Project Number: 89-Y1

UNIVERSITY OF CALIFORNIA, DAVIS

BERKELEY • DAVIS • IRVINE • LOS ANGELES • RIVERSIDE • SAN DIEGO • SAN FRANCISCO

SANTA BARBARA • SANTA CRUZ

COLLEGE OF AGRICULTURAL AND
ENVIRONMENTAL SCIENCES
AGRICULTURAL EXPERIMENT STATION
DEPARTMENT OF AVIAN SCIENCES

DAVIS, CALIFORNIA 95616

December 21, 1989

TO: Susan McCloud, Almond Board of California
FROM: Barry W. Wilson
SUBJECT: Progress Report
PROJECT: Minimizing Environmental Hazards During Dormant Spraying of Orchards

The project was submitted to the Almond Board in September 9, 1989 and approved September 20, 1989. (Technically, it is listed as beginning on July 1, 1989.) The few months of the project have been concerned with organizing the research for the upcoming dormant spray season, applying for funds from other agencies, and working with the Almond Board to design research to meet the specific data gaps outlined a letter from CDFA of October 19, 1989 to the registrants of dormant sprays (copy enclosed).

Additional funds have been sought from the Western Regional Pesticide Impact Assessment Program, the Sustainable Agriculture Program, and the Integrated Pest Management Program. Each was asked to contribute approximately $25,000/year. We will not know the outcome of these applications for several months or more. It is additional grant funds will be obtained soon enough to have an impact on the first year's field study and analyses. We have designed a small study this year, testing methodology and obtaining results important for a larger program next year. A site has been selected in Stanislaus County with the help of Wes Asai and we are preparing for our first field study in January, 1990.

A total of $60-70,000/year would permit us to modify sprayers and study more than one spray variable at a time. Thus, support from any one or two groups in addition to the Almond Board will permit us to examine several spray designs over a two year research cycle.

A copy of the proposal to the Almond Board for the next fiscal year that incorporates our latest plans is attached.

Situations that may make it advisable to change the design of our experiments include:

(1) A registrant project on hawks: We have been asked to prepare a proposal to present to the registrants of the OPs in February to meet the data gaps identified by CDFA on the effect of sprays on wildlife. It is not clear at this time whether the OP registrants will support a research project. If they do, it must necessarily focus on the work identified by CDFA, emphasizing the toxicology and behavior of the birds in the orchards, and possibly only secondarily addressing the important problems of drift and sprayer design.

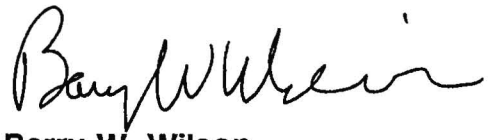
(2) Increased spray testing: We plan to continue to work toward an integrated spray testing program, combining the approaches of our current project and those of others (e.g.Dibble and his colleagues) so that both drift and exposure to wildlife can be examined with the most spray conditions possible at the lowest cost.

(3) Reregistration of oils: We have recently become aware that the oils used in the dormant sprays are subject to reregistration, and that the extent of research necessary to reregister them may lead some registrants to withdraw their products.

Of course, no changes in objectives will occur without conferring with the Almond Board. We will continue to work closely with Susan McCloud and with the Almond Research Advisory Committee to keep our study as simple as possible and of maximum benefit to almond growers.

I and my colleagues thank the Almond Board for their support and look forward to continuing the project.

Sincerely,



Barry W. Wilson
Professor

AES/CE MAR 84 Workgroup/Department _____

University of California
Division of Agricultural Sciences

Project Plan/Research Grant Proposal

Project Year 1990/91 Anticipated Duration of Project 2 years

Project Leader Barry W. Wilson Location UCD Campus

Cooperating Personnel J.N. Seiber, W.E. Steinke, D.K. Giles, F.F. Zalom, UCD; W. Asai, Coop. Extension; P. Detrich, S. Schwarzbach, US Fish and Wildlife; D. Glotfelty, USDA-ARS.

Project Title Minimizing Environmental Hazards During Dormant Spraying of Almond Orchards and Other Crops.

Keywords Almonds, Dormant Sprays, Organophosphates, Wildlife, Pesticide Drift, Spray Techniques

Commodity(s) Almonds, peaches, nectarines, prunes, other orchard crops. Relevant AES/CE Project No. 3954 H

Problem and Its Significance:

See Separate Page

Objectives:

See Separate Page

Plans and Procedures:

See Separate Page

BUDGET REQUEST

Budget Year 1990/91

Funding Source _____

Salaries and Benefits		
Postdocs/RA's	_____	_____
SRA's	Henderson, McChesney	16487
Lab/Field Assistance	Kullman, Crippen, Yamamoto	8000
Subtotal		Sub 2 24487
Employee benefits		Sub 6 4181
		TOTAL 28668
Supplies and Expenses		Sub 3 10000
Equipment		Sub 4 13000
Operating Expenses and Equipment Travel (Davis campus only)		Sub 5 _____
Travel		Sub 7 12000
		TOTAL 63668

Department account number 440385-59158

(continued from front)

Barry W Wilson
Originator's Signature Date 12/20/89

COOPERATIVE EXTENSION
County Director _____ Date _____
Program Director _____ Date _____

AGRICULTURAL EXPERIMENT STATION
Department Chair Hans Heydemann Date 12-21-89

LIAISON OFFICER _____ Date _____

PROBLEM AND ITS SIGNIFICANCE:

Combined dormant oil and organophosphate (OP) sprays were introduced to control San Jose Scale and Peach Twig Borer in almonds and stone fruits. Pesticides used include parathion, diazinon, methidathion and chlorpyrifos. Dormant spraying is said to have reduced up to 40 percent the amount of OPs applied in California orchards. However, raptors (e.g. red-tailed hawks) are exposed to and poisoned by OPs during dormant-spraying season (1,4,5) and the sprays appear in fog (2) and have drifted onto adjacent vegetable fields (6). CDFA has placed dormant sprays under reevaluation because of the exposure of raptors (3), and, in a separate action, is examining their drift onto adjacent fields (6). In addition, the oils used in the sprays are subject to Federal Reregistration, and there is a possibility that many may be withdrawn from use. Wilson has been asked by OP registrants and formulators to work with the Almond Board to prepare a research proposal that will meet the specific data gaps identified by CDFA concerning hazards to hawks and other wildlife (3). This proposal is more inclusive; it brings together the two important problems of wildlife exposure and drift, arguing that one cannot be adequately addressed without studying the other.

This multidisciplinary field research project of spray engineers, entomologists, chemical and biochemical toxicologists and wildlife biologists was approved by the Almond Board in the fall of 1989. It is designed to improve integrated pest management of orchards in California and reduce environmental hazards stemming from it. There are more than 400,000 acres of almonds and hundreds of thousands more acres of peaches, prunes and other stone fruits that face the problems discussed here. The results, when combined with other data, should lead to recommendations on how to reduce the drift of dormant sprays without increasing exposure of birds to the direct effect of the sprays.

OBJECTIVES:

The goal is to maintain the efficacy of dormant chemical application while reducing environmental hazards, especially drift and exposure to wildlife. Experiments will be conducted at field sites in the Central Valley of California in order to:

1. **Evaluate** alternative spray techniques and equipment.
2. **Monitor** amount of residues in selected parts of the orchard ecosystem and its surroundings.
3. **Measure** off-target movement of spray during dormant spraying.
4. **Reduce** the exposure of red-tailed hawks and other wild life to dormant sprays using surrogate species as test subjects when appropriate.
5. **Assess** the effectiveness of alternative sprayings on insect populations in the orchards.

The results will provide information to **improve the recommendations** for the integrated pest management of orchards and to meet requirements for reevaluation of dormant sprays imposed by the California Department of Food and Agriculture (CDFA).

PLANS AND PROCEDURES:

Detailed procedures were presented in the original application. The following extends and modifies them to mirror our latest plans and designs, incorporating criticisms and suggestions of the Almond Research Advisory Committee in a letter ofOctorber 9, 1989.

The first pesticide to be studied is diazinon (O,O-diethyl O-(2- isopropyl-6-methyl-4-pyrimidinyl) phosphorothioate), currently an important component of orchard sprays. It is less toxic than parathion, posing less risk to investigators who must enter the orchard shortly after the sprayer

passes to collect samples, and is less sensitive to weather conditions than chlorpyrifos. Ultimately, the toxicology of all pesticides used in the orchards to birds will be examined and compared before the end of the project.

The first spray conditions to be studied will be: (a) a conventional high volume (ca 200 gal/acre) air carrier spray control,(b) one or two test spray techniques designed to improve deposition on the branches and twigs and reduce the entrainment of pesticide aerosol into the fog and onto the ground and (c) no spray when appropriate. The number of tests depends on the funds and equipment available.

One study site will be a large commercial orchard plot divided into twelve blocks of approximately 1 acre each. Sampling strips will be 5 rows with 15 trees per row. One design is to treat replicates of three blocks each day with one of the test sprays. Soil, plant and air residues, sentinel birds and surrogate plants will be studied in the path and downwind of the sprayers. Experiments will be conducted at the Kearney Field Station of the University of California when appropriate.

Parameters to be determined include: diazinon spray, residues in soil, plants and air, in potted plants such as parsley, on caged sentinel birds and birds captured in the orchards when appropriate. Our first choice of a sentinel bird is the pigeon. Metabolites in excreta , blood ChEs, brain CHE levels of caged birds will be studied. Blood ChE levels of large wild birds and brain ChE of small birds will be examined. Insect numbers will be determined after spraying. Improved delivery systems will be studied in the second year of the project based on the findings of the first year, using larger areas and comparing efficacy, drift and safety to birds with the standard recommendation as a control.

Spray Techniques (Steinke, Giles and Asai):

The first winter (January, 1990) studies will be directed to gathering basic information concerning the placement of pesticide in the target from two sprayer systems. The second year will focus on developing an improved delivery stsem and comparing it to conventional application systems. Other sprayers may be evaluated on a trial plot basis during the second year if results warrant, time and funds permit. These include an over-the-row boom, a low volume sprayer, charged droplets, an oscillating boom or aerial application.

The first years trial will use a conventional, air carrier sprayer with an axial fan and hydraulic nozzles as a base system. Such systems are widely used in California and will provide a basis for comparison of other sprayers. The sprayer to be used is one we have previously described in terms of droplet spectrum. This machine is also capable of modification in terms of air movement generated by the fan. Its performance will be compared to that of a sprayer with a vertical mast positioned between the trees. Four fan-atomizer combinations will be positioned at various heights on the mast. These hydraulically powered units allow spray liquid to be emitted from various heights in the canopy and more closely targeted to the location of the pests. Such a sprayer has the potential to remove much, it not all, of the vertical component from the initial velocity of the droplets. These fans will be positioned to deliver an increased spray volume to locations in the canopy where the target is most dense. Whether such modifications will increase, or decrease, danger to the birds in and around the orchards is an important part of the studies.

The information gained will be used (together with data gained from collaborations with other projects, such as that of Dibble on low volume sprayers) to develop innovative designs useful for applications when foliage is present as well as when the trees are bare.

Wildlife (Detrich) and Biochemical Toxicology (Wilson): The blocks of trees in the first phase of the study are too small to permit adequate sampling of wild birds. Consequently, surrogate caged

species will be used as biomarkers to determine exposure. Pigeons obtained from a local commercial supplier will kept for a few days at the Department of Fisheries and Wildlife Biology facilities on the UCD campus and then transported to the study site, and kept in an enclosed vehicle overnight. Two birds per 1.6 square foot cage will be placed in the path of the sprayer and at several locations downwind, adjacent to spray sample collectors, to simulate different levels of exposure. There will be a total of 4 birds per location. The birds will be removed from the field after the sprayer has passed. Some birds will be sampled immediately for blood ChE levels. The birds will be taken to the State Diagnostic Laboratories in Turlock, more blood samples taken, and excreta collected on special teflon cage liners. Finally, the birds will be sacrificed and their brains collected for ChE assays. When appropriate, especially when a large scale trial is conducted in the 2nd year, small birds and raptors will be trapped in the orchards and studied for residues, blood ChE enzymes and excretory metabolites. Acute toxicology studies will be carried out on the UCD campus. Pigeons will be exposed to diazinon, parathion, methidathion and chlorpyrifos, and their blood and brain cholinesterases measured to establish a comparative scale of toxicity and a relationship between exposure and blood ChE levels. In this way results gained from one pesticide in the field tests can be used as a model for the others. Animal care protocols are under review by the UCD campus veterinarian and the campus Animal Care Committee. Collection permits will be obtained through the US Department of Fish and Wildlife and CDFA.

Decreased blood and brain cholinesterase levels are accepted biomarkers of exposure and possible adverse effects from OPs. Plasma will be separated from red blood cells by centrifugation (avian red blood cells do not contain ChEs). Fresh brains or brains stored at ultra-low temperature (-60^{o}C) will be homogenized and prepared for assaying. Brain acetylcholinesterase (AChE) levels and plasma AChE and non-specific ChE levels will be determined colorimetrically and oxime reactivation of the ChE enzymes will be carried out with 2-pralidoxime (2-PAM) using automated techniques developed by Wilson and his students. Decrease of ChE levels below control values, and their subsequent increase after 2-PAM treatment are strong indications of exposure to toxicologically active levels of OPs.

Chemical Analyses (Seiber): Evaluation of off-target movement of dormant sprays during and after spraying: Measurements to be taken include the deposition on plant surfaces (mass per area), deposition on ground surfaces (mass per area) and concentration of pesticide in the air downwind from the application site (mass per volume, time integrated over the entire application). The following samples will be collected from each treatment block (i.e., one treated with conventional, modified air carrier, mast, or no treatment):

a. Filter paper strips (2-ply) will be suspended from tree branches and retrieved after spraying is completed to determine the initial deposit within the tree canopy.

b. Filter paper strips or glass dishes will be placed at various distances downwind from the trees and on the soil floor, and collected after spraying is complete. These will provide measures of the amount of pesticide bypassing the target in both horizontal and vertical directions.

c. Air samples will be collected on a variable height mast at least one distance downwind both during and for periods of time after application is complete. These will provide measures of the horizontal flux of pesticides (vapor and particulate) moving off target by simple drift, and of pesticide vapors released to the air from the target after spraying ends ("lift-off").

d. Fog samples will be collected downwind of the spraying operation both during and after application (as weather permits). This will provide maximum concentration values for pesticides in fog.

Determination of exposure levels of birds and plants outside of the spray zone: Samples also will be collected from each treatment block to assess exposure :

a. The downwind fallout collectors and air samples will be placed at the same distances as caged test animals; analysis will yield the potential dermal and inhalation doses.

b. Excreta from test animals will be collected and analyzed for diagnostic pesticide metabolites. This will provide data on the amount absorbed by the animal.

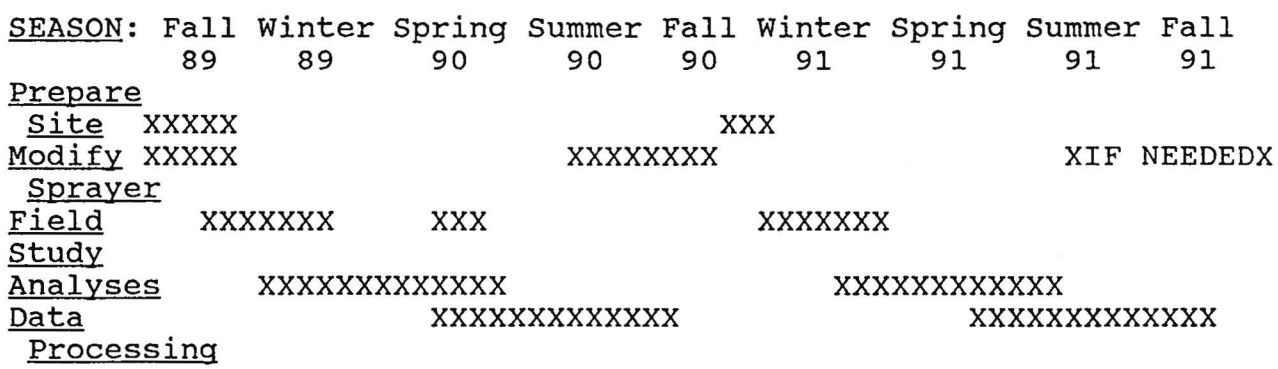
c. Potted parsley plants will be placed at various downwind distances and retrieved periodically for analysis. This determination of the actual exposure of downwind plants will tell us about the inadvertant buildup of pesticide residues in non-target rfood crops.

d. Wild-caught animals in the orchard or its environment will be similarly sampled for external pesticides and excreta metabolites when appropriate, especially in the second year of the study. The parent diazinon and its oxon conversion product will be determinedin all exposure samples. Excreta will be analyzed for diagnostic OP metabolites by a GC method developed in his laboratory. All analyses will be performed with the latest gas chromatographic and/or high performance liquid chromatographic methods using equipment in Seiber's laboratory.

Pest Monitoring (Zalom, Supported by Almond Board Funds): Both San Jose Scale and Peach Twig Borer will be monitored following each treatment. Relative population levels of San Jose Scale will be determined with sticky tape and pheromone traps. Populations will also be sampled directly by removing infested twigs. Sticky tape traps are clear plastic tapes that are wrapped around the scaffold limbs. Emerging males and crawlers that are migrating to a new location stick to the surface of the tape. The tape traps will be placed in the trees in April and monitored at biweekly intervals throughout the spring. Samples of scale infested twigs will be removed from each treatment replicate and dissected to determine mortality directly. The pheromone traps will be placed in each treatment replicate and monitored weekly during April and May. Peach Twig Borer populations will be evaluated in each treatment replicate by counting the number of twig strikes on each of 10 trees following emergence from hibernacula (which occurs in February). Funds for this part of the research are not requested here.

Anticipated Problems: Weather; our first choice for a field study is foggy weather. We plan to wait for a foggy stretch to carry out the work. Animal exposure: The animal part of the study is based on the plausible assumption that a large part of the exposure of birds in the orchards to OPs is due either to direct contact of the birds to the spray, the branches or to drift. It is important to study both drift and animal exposure in the same study to avoid a situation where conditions that would reduce one problem might exacerbate the other. Infestation: Orchard sites with a plentiful supply of insects will be sought to maximize the information gained from the study. Sprayer modifications: Funds to modify sprayers are a major limiting factor. Our experimental design provides for adding on treatments if additional funds are obtained. Preliminary tests: Tests of the sprayers, bird cages and air samplers will be performed on the UCD campus or at the Kearney Field Station.

RESEARCH SCHEDULE:



BUDGET:

	% Time	Dollars	Agency
Personnel:			
Barry Wilson (Coordinator)	10%	(8450)	UCD
James N. Seiber (Ag. Chemist)	5%	(3840)	UCD
William E. Steinke (Ag. Engineer)	5%	(2025)	UCD
Kenimer Giles (Ag. Engineer)	2%	(1620)	UCD
Frank G. Zalom (Entomologist)	2%	(1180)	UCD
Philip Detrich (Wildlife)	1% (USFW)	(1500)	USFW
Benefits UCD Personnel		(5413)	
Students			
Seth Kullman		(5000)	UCD/*
Tawni Crippen		(3000)	UCD**
Julie Yamamoto		(5000)	UCD/***
SRA's			
J.D. Henderson (SRA II,Biochem.)	20%	7132	****
M. McChesney (SRA IV,Analyt. Chem.)	20%	9355	****
Other Assistance		8000	****
Benefits		4181	****
Subtotal Sub 2 + Sub 6		**28668**	
Supplies and Expense			
Birds Costs		2000	****
Biochemistry Supplies		3000	****
Chemical Analyses Supplies		3000	****
Entomology Supplies		500	****
Sprayers		1500	****
Subtotal Sub 3		**10000**	
Equipment			
Sprayer Modifications		10000	****
Cages, Accessories		3000	****
Subtotal Sub 4		**13000**	
Travel			
Field study and trapping		12000	****
Subtotal Sub 7		**12000**	
Total		**63668**	

UCD: UCD personnel on project, percent contributions and salaries.
* Seth Kullman is an Ecotoxicology Trainee;** Tawni Crippen has a scholarship from Savannah River Laboratories of the Department of Energy.
*** Julie Yamamoto is an NIH Environmental Toxicology Trainee. All three of these Ph.D. students will assist in the field studies and toxicology research. **** Contributions are assumed from the Almond Board ($20,000 or more) plus one or two of the following agencies to which we have applied for approximately $25,000 each: Western Regional Impact Assessment; Sustainable Agriculture; Integrated Pest Management, USDA-ARS (fog analyses) and other grower organizations. The funds shown here would support testing several spray conditions on a small, and trapping and studying wild birds on another larger site. The funds ($20,000) given us this year have been sufficient to start up the project with a small study this spray season, but are insufficient to finish the project.
Jack Henderson is an experienced biochemistry laboratory technician working with Dr. Wilson. He will supervise the blood, brain samplings and enzyme assays. Michael McChesney is an experienced laboratory technician of Dr. Seiber. He will supervise the air and residue samplings and perform the analyses.

Literature Cited:

1. Hooper, M.J., Detrich, P.J., Weiskopf, C.P. and Wilson, B.W. 1989. Organophosphorus insecticide exposure in hawks inhabiting orchards during winter dormant-spraying. Bull. Envir. Contam. Toxicol. 42:651-659.

2. Glotfelty, D.E., Seiber, J.N. and Liljedahl, L.A. 1987 Pesticides in fog. Nature 325:602-605.

3. Jones, T. Letter to 14 registrants of dormant sprays. October 19, 1989.

4. Wilson, B.W., Hooper, M.J., Hansen, M.E., Detrich, P.J., Littrell, E.E. and Weiskopf, C.P. 1990. Dormant Sprays in Orchards: Raptors as Sentinels. Paper to be presented at 1990 ACS Symposium, "Impact of Pesticides on Wildlife".

5. Wilson, B.W., Hooper, M.J., Littrell, E.E. 1988. Exposure of Red-tailed Hawks to Agricultural Chemicals during Dormant Spray Season in the Central Valley of California. Report to California Department of Fish and Game.

6. Turner, B., Powell, S., Miller, N. and Melvin, J. 1989 A field study of fog and dry deposition as sources of inadvertant pesticide residues on row crops. CDFA report EH 89-11.

STATE OF CALIFORNIA GEORGE DEUKMEJIAN, Governor

DEPARTMENT OF FOOD AND AGRICULTURE

1220 N Street, Room A-400
Sacramento, California 95814

October 19, 1989

Pursuant to Section 6220 and 6221 (Title 3) of the California Code of Regulations, the Director placed all products which contain ethyl parathion, diazinon and/or methidathion for use on dormant almonds under reevaluation on January 23, 1989. The basis for this reevaluation is the adverse effects of these pesticides on Red-Tailed Hawks (Buteo jamaicensis) identified by the California Department of Fish and Game (CDFG).

As a registrant of pesticides which contain ethyl parathion, diazinon and/or methidathion for use as a dormant spray in almonds, the Department is hereby requiring you to submit the following studies:

1. A field study to characterize the circumstances, significance and mode of exposure of hawks to these sprays. This can best be accomplished with the use of a combination of visual observations and a short-term radio telemetry study coinciding with the almond dormant spray season. A pilot study is highly recommended. The telemetry study should identify the key exposure scenarios, such as the influences of spray application times and methods, concentration rates of active ingredients and the effects of weather on the hawk/pesticide interaction. Monitored birds should be observed for behavioral patterns of preening and dietary exposure probabilities, as well as roosting and movement patterns within almond orchards before, during and after spraying.

2. A field study involving caged Red-Tailed Hawks (non-releasable captives) or surrogate species (e.g. Kestrels (Falco sparverius)) confined in orchards where they would be exposed to the dormant sprays. The study should employ the use of a yellow florescent tracerite added to the final dormant spray solution, to trace pesticide movement within the orchard and spray patterns on hawk plumage, feet and perches. Data on spray drift, non-target foliage (including orchard floor) and effects on prey species should be analyzed.

Standard protocols and trapping procedures for field research can be obtained for the CDFG Pesticide Investigation Unit. The studies should commence in late December or early January. The results of the studies are to be submitted to the Department September 1, 1991.

3. A laboratory study on each active ingredient to define the principle avenue of exposure to captive hawks, or appropriate models, by simulated direct spraying, dermal absorption (toxic perch exposure), and preening studies following spray application. This study should also incorporate different oils, to determine differential effects such as feather penetration.

4. A laboratory study on each active ingredient which investigates the inhalation effects of end-product sprays on surrogate species using sprays of different droplet sizes.

Protocols for the laboratory studies should be submitted to the Department for approval. The results of the studies are to be submitted October 1, 1990.

The Almond Board has expressed an interest in the subject of dormant sprays used on almonds and is planning a number of research projects. The contact person for this research is : Susan McCloud, Research Director, Almond Board of California, P. O. Box 15920, Sacramento, California, 95852; telephone number (916) 929-6506.

If you have any questions concerning this proposed reevaluation, you may contact Ann Prichard at (916) 322-5031. For questions concerning protocols for the studies, you may contact Jon Shelgren at (916) 322-5031.

Sincerely,

Tobi Jones, Chief
Pesticide Registration Branch
(916) 322-5130