing of when this will occur (but not *whether* it will occur).

Using carpet lifespan data, the formula could apply a rolling average calculation, to recognize that not at all carpet will be discarded in the year of its “average” lifespan. Alternatively, a model could assign percentages of carpet disposal to each year until 100% is reached, with the majority of discards assumed to occur in the years around the expected lifespan and smaller portions of discards occurring over shorter and longer timeframes.

A cumulative approach to historical sales—such as average annual Sales over the life of the Program, or over the past 10 years—could offer another way to reflect changes in Sales over time in the recycling rate denominator.

4.2 Modified Formula: Sales Plus Deselection

In light of the data limitations of the historical sales approach, Cascadia returned to focusing on ways to improve the existing Discards formula. In the formula, Sales are the primary driver of carpet Discards over time. The Sales data are considered highly reliable, as carpet mills report Sales in California directly to an auditor for compilation.

When new carpet is sold, it is typically installed in either existing buildings or new construction, as described below and illustrated in Figure 9.

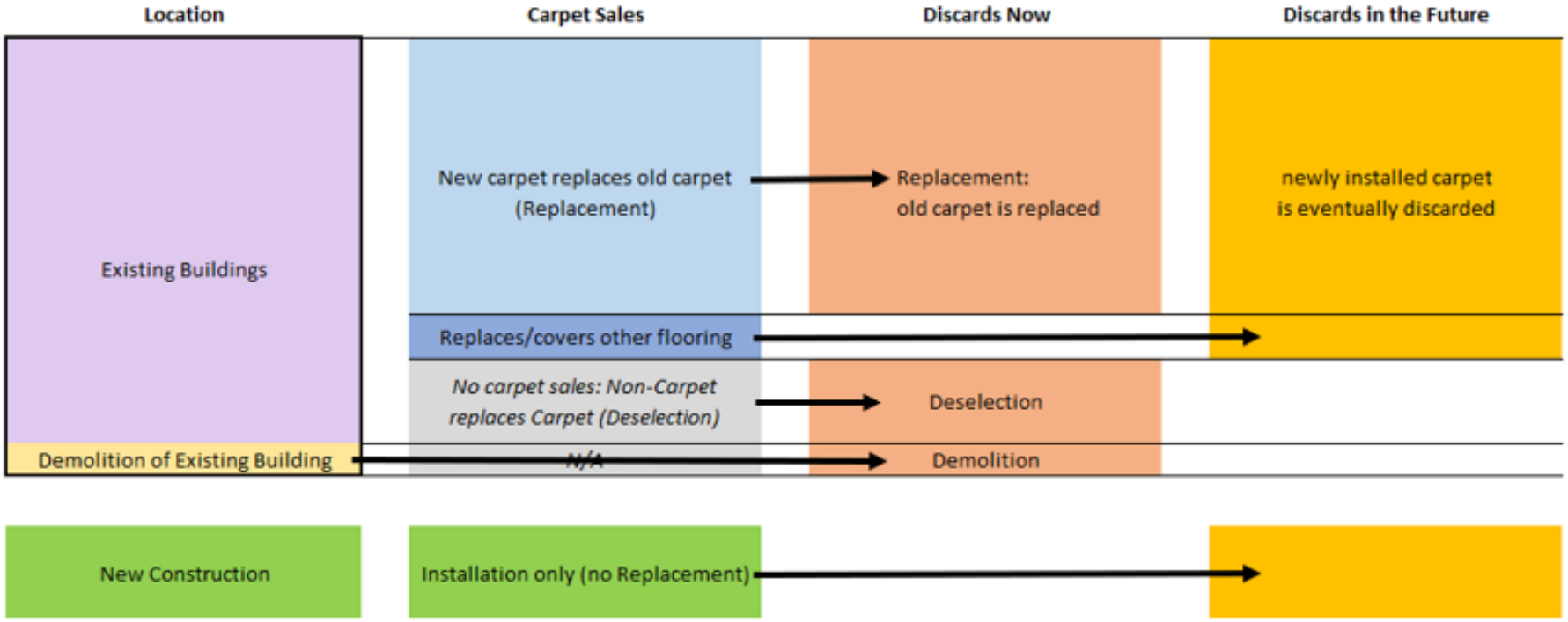
Existing buildings. When floor coverings are replaced in existing buildings, they are categorized as either carpet or non-carpet (hard surface). They can either replace the same type of flooring (e.g., carpet replaces carpet) or switch types (e.g., hard surface replaces carpet, or carpet replaces hard surface).

- When carpet replaces carpet, known as **Replacement**, it is expected to generate carpet discards both the current time (from the old carpet that is replaced) and in the future (when the new carpet reaches the end of its lifespan).
- When non-carpet replaces carpet, known as **Deselection**, it generates carpet discards at the current time only (no future carpet discards). Sales figures over the last decade illustrate the trend toward hard surfaces and away from carpet and indicate the need for a higher Deselection number.
- When carpet replaces non-carpet, no carpet discards are produced at the current time, but discards will be generated in the future when the carpet reaches the end of its lifespan. Switching *from* hard surfaces *to* carpet is thought to be uncommon today due to styling trends and the rapid advance in the technology to make luxury vinyl tile. Sales figures show the opposite trend, with carpet declining while non-carpet is rising—though that could change in the future as the “pendulum swings back” from the recent hard surface trend. Anecdotal reports suggest that Deselection has peaked, and the pendulum is moving back toward an equilibrium, particularly in the multifamily apartment and condominium sectors. Further data are needed.
- Non-carpet can also replace non-carpet. While some hard surfaces like stone, ceramic tile, and hardwoods have long lifespans, others like vinyl may be replaced on a shorter cycle. These sales and installations do not generate any carpet discards either now or in the future.

- Finally, sometimes an existing building is torn down, often to make way for newer, larger development. If the existing structure contains carpet, carpet discards are generated in the current time and known as **Demolition**. No future discards are expected (except from a replacement structure, but that would be reflected in future carpet sales to New Construction).

New construction. Carpet installed in new construction does not produce carpet discards in the year of sales, though the carpet will be discarded at some point in the future—in the form of future Replacement, Deselection, or Demolition. Non-carpet flooring in new construction will not generate carpet discards either at the current time or in the future.

Figure 9. Schematic of Current Carpet Sales by Location and Carpet Discards

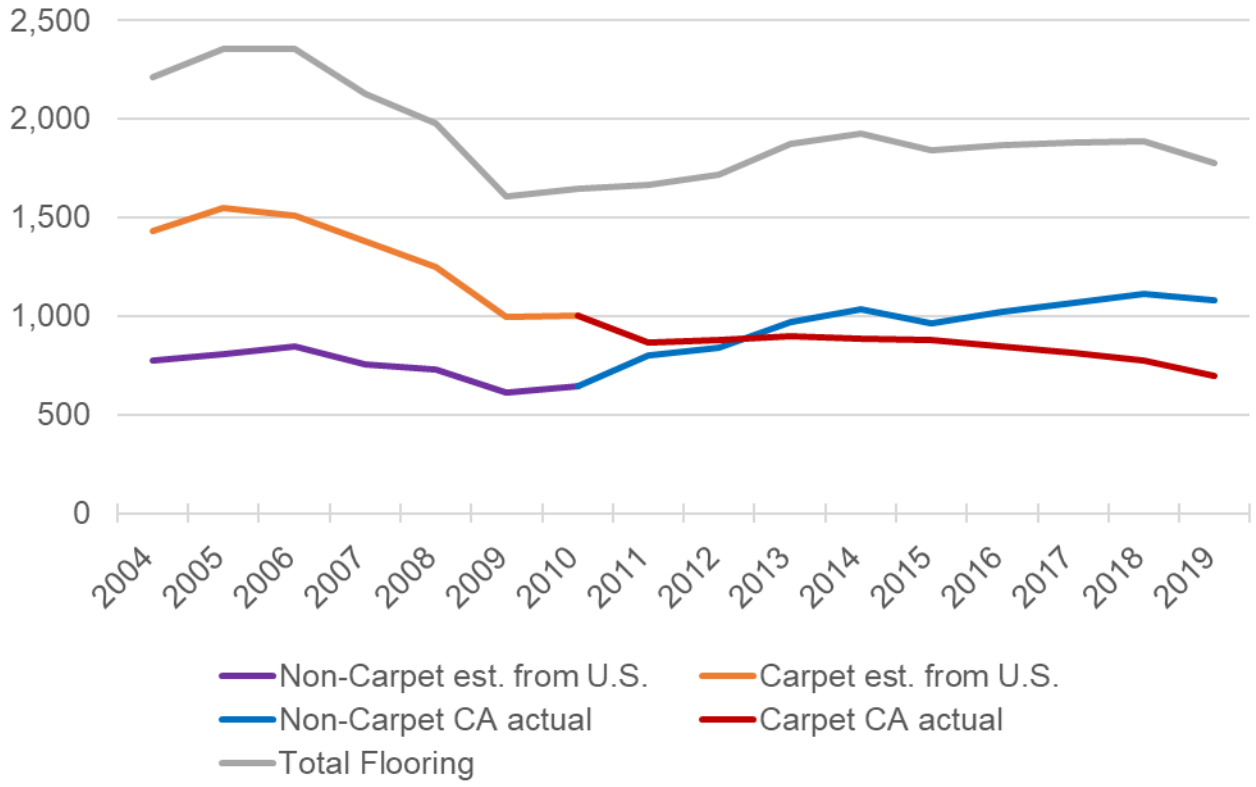


Revisiting the Deselection Variable

In the current Discards formula, Deselection is calculated as 0.75% of carpet Replacement sales. Replacement is assumed to be about 85% of carpet Sales, with the remainder going to New Construction. Accordingly, only small portions—less than 1.5% of carpet Replacement—are added back to the Replacement amount for both Deselection (0.75%) and Demolition (0.6%). As a result, approximately 14% of Sales are not accounted for in current or future Discards—the effect is an underestimation of Discards over time.

Deselection is intended to reflect Sales shifting from carpet to non-carpet, as observed in the sales trends for carpet (declining) and non-carpet flooring (increasing), as shown in Figure 10. However, the current Deselection calculation is based on *carpet* Sales, rather than *non-carpet* sales. The Deselection variable should logically be based on non-carpet sales, since it is intended to reflect the quantity of non-carpet sales that are replacing carpet—that is, where carpet is removed (generating carpet Discards) but no new carpet is purchased because a hard-surface flooring is purchased instead. Using carpet sales, instead of non-carpet sales, as the basis for Deselection does not substantially affect the results if the flooring types are split roughly evenly. With the market share shifting toward non-carpet, however, calculating **Deselection as a percentage of non-carpet sales is preferred.**

Figure 10. Estimated Sales of Carpet and Non-Carpet Flooring in California *(million square feet)*



The key question is how should Deselection be calculated. To improve the Deselection variable, CARE and Cascadia explored several options.

First, CARE worked with the installer group for a major big-box carpet retailer to analyze its database. For a recent one-year period, the installer group reviewed the flooring installation jobs that involved removal of carpet and replacement with hard-surface flooring. The quantity of flooring and size of installation jobs were not reported. The installation type was also not reported, but these are assumed be primarily in the single-family residential sector.

Market Insights also addressed Deselection in its annual reporting and estimated Deselection as a percentage of non-carpet sales in 2019. This figure was based on dollar values rather than quantities, however. An updated version for 2020 estimates Deselection based on flooring quantities in square feet, a preferred method.

When CARE's carpet industry members reviewed these figures, they noted that Deselection varies by sector and application, including differences between single-family homes, multifamily, commercial office space, and hotels. In some sectors with shorter cycles of flooring replacement, such as apartments, it is thought that the most of the Deselection shift from carpet to hard-surface flooring has already occurred. Some carpet industry members have estimated that this market segment represents 40% or more of carpet sales in California, and thus a lower figure for Deselection is suggested. More data on market share by type and replacement cycle are needed to support these statements.

Further research and evaluation on the Deselection variable is needed to reach a conclusion and agreement on the proper value and calculation to apply, including whether a sector-based approach (single-family, multifamily, commercial) is appropriate and can be supported with available data.

5 CONCLUSIONS AND NEXT STEPS

The work to date has made strong progress on multiple fronts, though as it has advanced, CARE and Cascadia have continued to uncover additional layers of complexity, nuances, data gaps, and new challenges as we move closer to reaching agreement on a new formula-based calculation.

5.1 Summary Findings

Findings to date include the following:

1. Overall, the individual variables used in the Discards formula appear conceptually reasonable. Cascadia suggests that further analysis of the data inputs and calculation approach is warranted. This should include decoupling the *Demolition* and *Deselection* rates from current carpet *Replacement* and considering options for reflecting changes in *Sales* from higher historical levels.

2. *Sales* data are compiled by an accounting firm and appear sound. *Sales* were higher in the past, however, and have decreased since the start of the Program. These past sales are the source of current and future Discards, at the end of the carpet's lifespan.

3. Supplemental measurements conducted during 2018 waste sampling field studies validate the Program's *Density* estimates of carpet weight per square yard. Considering variations in carpet weight by type (e.g., broadloom versus tile) may be a useful refinement but requires robust market share data, which are not readily available.

4. Data for the *Replacement*, *Demolition*, and *Deselection* variables are not verified with existing public data sources. The current estimates for *Demolition* and *Deselection* appear too low and warrant adjustments, to avoid underestimation of Discards.

5. *Deselection* of carpet replaced by other flooring materials is currently underestimated. Cascadia is considering several approaches for estimating Deselection, which raise additional questions, data requirements, and needs for external validation.

6. While waste characterization studies provide an overall view of waste flows, they are not intended to track annual changes in a relatively small, non-normally distributed single material like carpet.

7. Due to carpet's non-normal distribution, use of a modified Discards formula is the recommended method for estimating carpet discards.

8. This report considers a historical sales approach that supports a mass balance of materials over time, where carpet Discards are approximately equal to carpet *Sales* over time. Additional data and/or consensus assumptions would be needed to validate this approach.

9. Data and calculation adjustments are needed to the current Discards formula, which will result in a higher estimate of carpet Discards (and thus a lower recycling rate).

10. A modified formula as shown below uses *Sales* data and an updated *Deselection* parameter, based on non-carpet sales, which will result in higher estimated Discards from the current reporting. Additional review is needed to determine the viability and need for a *Demolition* variable. Further refinements of the data, calculations, and continued discussions with CARE, the Advisory Committee, and CalRecycle are still needed to reach agreement, finalize the Discards calculations, implement the updates, and address implications for the recycling rate and Program goals.

At this time, the following formula is the approach we are focused on, but certain parameters still need to be refined.

$$\textbf{Discards} = (\textbf{Sales} * \textbf{Density}) + \textbf{Deselection}_{\textbf{Non-Carpet}} + \textbf{\textit{Demolition}}$$

5.2 Next Steps

Key steps that are needed to recommend and finalize a modified Discards formula include the following:

- Obtain additional data to improve Deselection estimates, including carpet and non-carpet sales in California over time, replacement lifecycles for carpet and non-carpet materials, and allocation of sales across sectors and types (e.g., single-family/multifamily/commercial, replacement versus new construction), or reach agreement on reasonable assumptions. Modified approaches to estimating Deselection have not yet proven sufficiently robust without additional data collection and validation.

- Reach agreement on how to proceed given lack of up-to-date published data to support Demolition estimates and application to estimates of carpet Discards. The existing Demolition calculation based on carpet Replacement has weaknesses and should be revised or removed.

- Following discussions and review, the parties have reached agreement that the topic of statistical analyses for non-normally distributed materials like carpet—and the resulting larger confidence interval—has been sufficiently explored and confirmed based on the 2014 waste composition data and a preliminary analysis of 2018 data.

- Obtain additional flooring industry data (current and historical) for both carpet and non-carpet flooring to strengthen and calibrate historical sales / mass-balance models based on carpet weight, lifespan, and market share sales for key carpet types and markets, including single-family residential, multifamily residential, and commercial broadloom and carpet tile. Unfortunately, these data are not readily available through the industry's internal data collection systems.

- Develop and implement research protocols for ongoing data requirements to support improved future calculation methods with a modified formula and parameters.

Based on the current status of progress and the need for further consensus development with CARE, the Advisory Committee, CalRecycle, and key stakeholders, the project team recommends following this report with additional assessment of modified Discards formula approaches, including additional data collection and analysis,

to solidify an updated Discards formula. We believe this additional work can be completed by late fall 2021.

This work needs to consider implications for the recycling rate calculation, including discussions between CARE and CalRecycle on how these changes will affect the Program's goals, targets, and progress to date. Year-over-year growth in the recycling rate and in total Recycled Output quantities are also useful measures of progress. This follow-up work can be conducted as a standalone effort or may make sense to implement as part of the Program's upcoming 5-Year Plan Update.

End Report