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REPORT:
FIFRA Scientific Advisory Panel Meeting,
July 23, 1999, held at the Sheraton Crystal City Hotel,
Arlington, Virginia

Session IV -A Set of Scientific Issues Being Considered by the Environmental Protection Agency Regarding:

Spray Drift - Review of Proposed Pesticide Deposition Curves to Adjacent Areas

Mr. Paul Lewis
Designated Federal Official
FIFRA/Scientific Advisory Panel
Date:_____________________

Christopher Portier, Ph.D
Chair
FIFRA/Scientific Advisory Panel
Date:_______________________

FEDERAL INSECTICIDE, FUNGICIDE, AND RODENTICIDE ACT
SCIENTIFIC ADVISORY PANEL MEETING
JULY 23, 1999

Session IV -Spray Drift: Review of Proposed Pesticide Deposition Curves to Adjacent Areas

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PUBLIC COMMENTERS

Oral statements were received from:
Mr. Dave Esterly, DuPont Agricultural Products representing the Spray Drift Task Force
Mr. David Valcore, Dow Agricultural Sciences representing the Spray Drift Task Force

Written statements were received from:
No written comments were received.

INTRODUCTION

The Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), Scientific Advisory Panel (SAP) has completed its review of the set of scientific issues being considered by the Agency regarding Spray Drift - Review of Proposed Pesticide Deposition Curves to Adjacent Areas. Advance public notice of the meeting was published in the Federal Register on July 6, 1999. The review was conducted in an open Panel meeting held in Arlington, VA, on July 23, 1999. The meeting was chaired by Christopher Portier, Ph.D, National Institute of Environmental Health Sciences, Research Triangle Park, NC. Mr. Paul Lewis served as the Designated Federal Official.

The purpose of this session was to examine the validity of an approach developed to place bounds on the Spray Drift Task Force data for ground hydraulic boom and orchard airblast spraying applications. Curves developed from bounds are intended to be used in environmental exposure assessments to estimate deposition over a range of distances, replacing the use of a fixed estimate. The proposed bounding method is intended to be adaptable to allow the addition of data from new or existing application methods. Mr. Arnet Jones (Office of Pesticide Programs, EPA) discussed the goals and objectives of the Agency's presentation. Norman Birchfield, Ph.D, (Office of Pesticide Programs, EPA) summarized ground hydraulic spray drift data and analysis. Terrell Barry, Ph.D. (California Department of Pesticide Regulation) and Mr. David Farrar (Office of Pesticide Programs, EPA) summarized statistical analysis and bounded deposition curves. Concerning orchard airblast, Norman Birchfield, Ph.D. (Office of Pesticide Programs, EPA) made a presentation on orchard airblast spray drift data and analysis followed by Mr. David Farrar (Office of Pesticide Programs, EPA) summarizing statistical analysis and bounded deposition curves.

CHARGE

The specific issues addressed by the Panel are keyed to the background documents entitled "Downward Deposition Tolerance Bounds for Ground Hydraulic Boom Sprayers" and "Downward Deposition Tolerance Bounds for Orchards", dated June 21, 1999, and are presented below.

1. Do the data provide a sound basis from which to generate deposition curves which can be used in risk assessments?

2. What significant limitations, if any, exist in the ground hydraulic and orchard data in terms of:
a) application equipment (e.g., nozzles, sprayers)?

b) meteorological conditions (e.g., temperature, humidity, wind speed)?

c) site conditions (e.g., terrain, crop canopy)?

d) reliability of deposition data (e.g., tank mix tracer concentrations, analytical recoveries)?

3. Is the method used for generating the deposition curves appropriate given the data from which they were developed?

4. Does the SAP agree that the proposed approach is an improvement over the current methods used by OPP to predict deposition from off-target spray drift?

5. Given the available information, do the 95th percentile values for the deposition curves appear:
a. justified? Are additional correction factors required?

b. realistic? Do the percentile calculations overestimate "real world" levels?

6. Considering the performance of the tracers, is it appropriate to use target application rates for calculating deposition results?

Orchard only

7. Will the outlined method for incrementally increasing orchard size by summing depositions from inside treatments with increasing offsets be appropriate for adjusting results to varying sized orchards?

8. Are the given orchards groupings (high and low) reasonable for:
a. statistical purposes?

b. risk assessment purposes?

DETAILED RESPONSE TO THE CHARGE

1) Do the data provide a sound basis from which to generate deposition curves which can be used for ecological and human health risk assessment and in risk management?

The data generated in both the Ground and Orchard field tests provide a somewhat sound basis for generating deposition curves, but they are very limited in terms of the number of variables and the number of measurements made, especially when considering the complexity of pesticide spray drift. The data do not provide a comprehensive model of ground-applied spray drift, nor will they support a complete understanding of the way the many mechanical, meteorological, chemical, and site variables affect drift.

The critical part of this question is -- "which can be used for ecological and human health risk assessment." While the reported results may be an adequate descriptor for the specific sets of conditions and treatment parameters examined, they are not generally representative enough to provide a reliable basis for estimating risk assessments over the broad range of instances of spray application pertinent to the overall topic of ecological and human health.

Having some drift deposition data certainly it is better than having none at all and is certainly better than making a simplistic assumption that is applied to all spray drift situations. It is difficult to generate meaningful statistics when only one or two replications are used to describe phenomena that are highly variable. There was inadequate replication of these field tests, and the data generated provided little knowledge of the variability in similar applications. The restricted range of many of the important variables limit the ability to accurately determine the equation coefficients; i.e., drift cannot be reliably predicted from a specific chemical application in which one or more of the variables lie outside the studied range. The effects of the variables must be confounded (in a statistical sense) which limits sensitivity.

The greatest value of these data is in the verification of a model shape or general equation of drift. It would be useful, and in some senses preferable in orchards to select one or two crop-and-equipment configurations with which to conduct a large number of replications for data collection under conditions in which some of the uncontrolled variables might cluster around a typical range of values, and from which more reliable assumptions and predictions could be made about deposition trends in general (done for ground spray studies). This might lead to the development of a reasonable model of reinterpreting spray drift trends for different spray configurations and situations.

Although the data used to generate these curves are likely the best available, there are significant shortcomings, limitations, and uncertainties associated with them. These limitations and uncertainties are discussed in detail in the responses to the questions that follow, and are briefly summarized here:

There was no mass balance accounting of the material applied based on the *actual* application, (i.e., samples taken directly from nozzles pre-and post- spray).

Uncertainties associated with the tank mixture concentrations, collection efficiency of cards, analytical techniques, tracer stability, etc., are not included in the curve generation. Without the incorporation of these uncertainties, the deposition curves will not accurately reflect drift to real world targets.

Meteorological conditions during all the tests were cool and dry, and hot and dry with similarities in terms of wind speed, wind angle, ambient temperature and relative humidity. All the tests were conducted only during stable and unstable atmospheric conditions. No tests were conducted during stable conditions. This is a very important omission. As stated in the test report “stable atmospheric conditions, generally result in higher drift potential.” The finding that wind speed is not a significant factor that affects drift and the unexpected differences in wind effect on small and large drops is more an indicator of the weakness in the data than actual physical phenomena.

The spray practices used on the test fields may not be representative of what is commonly used. Only 4 parallel swaths measuring 13.7 by 305 m were used to generate the deposition curves. This does not relate to a typical field and will not accurately reflect what happens with applications of multiple passes on large fields or to applications to multiple fields upwind of potential problem sites.

Previous reviewers exhaustively detailed these limitations and raised questions that need to be addressed *concurrently* with implementation of the data sets. It appears that appropriate adjustments and factors of safety should be added to the deposit levels. Also, an examination of other spray deposition studies is warranted. The results of the other studies should be compared to the tolerance bounds to determine if the bounds truly are conservative when a wider range of sites and meteorological conditions are considered.

In summary, the use of this field data and the resulting drift vs. displacement deposition curves to assess real risk to real targets should be done with caution and with full knowledge of the numerous limitations listed above. It should also be kept in mind that these data were not generated with modeling in mind, as was mentioned during the Public Comment session of the meeting.

2) What significant limitations, if any, exist in the ground hydraulic and orchard data in terms of:

2a) Application equipment (e.g., nozzles, sprayers)?

Ground: Standard applicator practices were not specified in the report, and no justification was provided for selection of equipment, especially nozzles, as noted in the Agency's background document. Were the spray practices used in the studies representative of what in commonly used or were they better than the practices that might be followed by farmers in the real world? For example, do farmers turn nozzles off at orchard edges? Is their equipment always in excellent working condition? Are wind speeds always as low as in the field studies?

The selection of the 8010LP and 8004LP nozzles bear little resemblance to the typical selection in the field. “LP” nozzles are an old design that are nominally rated at 15 psi as compared to 40 psi for other nozzles. In other words, the 8004LP provides 0.4 gallons per minute of flow at 15 psi, whereas the (plain) 8004 provides 0.4 gallons per minute at 40 psi. The net result of using “LP” nozzles is significantly increased droplet sizes. Further, use of “drift reduction” nozzles on most row crops typically produce from 400 to 500 µm (VMD) sprays at usually no more than 10 gallons per acre spray rate. Increased spray rates reduce productivity through the need to refill often.

The test equipment appears to have been purposefully selected to provide a range of droplet sizes. The expected droplet sizes were estimated from laboratory tests. The actual droplet size spectrum resulting from nozzles of a particular type and fluid pressure, however, also depends on the fluid properties. Use of the same nozzles with different fluid properties will result in different results. Use of certain additives, temperature, and other factors can significantly affect fluid properties and therefore droplet size especially at low liquid volume application rates. The nozzle selection is not as critical, *per se,* than the overall ranges of droplet sizes tested for drift over varying environmental conditions.

Use of the TX6 nozzle at 15 mph and 50 inches boom height is a possible spray application method if the applicator is in a hurry and is less conscientious of the potential for drift. Increased spray rates, however, reduce productivity through the need to refill often. It should be noted that maintaining lower booms heights are often difficult with 60 ft and 80 ft boom lengths on non-flat and/or rough topography.

Public commenter, David Valcore, of the Spray Drift Task Force (SDTF) commented that the nozzles/sprayers were selected on the basis of providing a *worst case* situation for drift. This fact was neither stated in the EPA Background Document nor in any of the reviewers reports. In fact, previous reviewers commented that no explanation was provided to "justify the selection of the application equipment or operating parameters as representative of those in common use". Apparently, "No applicator surveys were done by the SDTF prior to spray ground trials."

The literature should be searched or a survey performed among extension agents, chemical suppliers, and growers in several representative states to establish what are typical operational practices in ground hydraulic spraying. It would then be possible to reference the database/model to the real world with defined confidence.

The intention of keeping the model flexible is laudable. As new technology and methods become adopted, EPA should periodically review the basis of the model to ensure that it reflects current operating practices. The model should not necessarily be focused on worst-case scenarios, but everyday equipment and operating practices.

Orchard: Before conducting the orchard studies, the SDTF conducted a survey of 59 growers in 9 states and based their choice of representative types of sprayers on those most commonly used in the field. Most reviewers agreed that droplet spectra did not vary much among different examples of airblast sprayers. The mist blower was the only piece of equipment that produced a different (smaller) spectrum. The four sprayers used for application, while not comprehensive, did represent a good cross section of equipment that is most often used. The grower survey, the results, and the basis for equipment selection, however, need to be published. One result of the survey that was not incorporated into the study design was the growing tendency in the industry to use tower sprayers. The Agency will need to incorporate this kind of sprayer into their model if the data are to be augmented in the future.

Although the sprayer types chosen to conduct the various orchard tests were quite representative of the designs and makes commonly used in commercial operations, certain aspects of the application methodology were not examined for their effect on deposition and apparently not even stated in the report for purposes of documentation. One important such parameter is the travel speed of the sprayers through the orchard plots. Most growers are accustomed to traveling at a certain *medium* speed for routine applications and when the orchard is in full leaf, but they routinely slow down or speed up for certain sprays, depending on the orchard phenology, the environmental conditions (weather), or the importance of coverage in control efficacy of a given pest. Any of these variations would be expected to have an important influence on spray drift and deposition.

Another potentially significant variable among orchard applications is airstream velocity produced by the fan. Although airstream velocities were reported to be identical in the different AGTec spray trials, no mention was made of their values relative to the radial blast sprayers, nor of the actual value. Many sprayer fans have a high- and low-speed adjustment, and grower choice of the setting to use is frequently related to orchard type and planting style. Similarly, pump operating pressure is a frequently varied parameter according to sprayer and application type, which can have a significant effect on droplet size and consequent drift potential.

2b) Meteorological conditions (e.g., temperature, humidity, wind speed)?

The range of temperature and relative humidity, both of which affect evaporation rate and therefore drift were very limited during the tests. These variable effects seem to be confounded. More significant than the limitations in temperature, humidity, and wind speed (which denied the use of the standard treatment spray for comparisons and best summarized by R. Mickle, review, Fig. 9 of the Agency's background document), is the limitation in atmospheric stability conditions. Under *ideal* spraying conditions, an updraft of air due to thermal heating carries spray particles upward so that they are not deposited downwind. The subject data were obtained under essentially ideal atmospheric stability conditions as indicated by the Richardson numbers. In other words, high wind speed is not necessarily a *worst case* scenario. It must be considered, however, since there was no crop canopy in the Ground-spray trials; a *worst case* scenario element is already included in the model.

Several reviewers stated that very few runs were performed at low wind speeds. The relatively high wind speeds in which the studies were performed contributed to the mostly near-neutral stability of the atmospheric conditions experienced in most of the runs. A few test runs were made under moderately unstable conditions. Some reviewers pointed out that, as a result of limiting the experiments to these near-neutral/unstable conditions, potentially high-drift scenarios were not investigated.

In order for the Agency to have a comprehensive drift prediction model for hydraulic ground sprayers, it needs to take into account atmospheric conditions that could result in high levels of drift. One reviewer suggested incorporating data sets from other studies to enlarge the applicability of the model. This should be considered, with studies that have been subjected to the peer-review process. Research groups which still have access to raw data would be of particular benefit, as essential details (such as the boom height used in the Ganzelmeier study) could be added to the published data. Given that the Ganzelmeier study was done for regulatory purposes under very likely stringent European Union rules, it is very likely that data missing in the study publication are available to the Agency. Contact should be made with the principal investigators to obtain these missing data points.

Because the proposed model lacks data suitable for modeling potentially high-drift meteorological conditions, the Agency may be forced to return to its existing assumption procedure where a fixed amount of drift is assumed to occur. The alternative of using other researchers' data, which may not have been subject to the same GLP procedures as the SDTF data, is an acceptable compromise.

The lack of correlation of drift with increasing wind speed was somewhat surprising as previous studies have shown a close correlation between these two variables. Figure 4 (8004 nozzles) seemed to indicate a marked wind effect between the 3 trials grouped at 7 mph and the two grouped at 11 mph approximate wind speeds. The Agency should assure themselves that maximum statistical investigation was used to establish whether this lack of correlation is the correct conclusion from the data.

There was limited range of stability ratio in the tests. This model would likely be inaccurate with stability ratios outside the range encountered in this study because of droplet transport and collector efficiency changes. Stable or inversion conditions such as those which occur in the humid south should certainly be avoided. Wind speeds were mostly high, leaving open the question of what happens at lower speeds. To say that drift is not affected by wind speed goes against previous findings in the published literature.

Wind speed and stability also affect deposition to targets, such as flat cards, leading to questions about the measurements of downwind deposition in this study. If droplet sizes become smaller downwind, then the collection of droplets on targets has a distance bias, because collection efficiency may not be constant for droplet size.

Based on the wind velocity and direction data, there appear to be no significant difference in wind among sites. Such a difference is necessary for determination of drift correlations with wind velocity. Maybe regional scenarios would be appropriate as suggested by a previous SAP (i.e., December, 1997).

The Panel suggests that the figures in the Agency's background document indicate that wind velocities were kph, not mph. The Agency should confirm that these units are correct; this could result in major differences in assessing the comprehensiveness of drift occurrence. Also, the elimination of the 23 mph data point because it was significantly different from other wind data seems inappropriate.

Orchard: The comments for ground hydraulic sprayers are also very applicable to orchard sprayers. Two thirds of the users surveyed stated that they sprayed at night, when stable atmospheric conditions are common, and most would spray during the early morning. No trials were performed under stable conditions. Consequently, there is a significant lack of contributing data in the model for conditions that would be very conducive to drift.

Most applicators adhere to a set of personal guidelines governing when they will and will not spray, for instance, avoiding periods above a certain temperature or humidity level, because of concerns over efficacy or phytotoxicity. It might have been reasonable, as well as a way to limit some of the inherent variability of the results, to put bounds on some of the meteorological conditions under which these data were collected.

The elimination of the very high wind speed trial data was appropriate. However, the confounding of canopy type with wind speed has been pointed out by reviewers. This was overcome by grouping the data into high drift and low drift categories. The intention to keep the model flexible and allow future redefinition of groupings is laudable.

The SDTF report states that the majority of the applications were made under unstable environmental conditions and that, since stable conditions would be expected to result in high drift potential, use of the data should not be extended to stable situations. Although some growers in the survey reported a willingness (sometimes presumably brought about by a necessity) to spray under unstable conditions (e.g., during periods of strong wind), it is not generally recognized as a standard practice to opt for these periods as the preferred time to apply sprays. Most growers try to go out of their way to carefully choose a stable set of conditions under which to spray to optimize coverage, many times waiting until the dusk and nighttime hours to avoid the wind. Bearing this in mind, the data would appear to be incomplete if they do not include any instances where the environment was relatively stable.

The actual meteorological data were recorded, but not reported. Therefore, there is no way of knowing how representative the test conditions actually were. There is a need to include a better distribution of high wind scenarios. This, however, is not as critical in the orchard scenario as in the row crop situation. The test scenarios are not representative to those in other orchard areas of the country such as west Texas, New England, or Washington.

2c) Site conditions (e.g., terrain, crop canopy)?

Ground and Orchard: The intention of modeling worst case scenarios makes the choice of short mown grass appropriate for the ground sprayer study, as spraying can take place in a range of environments ranging from bare ground to a high crop. The selection of many different orchard canopies at different times of foliation represents as comprehensive a study as is possible given finite resources. The sites seem well selected, but two treatments under similar conditions are inadequate to determine the inherent variability in the drift from such applications.

The site conditions seem adequate. However, differences in results with different crop surface, i.e., a different crop condition, may have captured more of the drift leaving less for capture downwind. The chosen conditions would produce more conservative prediction curves.

One reported trial in which a spray test was not conducted due to high winds, but whose collectors were analyzed nevertheless, showed downwind deposit levels which were "equivalent to or greater than the deposit measured during a field trial [with] deposit fall-off similar in shape to other ground trials." Although high winds picking up contaminated dust was the given explanation, 25% of the trials were done under high wind conditions, where winds exceeded 20 km/h. This observation was not commented by the Agency in its background document. It should be investigated and explained as it represents a serious challenge to the validity of the ground sprayer data set.

There is evidence of serious data contamination in some of the trials (Mickle, Ground Review, Figure 6). There is also evidence that the tank material was not well mixed and therefore the baseline for spike weathering was not known (not to mention the actual emission rate at any point along the release swath). Apparently, a weathering correction was not applied to the data even though there was possibly around 30% loss at the low level spikes. These various uncertainties probably obscure other relationships, such as the relationship with wind speed, which is surprisingly weak in these data. Using a curve with distance from the application area is probably better than assuming a straight percentage of material drifts, but given the uncertainties in the data it is not clear that the relationship based on these data is sound.

Uncertainties should be estimated that are based on the physical evidence of contamination, tank mix variability, and weathering. These uncertainty estimates should always accompany exposure levels calculated based on the curves. Also, a formal process that includes related peer reviewed studies as they become available should be developed. This will allow better estimates to supersede these curves, as appropriate.

2d) Reliability of deposition data (e.g., tank mix tracer concentrations, analytical recoveries)?

Ground: It appears that no adjustments (other than wind direction) were made to the deposition data for the actual sprayed material (tracer concentration), the sampler efficiency, and the recovery. The measured deposits, especially in the far field, underestimate actual deposit levels without proper adjustments.

Although the tank samples showed considerable variability and post-spray samples tended to show lower tracer values than pre-spray samples, there appears to be no sensible adjustment that can be made to the data. Similarly, possible hydrolysis or aquatic metabolism of tracers cannot be accounted for except by reference to fortification studies.

The collector fortification and long-term storage data would seem to show degradation trends according to reviewers and the Agency's background document. There seems, however, to have been no correction made in the model for these findings. If appropriate statistical tests indicate that corrections are valid, they should be implemented into the data set.

The model curves are based on the percent of application rate - which is a direct function of the tank mix concentration. The reported variability of tank mix concentration is cause for concern. Was this a normal sampling error or was it a result of poor mixing, poor sampling technique, or lab analysis? One must suspect the accuracy of quantitative estimates from the curves. If tank mix normally varies this much, then the curve estimates must be expected to vary as well.

Sampling of deposition itself is difficult to control. The collection efficiency of flat surfaces (cards) varies with wind speed and droplet size and the collection efficiency of cards for very small droplets is much less than for larger droplets. How can a flat surface be compared to crop surface? The applicability of the results to deposition on a real target whether it is a susceptible crop, water surface, or human, is questionable.

Spike recoveries are somewhat variable, which is troubling. pH measurements should be made following tank adjustments.

The model curves are based on the percent of application rate - which is a direct function of the tank mix concentration. This is of concern because of the reported variability of tank mix concentration. Was this a normal sampling error or was it a result of poor mixing, poor sampling technique, or lab analysis? One must suspect the accuracy of quantitative estimates from the curves. If tank mix normally varies this much, then the curve estimates must be expected to vary as well.

Orchard: Although the tank samples showed considerably variability, and post-spray samples tended to show lower tracer values than pre-spray samples, there appears to be no sensible adjustment that can be made to the data. Similarly, possible hydrolysis or aquatic metabolism of tracers cannot be accounted for except by reference to fortification studies.

As with the ground spray trials, the collector fortification and long-term storage data seem to show degradation trends according to reviewers and the Agency's final report. However, no correction seems to have been made in the model for these findings. If appropriate statistical tests indicate that corrections are valid, they should be implemented into the data set.

The replication of tests is a concern. The cost and resources required to make fully replicated tests and the random nature of the weather make the limited replication understandable. The normal variability of the data is unknown, which makes it more difficult to accept the reliability of the data for generation of regulatory curves.

There appear to have been some difficulties related to tank mix stability and uniformity, which obviously could have a significant effect on deposition rates, and which was apparently not dealt with very adequately in the assessment of the results. Furthermore, some inconsistencies in handling and other factors such as potential hydrolysis or volatilization of the pesticide tracers also combine to result in an overall weak point for this entire aspect of the study. Considering some of the levels of precision the SDTF is attempting to reach by using these data, the relatively poor handling and unaccounted variability of the tracer parameters tend to impart an element of lowered standards to this area of the work-- in contrast to the relative high quality evident otherwise. Actual field measurements in ten orchards from each of two regions have shown that around 240 replicate measurements of tank contents under field conditions produces as SE of 4 to 6%.

Again, replication of tests is a concern. It is recognized that the costs and resources required to make fully replicated tests is high. It is, however, difficult to accept the reliability of the data for generation of regulatory curves with so few replications since the weather is random by nature and the normal variability of the data under similar conditions is unknown.

3) Is the method used for generating the deposition curves appropriate given the data from which they were developed?

The methods used to generate the deposition curves were well thought out and are a considerable improvement over the methods currently used to estimate off-field exposures in pesticide risk assessments.

The use of a univariate regression approach constrains the analyses somewhat, because separate analyses must be done for each combination of spray droplet size and boom height (for ground hydraulic applications) or for each orchard group (for orchard airblasts). A multivariate regression approach is worth considering. The inputs could include a number of variables that affect spray drift (e.g., droplet size, boom height, wind speed, wind direction, atmospheric stability, canopy height, etc). The result of such an analysis would be a single model for each of the ground and orchard applications. Pesticide risk assessors could then use the models to estimate spray drift given certain application practices, meteorological conditions, and site conditions. Sensitivity analyses could also be performed on such models to determine the most important input variables. If there is considerable uncertainty regarding important input variables, then future research would be targeted at these variables.

The deposition curves are not as user friendly as they could be. Potential users must select the correct curve and correct for initial tank concentrations, sample losses during storage, collection efficiencies, field sizes, etc. As much as possible, the corrections should be incorporated in the deposition curves to make these steps easier for the user. The deposition curve models should also include a field size variable so that outputs are automatically scaled to field size. To estimate concentrations in ponds, the models could automatically do the integration to take account of pond depth.

To make the deposition curves more useful for risk assessment, it would be useful to present both upper and lower tolerance bounds.

Page 30 of the Agency's background document, with respect to the model coefficients, states that "at higher wind speeds the rate of decline in deposition with distance tended to increase" and "is contrary to the expected trend" and "may be due to lower collection efficiency of the alpha-cellulose cards at higher wind speed." Similarly, "as the wind angle increased, the value of the decline parameter also increased, so the rate of decline decreased. This is also contrary to the expected trend." Even R. Mickle's suggestion of adding 1 standard deviation to the wind angle still resulted in a lack of correlation between wind angle and far-field deposition (p 33, Background). Thus, these predictions are of concern.

The exponential decline equation and uses of constants (a) and (b) appear to be suitable, and the concern lies with original deposit data. Again, use of appropriate adjustments and factors of safety would, for the most part, address concerns for predicting drift for the atmospheric conditions tested. Methods to extrapolate the drift deposits for less ideal atmospheric conditions are not addressed.

The use of 95% confidence limits on a 95th percentile seems very conservative. Will this result in overly restrictive buffer zones and regulations?

There were several cases where the decline parameter (b) behaved counter-intuitively to what would be expected. It was hypothesized that the cause of such behavior could be due to decreased catch efficiency of droplets made smaller through evaporation. This hypothesis should be established convincingly through the use of established modeling procedures. In some of the extreme cases (e.g., 104ºF, 14% RH in California in the orchard airblast study), it is somewhat surprising that any droplets survived extinction beyond a very limited travel distance.

Because the flat cellulose acetate collectors were mimicking a flat water surface or an asphalt surface, it seems likely that the decreased catchment experienced by the collectors under some of the tested conditions would similarly occur with a pond (under low wind conditions) or a school playground.

4) Does the SAP agree that the proposed approach is an improvement over the current methods used by OPP to predict deposition from off-target spray drift?

It is the understanding of the SAP that the proposed approach is to allow for calculation of buffer zones since current methods are only applicable to an assumed 1% of the field spray into an assumed size pond adjacent to the field.

The proposed method has the potential for being an improvement, but only on the condition that the above-stated limitations are addressed before implementing the model. Some confidence intervals, that are not just upper confidence intervals, are needed. In addition, more regionally realistic data are needed.

The use of curves of the form developed in this report and within the limitations of the variables used would be superior to the use of a constant value (as is currently done) and would give new capability of estimation of drift from multiple passes and large fields. However, one would not expect to receive accurate values for drift prediction to a realistic target for a specific case.

An equally important factor, and perhaps there is a standard for this -- is the assumed size and layout of the field that is being sprayed. In other words, larger sprayed fields have the potential for increased spray drift.

The proposed approach using empirically based models represents a major advance over the current proportionate method. Flexibility in the models is essential so that they can be updated as new validated data sets become available. This applies to different application practices that were not tested in the field study (e.g., low-drift venturi nozzles), as well as a range of different formulations/additives (many of which were tested in the atomization study, but not in the field study).

The aerial application community has tools like AgDRIFT which allow the tailoring of the model to defined application situations through the input of many specific variables. The long-term goal of the Agency should be to aim towards a verified AgDRIFT type model for ground sprayers, allowing custom setting of numerous meteorological and application variables.

5) Given the available information, do the 95th percentile values for the deposition curves appear:

5a) Justified? Are additional correction factors required?

Given the data, it would seem a conservative approach. The charts showed that the actual deposition to targets was usually lower than the 95th percentile value. Most uncertainty comes from previously mentioned limitations in the data. The selected deviations from the range of variables studied could give drift values greater than 95th percentile curves. More data is needed to expand this model to a wider range of application choices.

Additional correction factors are required to account for initial tank concentrations, sample losses during storage, collection efficiencies during storage, field sizes, etc. Expecting the user to do these steps correctly is unreasonable.

It is hard to determine whether the 95th tolerance bounds for the deposition curves are justified and realistic because of limitations in the initial data sets. The statistical approach is justified but the underlying data may be sufficiently weak that our overall confidence in the bounds is not high (which is no fault of the statistical methodology). As recommended above, other field data sets need to be considered, perhaps quantitatively via a meta analysis.

Additional correction factors are needed on the actual data as stated above. There seems to be some conflict of whether the proposed 95th percentile values are literal 95th percentiles in terms of data scatter (p 37, Background). There are a number of interceptions and cross-overs between the data and 95th percentiles, especially cross over at the greatest distance (Figs 15-18, of the Agency's background document).

The variance in tank mix contents does affect deposition variation, but total off site deposition is integrated across all spray outputs. So, total offsite migration is balanced by high and low concentration scenarios.

5b) Realistic? Do the percentile calculations overestimate "real world" levels?

Again, the applicability of the results to deposition on real targets is in question. "Real world" levels of drift deposition only occur on real-world targets. The percentile calculations seem irrelevant when attempting to apply this approach to targets that breathe, move, and are not flat and vertical.

Because the bounds are upper 95th percentiles, they are designed to overestimate "real world" levels most of the time. This is fine for a screening level assessment where the goal is to determine whether a potential risk exists. However, to quantify risks in a higher tier assessment requires information on the entire deposition distribution at different distances from field edge.

From the evidence presented in the Agency's background document, the calculations don't seem to overestimate "real world" levels; however, the "real world" situation is not yet fully established. The extreme divergence of the 95th percentiles, based on the SDTF findings and the Ganzelmeier study, would indicate that the model is still at the development stage and should be open to revision as more high-quality ground spray drift studies become available.

In the present orchard model, the two different groups are essentially vineyards and orchards. A situation where dormant dwarf apple trees are in the same group as 60-foot high pecan trees with fully expanded canopies clearly shows the limitations of the data set that was used to construct the present model. The long term aim of the Agency should be to obtain more data from studies which would allow a more meaningful subdivision of the orchard group.

6) Considering the performance of the tracers, is it appropriate to use target application rates for calculating deposition results?

The studies indicate that target application rates were subject to much random noise. The regression analyses used to generate the spray deposition curves were based on a fixed-effects model (Model I regression) which basically assumes that the independent variable (target application rate) is not subject to random variation. In practice, this is not likely to occur often, but small random variation of the independent variable has only a minimal impact on the regression results. In this case, however, the independent variable is subject to much random variation. This suggests that a random-effects regression model (Model II regression) would have been more appropriate for spray deposition analyses.

There is less concern for the tracers than for the tank mix and target difficulties. The tracer materials are known to degrade and the study did quantify degradation but did not adjust for it. There are two sides of this. One is that these materials will degrade in the field, leaving lower measurements on the cards as well as on real targets. Perhaps this makes the uncorrected data more realistic for chemical exposure. However degradation (in the field and during storage prior to lab analysis) does give a reduced value that would lead to some underestimation of the actual material deposited.

For Orchard Only:

7) Will the outlined method for incrementally increasing orchard size by summing depositions from inside treatments with increasing offsets be appropriate for adjusting results to varying sized orchards?

The outlined method seems reasonable, but only for estimating deposition perpendicular to rows (the study orientation). As the authors pointed out, downwind deposition may be higher parallel to rows due to less restricted air movement in this direction.

The *inset* values that are applied to increasing distances inside an orchard to a given deposition point appear to be derived from a set of assumptions about how wind speed and wind angle vary according to the position inside of the orchard. However, equally important to the drift and deposition process (and somewhat independent of the wind factors) is how the canopy structure affects a spray according to how many additional rows the spray much pass through before it actually reaches a point outside of the orchard. It would seem that some functional relationship could be determined between canopy density, distance to the orchard's outside edge, and deposition, which could then be added into the function along with wind speed and angle, to arrive at a more realistic assumption of the amount of spray material that might be available to actually drift off-target.

There is a need to clarify the use of mathematical functions to describe drift from applications to outside and inside rows. Page 45 of SDTF Report I95-004 states that a linear function incorporating only rows 2-5 will be used to estimate drift from inside rows. The Agency presentations at the SAP meeting indicate the use of an exponential function. The exponential function should be used, but this needs to be clarified.

One Panel member indicated that the problem with this idea is not in the scheme itself, but it is with the implicit assumption that these deposition patterns are independent of wind speed and stability. For instance, in the lee of solid obstacles, a lee eddy will develop and pull material down from aloft (downwash). In this case, there may be more material deposited near the orchard than at lower wind speeds when downwash is weaker. In the case of plantings that are oriented in dense rows, downwashing may develop between the rows and will be dependent on row spacing. The turbulent structure over the orchard will also be a function of wind speed. In a stronger wind, the airflow is tripped at the upwind edge of the foliage, resulting in a strong downward component near the windward edge. At higher wind speeds, this motion will persist over the canopy and the flow may consist of rollers that will help push material back into the canopy. This will be especially prevalent over tall rough obstacles such as pecans. In this case, as an example, it will not be adequate to interpolate along the curve because more material is trapped from the interior rows.

Any drift study that concludes drift is not a function of wind speed needs to examine experimental procedures. In this study, the effect of wind is obscured by the attempt to describe a complex dynamical system statistically with a very small data set representing a limited range of conditions. This is exacerbated by various experimental problems such as contamination and variable tracer release due to tank mix problems. The issue of stability has been adequately covered previously but represents another serious concern in the implementation of the proposed method.

The bottom line is that the proposed method may be the best that can be done with such limited data. However, it is hoped that a physical model will be pursued that will describe drift from orchard airblast spraying in a realistic way.

8) Are the given orchard groupings (high or low) reasonable for:

8a) Statistical purposes?

The high and low orchard groupings seem contrived. Pecan and dormant apples orchards appear to differ dramatically in canopy structure and height and yet are placed in the same group. A multiple regression that includes information on canopy structure and height as input variables would seem a more appropriate way of dealing with orchard type effects on spray deposition.

Orchards should not be grouped. Field studies need to be conducted and/or reviewed to evaluate continuum of canopy parameters. Drift will occur across the spectrum of situations and not on the basis of a group.

Individual canopies are very different in height, spacing and density (Table 3, SDTF Report

195-004). Therefore, it is NOT correct to group them without statistically significant information on drift from each orchard type first. Grapes were removed from the larger list for this reason but the range in canopy type and density is still very large. Airflow and thus atmospheric transport of droplets will be effected differently dependent on the size and porosity of these barriers. Sub-groups of orchard types with much narrower ranges on porosity, height, and spacing are preferred. Unfoliated orchards (such as dormant apples) should be considered separately. In an ideal study, statistically significant replications should be taken on each orchard type since it is known that the dynamics differ for each situation (such things as foliage element size and stiffness are not considered in this study at all).

Again, using curves derived from these data is probably preferable to using a straight 5% rule, but the Agency should encourage and promote ongoing studies to collect more data and raise confidence in the adopted curves.

8b) Risk assessment purposes?

The original aim of the field trials was to collect empirical data in order to develop prediction models for drift onto aquatic habitats and terrestrial plants, and dermal and inhalation exposure to humans and animals. In the Agency's background document, the deposition curves pertain only to the possible drift of materials into flat areas. In this respect, they can be used in estimating water and land contamination and in constructing buffer zones and operating limits based on droplet size and boom height. No dermal exposure or inhalation risk assessments are possible with the current state of the data analysis.