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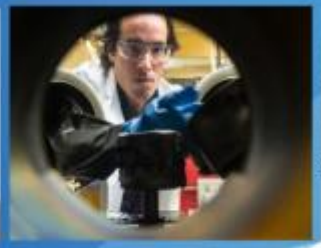



Assessing Potential Air Pollutant Emissions from Agricultural Feedstock Production using MOVES

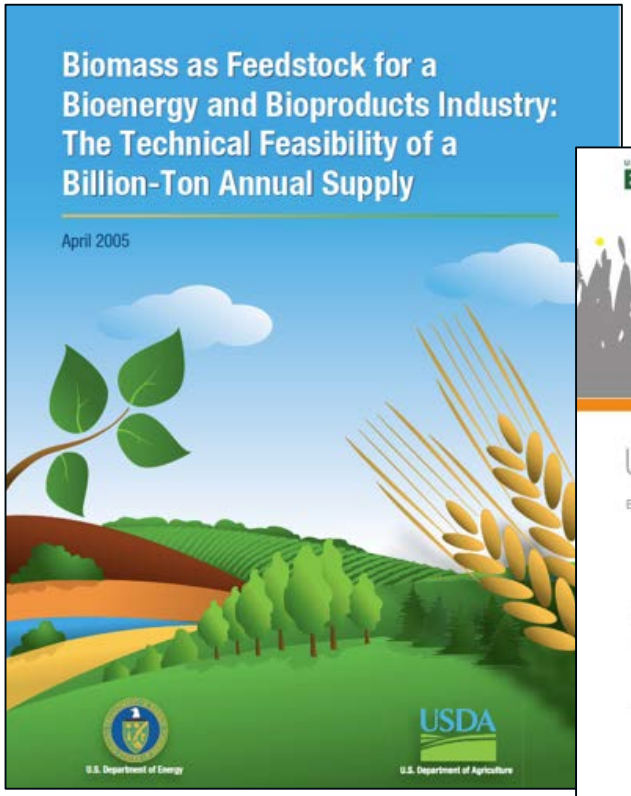
Annika Eberle

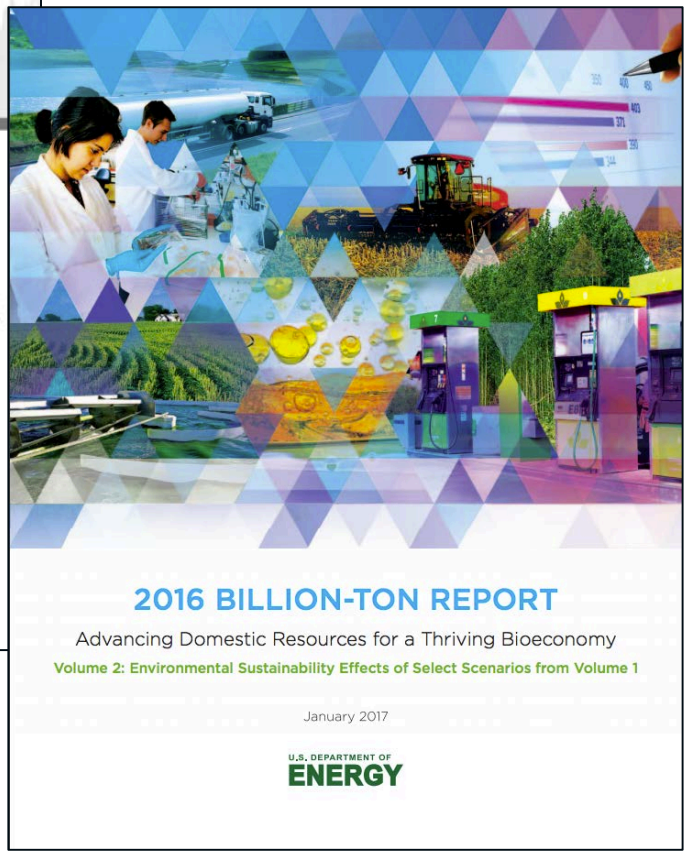
National Renewable Energy Laboratory

EPA's International Emissions Inventory Conference

August 16, 2017

Billion Ton Studies





Billion Ton Studies

Other contributors to Chapter 9: *Implications of air pollutant emissions from producing agricultural and forestry feedstocks* in Volume 2 of the 2016 Billion-Ton Report include:

- Ethan Warner (NREL)
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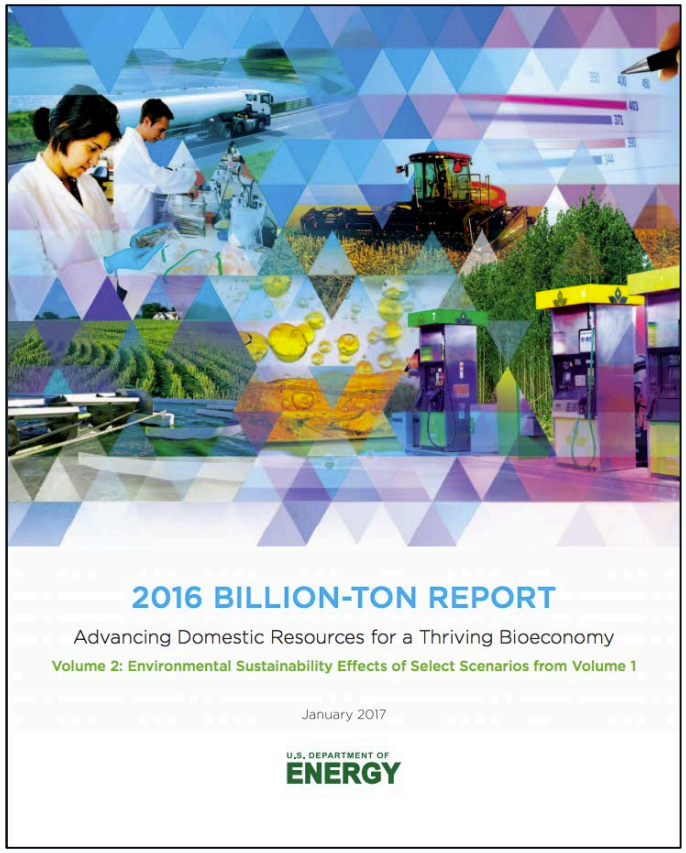
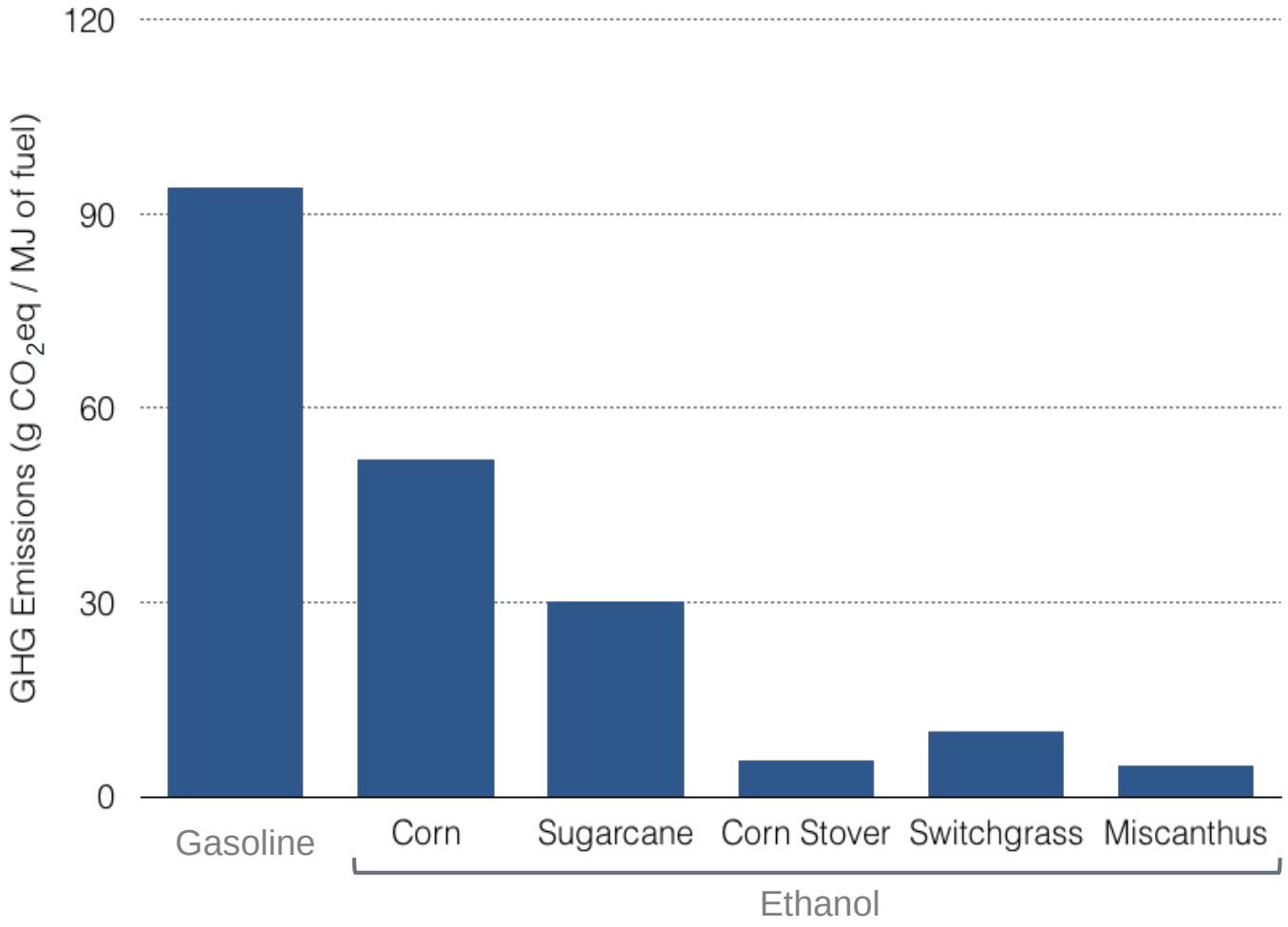


Context and Study Objectives

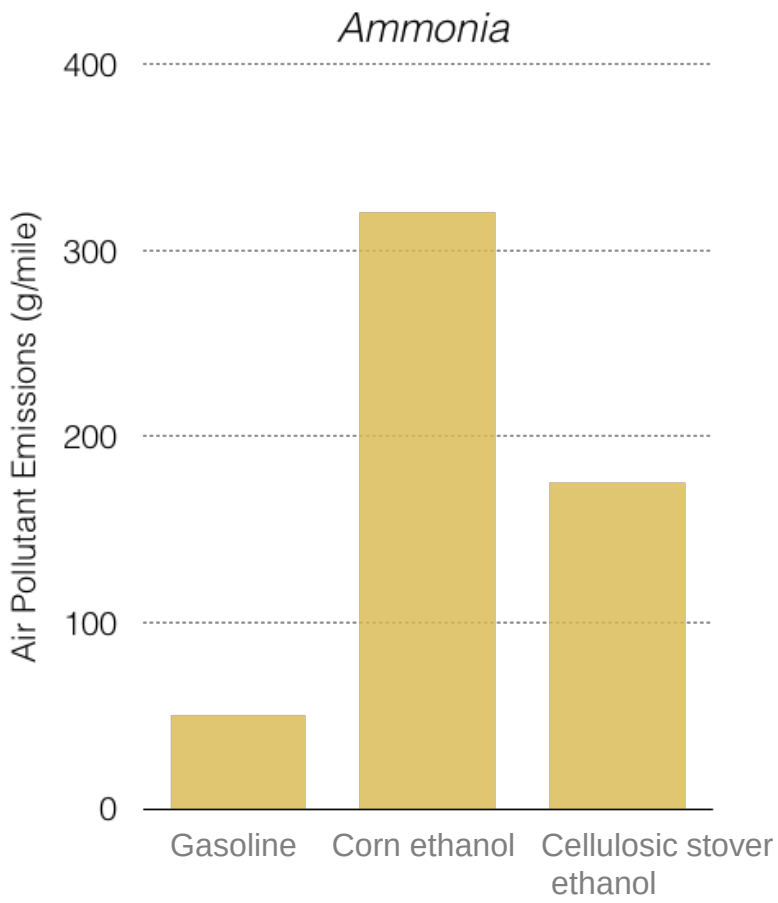
- Biofuel production may emit fewer GHG emissions than gasoline production



Source: Wang et al. *Environ. Res. Lett*. 7 (2012) 045905

Context and Study Objectives

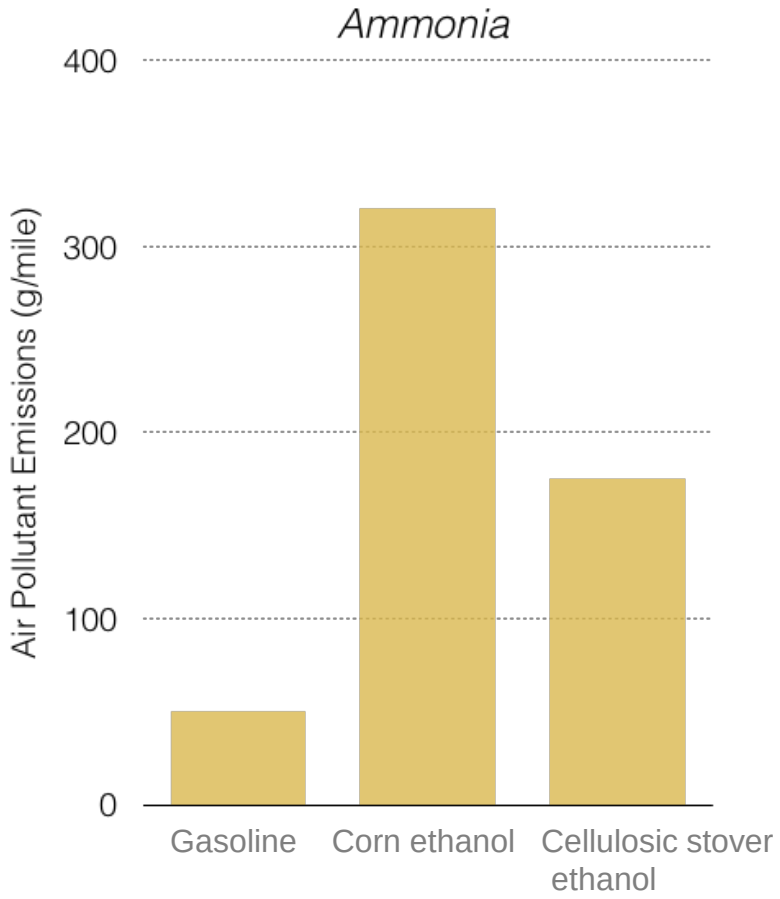
- Biofuel production may emit fewer GHG emissions than gasoline production
- However, the relative benefit may not hold for other air pollutants

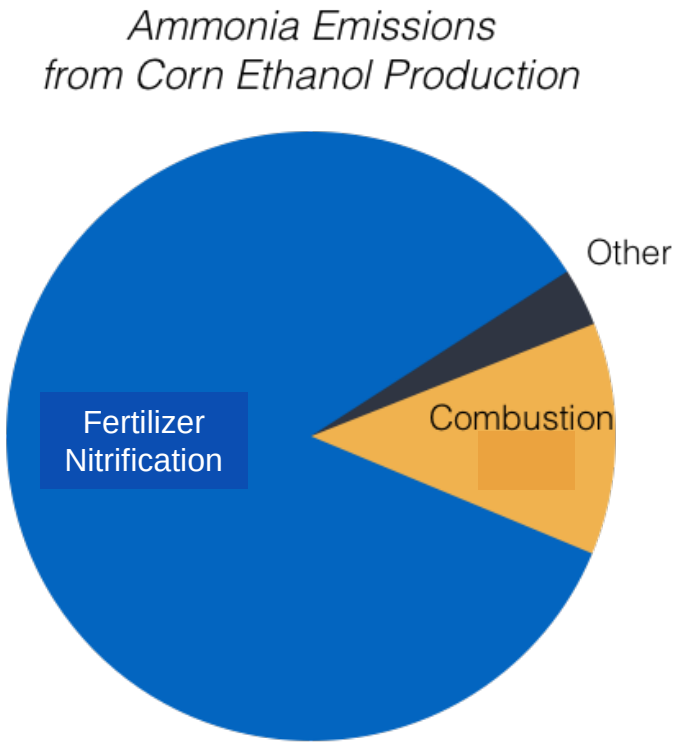


Source: Tessum et al. *Environ. Sci. Tech.* 46 (2012) 11408-11417

Context and Study Objectives

- Biofuel production may emit fewer GHG emissions than gasoline production
- However, the relative benefit may not hold for other air pollutants
- For some pollutants, farming activities comprise a large portion of emissions





Source: Tessum et al. *Environ. Sci. Tech.* 46 (2012) 11408-11417

Context and Study Objectives

- **Context**
  - Air pollution harms public health and environment
  - Many areas in the U.S. exceed the national air quality standards
  - Across the biomass supply chain, multiple operations emit air pollutants
  - No existing studies have yet assessed air pollutant emissions resulting from potential large-scale deployment of biomass systems
    - Developing a high-resolution emissions inventory is an essential piece of information for air quality and human health impact modeling

- **The objectives of this analysis were to**
  - Quantify air pollutant emissions associated with biomass production and supply logistics in order to examine
    - How emissions vary by feedstock
    - What the major emission contributors are along the biomass supply chain
    - How emissions vary spatially and may potentially impact local air quality
  - Identify opportunities to minimize potential adverse impacts

Scope of Analysis

- **Pollutants analyzed**
  - Carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10}), oxides of nitrogen (NO_x), oxides of sulfur (SO_x), volatile organic compounds (VOC), and ammonia (NH_3)
- **Scenarios evaluated**
  - Biomass production of corn grain
  - Biomass production and supply logistics of
    - Agricultural residues
    - Energy crops (e.g., miscanthus)
    - Whole trees
    - Logging residues



Source: www.pioneer.com; www.rhc-platform.org; www.ethanolproducer.com

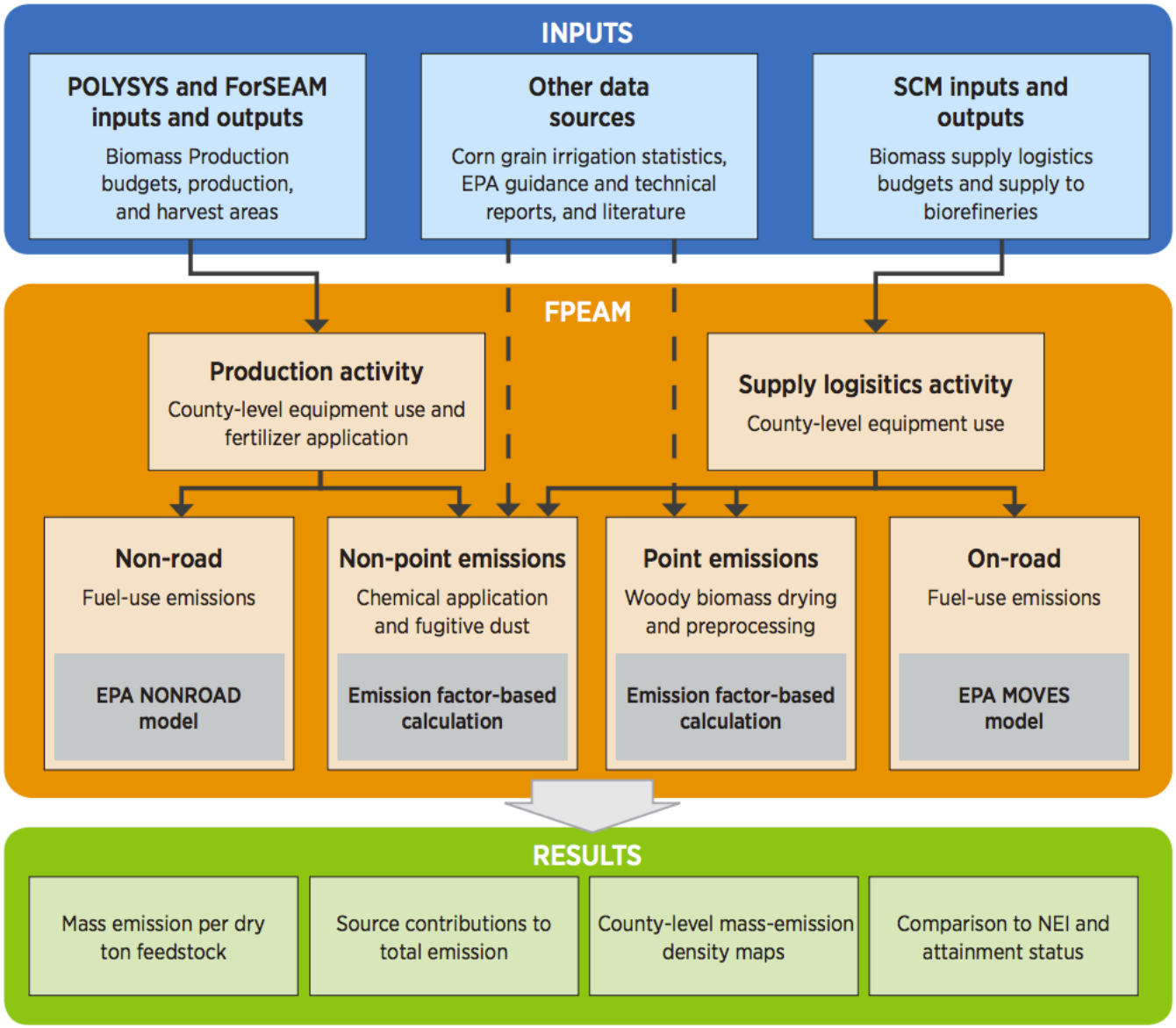
Scope of Analysis

- **Emission sources included**
  - Combustion emissions from on-farm machinery for
    - Planting
    - Maintenance
    - Harvesting
    - On-farm transport
  - Chemical application of fertilizers and pesticides
  - Fugitive dust emissions from soil-disturbing activities
  - Combustion emissions by off-farm transportation and pre-processing
  - Drying of feedstocks (if needed)



Source: www.mississippi-crops.com; www.bls.gov; www.westargroup.com

Methods – Feedstock Production Emissions to Air Model (FPEAM)



Acronyms:

POLYSYS = Policy Analysis System

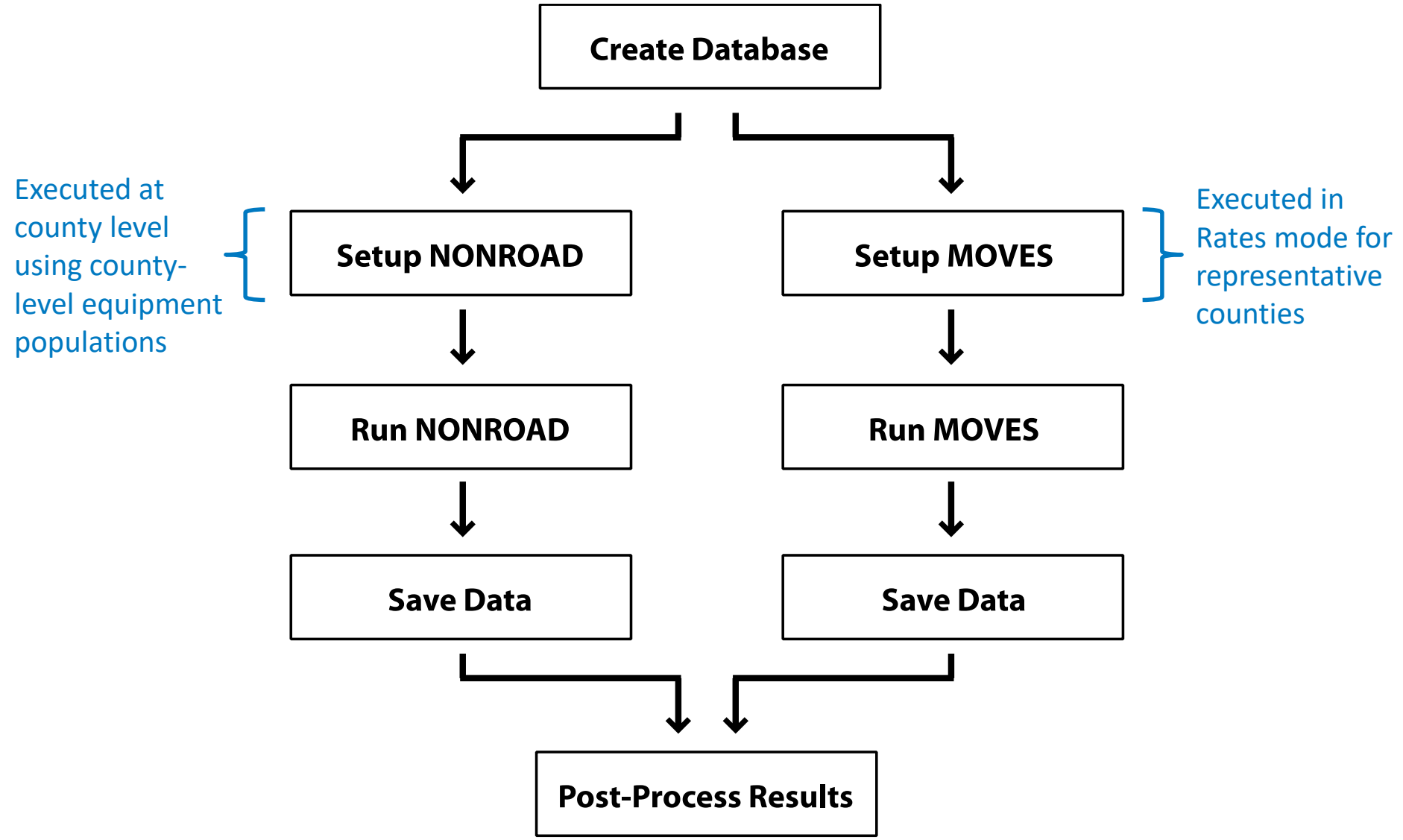
ForSEAM = Forest Sustainable and Economic Analysis Model

SCM = Supply Characterization Model

MOVES = MOtor Vehicle Emission Simulator

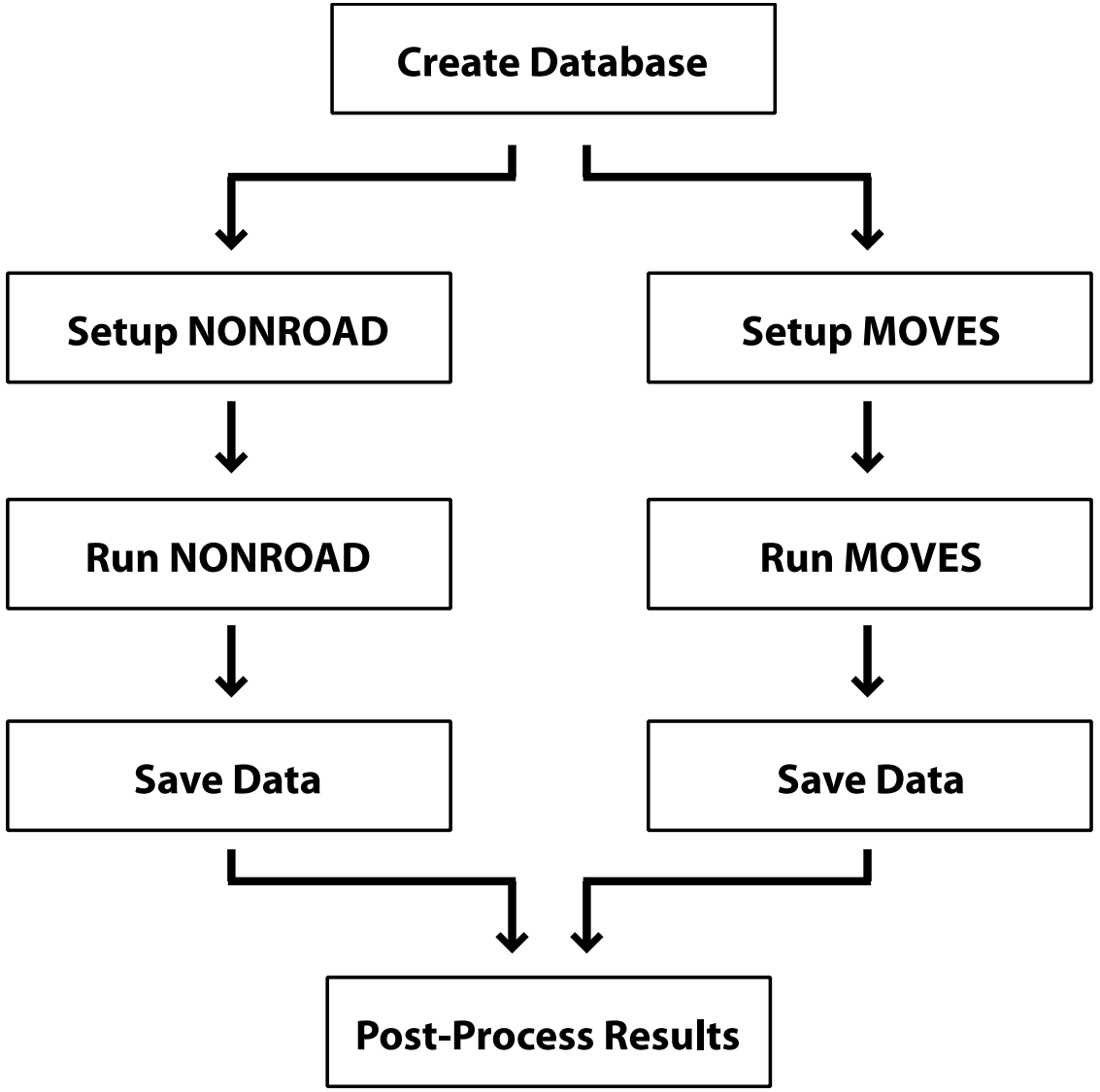
NEI = National Emissions Inventory

Methods – Executing NONROAD and MOVES

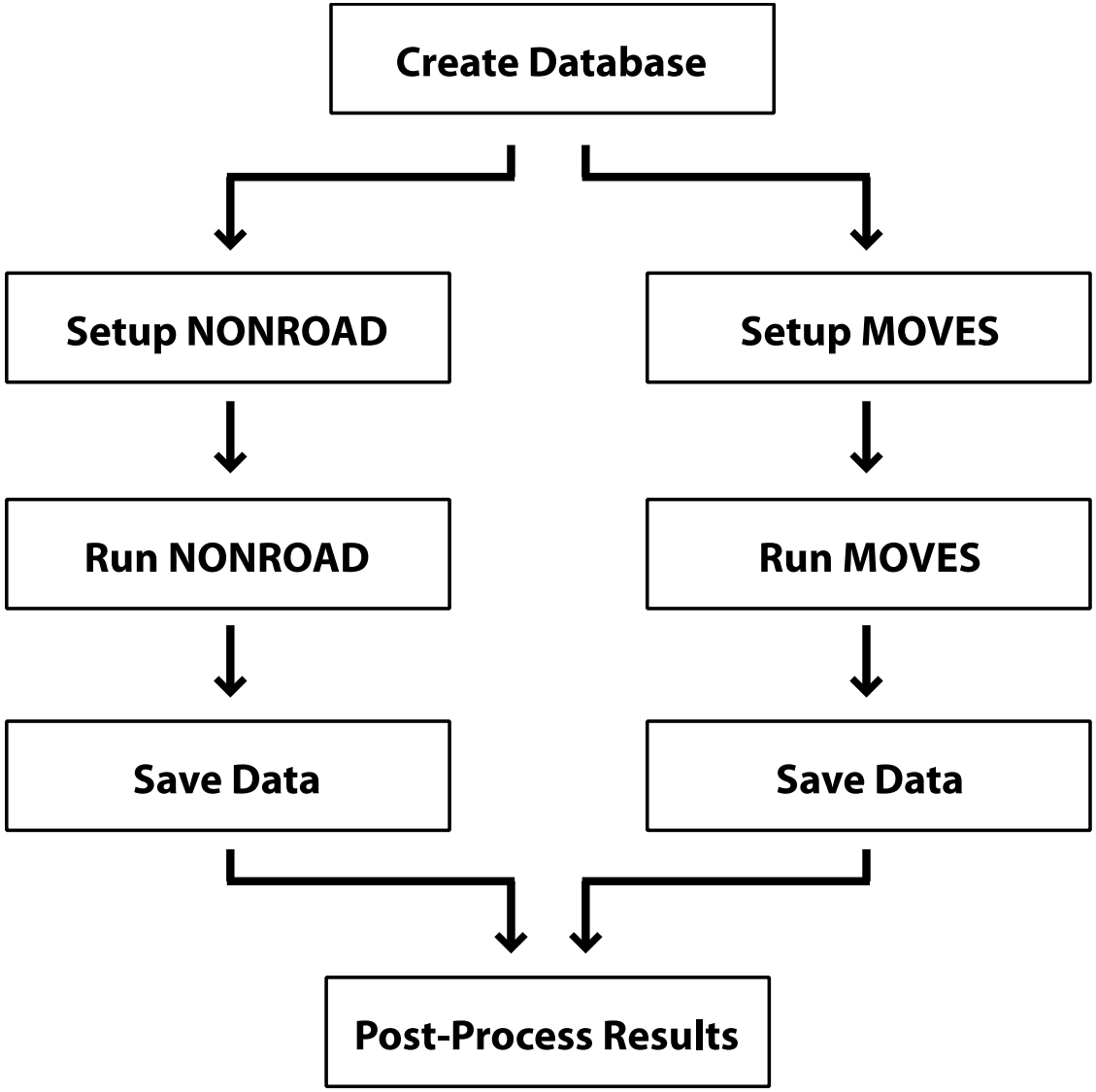


Methods – Executing NONROAD and MOVES

- Generate population files
- Create allocation and option files
- Execute batch runs
- Extract inventory data from text files

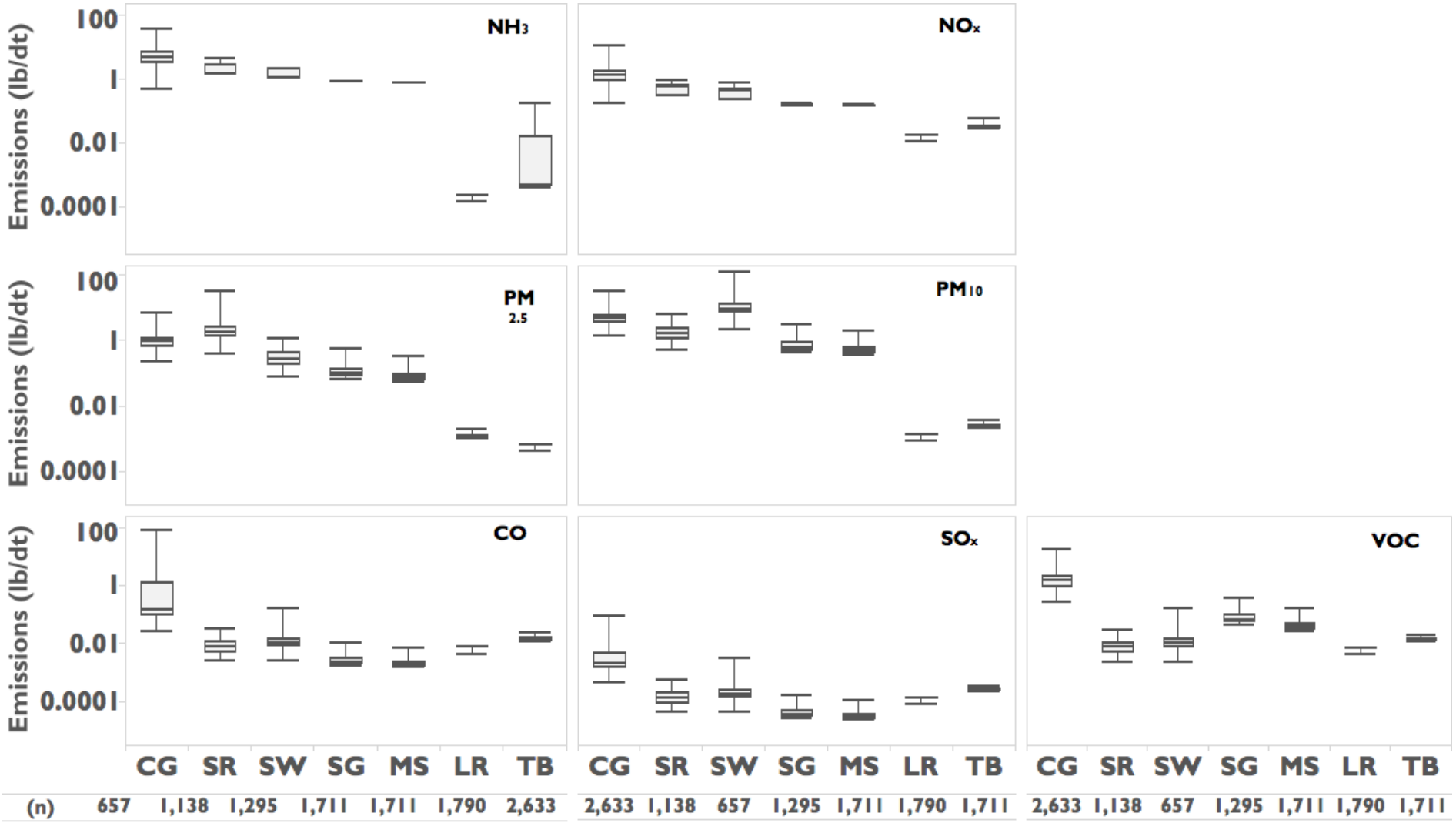


Methods – Executing NONROAD and MOVES

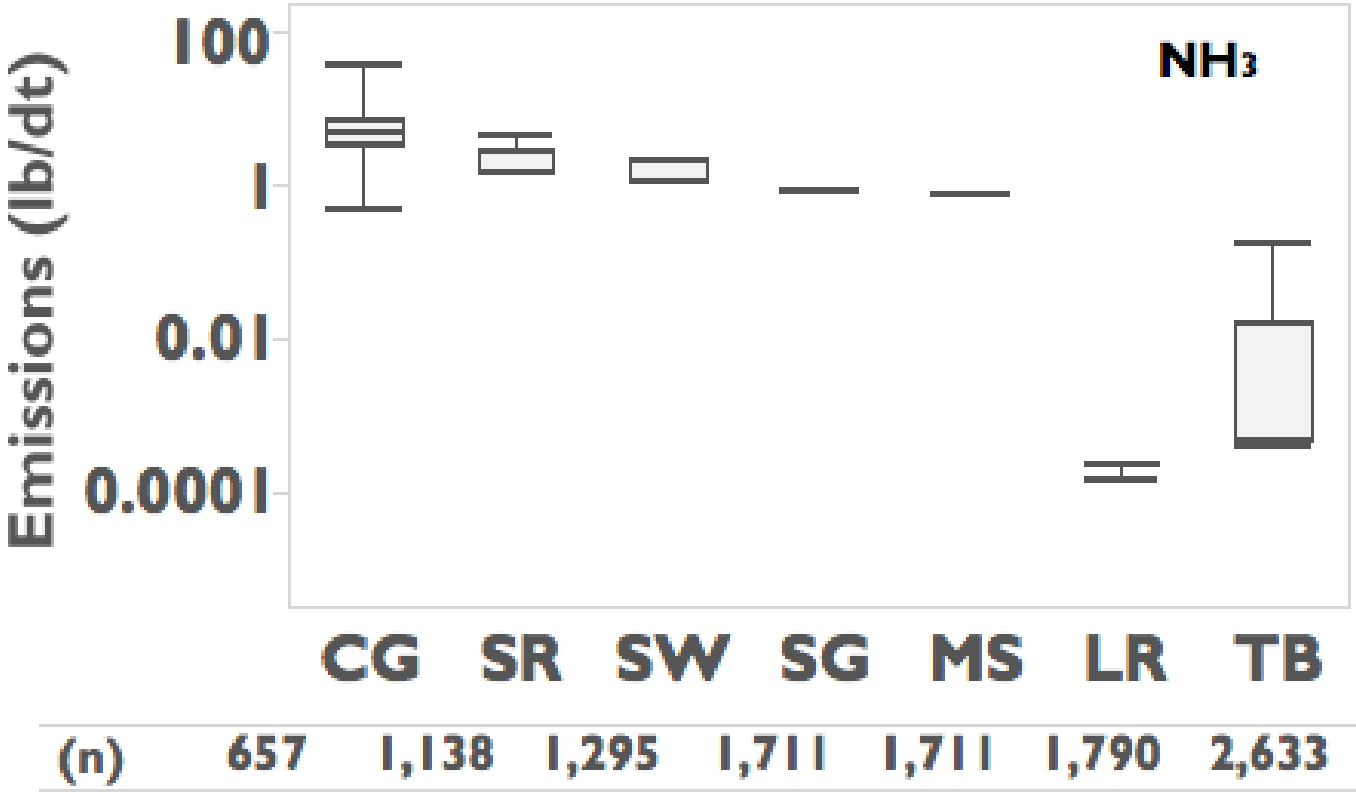


- Generate input data files
- Create XML file for data import
- Create XML file for MOVES run
- Execute batch runs (locally or via AWS)
- Post-process MOVES data to calculate emissions

FPEAM Results – Emissions from Production by Feedstock

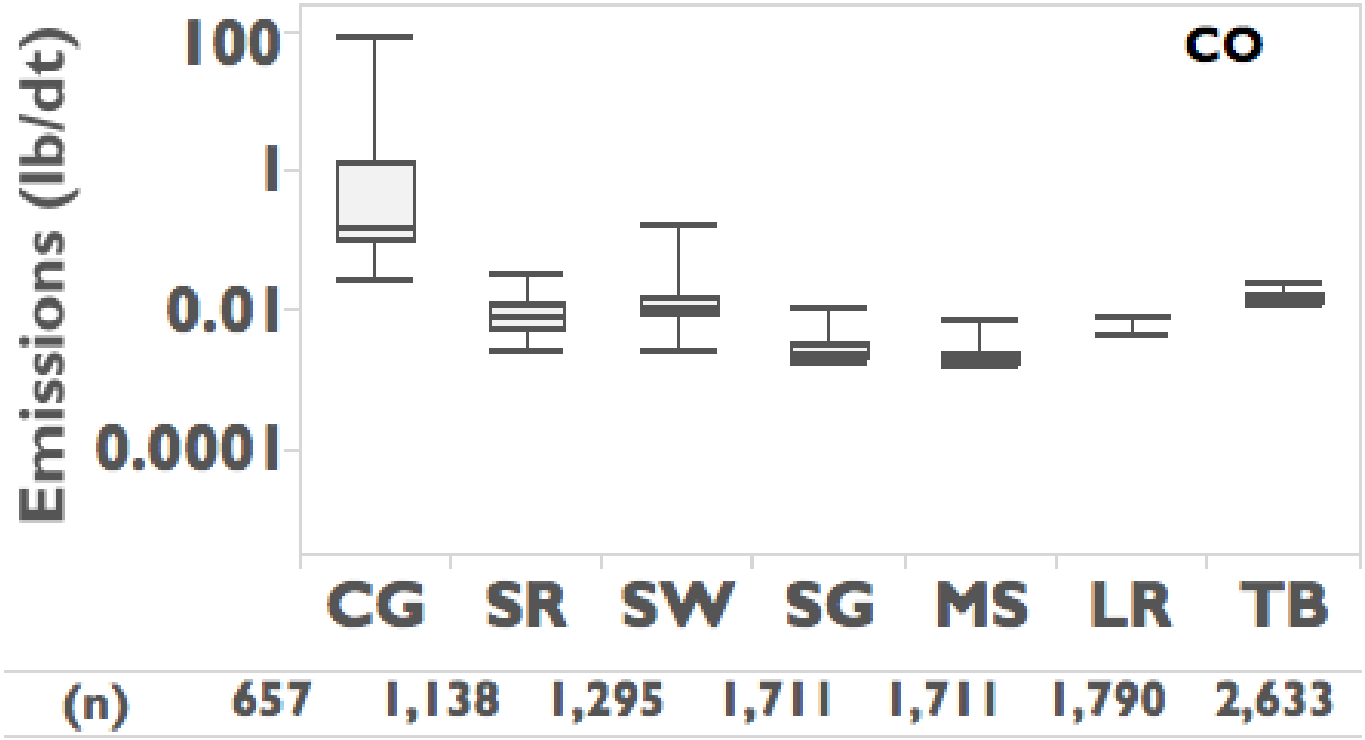


FPEAM Results – Emissions from Production by Feedstock



CG = corn grain
SR = stover
SW = straw
SG = switchgrass
MS = miscanthus
LR = logging residue
TB = whole-tree biomass
lb = pound
dt = dry ton
n = # of feedstock producing counties

FPEAM Results – Emissions from Production by Feedstock



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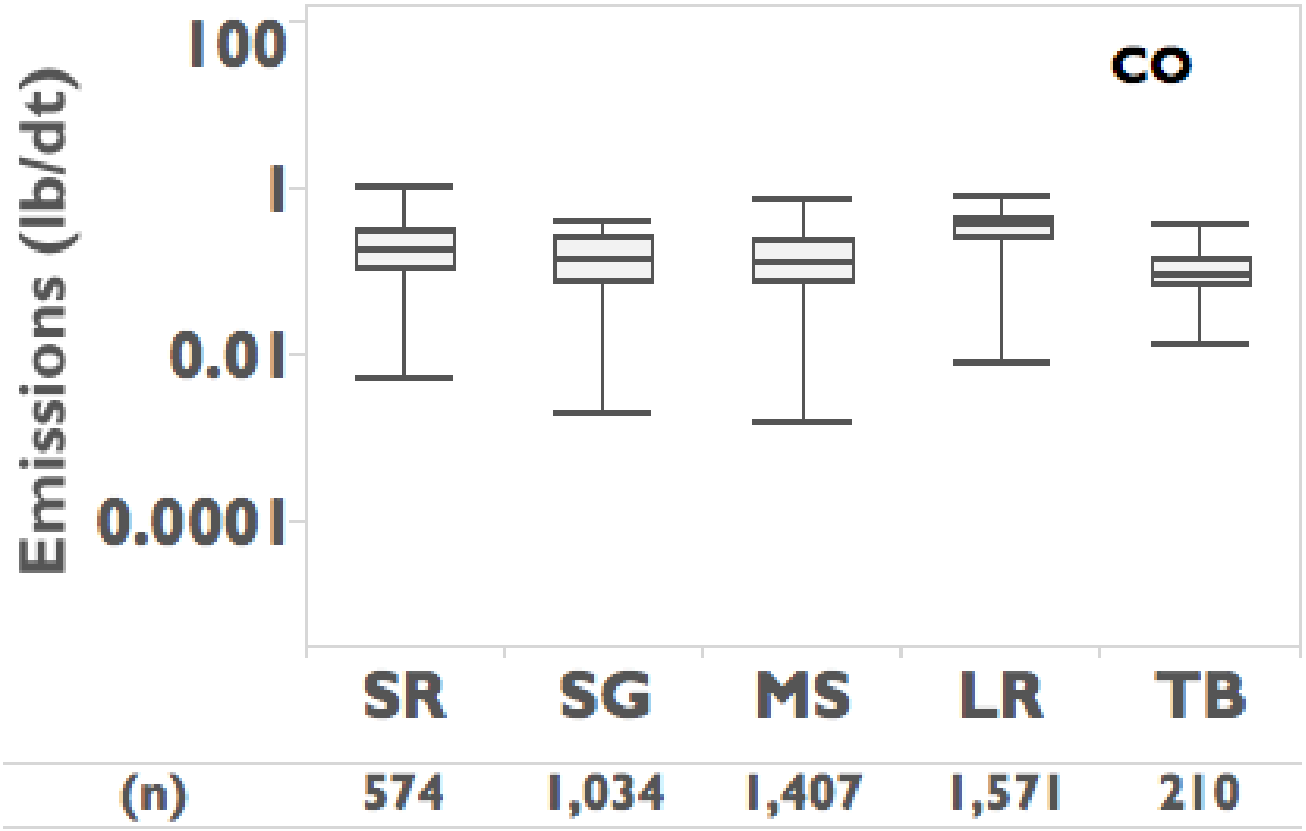
FPEAM Results – Emissions from Production and Supply Logistics



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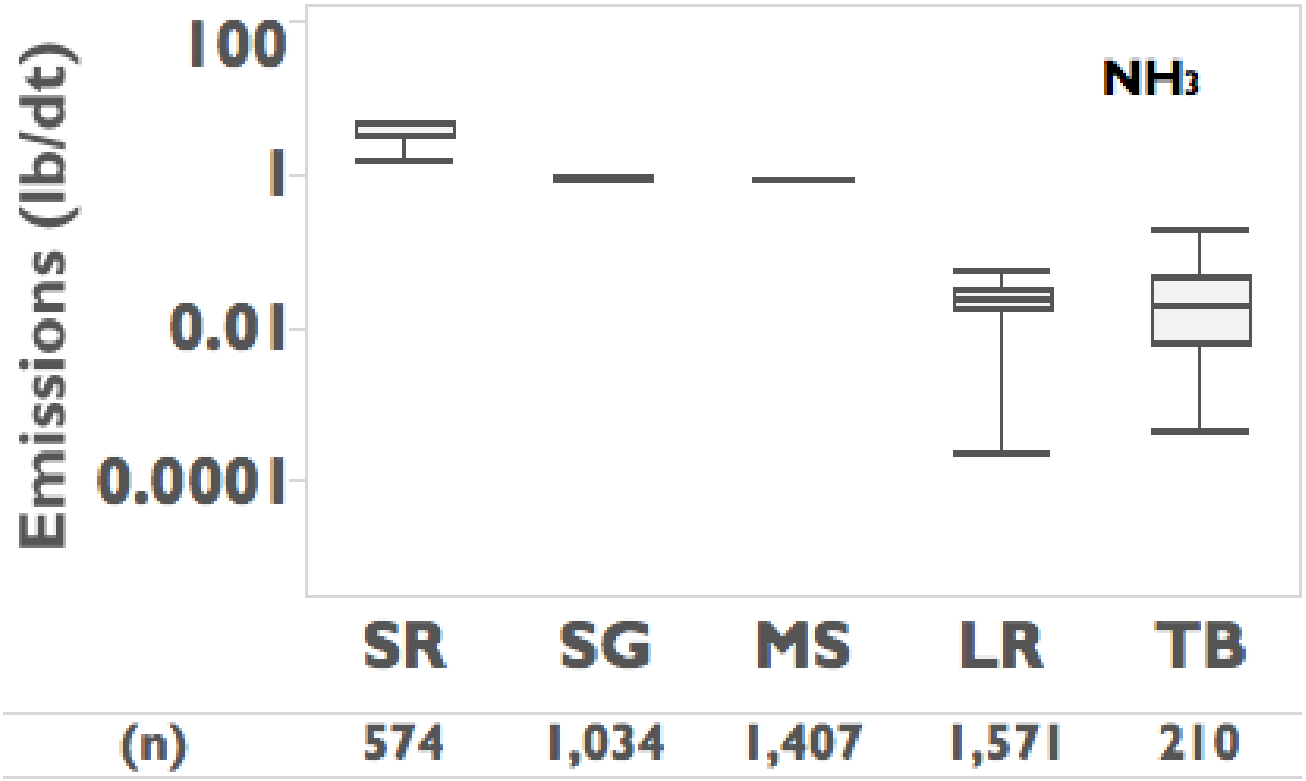
FPEAM Results – Emissions from Production and Supply Logistics



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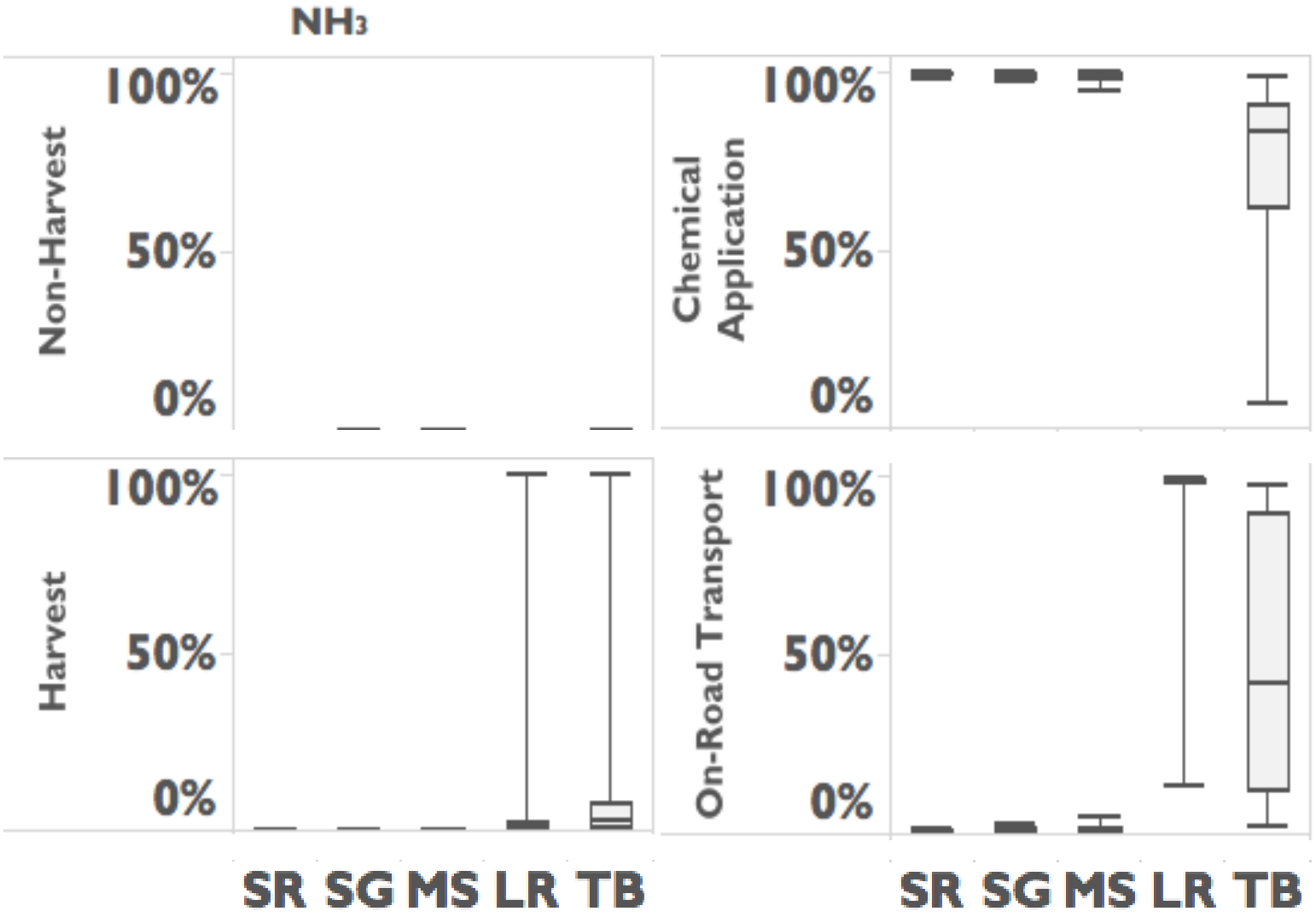
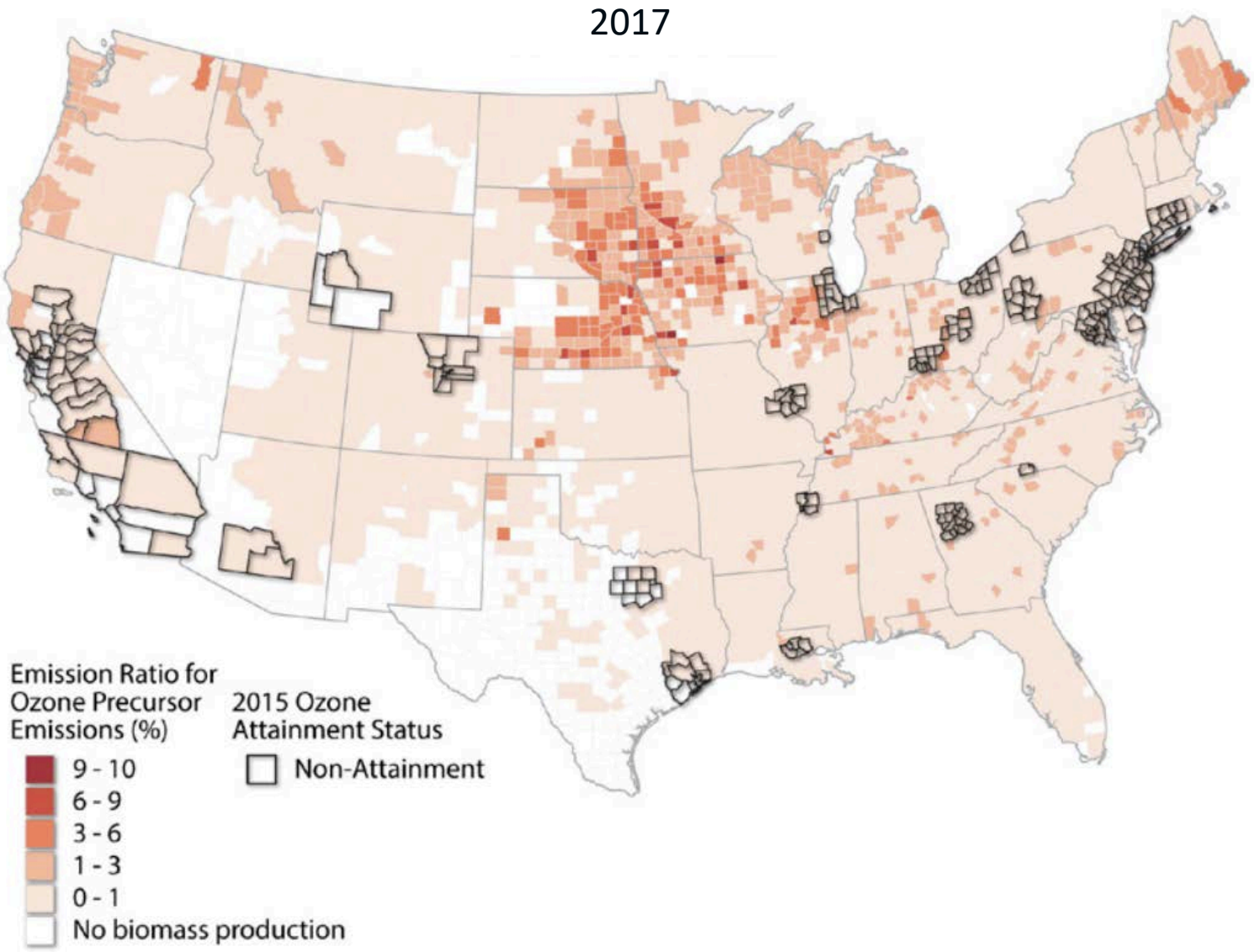
Results – Emissions Contribution by Source

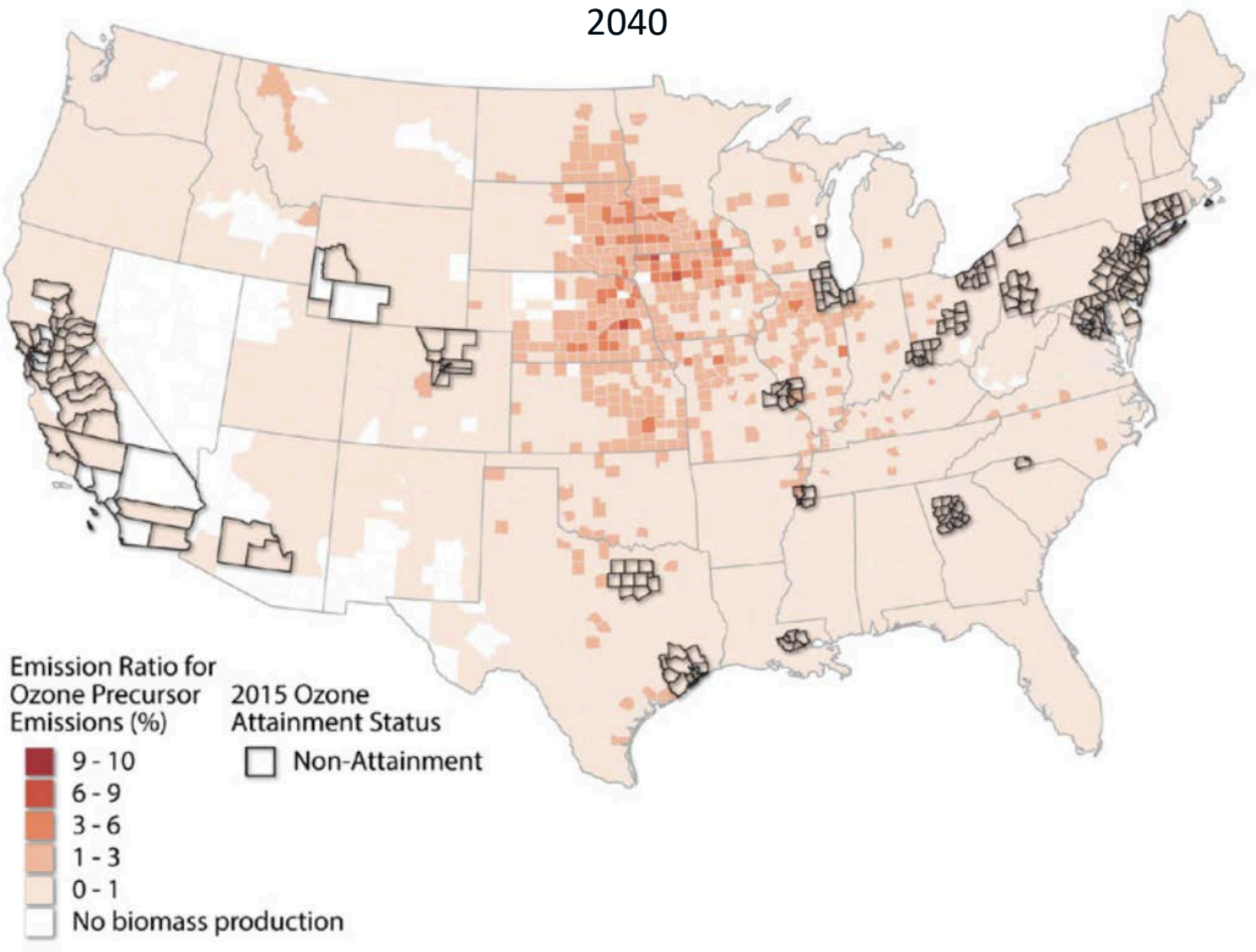


SR = stover; SG = switchgrass; MS = miscanthus; LR = logging residue; TB = whole-tree biomass

FPEAM Results – National Emissions Inventory (NEI) Ozone Emission Ratio



FPEAM Results – National Emissions Inventory (NEI) Ozone Emission Ratio



Key Findings

- **Air emissions vary by feedstock** (per dry ton [dt] of biomass produced or supplied)
  - Cellulosic feedstocks fare better than corn grain for most air pollutants
- **Potential air quality implications**
  - Future air pollutant emissions, if realized and additional, could pose challenges for local compliance with air quality regulations
- **Potential emission reductions**
  - Could be achieved through landscape management or technology improvements

Conclusions and Recommendations

- **Several important data and methods limitations in our modeling require future research and development, including**
  - Biogenic emissions attributed to biomass growth, harvest and preprocessing
  - Upstream emissions (e.g., fertilizer manufacturing)
  - Fugitive dust emissions from forestry activities

- **Emission estimates do NOT model changes in emissions relative to a reference "business as usual" (BAU) scenario**
  - A BAU scenario was not available for the 2016 Billion-Ton Report
  - The air emissions inventory was developed to understand potential implications
  - Full air quality and human health impact modeling would require a BAU scenario

- **Emission estimates from this study could**
  - Inform long-range air quality planning, such as state implementation plans, which are required to consider new emission sources for future scenarios
  - Be coupled with air-quality screening tools to evaluate important changes in emission concentrations and potential impacts on human health

Acknowledgements

This project was supported by the U.S. Department of Energy's Bioenergy Technologies Office under Contract No. DE-AC36-08-GO28308.

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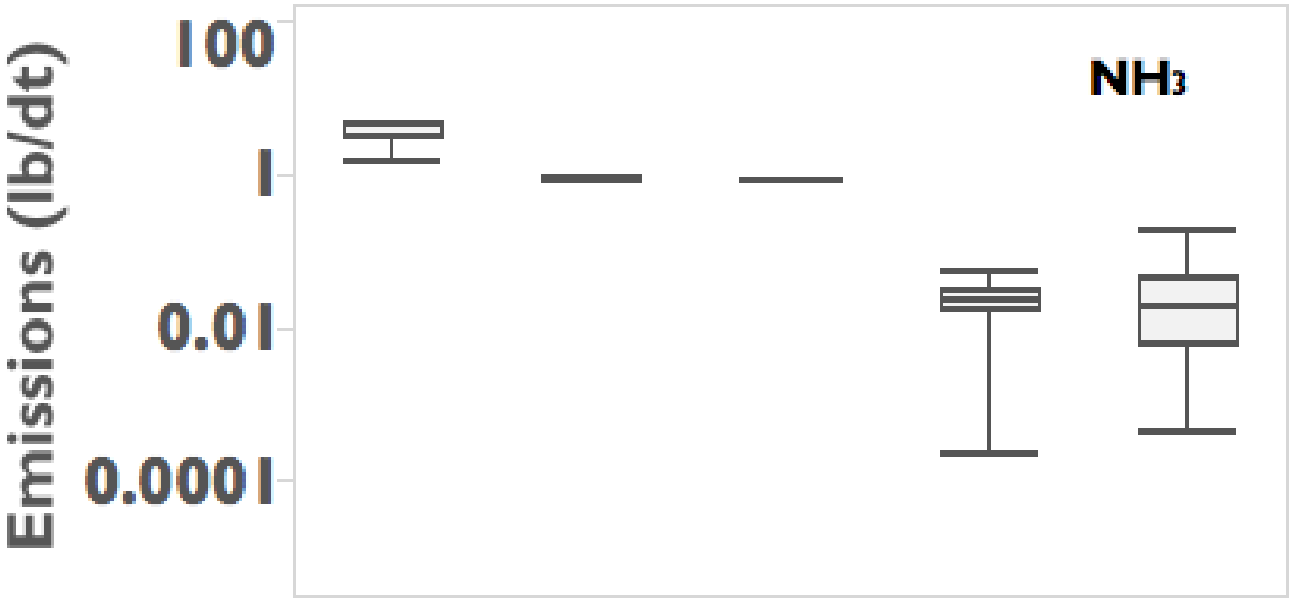
Many thanks to EPA MOVES support staff, Laurence Eaton (Oak Ridge National Laboratory), Erin Searcy and Damon Hartley (Idaho National Laboratory), Jennifer Dunn and Christina Canter (Argonne National Laboratory), Patrick Gaffney and Janet Spencer (California Air Resources Board), Maureen Puettmann (Consortium for Research on Renewable Industrial Materials), Craig Brandt and Erin Webb (Oak Ridge National Laboratory), and Bryce Stokes (Allegheny Science & Technology).

www.nrel.gov

Details on Methods

Purpose	FPEAM Modeling Method	Emission Species	Spatial Resolution	Estimation Methods/Data Sources	Details in Appendix Section
Annual Equipment Usage and Chemical Application	Equipment and Chemical Application Budgets[a]	CO, NO_X, SO_X, $PM_{2.5}$, PM_{10}, VOCs, NH_3	Agriculture: 13 regional budgets Forestry: 5 regional budgets Supply Logistics: National Corn Grain Irrigation: State	POLYSYS, ForSEAM, and SCM modeling inputs (DOE 2016) Corn Grain Irrigation: USDA (2009)	9.6.1.1
	Harvest Area and Biomass Production	CO, NO_X, SO_X, $PM_{2.5}$, PM_{10}, VOCs, NH_3	County	POLYSYS, ForSEAM, and SCM modeling estimates (DOE 2016)	9.6.1.1
EFs For Estimating Annual Emissions	Off-Road Fuel Use	CO, NO_X, SO_X, $PM_{2.5}$, PM_{10}, VOCs, NH_3	State EFs	NONROAD (EPA 2016b)	9.6.1.2.1
	On-Road Fuel Use	CO, NO_X, SO_X, $PM_{2.5}$, PM_{10}, VOCs, NH_3	State EFs	MOVES (EPA 2016a)	9.6.1.2.2
	Preprocessing Fuel Use	CO, NO_X, SO_X, $PM_{2.5}$, PM_{10}, VOCs, NH_3	State EFs	NONROAD (EPA 2016b)	9.6.1.2.3
	Chemical Application	NO_X, VOCs	National EFs	EPA (2015d) ANL 2015 USDA (2010) Davidson et al. 2004 Huntley (2012)	9.6.1.2.4
	Fugitive Dust	$PM_{2.5}$ and PM_{10}	EFs based on a combination of state and national data	Agriculture Harvest and Non-Harvest: CARB (2003), Gaffney and Yu (2003) Forestry: No methodology or data could be found Transportation: EPA (2006) Preprocessing: None due to dust-collection equipment (INL 2013, INL 2014)	9.6.1.2.5
	Drying and Preprocessing	VOCs	National EFs	Herbaceous: Assumed to be zero Woody: EPA (2002)	9.6.1.2.6

FPEAM Results – Emissions from Production and Supply Logistics



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Methods – Scope

- **Pollutants analyzed**
  - carbon monoxide (CO), particulate matter ($PM_{2.5}$, PM_{10}), oxides of nitrogen (NO_x), oxides of sulfur (SO_x), volatile organic compounds (VOC), and ammonia (NH_3)
- **Scenarios evaluated**

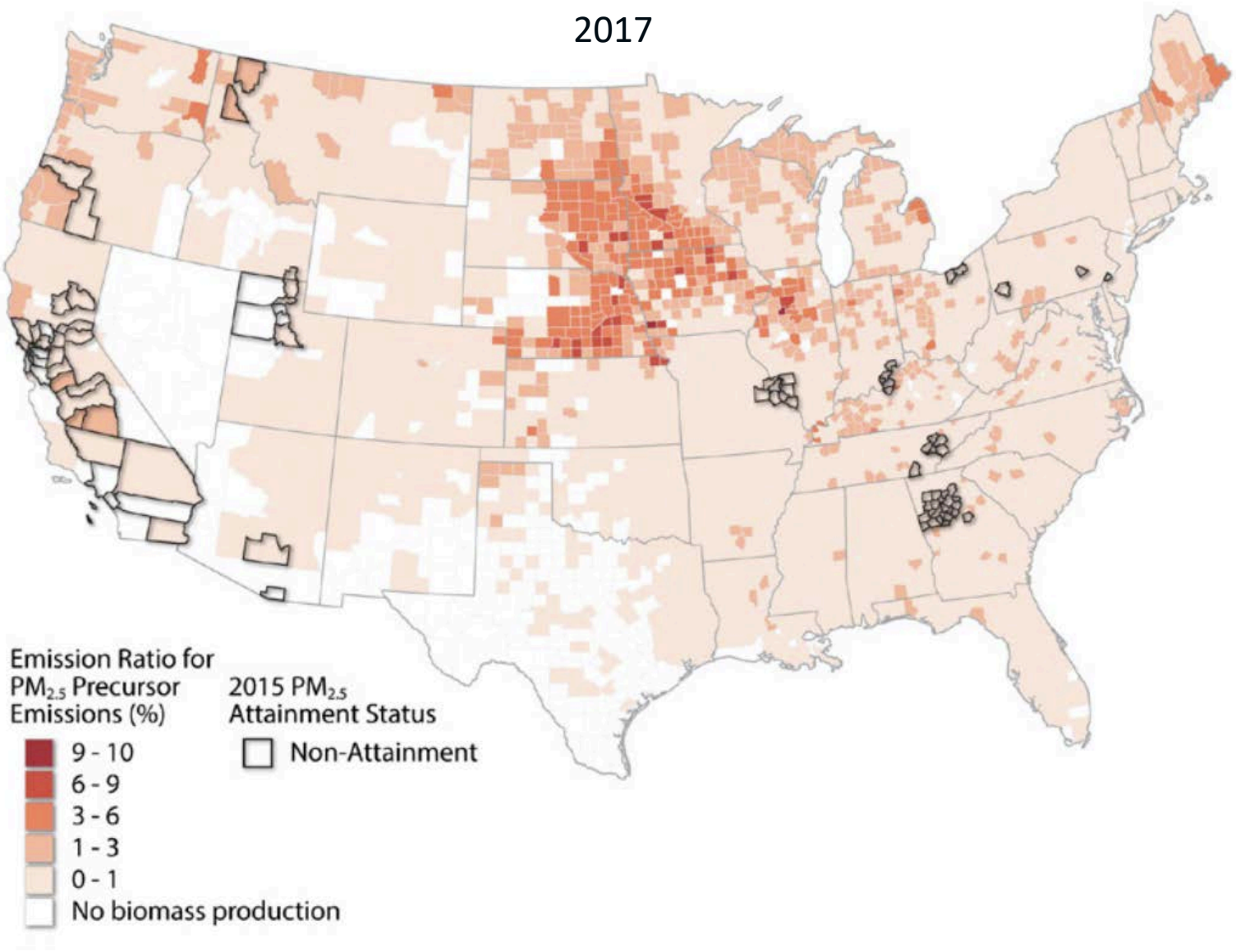
Feedstock type	Segment of supply chain	BC1&ML[a]	
		2017	2040
Corn grain	Biomass production	Up to $60/dt	Up to $60/dt
Agricultural residues, energy crops, whole tree biomass and logging residues	Biomass production	Up to $60/dt	Up to $60/dt
	Biomass supply logistics – near term	Up to $100/dt	Not modeled
	Biomass supply logistics – long term	Not modeled	Up to $100/dt[b]

[a] BC1=agricultural base case yield growth, ML = moderate housing and low wood energy
[b] Includes cost to produce and supply biomass

Emission sources included

1) Fuel use by on-farm machinery operation, harvesting, and on-farm transportation
2) Fuel use by off-farm transportation and biomass preprocessing
3) Chemical application of fertilizers and pesticides
4) Fugitive dust emissions from soil-disturbing activities (e.g., land preparation, harvesting, transportation)
5) Drying of feedstocks (if needed)

FPEAM Results – National Emissions Inventory (NEI) Emission $PM_{2.5}$ Ratio



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