Carpet Inventory Estimates Using Building Characteristics Data: Opportunities and Obstacles

Presented by Matthew Realff and Ning Ai
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Overview

- Team Members and Research Background
- Methodology of Carpet Modeling
  - Carpet inventory estimates
  - Discarded carpet estimates
- Region Illustrations and Results
  - Atlanta metro
  - Seattle metro
- Next Steps and Obstacles
Multidisciplinary Research Team

- City and Regional Planning (Georgia Tech)
  - Dr. Nacey Green Leigh
  - Dr. Steven French
  - Taelim Choi
  - Ning Ai

- Mechanical Engineering (Georgia Tech and Univ. Washington)
  - Bert Bras (Georgia Tech)
  - Joyce Cooper (Univ. of Washington, Seattle)
  - Caroline Guidry
  - Seung-Jin Lee

- Chemical Engineering (Georgia Tech)
  - Dr. Matthew J Realff
  - Dr. John Muzzy
  - Valli Subbiah

- Regional Economics and Geography (West Virginia Univ.)
  - Dr. Randy Jackson
“Reservoir Engineering”

Product Stockpiles

Product Retirement (Failure, Obsolescence)

Organization Behaviour
(Stockpile, Recycle, Dispose)

Transportation Costs (Distance, Frequency, Modes)
Ongoing Research

- Product Inventory Estimates (PIE) – current
  - Carpet
  - Computer CRTs
  - FPD TVs
- Product obsolescence estimates – current
- Transportation and environmental models
- Recycling center location analysis
- Socioeconomic impact analysis
Approaches of Product Inventory Estimates and Data Requirements

- General approaches of PIE
  - Focus on the beginning of product life cycle
    - Product sales & replacement rates
    - Ownership rates & demographic characteristics
  - Trace the end of product life cycle
    - Waste characterization study

- Data needed but unknown
  - Carpet sales
  - Carpet use rates
  - Distribution of carpet inventory
Data Availability at County Level

- Building characteristic data commonly provided by Tax Assessor’s Office
  - Land use or building structure use type
  - Building sq ft or parcel size
  - Year built
  - Improvement value
  - Address
Methodology Developed for Carpet Inventory Estimates

\[ C = \sum_{i=1}^{n} \text{BldgFloorspace}_i \times \text{CarpetUseRate}_i \]

- **Floorspace by Building Type**
- **Building Floorspace**
  - Data Source: Land Parcel Database Compiled by Local Tax Assessor’s Office
  - If not available: Regional Average
  - Improvement Value per Sq Ft

- **Land Parcel or Building ID**
  - Data Source: Land Parcel Database Compiled by Local Tax Assessor’s Office
  - GIS Layers

- **Land Use or Structure Use Type**
  - Data Source: Land Parcel Database Compiled by Local Tax Assessor’s Office
  - Carpet Use Rate by Building Type

- **Mapping Spatial Distribution**
  - Data Needs

- **Data Needs**
**Initial Estimate of Carpet Use Rate**

<table>
<thead>
<tr>
<th>General Categorization of Building Use</th>
<th>Estimated Carpet Use (% floor space)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>50</td>
</tr>
<tr>
<td>Industrial</td>
<td>10</td>
</tr>
<tr>
<td>Institutional</td>
<td>40</td>
</tr>
<tr>
<td>Multi-Family</td>
<td>90</td>
</tr>
<tr>
<td>Office</td>
<td>90</td>
</tr>
<tr>
<td>Single-Family</td>
<td>80</td>
</tr>
</tbody>
</table>

Please give us feedback!
Estimated Carpet Weight per Sq Yd

- Parameters for weight estimation:
  - Percent of broadloom carpet: 90%
  - Percent of carpet tile: 10%
  - weight/sq yd broadloom carpet: 4.5 lbs
  - weight/sq yd carpet tile: 9 lbs
  → Assume uniform weight: 5lb/sq yd

Note: Data estimation from a working document by Matthew Realff. The result is to be further refined for different building types.
Discarded Carpet Modeling

Assumption of carpet life span
- Commercial use: 8-10 yrs
- Residential use: 10-15 yrs

Two scenarios of carpet life span in general
- 10 yrs
- 15 yrs

Yearly carpet discard rate
- 10-yr lifespan: 1/10 of carpet stock
- 15-yr lifespan: 1/15 of carpet stock

Note: The life span information is provided by Dr. Matthew Realff.
Selection of Case Study Regions

**Greater Seattle Area:**
4-county of Central Puget Sound Region

**Atlanta Metro Area:**
13-county air quality non-attainment area
## Regional Comparison: Atlanta and Seattle

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Atlanta 13-county Region</td>
<td>2,578,493</td>
<td>3,698,679</td>
<td>4,316,054</td>
<td>2,030,804</td>
</tr>
<tr>
<td>Greater Seattle</td>
<td>4,025,600</td>
<td>3,275,847</td>
<td>3,449,417</td>
<td>1,816,383</td>
</tr>
</tbody>
</table>

Data source: (a) Land area: ARC and PSRC; (b) Population: US Census 2000, 2005; (c) Employment: Average of 12-month total civilian employment data provided by State Department of Labor LAUS (Local Area Unemployment Statistics) program – reflecting the worker’s county of residence rather than place of work.
Comparison of Regional Growth Rate

Note: Data of population and housing units in 2005 are estimated by US Census.
Comparison of Economic Indicators

Source: (1) National Association of Realtors; (2) US Census 2000; (3) US Conference of Mayors and the National Association of Counties.
Atlanta Data Illustration

- SMARTRAQ parcel-level database
- Latest data available by Year 2004
- Integrated data of 13 counties in one database
- 1,329,627 parcels in Atlanta metro
- Standardized by Center for GIS at Georgia Tech

Data processing method
- Re-categorize 13 building uses standardized in SMARTRQ database into six general types for carpet estimates
- Estimate building sq ft using the average sq ft by building type when sq ft data is not available (institutional, single-family, and multi-family residential)
# Atlanta Land Use Categories

<table>
<thead>
<tr>
<th>Land Use Categories by CGIS</th>
<th>Definition</th>
<th>Re-Categorization for Carpet Estimation</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>Property actively used in agriculture</td>
<td>NA</td>
</tr>
<tr>
<td>Cemetery/Park/Open Space</td>
<td>Public parks, cemeteries and open spaces</td>
<td>NA</td>
</tr>
<tr>
<td>Commercial</td>
<td>Wholesale and retail trade</td>
<td>Commercial</td>
</tr>
<tr>
<td>Industry</td>
<td>Manufacturing, light industry and warehousing</td>
<td>Industrial</td>
</tr>
<tr>
<td>Institutional</td>
<td>Government or other institutional uses</td>
<td>Institutional</td>
</tr>
<tr>
<td>Mobile Home</td>
<td>Single mobile home or mobile home park</td>
<td>Single-family</td>
</tr>
<tr>
<td>Multi-Family Residential</td>
<td>Apartment or other attached housing units</td>
<td>Multi-family</td>
</tr>
<tr>
<td>Office</td>
<td>High and low-rise offices</td>
<td>Office</td>
</tr>
<tr>
<td>Parking/TCU</td>
<td>Parking lot, structure or utility</td>
<td>NA</td>
</tr>
<tr>
<td>Recreation</td>
<td>Golf course or other recreation area</td>
<td>NA</td>
</tr>
<tr>
<td>Single-Family Residential</td>
<td>Owner occupied, detached housing unit</td>
<td>Single-family</td>
</tr>
<tr>
<td>Unknown</td>
<td>Use could not be determined</td>
<td>NA</td>
</tr>
<tr>
<td>Vacant</td>
<td>Undeveloped parcel</td>
<td>NA</td>
</tr>
</tbody>
</table>
## Atlanta 13-County Building Summary

<table>
<thead>
<tr>
<th>Categorization for Carpet Estimates</th>
<th>Statistics of Building Sq Ft</th>
<th>Statistics of No. of Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of Total Bldg Sq</td>
<td>Recorded Bldg Sq</td>
</tr>
<tr>
<td>Commercial</td>
<td>9.45</td>
<td>350,214,947</td>
</tr>
<tr>
<td>Industrial</td>
<td>10.04</td>
<td>371,800,262</td>
</tr>
<tr>
<td>Institutional</td>
<td>1.50</td>
<td>15,823,051</td>
</tr>
<tr>
<td>Multi-Family Res.</td>
<td>6.61</td>
<td>232,711,547</td>
</tr>
<tr>
<td>NA</td>
<td>6.94</td>
<td>257,262,017</td>
</tr>
<tr>
<td>Office</td>
<td>4.36</td>
<td>161,434,552</td>
</tr>
<tr>
<td>Single-Family Res.</td>
<td>61.10</td>
<td>2,042,354,436</td>
</tr>
<tr>
<td>Total</td>
<td>100</td>
<td>3,431,600,812</td>
</tr>
</tbody>
</table>

Note: (1) The category of “NA” includes land for agriculture, open space, parking, recreation, vacant, or unknown use. (2) The estimated bldg sq ft only includes estimations in this study; i.e., those estimated by SMARTRAQ study is considered as “recorded” for now.
## Atlanta Carpet Inventory Estimates

<table>
<thead>
<tr>
<th>Categorization for Carpet Estimate</th>
<th>Bldg Sq Ft (Estimated)</th>
<th>Est. Carpet Use (% Floorspace)</th>
<th>Est Carpet Use (Sq Ft)</th>
<th>Est Carpet Use (Sq yard)</th>
<th>Est Carpet Weight (lbs)</th>
<th>Est Carpet Weight (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>350,214,947</td>
<td>50</td>
<td>175,107,474</td>
<td>19,456,386</td>
<td>97,281,930</td>
<td>48,641</td>
</tr>
<tr>
<td>Industrial</td>
<td>371,800,262</td>
<td>10</td>
<td>37,180,026</td>
<td>4,131,114</td>
<td>20,655,570</td>
<td>10,328</td>
</tr>
<tr>
<td>Institutional</td>
<td>55,646,703</td>
<td>40</td>
<td>22,258,681</td>
<td>2,473,187</td>
<td>12,365,934</td>
<td>6,183</td>
</tr>
<tr>
<td>Multi-Family Res.</td>
<td>244,719,463</td>
<td>90</td>
<td>220,247,517</td>
<td>24,471,946</td>
<td>122,359,732</td>
<td>61,180</td>
</tr>
<tr>
<td>NA</td>
<td>257,262,017</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Office</td>
<td>161,434,552</td>
<td>90</td>
<td>145,291,097</td>
<td>16,143,455</td>
<td>80,717,276</td>
<td>40,359</td>
</tr>
<tr>
<td>Single-Family Res.</td>
<td>2,263,418,807</td>
<td>80</td>
<td>1,810,735,046</td>
<td>201,192,783</td>
<td>1,005,963,914</td>
<td>502,982</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,704,496,751</strong></td>
<td></td>
<td><strong>2,410,819,840</strong></td>
<td><strong>267,868,871</strong></td>
<td><strong>1,339,344,356</strong></td>
<td><strong>669,672</strong></td>
</tr>
</tbody>
</table>
Estimated Volume of Discarded Carpet in Atlanta

- Assumption 1: 10-yr life span of carpets
  - Each year in Atlanta metro area
    - In total: 669,672 tons/10yrs = 66,967 tons
    - (310 lbs/person-yr)/10 yrs = 31 lbs/person-yr

- Assumption 2: 15-yr life span of carpet
  - Each year:
    - In total: 669,672 tons/15yrs = 44,644 tons
    - (310 lbs/person-yr)/15 yrs = 21 lbs/person-yr
Greater Seattle Area Data Illustration

- Building data is collected from four counties and processed individually
- Data year: 2005 or 2006
- No. of records in each county
  - King: 596,467
  - Kitsap: 96,328
  - Pierce: 308,364
  - Snohomish: 214,517

- Data processing method
  - Match building use type with building sq ft via unique Parcel/Building ID across the tables
  - Re-categorize/standardize all building uses (approx. 100~ over 1,000 categories) into six general types for carpet estimates
  - Estimate building sq ft using the index of “improvement value per sq ft” when sq ft data is not available (in Snohomish County only)

Note: The number of records is not necessarily equal to the number of buildings, because some parcels may not have any building structure and some parcels may have more than one buildings.
# Seattle Building Summary

<table>
<thead>
<tr>
<th>Categorization for Carpet Estimates</th>
<th>Statistics of Building Sq Ft</th>
<th>Statistics of No. of Buildings</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>% of Total Bldg Sq</td>
<td>Recorded Bldg Sf</td>
</tr>
<tr>
<td>Commercial</td>
<td>7.81%</td>
<td>189,798,030</td>
</tr>
<tr>
<td>Industrial</td>
<td>12.39%</td>
<td>301,792,716</td>
</tr>
<tr>
<td>Institutional</td>
<td>4.01%</td>
<td>128,187,456</td>
</tr>
<tr>
<td>Multi-Family Res.</td>
<td>13.22%</td>
<td>383,606,177</td>
</tr>
<tr>
<td>NA</td>
<td>1.37%</td>
<td>45,156,558</td>
</tr>
<tr>
<td>Office</td>
<td>6.08%</td>
<td>168,400,048</td>
</tr>
<tr>
<td>Single-Family Res.</td>
<td>55.12%</td>
<td>1,854,524,371</td>
</tr>
<tr>
<td>Total</td>
<td>100.00%</td>
<td>3,071,465,356</td>
</tr>
</tbody>
</table>
### Seattle Carpet Inventory Estimate

<table>
<thead>
<tr>
<th>Building Categorization</th>
<th>Bldg Sq Ft</th>
<th>Est Carpet Rate (% floorspace)</th>
<th>Est Carpet Use (Sq Ft)</th>
<th>Est Carpet Use (Sq yard)</th>
<th>Est Carpet Weight (lbs)</th>
<th>Est Carpet Weight (tons)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Commercial</td>
<td>262,637,450</td>
<td>50</td>
<td>131,318,725</td>
<td>14,590,969</td>
<td>72,954,847</td>
<td>36,477</td>
</tr>
<tr>
<td>Industrial</td>
<td>416,820,697</td>
<td>10</td>
<td>41,682,070</td>
<td>4,631,341</td>
<td>23,156,705</td>
<td>11,578</td>
</tr>
<tr>
<td>Institutional</td>
<td>135,065,040</td>
<td>40</td>
<td>54,026,016</td>
<td>6,002,891</td>
<td>30,014,453</td>
<td>15,007</td>
</tr>
<tr>
<td>Multi-Family Res.</td>
<td>444,907,625</td>
<td>90</td>
<td>400,416,863</td>
<td>44,490,763</td>
<td>222,453,813</td>
<td>111,227</td>
</tr>
<tr>
<td>NA</td>
<td>46,249,277</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Office</td>
<td>204,521,295</td>
<td>90</td>
<td>184,069,166</td>
<td>20,452,130</td>
<td>102,260,048</td>
<td>51,130</td>
</tr>
<tr>
<td>Single-Family Res.</td>
<td>1,854,524,371</td>
<td>80</td>
<td>1,483,619,497</td>
<td>164,846,611</td>
<td>824,233,054</td>
<td>412,117</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>3,364,725,756</strong></td>
<td></td>
<td><strong>2,295,132,336</strong></td>
<td><strong>255,014,704</strong></td>
<td><strong>1,275,073,520</strong></td>
<td><strong>637,537</strong></td>
</tr>
</tbody>
</table>
Estimated Volume of Discarded Carpet in Seattle

- Assumption 1: 10-yr life span of carpets
  - Each year:
    - 63,754 tons/yr
    - 37 lbs/person-yr

- Assumption 2: 15-yr life span of carpet
  - Each year:
    - 42,502 tons/yr
    - 25 lbs/person-yr
## Summary Comparison: Atlanta vs. Seattle

<table>
<thead>
<tr>
<th></th>
<th>Atlanta 13-County</th>
<th>Greater Seattle</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Population (2005)</strong></td>
<td>4,136,054</td>
<td>3,449,417</td>
</tr>
<tr>
<td><strong>Total No. of Buildings</strong></td>
<td>1,267,957</td>
<td>1,247,402</td>
</tr>
<tr>
<td><strong>Total Building Sq Ft</strong></td>
<td>3,704,496,751</td>
<td>3,364,725,756</td>
</tr>
<tr>
<td><strong>Estimated Carpet Stock (tons)</strong></td>
<td>669,672</td>
<td>637,537</td>
</tr>
<tr>
<td><strong>Estimated Discarded Carpet (tons/yr)</strong></td>
<td>44,644 - 66,967</td>
<td>42,502 - 63,754</td>
</tr>
<tr>
<td><strong>Estimated Discarded Carpet (lbs/person-yr)</strong></td>
<td>21 - 31</td>
<td>25 - 37</td>
</tr>
</tbody>
</table>
Spatial Illustration by County

Greater Seattle Area

Atlanta Metro Area

CARPET_SF
- 31931325 - 100000000
- 100000001 - 150000000
- 150000001 - 200000000
- 200000001 - 300000000
- 300000001 - 500000000
- 500000001 - 1500000000

County Boundary
- Interstate Rd
- CCM
- IND
- INST
- SF
- MF
- OFFICE

0 25 50 100 150 200 Miles
Crucial Data Needed to Refine the Results

- Percentage of buildings that are carpeted (by building type)
- Quality and type of carpet (by building types) for estimation of carpet fiber types and carpet weight
- Regional sales data (total and split among buyers)
- Life span of carpet in different buildings
We appreciate any relevant information and comments you could provide to enhance our research.

Thank you!