Spatial and Temporal Allocation of Agricultural PM10 Fugitive Dust Emissions Using Land Use Information and Crop Calendars

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Agricultural land use information collected by the California Department of Water Resources and crop calendars are combined to spatially and temporally estimate the PM10 emissions from agricultural land preparation and harvesting in California. Crop specific emission factors are developed based on process specific emission rates, which are the result of extensive on-field testing performed by the California University, Davis. The data management and calculation are completed in MS Access® and ArcGIS™.

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INTRODUCTION

Fugitive dust from agricultural activities is potentially a significant source of the PM emissions for California, especially for the San Joaquin Valley. For air quality planning, it is important to know how, when, and where the emissions occur. Quantifying the emissions by crop types and presenting results temporally and spatially requires three elements:

1) Crop specific emission factors;
2) Crop calendars providing the number, type, and timing of agricultural operations for each crop;
3) GIS data set of detailed, spatially distributed crop acreage.

In addition to these technical elements, a helpful and engaged community of agricultural experts was also required to extrapolate the limited available emission factor data to all the other California practices and crops.

LAND USE DATA

Agricultural land use data are available from the California Department of Water Resources. The data provides detailed agricultural use information for each identified field, including the acreage of the field, up to three crops planted in the field, and the percent of acreage for each crop. The data was created by combining air photo interpretation and ground survey data, and the total survey area covers most of the agricultural counties in California. The data set is only updated once every seven years for each county.

Acres	Land Use			Acreage Percentage		
	1st	2nd	3rd	1st	2nd	3rd
100	Wheat	Beans	*	100	100	*

Note: fields attributes are changed for purpose of illustration

CROP CALENDARS

Crop calendars provide information about what harvest and land preparation activities are performed for each crop, as well as when they are typically performed. The crop calendars were developed through face-to-face meetings with growers and other agricultural experts for the most important crops (primarily based on acreage and potential emissions). Calendars were developed for alfalfa, almonds, citrus, corn, cotton, dry beans, garbanzo, garlic, grapes (raisin, table, and wine), lettuce, melons, onions, safflower, sugar beets, tomatoes, wheat, rice, and general land maintenance. Working with agricultural experts, we assigned the best-fit calendars to all of the other crops in the land use data set.

DWR Crops	Crop Calendar Profile
Olives	Citrus
Pistachios	Almond/Walnut
Grain sorghum	Wheat/Barley
Bush berries	Grapes-Raisin
Spinach	Lettuce/ 1 season
Field Corn	Corn

Farming Operations	Crop Cycles Per Year	Passes Per Crop Cycle	Fraction of Acreage Per Cycle	Passes During Month											
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Land Preparation															
Stubble Disc	1	1	1.0												
Field Disc	1	1	1.0												
Mulch Beds	1	1	1.0												
Planting	1	1	1.0												
Cultivation	1	2	1.0												
Harvesting	1	1	1.0												

CROP SPECIFIC EMISSION FACTORS

Over the past eight years, the researchers of University of California, Davis, have performed extensive field testing to develop geologic PM10 emission factors for a number of agricultural land preparation and harvest operations. These operation-specific emission factors were assigned to all of the land preparation or harvest operations in our crop calendar, and then all operations for each crop were summed to generate the crop specific emission factor (see following equation).

Crop Specific EF = ∑ (Operation Specific EF × Passes per Crop Cycle × Fraction of Acreage Per Cycle × Crop Cycles per Year)

Land Preparation and Harvest Emission Factors

Activity	Emission Factor (lbs PM_{10}/acre-pass)
Land Preparation	
Root cutting	0.3
Discing, Tilling, Chiseling	1.2
Ripping, Subsoiling	4.6
Land Planing & Floating	12.5
Weeding	0.8
Harvest	
Cotton Harvest	3.4
Almond Harvest	40.8
Wheat Harvest	5.8

Land Preparation Emission Factor Assignments*

Land Preparation Operation	Emissions Category	Emission Factor (lbs PM_{10}/ acre-pass)
List & Fertilize	Weeding	0.8
Roll	Weeding	0.8
Spring Tooth	Weeding	0.8
Seed Bed Preparation	Weeding	0.8
Disc & Furrow-out	Discing	1.2
Finish or Harrow Disc	Discing	1.2
Post Burn/Harvest Disc	Discing	1.2
Unspecified Operation	Discing	1.2
Land Preparation, Gen	Discing	1.2
Subsoil-deep chisel	Ripping	4.6
Float	Land planing	12.5
Land Plane	Land planing	12.5
Laser Level & Leveling	Land planing	12.5

*Not complete list

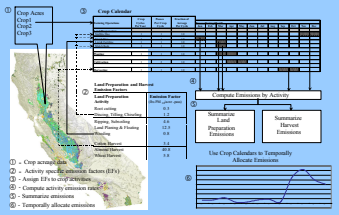
Harvest Emission Factor Assignments*

Crop Name	Crop Calendar Profile	Harvest EF Base Factor	Harvest EF Division Factor
Almonds	Almonds	Almonds	1
Beans, Dry	Dry Beans	Cotton	2
Corn, Grain	Corn	Cotton	2
Corn, Silage	Corn	Cotton	20
Cotton	Cotton	Cotton	1
Grapes, Wine	Grapes-Wine	Cotton	20
Alfalfa	Alfalfa	Zero	1
Oranges	Citrus	Cotton	40
Pistachios	Almonds	Almonds	10
Rice	Rice	Cotton	2
Safflower	Safflower	Wheat	1
Tomatoes	Tomatoes	Cotton	20
Wheat	Wheat	Wheat	1

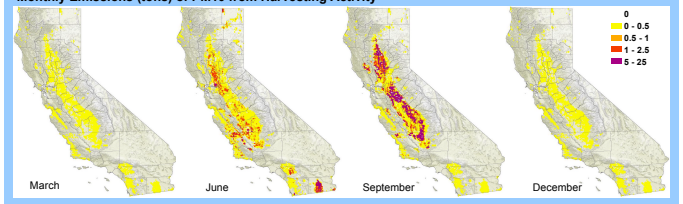
*Not complete list

PUTTING IT ALL TOGETHER

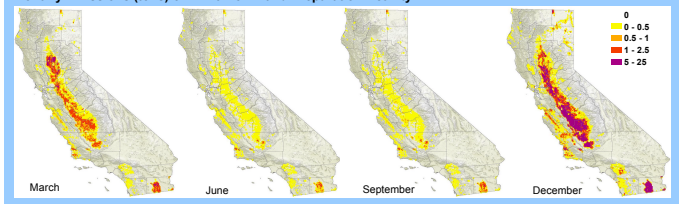
The figure at right provides a schematic of the entire emission estimation process. A database was created to manage all the data sets. All calculations and mapping were completed in ArcGIS and Access.



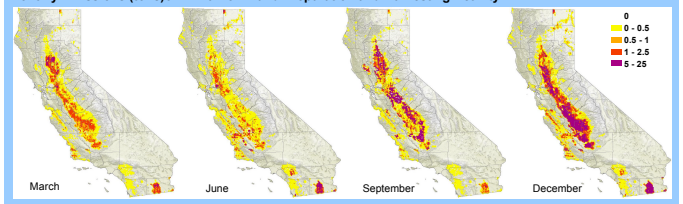
Monthly Emissions (tons) of PM10 from Harvesting Activity



Monthly Emissions (tons) of PM10 from Land Preparation Activity



Monthly Emissions (tons)of PM10 from Land Preparation and Harvesting Activity



RESULTS and DISCUSSION

Using ArcGIS™ and MS Access®, we calculated the PM10 emissions at the field level, and then aggregated the results into 4km x 4km gridded emissions. The state maps below show the emissions from harvesting, land preparation, and the sum of both for March, June, September, and December.

By incorporating the crop calendars and GIS land use mapping into our methodology, the temporal and spatial variations in emissions for each activity or between activities are clearly visible.

Also, by assigning activity specific emission factors to all land preparation and harvest activities and creating crop specific emission factors, the relative emissions between crops can be clearly compared (see following bar charts).