

Northeastern IPM Partnership Grant program
Interim Report
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A. Grant Data

- Title: Measurement of Worker/Scout Exposure to Pesticides in “Standard” and “Reduced Risk” IPM Systems for New England Apples
- Type: Critical and Emerging Issues
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B. Non-technical Summary

This study began with our desire to take our work in integrated pest management (IPM) of apple in Massachusetts a step further, by examining the economic and human health costs and benefits of IPM practices more intensely than we have in the past.

Many commonly used crop protection chemicals, including highly toxic, broad-spectrum, long residual, organophosphate and carbamate insecticides, certain fungicides that are possible human carcinogens, and other pesticides with estrogenic effects, are now thought to represent a significant risk to human health, to beneficial natural enemies and other non-target organisms and to the environment.

The passage in 1996 of the Food Quality Protection Act (FQPA) raised the prospect that future pest management systems may be far less reliant on these relatively inexpensive, but often riskier materials. In recent years, while many commonly used apple pesticides have been under review by the EPA, new, more environmentally benign chemicals have been working their way into the IPM toolbox. The terms reduced-risk, low-risk, and high risk are often used to describe the relative toxicity of pesticides, taking into account risk to consumers (through residues on fruit), risk to agricultural workers (primarily through worker exposure in the orchard) and risk to the environment (through pollution of soil, air and water, and/or toxicity to non-target organisms). The project team believes it is critical for the public sector to test and analyze innovative pest management programs that use lower risk pesticides

in the context of an IPM strategy, and to document their impacts. Only when such systems are fully characterized and demonstrated to be both affordable and effective, can we anticipate that growers will willingly adopt them.

Our study brought together a small group of growers with university-based agricultural research and extension scientists, and an independent crop consultant, to address these questions: 1) What is an average or “standard” IPM system now in common use, and what “reduced-risk” system makes sense for Pioneer Valley apple growers to employ at this time? 2) How do reduced-risk systems compare economically with standard systems? 3) How do these systems differ in terms of potential pesticide exposure risk to farm workers, and particularly to IPM scouts.

The “standard” system involved grower use of any material they chose based on their past experience. The “reduced-risk” system protocol eliminated the use of pyrethroid insecticides (hard on beneficial organisms) and nearly eliminated the use of organophosphate insecticides (harmful to workers, beneficials, consumers, and the environment). It featured early oil sprays for mites and the use of Actara, Avaunt, Spintor, or trap-out spheres for most insect controls. Provisions were made for emergency use of Apollo or Acramite for mites or Provado for aphids. Fungicide sprays were designed to reduce the use of materials that are likely to have re-registration toxicology problems. They featured fixed copper at the start of the season and judicious use of the environmentally benign strobilurin fungicides.

To measure worker exposure to pesticides in the 2 types of apple blocks, an IPM specialist timed site visits several times during the growing season to coincide with the re-entry interval for the targeted pesticides. Samples were taken according to two methods.

For a “dosimetry” sample, a white cotton shirt, pants, gloves, and socks, and leather sneakers were worn. If the pesticide was a volatile compound (Sevin, captan, Imidan), an air sampler unit was also attached to the collar of the shirt. The worker then spent 20 minutes inside each block type, performing appropriate activities for a grower or an IPM scout at that time. From mid-May through mid-June, those activities were: assessing damage by plum curculio, other early insect pests and apple scab disease. Later in the summer, the activities were: summer pruning, and assessing damage by apple maggot and flyspeck disease.

At the end of 20 minutes, the suit was carefully cut into sections: torso, upper arms, lower arms & gloves, pants, lower legs, and socks. Suit sections and air samplers were placed in labeled bottles and frozen until the lab procedures were performed.

For a “bio-monitoring” sample, the specialist began by collecting his urine 24-48 hours before the exposure, to get a baseline. The exposure sample was performed in street clothes (short sleeve shirt and long pants), and urine was collected at several intervals after the exposure. The urine samples were frozen awaiting lab work. This procedure was only used for the fungicide mancozeb during the 2004 growing season.

C. Introduction

In the six New England states, apples are grown on 21,432 acres (USDA, 1997). In the northeast US, acreage of this crop is even more substantial. As such, apples represent a substantial dollar value to the region’s diversified farms. In spite of their proximity to markets, for many growers, profitability has not kept pace with improved yields and quality, and many farmers now operate on thin profit margins if they make any profit at all. In order to stay in business, most farmers feel that they must use the least expensive pesticides possible. However, many commonly used crop protection chemicals are now thought to represent a significant risk to human health, to beneficial natural enemies and other non-target organisms and to the environment. These include highly toxic, broad-spectrum, long residual, organophosphate and carbamate insecticides, certain fungicides that are possible human carcinogens, and other pesticides thought to have estrogenic effects.

Pesticide residues on foliage and other surfaces after application represent a hazard for agricultural re-entry workers (Spear, 1991). Workers such as scouts, whose jobs involve extensive hand contact with treated plants, can receive a significant dermal exposure of pesticides from the transfer of residues from treated surfaces to exposed and/or clothed skin. Due to the necessity of entering the tree canopy and wading through tall grass, exposure of this type may be heightened for tree fruit workers compared to other crop situations

Fenske (2003) showed that children who live in close proximity to farms using pesticides have higher exposures than those who live away from farms, and that dust in homes near farms was found to be contaminated with agricultural pesticides. Fenske (2003) also found that 44 pre-school children living in the tree fruit growing regions of Washington State showed increased levels of pesticide metabolites in urine during periods of spraying. Although most consumers do not really know much about pesticide use by farmers, well-publicized examples of environmental contamination from agrochemicals have caused many in the non-farming public to develop negative attitudes toward modern agriculture and the majority of the American public now believes that it is very important for U.S. farmers to switch to low-chemical production strategies that rely primarily on natural methods.

While many growers now practicing IPM do everything possible to reduce use of pesticides and have begun to switch to less risky materials, the generally higher cost of such materials means that grower profitability continues to be at risk. Hence, it is imperative that public-sector demonstrate other potential benefits (e.g., protection of the health of farmers, farm families and farm workers) of using reduced risk materials.

D. Objectives

1. To bring together a diverse group of apple producers and private IPM consultants to describe the standard IPM (SIPM) system now in use, and to design a reduced risk Integrated Pest Management (RRIPM) system applicable to the New England apple production region. This objective was successfully completed (see Results).
2. To assess these systems using a published toxicity unit index and field testing for efficacy and effects on farm worker and applicator risk. This objective was successfully completed (see Results).
3. To conduct a comparative economic analysis of SIPM and RRIPM impacts on grower profitability, and work with a regional organization that is actively certifying and marketing “eco-grown” crops in order to investigate market potential and opportunities for increased profitability of crops grown using a Reduced Risk IPM System. Both elements of this objective have been successfully completed (see Results).

E. Approach

During the initial phase of the project, the team worked collaboratively with private sector partners to describe the current standard integrated management (SIPM) system along with a reduced risk IPM (RRIPM) system for New England apples. We began by reviewing existing Crop Profiles and receiving input from growers, The SIPM protocol involved free choice of material, rates and frequency of application by cooperating growers based solely on efficacy and cost (Table 2 example). RRIPM protocols were derived from those developed by the 6 state Apple/Peach RAMP Grant led by Rutgers University and generally prescribed materials that are considered “low risk” by EPA.

During stakeholder meetings, concern was expressed that a strict reduced-risk system that eliminated all OP insecticides and severely reduced the EBDC fungicides and captan (possible B₂ carcinogens), would be prohibitively expensive for growers to adopt. Early data from the 5 state RAMP study reported some reduced-risk apple orchard blocks with three times the pesticide costs of the

corresponding standard blocks. Diverse methods for evaluating the environmental impact of pesticides were evaluated (Benbrook et al., EIQ, the Red, Orange, Green pesticide label system developed/used in Europe). We decided to design a flexible reduced-risk spray program (Table 3) with built-in choices through-out the growing season. The more expensive reduced-risk pesticides could be used when they were most effective, but using some of the older broad spectrum materials was allowed in order to keep costs down and to preserve efficacy of the new materials. Growers were encouraged to reduce or eliminate OP insecticides and the more toxic fungicides, but certain of these materials could be used sparingly if pest pressure was high or extended.

In April, 2004, 3 of the 4 growers involved in system design agreed to dedicate a block of apple trees to reduced-risk methods for the 2004 growing season, and began to implement the flexible plan that we jointly developed. An adjacent or nearby block, employing a standard system served as a comparison. During the summer, when it was known what sprays were planned, the economists used the grower spray record data to compare costs of the reduced risk and standard systems.

To measure potential worker exposure, we used the “whole body dosimetry” approach. For dosimetry, participants wore a single layer of white, sanforized 100 % cotton long-sleeved shirt and long pants (Universal Overall Corp, Chicago Il), a double layer of cotton gloves, and cotton socks. These dosimeters serve as a passive collection medium for dislodgeable foliar pesticide residues present on the foliage. If the pesticide was a volatile compound (Sevin, captan, Imidan), an air sampler unit was also attached to the collar of the shirt. Inhalation exposure was measured using personal air sampling pumps (2.0 liter of air per minute) with XAD-2 glass fiber air sampling tubes attached to the volunteer’s collar (Figure 1).

The worker then spent 20 minutes inside each block type, performing appropriate activities for a grower or an IPM scout at that time. From mid-May through mid-June, those activities were: assessing damage by plum curculio, other early insect pests and apple scab disease. Later in the summer, the activities were: summer pruning, and assessing damage by apple maggot and flyspeck disease. At the end of 20 minutes, the suit was carefully cut into sections: torso, upper arms, lower arms & gloves, pants, lower legs, and socks. Suit sections and air samplers were placed in labeled bottles and frozen until the lab procedures were performed.

For biomonitoring, the individual wore long pants, short sleeve shirt and shoes/boots (Figure 2). Pre-exposure and post-exposure urine was collected from these individuals, generally for 24 h pre- and post-exposure, but varied depending on the target pesticide (see below). To date, biomonitoring samples have been collected/analyzed for the EBDCs, carbaryl, and azinphos-methyl. Biological monitoring (biomonitoring) is increasingly being used to quantify human exposure to pesticides because it requires fewer assumptions and measures the internal dose that likely represents the biologically relevant dose. The advantage of biomonitoring is that it directly measures the amount of pesticide in collected human tissues and fluids, which is directly related to absorbed dose. Thus, when the pharmacokinetics (absorption, distribution, metabolism, elimination) of a compound is known, and when suitable biomarkers of exposure is available (major urinary metabolite), biomonitoring presents the most complete picture for assessing whole body dose and the health implications of that exposure. Figure 1 shows a scouting volunteer wearing dosimetry suit used to estimate exposure to pesticides. Figure 2 shows a scouting volunteer in the biomonitoring group. Urinary pesticide metabolites were measured before and after scouting activity to estimate exposure to pesticides.

The comparison of exposure was conducted in paired blocks (SIPM and RRIPM) on 3 Massachusetts commercial fruit farms in 2004 and on 1 farm in 2005. We chose 10 target pesticides from both “standard” and “reduced-risk” plots based on their use pattern and our analytical capabilities (Table 1). Complete spray records were collected at the end of each growing season. Application rates and timings were decided by the individual growers. The work done in 2005 was specifically to acquire samples for potential exposure to azinphosmethyl (Guthion), a highly toxic OP insecticide that is under time-limited registration, and which no growers chose to use in 2004.

In year 1 (2004), an IPM specialist timed several site visits during the growing season to coincide with the re-entry interval for the targeted pesticides. The IPM specialist was able to conduct 12 site-visits at the re-entry interval for a target pesticide. Generally, each visit corresponded to the re-entry interval of only one compound, however dosimetry media were analyzed for all targeted pesticides that may have been sprayed in that plot earlier in the growing season. The IPM specialist spent 20 minutes total in the plot conducting routine scouting procedures. Opportunities to scout the plots at a given re-entry interval were lost because the IPM specialist had other responsibilities, and the orchards were several miles apart. So, for year 2 (2005), we utilized student volunteers who were trained how to conduct scouting activities. This allowed us to use 4 or 8 volunteers at each plot/time, significantly increasing our sample numbers.

Volunteers were recruited by word of mouth from the UMASS Environmental Toxicology and Risk Assessment Program (School of Public Health) and the Department of Veterinary and Animal

Science. A protocol that described the work to be done and protected the rights of the volunteers has been approved by the Human Subjects Review Committee, UMASS. The approved protocol including informed consent was reviewed with potential participants at an orientation meeting prior to their participation.



Figure 1.



Figure 2.

F. Progress

Objective 1

This objective was completed in 2004.

Objective 2

The team ultimately opted to not use the proprietary software developed by Benbrook et al. or the EIQ to design the reduced risk systems. Instead we patterned the Reduced Risk programs after those used in the 6 state Apple/Peach RAMP Grant led by Rutgers Univ. One field season was conducted in 2004. Difficulties in coordinating site visits to the end of the REI resulted in fewer samples for analysis than originally planned. After requesting a no-cost extension we had adequate funding remaining to conduct another field season at 1 orchard in 2005. Laboratory analysis of dosimetry and biomonitoring

samples from 2004 is complete. Analysis of samples from 2005 is mostly completed, but still in progress and will be finished by Spring, 2006.

Objective 3

The economic analysis was completed in 2004 (see Results). Our role in developing the Eco Apple Standards and marketing plan was completed in 2004 (see Results)

G. Results

Objective 1

Our team studied reduced-risk apple production systems from other regions, especially the systems developed by the 5 state RAMP grant led by Peter Shearer of Rutgers University. Concerns were raised that a strict reduced-risk system that eliminated all OP insecticides and severely reduced the EBDC fungicides and captan (possible B₂ carcinogens) would be prohibitively expensive for growers to adopt, given that early data from the 5 state RAMP study reported some reduced-risk apple orchard blocks with three times the pesticide costs of the corresponding standard blocks.

Ultimately, while the “reduced-risk” protocol used here eliminated the use of pyrethroid insecticides (hard on beneficial organisms), it reduced, but did not eliminate the use of organophosphate insecticides (potentially harmful to workers, beneficial organisms, consumers, and the environment) and materials such as EBDC, SI, and captan fungicides (likely to have re-registration toxicology problems). The protocol featured early oil sprays for mites and the use of Actara, Avaunt, Spintor, or trap-out spheres for most insect controls. Provisions were made for emergency use of Apollo or Acramite for mites or Provado for aphids. The program also featured fixed copper at the start of the season and judicious use of the environmentally benign strobilurins. All blocks were able to use carbaryl (Sevin) as a fruit thinner.

Objective 2

To measure worker exposure to the pesticides in the 2 types of apple blocks site visits were made several times during the growing season to coincide with the re-entry interval (REI) for the “targeted” pesticides.

The three sites were in Belchertown, West Brookfield, and Ashfield, Massachusetts. Blocks in the study ranged in size from 16 to 3 acres, and included common cultivars, such as McIntosh, Cortland, Empire, Gala, and Jonagold. A total of nine site visits were made in 2004. On each visit, an average of 4 samples was taken (a total of 35 samples): more than one pesticide may have been sampled for and/or more than 1 method may have been used. Each of the 21 dosimetry samples was further partitioned into 6 subunits for testing. Based on the protocol, we planned to test for 12 possible pesticide compounds in the “reduced-risk” blocks over the season, and 9 possible compounds in the “standard” blocks.

Samples were taken according to two methods. Worker exposure estimated from dosimetry data for each application scenario is summarized in Table 7. Exposure estimates were estimated according to the following equation:

Exposure = Dermal exposure from lower arms and hands [LA/G x DPF] + dermal exposure from remaining body surface [RD x CPF x DPF] + amount inhaled.

To derive the dermal dose received from the lower arms and hands, pesticide residues collected on these dosimeter sections were multiplied by a dermal penetration factor (DPF) appropriate for the pesticide. This assumes that IPM scouts will be wearing short-sleeve shirts and no gloves. The dermal penetration factors come from previously published work (e.g., Captan 9 %, carbaryl 20.2%, etc.)

To derive the dermal dose received from the rest of the body surface, residues on the remaining dosimeter sections (RD) are multiplied by a clothing penetration factor (CPF) of 10 % in addition to the

appropriate DPF. To estimate the total amount of pesticide inhaled during the exposure period, the amount of residues collected on the air samplers is adjusted to an inhalation rate for light workloads (21 liters/minute) and the time over which the exposure occurred (20 minutes).

Risk Assessment

Risk assessments in the form of margin of exposure (MOE) and the USEPA Hazard Quotient (HQ) were performed for each individual scouting event (20 minute duration) (Table 7). The MOE is the ratio of the dose ($\mu\text{g}/\text{Kg}$) that was shown to cause no adverse effect (no observable adverse effect level, NOAEL) vs. the actually exposure measured during scouting activities.

$$\text{MOE} = \frac{\text{NOAEL } (\mu\text{g}/\text{Kg}/\text{d})}{\text{Human Exposure } (\mu\text{g}/\text{Kg}/\text{d})}$$

So, for example, a MOE of 100 signifies that the dose received during the 20 min scouting was 100 times lower than a dose level determined to cause no observable effects (NOAEL). Lower margins of exposure pose greater concern. Margins of exposure are specific to individual situations and do not by themselves communicate the likelihood of risk in an exposed population. Margins of exposure simply reflect the ratio between a level associated with observed toxicity in humans or animals and the actual level of exposure in a particular situation. Risk managers and stakeholders can evaluate a particular margin of exposure and decide whether it reflects an appropriate level of protection given the relevant risk management criteria. Typically, margins of exposure are much smaller in the workplace than in community settings.

NOAELs are based on available chronic toxicological data where an amount of pesticide per unit of weight (usually mg/Kg or $\mu\text{g}/\text{Kg}$) of the test subject's body weight has no observable adverse effect when a test subject is exposed to this amount on a daily basis over their lifetime. The toxicological data is obtained from studies in which test animals are exposed to the pesticide, mainly through oral exposure, beginning with young (post-weaning) animals, and exposure continues through their adulthood.

Hazard was similarly assessed using the US EPA Hazard Quotient calculation independently utilizing exposure estimates from dosimetry versus biomonitoring data following 20 min scouting activities. The estimated absorbed dose (AD) received during scouting was divided by the US EPA chronic reference dose (Rfd) to give a Hazard Quotient ($\text{AD}/\text{Rfd} = \text{HQ}$). A HQ value less than or equal to 1.0 indicates that the residues present are at concentrations below those that are expected to cause adverse effects to humans. A HQ value greater than 1.0 does not necessarily infer that adverse effect will occur, but rather that the absence of adverse effects is less certain. Chronic reference doses (RfDs) are estimated by the USEPA using NOEL values and are dependent on the amount and quality of available toxicity data. RfD values are proposed for humans by applying a suitable safety factor. The safety factor is intended to allow an extra margin of safety to compensate for 1) the scientific uncertainty in the process of extrapolating human risk projections from animal data, and 2) the possibility of differing sensitivities within the general population. Safety factors are assigned by EPA in multiples of 10 depending on the toxicological effects and on the amount of toxicity data available, but a 100-fold safety factor is used in most instances.

Determination of Exposure by Biomonitoring.

Biomonitoring of worker exposure to mancozeb (N = 4) was evaluated utilizing a modified method of Cloisio et al, (2002). It is not surprising that no mancozeb metabolites were detected, as mancozeb has a low dermal penetration rate. The reported dermal penetration rates of 0.2%-6.5% are considered to be overestimates (Ollinger et al 2001). The lack of detection of mancozeb metabolites in urine samples also indicates there is a wide margin of safety for this material when observing the REI.

For the fruit thinner Carbaryl (Sevin), as much as 7,917 ug were detected on 18 May in lower arm and glove sample in the Belchertown reduced-risk block. This material was used at the same rates and frequencies in both block types and residues were high in each. Assuming 100% absorbance of the material in the lungs, and 12% absorbance through skin, an IPM scout entering this block without gloves and with a short sleeve shirt, would be taking in 972.3 ug of carbaryl (22.2 ug via air intake x 100% absorbance + 7917.3 ug residue on lower arms and gloves x 12% absorbance = 972.3 ug total absorbance). Using a human body weight of 70 kg, a single day's intake by this scout would be 972.3 ug/70 Kg or 13.89 ug/kg/day. Reference texts cite an Acceptable Daily Intake (ADI) value of 8 ug/kg/d for carbaryl, so that this level of exposure exceeded the ADI even if other potential exposure routes (e.g., upper arms, torso, hair and face) are not included in calculations. It is noteworthy that Sevin residue still could be found on suits sampled for Avaunt on 9 July. Carbaryl MOE and HQ levels in both block types are considered hazardous.

Phosmet (Imidan) was detected at very high levels in all standard blocks where it was sprayed and sampled-for. Levels reached 9,377 ug in lower arms and gloves on one date in one "Standard IPM" block. Although Phosmet was used against plum curculio even in RRIPM Blocks, levels of dislodgeable residues consistently were many times lower than in standard blocks. Using the same calculation method as above, exposure on hands and lower arms in the Standard IPM block referred to above would result in a daily intake of 16 ug/kg body weight. Reference texts cite an ADI for phosmet of 10 ug/kg body weight. To our surprise, phosmet was also detected at much lower levels (120, 220, 142 ug) in 3 reduced risk blocks where it was not sprayed. This is likely due to spray tank contamination or carryover. In one reduced risk block at Belchertown, the level reached 606 ug on lower arms and gloves, which may mean the grower inadvertently sprayed a mixture of Avaunt and Phosmet. In spite of being found at relatively high levels in some blocks, MOE and HQ for phosmet are not considered hazardous.

For Captan, 3,959 ug were detected on pants and 3,352 ug on lower arms and gloves on 9 July in the standard block in Belchertown. Whole body Captan residues appear higher in "standard" compared to "reduced-risk" blocks, however, no exposure levels approached the ADI (100 ug/kg/d) for this material. MOE and HQ measures were also not at hazardous levels.

Indoxcarb (Avaunt) was used instead of Imidan for plum curculio and apple maggot in "reduced-risk" blocks. The amount of Avaunt detected never exceeded 601ug in any of the samples.

The fungicide Fenarimol (Rubigan) was not detected in any blocks in 2004, even though it was sprayed and sampled for.

Objective 3

The team worked with staff of the IPM Institute of North America and the Massachusetts-based non-profit brokerage firm Red Tomato to help develop a marketing program intended to recognize the pioneering efforts of certain regional (New England and New York) growers to reduce and eliminate their reliance on the most toxic agricultural pesticides. This effort to market ecologically-grown tree fruits in the Northeastern United States had as objectives to earn farmers marketplace recognition, a growing market share, and eventually more income per unit sold for their apples.

We worked collaboratively to design the Eco Apple production standards and the verification process, and the final draft of the Protocol and Grower Self-Assessment was completed by Tom Green, IPM Institute of North America, on April 1, 2005. The standards constitute a reduced risk system for apple production as they eliminate highly toxic materials (OPs, Carbamates, certain other materials) or allow their use only with excellent justification. The standards were implemented on 6 participating farms, approx. 650 acres total, including one site included in the residue monitoring study. Six farm inspections were conducted by Kathleen Leahy (Polaris Orchard Management) and Rob Koch (Apple Leaf), supervised by IPM Institute, during August, 2005, and all six earned Eco Apple certification for 2005:

- Alyson's Apple Orchard, Walpole, N.H.
- Clark Bros. Orchard, Ashfield, Mass.
- Lyman Orchards, Middlefield, Conn.
- Scott Farm, Dummerston, Vt.
- Stone Ridge Orchard, Stone Ridge, N.Y.
- Sunrise Orchards, Cornwall, Vt.

Eco Apples were introduced into the marketplace in late August, and sold through ~ 200 supermarkets and food co-ops. Markets were mostly in New England, but some were also developed in the Mid-Atlantic States and parts of Texas. Certified apples were sold through: Whole Foods; Trader Joe's; Shapiro Produce (regional distributor); Associated Grocers of New England (supplies 400 independents); Albert's Organics (supplier to Wild Oats and food co-ops); Big Y Supermarkets. Eco Apples were also sold and marketed directly by participating farmers, and thereby reached an additional 25 supermarkets in the Price Chopper and Hannaford Bros. chains in Vermont and New York.

Sales of Eco-Apples by Red Tomato increased by more than 100% over 2004 as measured in dollars (\$>300,000 in 2005; \$146,200 in 2004), and are approaching 115% as measured in cases (~16,000 cases in 2005; ~7,500 cases in 2004). Eco Apple sales remain steady, and promise to continue. Sales for 2005 could easily surpass \$350,000 or growth of 140% over 2004. The economic costs of implementing the reduced-risk production practices will be analyzed and compared to conventional and/or baseline practices during January, 2006. Also available in January 2006 will be a report on Red Tomato's evaluation of farmer satisfaction and benefits through their participation in the Eco Apple and local marketing program.

Data on the economic aspects of a reduced-risk cropping system were developed for 4 commercial apple orchards covering years 2002- 2004. All data were expressed in terms of annual cost and revenue per acre. Cost of pesticide for each year was calculated by summing the amount each grower reported spent on all materials that fell under the categories listed. For example, one grower's fungicide costs for 2003 was determined by adding up the amount spent on the following materials: Benlate, Captan, Captec, Dithane, Flint, Mancozeb DF, Manzate DF, Procure, Rubigan EC, Sovran, and Topsin. This grower spent \$74.51 per acre on fungicides for the entire year. Costs for other orchards and cost categories were determined in a similar manner.

Cost data were described separately for each of three years: 2002 (a dry year), 2003 (a wet year), and 2004. The yearly presentation is intended to provide an indication of the nature of year-to-year variability of cost by category that can be expected under either reduced-risk or standard cropping systems. Net revenue for each orchard and each year were calculated. Net revenue was calculated by taking the total estimated crop value per acre and subtracting the total amount spent on the materials used and the total amount spent on other costs relevant to chemical (e.g., pruning, pest monitoring, mowing, spraying labor). When reduced risk IPM cost and net revenue per acre for each year are compared with corresponding figures for a conventional orchard results indicates that there is about a 35 percent chance that net revenue per acre will be between \$4000 and \$6000 with the reduced-risk cropping system.

Curves developed from the data should be regarded as a smooth histogram for net revenue per acre. So, if all farms in the region use reduced (environmental) risk production, then we should see 35 percent earning between \$4000 and \$6000 per acre. The chance of achieving between \$4000 and \$6000 in net revenue is only 29 percent for conventional farms. So, when both crop value and cost are considered along with variability of both across farms, reduced (environmental) risk production outperforms conventional production from an industry standpoint and would provide more satisfactory results from an industry-wide perspective regardless of the degree of averseness to bearing (financial) risk.

One qualification should be made: This was a pilot study and our sample is small; we need more participants to accurately generalize. One possible explanation of our finding is that sample used (4 growers) is not typical. That is, if these same 4 growers were using conventional methods they potentially would be making far more than typical conventional growers, and hence it costs them money to use the low risk approach. The other, more intriguing possibility is that the low-risk approach actually is more profitable than a conventional approach. Under that explanation, our analysis suggests that, contrary to common belief, low-risk IPM systems in apples are actually more profitable than conventional pest management. This needs to be looked at using a much larger sample of conventional and low-risk growers to be sure that this result is real.

H. Impacts

The project *per se* has not reduced risk associated with pesticides. However, it has shown that exposure to OP and Carbamate insecticides can be significant even after working for only 20 minutes in treated orchards after the expiration of the REI. Because IPM Scout/consultants and other workers spend substantially more than 20 minutes in treated orchards, the likelihood of greater exposure than found here is high. Thus, it is possible that exposure to toxic pesticides may reach the ADI or result in MOE or HQ levels that raise safety concerns with even greater frequency than noted here unless steps are taken to protect oneself, especially in “Standard IPM” orchards. An April 29, 2005 report from the National Institute of Environmental Health Sciences (NIEHS) shows that farmers who used agricultural insecticides experienced increased neurological symptoms, even when they were no longer using the products. Data from 18,782 North Carolina and Iowa farmers linked use of insecticides, including organophosphates and organochlorines, to reports of reoccurring headaches, fatigue, insomnia, dizziness, nausea, hand tremors, numbness and other neurological symptoms. Therefore, adoption of reduced risk IPM systems and use of simple protective gear may have long term positive impacts on farmer and farm worker health.

The most hazardous exposure to scouts occurred when entering either block type after the expiration of the 24 hour REI for the fruit thinner Carbaryl. Significant exposure also occurred in “Standard IPM” blocks that used the OP Phosmet. Although the material was used in “Reduced Risk IPM” blocks as well, use of reduced rates and frequency substantially limited worker exposure. At minimum, persons entering treated “Standard IPM” orchards should wear long sleeved shirts and disposable gloves to reduce the potential movement of pesticides through the skin barrier. Similar protection should be used when entering either “Standard IPM” or “Reduced Risk IPM” orchards within 1 week of thinning sprays using carbaryl.

The economic analysis appears to indicate that use of a reduced risk IPM strategy may be more profitable than previous studies have shown. Further research needs to be done using spray cost data from a much larger grower sample to be sure our results are typical. The analysis also did not take into account changed prices or sales volume that were generated through the Eco-Apple project. In addition to increased access to new market outlets by participating growers, we have verbal evidence from farmers that the project enabled them to receive higher prices than before, particularly for some sizes of certain cultivars (e.g., smaller Empires). In addition, development of large wholesale outlets (e.g.,

Trader Joe's, Whole Foods Markets) previously not served, allowed growers to sell fruit sooner after harvest than before, ultimately resulting in improved fruit quality and lower storage costs. According to Project leaders, demand for certified Eco-apples outstripped supply in 2004, indicating substantial "market pull". Continued availability of market outlets for growers using reduced risk IPM systems is anticipated to provide a strong adoption incentive for such systems, even if materials used are most costly.

The project has definitely enhanced collaboration among stakeholders interested in adopting reduced risk IPM systems, including: Fruit Extension staff from MA, NY, CT and RI, Red Tomato, IPM Institute of North America, Region I EPA (primary funding source for development of Eco Apple standards), private sector growers, and IPM consultants.

I. References

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J. Appendices

Table 1. List of pesticides evaluated and method of exposure assessment.

Target pesticides	Dosimetry	Biomonitoring
Carbaryl	yes	yes
Captan	yes	no
Phosmet	yes	no
Indoxcarb	yes	no
Fenarimol	yes	no
Thiophanate-methyl	yes	no
Azinphos-methyl	yes	yes
EBDCs	no	yes

Notes:

Clofentezine and Imidacloprid – on the list but never sprayed

Table 2. Overall mean residues (μg) from whole body dosimetry in 3 Massachusetts Commercial Apple orchards, 2004

Block Type	Sample	Phosmet	Carbaryl	Captan	Indoxcarb
Standard	Torso	3422	604	4976	ND **
	Upper Arms	524	260	902	ND
	Lower arms & gloves	4973	1110	2415	ND
	Pants	1169	553	3433	ND
	Lower legs	559	906	833.5	ND
	Socks	168	77	298	ND
	Air sampler	5	12	NC *	ND
Reduced Risk	Torso	254	711	2482	254
	Upper Arms	36	181	246	51
	Lower arms & gloves	215	925	2843	311
	Pants	117	493	145	56
	Lower legs	47	267	634	26
	Socks	15	50	124.5	52
	Air sampler	ND	22	NC	NC

NC = Not Collected

ND = None Detected

Table 3. 2004 “Standard IPM system”: grower 3 example

Background information:
 Name of grower: Grower 3
 Orchard name: Orchard 3
 Number of acres: 3
 Cultivars: McIntosh
 Ave. age of trees: 20
 Ave. height and width: 12 feet X 14 feet
 Planting density: 16 x 24 (113 trees/acre)
 Application rate: 50
 Tree row volume: 250
 Value of crop in 2003: \$6,715
 (790 bu/acre @ \$8.50/bu)

<p><u>Type of Material</u> M = miticide B = bacteriocide F = fungicide I = insecticide T = thinner H = herbicide A = adjuvant GR = growth regulator R = rodenticide</p>
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<u>Date</u>	<u>Activity</u>	<u>Material</u> (rate/formulation)	<u>Type</u>	<u>Rate/acreUnit</u>	<u>Cost/Acre</u> (material)	<u>Cost/Acre</u> (other)	<u>Target</u>
March	pruning	NA				\$452.00	
March	brush removal	NA				\$40.00	
4/14	pest mgt.	Damoil	M	3.00gal	\$5.03		ERM
		NuCop 50DF	B	9.00lb	\$19.08		FB
4/21	pest mgt.	Dithane 75DF	F	4.50lb	\$10.13		AS
4/29	pest mgt.	Dithane 75DF	F	4.50lb	\$10.13		AS
5/9	pest mgt.	Dithane 75DF	F	4.50lb	\$10.13		AS
		Asana	I	9.00oz	\$5.97		TPB
5/16	pest mgt.	Dithane 75DF	F	4.50lb	\$10.13		AS
5/25	pest mgt.	Flint	F	2.00oz	\$22.00		AS
	crop load mgt.	Sevin XLR	T	3.00pt	\$13.28		
5/26	pest mgt.	Imidan 70WSB	I	0.30lb	\$2.09		PC border spray
5/30	pest mgt.	Simazine 90DF	H	0.50lb	\$1.58		Weeds

		Gramoxone Max	H	0.67pt	\$3.18	Weeds
		Induce	A	3.00oz	\$1.12	Weeds
6/3	pest mgt.	Sovran	F	4.00oz	\$22.00	AS
		Imidan 79WSB	F	3.00lb	\$20.91	PC
	crop load mgt.	Sevin XLR	T	3.00pt	\$13.28	
6/12	pest mgt.	Captec 4F	F	2.00qt	\$10.78	AS
		Imidan 70WSB	I	3.00lb	\$20.91	PC
6/19	pest mgt.	Imidan 70WSB	I	0.30lb	\$2.09	PC border spray
6/23	pest mgt.	Captec 4F	F	2.00qt	\$10.78	AS
		Savey 50DF	M	3.00oz	\$40.62	ERM
7/7	pest mgt.	Captec 4F	F	1.00qt	\$5.39	AS
		Provado 1.6F	I	3.00oz	\$10.20	WAL
7/21	pest mgt.	Captec 4F	F	1.00qt	\$5.39	AS
		Imidan 70WSB	I	1.50lb	\$10.46	AMF
8/7	pest mgt.	Captec 4F	F	1.00qt	\$5.39	AS
		Topsin 70WSB	F	9.00oz	\$8.58	SB/FS
		Imidan	I	1.50lb	\$10.46	AMF
8/14	pest mgt.	Flint	F	2.00oz	\$22.00	AS
		Imidan 70WSB	I	1.50lb	\$10.46	AMF
8/30	pest mgt.	Captec 4F	F	1.00qt	\$5.39	AS
		Topsin 70WSB	F	9.00oz	\$8.58	SB/FS
November	pest mgt.	zinc phosphide	R	10.00lb	\$9.50	Voles
April - August	spray labor					\$150.00
"	spray/mow equip.					\$200.00
"	mow labor					\$135.00
"	pest monitoring					\$50.00
				Totals	\$367.02	\$1,027.00
				Grand total		\$1,394.02

Table 4. 2004 spray protocol for the "reduced-risk" blocks.

A. Fungicides: this is a guide, the amount/ timing of rainfall and accumulation of day degrees should be used for fine-tuning. The goal is to gradually reduce the use of the fungicides that are most likely to have re-registration toxicology or resistance problems (EBDCs, SIs, and captan) and increase the use of the more environmentally benign materials like copper, Flint, and Sovran. As noted in the May 2004 issue of *Healthy Fruit*: Copper, as Kocide, COCS or other labeled formulation, is a good early-season material. It can also help with fire blight, and reduces some canker pressure. Syllit (dodine) is also good at this time, as long as there is no indication that scab resistance has developed. Finally, the EBDCs such as Dithane, Manzate, Penncozeb or Polyram make a good early season fungicide. Captan should not be used where oil is in use during the early season. All of the materials listed are best-used before a rain. Kickback is limited to a day or less from the start of a rain, making post-infection applications tricky at best. If you plan to use Sovran or Flint this year, save it for the period of tight cluster through bloom when scab pressure is high.

For early scab control, at green tip or 1/2 inch green, the first choice is a copper, such as Kocide or COCS, the 2nd choice is Syllitt (unless you have seen loss of effectiveness), and the 3rd choice is an EBDC.

At Tight Cluster, use Flint.

At Pink/ Early Bloom use Flint.

At Bloom, use an EBDC or captan. You may add an SI, but not if you have noticed loss of effectiveness.

At Petal Fall, use captan or captan + an SI.

At 1st cover, use captan or an SI (if this is the 2nd SI application, for resistance management try not to use SIs more than twice this year).

At 2nd cover use Flint.

3rd and 4th covers, use captan or captan + Topsin M.

Insecticides and Miticides:

Early season, use oil for mites; you can also use Apollo early season if needed. For summer mite emergencies use acramite or pyramite or summer oil.

If you have problems with **early season insects**, such as TPB or EAS, Actara is the material of choice. However, the label was changed and apples in MA are not labelled in 2004. If you have some Actara from before, you may use it according to the label at that time. Otherwise, Avaunt could be used.

For Plum Curculio, if there is a need to spray for PC at pink or Petal Fall, Actara is the first choice if you have some in stock. Otherwise, Avaunt is a good second choice. At 1st or 2nd cover, Avaunt is the material of choice. Ron Prokopy's recommendation for a full block spray at the appropriate time,

followed by a border row spray is a good "reduced-risk" strategy. If you feel that Avaunt is prohibitively expensive, use Imidan once during PC season and/or once during AMF season.

For wooly apple aphid use Provado if needed.

For apple maggot, use Spintor or Avaunt or trap-out spheres. Avaunt has a maximum usage of 4 times a year for a total of 24 oz. per acre. It also has a 28 day pre-harvest interval. One possibility is to use trap-out spheres for early season maggot control plus a few monitoring spheres, and then 1 Avaunt spray in early or mid-August depending on maggot population and projected harvest date.

Table 5. 2004 "Reduced Risk IPM System: Grower 3 example

<u>DATE</u>	<u>MATERIAL AND RATE</u>	<u>PEST</u>
actual:		
5/1-5/3	4 oz/100 Rubigan	Scab
	1 #/100 Mancozeb	
	1 gal/100 oil	Mites
5/9-5-10		
	4 oz/100 Rubigan	Scab
	1 #/100 Mancozeb	
5/19-5/20	border spray of 1#/100 Imidan	plum curculio (PC)
	4 oz/100 Rubigan	Scab
	1 #/100 Mancozeb	
	6 oz per acre Apogee	growth control
5/29-5/31	2/3 oz/100 Flint	Scab
	6 oz per acre Apogee	growth control
6/7	border spray of 1#/100 Imidan	PC
6/9-6/10	1#/100 Captan 80	scab/summer diseases
	1 oz/100 Savey	Mites
	6 oz per acre Apogee	growth control
projected:		
6/16	1/2 #/100 Captan 80	summer diseases
7/1	1/2 #/100 Captan 80	summer diseases
	2 oz/100 Avaunt	apple maggot
	assuming a "normal" season regarding wetting periods	
7/21	1/2 #/100 Captan 80	summer diseases
	2 oz/100 Avaunt	apple maggot
8/11	same as 7/21	
8/30	1/2 #/100 Captan 80	summer and post-harvest diseases
	2 oz/100 Topsin	

Table 6. 2004 “Reduced-risk IPM System”: Grower 4 example

Date	Activity	Name of material & formulation	Rate per acre	Cost/acre
4/21	Fungicide/ bacteriocide for early fungi and fire blight	Copper		18.00
4/29	Insecticide (for pug moth)	Avaunt	5 oz	22.00
4/29	Oil (for mites)	Oil	4 gal	14.64
4/29	Fungicide for scab (low rate)	Flint	0.7 oz	7.70
5/4	Fungicide for scab	Flint	1.4 oz	15.40
5/11	Fungicide for scab	Dithane +	2 lb	5.50
		Topsin M	2 oz	2.40
5/18	Fungicide for scab	Captan 80 WP	2 lb	8.00
5/25	Insecticide for plum curculio	Avaunt	5 oz	22.00
6/9	Fungicide + insecticide (scab and Plum curculio)	Flint + Imidan	1.4 oz 0.38	15.40 13.57
7/2	Fungicide for summer diseases	Captan 80 WP	2 lb	8.00
8/2	Fungicide + insecticide for Summer diseases and apple maggot	Flint + Avaunt	1.4 oz 5 oz	15.40 22.00
8/24	Fungicide + insecticide for Summer diseases and apple maggot	Captan 80 WP + Imidan	2 lb 0.38	8.00 13.57

Table 7. Exposure and hazard (MOE and HQ) estimates to IPM scouts during 20 minute scouting activities

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
5/17/2004	1	LA/G ^[1]	<u>12 h REI</u> 723.4 ug	<u>NA</u> ND	<u>NA</u> ND	<u>24 hr REI</u> 331.1 ug	<u>NA</u> ND
HRC stnd		RD ^[2]	139.2 ug	ND	ND	80.4 ug	
		Inhalation	21.4 µg	ND	ND	9.81µg	ND
		Total	884 ug			421.1 ug	
		Dose (µg/Kg b.w) ^[3]	12.6 ug			6.0 ug	
		MOE ^[4]	79			333	
		HQ ^[5]	0.126			0.3	
			<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
5/18/04	1	LA/G	<u>12 h REI</u> 1583.5 ug	<u>NA</u> ND	<u>NA</u> ND	<u>Unknown</u> ^[6] 12.7 ug	<u>12 hr REI</u> 32.9 ug
HRC RR		RD	245.9 ug	ND	ND	2.8 ug	5.7 ug
		Inhalation	22.2 µg	ND	ND	ND	0.85 µg
		Total	1851.6 ug			15.5 ug	39.45 ug
		Dose (µg/Kg b.w)	26.5 ug/Kg			0.22 ug/Kg	0.56 ug/Kg
		MOE	38			9091	3549
		HQ	0.265			0.011	0.028
			<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
5/20/04	1	LA/G	<u>unknown</u> 540.0 ug	<u>NA</u> ND	<u>NA</u> ND	<u>24 hr REI</u> 937.7 ug	<u>NA</u> ND
ARSE STND		RD	70.4 ug	ND	ND	87.8 ug	ND
		Inhalation	ND	ND	ND	1.93 ug	ND
		Total	610.4 ug			1027.4 ug	
		Dose (µg/Kg b.w)	8.72 ug/Kg			14.7 ug/Kg	
		MOE	115			136	
		HQ	0.087			0.735	

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxicarb</u>
5/26/04	1	LA/G	unknown	<u>24 hr REI</u>	<u>NA</u>	unknown	<u>12 hr REI</u>
Ashfield RR		RD	3.78 ug	294.0 ug	ND	22.0 ug	14.1 ug
		Inhalation	0.59 ug	26.9 ug	ND	3.78 ug	4.0 ug
		Total	ND	ND	ND	ND	ND
			4.37 ug	320.9 ug		25.8 ug	18.1 ug
		Dose (µg/Kg b.w)					0.26
		MOE	0.06 ug/Kg	4.6 ug/Kg		0.37 ug/Kg	ug/Kg
		HQ	> 10,000	2717		5405	7692
			< 0.001	0.035		0.002	0.013

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxicarb</u>
5/26/04	1	LA/G	unknown	<u>NA</u>	<u>NA</u>	<u>24 hr REI</u>	<u>NA</u>
Ashfield STND		RD	3.56 ug	ND	ND	323.8 ug	ND
		Inhalation	1.6 ug	ND	ND	52.6 ug	ND
		Total	ND	ND	ND	1.55 ug	ND
			5.16 ug			379.0 ug	
		Dose (µg/Kg b.w)				5.4 ug/Kg	
		MOE	> 10,000			370	
		HQ	< 0.001			0.27	

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxicarb</u>
6/3/04	1	LA/G	<u>8 D REI</u>	<u>NA</u>	<u>NA</u>	<u>24 hr REI</u>	<u>8 D REI</u>
HRC STND		RD	60.5 ug	ND	ND	567.3 ug	5.97 ug
		Inhalation	4.83 ug	ND	ND	42.2 ug	0.22 ug
		Total	2.6 ug	ND	ND	15.0 ug	ND
			67.9 ug			644 ug	6.18 ug
		Dose (µg/Kg b.w)					0.09
		MOE	0.97 ug/Kg			8.9 ug/Kg	ug/Kg
		HQ	1030			225	> 10,000
			0.010			0.446	< 0.001

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
6/8/04	1	LA/G	<u>12 D REI</u> 41.5 ug	<u>NA</u> ND	<u>NA</u> ND	<u>12 D REI</u> 60.6ug	<u>12 hr REI</u> 32.1 ug
HRC RR		RD	3.9 ug	ND	ND	20.6 ug	2.0 ug
		Inhalation	ND	ND	ND	ND	0.91ug
		Total	24.6 ug			81.2 ug	35.1 ug
		Dose (µg/Kg b.w)	0.35 ug/Kg			1.2 ug/Kg	0.5 ug/Kg
		MOE	5714			1666	4000
		HQ	0.0035			0.06	0.025

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
6/8/04	1	LA/G	<u>12 D REI</u> 9.16 ug	<u>24 hr REI</u> 217.8 ug	<u>NA</u> ND	<u>unknown</u> 14.2 ug	<u>12 hr REI</u> 37.6 ug
ARSE RR		RD	1.6 ug	38.5 ug	ND	1.9 ug	4.95 ug
		Inhalation	<i>NC</i>	<i>NC</i>	<i>NC</i>	<i>NC</i>	<i>NC</i>
		Total		256.3 ug		16.1 ug	42.6 ug
		Dose (µg/Kg b.w)		3.66 ug/Kg		0.23 ug/Kg	0.6 ug/Kg
		MOE		3415			3333
		HQ		0.028			0.03

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
7/9/04	1	LA/G	<u>NA</u>	<u>unknown</u> 20.4 ug	<u>NA</u> ND	<u>unknown</u> 11.8 ug	<u>12 hr REI</u> 60.1 ug
HRC RR		RD		2.5 ug	ND	1.3 ug	29.5 ug
		Inhalation		<i>NC</i>	<i>NC</i>	<i>NC</i>	<i>NC</i>
		Total		22.9 ug		13.1 ug	89.6 ug
		Dose (µg/Kg b.w)		0.04 ug/Kg		0.19 ug/Kg	1.28 ug/Kg
		MOE					1562
		HQ					0.064

<u>Application</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
7/9/04	LA/G	unknown	unknown	<u>NA</u>	unknown	unknown
HRC STND	RD	ND	301.2 ug	ND	495 ug	ND
	Inhalation		70.6 ug	ND	72.0 ug	ND
			ND		5.98 ug	NC
	Total		371.8 ug		573 ug	
	Dose (µg/Kg b.w)		5.3 ug		8.19 ug/Kg	
	MOE		2358		244	
	HQ		0.041		0.41	

<u>Application</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
7/22/04	LA/G	unknown	unknown	<u>NA</u>	unknown	unknown
ARSE STND	RD	ND	1329 ug	ND	469 ug	ND
	Inhalation		117.4 ug	ND	53.3 ug	ND
			ND		3.53 ug	NC
	Total		1446.4 ug		526.0 ug	
	Dose (µg/Kg b.w)		20.7 ug		7.5 ug/Kg	
	MOE		603		267	
	HQ		0.16		0.375	

<u>Application</u>	<u>Dosimeter Section</u>	<u>12 hr REI</u>
7/22/04	LA/G	18.8 ug
West Brook	RD	1.8 ug
STND	Inhalation	NC
	Total	20.6 ug
	Dose (µg/Kg b.w)	0.29 ug/Kg
	MOE	>10000
	HQ	0.0036

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
6/1/05	4	LA/G	<u>12 hr REI</u> 26.4 ug	<u>24 hr REI</u> 223.9 ug	<u>NA</u>	<u>72 hr</u> 25.5 ug	<u>12 hr REI</u> 9.6 ug
Clark Fortune		RD	7.9 ug	29.2 ug		4.3 ug	9.0 ug
		Inhalation	1.29 ug	9.22 ug		2.22 ug	ND
		Total	35.59 ug	262.4 ug		32.02 ug	18.6 ug
		Dose (µg/Kg b.w)	0.51 ug/Kg	3.75 ug/Kg		0.46 ug/Kg	0.27 ug/Kg
		MOE	2000	3333		4348	7407
		HQ	0.005	0.029		0.023	0.014

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
6/1/05	4	LA/G	<u>NA</u>	<u>24 hr REI</u> 230.9 ug	<u>NA</u>	<u>24 hr REI</u> 194.9 ug	<u>NA</u>
Clark Campsite		RD		30.7 ug		37.9 ug	
		Inhalation		10.84 ug		6.13 ug	
		Total		272.4ug		238.9 ug	
		Dose (µg/Kg b.w)		3.89 ug/Kg		3.4 ug/Kg	
		MOE		3213		588	
		HQ		0.03		0.17	

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Carbaryl</u>	<u>Captan</u>	<u>Fenarimol</u>	<u>Phosmet</u>	<u>Indoxcarb</u>
7/14/05	4	LA/G	<u>12 hr REI</u> 149.0 ug	<u>24 hr REI</u> 230.9 ug	Unknown 27.2 ug	Unknown 22.4 ug	<u>NA</u>
Clark Campsite		RD	7.44 ug	30.69 ug	Not analyzed		
		Inhalation	6.47 ug	10.44 ug	ND	ND	
		Total	162.9 ug	272.0 ug			
		Dose (µg/Kg b.w)	2.32 ug/Kg	3.89 ug/Kg			
		MOE	431	3213			
		HQ	0.023	0.030			

<u>Application</u>	<u>Replicates</u>	<u>Dosimeter Section</u>	<u>Azinphos-methyl</u>
9/6/05	4	LA/G	<u>14 D REI</u>
Clark Campsite		RD	Not analyzed
		Inhalation	
		Total	
		Dose ($\mu\text{g}/\text{Kg}$ b.w)	
		MOE	
		HQ	

^[1] LA/G (lower arms and hands) assumed to be unprotected, so only dermal penetration rate applies (Carbaryl 20%; Captan 9 %; Phosmet and Indoxicarb and fenarimol 10 %); Residues collected on lower arms and gloves x dermal penetration rate.

^[2] RD (remaining dosimeter sections) has 10% clothing penetration rate in addition to dermal penetration; Residues collected on remaining dosimeter sections x 10 % x dermal penetration rate.

^[3] Dose ($\mu\text{g}/\text{Kg}$ b.w); assumes 70 Kg body weight.

^[4] MOE (Margin of exposure: NOEL/exposure). NOEL for carbaryl 1 mg/Kg/d; phosmet and indoxicarb 2 mg/Kg/d; captan 12.5 mg/Kg/d, fenarimol 1.2 mg/Kg/d. Values < 100 are potentially hazardous.

^[5] HQ (US EPA Hazard Quotient: exposure/Rfd). Rfd for carbaryl 100 ug/Kg/d; phosmet and indoxicarb 20 ug/Kg/d; captan 130 ug/Kg/day, fenarimol 65 ug/Kg/d. Values >1 are potentially hazardous.

^[6] Application date needs to be verified from application records.

