Spatially Explicit Modeling of Criteria Air Pollutants from Agricultural and Forestry Feedstock Production

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Background: FPEAM 1.0

- <u>F</u>eedstock <u>P</u>roduction <u>E</u>missions to <u>A</u>ir <u>M</u>odel
- Python codebase initially developed in 2014, revised and expanded for the 2016 update to DOE's Billion Ton Report
  - Calculate spatially explicit, county-scale inventories of air pollutants produced during biomass feedstock production, harvest and transportation
  - Identify counties where biomass production could put counties out of 2015 National Ambient Air Quality Standards attainment
- Public release planned since 2017, following extensive refactoring to increase utility to air pollutant analysts

Efroymson RA, et al. (2017)

Use Cases

Basic

- Assess change in pollutant type, quantity and location associated with increase in feedstock production or change in feedstock type

User-customized spatial scale

- Calculate inventories by congressional district, farm or other stakeholder-relevant regions

Calculate inputs to other models

- Use FPEAM to generate pollutant inventories for inputs into air quality models

Objectives

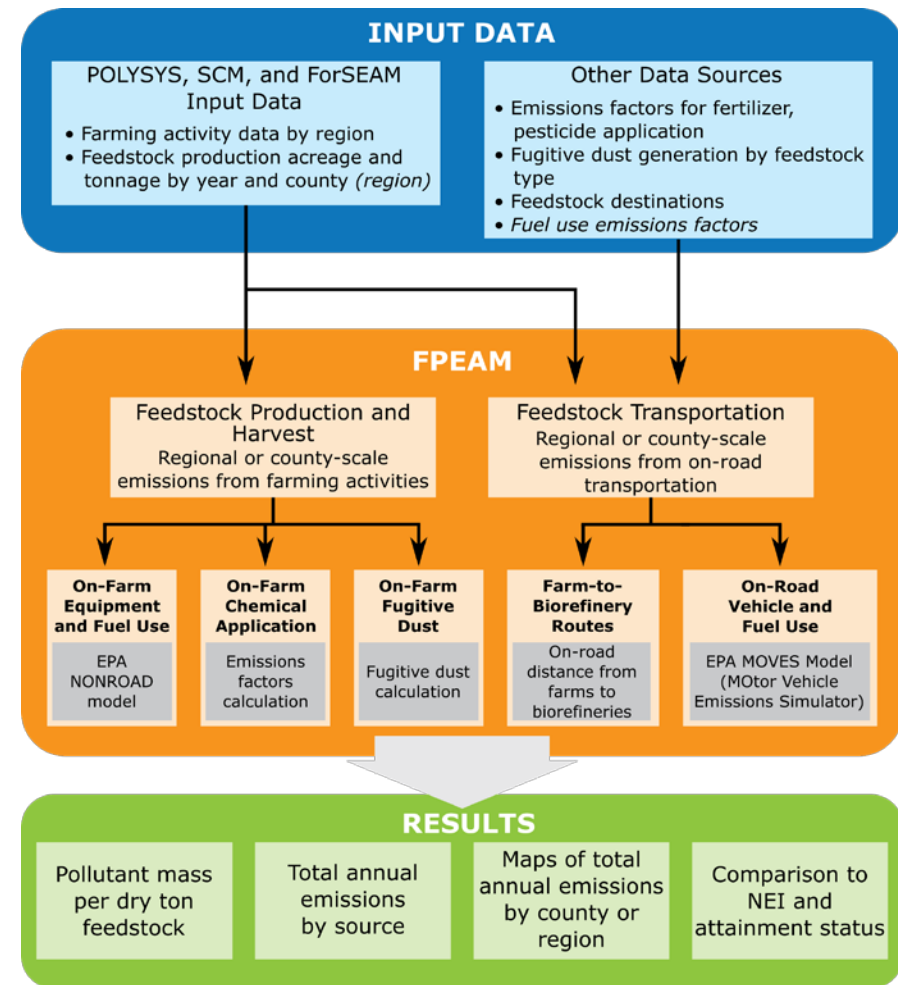| FPEAM Release	Target Date
Limited beta	September 2018
Public	September 2019

- Data-driven model structure to ensure flexibility and user control over scenarios
  - Model any feedstock, any farming practice, any spatial scale
  - Analysis capabilities limited by input data availability rather than model structure
- Build code base to make future expansions, updates easy to implement
  - Reduce effort for continued improvement by developers and by users

FPEAM 2.0 Model Structure

- Codebase consists of five semi-independent calculation modules

Module	Pollutant Calculation
MOVES	Feedstock transportation
Routing	
NONROAD	On-farm equipment use
Fugitive Dust	On-farm dust generated
Emissions Factors	On-farm chemical application; any factor-based calculation

- Outputs include raw pollutant inventory and basic visualizations

INPUT DATA

POLYSYS, SCM, and ForSEAM Input Data
- Farming activity data by region
- Feedstock production acreage and tonnage by year and county (region)

Other Data Sources
- Emissions factors for fertilizer, pesticide application
- Fugitive dust generation by feedstock type
- Feedstock destinations
- Fuel use emissions factors

FPEAM

Feedstock Production and Harvest
Regional or county-scale emissions from farming activities

Feedstock Transportation
Regional or county-scale emissions from on-road transportation

On-Farm Equipment and Fuel Use
EPA NONROAD model

On-Farm Chemical Application
Emissions factors calculation

On-Farm Fugitive Dust
Fugitive dust calculation

Farm-to-Biorefinery Routes
On-road distance from farms to biorefineries

On-Road Vehicle and Fuel Use
EPA MOVES Model (MOtor Vehicle Emissions Simulator)

RESULTS

Pollutant mass per dry ton feedstock

Total annual emissions by source

Maps of total annual emissions by county or region

Comparison to NEI and attainment status

Input Data

- Feedstock production (where, what, how much)
- Transportation vehicle parameters
- Agricultural equipment and resource use
- Fugitive dust factors by feedstock type
- Emissions factors by resource and pollutant

FPEAM Modules

- MOVES
- Routing
- NONROAD
- Fugitive Dust
- Emissions Factors

Output

Air Pollutant Inventory

- Pollutants by feedstock, region, farming practice and activity

MOVES

CO, VOC, PM$_{10}$, PM$_{2.5}$, NO$_x$, SO$_x$, NH$_3$, other pollutants

- <u>Mo</u>tor <u>V</u>ehicle <u>E</u>mission <u>S</u>imulator, developed by U.S. EPA, is an emissions modeling system that simulates mobile criteria and other pollutant sources at various spatial scales

feedstock	tillage	region_production	region_destination	measure	amount	unit
switchgrass	no tillage	40025	31067	harvested	28888.0	acre
switchgrass	no tillage	40025	31067	production	91284.3	dry short ton
switchgrass	no tillage	40025	31067	planted	29014.6	acre
switchgrass	no tillage	40025	31067	yield	3.1	dry short ton/acre

- Output: Emissions factors that are postprocessed with routing information to yield total pollutant inventories by feedstock and region

Default data source: See Zhang et al. (2015)

Routing

Combined with MOVES-calculated emissions factors

Sample route from Cherokee County, NC to Jefferson County, CO
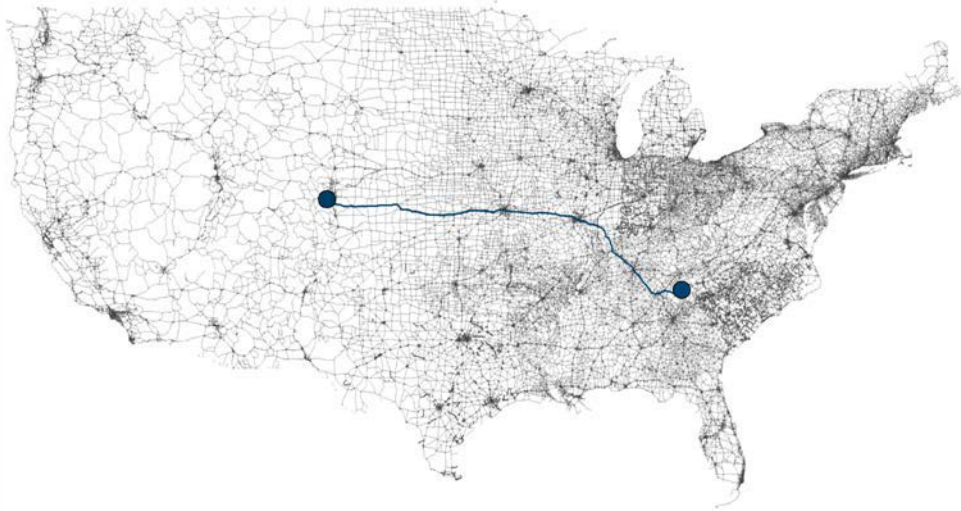
Global Roads Open Access Data Sets (gROADS) v1

- Input data specifies feedstock production regions and destinations
  - Depot or biorefinery location
- Routing module finds shortest path between region centroids via major roads
- Output: transportation emissions in every region along calculated route

NONROAD
CO, VOC, PM$_{10}$, PM$_{2.5}$, NO$_x$, SO$_x$, NH$_3$, other pollutants

MOVES — Motor Vehicle Emission Simulator

- Emissions simulator developed by U.S. EPA for off-road mobile sources, packaged with MOVES2014b
- Output: pollutant inventories for on-farm agricultural equipment use

feedstock	tillage	activity	equipment	resource	rate	unit
biomass sorghum	reduced tillage	establishment	tractor 2wd 135 hp	time	0.09	hour/acre
biomass sorghum	reduced tillage	harvest	forage harvester (6 row head)	time	0.96	hour/acre
biomass sorghum	reduced tillage	maintenance	tractor 2wd 55 hp	time	0.04	hour/acre

Default data source: See Zhang et al. (2015)

Emissions Factors
VOC, NO_x, NH_3, other pollutants optional

- Default: NO_x and NH_3 from nitrogen fertilizer; VOC from herbicide, insecticide

- Calculation can be extended to any number of pollutants and activities with sufficient input data

- Potential for replacing MOVES and/or NONROAD, but tradeoff exists between model run time and accuracy

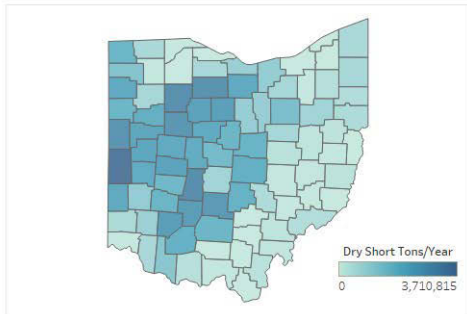Default data source: Zhang et al. (2015)

Fugitive Dust
PM_{10}, $PM_{2.5}$

- Default: PM_{10} and $PM_{2.5}$ emissions from agricultural equipment use and tilling operations
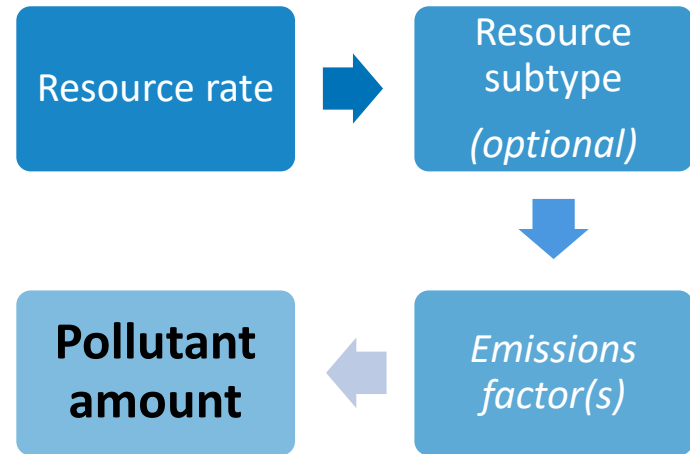
Default data source: California Air Resources Board, Midwest Research Institute

Sample Pollutant Inventory Visualizations

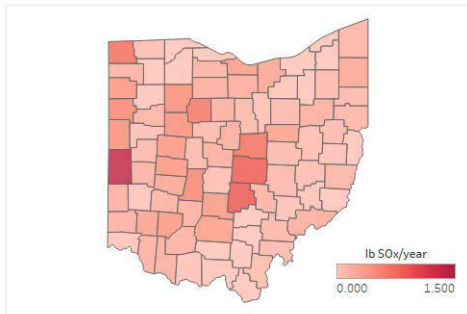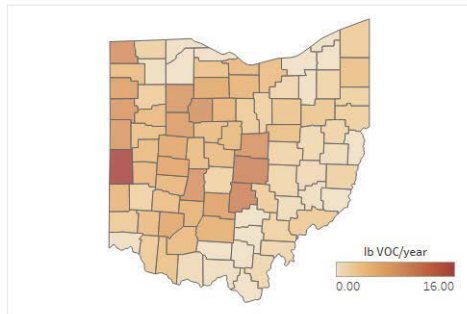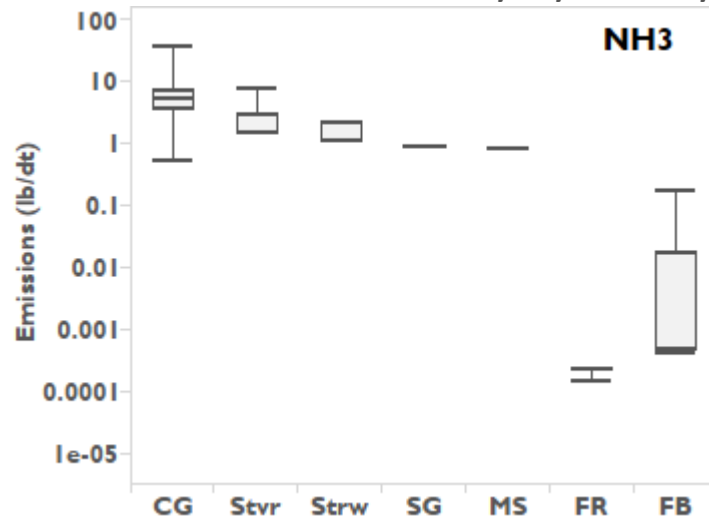## Miscanthus Production

Dry Short Tons/Year
0 — 3,710,815

PM10 Emissions

lb PM10/year
0.00 — 60.00

SOx Emissions

lb SOx/year
0.000 — 1.500

VOC Emissions

lb VOC/year
0.00 — 16.00
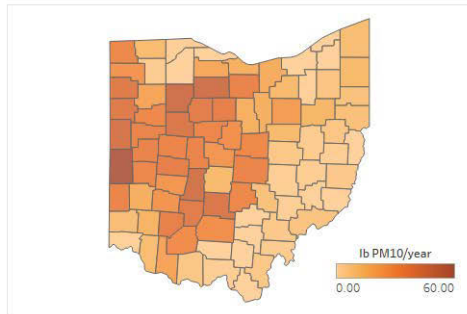
Emissions variability by county

NH3

Efroymson RA, et al. (2017)

PM10 NAA Status
☐ Counties in Attainment
☐ Whole or Partial Non-Attainment
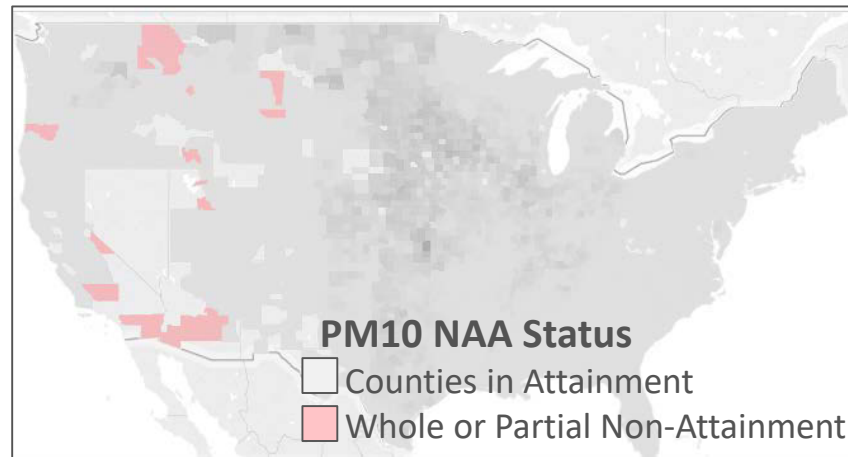
Continuing Development

- Assess the human health impacts of criteria air pollutant inventories

- Calculate fugitive dust from feedstock transportation using road-surface data and routing info

- Adjust path-finding algorithm used in routing to favor interstates, circumvent population centers and use multiple modes of transportation

- Expand calculations to include economic impacts such as jobs created by region and whether those jobs are seasonal or year-round

Conclusion

FPEAM Release	Target Date
Limited beta	September 2018
Public	September 2019

- FPEAM calculates spatially explicit inventories of air pollutants produced during biomass feedstock production, harvest and transportation

- Modeling capabilities are flexible, limited primarily by input data availability

- Use cases include identification of criteria air pollutant hot spots, air quality modeling *(in progress)*, and inventory analyses at the farm or congressional district scale

Workshop for FPEAM beta testers

- September 20-21, 2018
- Held on NREL campus
- Interested? Contact Garvin Heath at garvin.heath@nrel.gov and Melissa Hudman at melissa.hudman@nrel.gov

Further information and questions, contact rebecca.hanes@nrel.gov

Thank you

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