Community air monitoring for pesticides.
Part 1: Selecting pesticides and a community

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ABSTRACT

The CA Department of Pesticide Regulation (CDPR) developed methods to select pesticides and a community to fulfill criteria for an ambient air monitoring study it conducted as part of the CA Environmental Protection Agency's Environmental Justice Action Plan. Using a scoring system, CDPR evaluated 100 pesticides based on statewide reported pesticide use, volatility, and priority in CDPR's risk assessment process (indicators of exposure and toxicity) to produce a list of pesticides to consider as candidates for monitoring. The CDPR also evaluated and scored 83 communities based on demographics and health factors, availability of cumulative impacts data, and reported pesticide use to create a list of community candidates. The scores provide relative rankings to distinguish more highly impacted communities from less impacted ones and to identify which pesticides might contribute most to potential adverse health effects. These methods use criteria that can be quantified, validated, and verified in order to provide a transparent and fair selection process. Based on public comments and highest scores, CDPR recommended 40 pesticides (including some of their degradation products) and one community for its yearlong monitoring study. The CDPR then further refined its list of pesticides by soliciting input from local and technical advisory groups. The CDPR plans to use these methods to select pesticides and communities in future monitoring activities.

Key words: Pesticides, agriculture, ambient air monitoring, scoring systems, air sampling

1. Introduction

Historically, the CA Department of Pesticide Regulation (CDPR) and the CA Air Resources Board (CARB) have conducted air monitoring of pesticides to provide data to assess public exposure covering periods ranging from short term (hours to days) to seasonal (2 weeks to 2 months). Monitoring has focused on individual pesticides or small numbers of pesticides in locations of high historical use during seasonal high periods of use (Baker et al. 1996; Wofford et al. 2003a, b). However, CDPR is also interested in monitoring many pesticides simultaneously and over a longer time frame to assess potential public exposure to multiple pesticides that may be present in agricultural areas in ambient air. Therefore, CDPR conducted a yearlong study in 2006 and, along with CARB, monitored concentrations of 40 pesticides (including five degradation products) in ambient air in Parlier, a rural farming community in CA (Hengel and Lee 2013; Wofford et al. 2013). The study also was conducted as part of the CA Environmental Protection Agency's (Cal/EPA) Environmental Justice (EJ) Action Plan (Cal/EPA 2004). This article describes the methods CDPR used to select the pesticides and a community for its yearlong community air monitoring study.

Several studies describe how to select communities with potentially disproportionately high and adverse environmental and public health burdens. One study used geographical information system methodology to evaluate EJ implications of the US EPA's Toxics Release Inventory (Miranda et al. 2008). It selected three US Census variables as standard metrics for assessing impacts across income groups: percent minority, percent minority less than age 5, and percent in poverty. Another study modeled ambient air toxics concentrations in US metropolitan areas and combined the data with cancer potency information (Morello-Frosch and Jesdale 2006). It used socioeconomic and demographic information from US Census data to derive the following variables: racial segregation, regional grouping of states, population density, population size, poverty and material deprivation, and civic engagement. The US EPA uses its EJ Strategic Enforcement Assessment Tool to identify such areas (US EPA 2013). Recently the CA Office of Environmental Health Hazard Assessment (2013) released for public comment its environmental health screening tool to analyze, prevent and reduce cumulative impacts of multiple types and sources of pollution. Cumulative impacts are a function of pollution burden from pollutants and sensitive populations. Three components represent the pollution burden: exposures (e.g., ozone concentrations in air or reported pesticide use), environmental effects (e.g., cleanup sites), and public health effects (e.g., asthma). Two components represent population characteristics: sensitive populations (prevalence of children and elderly) and socioeconomic factors (e.g., income). The US EPA and CARB also have guidelines on how to site air monitoring equipment within a community once that community has been selected for monitoring air pollutants (CARB 1994; 40 US Code of Federal Regulations [CFR] §58.11 & Appendix E 2012).

At the time this study was conducted, however, CDPR was not aware of any selection guidelines to achieve the following objectives:

(1) Focus on pesticides that pose the greatest risk to human health when air monitoring is being done for more than one pesticide, and
(2) Focus on a community or communities with particular demographics (e.g., children and the elderly) or other characteristics.

Therefore, CDPR developed methods to select pesticides and a community to meet these objectives.

This study differed from CDPR's previous air monitoring projects in that before beginning work CDPR sought public comment on study priorities, which pesticides and community to select for monitoring, and its draft study protocol. This community-based participatory research approach met requirements of Cal/EPA's EJ Action Plan. After three rounds of public comments, CDPR completed its draft protocol in early 2005 and solicited review from local and technical advisory groups (Wofford et al. 2013). These groups provided input on pesticide selection, sampling locations, and other technical and scientific elements of the study.

2. Methods

2.1 Selecting pesticides for monitoring

The CDPR developed methods to select ambient airborne pesticides that pose the greatest risk to human health. Risk is a function of exposure and toxicity; however, exposure data are not always available. Therefore, CDPR used both statewide reported pesticide use data[1] (CDPR 2003) and volatility data (CDPR 2005a) as surrogates for exposure. For toxicity, CDPR used the priority it assigned a pesticide in its human health risk assessment process. This priority reflects toxicologists' ranking of pesticides based on potential risk to human health (CDPR 2004, 2011). The CDPR uses risk assessment to determine whether changes to current or proposed use practices are necessary. Risk assessments may be initiated for a number of reasons, for example, to identify adverse health effects under the Birth Defect Prevention Act (2012). The CDPR sets priorities for risk assessments to ensure an orderly focus on chemicals that pose the greatest potential risk.

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[1] The CDPR used data from 2002 since this was the most recent available when this analysis was done.

In this study, CDPR was especially interested in selecting pesticides that met the following four criteria:

(1) High statewide use,
(2) High volatility,
(3) High priority in CDPR's risk assessment process, and
(4) Availability of a valid analytical method or suitability for the multi-pesticide analytical method to be used (Hengel and Lee 2013).

Using the first three criteria, CDPR developed a formalized rating system (Fig. 1). First, CDPR produced a list of 100 pesticides by selecting those that had the highest statewide reported use on agricultural sites. These pesticides were assigned points as shown in Table 1 (criterion 1). Next, these pesticides were assigned points for volatility and risk assessment priority (Table 1, criteria 2 and 3). Then, the points from the three categories were summed for a total score and the 100 pesticides were ranked from highest to lowest total score. This approach provided a broad-brush tool for initial selection based on statewide usage and generally known health hazards. Table 2 lists the 20 pesticides that had the highest total scores and their points for each of the three criteria.

Next, CDPR informally considered certain factors without assigning points, such as the status of each of the 100 pesticides as a Toxic Air Contaminant (TAC; TAC Identification and Control Act 2012) or a Proposition 65 chemical[2] (Table 2). A TAC or Proposition 65 chemical would receive more informal weight. Finally, the fourth criterion was critical: only those pesticides that could be analyzed were included in the final list of pesticides.

2.2 Selecting a community for monitoring

To implement its EJ action plan, Cal/EPA conducted six projects in different parts of the state (Cal/EPA 2004). The Cal/EPA asked CDPR to conduct its study in the Central Valley, focusing on pesticides in a rural, farming community. Because they are closer to agricultural fields, rural farming communities may have higher concentrations of pesticides in ambient air compared to urban communities.

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[2] The Safe Drinking Water and Toxic Enforcement Act of 1986 (2012; added by Proposition 65 in the 1986 General Election), also known as Proposition 65, is intended to protect CA residents and the State's drinking water sources from chemicals known to cause cancer, birth defects or other reproductive harm, and to inform residents about exposures to such chemicals. Proposition 65 requires the Governor to publish, at least annually, a list of chemicals known to the state to cause cancer or reproductive toxicity.

The CDPR chose the San Joaquin Valley (SJV), the southern half of the Central Valley. The SJV is a major agricultural region. It also is home to major freeways with heavy traffic moving goods and people from one end of the state to the other. The region's topography and weather provide ideal conditions for producing pollutants and trapping air pollution for long periods (SJV Air Pollution Control District 2008). Therefore, the SJV has poor air quality and serious summer ozone and winter particulate matter problems (Capitman and Tyner 2011; Zhao et al. 2010).

Figure 2 summarizes the community selection process. First, CDPR (2003) ranked the counties in the SJV by reported pesticide use from highest to lowest and eliminated those counties that were too far away to be sampled by its Fresno-based staff. Merced, Madera, Fresno, Kings, and Tulare counties were among the 10 counties that had the highest pesticide use and were feasibly close. In these five counties, CDPR evaluated all communities included by name in the US Census (US Census Bureau 2000), except those communities in foothill areas where farming and pesticide use are lower. This resulted in 81 communities. Based on public comments, CDPR added two more communities: Arvin (Kern County) and Grayson (Stanislaus County).

After reviewing public comments and the literature, CDPR identified three criteria as central to selecting a community that it would monitor for this study. These three criteria were the following:

1. Social demographics and human health data,
2. Availability of data for cumulative impacts evaluation, and
3. Pesticide use density data.

Also, CDPR examined meteorological data and determined that weather conditions in the SJV were homogeneous and would not be useful as a selection criterion.

The CDPR further subdivided each of the three criteria into subgroups (Tables 3, 4, 5, and 6). As part of the social demographics and human health category, CDPR wanted to select a community that had the following:

- A large number of children (<18 years of age) because this subgroup can be sensitive to pesticides;
- A majority of its population is non-White;
- Low median family income, a criterion suggested by public comments; and
- High number of reported non-occupational illnesses due to airborne pesticide exposure, a criterion suggested by public comments.

Table 3 shows how points were assigned to the four subgroups within the social demographics and human health criterion. The child population subgroup was based on population density rather than total population to minimize the effect of the size of the communities.

For the second criterion, CDPR assigned points for communities with additional exposure and pollutant data. Such data could aid cumulative impacts assessment, an objective of the Cal/EPA EJ plan though not part of the scope of the CDPR analysis. Table 4 shows how points were assigned to the subgroups of this criterion.

The selection process used to develop a list of candidate pesticides to consider for monitoring ensured that the monitoring would include those pesticide that were the greatest health concern, could be analyzed using the multi-pesticide analytical method (Hengel and Lee 2013; Wofford et al. 2003a) and had the highest use statewide. It makes no sense to monitor in a community where the highest scoring candidate pesticides were not used. Therefore, CDPR created a third criterion, pesticide use density. The pesticides in this criterion were among the highest scoring pesticide candidates or were those which could easily be included in the multi-pesticide analytical method. As shown in Table 5, CDPR organized the pesticides in this criterion into four groups: organophosphates[3], fumigants, metals, and "analytical method available" pesticides (i.e., those that could be analyzed as described above). To evaluate use of these pesticides in the area(s) around a community, CDPR further subdivided this criterion into two different-sized areas, arbitrarily choosing areas within 8 km (regional) and 1.6 km (local) from the community boundary. Use density (kilogram per square kilometer) within these areas provided a standard measure of pesticide use. Then CDPR determined reported pesticide use density for these pesticides both locally and regionally from its pesticide use report database (CDPR 2003). Table 6 shows the eight subgroups and how points were assigned.

To summarize, data for each subgroup in each criterion were used to assign each community to one of four quartiles (Fig. 2; Tables 3, 4, 5 and 6). Each quartile was assigned a point value of one to four (or zero if the community had no data). For each criterion, an average score was calculated by averaging the subgroups' scores, and the three criteria average scores were summed for a total score (Table 7). This system gives equal weight to each of the three categories.

[3]The organophosphates (OPs) included those most commonly used statewide even if they were not among the 100 highest-use pesticide candidates. Since OPs share the same mechanism of toxicity, CDPR would have considered monitoring any that were high-use in the community.

3. Final approach and discussion

3.1 Pesticides selected for monitoring

This method produced a list of 100 pesticides used on agricultural sites in CA during 2002 for the advisory groups to consider. Table 2 lists the 20 pesticides that had the highest total scores out of the 100 pesticides considered. The 19 pesticides with total scores ≥ 10 were considered the highest priority candidates for monitoring. The CDPR was able to monitor 13 of these. The CDPR also was able to monitor some of the lower scoring pesticides because they were easy to include in the multiple pesticide analysis to be used.

The CDPR had resources to fund no more than two analytical methods. The first method, a multi-pesticide analytical method, allowed analysis of a single sample in a single run to detect multiple pesticides—in this case, as many as 24 pesticides (Hengel and Lee 2013). However, several of the candidate pesticides could be monitored only as individual compounds, not in combination with other pesticides. So, the second method would analyze one of the highest priority candidates that could not be detected using the multi-pesticide method. The CDPR proposed to its local advisory group that either chloropicrin or MITC be monitored. The group chose MITC. Although paraquat and maneb were among the 19 highest priority candidates, both required monitoring as individual pesticides. Due to the limitation of using only two analytical methods, neither paraquat nor maneb was monitored.

Due to lack of instrumentation, CDPR could not analyze the remaining highest priority candidates: methyl bromide; 1, 3-dichloropropene; acrolein; and sulfuryl fluoride. However, CARB was able to conduct these analyses and agreed to monitor methyl bromide, 1, 3-dichloropropene, and acrolein. Methyl bromide and 1, 3-dichlorpropene pesticides also are listed as TACs. Sulfuryl fluoride is almost always used for structural fumigations. Since CDPR only receives reported pesticide use data for structural applications on a countywide basis, it could not determine how much use occurs near Parlier or any other community. However, reported use in Fresno County is low compared to elsewhere in CA. Hence, sulfuryl fluoride was not monitored in Parlier.

The CARB also was able to monitor for arsenic, carbon disulfide, copper, and sulfur, all of which scored <10 but >6. The CDPR added formaldehyde and xylene to the list because CARB could monitor for them as part of a VOC method it was already using. Wofford et al. (2013) list the 40 pesticides monitored in Parlier and discuss monitoring results from CDPR's yearlong study.

3.2 Community selected for monitoring

After evaluating data for social demographics and human health, availability for cumulative impacts evaluations, and use of specific pesticides of concern, CDPR selected the city with the highest total score—Parlier in Fresno County. Parlier is a small city about 32 km southeast of Fresno (Fig. 3). During the winter and spring the predominant winds are from the southeast, while during the summer and fall the winds are mainly from the northwest. According to the US Census (US Census Bureau 2000), 11,088 people lived in Parlier. About 38% of the population was <18 years old, 97% were Hispanic, and the median annual family income was $24,275 (compared to the state median income in 2000 of $47,493) (Umbach 2005). Parlier is surrounded by agriculture: the major crops are grapes and tree fruit. Insecticides and fungicides are the most heavily used pesticides in the area.

Tables 3, 4, 5, and 6 summarize how points were assigned to the social demographics and human health subgroups. Table 7 and Figs. 3 and 4 show the 27 communities with the highest total scores among the 83 communities considered. The five communities with the highest total scores were Parlier, Visalia, Arvin, Orange Cove, and London. Parlier's total score is 1.6 points greater than the next highest scoring communities, which is considerably more than the 0.1 to 0.2 points that separate the rest of the communities. In addition, Parlier offered opportunities for collaborative health studies. Since pesticides can occur on particulate matter and Parlier was the location of a particulate matter exposure study by the University of CA Davis' Western Center for Agricultural Health and Safety (Ngo et al. 2010), conducting the study in Parlier offered a potential to collaborate with this group. Another potential collaborator, the University of CA Kearney Agricultural Center (Kearney Center), was located in Parlier. Its mission is to promote sustainability of CA's agriculture industry and to enhance the quality of the rural environment. It maintains a meteorological record for the area. Collaborating with the Kearney Center would be very important during any mitigation developments resulting from this study. Parlier also had several schools or other sensitive sites near agricultural areas that met US EPA siting criteria (40 US CFR §58.11 2012). Selecting Parlier for monitoring had two drawbacks: (1) no non-occupational illnesses from airborne exposures to pesticides had been reported, and (2) the points assigned it in the pesticide use density criterion for "analytical method available" pesticides both regionally and locally were moderate rather than high (Table 7).

The CDPR considered one other community, Arvin. It had the second highest total score and CDPR would have preferred to monitor there if availability of cumulative impacts data had not been a factor or if fumigant use were an overriding factor. However, Arvin, unlike Parlier, was not a candidate for any collaborative health studies, which was a disadvantage. Other drawbacks included (1) Arvin may have had only one or two sites meeting monitoring siting criteria, and (2) its distance from Fresno-based CDPR staff

(>130 miles) would have necessitated additional travel and per diem expenses, resulting in fewer resources for sampling.

3.3 Discussion

For this study, CDPR's objective was to select those pesticides that had high combined use statewide, could be the most harmful to human health and would result in the greatest exposure, and to monitor for them in a community with the largest portion of sensitive populations (e.g., children and the elderly) that CDPR considers in its risk assessment, among other factors.. This approach provides CDPR information to regulate pesticide use statewide to best protect human health. Although monitoring a control or background community might have been valuable, as suggested by public comments, it was not essential. Moreover, including a control community would have meant many fewer pesticides could have been monitored due to finite resources.

This study tested and optimized inexpensive methods to select pesticides and a community using criteria and data that could be objectively evaluated. The methods were also transparent and acceptable to stakeholders. The scoring systems allow flexibility to add or subtract pesticides or other pollutants, demographic data, or other factors. The CDPR has modified these methods to select pesticides and communities as part of an air monitoring network it initiated in 2011 (Vidrio et al. 2013).

References

40 US CFR §58.11 & Appendix E (2012). Resource documents. http://www.law.cornell.edu/cfr/text/40/58.11 & http://www.law.cornell.edu/cfr/text/40/58/appendix-E. Accessed 1 February 2013.

Baker, L.W., Fitzell, D.L., Seiber, J.N., Parker, T.R., Shibamoto, T., Poore, M.W., et al. (1996). Ambient air concentrations of pesticides in CA. *Environmental Science & Technology, 30*(4), 1365-1368.

Bartkowiak, D., Pepple, M., Spurlock, F., Troiano, J., & Weaver, D. (1999). *Sampling for pesticides in CA well water: 1999 update of the well inventory database. Report EH 00-04*. Sacramento: CDPR, Cal/EPA.

Birth Defect Prevention Act, Cal. Food & Agric. Code §§ 13121–13135 (West 2012).

CA Office of Environmental Health Hazard Assessment. (2013). CA communities environmental health screening tool, Version 1.1. Resource document. Cal/EPA. http://oehha.ca.gov/ej/pdf/CalEnviroscreenVer11report.pdf. Accessed 3 October 2013.

Cal/EPA. (2004). October 2004 environmental justice action plan. Resource document. http://www.calepa.ca.gov/envjustice/ActionPlan/Documents/October2004/ActionPlan.pdf. Accessed 11 October 2011.

Capitman, J. & Tyner, T. (2011). The impacts of short-term changes in air quality on emergency room and hospital use in CA's SJV. Resource document. CA State University, Fresno. http://www.fresnostate.edu/chhs/cvhpi/documents/aqr-web.pdf. Accessed 6 February 2013.

CARB. (1994). Air monitoring quality assurance manual, volume II, standard operating procedures for air quality monitoring, section 2.0.7, siting requirements for toxics monitoring equipment. Resource document. Cal/EPA. http://www.arb.ca.gov/airwebmanual/aqsbdocs1/V2/v2sec2.0.7.pdf. Accessed 5 March 2013.

CARB. (2009). State and local air monitoring network plan. Resource document. Cal/EPA. http://www.arb.ca.gov/adam/netrpt/. Accessed 15 January 2010.

CDPR. (2003). Summary of pesticide use report data 2002 indexed by chemical. Data file. Cal/EPA. http://www.cdpr.ca.gov/docs/pur/pur02rep/comrpt02.pdf. Accessed 7 October 2004.

CDPR. (2004). Process for human health risk assessment prioritization and initiation. Resource document. Cal/EPA. http://www.cdpr.ca.gov/docs/risk/raprocess.pdf. Accessed 1 February 2013.

CDPR. (2005a). Pesticide chemistry database. Data available upon request.

CDPR. (2005b). Pesticide illness survey program database 1993-2002. Data file. Cal/EPA. http://www.cdpr.ca.gov/docs/whs/pisp.htm. Accessed 15 December 2005.

CDPR. (2011). Assessing pesticide risks to human health. In CDPR (Ed.), *A guide to pesticide regulation in CA* (pp. 39-48). Sacramento: Cal/EPA.

Guo, F., Bartkowiak, D. Weaver, D., Troiano, J. Pepple, M., Spurlick, F. et al. (2000). *Sampling for pesticides in CA well water: 2000 update of the well inventory database. Report EH 00-15*. Sacramento: CDPR, Cal/EPA.

Hengel, M. & Lee, P. (2013). Community air monitoring for pesticides. Part 2: Multi-residue determination of pesticides in air by gas chromatography, gas chromatography mass spectrometry and liquid chromatography mass spectrometry. *Environmental Monitoring and Assessment*. DOI 10.1007/s10661-013-3395-9.

Miranda, M.L., Keating, M.H. & Edwards, S.E. (2008). Environmental justice implications of reduced reporting requirements of the Toxics Release Inventory burden reduction rule. *Environmental Science and Technology, 42*(15), 5407-5414.

Morello-Frosch, R. & Jesdale, B. M. (2006). Separate and unequal: Residential segregation and estimated cancer risks associated with ambient air toxics in US metropolitan areas. *Environmental Health Perspectives*, *114*(3), 386-393.

Ngo, M., Pinkerton, K., Freeland, S., Geller, M., Ham, W., Hopkins, L., et al. (2010). Airborne particles in the SJV may affect human health. *California Agriculture, 64*(1), 12-16.

Safe Drinking Water and Toxic Enforcement Act of 1986, Cal. Health & Safety Code §§ 25249.5–25249.13 (West 2012).

Schuette, J., Weaver, D., Troiano, J., & Pepple, M. (2001). *Sampling for pesticides in CA well water: 2001 update of the well inventory database. Report EH 01-03*. Sacramento: CDPR, Cal/EPA.

Schuette, J. Weaver, D., Troiano, J., & Dias, J. (2002). *Sampling for pesticides in CA well water: 2002 update of the well inventory database. Report EH 02-07*. Sacramento: CDPR, Cal/EPA.

Schuette, J., Weaver, D., Troiano, J., Pepple, M., & Dias, J. (2003). *Sampling for pesticides in CA well water: 2003 well inventory database cumulative report 1986-2003. Report EH 03-08*. Sacramento: CDPR, Cal/EPA.

Schuette, J., Troiano, J., Pepple, M., & Dias, J. (2004). *Sampling for pesticides in CA well water: 2004 update of the well inventory database. Report EH 04-04*. Sacramento: CDPR, Cal/EPA.

SJV Air Pollution Control District. (2008). Annual report to the community. Fresno, CA.

TAC Identification and Control Act, Cal. Food & Agric. Code §§ 14021–14027 (West 2012).

Umbach, K. (2005.) *San Joaquin Valley: Land, people, and economy. Report CRB 05-007*. Sacramento: CA State Library.

US Census Bureau. (2000). Decennial Census. [US Census 2000 Summary File 1 (SF 1) 100-Percent Data]. Data file. http://www.census.gov/mp/www/cat/decennial_census_2000/summary_file_1.html. Accessed 25 March 2008.

US EPA. (2013). Plan EJ 2014 Progress Report. Resource document. http://epa.gov/environmentaljustice/resources/policy/plan-ej-2014/plan-ej-progress-report-2013.pdf. Accessed 31 October 2014.
[Since this article was published, US EPA has replaced EJ SEAT with EJSCREEN, described in this report. It is still an internal tool.]

Vidrio, E., Wofford, P., Segawa, R., & Schreider, J. (2013). Air monitoring network results for 2011. Volume 1. Resource document. CDPR, Cal/EPA. http://www.cdpr.ca.gov/docs/emon/airinit/amn_vol1_final.pdf. Accessed 20 November 2013.

Wofford, P., Segawa, R., Brattesani, M., Schreider, J. & Powell, S. (2003a). Ambient air monitoring for pesticides in Lompoc, CA: Volume 3, multiple pesticides. Resource document. CDPR, Cal/EPA. http://www.cdpr.ca.gov/docs/specproj/lompoc/vol3_multiple_pest/volume3_march2003.pdf. Accessed 15 October 2010.

Wofford, P., Segawa, R., Ross, L., Schreider, J. & Spurlock, F. (2003b). Ambient air monitoring for pesticides in Lompoc, CA: Volume 2, fumigants. Resource document. CDPR, Cal/EPA. http://www.cdpr.ca.gov/docs/specproj/lompoc/vol2_fumigants/volume2_march2003.pdf. Accessed 15 October 2010.

Wofford, P., Segawa, R., Schreider, J., Federighi, V., Neal, R., & Brattesani, M. (2013). Community air monitoring for pesticides. Part 3: Using health-based screening levels to evaluate results collected for a year. *Environmental Monitoring and Assessment*. DOI 10.1007/s10661-013-3394-x

Zhao, Z., Chen, S., Kleeman, M., Tyree, M., & Cayan, D. (2010). The impact of climate change on air quality-related meteorological conditions in CA. Part I: Present time simulation analysis. *Journal of Climate, 24*(13), 3344-3361.

Table 1 Data and points assigned for the three criteria (statewide reported pesticide use, volatility, and risk assessment priority) used to develop a list of 100 pesticides to consider as candidates for ambient air monitoring.

Exposure	**Criterion 1: Statewide reported pesticide use (2002)**		
	Points	**Kg**	**Notes**
	4	386,658 – 2.431917×10^{7}	Top 25 pesticides
	3	157,568 – 383,931	2nd 25 pesticides
	2	86,250 – 155,998	3rd 25 pesticides
	1	49,223 – 85,446	4th 25 pesticides
	Criterion 2: Volatility[a]		
	Points	**mm Hg**	**Notes**
	4	$>10^{-2}$	High
	3	$10^{-6} – 10^{-2}$	Medium
	2	$<10^{-6}$	Low
	1	Volatility unknown	
Toxicity	**Criterion 3: Risk assessment priority**[b]		
	Points	**Priority**	
	4	High	
	3	Medium	
	2	Low	
	1	No priority assigned	

[a]Cutoff values based on historical frequency of detection for pesticides in air.
[b]DPR's prioritization of pesticides for risk assessment is a subjective process based upon the nature of potential adverse effect, the number of potential adverse effects, the number of species affected, the no observable effect level, and other factors.

Table 2 The 20 pesticides with the highest total scores out of 100 pesticides considered as candidates for ambient air monitoring. The total score column represents the sum of the statewide reported use (2002), volatility, and risk assessment priority criteria scores (maximum possible total score = 12 points). Other factors that were considered are shown in the last three columns. Those pesticides shown in italics were monitored by CARB (formaldehyde and xylene are not included since they were added later); those shown in bold were monitored by CDPR.

	Exposure		**Toxicity**		**Other Factors**		
	Criteria				**Criterion**		
Pesticide	**(1) Statewide reported use**	**(2) Volatility**	**(3) Risk assessment priority**	**Total Score**	**(4) Is it a TAC?**	**(4) Is it Proposition 65-isted?**	**(4) Is an analytical method available?**
	Points						
1,3-dichloropropene	4	4	4	12	Y	Y	Y[a]
Chloropicrin	4	4	4	12	N[b]	N	Y
Methyl bromide	4	4	4	12	Y	Some[c]	Y
MITC-generating pesticides	4	4	4	12	Y	Y	Y
Chlorpyrifos	4	3	4	11	N	N	Y
Molinate	4	3	4	11	N	N	Y
Propargite	4	3	4	11	N	Y	Y
Sulfuryl fluoride	4	4	3	11	N	N	Y
2,4-D, dimethylamine salt	3	3	4	10	Y	N	Y
Acrolein	2	4	4	10	Y	N	Y
Chlorothalonil	3	3	4	10	N	Y	Y
Diazinon	3	3	4	10	N	N	Y
Diuron	4	3	3	10	N	N	Y
Malathion	3	3	4	10	N	N	Y
Maneb	4	2	4	10	N	Y	Unsuccessful[d]
Paraquat dichloride	4	2	4	10	N	N	Unsuccessful
Propanil	4	2	4	10	N	N	Y
Trifluralin	4	3	3	10	Y	N	Y
Acephate	2	3	4	9	N	N	Y
Aldicarb	2	3	4	9	N	N	Y
Captan	2	3	4	9	Y	Y	Unsuccessful

[a] Y = Yes
[b] N = No
[c] Some = Some uses are listed under Proposition 65.
[d] Unsuccessful = Previous attempts to develop a method were unsuccessful.

Table 3 Social demographics and human health subgroups' data and points assigned for the 83 communities considered as candidates for ambient air monitoring.

Criterion 1: Social demographics and human health[a]							
	Subgroup 1	**Subgroup 2**		**Subgroup 3**		**Subgroup 4**	
Points	**Child Population density (No. children / km^2)**	**Non-white population (%)**	**Notes for subgroups 1 & 2**	**Median family income ($ / yr)**	**Notes**	**No. reported pesticide illnesses from airborne exposures[b, c]**	**Notes**
4	517-1,146	65.5-91.1	~highest 20 communities	20,524-25,481	~lowest 20 communities	51-78	4 communities
3	304-487	52.8-65.0	~2nd highest 21 communities	26,166-32,470	~2nd highest 21 communities	17-50	No communities
2	136-295	42.1-52.4	~3rd highest 21 communities	32,852-37,033	~3rd 21 communities	13-16	3 communities
1	8-131	6.9-41.5	~lowest 21 communities	37,979-86,653	~highest 21 communities	2-7	4 communities
0	N/A[d]	N/A	N/A	N/A	N/A	0	72 communities

[a] US Census Bureau (2000)
[b] Number of non-occupational illnesses from airborne exposure to pesticides that occurred during 1993-2002 (CDPR 2005b).
[c] The number of drift illnesses was determined from CDPR's Pesticide Illness Surveillance Program database for 1993 through 2002 (CDPR 2005b), and expressed as the number of non-occupational drift illnesses within the community. Only 11 of the 83 communities had illnesses documented in the database, so instead of basing scores on quartile rank, scores were assigned as shown in this table. All other communities received 0 points. The CDPR considered expressing drift illnesses as a density or on a per capita basis, but this added an unnecessary level of complexity since CDPR also considered using number of drift episodes, rather than number of illnesses for this subgroup. However, since few communities had more than one episode, this provided little separation in scores between communities.
[d] N/A = not applicable.

Table 4 Availability of data for cumulative impacts evaluation subgroups' data and points assigned for 83 communities considered as candidates for ambient air monitoring.

	Criterion 2: Availability of data for cumulative impacts evaluation			
	Subgroup 1: Municipal well monitoring density[a, b]		**Subgroup 2: Air monitoring stations**[c]	
Points	**[(No. wells) x (No. pesticides sampled)] / km^2**	**No. of communities**	**No. of criteria pollutants monitored**	**No. of communities**
4	10.0-510.4	23	5-6	3
3	3.3-9.5	13	3-4	1
2	2.2-2.8	7	1-2	4
1	0.2-1.8	12		
0	No wells sampled	28	0	75[d]

[a]Sampling conducted during 1999-2004

[b]Monitoring density for pesticides in municipal wells was determined from CDPR's Well Inventory database (Bartkowiak et al. 1999; Guo et al. 2000, Schuettte et al. 2001; Schuette et al. 2002, Schuette et al. 2003; Schuette et al. 2004) and expressed as:

$$\frac{\text{Number of municipal wells sampled x number of pesticides sampled}}{\text{km}^2 \text{ of the community}}$$

[c]Air monitoring stations were determined from the CARB's and San Joaquin Valley Air Pollution Control District's air monitoring networks, and expressed as the number of criteria air pollutants monitored within the community (CARB 2009). Criteria air pollutants include the six most common air pollutants in the USA: CO, Pb, NO_2, O_3, particulate matter, and SO_2. The US Congress has focused regulatory attention on these six pollutants because they endanger public health and the environment, are widespread throughout the USA, and come from a variety of sources. Criteria pollutants are the only air pollutants with national air quality standards that define allowable concentrations of these substances in ambient air.

[d]Communities where no monitoring stations were located received 0 points

Table 5 Pesticide use density groups of pesticides.

Criterion 3: Pesticide use density		
Group		**Pesticides**
Organophosphate pesticides		Azinphos-methyl
		Chlorpyrifos
		Diazinon
		Dichlorvos (a degradation product of Naled)
		Dimethoate
		Malathion
		Methidathion[a,b]
		Methyl parathion[a,b]
		Oxydemeton-methyl[a,b]
		Parathion[a,b]
		Phorate[a,b]
		Phosmet
		SSS-tributylphosphorotrithioate
Fumigants		1,3-dichloropropene
		Chloropicrin[b]
		MITC (a degradation product of metam-sodium)
		Methyl bromide
Metals		Copper
		Sulfur
"Analytical method available" pesticides[c]		(S)-metolachlor
		Carbaryl[b]
		Cypermethrin
		Dicofol
		Diuron
		EPTC
		Oxyfluorfen
		Permethrin
		Simazine
		Trifluralin

[a]Although these organophosphate compounds were not among the 100 highest-scoring pesticide candidates, they were included because they share the same mechanism of toxicity. If their use had been high in the community selected, they would have been considered for monitoring.
[b]This pesticide was not subsequently monitored (Wofford et al. 2013) because it was not among the 100 highest-scoring pesticide candidates, it could not be analyzed in the multi-pesticide analytical method, or its use was not high in the community selected.
[c]"Analytical method available" pesticides refer to those that had been included in a multi-pesticide analytical method CDPR used previously (Wofford et al. 2003a) or that would be included in the method modified for this study (Hengel and Lee 2013).

Table 6 Pesticide use density subgroups, data, points assigned, and quartile ranks for 83 communities considered as candidates for ambient air monitoring for regional (8 km) and local (1.6 km) use.

Pesticide use density subgroups					
Pesticides	**Regional use**			**Local use**	
	Points	**kg / km²**		**Points**	**kg / km²**
Organophosphates					
	4	48-139[a]		4	50-22[a]
	3	27-43[b]		3	25-44[b]
	2	16-26[c]		2	15-23[c]
	1	2-15[d]		1	0-14[d]
Fumigants					
	4	201-2,215[a]		4	260-2,783[a]
	3	63-188[b]		3	47-246[b]
	2	13-60[c]		2	16-39[c]
	1	1-12[d]		1	4-7[d]
	0	None[e]		0	None[e]
Metals					
	4	1,388-3,865[a]		4	1,119-2,876[a]
	3	544-1,132[b]		3	335-840[b]
	2	257-503[c]		2	16-256[c]
	1	1-241[d]		1	2-11[d]
				0	None[e]
"Analytical method available" pesticides[f]					
	4	62-99[a]		4	68-197[a]
	3	42-58[b]		3	39-61[b]
	2	27-41[c]		2	23-37[c]
	1	1-26[d]		1	1-22[d]

[a] Community quartile rank = ~ highest 20 communities
[b] Community quartile rank = ~2nd 21 communities
[c] Community quartile rank = ~3rd 21 communities
[d] Community quartile rank = ~lowest 21 communities
[e] A few communities had no reported use of some of the pesticide subcategories; they received 0 points
[f] "Analytical method available" pesticides refer to those that had been included in a multi-pesticide analytical method CDPR used previously (Wofford et al. 2003a) or that would be included in the method modified for this study (Hengel and Lee 2013).

Table 7 The 27 communities that had the highest total scores among the 83 communities that CDPR evaluated as candidates for ambient air monitoring, with their categories, subcategories, points assigned, average, and total scores. Each subcategory is assigned a point value of one to four (or zero if no data were available) with four representing the highest priority for monitoring (see Tables 3-6 for more information about the points associated with each score). The subcategories' points are averaged. These three average scores are summed to give the total score (maximum points possible = 12). Regional pesticide use density = 8 km from the community boundary; local pesticide use density = 1.6 km from the community boundary.

Community	**Criteria**																	
	1. Social Demographics and Human Health					**2. Availability of Data for Cumulative Impacts Evaluation**			**3. Pesticide Use Density**									
	Subgroups					**Subgroups**			**Subgroups**									**Total Score**
	Child Population	**Non-white Population**	**Income**	**Drift Illness**	**Avg. Score**	**Well Monitoring**	**Air Monitoring**	**Avg. Score**	**Regional OPs[a]**	**Regional Fumigants[b]**	**Regional Metals[c]**	**Regional Analytical Method Available Pesticides[d]**	**Local OPs**	**Local Fumigants**	**Local Metals**	**Local Analytical Method Available Pesticides**	**Avg. Score**	
	Points					**Points**			**Points**									
Parlier	4	4	4	0	**3.0**	4	3	**3.5**	4	4	4	2	4	4	4	2	**3.5**	**10.0**
Visalia	3	1	1	4	**2.3**	3	4	**3.5**	3	3	2	3	3	3	2	2	**2.6**	**8.4**
Arvin	3	3	4	4	**3.5**	3	2	**2.5**	3	4	4	2	3	4	4	3	**3.4**	**8.4**
Orange Cove	4	4	4	0	**3.0**	4	0	**2.0**	4	3	2	4	4	1	3	4	**3.1**	**8.1**
London	3	2	4	0	**2.3**	4	0	**2.0**	4	4	3	3	4	4	4	4	**3.8**	**8.0**
Cutler	4	3	4	0	**2.8**	3	0	**1.5**	4	3	3	4	4	4	3	3	**3.5**	**7.8**
Reedley	4	2	1	2	**2.3**	4	0	**2.0**	4	4	3	3	4	4	3	2	**3.4**	**7.6**
Farmersville	4	3	3	0	**2.5**	4	0	**2.0**	4	3	2	4	4	4	2	2	**3.1**	**7.6**
Orosi	3	4	3	0	**2.5**	3	0	**1.5**	4	3	3	4	4	3	3	4	**3.5**	**7.5**
Sanger	4	2	2	0	**2.0**	4	0	**2.0**	4	3	4	3	4	3	4	3	**3.5**	**7.5**
Selma	4	3	2	0	**2.3**	4	0	**2.0**	4	4	4	2	3	3	4	2	**3.3**	**7.5**
Ivanhoe	3	3	3	0	**2.3**	4	0	**2.0**	4	2	2	4	4	3	2	4	**3.1**	**7.4**
Dinuba	4	2	2	1	**2.3**	3	0	**1.5**	4	4	3	4	4	4	3	2	**3.5**	**7.3**
Traver	1	2	4	0	**1.8**	4	0	**2.0**	4	3	3	4	4	4	3	3	**3.5**	**7.3**
Exeter	4	1	1	2	**2.0**	4	0	**2.0**	4	2	2	4	4	3	3	4	**3.3**	**7.3**
Calwa	3	4	3	0	**2.5**	4	0	**2.0**	2	4	4	1	2	4	4	1	**2.8**	**7.3**
Woodlake	3	3	4	0	**2.5**	4	0	**2.0**	3	2	1	4	3	3	2	4	**2.8**	**7.3**
Madera	3	2	3	2	**2.5**	2	3	**2.5**	2	2	4	2	1	1	4	2	**2.3**	**7.3**
Fresno	4	2	2	0	**2.0**	2	4	**3.0**	2	2	4	2	1	3	3	1	**2.3**	**7.3**

Kingsburg	3	1	1	0	**1.3**	4	0	**2.0**	4	4	4	3	4	4	4	4	**3.9**	**7.1**
Poplar	2	4	3	0	**2.3**	4	0	**2.0**	3	3	2	4	2	4	2	3	**2.9**	**7.1**
Lindsay	4	3	4	0	**2.8**	3	0	**1.5**	4	0	2	4	4	0	3	4	**2.6**	**6.9**
Huron	4	4	4	0	**3.0**	0	0	**0.0**	4	4	4	4	4	3	3	3	**3.6**	**6.6**
Strathmore	2	3	3	0	**2.0**	4	0	**2.0**	4	1	1	4	4	0	3	4	**2.6**	**6.6**
Earlimart	4	4	4	4	**4.0**	0	0	**0.0**	2	2	4	1	2	3	4	2	**2.5**	**6.5**
Mendota	4	4	4	0	**3.0**	2	0	**1.0**	3	3	3	3	3	0	2	3	**2.5**	**6.5**
Clovis	3	1	1	1	**1.5**	3	4	**3.5**	1	2	2	1	1	2	1	1	**1.4**	**6.4**

[a]OPs = organophosphate pesticides, specifically azinphos-methyl, chlorpyrifos, diazinon, dichlorvos, dimethoate, malathion, methyl parathion, methidathion, oxydemeton-methyl, parathion, phorate, phosmet, and SSS-tributylphosphorotrithioate.
[b]Fumigants = 1,3-dichloropropene, chloropicrin, MITC, and methyl bromide.
[c]Metals = sulfur and copper.
[d] "Analytical method available" pesticides = (S)-metolachlor, carbaryl, cypermethrin dicofol, diuron, EPTC, oxyfluorfen, permethrin, simazine, and trifluralin.

Figure 1 Pesticide selection process.

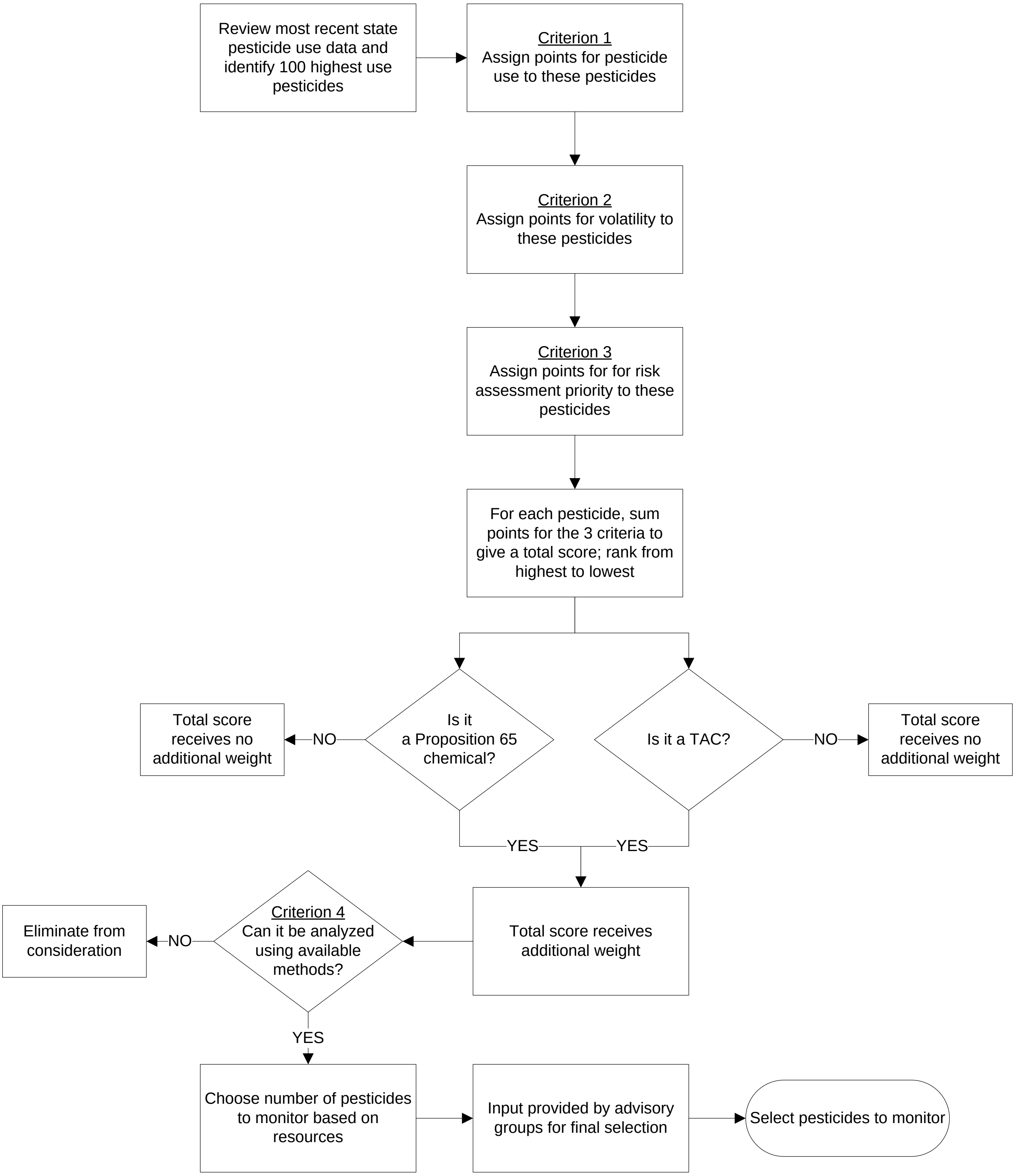

Figure 2 Community selection process.

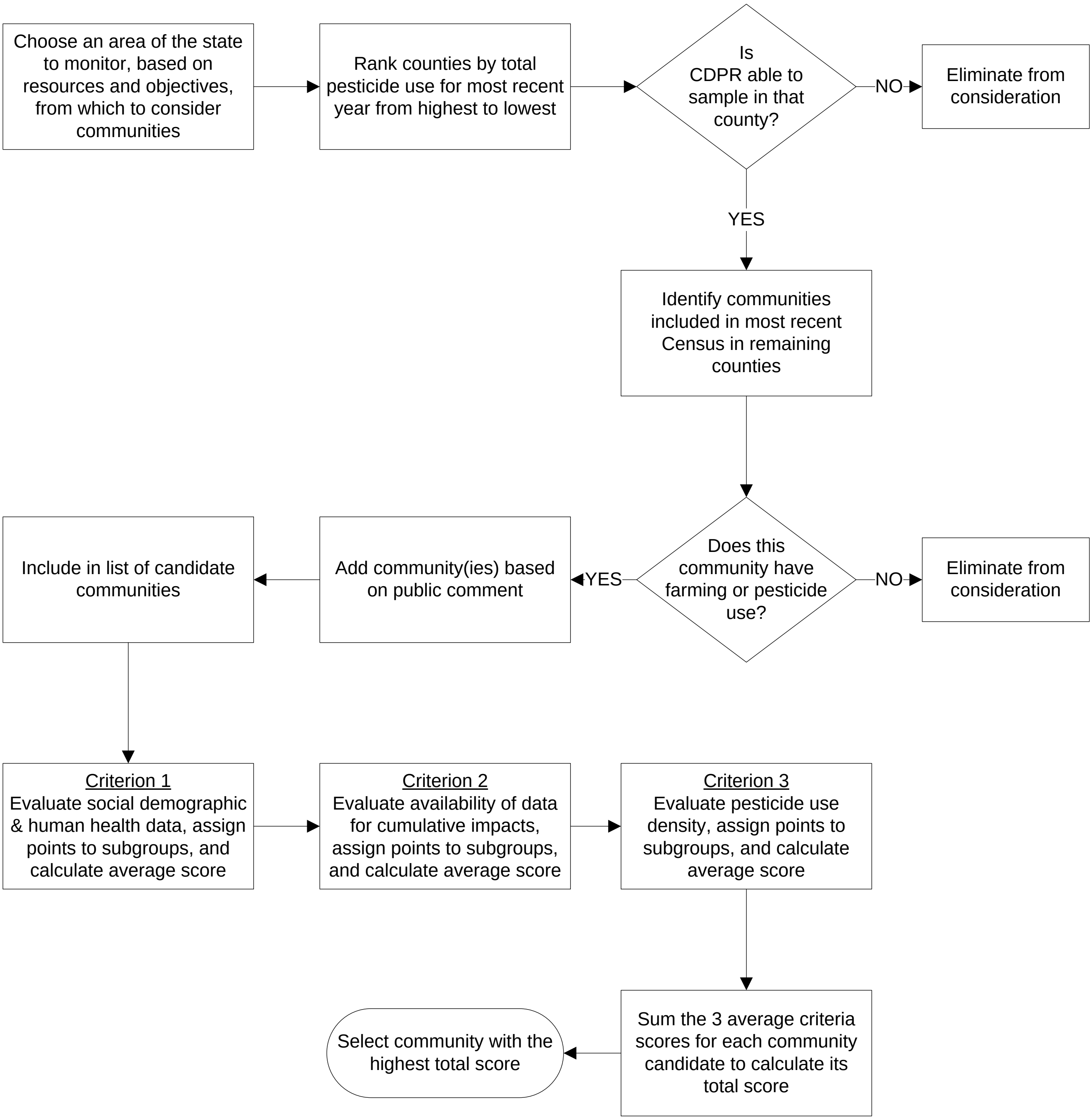

Figure 3 Map of a portion of the San Joaquin Valley in CA showing locations of the 27 communities *(black dots)* with the highest total scores, among 83 considered for ambient air monitoring. Map of CA. *Insert* shows a map of CA; *the black box* indicates the enlarged area.

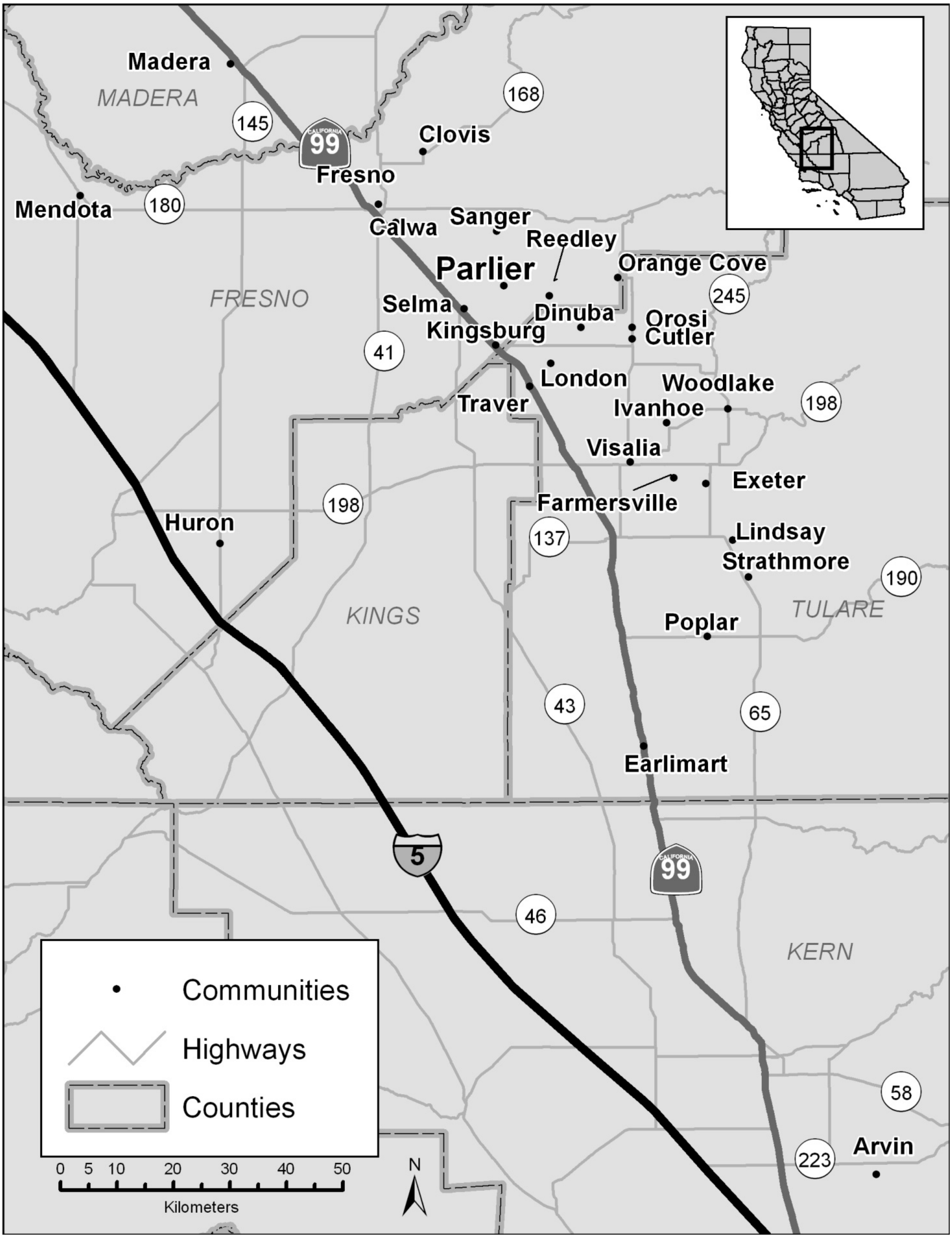

Figure 4 Average scores for reported pesticide use density, availability of cumulative impacts data, and demographics and health criteria for the 27 communities with the highest total scores.