Improving Spatial Precision of Agricultural Pesticide Use Indices

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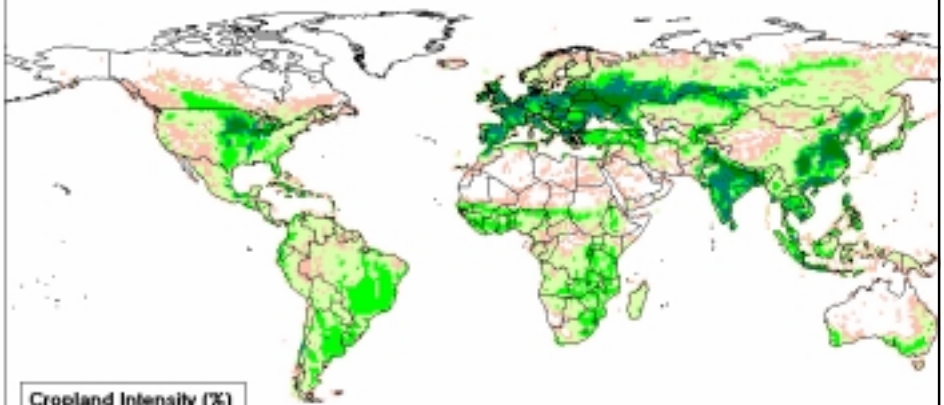
Percentage of Land that is Agriculture



Map available to the public by the Canadian Global Emissions Center: www.info.ortech.on.ca/cgeic

Agriculture in California

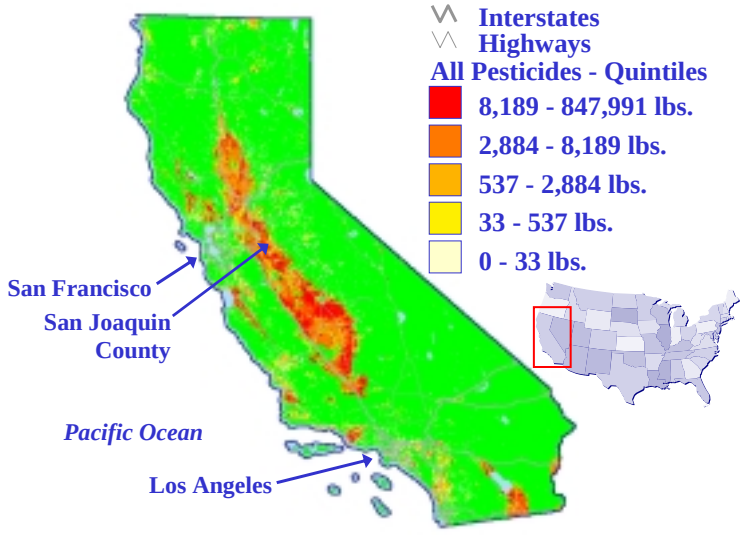
- **California has large agricultural Valleys and a long growing season.**
- **16% of United States agricultural pesticide use is applied in California.**
- **In 2002, 172 million pounds (78 million kilograms) of pesticide active ingredients were applied on California agricultural fields.**

California Pesticide Use Reporting

All **agricultural** pesticide use is legally required to be reported by growers to the CA Dept Pesticide Regulation. Database includes:

- **pounds** of active ingredient
- **crop**
- **location** of use: growers use a grid known as the Public Land Survey System (PLSS), units or "sections" of approximately 1 mile square area or 1.62 square kilometers

Annual Average Pesticide Use (lbs. per square mile) in California

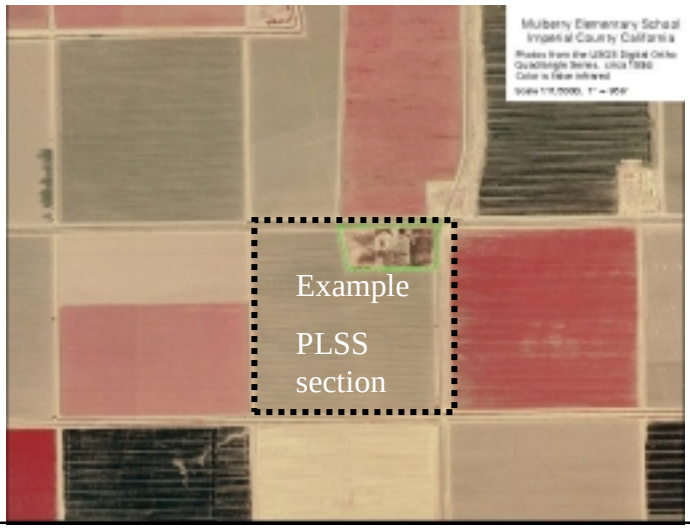


Epidemiological Studies Using Reported Agricultural Pesticide Use Near Homes as an Indirect Measure of Exposure

- **Childhood Cancer: Reynolds P et al: *Env Health Perspectives* 110 (2002): 319-214**
- **Breast Cancer: Reynolds P et al, *Environmental Research* 96 (2004): 206-218**
- **Congenital anomalites: Bell EM, et al: *Epidemiology* 12:148-56.**

Location of Pesticide Use-- Public Land Survey System (PLSS): Units or "sections" of about 1.0 square mile or 1.62 square kilometers

Land Use patterns follow PLSS section boundaries



Range of possible exposure that "nearness" to agricultural pesticide use or fields may suggest:

- **exposures to air, groundwater, and household dust**
- **children playing in fields**
- **eating produce directly from field.**
- **carry home exposures from parents working**

CHAMACOS

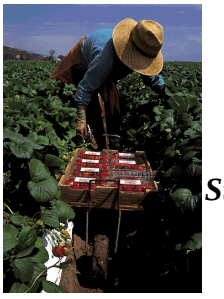
CENTER FOR THE HEALTH ASSESSMENT OF MOTHERS AND CHILDREN OF SALINAS

- **Cohort study of 600 pregnant women and their children**
- **Two of five study aims:**
  - **To estimate sources and pathways of pesticide exposures to children living in an agricultural community.**
  - **To determine relationship of pesticide exposure and:**
    - **neurodevelopment**
    - **growth**
    - **respiratory disease**

CHAMACOS

CENTER FOR THE HEALTH ASSESSMENT OF MOTHERS AND CHILDREN OF SALINAS

Salinas Valley: Intensive Farming of Row Crops



Strawberries

Lettuce

Broccoli

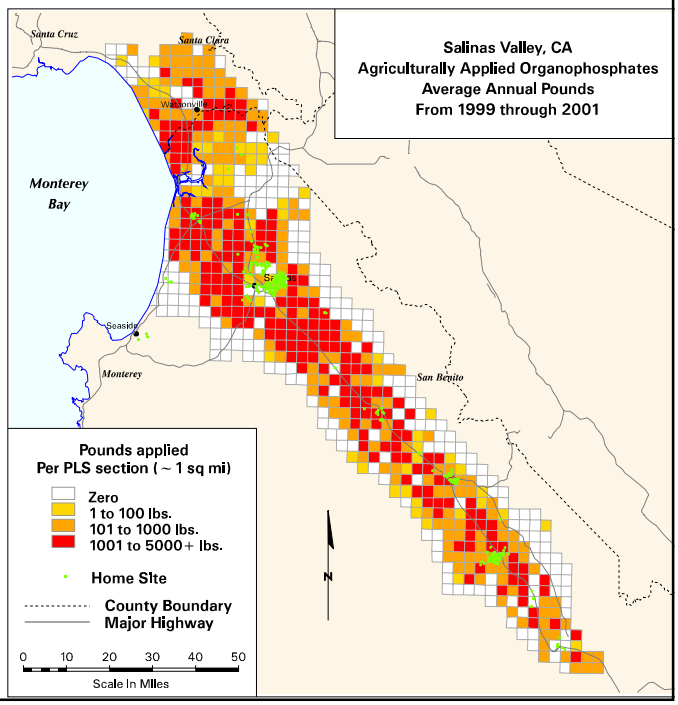
Some "PESTS"

BUGS

WEEDS

Salinas Valley: Pesticide Use Reporting

Annual Pounds of Organophosphates applied in Salinas Valley: 450,000 (or 204,116 kilograms)



Characteristics of CHAMACOS Mothers (N=601)

- 92% Spanish-speaking
- 54% ≤ 5 years in U.S
- 44% 6th grade education
- 84% have agricultural workers in household

Overview

	Enrollment	26-Weeks	Delivery	6-Months	12-Months	24-Months
Questionnaire	✓	✓	✓	✓	✓	✓
Neurodevelopment & Growth Assessments			✓	✓	✓	✓
Home inspection/ Environmental samples: e.g., dust	✓			✓	✓	✓
Biological Specimens	Urine	Urine Blood	Urine Blood Cord Blood Breastmilk	Urine Breastmilk	Urine Blood	Urine Blood

Household Dust and Exposure

- **Children have opportunity for direct exposure.**
- **Dust is a "sink" or reservoir for pesticides that adhere to soil particles.**
- **Little opportunity for environmental breakdown, i.e., little uv light.**
- **Residential soil and air measurements (other studies) are well correlated with household dust measurements**

Dust Sampling Method

- **Square meter in living area or living/kitchen area**
- **HSV sampling: deep dust.**
- **Home visit included a GPS reading of home location**

Selection of Dust Samples for Laboratory Analysis

- **170 homes randomly selected from 380 homes with home visits at all three home visits:**
  - **baseline**
  - **child 6 months of age.**
  - **child 12 months of age**

Dust Analyte Selection

<u>High Priority</u>: Organophosphate pesticides (OP): 34% of worldwide insecticide market is organophosphates.

<u>Potential Health Effects of Organophosphates</u>: neurotoxicity: mode of action is neuro transmitter inhibition

Reference: Eskenazi B, Bradman A, Castorina R. Exposure of children to organophosphate pesticides and their potential adverse health effects. *Env Health Perspect* 107 (suppl3):409-419 (1999).

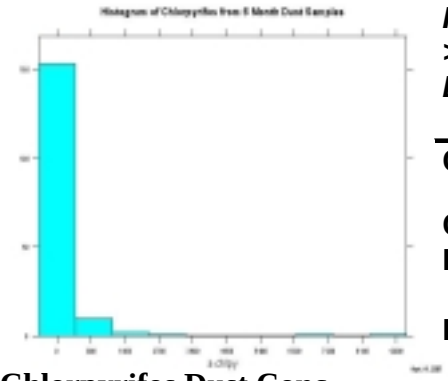
Dust Analyte Selection

Analyte	Pounds used agriculturally in Salinas Valley in 2001
Diazinon(op)	133,537
Malathion(op)	96,520
Chlorthal-dimethyl	74,349
Methomyl	65,366
Oxydemeton(op)	57,859
Chlorpyrifos(op)	54,945
Iprodione	45,700
Bensulide(op)	32,669
Permethrin	30,187

Household Dust: Quantification Limits (QL)

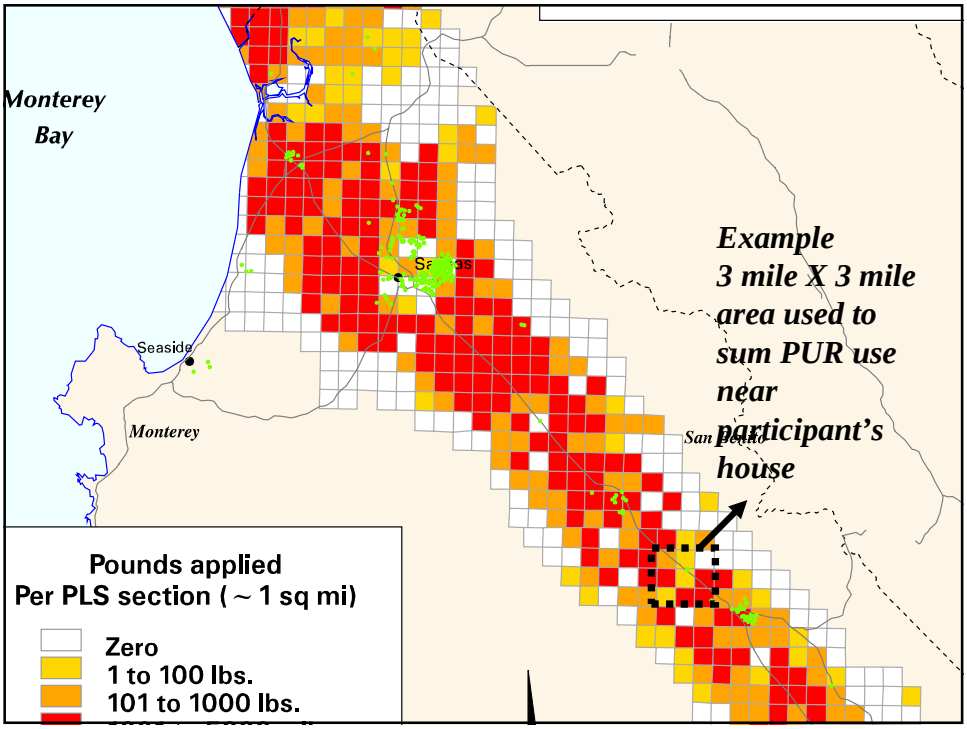
Analyte	Range of QLs (ng/g) QL for highest mass(.5 g)	QL for lowest mass(.01 g)	% of Samples Above QL
Permethrins	2	50	99%
Dacthal	2	20	93%
Chlorpyrifos (OP)	2	20	86%
Diazinon(OP)	1	20	87%
Oxydemeton (OP)	1	50	67%
Malathion(OP)	3	100	49%
Iprodione	3	100	44%
Methomyl	15	600	41%
Bensulide(OP)	5	300	17%
Methamidophos(OP)	1	50	9%
Phosmet(OP)	3	100	5%
Azinphosmethyl(OP)	100	2000	4%
Fenamiphos(OP)	1	50	5%

Normality of Distributions?



Chlorpyrifos Dust Conc (ng/g)

Pesticides with >70% Above DL	*Shapiro-Wilk Test for Normality of Logged Conc*
Chlorpyrifos[(OP)]	P<0.001,Failed
Chlorthal Dimethyl	P=0.04, Failed
Diazinon[(OP)]	P<0.0002, Failed
Permethrin cis	P=0.08, Failed



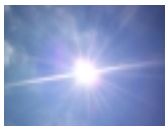
Pesticide Use near Home vs Dust Concentrations Spearman Correlation Coefficients (N=168)

Days 1-14 is dust collection day plus the 13 days prior
Days 1-60 is dust collection day plus the 59 days prior

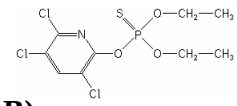
	DAYS 1-14		*DAYS 1-60*	
	Pesticide Use: Median *pounds/ 9 miles^2*	**Spearman Coefficient**	**Pesticide Use: Median *pounds / 9 miles^2***	**Spearman Coefficient**
Permethrin cis	5.8	0.04	75	0.01
Chlorthal Dimethyl	0.0	**0.32*** **	64	**0.49*** **
Chlorpyrifos$^{(OP)}$	8.4	0.07	83	0.10
Diazinon$^{(OP)}$	37	0.003	334	-0.07
Oxydemeton $^{(OP)}$	1.0	0.08	116	0.08
Malathion$^{(OP)}$	0.0	0.07	61	-0.02
Iprodione	2.1	**0.30*** **	135	**0.33*** **
Methomyl	22	-0.04	232	0.11

*****p,<0.0001**

Environmental Persistence

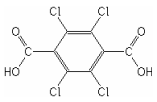


- **Chlorpyrifos (**OP insecticide)
  - **vapor pressure: 2*10-5 mm hg**
  - **half-life in air: 4 hours (ref: HSDB)**

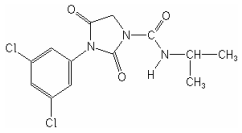


- **Dachtal, aka: chlorthal-dimethyl** (herbicide)
  - **vapor pressure: 3*10-6 mm hg**
  - **half-life in air: 36 days (ref: HSDB)**

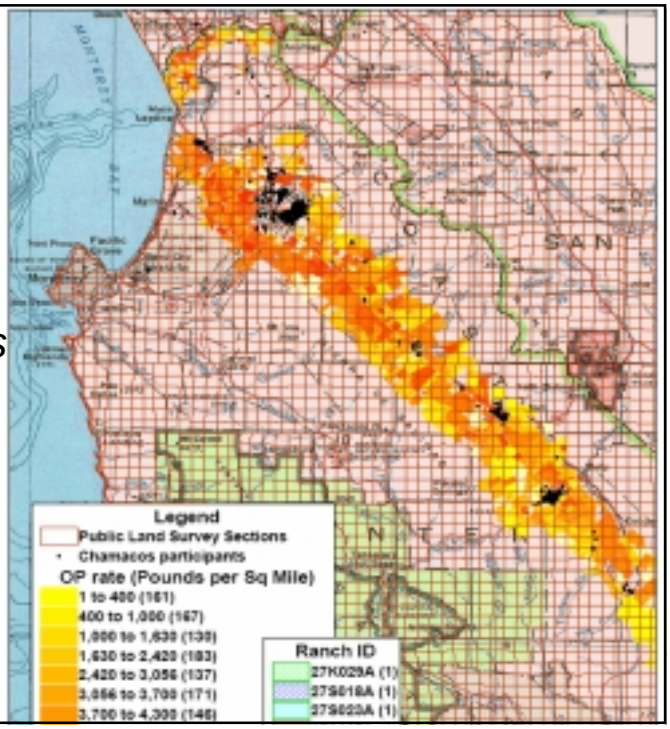
Dimethyl ester of:

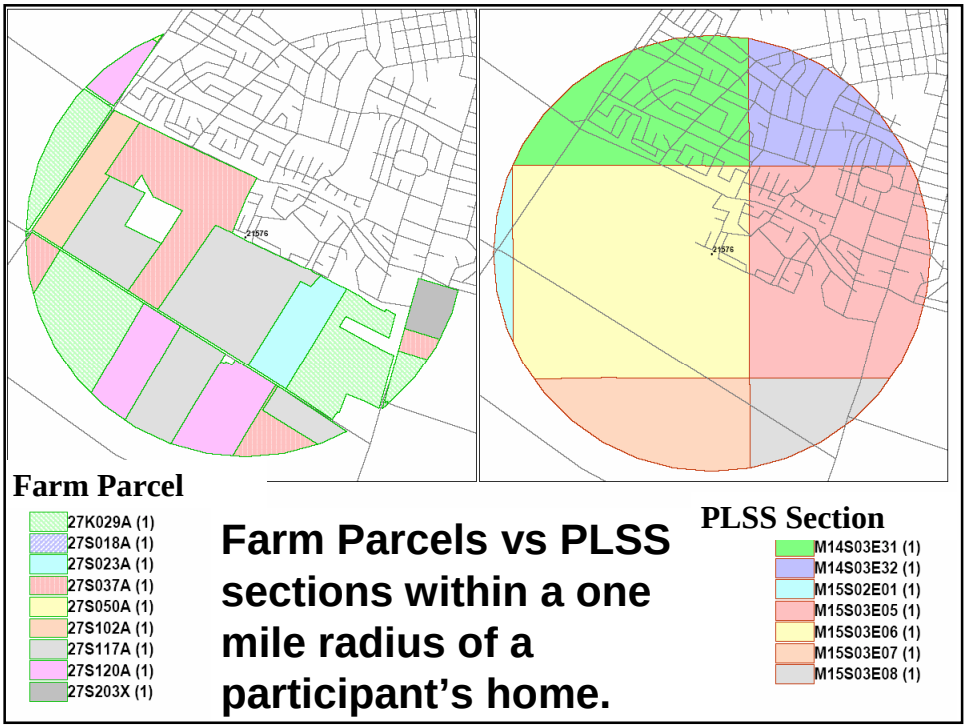


- **Iprodione (**fungicide)
  - **vapor pressure: 4*10-9 mm hg**
  - **not expected to vaporize: (ref: HSDB)**



Farm Parcel Map of OP use: *In Monterey County (Salinas), pesticide use is also reported by ownership unit–the farm parcel-- which is smaller than PLSS sections*





Farm Parcels vs PLSS sections within a one mile radius of a participant's home.

Correlations between House Dust Concentrations and two Pesticide Use Indices with different Geographical Reporting Units

	PLSS SECTION		*FARM PARCEL*	
DUST Analyte (parent product)	***Median Pest Use Days 1-60***	***Correlation Coefficient***	***Median Pest Use, Days 1-60***	***Correlation Coefficient***
Chlorpyrifos (OP)	**9.7**	**0.07**	**3.4**	**0.04**
Chlorthal-Dimethyl	**0.6**	**0.45*** **	**0.4**	**0.39*** **
Diazinon (OP)	**34.9**	**-0.03**	**11.0**	**-0.01**
Iprodione	**12.3**	**0.24****	**1.3**	**-0.05**
Oxydemeton Methyl (OP)	**12.4**	**0.01**	**4.5**	**-0.01**
Permethrin cis	**4.5**	**0.00**	**1.3**	**0.05**

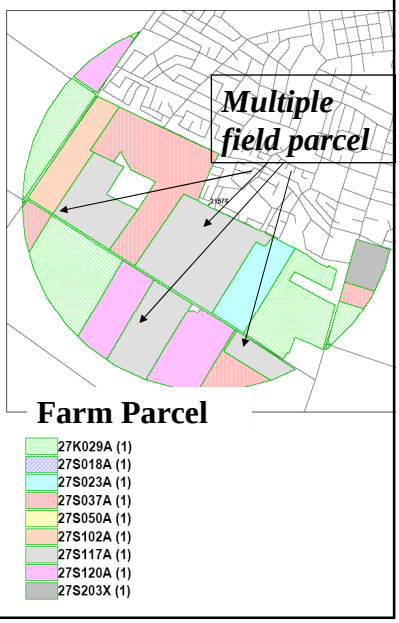
** p<0.01, *** p < 0.001

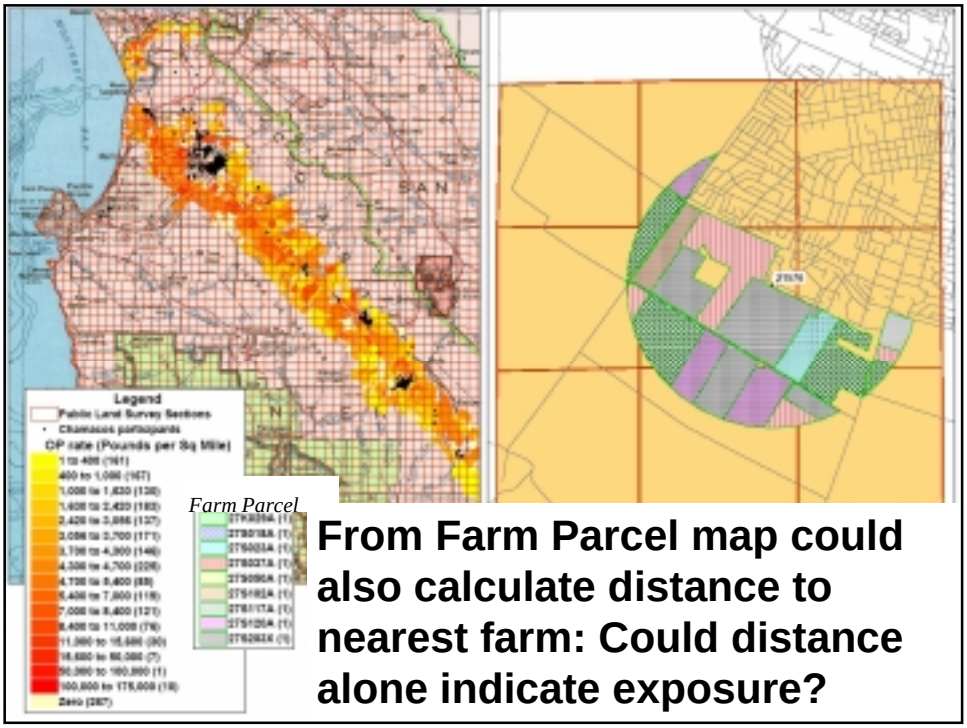
Spatial accuracy of Farm Parcel

Result: Correlations between dust and pesticide use did not improve with farm parcel use indices.

Interpretation: However, farms in Monterey County have multiple, geographically-separate, fields which are disperse and are not identified in the PUR.

Farm parcels may not provide an improved level of spatial accuracy for pesticide use measures.





From Farm Parcel map could also calculate distance to nearest farm: Could distance alone indicate exposure?

Correlation of House Dust Concentrations with Distance to Nearest Farm on Farm Parcel Map

DUST Analyte	Spearman Correlation Coefficient
Chlorpyrifos	-.07
Chlorthal dimethyl	-.33***
Diazinon	-.08
Iprodione	0.11
Oxydemeton Methyl	0.01
Permethrin cis	-0.04

Summary: Distance to Field

- ***Result*:** For one persistent analyte, chlorthal-dimethyl, proximity to nearest farm was correlated with household dust measurements.

- ***Conclusion*:** For persistent compounds, distance to nearest agricultural field may be a useful indirect pesticide exposure measure and should be further explored.

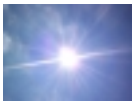
Summary: Organophosphates

***Result*:** For OPs, there was no correlation between house dust concentrations and either agricultural pesticide use or distance to agricultural field.

Conclusion: This is not consistent with other studies. Possible explanations include:

- **Only 10% of homes (n=17) of homes in our study were < 200 feet from agricultural fields, the distance studied by others (Fenske R, et al Env Health Perspectives 110:549-553 (2002) . Our sample may have had too few homes close to fields to observe an impact.**
- **OPs have a very short environmental half-life. Agricultural pesticide use may not be impacting household dust levels.**

Top Five Ranked Pesticides in Outdoor Air in Agricultural Areas of California



Inhalation, Child, Noncancer Risks

	Subchronic HQ	Chronic HQ
	(50^{th} – 75^{th} – 95^{th} Percentile Estimates)	
MITC:	2.1 - 3.8 - 8.5[a]	1.0 - 6.8 -118[a]
Methyl Bromide:	4.3 - 9.1 - 27	0.2 - 0.4 - 2.0[a]
Telone:	1.6 - 3.5 - 12[a]	0.2 - 0.5 - 2.0[a]
Chlorpyrifos(OP)	0.9 - 1.3 - 2.2	0.3 - 0.6 - 1.7
Diazinon (OP)	0.2 - 0.4 - 0.9	0.02-0.05 - 0.1

HQ= Hazard Quotient = intake (mg/kg/day) or [a]exposure (mg/m^3)) / corresponding health reference value

Lee S, et al. Environmental Health Perspectives 110:1175-84 (2002)

Independent Pesticide Use Variables

Daily Use

- **Lbs inner=lbs used per section on day i, sections within 1.5 miles**
- **LBS outer=lbs used per section on day i, sections within 1.6 to 3 miles**

Lagged use, i.e.,

- **Lbs inner-1=lbs used per section day i-1, sections within 1.5 miles**
- **Lbs inner-2=lbs used per section day i-2, sections within 1.5 miles**
- **Lbs inner-3=lbs used per section day i-3, sections within 1.5 miles**
- **LBs outer-1 =lbs used per section day i-1, sections within 1.6 to 3 miles**
- **LBs outer-2 =lbs used per section day i-2, sections within 1.6 to 3 miles**
- **LBs outer-3 =lbs used per section day i-3, sections within 1.6 to 3 miles**

Conclusions

- For epidemiological studies where PUR is not available, distance to nearest agricultural field may be an indicator for pesticide exposure.
- When deciding what pesticides to study environmental persistence should be considered along with toxicity.

Funders

U.S. Environmental Protection Agency

National Institute of Environmental Health Sciences