

**ENVIRON**

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

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## **Introduction**

**California Regional PM<sub>10</sub>/PM<sub>2.5</sub> Air Quality Study (CRPAQS) -- Multi-year study of PM in Central California including:**

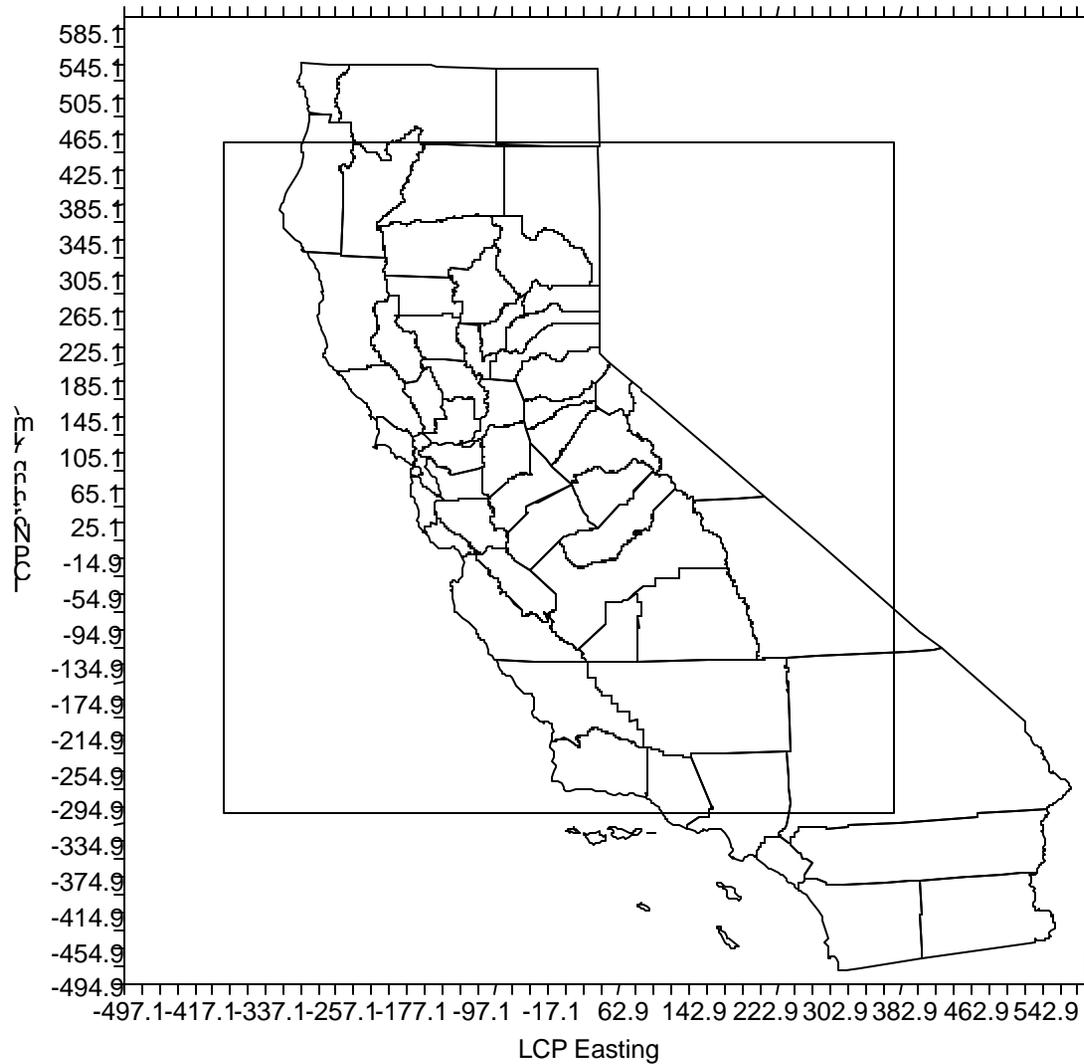
- meteorological modeling*
- air quality monitoring*
- emission inventory development*
- data analysis*
- air quality modeling*

## **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 NH<sub>3</sub> 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 NH<sub>3</sub> 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

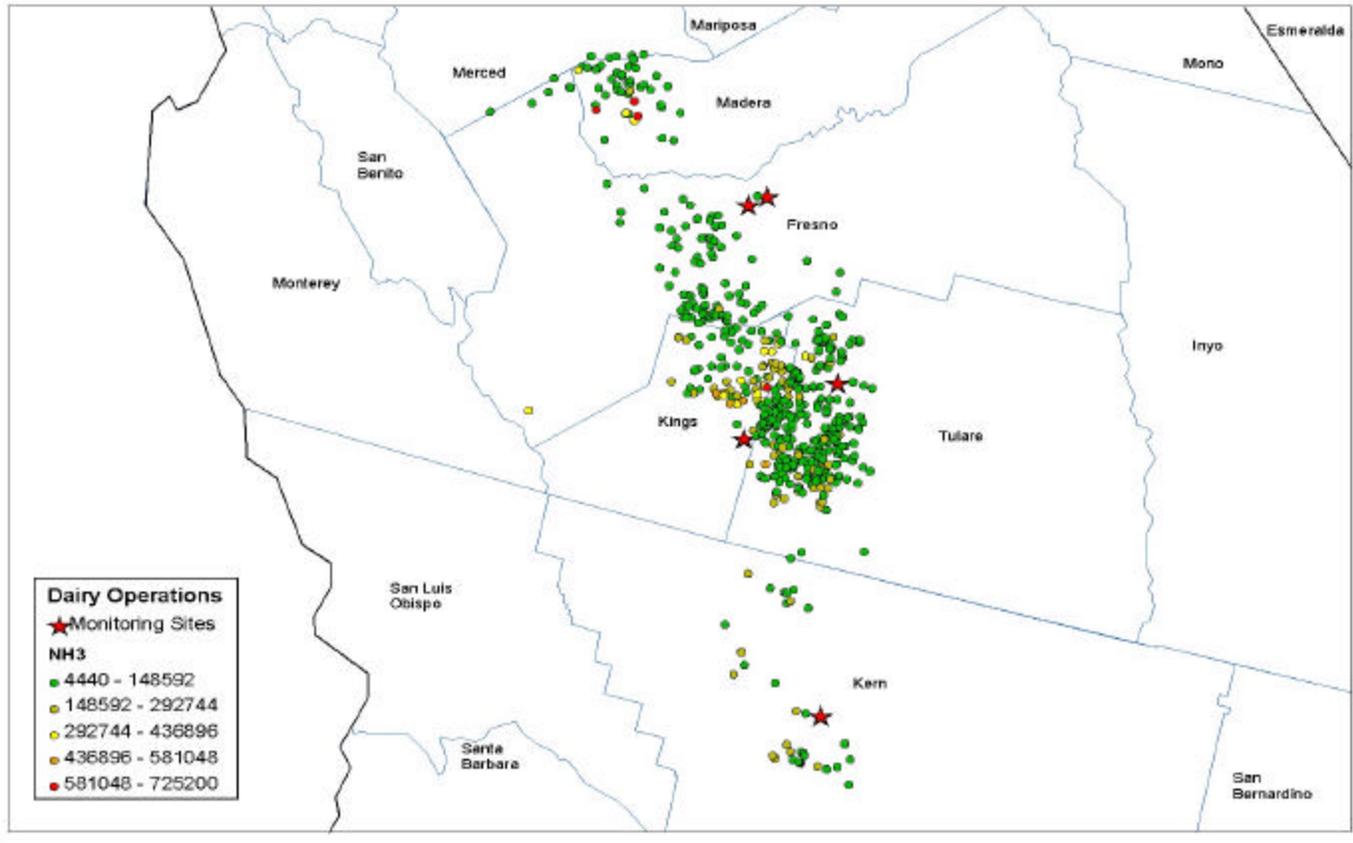
- SJV is an Ag-Intensive Area
  - *Over 2.2 million dairy cattle in the 8-county area*
  - *About 650,000 beef cattle*
  - *Over 26 million broiler chickens*
  - *Numerous other CAOs - hogs, horses, goats*
  - *Over 5.3 million acres of crop land*
- Previous inventory - livestock contributes > 75% of NH<sub>3</sub> (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**



## Cattle Source Characterization

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

## **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*

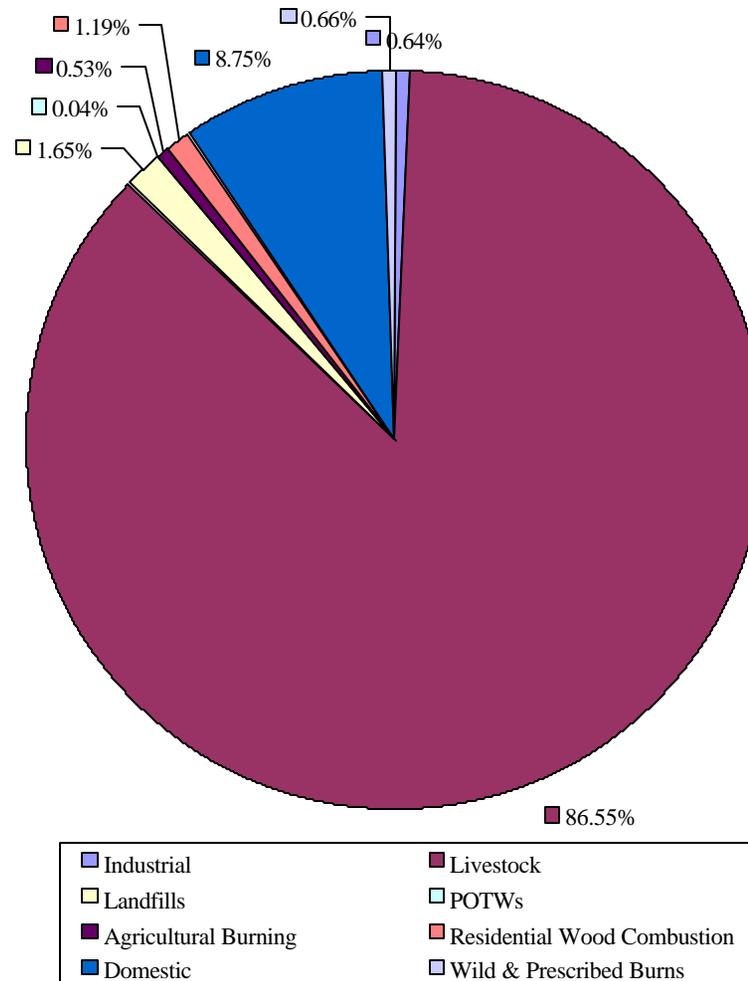
## **Methods & Data Sources for Other Source Categories**

- Fertilizer Application & Natural Soils
  - *Emission estimates from CAL/CASA model*
- Mobile Sources
  - *Gridded VMT; Fleet-wide emission factors*
- Landfills
  - *NH<sub>3</sub>:CH<sub>4</sub> emissions ratio (0.007); CH<sub>4</sub> emissions from CARB; geo-coded point locations*
- Prescribed Burns & Wildfires
  - *NH<sub>3</sub>:CO emissions ratio; CO emissions from CARB*

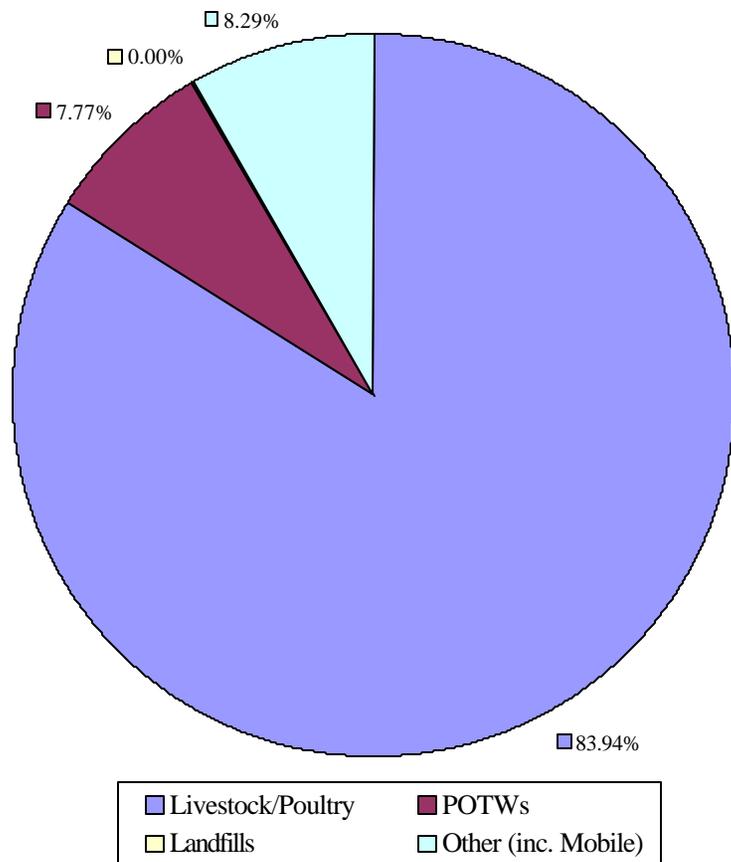
## **Methods & Data Sources for Other Source Categories**

- Agricultural Burns
  - *NH<sub>3</sub>:CO emissions ratio; CO emissions from CARB*
- Residential Wood Combustion
  - *NH<sub>3</sub>: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*

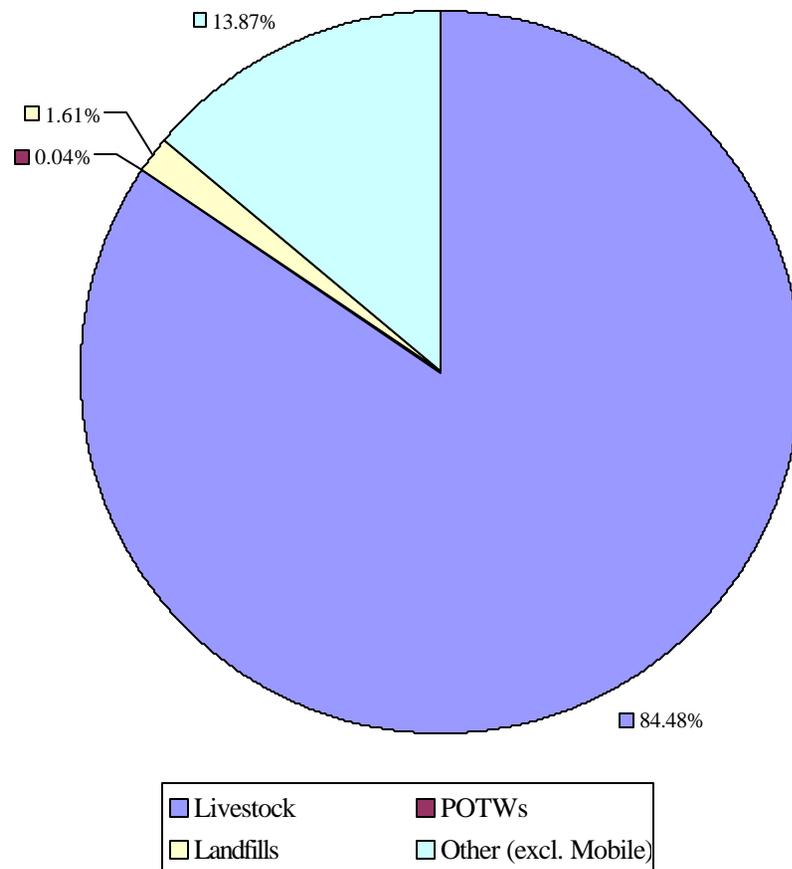
## Annual NH3 Emissions by Source Sector



### 1990 Annual NH3 Emissions (STI)



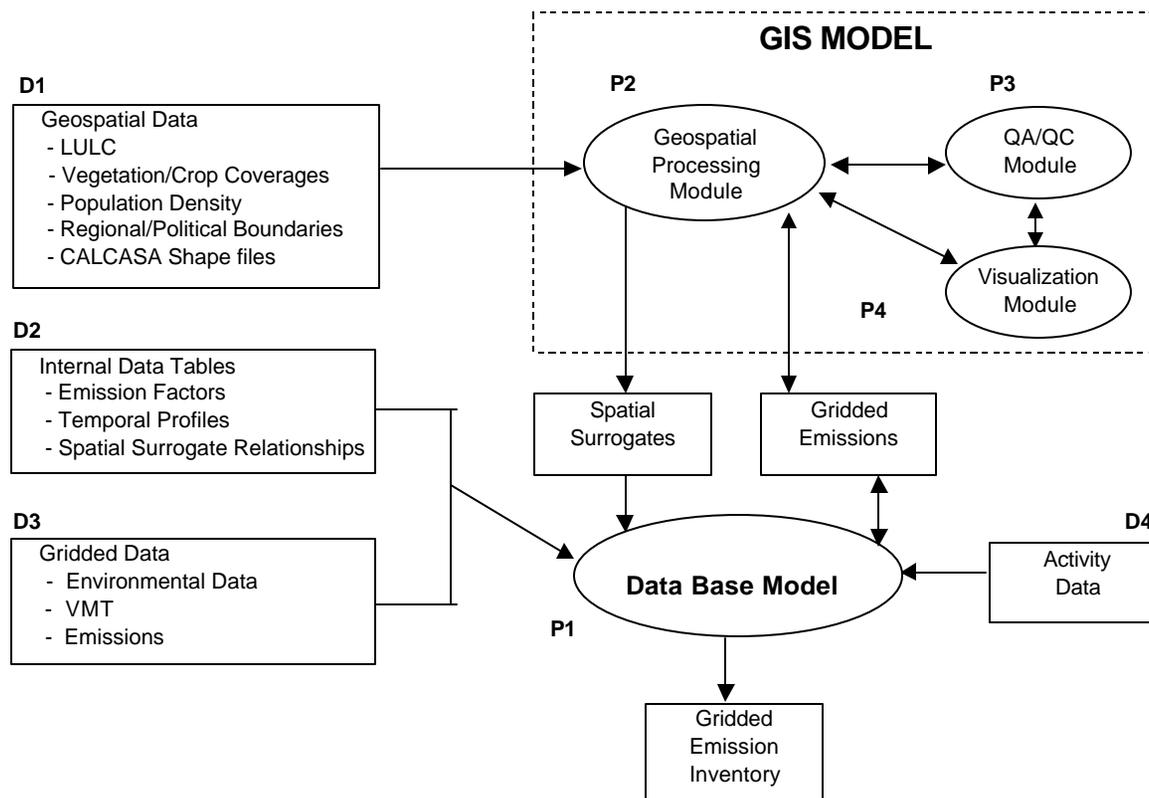
### CRPAQS 2000 Annual NH3 Emissions



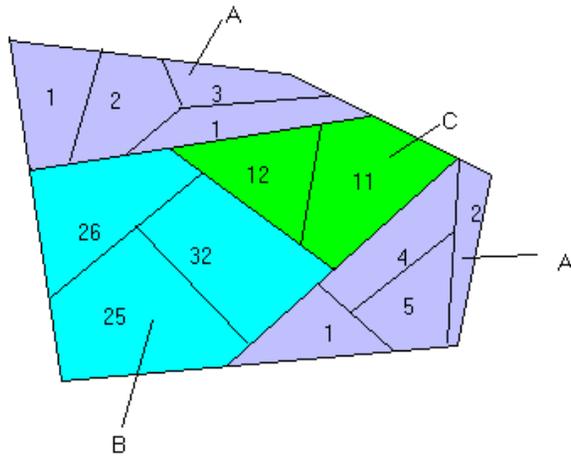
## **GIS-Based Emissions Model Development**

- 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)

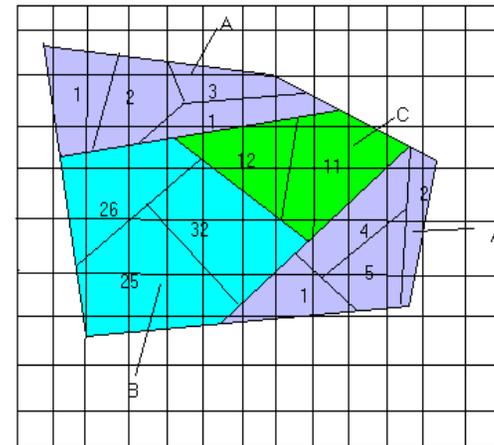


## Spatial Allocation



ID CODE	CLASS1	CLASS2	CLASS3	CLASSn
1	A	AA	X	...
2	A	AA	X	...
3	A	...	...	...
4	A	BB	...	...
5	A	...	N/A	...
6	...	...	N/A	...
...	...	...	...	...
...	...	...	...	...
10	D	XX	...	...
11	C	YY	...	...
12	C	YY	...	...
...	...	...	...	...
25	B	Z	N/A	...
26	B	...	N/A	...
27	E	...	N/A	...
...	...	...	...	...
...	...	...	...	...

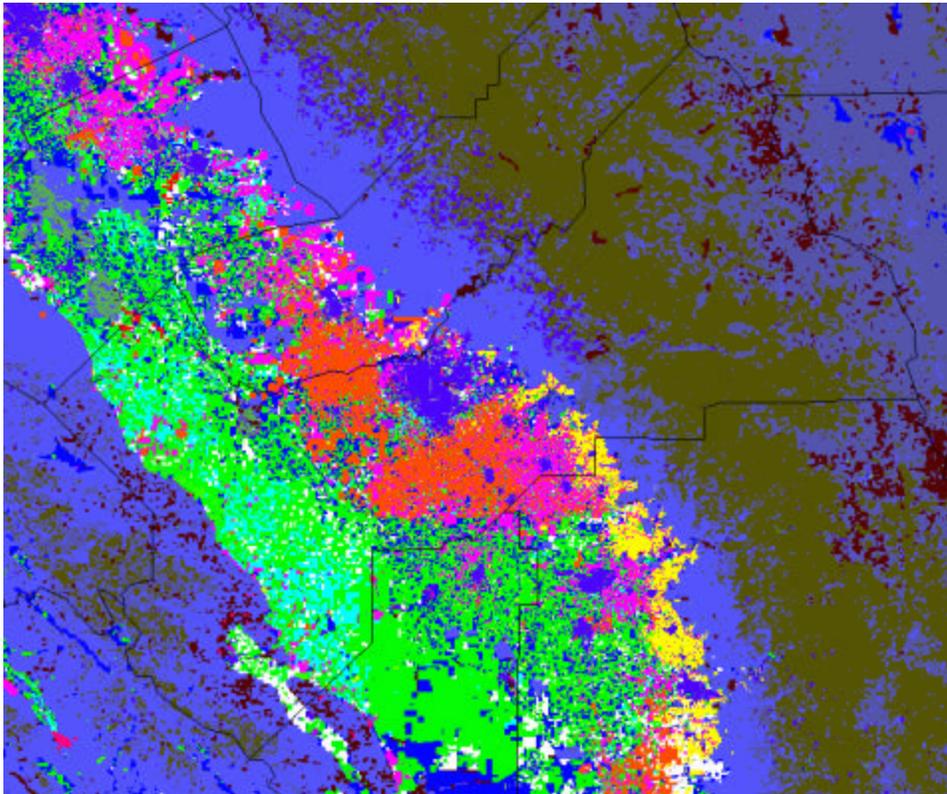
EIC	CLASS#	CLASS CODE	EF	...	...
450-900-000-1001	1	A	...	...	...
450-900-001-1001	1	C	...	...	...
670-333-002-0000	2	XX	...	...	...
xxx-xxx-xxx-xxxx	3	X	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...
...	4	B	...	...	...
...	4	C	...	...	...
...	...	...	...	...	...
...	...	...	...	...	...
...	5	CC	...	...	...
...	5	CC	...	...	...
...	...	...	...	...	...



## 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

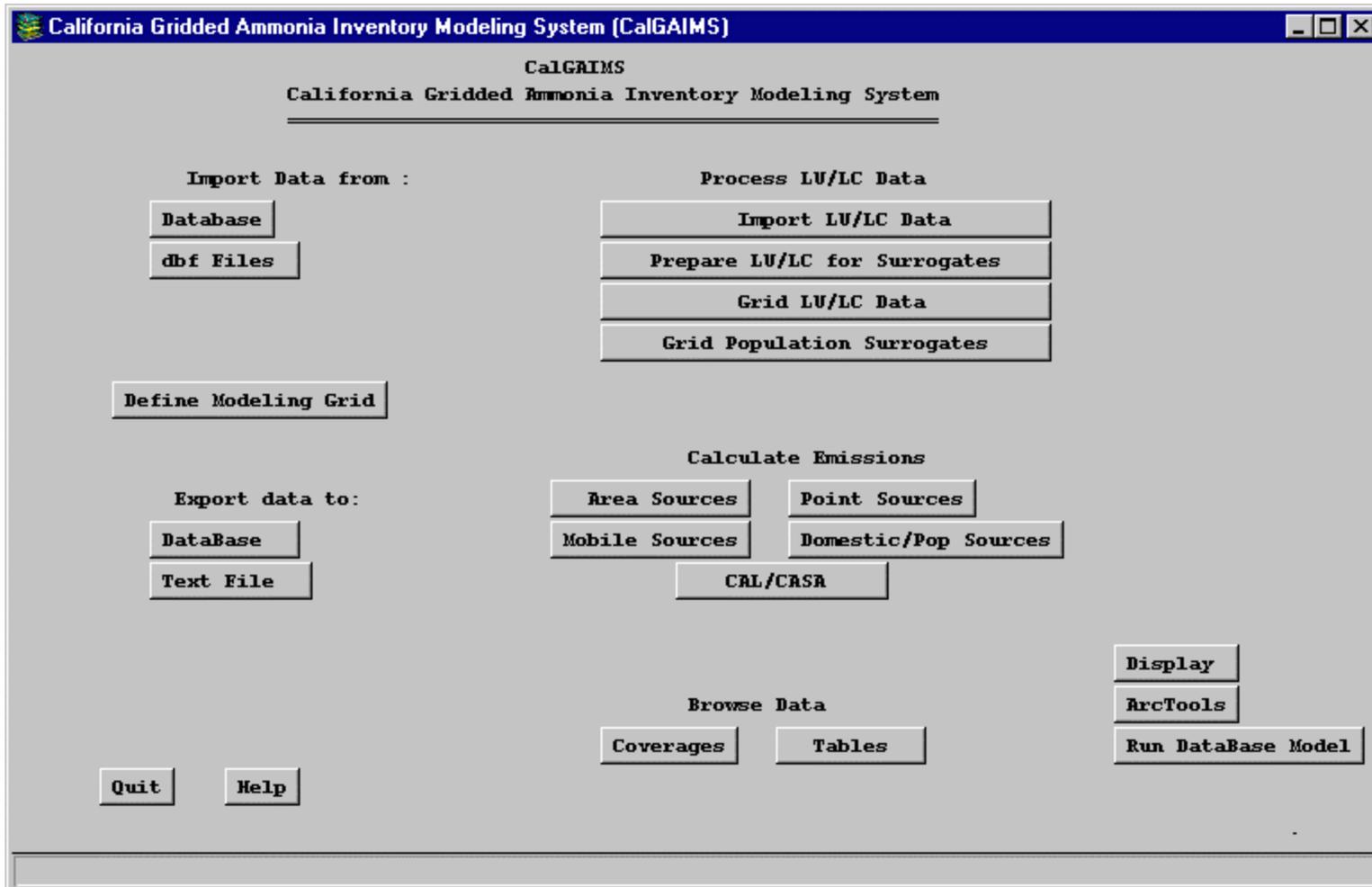


- Evergreen Forest
- Bare Rock/Sand/Clay
- Shrubland/Range
- Grassland/Herbaceous
- Open Water
- Deciduous Forest
- Mixed Forest
- Ice/Snow
- Urban-residential
- Field Crops
- Semiagricultural
- Grain & Hay Crops
- Pasture
- Emergent Wetlands
- Truck, Nursery & Berry Crops
- Urban-Commercial
- Vacant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

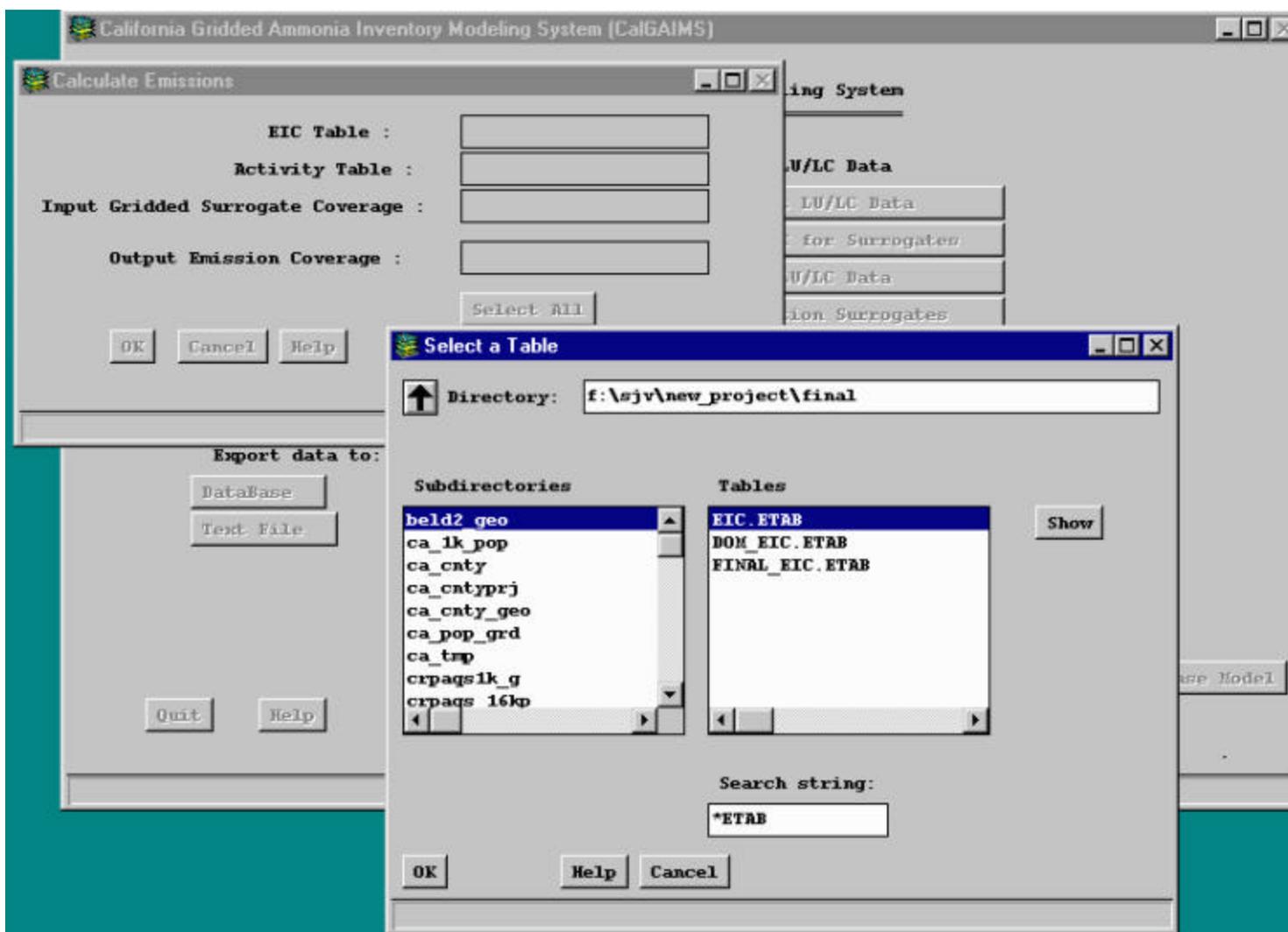
## Spatial Allocation by Source Category

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

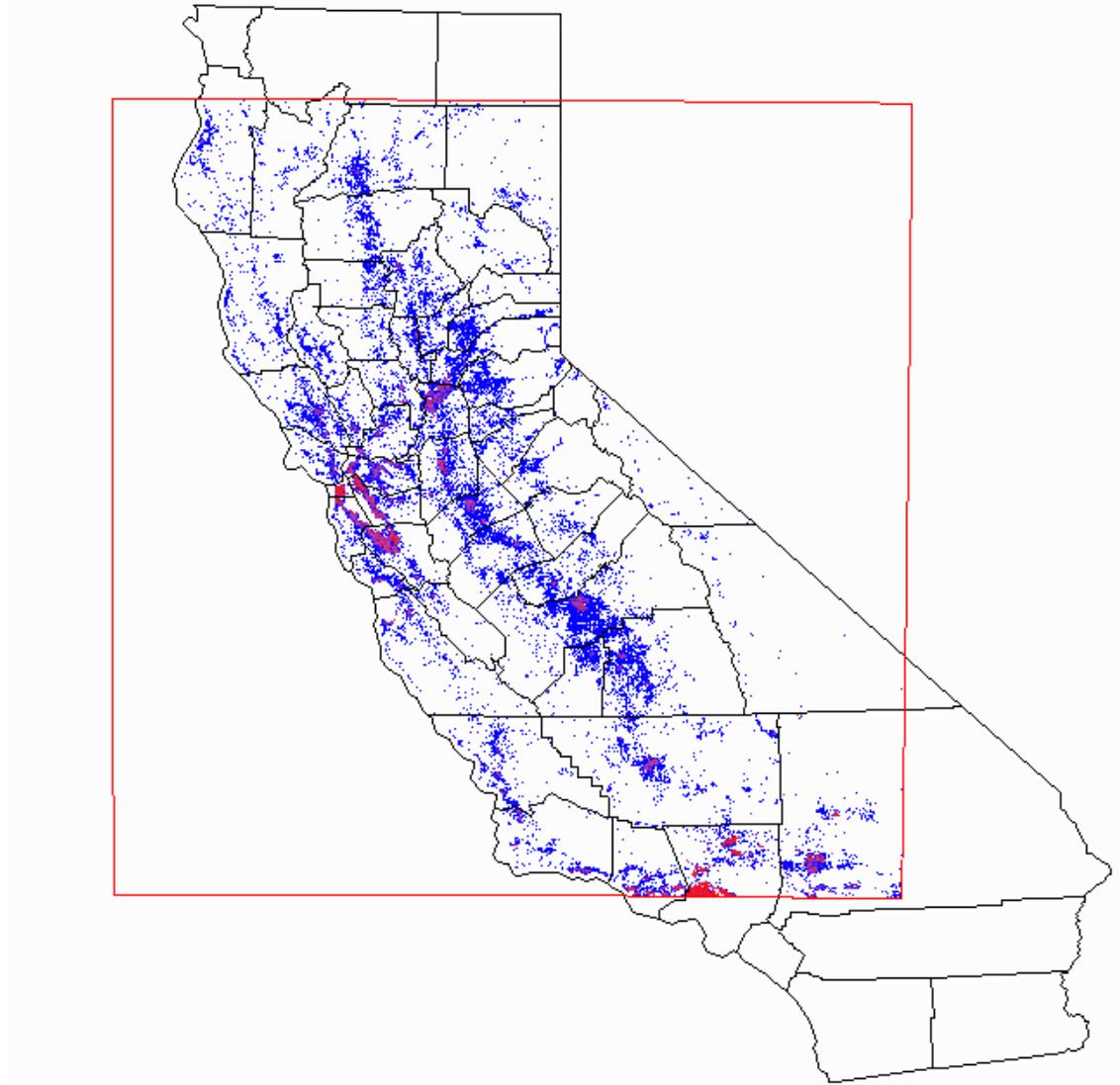
## CalGAIMS Main Menu



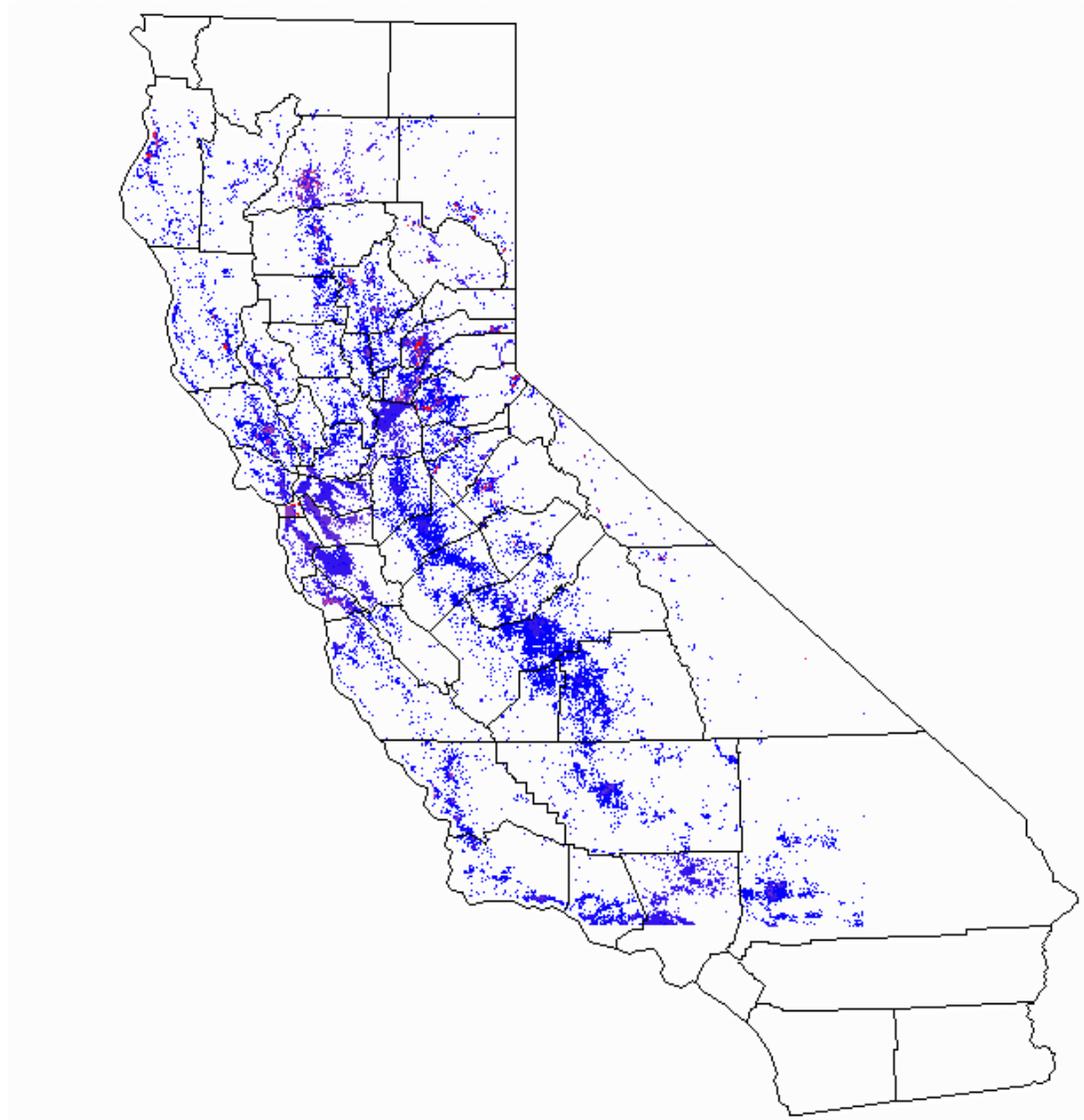
## Emission Calculation Menu



## Annual Gridded Domestic NH<sub>3</sub> Emissions



## Annual Gridded RWC NH<sub>3</sub> Emissions



## Annual Gridded Area Source NH<sub>3</sub> Emissions

