Improvements to Lawn and Garden Equipment Emission Estimates for Baltimore, Maryland

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Presented to the
19th International Emissions Inventory Conference
San Antonio, TX
September 29, 2010

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Air Quality Research and Innovative Solutions

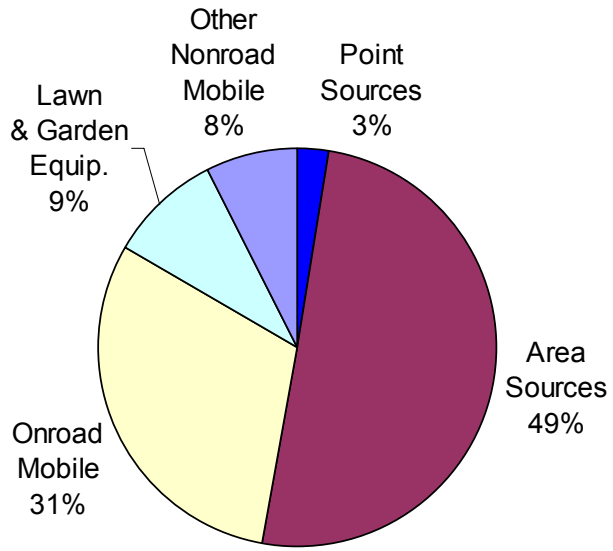
Presentation Outline

- Background
- Preview of findings
- Technical approach
  - Survey design and implementation
  - Data analysis and emission estimates
- Summary of results
- Questions and discussion

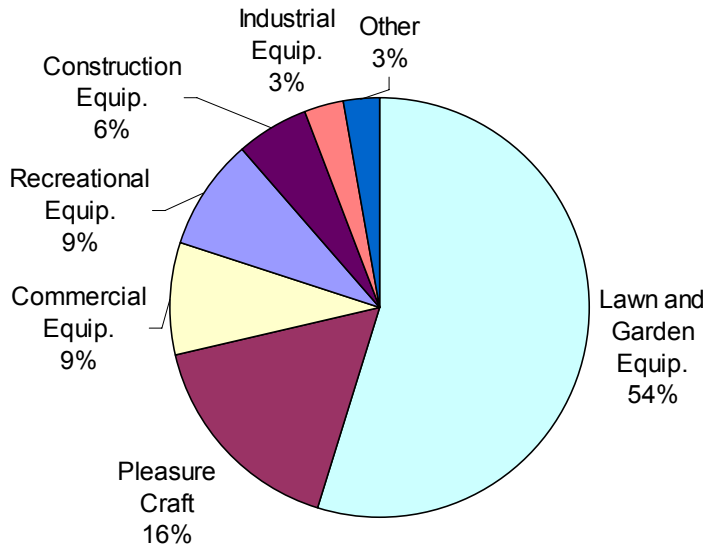
Background (1 of 3)

Lawn and garden equipment can be a significant source of VOC and other pollutants in suburban and urban areas

2005 anthropogenic VOC emissions in the Baltimore metropolitan area



2005 non-road VOC emissions in the Baltimore metropolitan area



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Background (2 of 3)

EPA's NONROAD model is used to calculate county-level emissions from lawn and garden equipment

$$\text{Emissions} = \text{Pop} \times \text{Power} \times \text{LF} \times \text{A} \times \text{EF}$$

where:

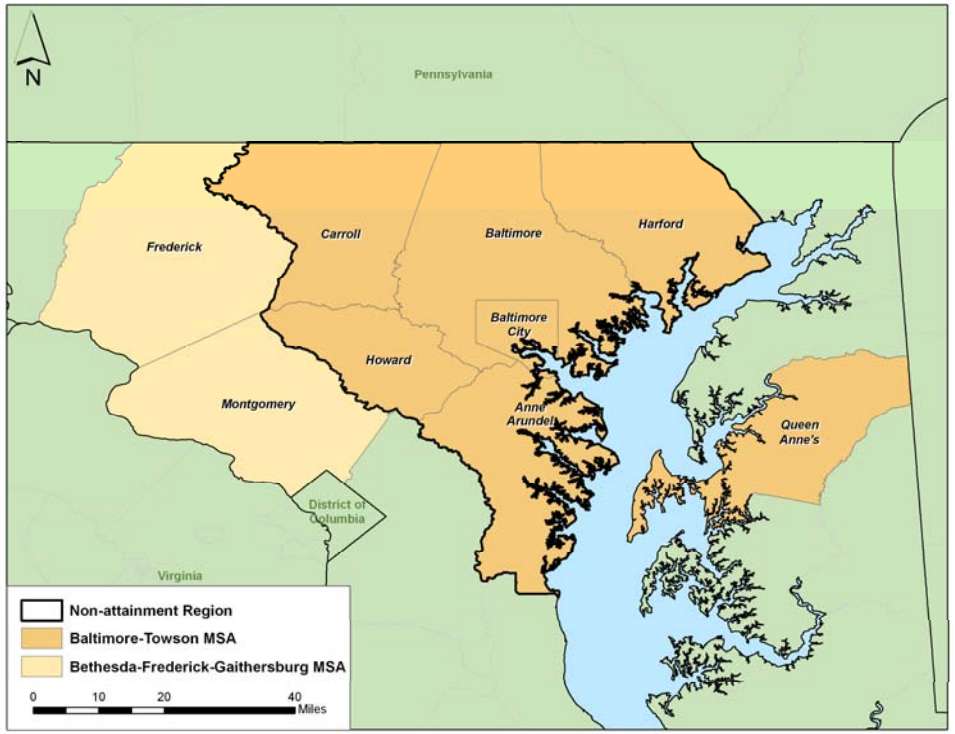
Pop	=	equipment populations
Power	=	average horsepower (hp)
LF	=	load factor (fraction of available power)
A	=	activity (hours per year)
EF	=	emission factor in grams per horsepower-hour (g/hp-hr)

Background (3 of 3)

Objective: To assess the potential for improving lawn and garden equipment emission estimates in NONROAD through the collection of local activity data

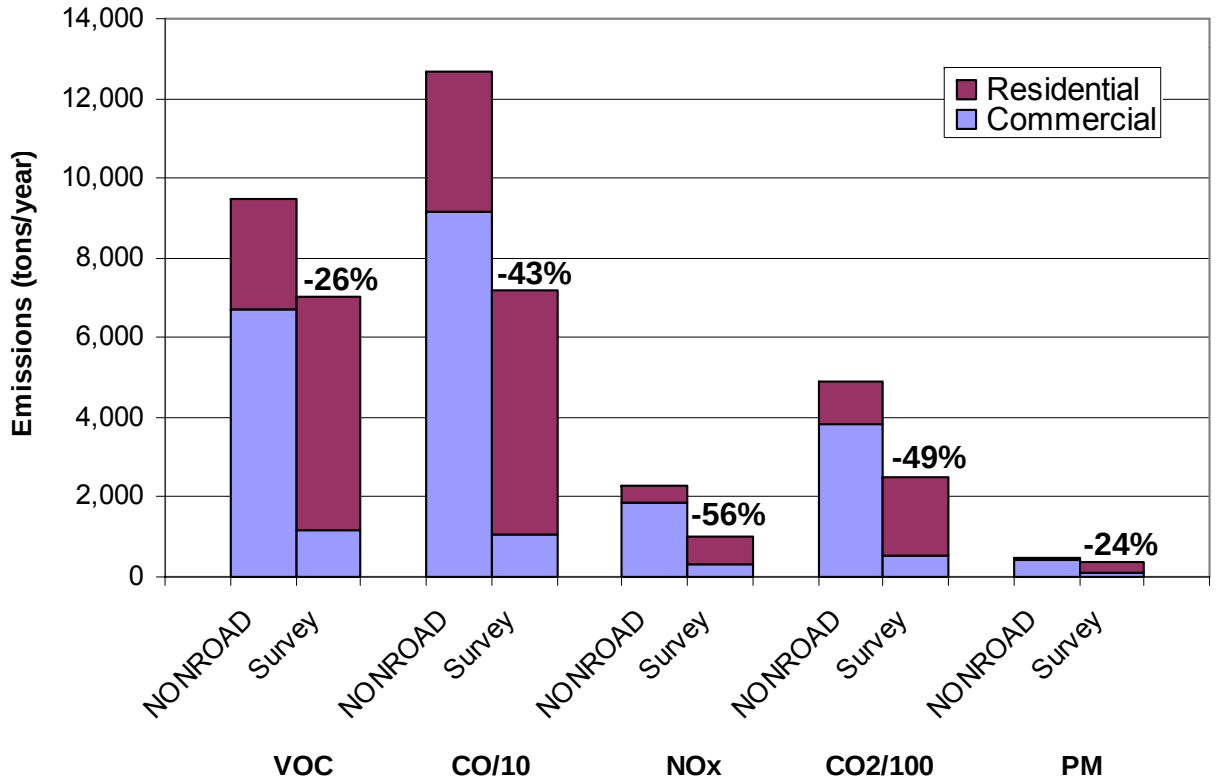
Nine-county area around Baltimore chosen due to

- Nonattainment status
- Population
- Climate
- Availability of AQ data



Preview of Findings

Comparison of 2009 lawn and garden equipment emission estimates for Baltimore



Survey Design and Implementation (1 of 3)

- Residential survey sample size of 7,000 (350 completes)

Dwelling Type	Number
Single family detached	6,477
Duplex	377
Multi-family (apartment, condominium, etc.)	146
Total	**7,000**

- Commercial survey sample size of 2,500 (150 completes)

SIC Code	Description	Sample Size
0781	Landscape counseling and planning	114
0782	Lawn and garden services	1,214
0783	Ornamental shrub and tree services	317
7261	Funeral service and crematories (for cemeteries)	198
7992	Public golf courses	75
7997	Membership sports and recreation clubs (private golf courses)	340
8221	Colleges, universities, and professional schools	202
8222	Junior colleges and technical institutes	16
9512	Land, mineral, wildlife, and forest conservation	45
Total businesses		**2,521**

Survey Design and Implementation (2 of 3)

- Telephone surveys conducted by Population Research Systems

Data Elements		
Residential Survey	**Business Survey**	**Both Surveys**
• Property characteristics – Single-, dual-, or multi-family structure – Lot size – Size of landscaped or maintained area – Condition of vegetation on maintained areas – Living space square footage – Number of bedrooms and bathrooms	• Business characteristics – Services provided – Counties of operation – Number of clients or accounts – Types of clients served – Number of employees – Annual revenue	• Number of lawn and garden equipment units owned • Equipment characteristics: make, model, type, fuel, power rating, and age • Equipment usage characteristics: engine load fuel use, and time in use • Weekday and weekend-day usage patterns • Seasonality of usage patterns • Anticipated plans for equipment replacement • Owner assessment of equipment condition

Survey Design and Implementation (3 of 3)

- Residential surveys used a pre-announcement letter and a financial incentive of $20
- Residential surveys conducted July–August 2009
- Commercial surveys used a telephone pre-screening, an optional phone/fax/email survey, and a financial incentive of $30
- Commercial surveys conducted August–November 2009

Data Analysis and Emission Estimates (1 of 2)

- Analyses conducted at the regional level
- Residential and commercial equipment populations scaled from survey results

1. **Sum the equipment population for each equipment type**
2. **Divide the equipment populations by the total number of households or businesses in the sample (including responses that documented no equipment ownership)**
3. **Multiply by the total number of households or businesses in the geographic area of interest**

Data Analysis and Emission Estimates (2 of 2)

- Survey results also used to calculate average annual usage rates, temporal patterns of usage, and equipment age distributions
- Usage rates correlated with other variables (e.g., residential lot sizes, number of employees) to identify potential surrogates for lawn and garden equipment activity
- Survey results converted to NONROAD inputs; NONROAD run with local and default data

Summary of Results (1 of 9)

- Residential survey
  - 511 participants
  - 371 with equipment
  - 26% response rate

Disposition	Description	Number
Excluded from survey	Wrong number, fax line, phone disconnected or non-working, non-English household	910
Eligibility unknown	Answering machine, busy signal, or no answer	4,059
Total non-contacts		**4,969**
Refusals	Refused to participate in survey	1,454
Participant - equipment owner	Owns lawn and garden equipment	371
Participant - no equipment	Does not own lawn and garden equipment	140
Total contacts		**1,965**
Total attempts		**6,934**

- Commercial survey
  - 721 participants
  - 92 with equipment
  - 70% response rate

Disposition	Description	Number
Excluded from survey	Wrong number, fax line, phone disconnected or non-working, non-English business	228
Eligibility unknown	Answering machine, busy signal, or no answer	1,267
Total non-contacts		**1,495**
Refusals	Refused to participate in survey	305
Participant - equipment owner	Owns lawn and garden equipment	92
Participant - no equipment	Does not own lawn and garden equipment	629
Total contacts		**1,026**
Total attempts		**2,521**

Summary of Results (2 of 9)

Commercial equipment ownership minimal for businesses in most SIC codes surveyed

SIC Code	Description	Owns Equipment	No Equipment
0781	Landscape counseling and planning	0	33
0782	Lawn and garden services	67	103
0783	Ornamental shrub and tree services	9	16
7261	Funeral service and crematories (for cemeteries)	4	145
7992	Public golf courses	7	9
7997	Membership sports and recreation clubs (private golf courses)	4	160
8221	Colleges, universities, and professional schools	1	118
8222	Junior colleges and technical institutes	0	8
9512	Land, mineral, wildlife, and forest conservation	0	37
–	**Total**	**92**	**629**

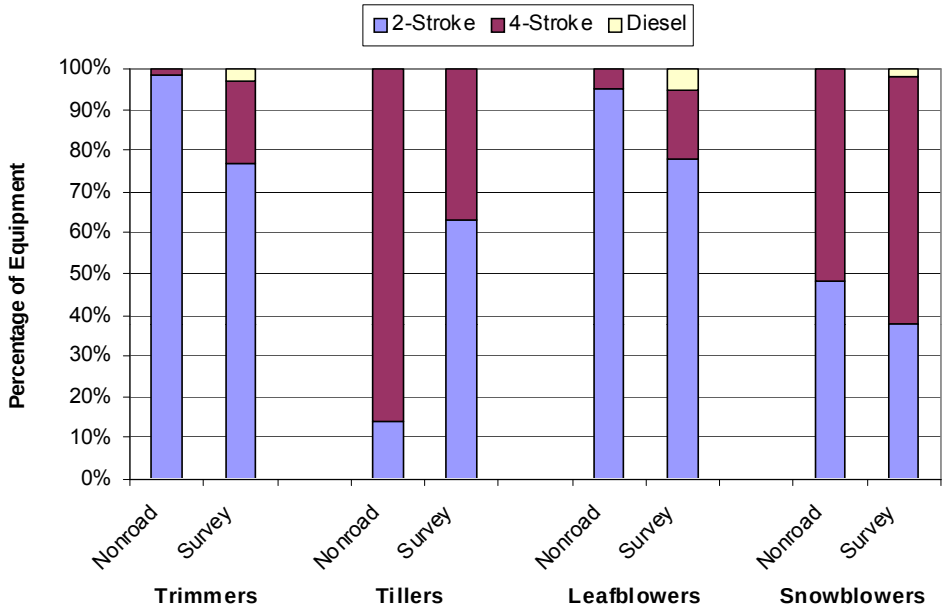
SIC code	Description
078203	Sodding services
078204	Landscape contractors
078206	Lawn and grounds maintenance
078207	Topsoil
078213	Hydroseeding

Summary of Results (3 of 9)

- Survey-derived residential populations 75% higher than NONROAD populations
- Survey-derived commercial populations 87% lower than NONROAD populations

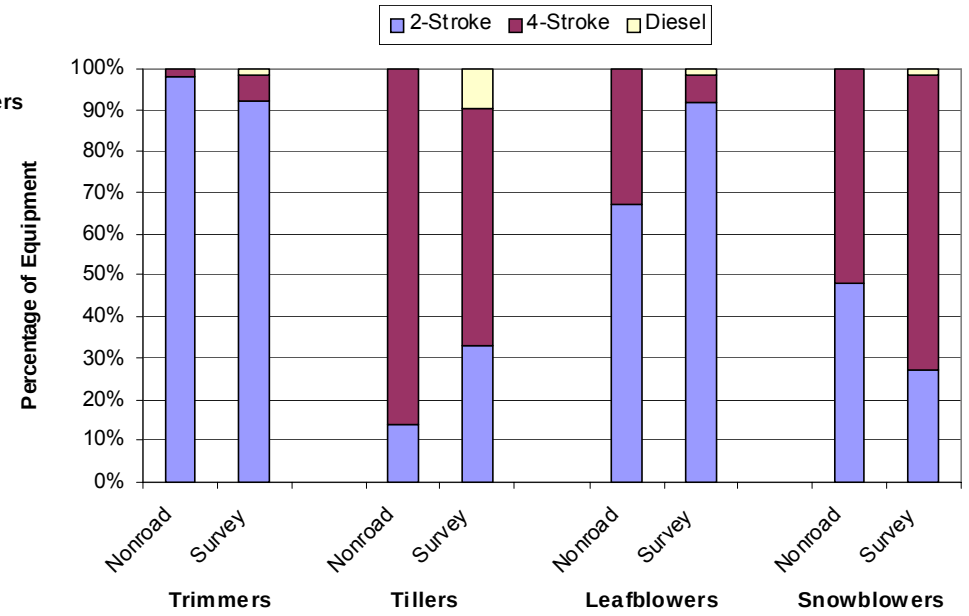
Equipment Type	NONROAD Default Populations			Survey-Derived Populations		
	Commercial	Residential	Total	Commercial	Residential	Total
Chainsaws	18,647	83,850	102,496	4,326	340,725	345,051
Chippers/Stump Grinders	2,708	–	2,708	679	29,929	30,608
Front Mowers	10,225	–	10,225	871	57,555	58,426
Lawn and Garden Tractors	9,674	191,311	200,985	781	92,088	92,869
Lawn Mowers	38,858	525,821	564,678	3,302	702,170	705,472
Leafblowers	27,031	118,166	145,197	5,262	421,302	426,564
Rear Engine Riding Mowers	1,189	27,995	29,185	1,505	75,972	77,477
Rotary Tillers	14,236	53,614	67,850	1,063	103,599	104,662
Shredders	7,466	–	7,466	74	18,418	18,492
Snowblowers	29,471	140,350	169,822	2,001	174,967	176,968
Trimmers/Edgers/Brush Cutters	47,526	225,018	272,544	8,636	368,351	376,987
Turf Equipment	23,984	–	23,984	1,463	–	1,463
Other Equipment	17,845	9,423	27,268	2,233	18,418	20,651
Total	**248,859**	**1,375,548**	**1,624,407**	**32,196**	**2,403,492**	**2,435,688**

Summary of Results (4 of 9)



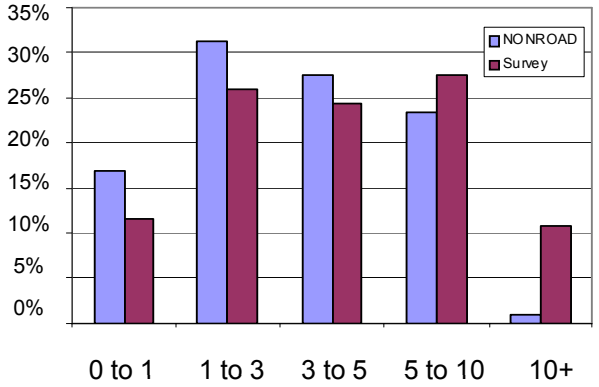
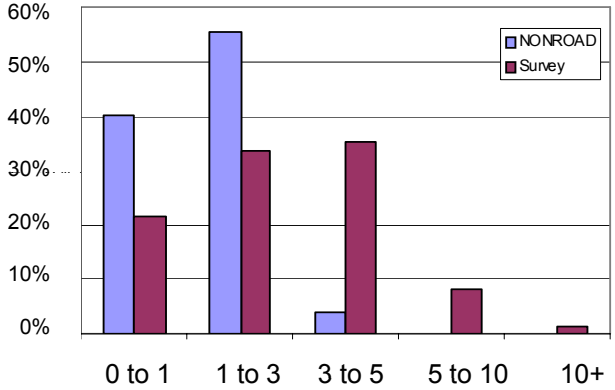
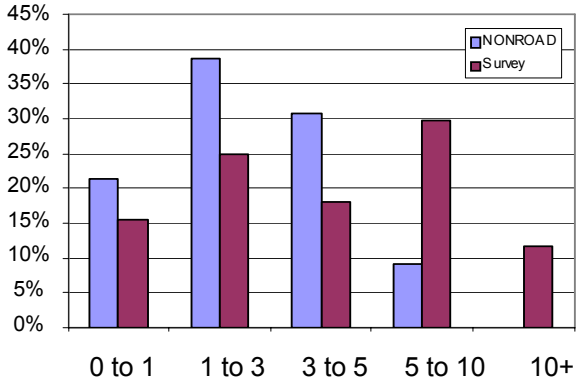
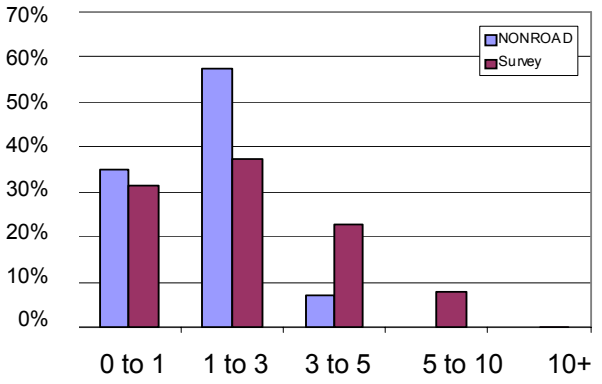
Residential equipment populations by fuel type

Commercial equipment populations by fuel type

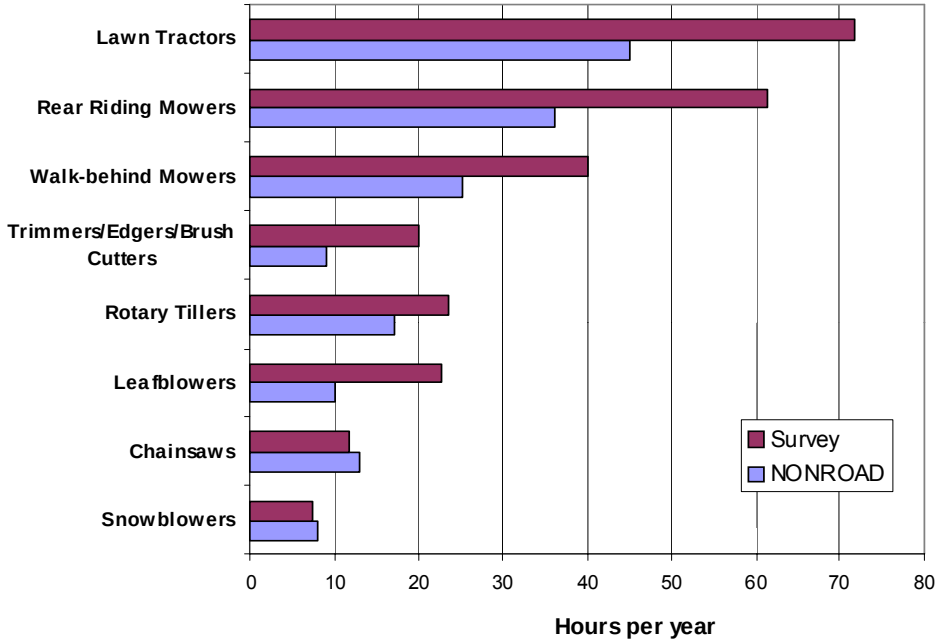


Summary of Results (5 of 9)

Equipment age distributions (in years)

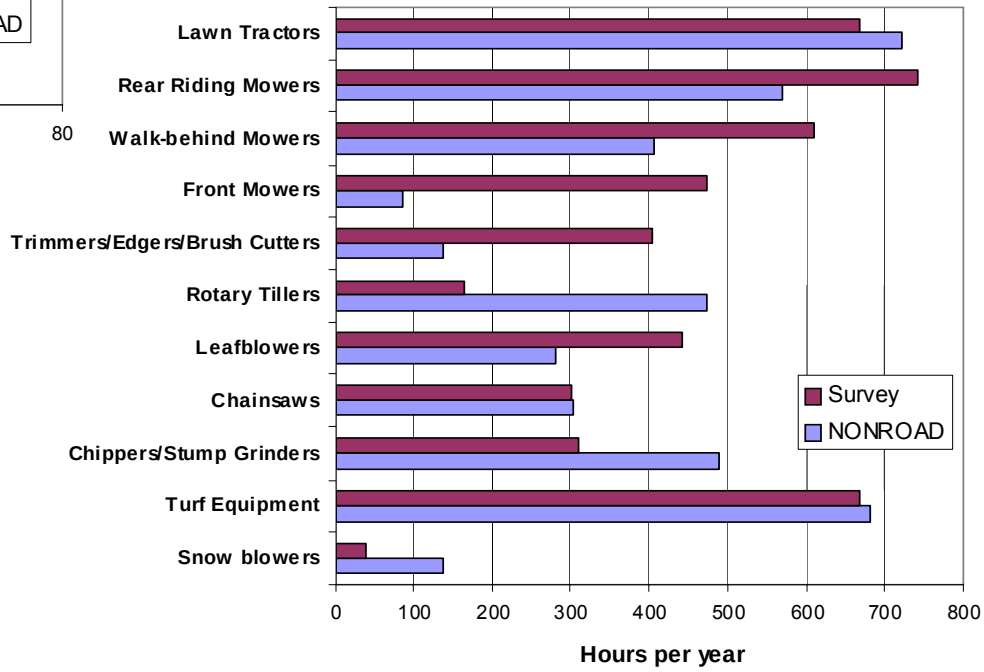
	Residential	Commercial
Walk-behind mowers		
Trimmers/edgers/ brushcutters		

Summary of Results (6 of 9)



Annual activity for **residential** equipment types

Annual activity for **commercial** equipment types



Summary of Results (7 of 9)

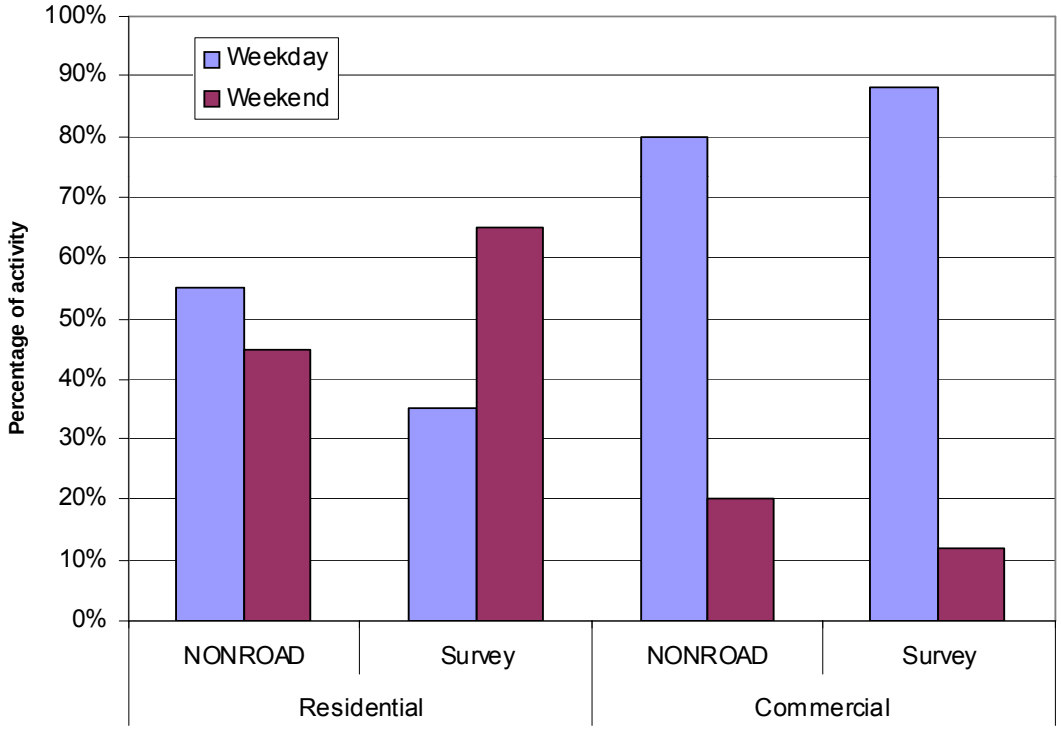
Day-of-week activity

Residential

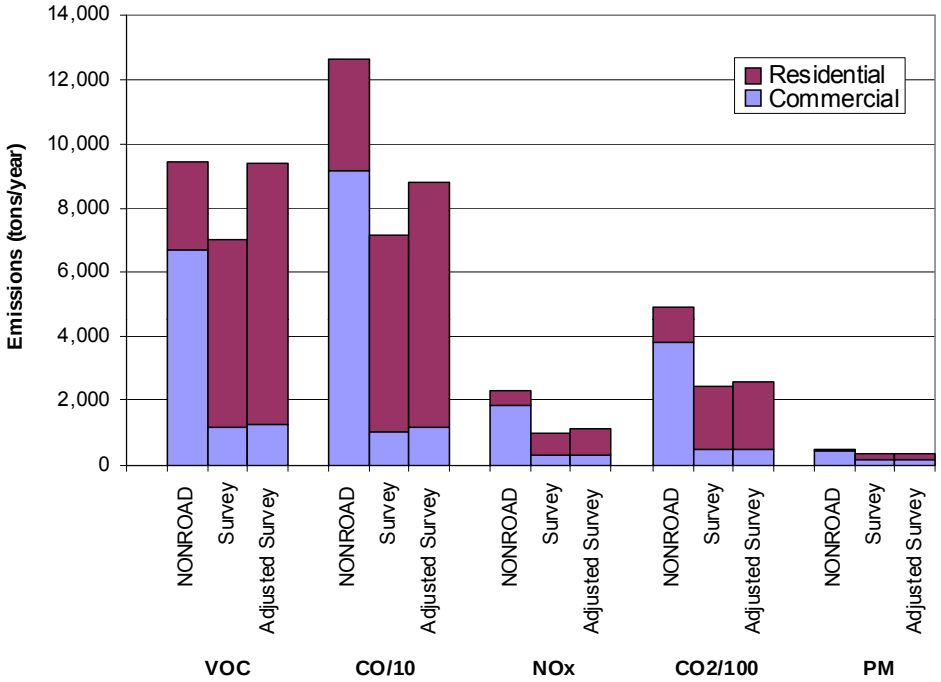
- NONROAD − 45% of activity on weekend days
- Survey results − 65% of activity on weekend days

Commercial

- NONROAD − 80% of activity on weekdays
- Survey results − 88% of activity on weekdays

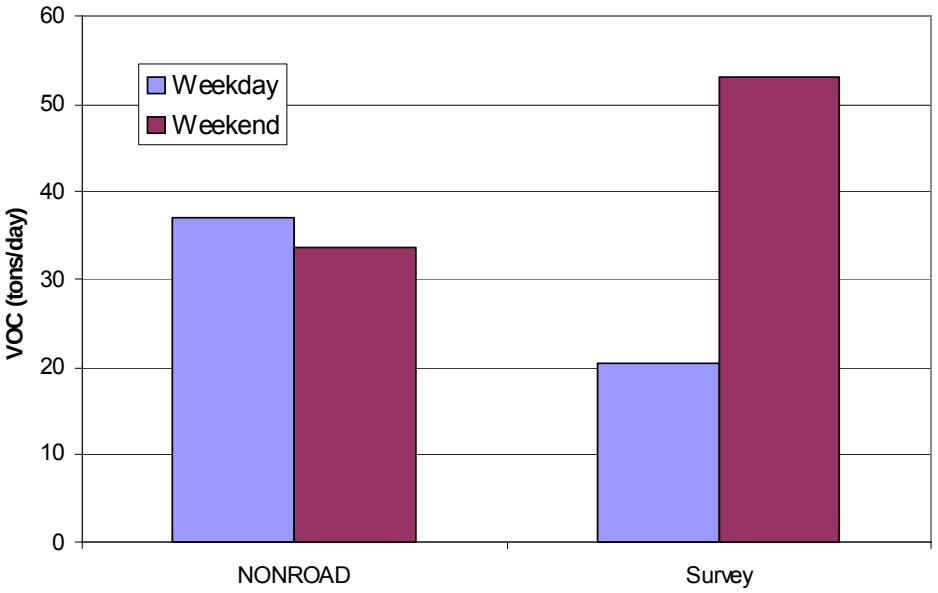


Summary of Results (8 of 9)



Comparison of 2009 lawn and garden equipment emission estimates for Baltimore

Comparison of average July weekday and weekend day emission estimates



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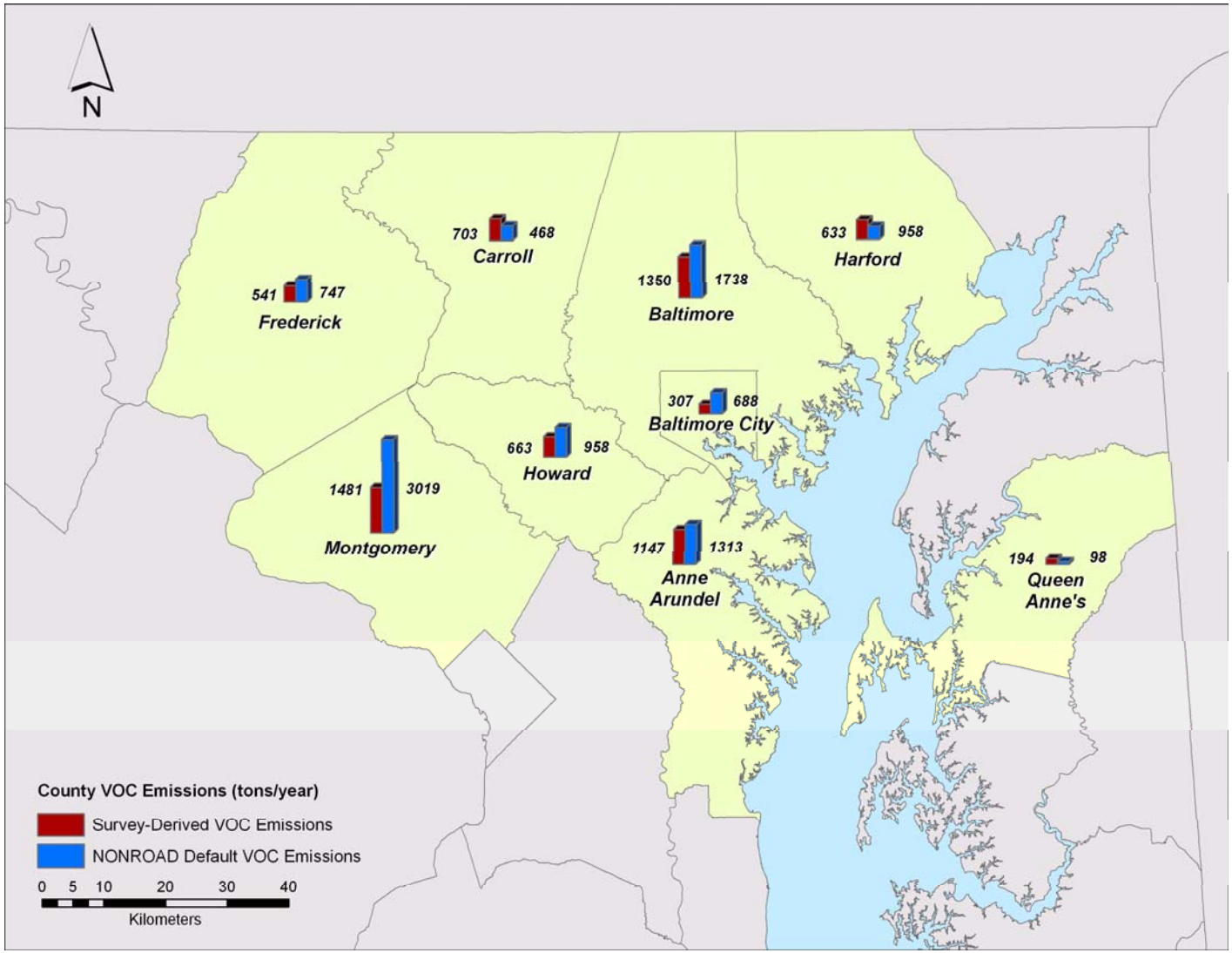
Summary of Results (9 of 9)

Comparison of county-level 2009 lawn and garden equipment emission estimates for Baltimore



Conclusions (1 of 2)

Project results show that NONROAD default equipment population and activity data are not representative of local conditions in Baltimore

- Emission estimates based on survey results are 24% to 56% lower than estimates produced using NONROAD default data
- Equipment populations based on survey results are significantly higher than NONROAD default data (2.4 million vs. 1.6 million)
- Equipment populations based on survey results have a significantly higher proportion of residential equipment than NONROAD default data (98% vs. 85%)

Conclusions (2 of 2)

- Project results also show that local data can be used to improve temporal and spatial allocation factors in the NONROAD model
  - Survey-derived temporal profiles apportion 65% of residential equipment activity to weekends (vs. 45% for NONROAD)
  - Survey-derived data result in lower equipment populations and emissions for urbanized Baltimore County than NONROAD data
- Studies in other areas are needed to further evaluate potential biases in the NONROAD model's default data (e.g., issues with residential/commercial population splits)

Questions and Discussion

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