



Assessing Potential Air Pollutant Emissions from Agricultural Feedstock Production using MOVES

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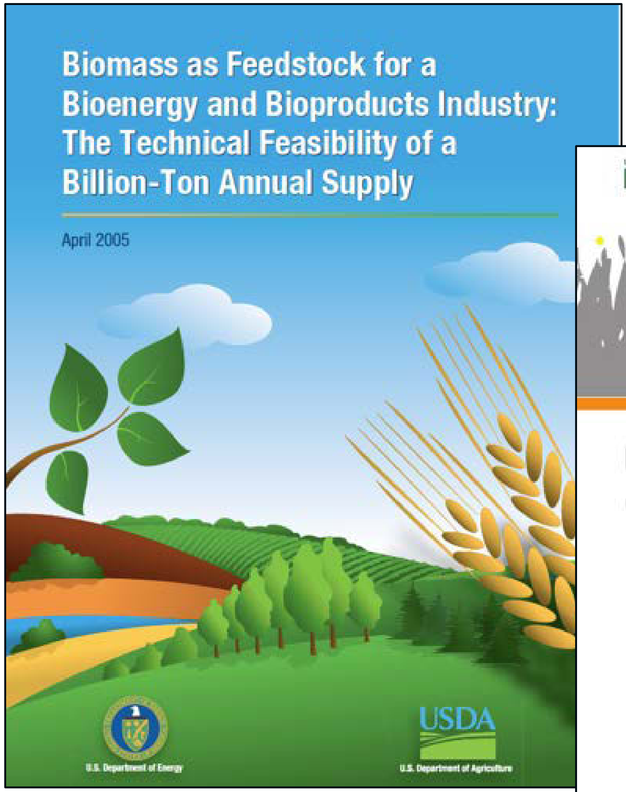
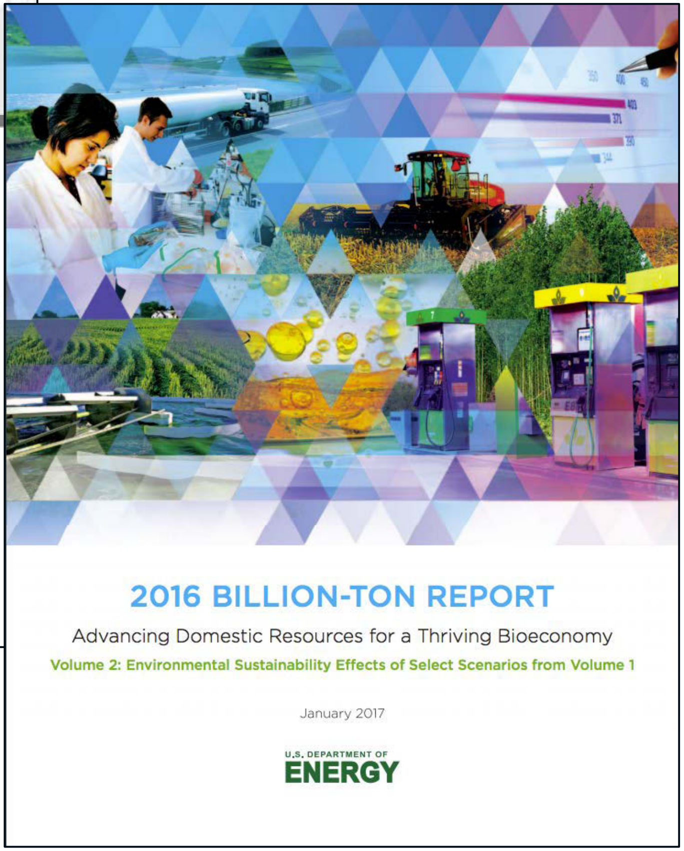
Billion Ton Studies





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:

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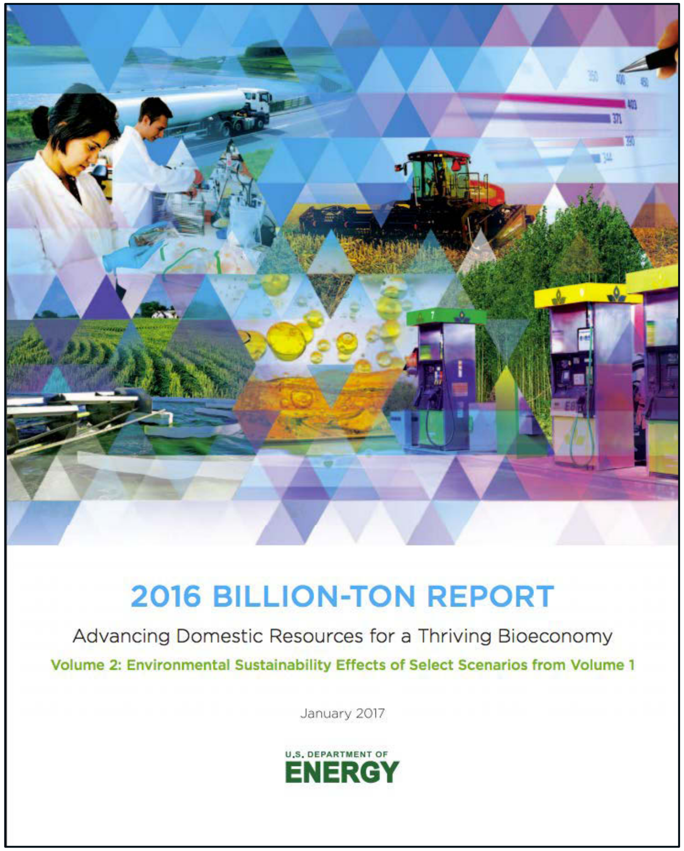
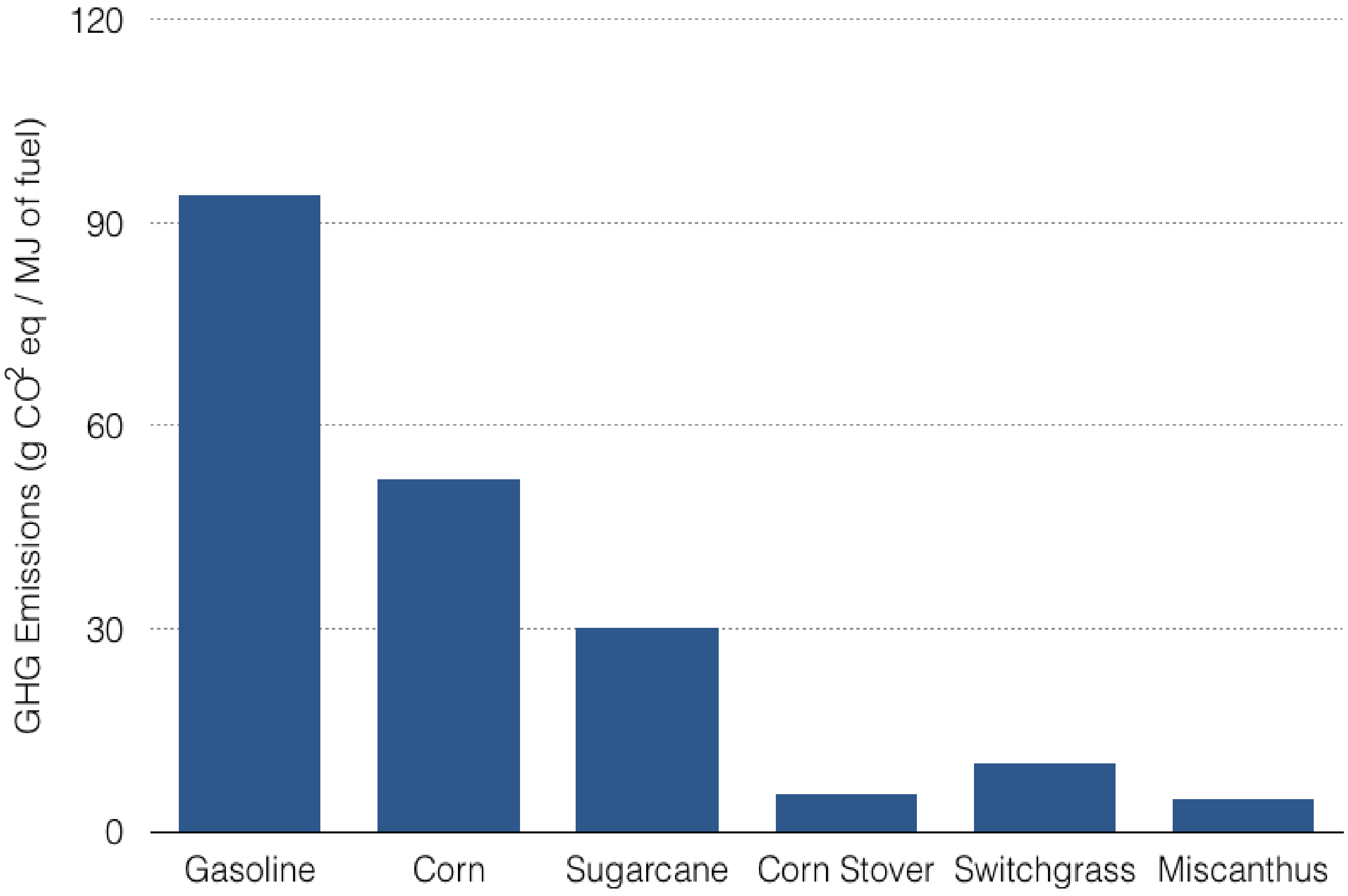


Context and Study Objectives

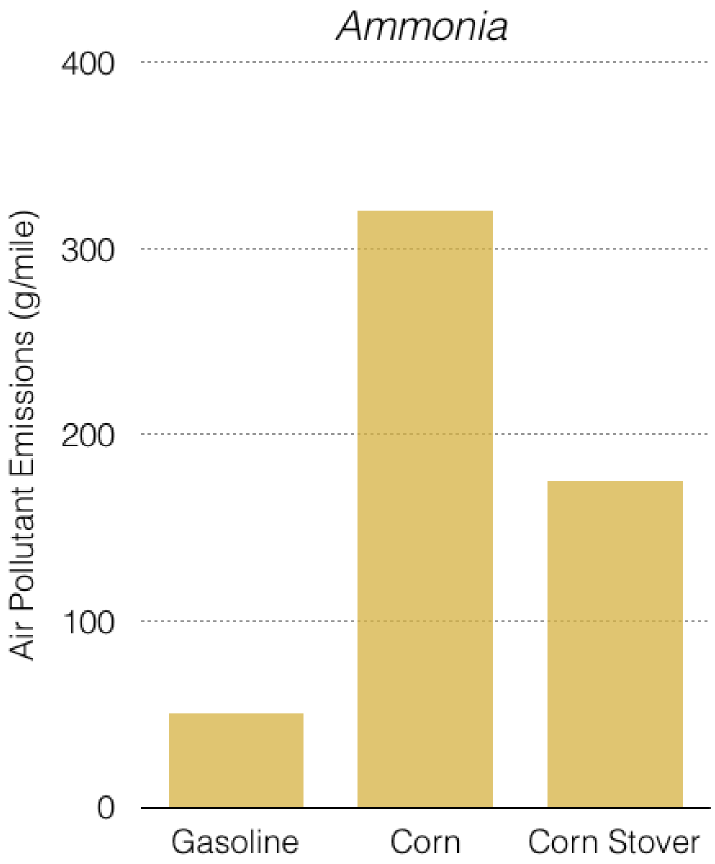
- **Context**
  - Ethanol may produce fewer GHG emissions than gasoline

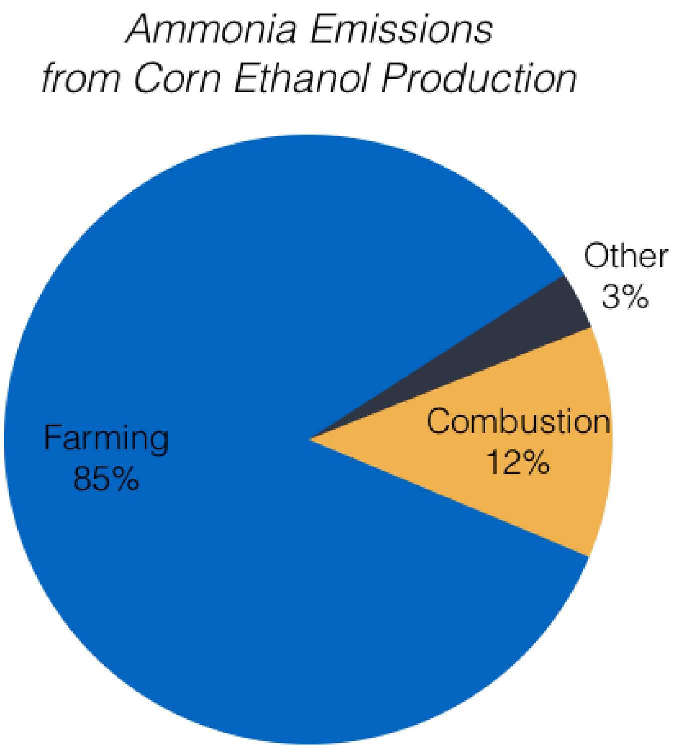


Source: Wang et al. *Environ. Res. Lett.* 7 (2012) 045905

Context and Study Objectives

- **Context**
  - Ethanol may produce fewer GHG emissions than gasoline
  - 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

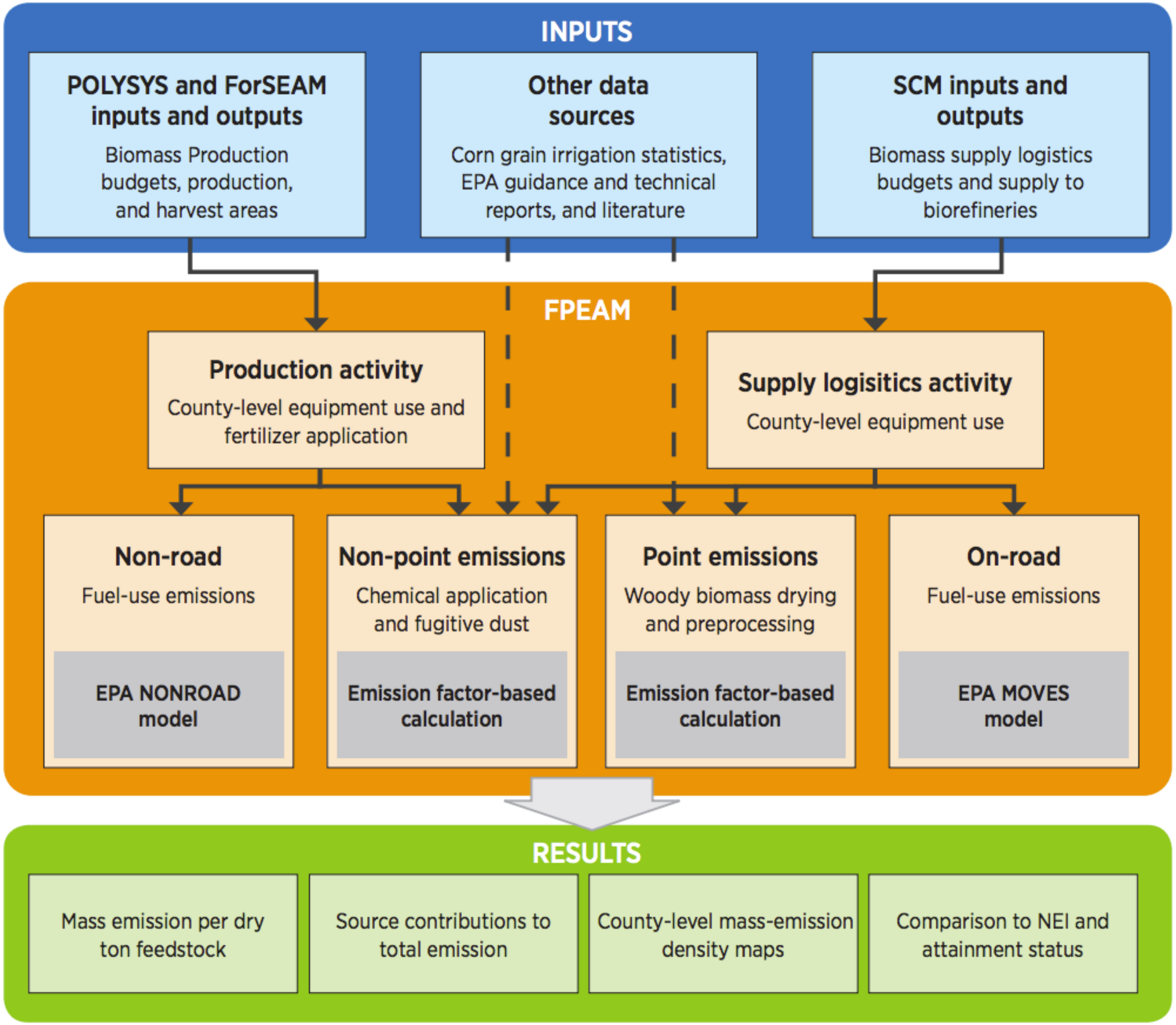
- **Context**
  - Air pollution harms public health and environment
  - Many areas in the U.S. exceed the national air quality standards
  - Across the biomass supply chain, multiple operations emit air pollutants
  - No existing studies assessed air pollutant emissions resulting from potential large-scale 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
- **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)

Methods – Feedstock Production Emissions to Air Model (FPEAM)



Acronyms:

POLYSYS = Policy Analysis System

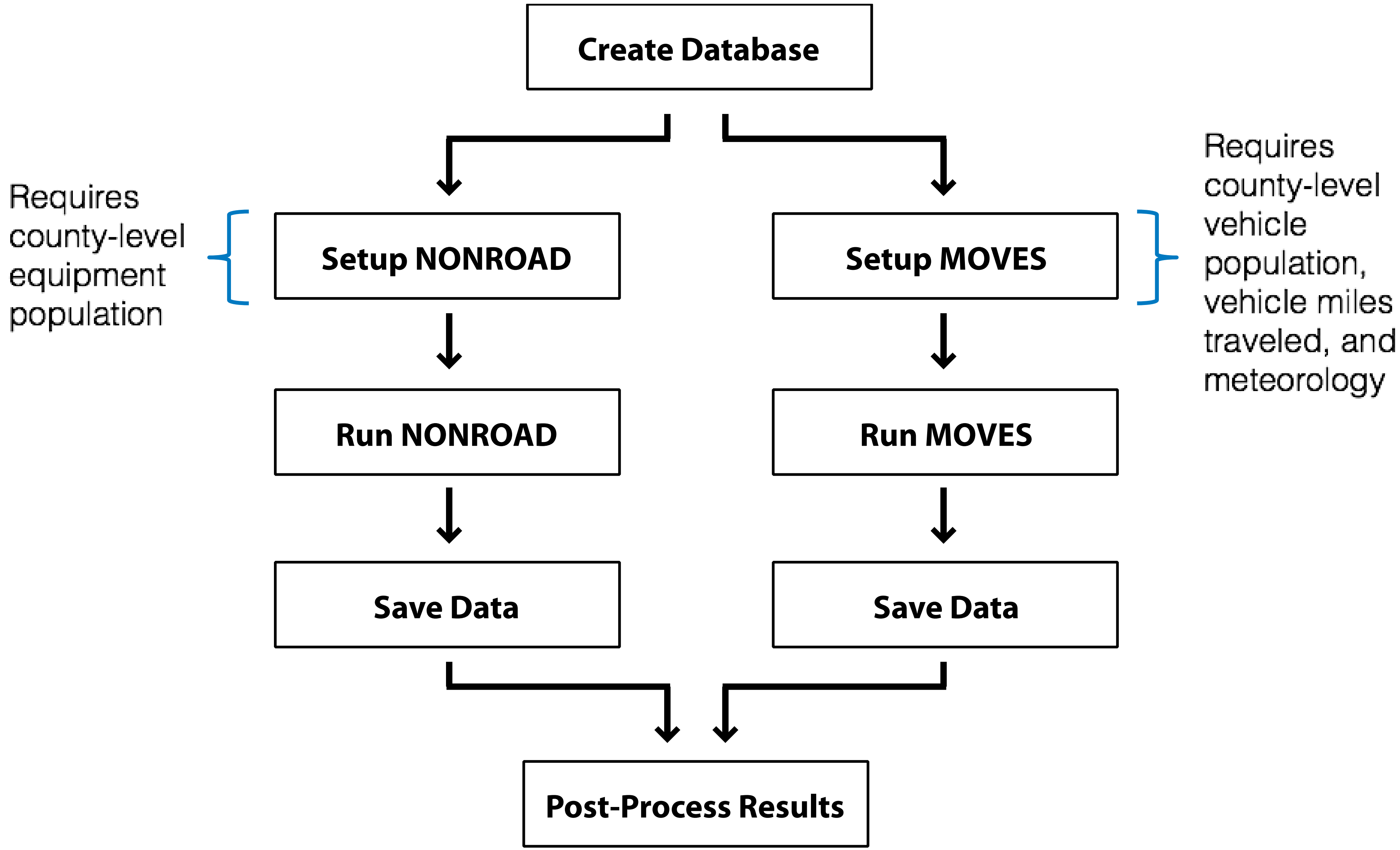
ForSEAM = Forest Sustainable and Economic Analysis Model

SCM = Supply Characterization Model

MOVES = MOtor Vehicle Emission Simulator

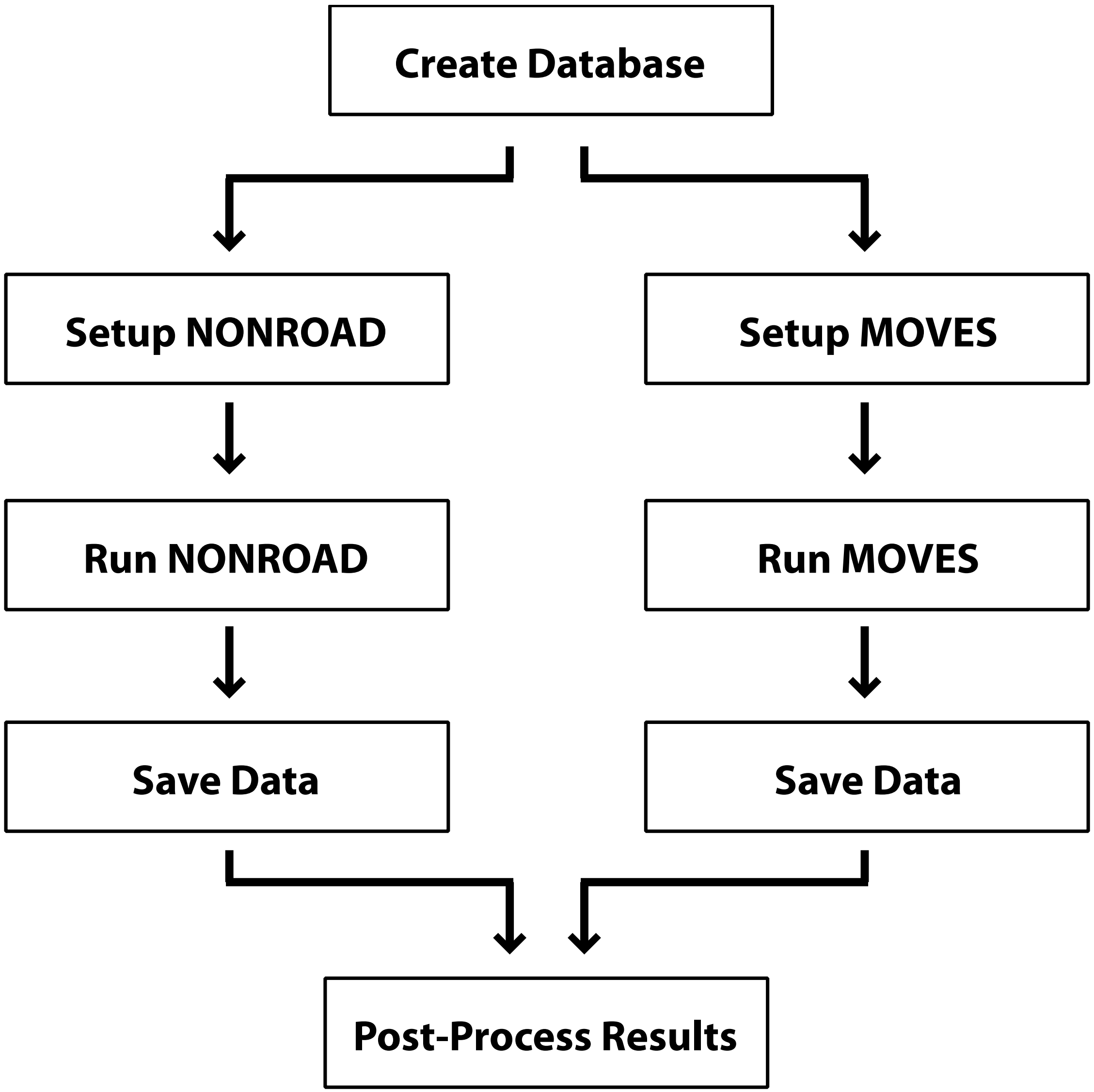
NEI = National Emissions Inventory

Methods – Executing NONROAD and MOVES

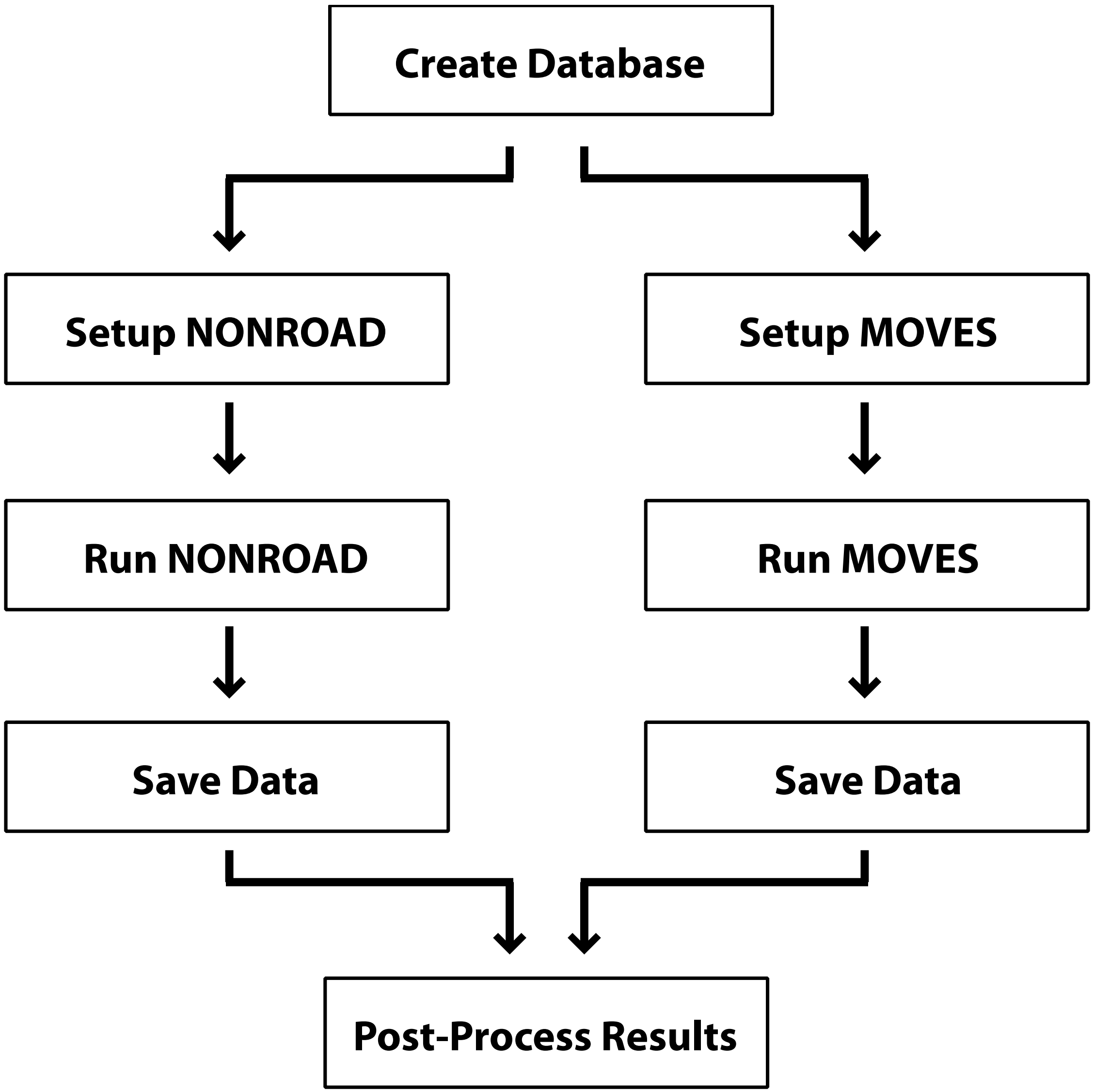


Methods – Executing NONROAD and MOVES

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



Methods – Executing NONROAD and MOVES

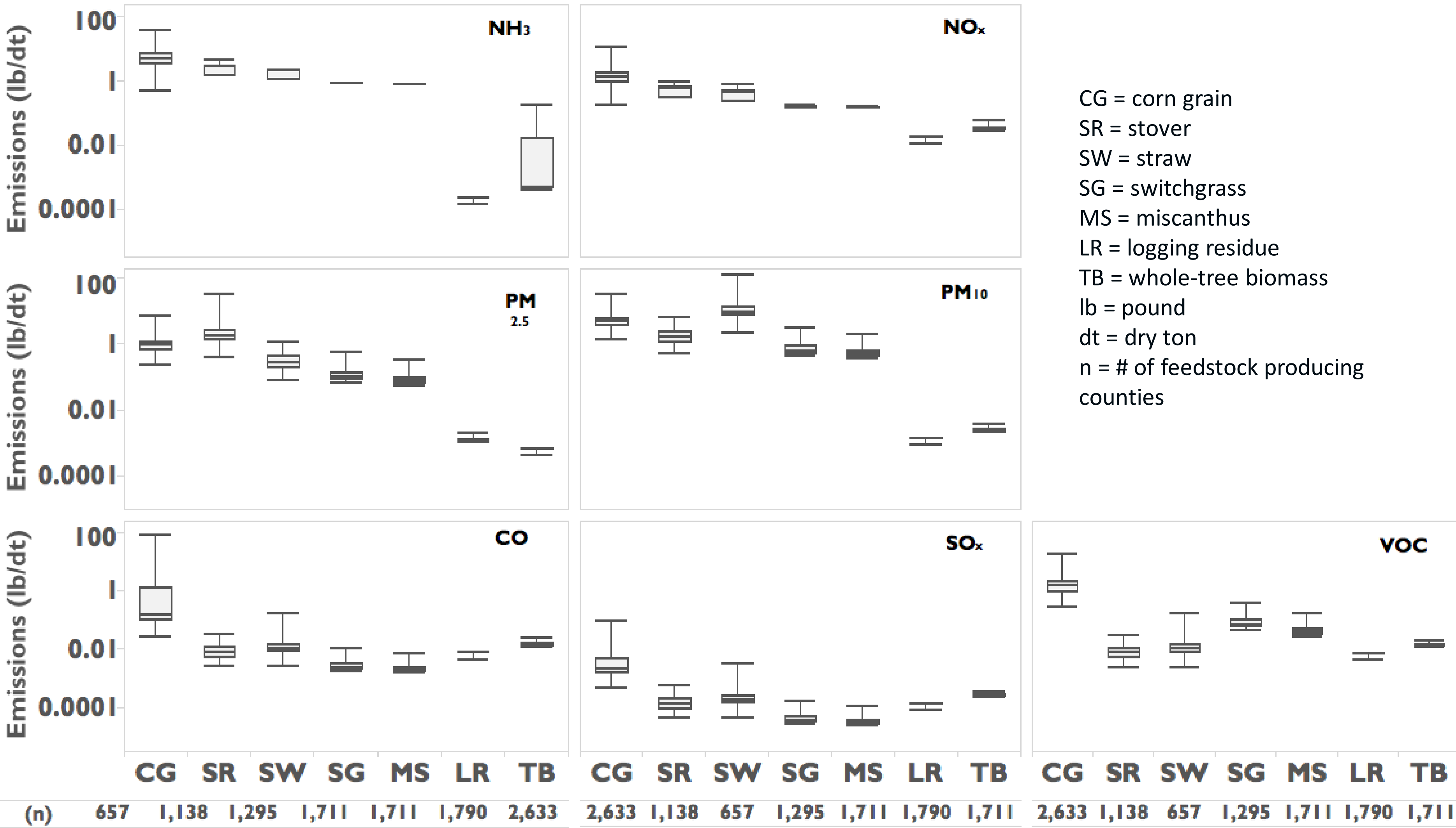


- Generate input files
- Create XML file for data import
- Import input files into database
- Create XML file for MOVES run

- Execute batch runs (locally or via AWS)

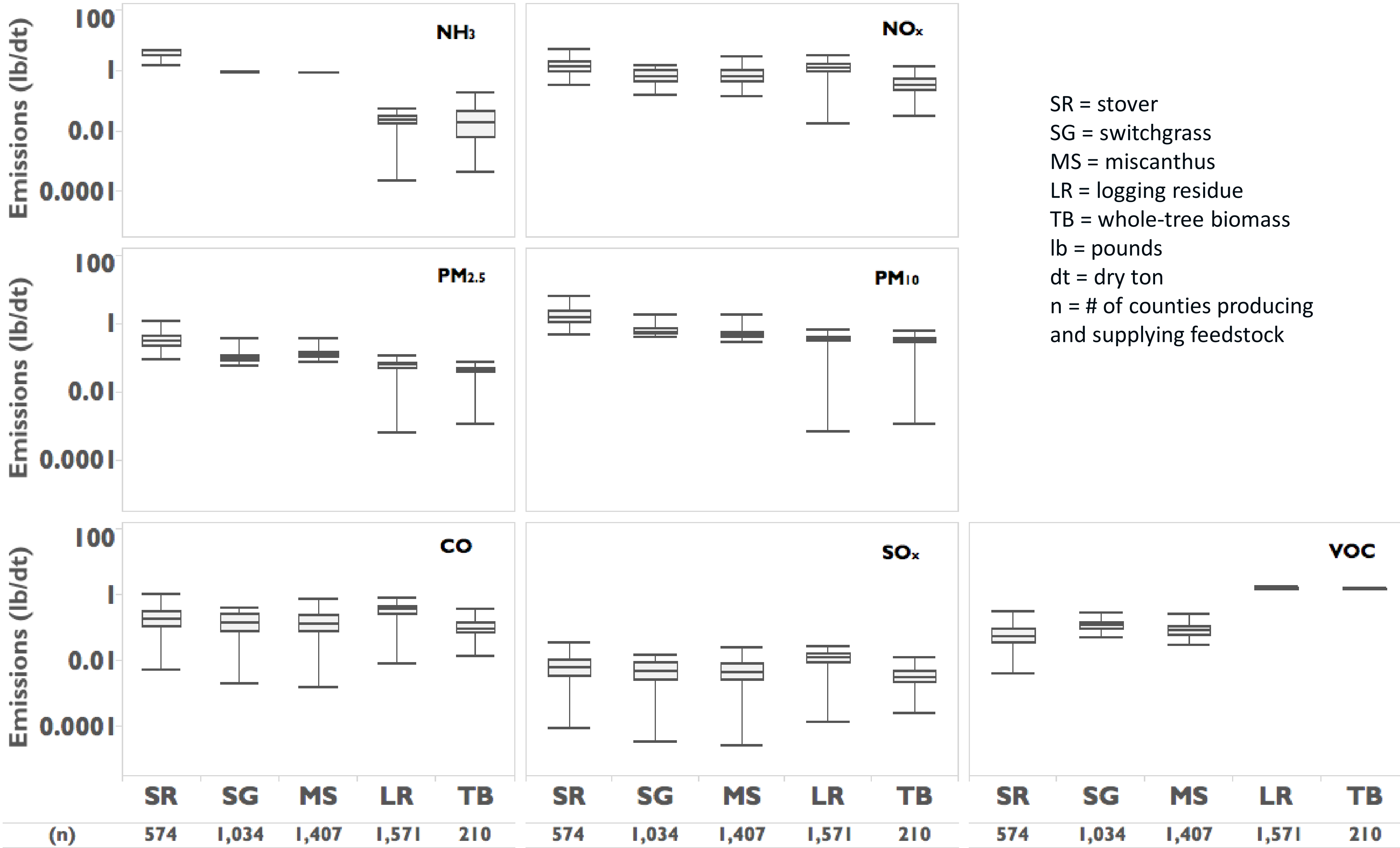
- Post-process MOVES data to calculate emissions

FPEAM Results – Emissions from Production by Feedstock



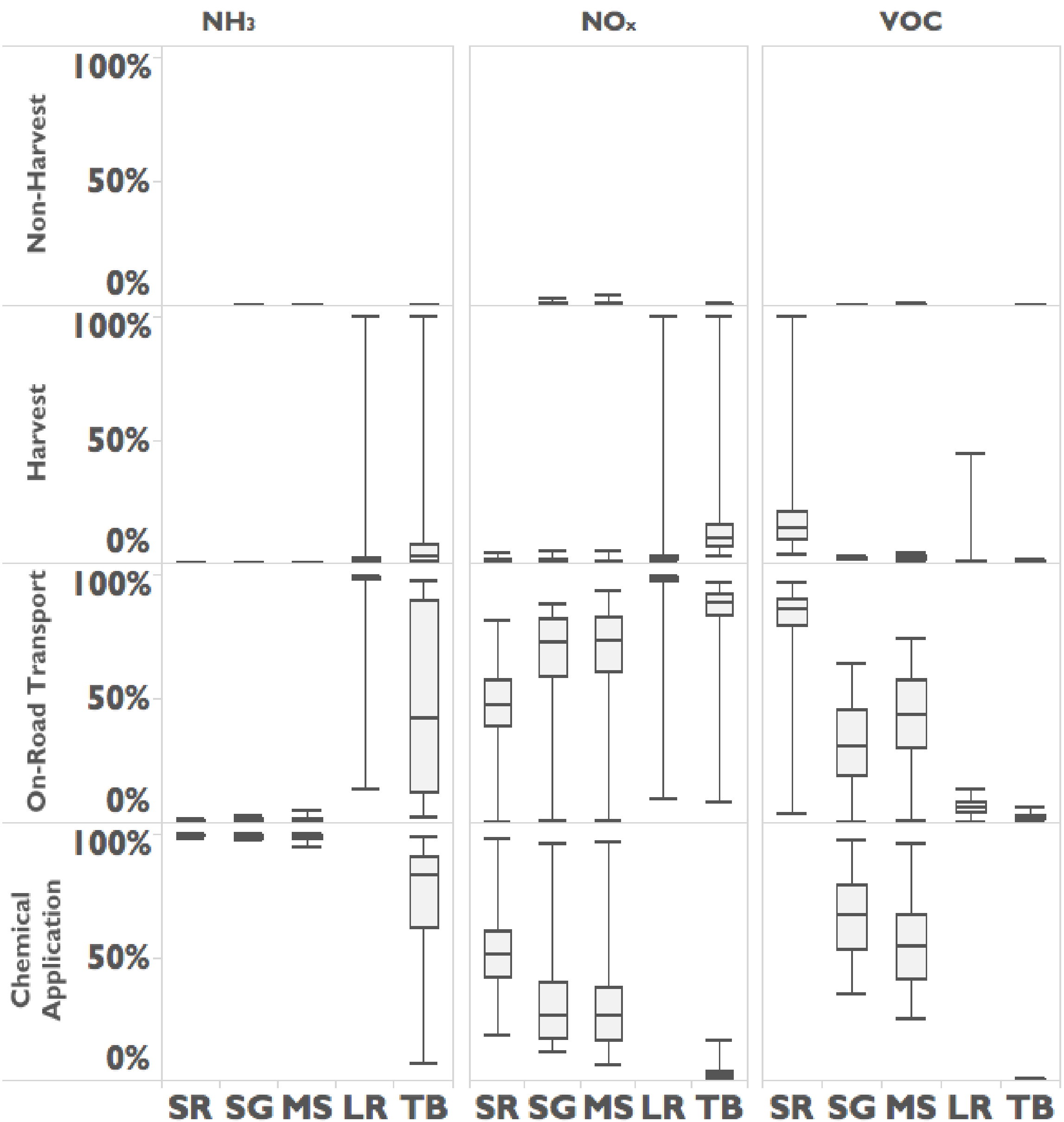
CG = corn grain
SR = stover
SW = straw
SG = switchgrass
MS = miscanthus
LR = logging residue
TB = whole-tree biomass
lb = pound
dt = dry ton
n = # of feedstock producing counties

FPEAM Results – Emissions from Production and Supply Logistics



SR = stover
SG = switchgrass
MS = miscanthus
LR = logging residue
TB = whole-tree biomass
lb = pounds
dt = dry ton
n = # of counties producing and supplying feedstock

Results – Emissions Contribution by Source



SR = stover
SG = switchgrass
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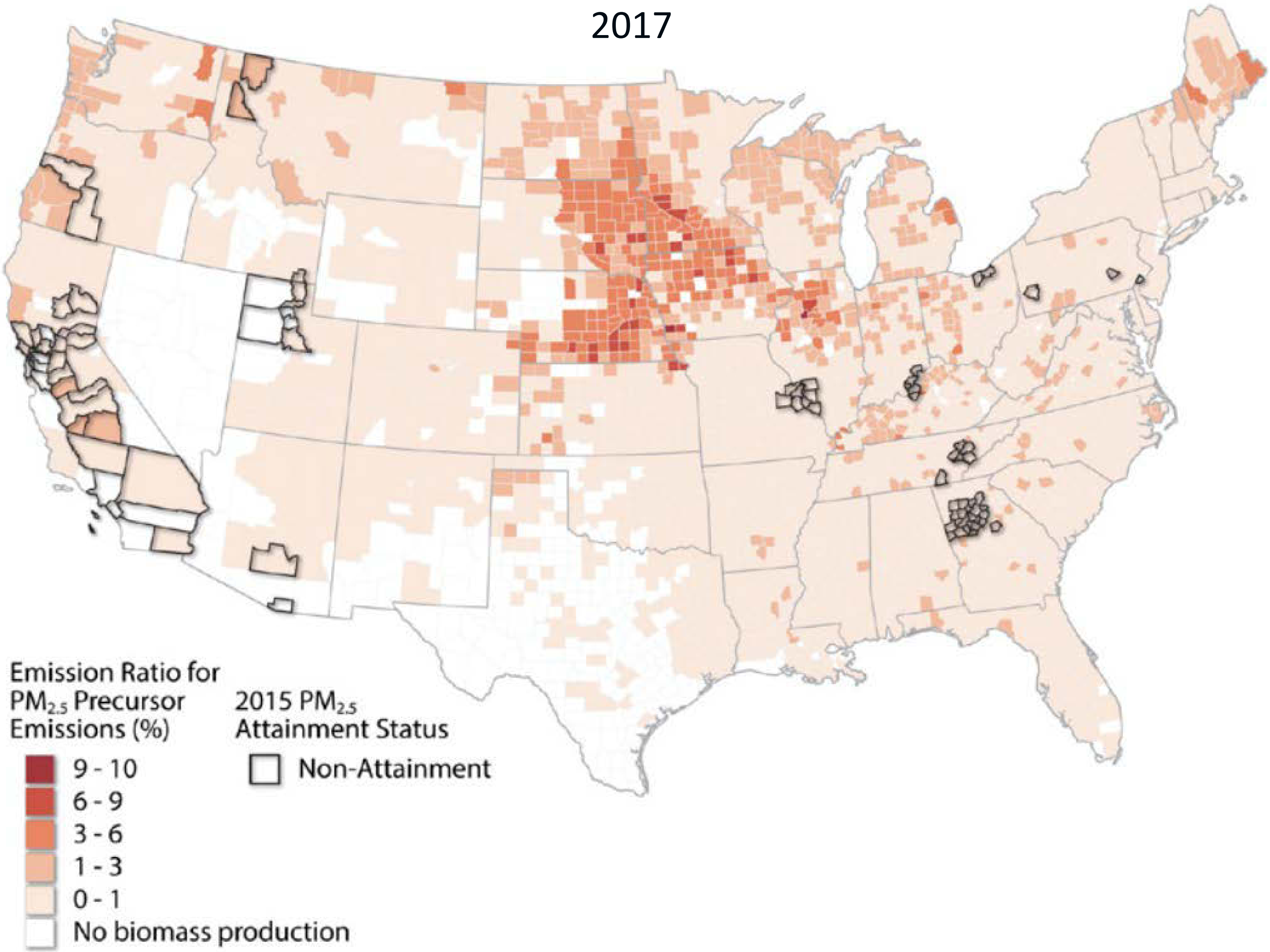
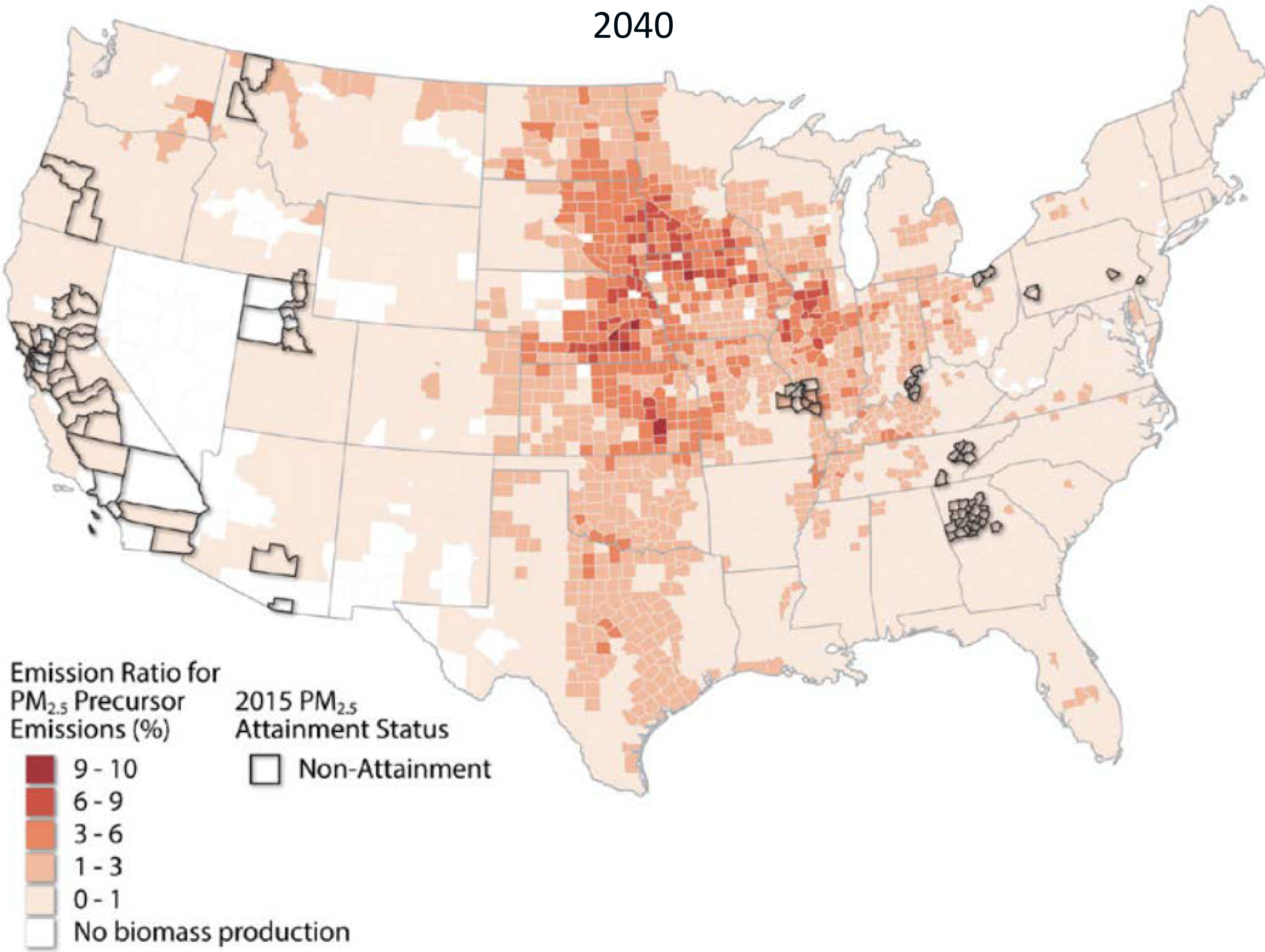
FPEAM Results – National Emissions Inventory (NEI) Emission $PM_{2.5}$ Ratio

2017

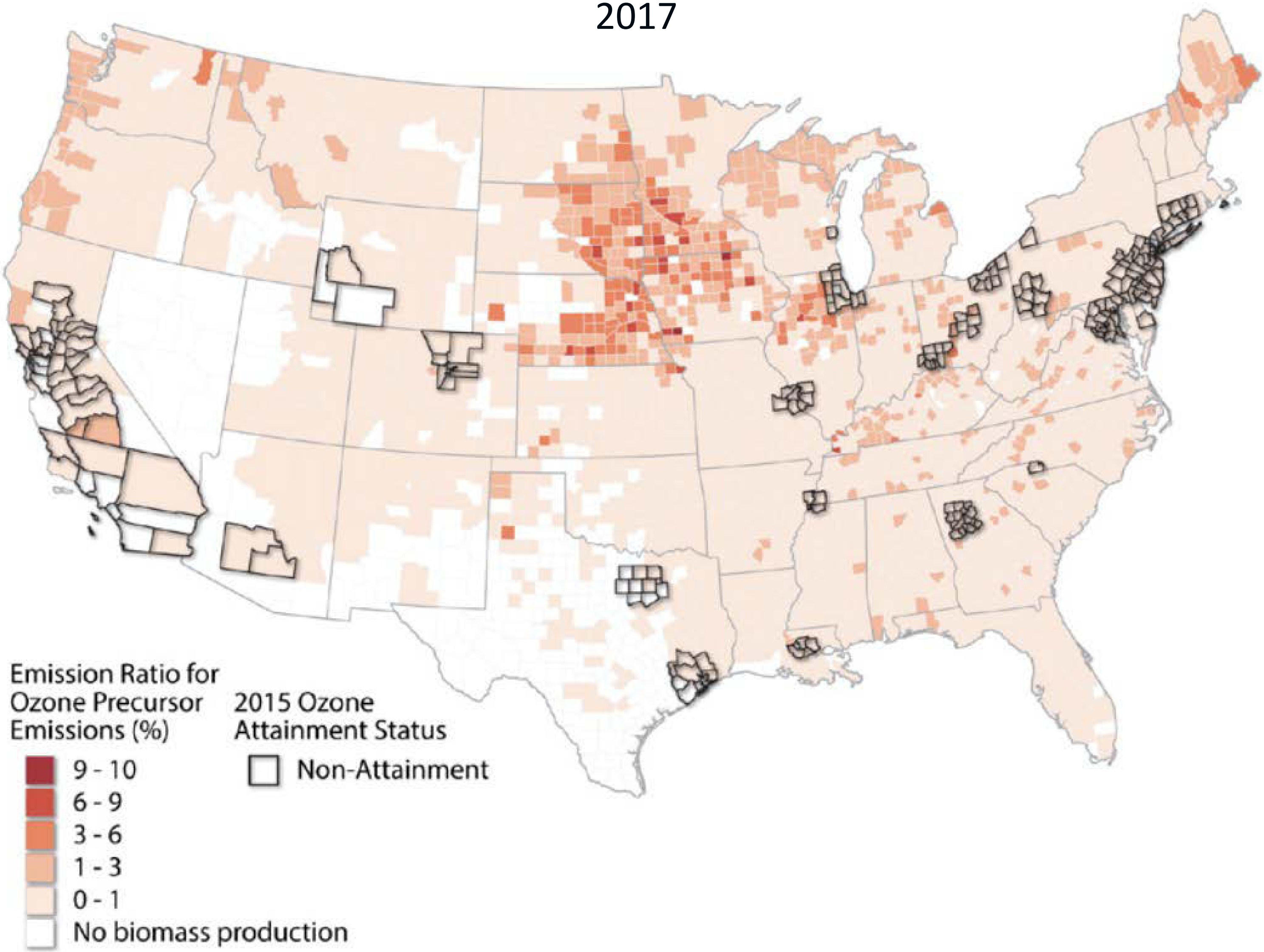


FPEAM Results – National Emissions Inventory (NEI) Emission $PM_{2.5}$ Ratio



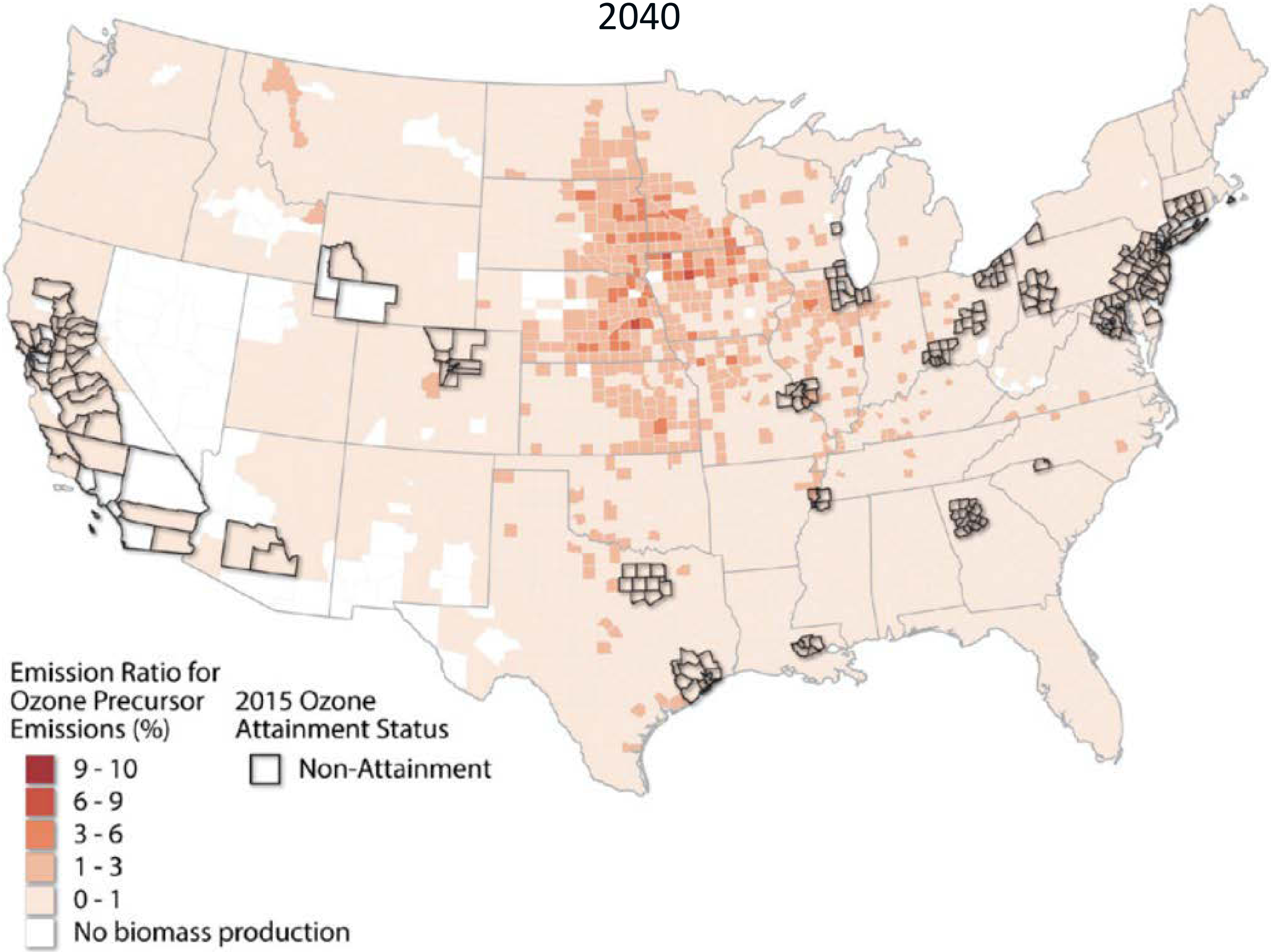
FPEAM Results – National Emissions Inventory (NEI) Ozone Emission Ratio

2017



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

2040



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

Recommendations for Future Research

- **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 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

- **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

Acknowledgements

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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

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)