

# A Comprehensive Research Plan for Developing PM<sub>2.5</sub> Emission Inventories

Patrick Gaffney  
California Air Resources Board

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# Presentation Overview

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- Evaluating PM<sub>2.5</sub> Inventory Needs
- Incorporating GIS
- Summary of Projects
- The Future and Conclusions

# Evaluating PM<sub>2.5</sub> Inventory Needs

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- Emission Sources Evaluated
  - Geologic particulates
  - Smoke and combustion
  - Ammonia emissions
  - Biogenic sources
- Paper evaluates non-mobile sources only
- Major focus on area sources

# Pollutants Evaluated

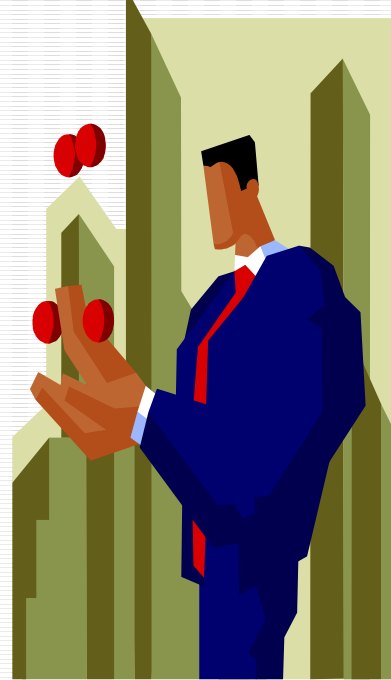
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- Directly emitted PM<sub>2.5</sub> from combustion and geologic sources
- Precursor emissions including NO<sub>x</sub>, VOCs, and ammonia

# Prioritization of Sources

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- Importance based on policy, health effects, other issues
- Approximate magnitude of emissions
- Quality of existing emission factors and activity data
- Availability of size speciation, spatial, and temporal data for the source



# PM<sub>2.5</sub> Sources and Priority Scoring for Inventory Development Needs

| Source Type     | Source Name           | a                        | b                  | c                            | d                   | e                   | f            | g                | h      |
|-----------------|-----------------------|--------------------------|--------------------|------------------------------|---------------------|---------------------|--------------|------------------|--------|
|                 |                       | Primary Score Categories |                    |                              |                     | Secondary Scores    |              |                  | Totals |
|                 |                       | Source Importance        | Source Magnitude   | PM <sub>2.5</sub> EF Quality | Activity Data       | Speciation Data     | Spatial Data | Monthly Temporal |        |
| Geologic        | Paved road dust       | 3                        | 2                  | 3                            | 2                   | 3                   | 2            | 2                | 12.3   |
|                 | Unpaved road dust     | 3                        | 3                  | 3                            | 4                   | 3                   | 4            | 4                | 16.7   |
|                 | Agricultural dust     | 4                        | 3                  | 3                            | 2                   | 4                   | 2            | 1                | 14.3   |
|                 | Windblown dust        | 2                        | 3                  | 3                            | 3                   | 4                   | 2            | 2                | 13.7   |
|                 | Construction dust     | 2                        | 2                  | 3                            | 4                   | 3                   | 4            | 3                | 14.3   |
| Vegetative Burn | Residential wood      | 5                        | 4                  | 3                            | 3                   | 3                   | 3            | 2                | 17.7   |
|                 | Prescribed burn       | 5                        | 3                  | 3                            | 3                   | 2                   | 3            | 3                | 16.7   |
|                 | Wildfire              | 5                        | 3                  | 3                            | 3                   | 3                   | 3            | 3                | 17.0   |
|                 | Agricultural burn     | 5                        | 3                  | 3                            | 3                   | 2                   | 3            | 3                | 16.7   |
| Motor Vehicles  | Diesel exhaust        | 5                        | 3                  | 3                            | 2                   | 2                   | 2            | 3                | 15.3   |
|                 | Gasoline exhaust      | 3                        | 2                  | 2                            | 2                   | 2                   | 2            | 3                | 11.3   |
|                 | Tire wear             | 2                        | 1                  | 4                            | 3                   | 4                   | 2            | 3                | 13.0   |
|                 | Brake wear            | 2                        | 1                  | 4                            | 3                   | 4                   | 2            | 3                | 13.0   |
|                 | Off-road exhaust      | 3                        | 1                  | 4                            | 3                   | 3                   | 4            | 4                | 14.7   |
| Stationary      | Charbroilers & fryers | 3                        | 3                  | 2                            | 4                   | 4                   | 4            | 3                | 15.7   |
|                 | Industrial combustion | 2                        | 1                  | 3                            | 3                   | 1                   | 2            | 2                | 10.7   |
|                 | Mining                | 1                        | 1                  | 3                            | 3                   | 3                   | 2            | 2                | 10.3   |
|                 | Sand & gravel         | 1                        | 1                  | 3                            | 3                   | 3                   | 2            | 2                | 10.3   |
|                 | Other stationary      | 1                        | 1                  | 3                            | 3                   | 3                   | 2            | 2                | 10.3   |
|                 | Livestock dust        | 1                        | 1                  | 4                            | 4                   | 4                   | 3            | 3                | 13.3   |
|                 | Sea salt              | 1                        | 1                  | 5                            | 5                   | 5                   | 5            | 5                | 17.0   |
|                 | Scoring Criteria      | 5 = most important       | 5 = most important | 1 = highest quality          | 1 = highest quality | 1 = highest quality |              |                  |        |
|                 |                       |                          |                    |                              |                     | x 1/3               |              |                  |        |

## Description of Scoring Categories

|                           |                                                                                                                                                                                                                                                       |
|---------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| a – Source Importance     | Based on magnitude, perception, public awareness, existing resources, industry interest, potential for control, potential toxicity                                                                                                                    |
| b - Source Magnitude      | Estimated based on previous PM <sub>2.5</sub> inventories, number of sources, Chemical Mass Balance (CMB) data                                                                                                                                        |
| c - EF Quality            | Score based on estimated uncertainty and variability of existing emission factors (EFs) and complexity of source category. Highest quality means many tests were performed which are California specific and directly related to the source category. |
| d - Activity Data Quality | Estimation of quality and availability of overall annual activity data; includes detail available and expected newness of available data                                                                                                              |
| e – Speciation Data*      | Quality of size speciation data, age, applicability to CA, applicability to PM <sub>2.5</sub>                                                                                                                                                         |
| f - Spatial Data*         | Availability of spatial data; general quality and resolution expected to be available                                                                                                                                                                 |
| g- Monthly Temporal*      | Availability of data which could be used to estimate monthly variations in emissions                                                                                                                                                                  |
| h- Totals                 | This is the total prioritization score. Score = (a+b+c+d) + (e+f+g)/3                                                                                                                                                                                 |
| * Note on e, f, g         | *The spatial and temporal column scores are multiplied by 1/3 prior to summing because they are of less significance in preparing an initial inventory                                                                                                |

# Selection of Projects

- High scoring sources are:
  - Those that are potentially significant contributors to elevated  $PM_{2.5}$  levels or
  - Those sources with high uncertainties
- Verify there is not overlap with ongoing research
  - EPA, BACM, WESTAR, study groups



# Results of Scoring

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- Initial research focuses on improving methods and activity data
- No emission factor development
  - Expensive
  - For combustion sources nearly all PM emissions are PM<sub>2.5</sub>
  - Non-combustion sources are less important PM<sub>2.5</sub> contributors; use existing scaling factors

# Contractor Selection and Management

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- Most projects are performed by researchers in California university system
- Statements of work are developed in cooperation with researchers
- Contracts are managed by emission inventory staff
  - Helps to ensure concrete results

# Incorporation of GIS

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- Nearly all inventory data has a spatial component
- Geographic information systems (GIS) provides storage, analysis, and visualization of spatial data
- GIS technology is an integral part of most ARB inventory contracts
- Spatial inventory data can be combined with other spatial data

# California Air Analysis Information System



My County

Nighborhood

Create Maps

Create Graphs

Ask Questions

Scenarios

Future

Air Quality

Help

## Facility Info

Name: ACME Paint and Body

## Pollutant Info

| <u>Pollutant</u> | <u>Quantity</u> | <u>Risk Info</u> |
|------------------|-----------------|------------------|
|------------------|-----------------|------------------|

|         |       |                       |
|---------|-------|-----------------------|
| Benzene | 300.3 | <a href="#">Ref 1</a> |
|---------|-------|-----------------------|

|         |        |                       |
|---------|--------|-----------------------|
| Toluene | 3423.3 | <a href="#">Ref 2</a> |
|---------|--------|-----------------------|

|          |       |                       |
|----------|-------|-----------------------|
| Chromium | 34.33 | <a href="#">Ref 3</a> |
|----------|-------|-----------------------|

ARB Programs Addressing  
These Pollutants

[2588](#), [AB25](#), etc. Click for more info



Facilities



Schools

# Summary of Projects

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# Geologic Dust

- Dust entrainment, removal, and transport
- Using GIS for estimating unpaved road travel
- Real-time PM measurements of paved road dust
- Evaluation of hexavalent chromium in geologic dust



# Open Burning

- Wildfire and prescribed burn emissions using GIS and remote sensing
- Estimating agricultural burning emissions using GIS
- Method development for estimating fireplace & woodstove emissions
- Collection of activity information for commercial charbroiling



# UC Berkeley Fire Emissions

## Remote sensing

Satellites can detect fire in California on a daily basis.

California fires detected using MODIS fire algorithm and NOAA-14 AVHRR data (September 2, 1996)



California Center for Remote Sensing

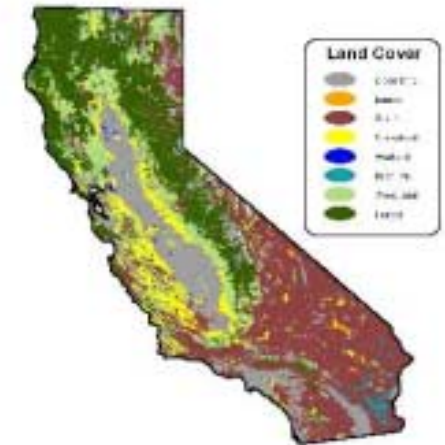
## Fire history data

The California Dept. of Forestry maintains a historical fire database.



## Vegetation data

California Fish and Game built a vegetation map of the state.



## Fire science - Emission factors

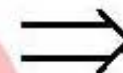
CAMFER is assembling research on emission factors.

where was  
the fire?

what kind of  
pollutants?

what was the  
vegetation?

when  
was/is/will be  
the fire?



Emissions  
Estimation

# Ammonia Emissions

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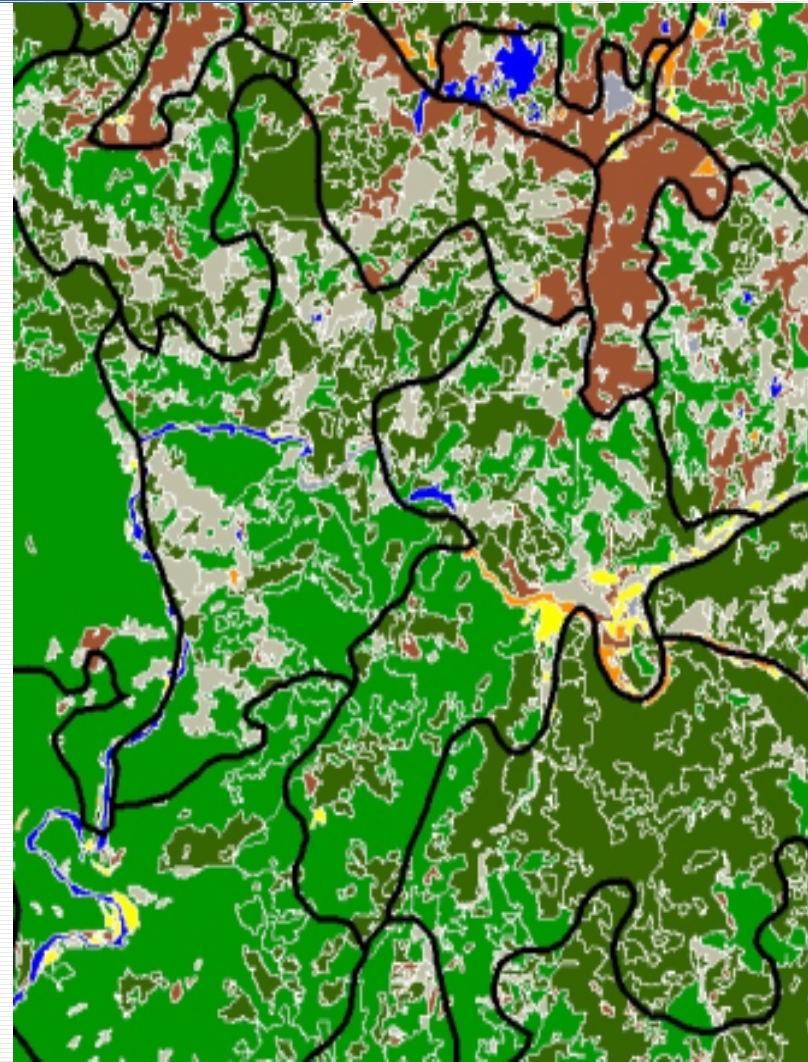
- Measurement and modeling of ammonia from fertilizer application
- Measurement and modeling of ammonia from natural soils
- Real-time remote sensing of ammonia using Lidar



# Biogenic Emissions

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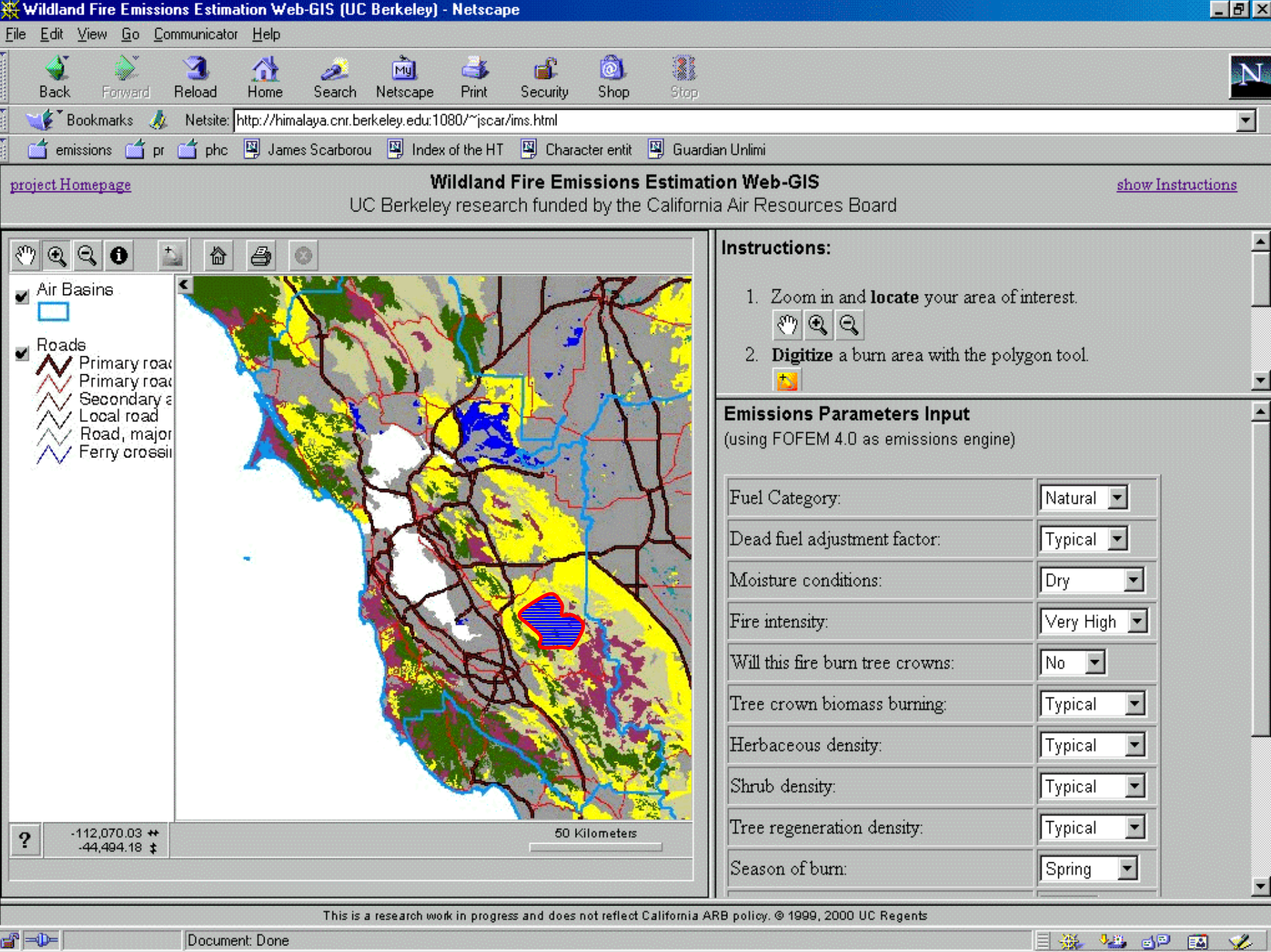
- Development of GIS-based biogenics model
- Measurement of biogenic particulate precursors and model validation



# GIS and Internet

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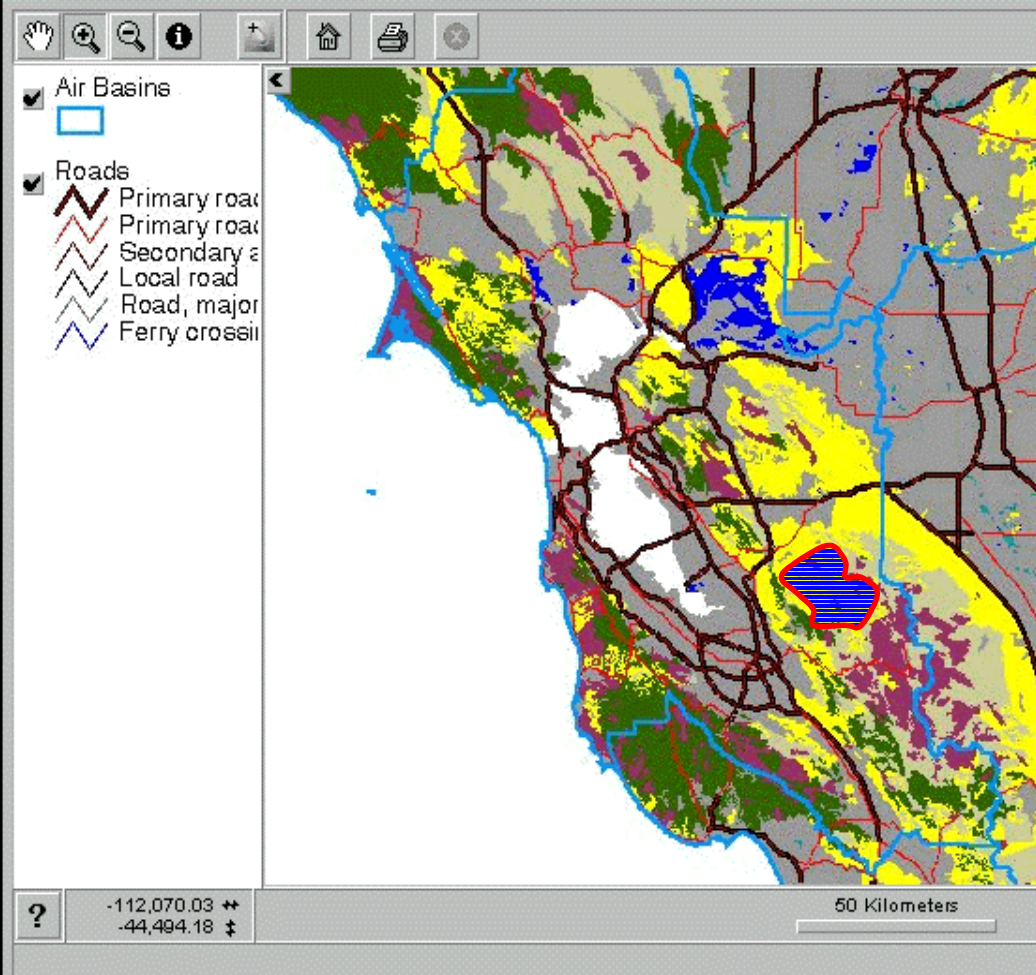
- Development of community health air pollution information system
- Biomass user and power plant mapping system
- Web based smoke management tools
- Mapping toxics risks
- Real-time air quality maps

[project Homepage](#)

## Wildland Fire Emissions Estimation Web-GIS

[show Instructions](#)

UC Berkeley research funded by the California Air Resources Board



## Instructions:

- Zoom in and **locate** your area of interest.



- Digitize** a burn area with the polygon tool.



## Emissions Parameters Input

(using FOFEM 4.0 as emissions engine)

|                                  |           |
|----------------------------------|-----------|
| Fuel Category:                   | Natural   |
| Dead fuel adjustment factor:     | Typical   |
| Moisture conditions:             | Dry       |
| Fire intensity:                  | Very High |
| Will this fire burn tree crowns: | No        |
| Tree crown biomass burning:      | Typical   |
| Herbaceous density:              | Typical   |
| Shrub density:                   | Typical   |
| Tree regeneration density:       | Typical   |
| Season of burn:                  | Spring    |



## Wildland Fire Emissions Estimation Web-GIS: Output table

UC Berkeley research funded by the California Air Resources Board. Please visit <http://camfer.cnr.berkeley.edu/fire>

*These results serve as example only. This is a research work in progress and does not reflect California ARB policy. © 1999, 2000 UC Regents*

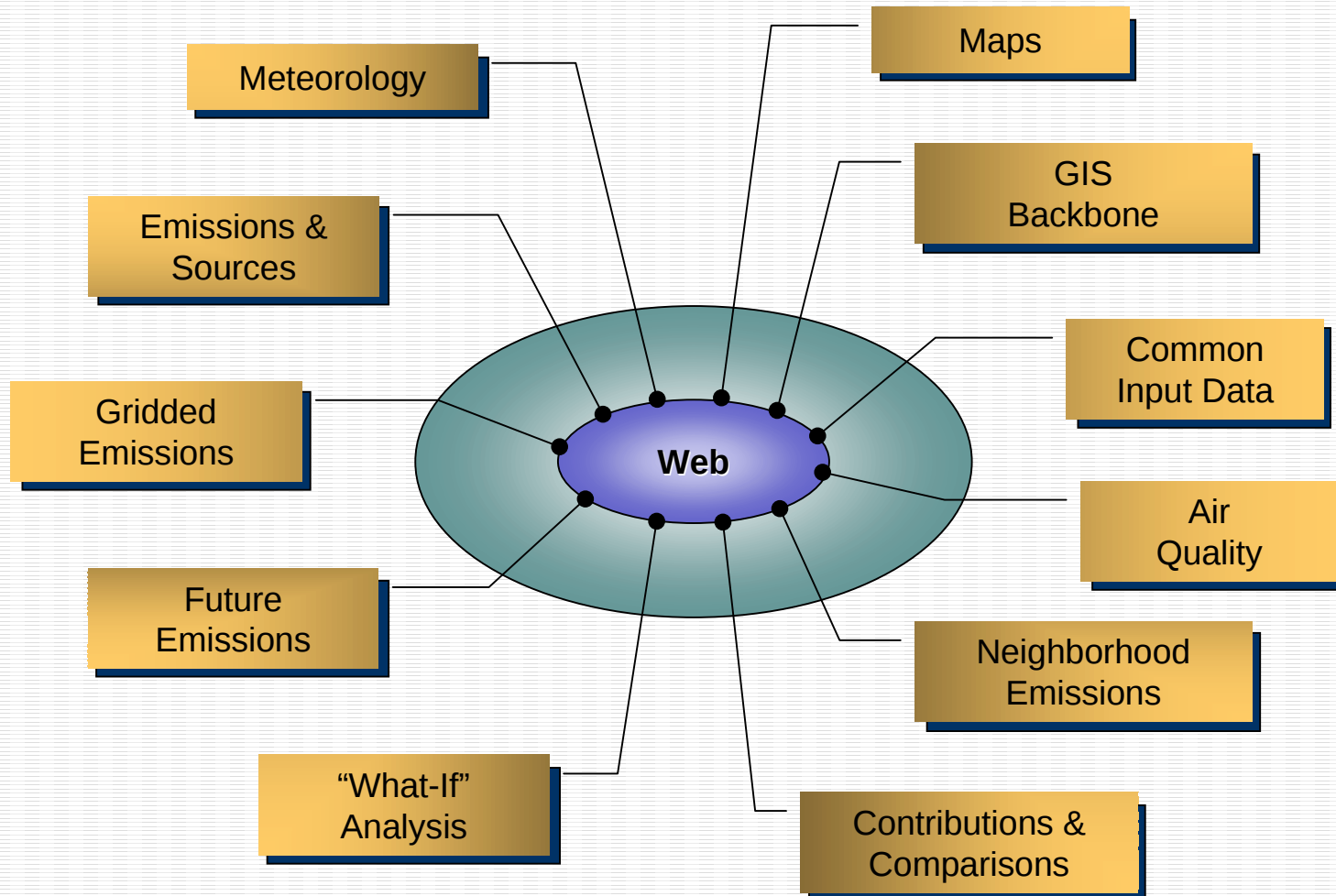
| Cover Code | Component      | Fuel Load (tons/ac) | PM 10 (pounds/ac) | PM 2.5 (pounds/ac) | CO (pounds/ac) | Area (acres) | PM 10 Total (tons) | PM 2.5 Total (tons) | CO Total (tons) | Cover Type (Holland)               |
|------------|----------------|---------------------|-------------------|--------------------|----------------|--------------|--------------------|---------------------|-----------------|------------------------------------|
| 32100      | Litter         | 0.11                | 1.00              | 0.90               | 5.80           | 1024.64      | 0.51               | 0.46                | 2.97            | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Wood 0-1 inch  | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Wood 1-3 inch  | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Wood 3+ inches | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Herbs          | 0.40                | 10.00             | 8.50               | 99.70          | 1024.64      | 5.12               | 4.35                | 51.08           | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Shrubs         | 2.28                | 28.60             | 24.30              | 284.10         | 1024.64      | 14.65              | 12.45               | 145.55          | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Regen          | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Duff           | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |
| 32100      | Canopy foliage | 0                   | 0                 | 0                  | 0              | 1024.64      | 0                  | 0                   | 0               | NORTHERN(FRANCISCAN) COASTAL SCRUB |

# Future Priorities

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- Particle size and chemical speciation
- PM<sub>2.5</sub> emission factor measurements
- Further development of GIS analysis and visualization capabilities
- Continuing analysis of geologic dust contributions

# Developing methods to combine and relate emissions, demographics, and air quality data



# Conclusions

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- Comprehensive and integrated PM<sub>2.5</sub> inventory research program
- Initial emphasis on method and activity data improvements
- Focus on improving our ability to communicate what we do and what it means
- Promote involvement and improve quality of life for California citizens

# Contact Information

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- Patrick Gaffney  
California Air Resources Board  
1001 I Street  
Sacramento, CA 95814  
916-322-7303

- [pgaffney@arb.ca.gov](mailto:pgaffney@arb.ca.gov)

<http://arbis.arb.ca.gov/emisinv/pmnh3/pmnh3.htm>