Development of a Gridded Ammonia Emissions Inventory for the San Joaquin Valley of California

Presented by
Gerard E. Mansell
ENVIRON International Corporation

Stephen M. Roe
April 18 2002
Introduction

California Regional PM$_{10}$/PM$_{2.5}$ Air Quality Study (CRPAQS) -- Multi-year study of PM in Central California including:

- meteorological modeling
- air quality monitoring
- emission inventory development
- data analysis
- air quality modeling
Introduction

**CRPAQS Objectives**

- Provide improved understanding of emission and atmospheric processes influencing PM formation and transport
- Develop methods for formulating and assessing control strategies for attainment demonstrations
- Develop reliable tools for estimating PM control strategy impacts
CRPAQS Modeling Domain
Ammonia Inventory Development

- Development of improved methods and data sources for the generation of a gridded NH3 inventory on a 1-km x 1-km grid for aerosol modeling.
- Development of a GIS-based modeling system designed to handle new and emerging issues in NH3 EI development including:
  - relationship of ammonia emission to environmental variables (e.g., temperature, relative humidity, soil characteristics);
  - incorporation of highly-resolved spatial data (LU/LC databases, geo-coded point sources); and
  - detailed source classification schemes -- for improved spatial/temporal resolution, control strategy assessment.
Methods and Data Sources

- SJV is an Ag-Intensive Area
  - Over 2.2 million diary cattle in the 8-county area
  - About 650,000 beef cattle
  - Over 26 million broiler chickens
  - Numerous other CAOs - hogs, horses, goats
  - Over 5.3 million acres of crop land

- Previous inventory - livestock contributes > 75% of NH3 (excluding soils)

- Dairy cattle make up a considerable fraction of the livestock emission (~ 57%)

- Additional effort placed on better characterization of emission from CAOs, especially SJV dairies
Cattle Source Characterization

• Seasonal and diurnal temporal allocation factors developed to:
  – *account for lower emission during colder seasons and at night* (dairies, feedlots, hog farms)
  – *correspond to the seasons during which activity occurs* (manure spreading emissions)

• Area sources mapped to specific LU/LC data (e.g., DWR dairy/feedlot coverage; manure spreading to specific crop type)
Cattle Source Characterization

NH₃ EMISSIONS FROM DAIRY OPERATIONS - SAN JOAQUIN VALLEY

Dairy Operations
- Monitoring Sites
- NH₃
  - 4440 - 148592
  - 148592 - 292744
  - 292744 - 436896
  - 436896 - 581048
  - 581048 - 720200
# Cattle Source Characterization

<table>
<thead>
<tr>
<th>Category</th>
<th>EIC</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cattle – Confined Beef Operations</td>
<td>630-618-0262-0002P</td>
<td>Point Source Cattle Feedlots</td>
</tr>
<tr>
<td>Cattle – Confined Dairy Operations</td>
<td>630-618-0262-0001P</td>
<td>Point Source Dairies</td>
</tr>
<tr>
<td>Cattle – Dairy calves</td>
<td>630-618-0262-0005P</td>
<td>Point Source Dairy Replacement Operations</td>
</tr>
<tr>
<td>Cattle – Range calves</td>
<td>630-618-0262-0003A</td>
<td>Area Source Range Calves</td>
</tr>
<tr>
<td>Cattle – Stocker inshipments</td>
<td>630-618-0262-0009A</td>
<td>Area Source Range Stocker Inshipments</td>
</tr>
<tr>
<td>Cattle – Range cows</td>
<td>630-618-0262-0010A</td>
<td>Area Source Range Cows</td>
</tr>
<tr>
<td>Cattle – Dairy cows</td>
<td>630-618-0262-0006A</td>
<td>Area Source Dairy Cows</td>
</tr>
<tr>
<td>Cattle – Dairy heifers</td>
<td>630-618-0262-0007A</td>
<td>Area Source Dairy Heifers</td>
</tr>
<tr>
<td>Cattle – Dairy bulls</td>
<td>630-618-0262-0008A</td>
<td>Area Source Dairy Bulls</td>
</tr>
<tr>
<td>Cattle - Confined beef operations, dry manure</td>
<td>630-618-0262-0004A</td>
<td>Area Source Confined Beef Operations, Dry Manure Spreading</td>
</tr>
<tr>
<td>spreading</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Cattle – Dairy operations, dry manure spreading</td>
<td>630-618-0262-0011A</td>
<td>Area Source Dairy Operations, Dry Manure Spreading</td>
</tr>
<tr>
<td>Cattle – Dairy operations, liquid manure spreading</td>
<td>630-618-0262-0012A</td>
<td>Area Source Dairy Operations, Liquid Manure Spreading</td>
</tr>
</tbody>
</table>
Methods & Data Sources for Livestock Operations

• Improvements to spatial and temporal allocation of Livestock emissions in SJV counties
  – Geo-coded herd population for 577 dairies
  – Geo-coded herd population for 155 feedlots in Tulare & Imperial counties (accounts for ~75% of 1000+ head feedlots in CA)
  – Geo-coded herd population for 92 other CAOs in Tulare, Fresno & Kings counties
  – Stocker Inshipments

• Increased level of source resolution allows for:
  – improved spatial & temporal allocation
  – improved emission estimates
  – better control strategy assessment
Methods & Data Sources for Other Source Categories

• Fertilizer Application & Natural Soils
  – Emission estimates from CAL/CASA model

• Mobile Sources
  – Gridded VMT; Fleet-wide emission factors

• Landfills
  – NH₃:CH₄ emissions ratio (0.007); CH₄ emissions from CARB; geo-coded point locations

• Prescribed Burns & Wildfires
  – NH₃:CO emissions ratio; CO emissions from CARB
Methods & Data Sources for Other Source Categories

- **Agricultural Burns**
  - $NH_3:CO$ emissions ratio; CO emissions from CARB

- **Residential Wood Combustion**
  - $NH_3:CO$ emissions ratio; CO emissions from CARB

- **POTWs**
  - Activity data from CA SWRCB; geo-coded point locations

- **Industrial Sources**
  - Point source emission estimates from CARB CEIDARS
Annual NH3 Emissions by Source Sector

- Industrial: 86.55%
- Livestock: 0.66%
- POTWs: 0.64%
- Agricultural Burning: 0.53%
- Residential Wood Combustion: 8.75%
- Wild & Prescribed Burns: 1.19%
- Domestic: 1.65%
- Landfills: 0.04%
GIS-Based Emissions Model Development

- Designed to:
  - treat relationship of ammonia emissions to environmental variables
  - incorporate high resolution spatial data (LU/LC databases; population density; geo-coded point sources)
  - incorporate detailed source classification schemes
- Based on Arc/INFO GIS and Access database
- Flexible input data sources/formats; easily modified input tabular data (activity data, EF, spatial surrogate relationships)
- Efficient processing capabilities
- Modular
- Intuitive user interface
California Gridded Ammonia Inventory Modeling System (CalGAIMS)
Geospatial Data

- **Land Use/Land Cover (LULC)**
  - *CA DWR Crop coverages* -- GIS shapefiles for each county; high spatial resolution w/ detailed agricultural land use characteristics
  - *NLCD LU/LC coverages* -- GIS raster data; high spatial resolution (30 m); 21 LU/LC classifications for non-agricultural land use

- **Population**
  - *2000 US Census data for California*
  - *1-km gridded population density (based on 1990 data)*
Geospatial Data

- Evergreen Forest
- Bare Rock/Sand/Clay
- Shrubland/Range
- Grassland/Herbaceous
- Open Water
- Deciduous Forest
- Mixed Forest
- Ice/Snow
- Urban-residential
- Field Crops
- Semi-agricultural
- Grain & Hay Crops
- Pasture
- Emergent Wetlands
- Truck, Nursery & Berry Crops
- Urban-Commercial
- Vacant
- Deciduous Fruits & Nuts
- Idle
- Urban-Industrial
- Rice
- Vineyards
- Citrus & Subtropical
- Quarry/Strip Mines/Gravel Pits
- Landscape
- Woody Wetlands
### Spatial Allocation by Source Category

<table>
<thead>
<tr>
<th>Source Category</th>
<th>Spatial Surrogate</th>
</tr>
</thead>
<tbody>
<tr>
<td>On-Road Mobile Sources</td>
<td>Allocated based on existing gridded VMT.</td>
</tr>
<tr>
<td>Fertilizer Application</td>
<td>Crop coverages developed by Potter et al (2001)</td>
</tr>
<tr>
<td>Soils and Plant Canopy Systems</td>
<td>Crop coverages developed by Potter et al (2001)</td>
</tr>
<tr>
<td>Agriculture Burning</td>
<td>NLCD LULC and DWR Crop coverages</td>
</tr>
<tr>
<td>Prescribed Burns/Wildfires</td>
<td>NLCD LULC and DWR Crop coverages</td>
</tr>
<tr>
<td>Residential Wood Burning</td>
<td>DWR and NLCD LULC and census data</td>
</tr>
<tr>
<td>Livestock: Beef Cattle</td>
<td>NLCD LULC and DWR Crop coverages</td>
</tr>
<tr>
<td>Livestock: Hogs, Rabbits, Sheep, Goats</td>
<td>NLCD LULC and DWR Crop coverages</td>
</tr>
<tr>
<td>Livestock: Horses, Mules, Donkeys, Burros</td>
<td>NLCD LULC and DWR Crop coverages</td>
</tr>
<tr>
<td>Native Animals</td>
<td>NLCD LULC coverages</td>
</tr>
<tr>
<td>Domestic Sources Human</td>
<td>DWR and NLCD LULC coverages and census data</td>
</tr>
</tbody>
</table>
CalGAIMS Main Menu
Annual Gridded Domestic NH3 Emissions
Annual Gridded RWC NH3 Emissions
Annual Gridded Area Source NH3 Emissions