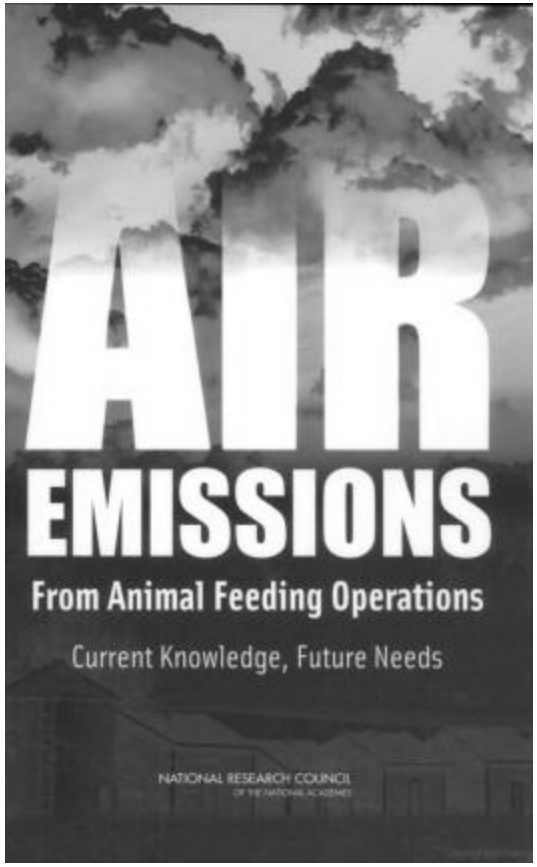
Ammonia Emissions Estimation for Modeling – Current Practice

Julie McDill, PE

MARAMA

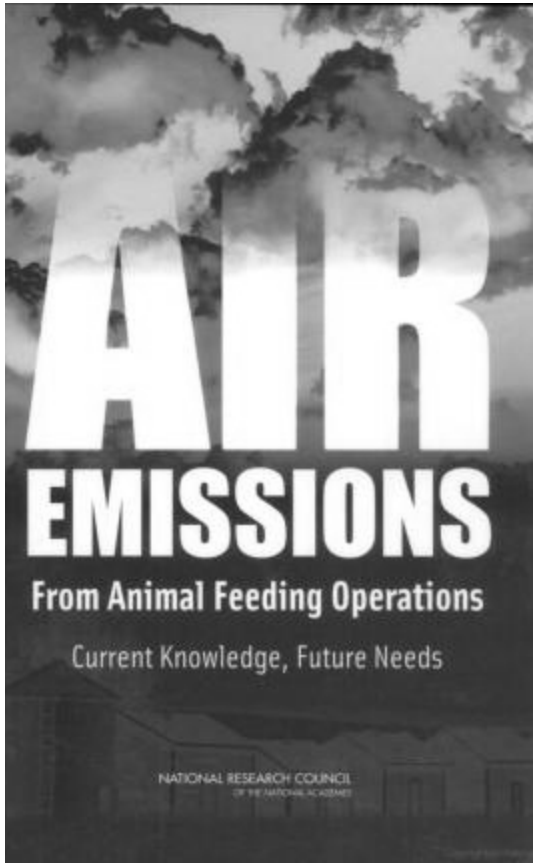
jmcdill@marama.org

2003 National Academy of Science Recommended approach for ammonia estimation from AFOs



- **Improve emission factors**
- **Define relationship between air emissions & factors including:**
  - animal types,
  - nutrient inputs,
  - manure handling practices,
  - output of animal products,
  - management of feeding operations,
  - confinement conditions,
  - site characteristics,
  - climate and weather

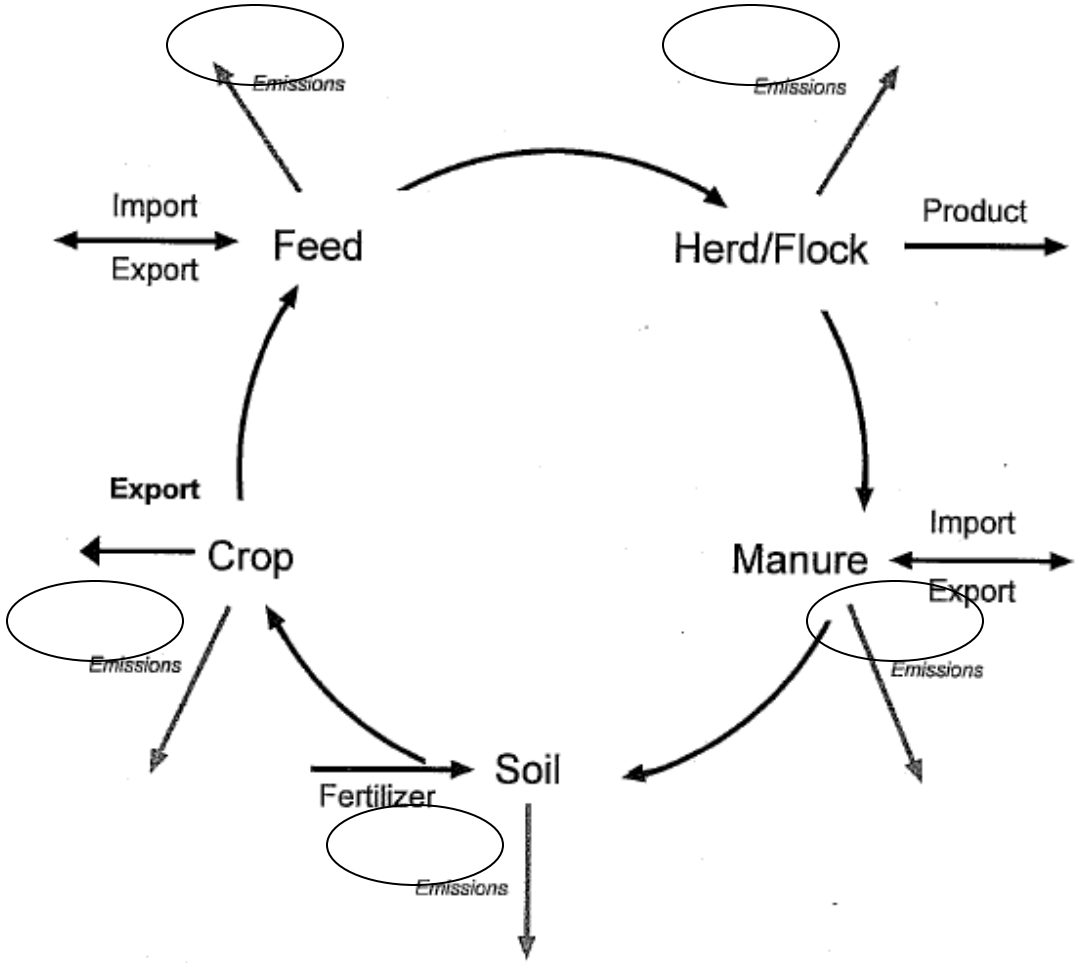
2003 National Academy of Science Recommended approach for ammonia estimation from AFOs



Integrate discharges to air & water

- "Mass balance" of nitrogen-containing compounds around entire on & off-farm system
- Avoid control strategies that only shift Nitrogen to a different chemical species or emission point
- Use in conjunction with emission factors
- Check on total estimated emissions
- Evaluate impact of control strategies on both air and water

2003 National Academy of Science Recommended Process Based Model



MANE VU 2002 AND 2007 MODELING INVENTORY AMMONIA ESTIMATION

- Agricultural sources
  - Carnegie Mellon University Model
- Industrial Sources – Point & Area
  - Industrial Refrigeration – Area
  - Cement Plants – Point
  - Wastewater treatment plants - Point
- Soil Emissions
  - Not included in the inventory

CMU MODEL

- Developed in 2001 for MARAMA
- Emission factor X Activity data
- Advantages:
  - Structure allows for easy updating
    - activity data
    - Emission factors
  - Inventories at varying spatial resolution can be generated
    - National/ State/ County / Sub-county
  - Temporal resolution
    - Yearly – Livestock emissions
    - Monthly – Fertilizer application emissions

AGRICULTURAL FERTILIZER USAGE

- Database from Association of America Plant and Food Control Officials – 2002 and 2007

AGRICULTURAL LIVESTOCK EMISSIONS

- CMU compiled available emission factors
- Most emission factors developed in Europe
- Emission factors highly uncertainty

  Example: Dairy

  Avg = 23.9 kg NH3/cow yr

  5-95% Confidence Interval = 18–36 NH3/cow yr

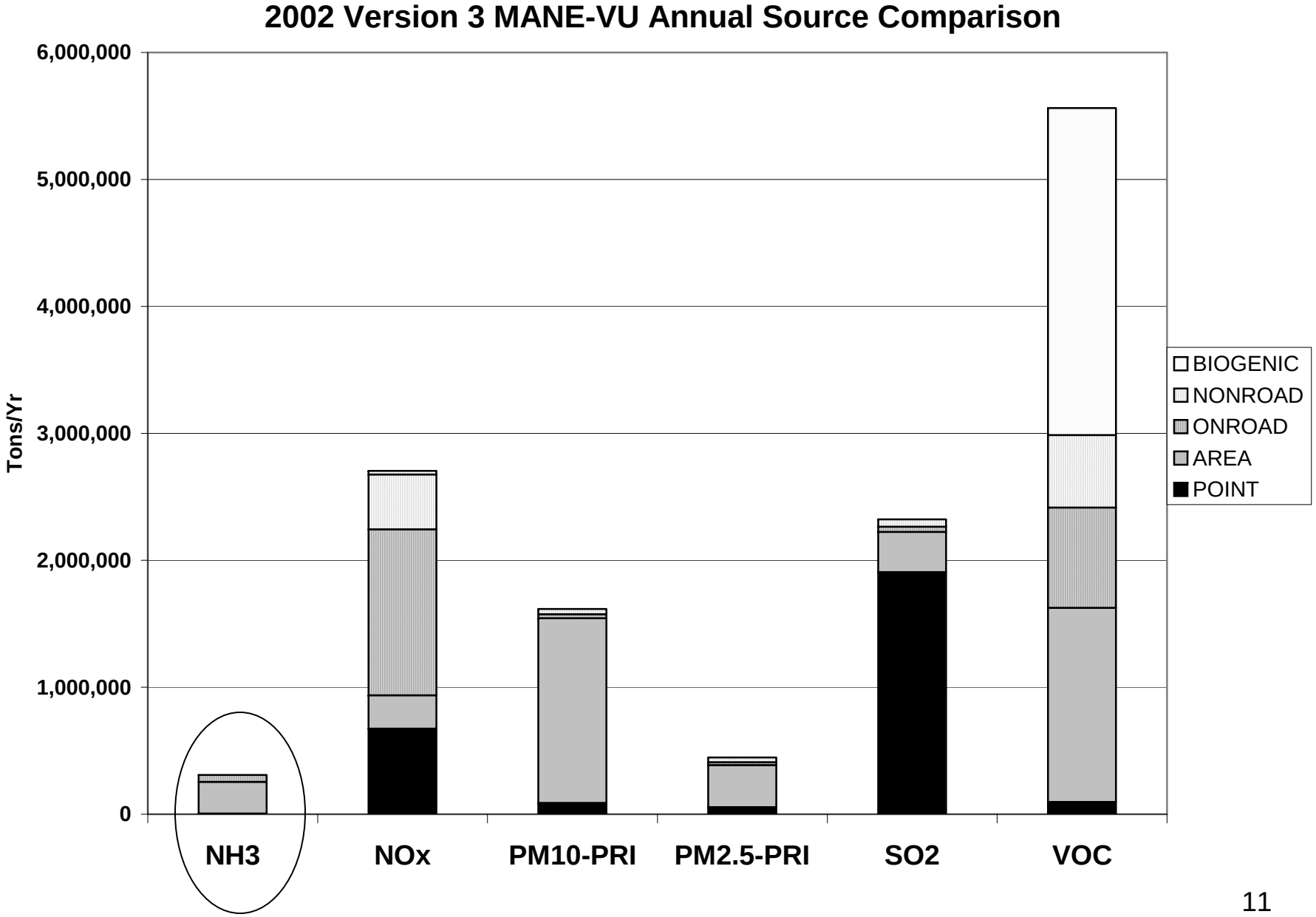
- Only ammonia emissions are addressed – other emissions of interest include VOC, CH4, H2S, PM10, PM2.5
- Emission factors are a composite of several processes
  - Example confined versus grazing cattle

AGRICULTURAL LIVESTOCK EMISSIONS

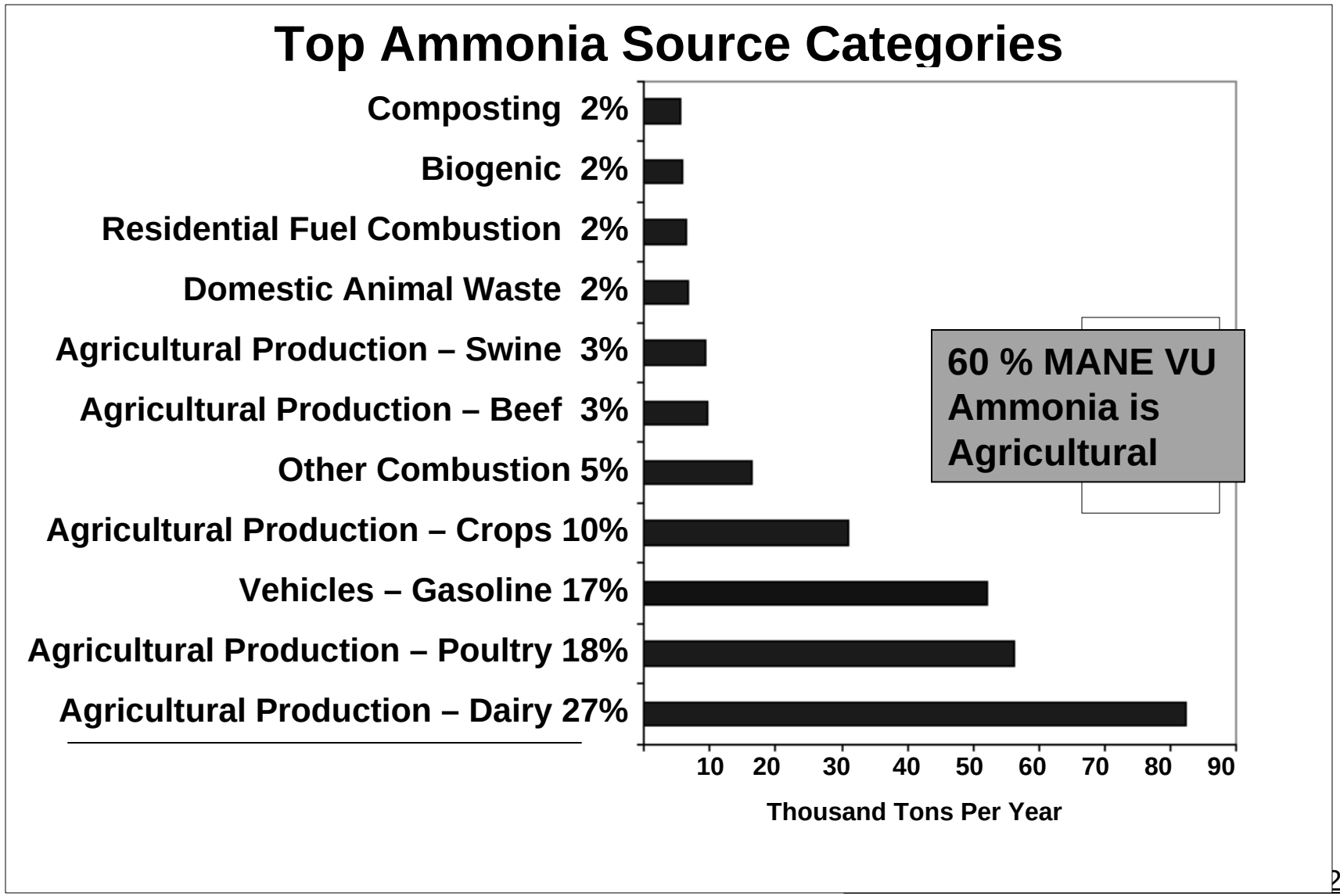
- Activity data - Animal Numbers – USDA Census of Agriculture
  - Average annual animal population by animal group & state/county
  - Manure Management Trains (MMT) identified
  - Estimate proportion of animal population using each MMT
- Annual emissions temporalized for modeling
  - Fertilizer emissions temporalized using curves incorporated into CMAQ – Max emissions in spring & fall
  - Livestock emissions constant throughout the year

AGRICULTURAL LIVESTOCK EMISSIONS

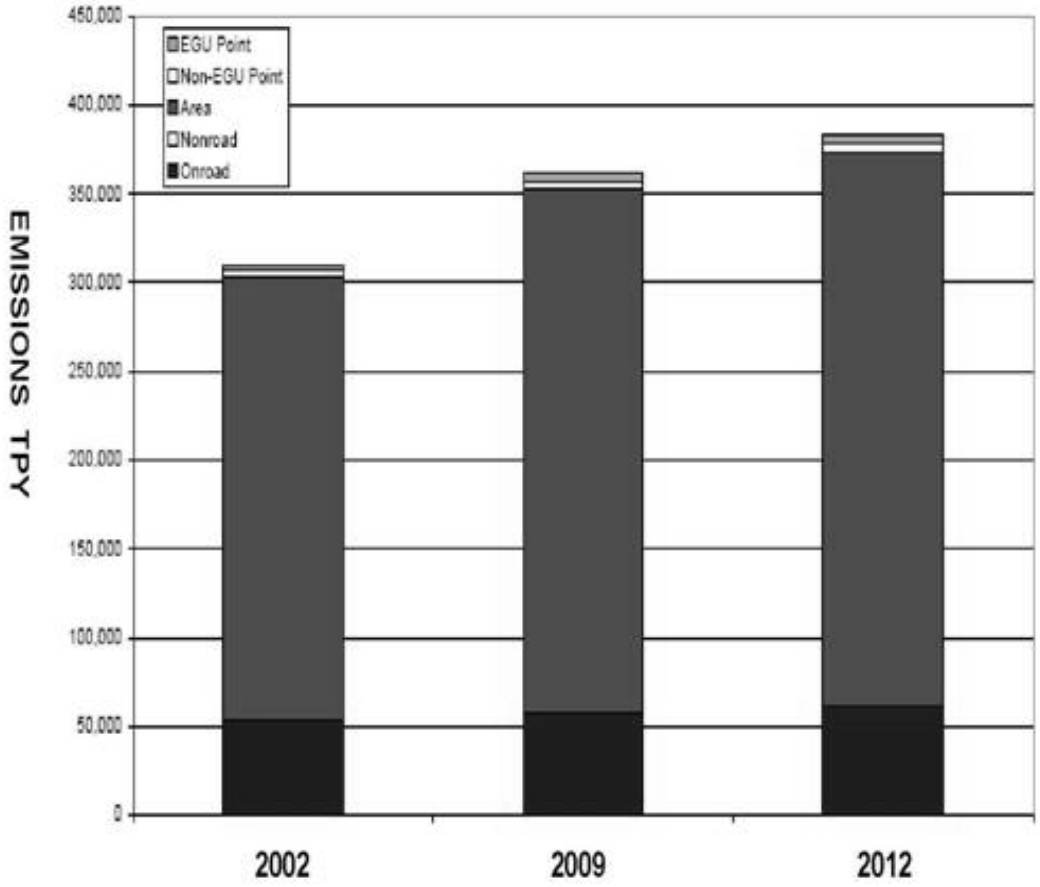
- Areas needing work
  - Spatial and temporal resolution
    - Locations of large CAFOs is not included or defined
    - Temporal profiles only for fertilizer application (spring/fall)
  - Housing conditions which affects emissions
  - Application of control strategies difficult as parameters and emission factors are not site specific
  - Emission difference due to climate are not characterized
  - Emissions transfer between chemical species & emission points not captured


2002 Version 3 MANE-VU Annual Source Comparison
Tons/Yr
6,000,000
5,000,000
4,000,000
3,000,000
2,000,000
1,000,000
0
NH3
NOx
PM10-PRI
PM2.5-PRI
SO2
VOC
BIOGENIC
NONROAD
ONROAD
AREA
POINT

MANE VU 2002


Top Ammonia Source Categories
Composting 2%
Biogenic 2%
Residential Fuel Combustion 2%
Domestic Animal Waste 2%
Agricultural Production – Swine 3%
Agricultural Production – Beef 3%
Other Combustion 5%
Agricultural Production – Crops 10%
Vehicles – Gasoline 17%
Agricultural Production – Poultry 18%
Agricultural Production – Dairy 27%
10 20 30 40 50 60 70 80 90
Thousand Tons Per Year
60 % MANE VU Ammonia is Agricultural

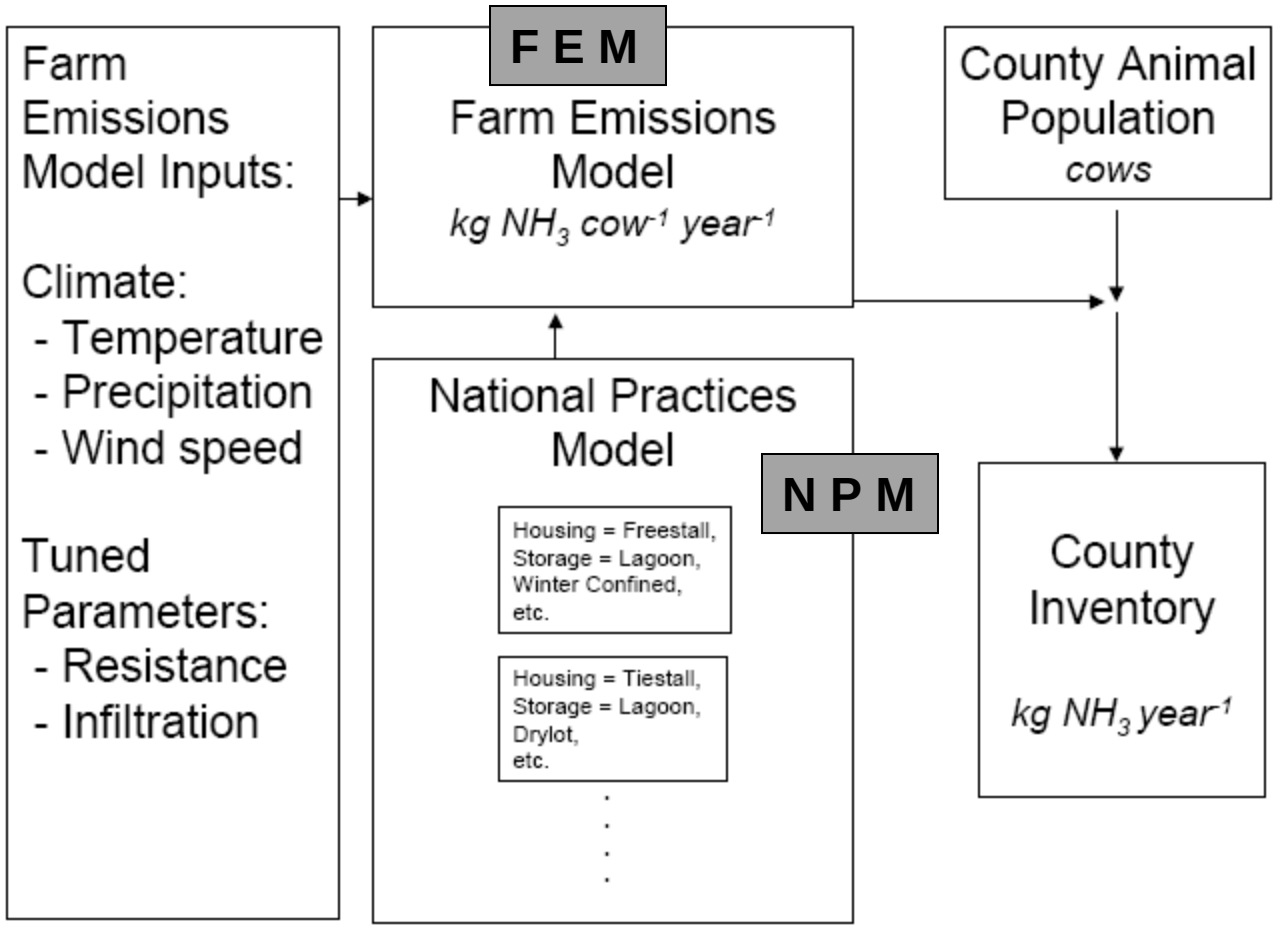
MANE VU AMMONIS EMISSIONS PROJECTIONS



CMU IMPROVED DAIRY MODEL

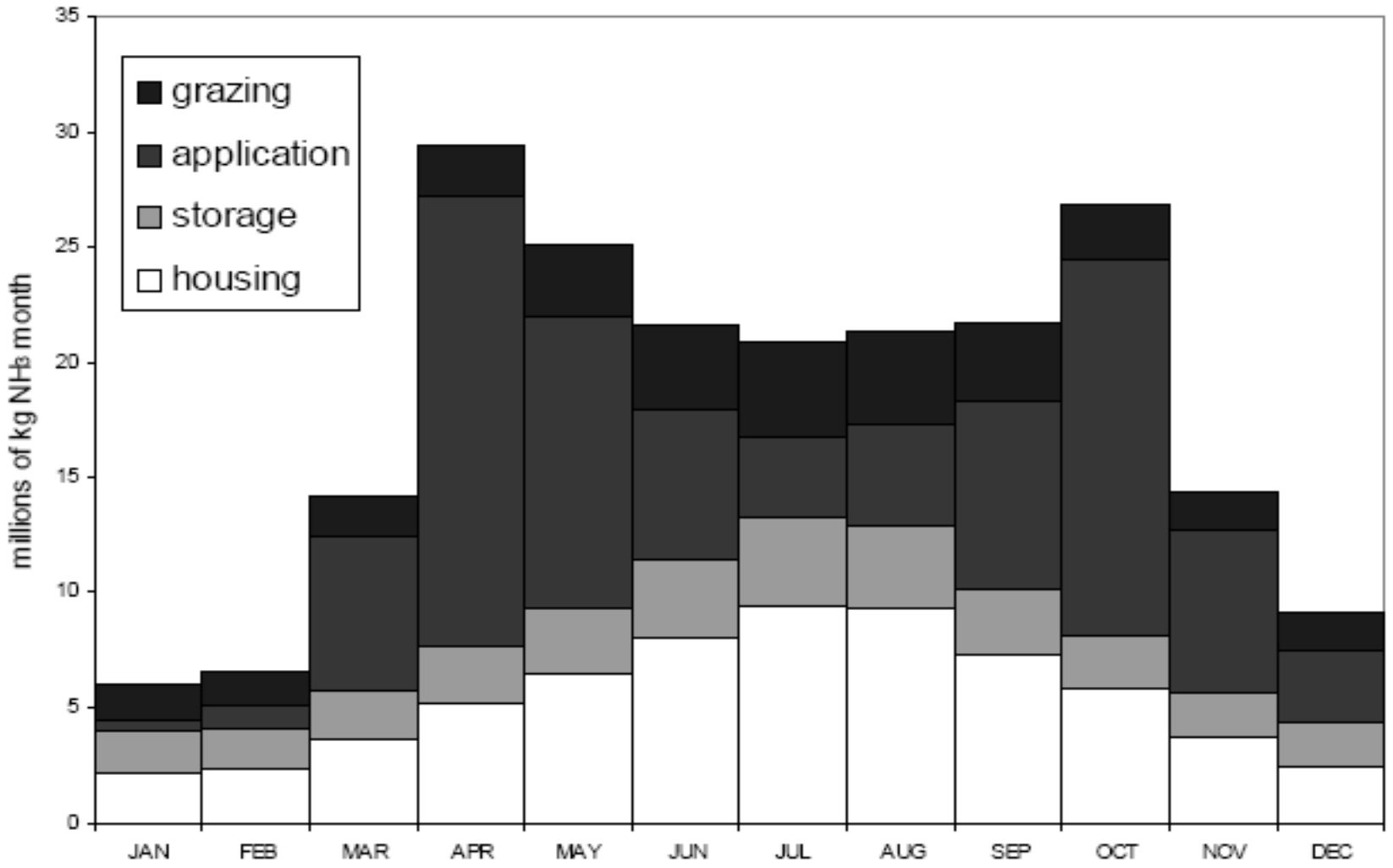
- CMU refined model for Dairy Emissions
- Nationally largest Livestock emission source
  - Seasonal and geographical emission variation
  - Farming practices – confinement conditions
- Two part model
  - FEM – Develops per animal emissions based on farming practices and climate
  - NPM – Statistical regression model predicting farming practices in each county in United States

CMU IMPROVED DAIRY MODEL

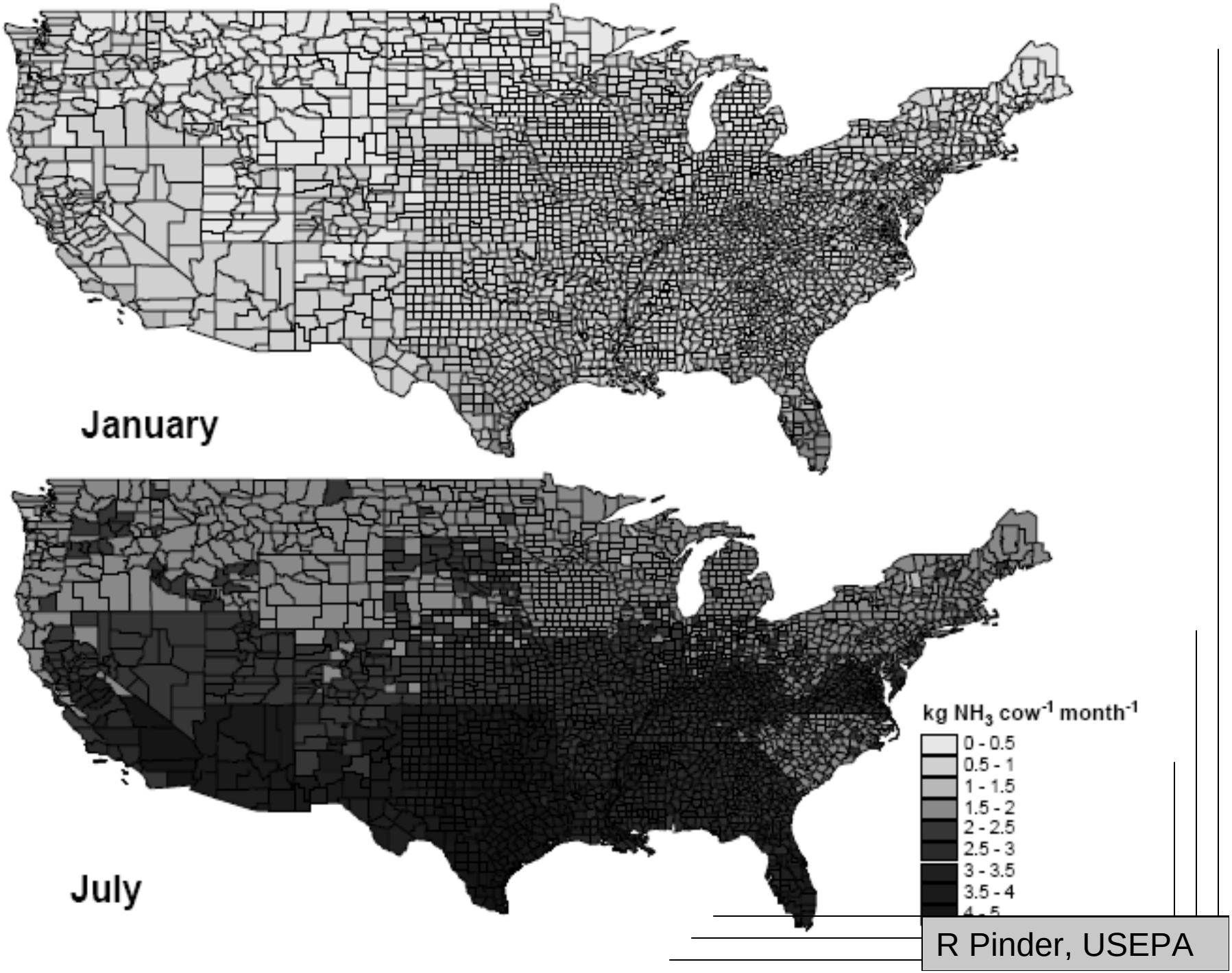


R Pinder, USEPA

Seasonal Variability in National Emissions

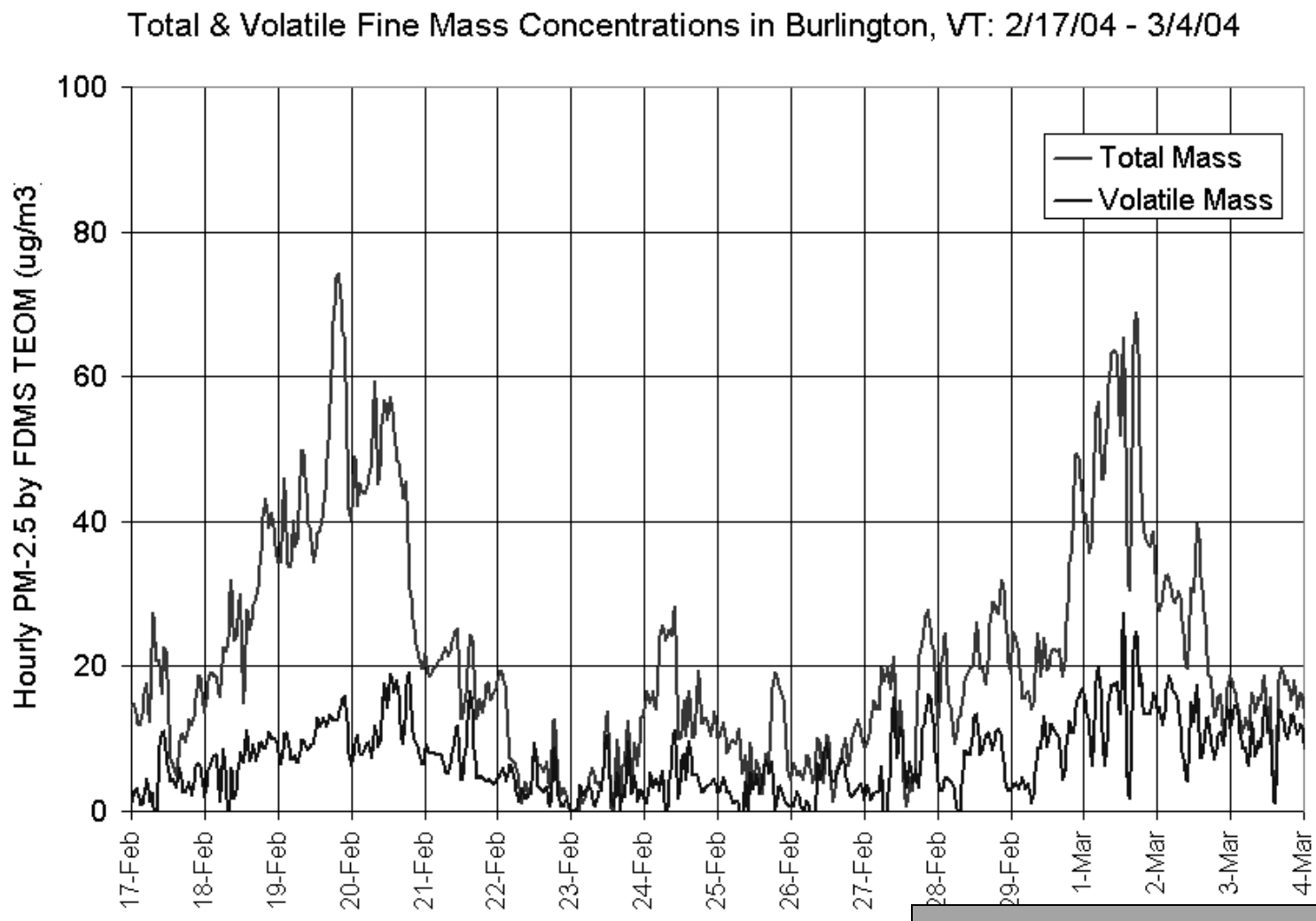


R Pinder, USEPA


January
July
kg NH_3 cow^{-1} $month^{-1}$
0 - 0.5
0.5 - 1
1 - 1.5
1.5 - 2
2 - 2.5
2.5 - 3
3 - 3.5
3.5 - 4
R Pinder, USEPA

TEMPORAL EFFECT OF AMMONIA VOLATILIZATION

2004 $PM_{2.5}$ Event in Burlington, VT 2004



Rich Poirot, VT DEC

CONCLUSION

- MANE VU is using the CMU model to predict agricultural emissions
- CMU model is a step forward but more needs to be done to meet National Academy of Science recommendations
- Agricultural emissions dominate the ammonia inventory
- Temporal and spatial emission variation matters as was shown in the Vermont data