Comprehensive Pesticide Environmental Assessment Tool for U.S. Agriculture

Final Report

December 1, 2011

Grantee Name: IPM Institute of North America, Inc.
Project Title: Comprehensive Pesticide Environmental Assessment Tool for U.S. Agriculture

Project Director: Dr. Thomas Green

Period Covered by Report: September 1, 2007 – August 31, 2011

Deliverables:

1. An on-line pesticide product ranking tool.
2. An outreach program including website, electronic and print communications.
3. An external peer review (including NRCS staff) at three stages and an ongoing internal review by our diverse, broad stakeholder advisory group.
4. A comprehensive evaluation of use over two seasons in key cropping systems and production regions; 12 quarterly and one final progress reports; three annual advisory meetings by conference call and three in person.
5. Reduction in impacts of the highest hazard pesticides by 10% by tool users by the end of the 2010 season.

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Executive Summary

When a pesticide application is needed, choosing least-hazardous options is a key component of Integrated Pest Management (IPM). Data and tools needed to fully evaluate potential impacts and tradeoffs across chemical and non-chemical management options are not readily available to the pesticide user. The lack of a credible, comprehensive and easy-to-use pesticide evaluation tool has limited IPM promotion and performance benchmarking by grower groups, USDA, eco-certifiers and commercial food buyers.

This project developed the Pesticide Risk Mitigation Engine (PRiME), an efficient, user-friendly option for farmers, advisors, program managers, policy makers and others to evaluate pesticide options for impacts on health and the environment, improving the quality and quantity of IPM. PRiME addresses NRCS priority concerns by seeking to protect and improve water quality and help pesticide users minimize impacts on non-targets including humans, wildlife and aquatic ecosystems.

Our primary goal was to develop an online, user-friendly tool to evaluate pesticide risks in agriculture. Our deliverables, as stated in the original grant proposal, were:

1. Develop a web application that would:
    a. estimate risks to resources including: ground and surface water, soil and air quality, worker safety, consumer safety (residues on food), wildlife habitat, pollinators, beneficial insects, and birds**;**
    b. evaluate hazards to each resource of concern separately or in combination;
    c. assess individual or combined pesticide products;
    d. weigh impacts of application methods, quantity and frequency of application;
    e. account for site-specific conditions;
    f. provide access to information on mitigation options for specific product/application selections; and
    g. provide an index "score" and ranking for each application and for all applications over a single season, as well as sub-scores for each resource concern.

2. An outreach program including website, electronic and print communications targeting key user groups.

3. An external peer review at three stages and an ongoing internal review.

4. A comprehensive evaluation of use over two seasons in key cropping systems and production regions.

5. Reduction in impacts of the highest hazard pesticides by 10% by tool users by the end of the 2010 season.

We have succeeded in launching PRiME, www.ipmprime.org. This user-friendly web application includes eight risk indices (Aquatic Invertebrates, Algae, Fish, Earthworms, Small Mammal, Avian Acute Risk, Avian Reproductive Risk, and Inhalation Risk for Workers/Bystanders) and weighs impacts of application methods, quantity and frequency of application.

Additionally, we developed outreach materials including website, electronic and print communications targeting key user groups (Appendix A). We completed an external peer review of all risk indices included in PRiME, as well as pilot testing over two growing seasons and six crops (apples, pears, cherries, green beans, potatoes and grapes; see Appendix D for a summary of pilot testing).

We fell short of our proposed deliverables in the following areas:

- PRiME does not include risk indices for: ground water, consumer safety, pollinators or beneficial insects. A dietary risk index has been developed and peer-reviewed, but we were unable to operationalize this index within the grant period. A pollinator index is nearly complete, and will be added to PRiME as time and resources allow.
- PRiME does not yet account for site-specific conditions. We are currently upgrading PRiME's pesticide fate and transfer modeling to account for site-specific soil, weather and crop type, as well as edge-of-field filter strips, all of which will affect pesticide movement off site.
- Although PRiME accounts for some differences in exposure potential associated with application methods, it does not suggest mitigation measures based on risk outputs. This component is being developed in conjunction with site-specific pesticide fate and transfer modeling described above.
- Although PRiME can aggregate risk scores from multiple pesticide applications within each risk index, it does not aggregate scores across risk indices to produce a single risk score. After much effort developing and evaluating various methods for such aggregation, the project team could not reach a consensus that there is a scientifically justifiable way to aggregate scores across disparate risk indices without obscuring important risk trade-offs (see our Policy on Indicator Structure, Appendix H). As we continue to refine and add risk indices to PRiME, we will continue to seek more concise ways of reporting risk and summarizing large datasets.
- We cannot report a reduction in highest risk pesticide applications among PRiME users. PRiME was not developed fully enough to suggest that 2011 pilot testers make pest management decisions based on PRiME output.

Project timeframe

Due to programming delays that limited our opportunity to interact with growers prior to the 2010 growing season, our project required a one-year, no-cost extension through September 2011. The extension allowed us to conduct post-season testing of the PRiME tool in fall of 2010 and continue testing and development through the 2011 growing season. It also allowed us to more fully develop and test the pesticide fate and transfer modeling and additional risk indices to ensure that our end product met the needs of its potential users including NRCS.

Project beneficiaries
Potential beneficiaries of the PRiME tool include (1) conventional and organic producers and crop advisors, (2) NRCS staff working with producers to develop and implement pest management plans, (3) Extension specialists advising producers, (4) food and fiber processors evaluating performance of supplier IPM programs, (5) certification organizations, (6) pesticide developers and manufacturers, and (7) regulators evaluating relative hazards of alternatives to products facing restrictions or loss of registration.

Project funds
Project funds were predominantly spent as anticipated. Although minor changes were made to budget lines, we did not incur additional cost beyond what was included in our initial 2007 proposal to NRCS. In 2009, we requested the addition of new subcontractors to the project. In our initial proposal, we included $100,000 in our budget for the 'purchase of existing databases and/or database development.' This amount was budgeted for additional needs that we anticipated identifying as our project developed. The expenditures of the additional subcontractors, totaling $60,000, were drawn from the database budget line. Additionally, after receiving a one-year, no-cost extension, funds for another year of personnel time were needed. A portion of the grant funds originally budgeted for travel expenditures were shifted to cover personnel salary for the additional year of project development.

Demonstrating alternative technology
PRiME project team members engaged in a variety of outreach opportunities to present and demonstrate the PRiME tool to potential users. Before an accessible web application and user interface was developed, team members presented the PRiME indices and risk calculations. Throughout the development of the tool and user interface, team members presented both the PRiME risk indices and web application to a variety of audiences including professional associations, regulatory agencies, grower groups, distributors, processers, certification agencies and NRCS. Through presentations at meetings, conference calls, workshops and trainings, the project team was able to demonstrate the usefulness of PRiME and collect valuable feedback for incorporation into the tool. For a detailed list and description of PRiME outreach, see Appendix G.

Physical and economic results
Because PRiME was not developed fully enough to suggest that 2011 pilot testers make pest management decisions based on PRiME output, we cannot report quantifiable results achieved through the use of PRiME.

As we continue to develop and refine PRiME, we do expect the tool to help users realize both economic and physical results in the coming years. We expect quantifiable physical results from the use of PRiME to include (1) users evaluating applications and changing the types of pesticides used and (2) users implementing suggested mitigation strategies, resulting in reduced pesticide risk. We anticipate that growers using PRiME will realize cost savings associated with reduced pesticide applications as well an increased ability to demonstrate risk reduction, allowing them to access and compete in new markets including eco-certifications.

Programs that could potentially use PRiME

NRCS staff working with producers to develop and implement pest management plans could use PRiME to improve a producer's ability to reduce impacts on key environmental resources. PRiME could also be used to evaluate a producer's eligibility for cost share and incentive payments. See also Appendix C, Technology Review Criteria for Alternative Technologies.

Recommendations

We have identified the following recommendations that would facilitate further implementation of the PRiME tool.

- **Remaining key indices**. We will complete and implement the dietary risk and pollinator indices so that users are not making decisions based on incomplete data.
- **Site-specificity**. We will complete next year's planned beta test of estimating pesticide concentrations in water based on site-specific scenarios, evaluate results and revise water modeling based on results.
- **Continued and expanded outreach**. Our outreach approach will continue to include presentations at scientific and industry meetings, a peer-reviewed publication in progress led by Pierre Mineau, and close collaborations with key industry pilot testers including organizations with potential to impact many users including food processors, distributors and retailers, and eco-certification programs.
- **Formal launch of PRiME**. Once next year's beta test is complete, we will announce a formal launch including press releases and an inaugural newsletter focused on PRiME for users and potential users.
- **Collaboration with NRCS**. We will continue to work closely with the NRCS WIN-PST group and with NRCS state and county staff to explore opportunities to use PRiME to support NRCS's mission.
- **Internationalization.** We will continue to develop and implement our plan for internationalization to facilitate use in any country worldwide.

Introduction

Over the last four years, the IPM Institute of North America, with project partners Oregon State University, Carleton University, BCS Ecologic, The Pesticide Research Institute, the Natural Resources Defense Council and Waterborne Environmental, has developed the Pesticide Risk Mitigation Engine (PRiME), a web application that estimates agricultural pesticide risks to key resource concerns, including, birds, earthworms, small mammals, aquatic ecosystems and worker/bystander health and safety.

Key personnel:

Dr. Thomas Green (PI), president, IPM Institute of North America, Inc. Green has more than 25 years experience in environmental protection and four successful ventures including an IPM supply business he grew to more than $1.6 million in annual sales. He holds a Ph.D. in entomology from the University of Massachusetts and is a Certified Crop Advisor and Technical Service Provider and chief scientist for the Eco Apple eco-label program.

Dr. Charles Benbrook, chief scientist, The Organic Center. Benbrook provides expertise on pesticide impacts on human dietary risk. Benbrook worked in Washington, D.C. on agricultural policy, science and regulatory issues from 1979 through 1997. He served for 1.5 years as the agricultural staff expert on the Council for Environmental Quality; from 1981-1983, he was the Executive Director of the Subcommittee on Department Operations, Research, and Foreign Agriculture, U.S. House of Representatives; from 1984-1990, served as the Executive Director, Board on Agriculture, National Academy of Sciences; he ran Benbrook Consulting Services from 1991 through 2006.

Karen Benbrook, principal of BCS-Ecologic, Inc., is a primary developer of the existing toxicity unit system used by Protected Harvest. Karen's responsibilities related to the PRiME project include the development of pesticide hazard databases which include pesticide products, environmental fate and toxicological properties of pesticide active ingredients, and pesticide residues found in food.

Mark Cheplick, agricultural engineer, Waterborne Environmental, assists in the implementation of the EXAMS - PRZM Exposure Simulation Shell (EXPRESS) within the PRiME user interface. Mark has extensive experience developing EXPRESS and provides the PRiME project with code and consultation.

Dr. Michael Guzy, assistant professor senior research, Biological and Ecological Engineering, Oregon State University, is responsible for overall system design, including database structure, pesticide fate and transfer modeling, and user interface. Michael has 15 years experience programming in industry and academia on mission-critical, distributed, GIS, and web-based systems.

Dr. Paul Jepson, director, Integrated Plant Protection Center, Oregon State University provides expertise on pesticide impacts on beneficials and other non-target organisms and supervises the information technology experts who design and maintain the online interface. Paul's research interests in IPM include the study of pest and natural enemy population dynamics in agricultural systems and have focused particularly on pesticide management and side effects, biological pest control and the development of ecological risk assessment for beneficial invertebrates.

Jonathan Kaplan, senior policy specialist, Natural Resources Defense Council, will assist with outreach to users, recruitment of user testers and development of the sustainable funding plan. Jonathan is a project specialist in the health program and coordinates NRDC's efforts to promote alternatives to pesticide use.

Dr. Susan Kegley, principal and CEO, Pesticide Research Institute, provides expertise on dermal and inhalation risk to workers and bystanders. Susan is an organic chemist with expertise in pesticide toxicology, pollutant fate and transport; environmental monitoring and analytical chemistry; and experience with pesticide regulation, pesticide data sources and the pesticide toxicology and epidemiology literature.

Dr. Pierre Mineau, senior research scientist, Pesticides Section, National Wildlife Research Centre, Science and Technology Branch, Environment Canada and Department of Biology, Carleton University will provide expertise on pesticide impacts on birds and other non-target organisms, and serve as liaison to a complimentary effort underway within the Canadian government.

Wade Pronschinske, technical services manager, IPM Institute of North America, provides overall management of technical design and implementation, as well as design of new user interface components, quality assurance of the web application and databases, user interface aesthetics, pilot testing and user training. Wade studied environmental ethics at Florida State University and has experience developing web-based training and evaluation materials for the United States Air Force.

Joe Bagdon, NRCS Technical Advisor

Project Goals

Our primary goal was to develop an online, user-friendly tool to evaluate pesticide risks in agriculture. This tool would apply best available science, in an easy-to-use platform, to give all U.S. producers, advisors and regulatory professionals the ability to make more informed pest management decisions by comparing options for any commodity and selecting those with the least risk and/or effective mitigation options. Unlike current tools, our goal was to develop a tool that would be easy to use, regularly updated and readily accessible nationwide.

Our deliverables, as stated in the original grant proposal, were:

1. Develop a web application that would:
    a. estimate risks to resources including: ground and surface water, soil and air quality, worker safety, consumer safety (residues on food), wildlife habitat, pollinators, beneficial insects, and birds**;**
    b. evaluate hazards to each resource of concern separately or in combination;
    c. assess individual or combined pesticide products;
    d. weigh impacts of application methods, quantity and frequency of application;
    e. account for site-specific conditions;
    f. provide access to information on mitigation options for specific product/application selections; and
    g. provide an index "score" and ranking for each application and for all applications over a single season, as well as sub-scores for each resource concern.

2. An outreach program including website, electronic and print communications targeting key user groups.

3. An external peer review at three stages and an ongoing internal review.

4. A comprehensive evaluation of use over two seasons in key cropping systems and production regions.

5. Reduction in impacts of the highest hazard pesticides by 10% by tool users by the end of the 2010 season.

Scope of Project Tasks

To create our assessment tool, we began with a review of existing approaches and models to develop a list of potential attributes. We created mock up web pages to illustrate our planned approach and began development of a prototype using apples as our pilot crop. We began developing a prototype tool including a database of pesticides (active ingredients and formulated products) used in U.S. apple production.

Our project team scientists developed white papers describing PRiME's risk calculations. These white papers were peer reviewed by independent experts and revised based on feedback.

We released a prototype of the PRiME web application online including the following features: a Google Earth mapping tool and subsequent retrieval of NRCS soils data; product and use pattern selection; manual entry of application data; bulk upload of spray records; and risk evaluation for seven indices, including evaluation of individual applications as well as cumulative risk for multiple applications. After the release of the prototype tool, we began development of an informational website to complement the web application housed on servers at Oregon State University. We developed supporting documents for the website including help files, frequently asked questions, terms of use and a privacy statement. We sought input from users including crop advisors, growers and the PRiME advisory committee and refined the user interface accordingly.

A beta version of the PRiME website was launched and we began expanding our products database to include products registered for additional specialty crops. PRiME-beta included a shopping cart for accounts and free guest access. We also implemented first tier water modeling in PRiME-beta, allowing us to operationalize the aquatic risk indices and develop the infrastructure necessary to implement more sophisticated water modeling in the future.

Throughout the development process, we continually sought user feedback and refined the web application to streamline processes, in terms of data entry from the user as well as background processes to make PRiME run more quickly and efficiently over the internet. We continue to develop and refine the databases that are the foundation of PRiME risk calculations.

Project Support
Primary support came from the NRCS CIG grant. Additionally, the project was facilitated by several key collaborations. The following collaborators provided in-kind and direct support in development of the PRiME project:

Canadian Department of Agriculture
General Mills – matching funds contribution of $15,000 over three years
Great Lakes Protection Fund – $10,000 grant for work on user interface and risk indices
Oregon State University – $70,000 subcontract as part of USDA NIFA – IPM PIPE grant to develop PRiME for six specialty crops, $124,684 cash match for Paul Jepson and project assistant time for PRiME development
Unilever – in-kind contribution of intellectual property of PRoMPT tool, valued at $325,000
University of Illinois – in kind contribution of graphic design work on elements of PRiME website and user interface by Scott Martin, University of Illinois graduate student
University of Wisconsin – Center for Integrated Agricultural Systems – contribution of meeting space, time, food for PRiME presentation and training, valued at $187.00
US EPA Region V - $26,308 for the Inhalation Risk Index and pesticide fate and transfer modeling
US EPA Region X –$6,120 to develop PRiME for use with potatoes in Washington and Oregon
Wescott Agri Products – contribution of meeting space, time, food for PRiME grower testing, valued at $529.56
Chuck Benbrook, Organic Center – in-kind contribution of time for participation on project team, $181,700 cash match for Chuck and Karen Benbrook for PRiME development
Karen Benbrook, BSC Ecologic – in kind contribution of time for participation on project team
Paul Jepson, Oregon State University – in kind contribution of time for participation on project team
Jonathan Kaplan, Natural Resources Defense Council – in kind contribution of time for participation on project team, $17,000 cash match for evaluating PRiME for compatibility with Stewardship Index and development of pesticide impact metric for sustainability index
Susan Kegley, Pesticide Research Institute – in kind contribution of time for participation on project team
Pierre Mineau, Environment Canada– in kind contribution of time for participation on project team, $93,654.85 cash match for PRiME development
PRiME advisory committee members – meeting time, participation in conference calls

Background

Currently, agricultural pesticide users face a variety of options when a pesticide application is required. To select the optimum product and mitigation options considering efficacy, cost and relevant hazards, users must evaluate a wide variety of criteria including the target pest, product price, persistence, transport and fate in the environment, potential for residue at harvest and post-harvest, as well as acute and chronic toxicity to applicators, consumers and other non-target organisms including beneficials, aquatic and terrestrial organisms. Data needed to fully evaluate products are not readily available and must be compiled from product labels, MSDS, and research and Extension publications and websites. No producer is presently equipped to perform this evaluation efficiently and effectively.

PRiME was developed to provide a readily available, easy to use tool that would permit producers, advisors and regulatory professionals to compare different pest management scenarios for any specialty or commodity crop and select options with the fewest potential environmental and health hazards, and to identify mitigation options for products/uses selected.

Several pesticide hazard assessment tools are currently in limited use but none are ideal, i.e., easy to use, regularly updated, readily accessible nationwide, customizable to specific cropping systems and environments, and addressing the full range of primary resource concerns. State-of-the-art examples include the Pesticide Environmental Assessment System (PEAS), currently in use in a very limited number of crops and locales by Protected Harvest, an eco-label program developed in collaboration with growers, university-based and independent scientists and environmental advocates.

NRCS-developed the Windows Pesticide Screening Tool (WIN-PST) is widely used by NRCS professionals to assess impacts of pesticide options in conjunction with technical assistance and incentive programs for producers. Unilever has also developed a proprietary system called the Pesticide Risk Management Profiling Tool (PRoMPT) which includes an innovative user interface and strengths in water resource impact mitigation. Joe Kovach, IPM Coordinator, Ohio State University, developed the Environmental Impact Quotient (EIQ), a pesticide hazard indexing system used in several crops in the US and Canada. The IPM Institute, in conjunction with growers, crop advisors and scientists from Cornell and the University of Massachusetts, has developed a three-tier ranking system for pesticides used in apple production for the Northeast Eco Apple project, including: “use with justification” for products with few impacts; “use with restrictions” for products where specific mitigation of impacts is advisable and available; and “do not use” where effective alternatives are available.

Rather than reinvent the wheel or lose the knowledge base in this arena that has been developed to date, we enlisted these programs and scientists behind the development of these systems to best complement or incorporate the capabilities of existing tools, where appropriate as judged by our advisory group, external review panel and project team.

Project beneficiaries

Potential beneficiaries and uses of the PRiME tool include: (1) conventional and organic producers and crop advisors will maximize incentives and minimize hazards, liabilities and costs; (2) NRCS staff working with producers to develop and implement pest management plans will improve ability to identify and mitigate resources impacts and evaluate eligibility for cost share and incentive payments; (3) Extension specialists advising producers will improve product selection and evaluation of their program impacts; (4) food and fiber processors will improve ability to evaluate performance of supplier IPM programs; (5) certification organizations will be able to optimize sustainable performance standards to protect resource concerns and improve evaluation of program impacts; (6) pesticide developers and manufacturers will gain ability to identify high-hazard pest-crop combinations in need of new technology and evaluate cost and risk trade-offs; and (7) regulators will be able to evaluate relative hazards of alternatives to products facing restrictions or loss of registration.

Natural resource issues addressed

The PRiME tool seeks to protect and improve water quality and help users identify and mitigate pesticide impacts on birds, earthworms, small mammals, aquatic ecosystems, and worker/bystander health and safety.

Limited access to comprehensive information about potential impacts of pesticide products on resource concerns limits a user's ability to make an informed decision when choosing between multiple products and application methods. Without having the tools available to efficiently and effectively compare between options, a user may apply a high risk product, potentially causing an unintentional negative impact on the environment or worker health, when an alternative, lesser risk and equally effective product is available.

Review of Methods

There have been many environmental indicators developed in the past, with some still in use today. Rather than reinvent the wheel or lose the knowledge base that has been developed to date, we enlisted some of these programs and scientists behind the development of these systems to best complement or incorporate the existing capabilities of existing tools.

We began with a thorough review of the programming and rationale behind Unilever's PRoMPT tool. Much of the initial user interface design was based on this model. From the Pesticide Environmental Assessment System (PEAS), we borrowed databases and the concept of Use Pattern Adjustment Factor (UPAFs) which adjust risk scores, up or down, based on likely exposure potential. We made use of databases from WIN-PST. For our initial pesticide fate and transfer modeling, we use a modified version of the GENeric Estimated Exposure Concentration (GEENEC2).

While these tools represented the state of the art of pesticide risk indicators, none was user-friendly, online and up-to-date. Our task was to develop a new tool that would be easy to use, regularly updated and readily accessible nationwide.

Innovation

PRiME includes a greater number of risk indices than have been previously addressed in a single tool. We have accessed a broad array of data sources to calculate risk rather than a narrow selection of indicator species, e.g., data for many species of birds rather than just one or two.

We have attempted as much as possible, to anchor PRiME's risk indices to field-level data and reduce reliance on theoretical extrapolations which are less precise. Field-level calculations will also provide a more empirical basis for estimating the impacts of management practices which can mitigate or exacerbate risk.

PRiME also includes a Geographic Information Systems (GIS) interface for users to identify their location, including outlining their field on a map to access spatially referenced data such as area and soils. Soils data are imported from NRCS Web Soil Survey. Users are also able to import pesticide data from electronic spray records and save scenarios they generate to save time and effort.

User Requirements
In order to utilize the PRiME tool, there is no need for a producer to alter their operations. PRiME calculates risk assessments using basic pesticide application information entered by the users, including product applied, amount applied, application method and area to which the product was applied. All pilot participants were already keeping the necessary pesticide application records. In many cases, only the format of the recorded data needed to be altered in order to effectively communicate with PRiME.

Timeline of Development
<u>Fall 2007-Spring 2008</u>

- Held first annual advisory meeting with project team and 20 advisors. Reviewed existing approaches and models developed a list of potential attributes for our tool with input from advisors.
- Developed and refined a set of user scenarios using real-world potential applications to help drive design and development.
- Mocked up an initial series of web pages to illustrate our planned approach.

<u>Spring 2008-Fall 2008</u>

- Began development of prototype for apple pilot.
- Developed database for pesticides (active ingredients and formulated products) used in U.S. apple production.

<u>Fall 2008-Spring 2009</u>

- Developed white papers describing risk calculations for the following indices: Avian Acute, Avian Reproduction, Aquatic Invertebrates, Fish, Algae, Earthworms, Small Mammals, Inhalation and Human Dietary Risk.
- Developed GIS mapping capabilities of field boundaries, sensitive sites and mitigation features using high-resolution Google Earth imagery and automatic retrieval of NRCS soils data.
- Operationalized four risk indices.
- Unexpected setbacks delayed full integration of all desired components of the beta version. Collected user feedback to prepare for a fully integrated prototype by summer

2009.

Spring 2009-Fall 2009

- Chose a name for the risk evaluation tool: Pesticide Risk Mitigation Engine (PRiME).
- Prototype of PRiME web application released online, features included Google Earth mapping and subsequent retrieval of NRCS soils data, product and use pattern selection, manual entry of application data, bulk upload of spray records, and risk evaluation for seven indices, including evaluation of individual applications as well as cumulative risk for multiple applications.
- Tested PRiME tool with actual apple and pear orchard spray records.
- Initiated the peer review process for six risk indices (VOC Emission Potential, Inhalation, Avian Acute, Avian Reproductive, Small Mammals and Earthworm Risk Indices).
- Purchased domain name www.ipmprime.org and began developing informational website to complement the web application housed on the OSU server.
- Due to the complexity of the task, development of the pilot tool fell behind schedule during this period.

Fall 2009-Spring 2010

- Developed new website and PRiME web application with input from graphic designer.
- Streamlined user interface with input from users including, crop advisors, growers and PRiME advisory committee.
- Launched a beta version of the PRiME web application for limited release featuring nine risk indices and three options for risk output: (1) grouped by index, (2) grouped by product, and (3) cumulative.
- Greatly expanded products database to include nearly two thousand products registered for use in almonds, apples, green beans, cherries, grapes, pears, peas, potatoes, strawberries and tomatoes.
- Operationalized GENEEC2 within the PRiME web application for first tier water modeling, allowing us to operationalize the aquatic risk indices and develop the infrastructure necessary to implement more sophisticated water modeling in the coming months.
- Developed supporting documents including help files, frequently asked questions, terms of use and privacy statement.
- Lack of programming resources and the complexity of the programming task delayed the release of the tool's beta version during this period. To remedy this shortcoming, we hired a second full-time programmer in May 2010.

Spring 2010 – Fall 2010

- Released PRiME-beta including shopping cart and free guest access.
- Began implementation of EXPRESS to replace GEENEC2 for our pesticide fate and transfer modeling.

Fall 2010 – Spring 2011

- We refined the PRiME user interface with the goal of streamlining the process from data entry to risk calculation.
- Improved PRiME's underlying databases of pesticide products, physical and chemical properties and chemical toxicity, allowing users to run calculations on a greater number of products with fewer missing scores.
- The loss of our programmer and inability to finalize an IPM Institute web development environment caused a significant delay in user interface updates and the implementation of EXPRESS.

Fall 2011

- Released PRiME-CIG with user-friendly interface (www.ipmprime.org).

What Worked and What Did Not

We succeeded in creating a readily available tool to assess the impact of most available agricultural products on a series of environmental indices. However, we faced our biggest challenge in assembling a programming team and programming environment appropriate for the scope of this project. Most of the programming was done by Michael Guzy at Oregon State University, assisted by our manager of technical services. We hired a programmer to assist Dr. Guzy remotely from the IPM Institute, but the geographical separation and complexity of establishing a remote development environment proved too difficult for the new programmer, who left for better pay after six months.

An element we were not able to incorporate into the CIG version of PRiME was aggregation. In an effort to satisfy user needs and fulfill goals outlined in the grant proposal, we developed and tested several methods for aggregating risk scores to provide one output summarizing the combined risk of multiple scenarios. Ultimately, the project team could not reach a consensus that there is a scientifically justifiable way to aggregate scores across disparate risk indices without obscuring important risk trade-offs (see our Policy on Indicator Structure, Appendix H). As we continue to refine and add risk indices to PRiME, we will continue seek more concise ways of reporting risk and summarizing large datasets.

The primary setbacks in the development of PRiME stemmed from a lack of available programming resources. If the project began today, we would allocate more of the grant dollars toward programming and development of the user interface.

Discussion of Quality Assurance

PRiME has been designed as a probabilistic risk ranking tool, as opposed to an absolute measure of environmental harm. It is strongest in its ability to compare pesticide options relative to each other. PRiME risk indicators are one of three types, depending on the availability of information: empirically-based indicators that rely on actual field impact data;

indicators based on a reasonable theoretical construct but 'benchmarked' against specific incidents (e.g. the fish kill record) or against well studied pesticides; or indicators that rely entirely on risk quotients (typically expressions that relate projected exposure to predicted, single endpoint toxicity) without the possibility of validating the results or considering other endpoints (e.g. the bulk of human safety assessments, most assessments of reproductive and chronic toxicity etc).

Accuracy and completeness of the underlying databases for pesticide product information, physical and chemical data, and calculated toxicity values for each endpoint of concern are critical in calculating risk index scores. These databases are quality assured using various methods.

The pesticide products database was developed primarily from US EPA's Pesticide Product Information System (PPIS). Inconsistencies discovered after combining these data with data from California Department of Pesticide Regulation (CDPR) helped identify numerous errors. Additionally many data points were verified or corrected based on information obtained directly from pesticide labels.

Physical and chemical data were pulled from various quality-assured databases such as The Pesticide Manual and FOOTPRINT Pesticide Products Database. There are inconsistencies between data sources and within data sources, where experimental conditions varied. Where multiple values were found, data are summarized.

Much of our toxicity database came from previous work by Environment Canada, continued by our project team over the course of the grant period. Although our methodology for calculating toxicity values has been peer reviewed, our final data values do lack transparency. We have developed a work plan for a computer application that will record data points used for the calculations, thereby increasing transparency and giving us the ability to verify and update older data.

The PRiME web application has been quality-checked at numerous stages of development, assuring that output data are consistent with the original algorithms for risk index calculations, that UPAFs are correctly applied, and that data to and from pesticide fate and transfer modeling are correct.

For detailed descriptions of quality assurance for each risk index, see Appendix H, PRiME Project Materials.

Findings

We have accomplished our primary objective of creating a readily available tool to assess the impact of most available agricultural products on a series of environmental indices. This tool has potential to be used by producers, advisors and regulatory professionals to compare different pest management scenarios for any commodity and select options with the least potential environmental and health risks.

Two examples of potential uses of PRiME reveal that there is a need for a tool that can identify high risk pesticide applications, allowing users to make informed pest management decisions that will help reduce their impact on environmental resources.

Need for further risk reduction

Comparing PRiME cumulative risk summaries of applications on a peach block in California in 1999 and 2009 reflects efforts over the past years to reduce high risk pesticide applications. Although the comparison illustrates that risk reduction was achieved over the ten year span, the 2009 cumulative risk output still shows a number of applications in the high risk category. Despite the availability of new reduced risk products on the market, there remains a need for further reduction of high risk applications. PRiME presents a method for pinpointing those high risk applications, allowing the user to target them for reduction.

1999

Product	EPA Reg. No.	Product App Rate	Active Ingredient(s) App Rate
BASICOP	19713-72	20.000 lb/ac	[Copper sulfate (basic) 10.600 lb/acre]
GOWAN DIAZINON 4E10163-163	5905-248	0.500 gal/ac	[Diazinon 1.992 lb/acre]
OMNI SUPREME SPRAY	5905-368	4.000 gal/ac	[Mineral oil, petroleum distillates, solvent refined light 27.871 lb/acre]
BREAK EC	100-702	4.000 floz/ac	[Propiconazole 0.112 lb/acre]
ROVRAL	264-453	1.500 lb/ac	[Iprodione 0.750 lb/acre]
ZIRAM 76 FUNGICIDE	4581-140	8.000 lb/ac	[Ziram 6.080 lb/acre]
PENNCAP-M MICROENCAPSULATED INSECTICIDE	70506-193	0.750 gal/ac	[Methyl parathion 1.501 lb/acre]
RED-TOP SPRAY SULFUR	2935-92	20.000 lb/ac	[Sulfur 19.400 lb/acre]
DU PONT VENDEX 50WP MITICIDE	70506-211	1.000 lb/ac	[Fenbutatin-oxide 0.500 lb/acre]
ELITE 45 DF	264-749	8.000 oz/ac	[Tebuconazole 0.225 lb/acre]
DU PONT LANNATE INSECTICIDE	352-342	2.000 lb/ac	[Methomyl 1.800 lb/acre]
ELITE 45 DF	264-749	6.000 oz/ac	[Tebuconazole 0.169 lb/acre]
DU PONT LANNATE INSECTICIDE	352-342	2.000 lb/ac	[Methomyl 1.800 lb/acre]
METHYL BROMIDE 89.5%	11220-17	30.000 gal/ac	[Methyl bromide 387.472 lb/acre]
ZIRAM 76DF FUNGICIDE	4581-140	8.000 lb/ac	[Ziram 6.080 lb/acre]

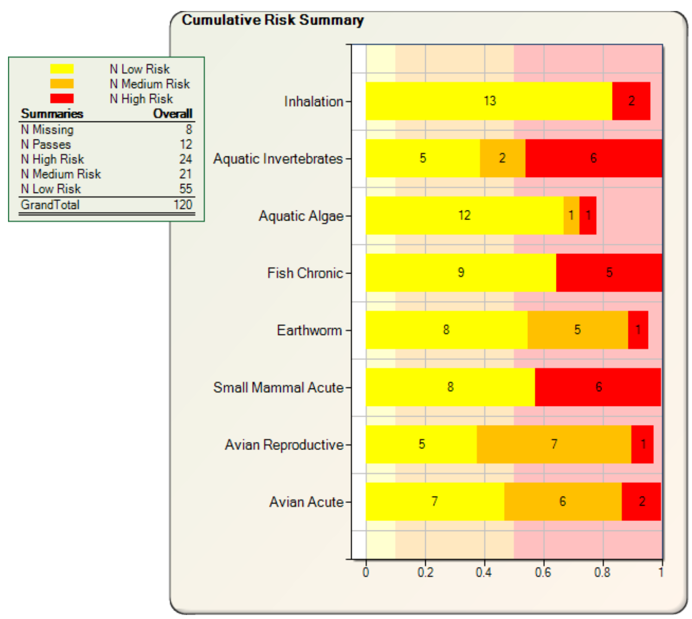

Figure 1. PRiME cumulative risk summary of applications on peach block in 1999 shows 24 applications in the high risk category. Data source: California DPR Pesticide Use Reporting.

2009

Product	EPA Reg. No.	Product App Rate	Active Ingredient(s) App Rate
BUMPER 41.8EC (PROPICONAZOLE) FUNGICIDE	66222-42	3.250E-002 gal/ac	[Propiconazole 0.122 lb/acre]
DUPONT ALTACOR INSECT CONTROL	352-730	0.200 lb/ac	[Chlorantraniliprole 7.000E-002 lb/acre]
SULFUR 6L	66330-211	1.000 gal/ac	[Sulfur 6.032 lb/acre]
ZIRAM 76DF FUNGICIDE	4581-140	8.000 lb/ac	[Ziram 6.080 lb/acre]
CHATEAU HERBICIDE SW	59639-99	0.750 lb/ac	[Flumioxazin 0.383 lb/acre]
GLYFOS X-TRA HERBICIDE	4787-23	0.600 gal/ac	[Glyphosate, isopropylamine salt 2.391 lb/acre]
SURFLAN A.S. AGRICULTURAL HERBICIDE	70506-43	1.000 gal/ac	[Oryzalin 4.000 lb/acre]

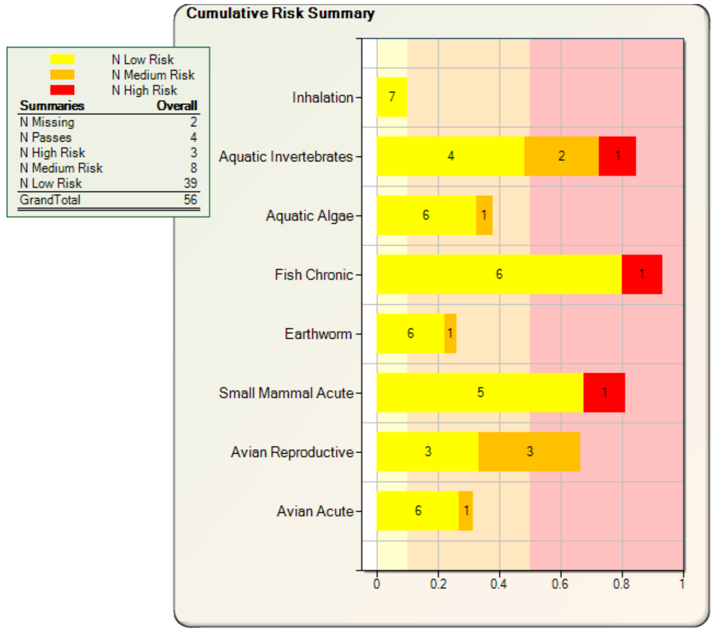

Figure 2. PRiME cumulative risk summary of applications on peach block in 2009 shows three applications in the high risk category. Data source: California DPR Pesticide Use Reporting.

Evaluating potential impacts of infestation

PRiME can be valuable in assessing the potential environmental impacts of a serious pest issue. Figure 3 (below) shows a PRiME cumulative risk summary for a typical season of applications on a block of apples enrolled in the Eco-Apple program. Figure 4 (below) shows a risk summary for the same block of apples but with a potential response to high brown marmorated stink bug (BMSB) pressure.

No BMSB

Product	EPA Reg. No.	Product App Rate	Active Ingredient(s) App Rate
Altacor	352-730	4.000 oz/ac	[Chlorantraniliprole 8.750E-002 lb/acre]
Avaunt	352-597	4.000 oz/ac	[Indoxacarb, S-isomer 7.500E-002 lb/acre]
Altacor	352-730	4.000 oz/ac	[Chlorantraniliprole 8.750E-002 lb/acre]
Assail	8033-26	5.330 oz/ac	[Acetamiprid 9.994E-002 lb/acre]
Assail	8033-26	8.000 oz/ac	[Acetamiprid 0.150 lb/acre]
Delegate	62719-541	6.000 oz/ac	[Spinetoram (XDE-175-J) 9.375E-002 lb/acre]

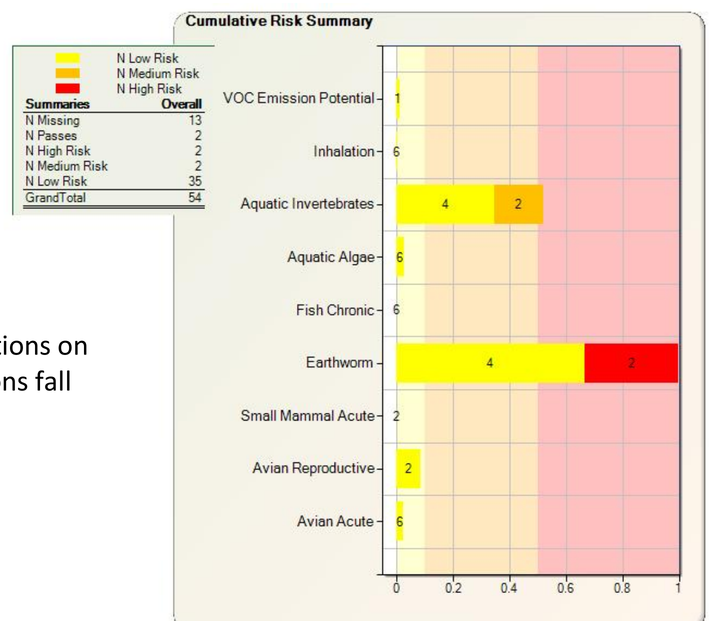

Figure 3. Cumulative risk summary of applications on block of apples without BMSB. Two applications fall in the high risk category.

Worst Case Scenario with BMSB

Product	EPA Reg. No.	Product App Rate	Active Ingredient(s) App Rate
Altacor	352-730	4.000 oz/ac	[Chlorantraniliprole 8.750E-002 lb/acre]
Actara	100-1250	5.500 oz/ac	[Thiamethoxam 7.425E-002 lb/acre]
Surround	61842-18	40.000 lb/ac	[Kaolin 38.000 lb/acre]
Actara	100-1250	5.500 oz/ac	[Thiamethoxam 7.425E-002 lb/acre]
Surround	61842-18	40.000 lb/ac	[Kaolin 38.000 lb/acre]
Altacor	352-730	4.000 oz/ac	[Chlorantraniliprole 8.750E-002 lb/acre]
Actara	100-1250	5.500 oz/ac	[Thiamethoxam 7.425E-002 lb/acre]
Surround	61842-18	30.000 lb/ac	[Kaolin 28.500 lb/acre]
Thionex 50W	66222-62	2.000 lb/ac	[Endosulfan 1.000 lb/acre]
Lannate LV	352-384	3.000 pint/ac	[Methomyl 0.927 lb/acre]
Danitol	59639-35	21.333 floz/ac	[Fenpropathrin 0.422 lb/acre]
Lannate LV	352-384	3.000 pint/ac	[Methomyl 0.927 lb/acre]
Danitol	59639-35	21.333 floz/ac	[Fenpropathrin 0.422 lb/acre]
Belay	59639-150	12.000 floz/ac	[Clothianidin 0.205 lb/acre]
Baythroid	264-840	2.400 floz/ac	[Cyfluthrin, beta 2.006E-002 lb/acre]

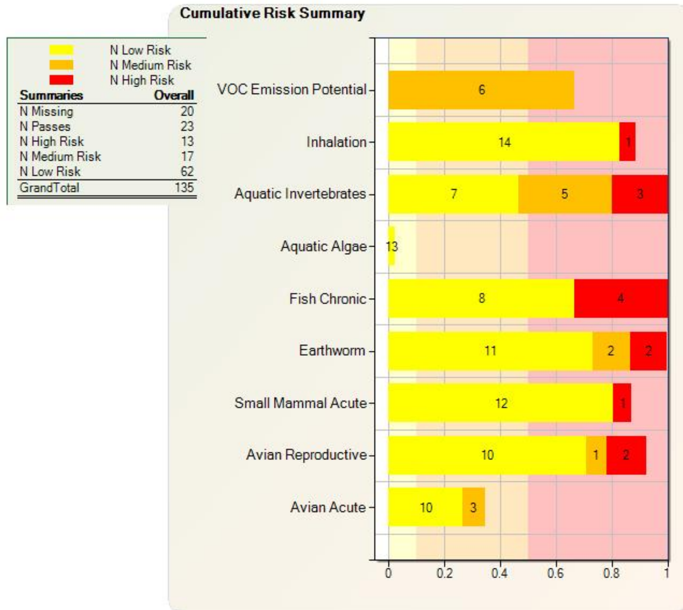

Figure 4. Worst case scenario: potential risk summary of applications on a block of apples with BMSB. 13 applications fall in the high risk category.

Conclusions and Recommendations

As we develop PRiME beyond the CIG grant period, we seek to maintain PRiME's financial sustainability while refining the tool to meet user and potential user needs. We have identified the following recommendations that would facilitate further development and implementation of the tool.

- **Remaining key indices**. We will complete and implement the dietary risk and pollinator indices so that users are not making decisions based on incomplete data. A dietary risk index has been developed and peer-reviewed, and we plan to operationalize this index within the coming months. A pollinator index is nearly complete, and will be added to PRiME as time and resources allow.
- **Site-specificity**. We will complete next year's planned beta test of estimating pesticide concentrations in water based on site-specific scenarios, evaluate results and revise water modeling based on results.
- **Continued and expanded outreach**. Our outreach approach will continue including presentations at scientific and industry meetings. Pierre Mineau is leading the compilation of a peer-reviewed publication explaining the PRiME tool in detail and the science behind PRiME risk indices. We will continue collaborating with key industry pilot testers including organizations with potential to impact many users including food processors, distributors and retailers, and eco-certification programs.

- **Formal launch of PRiME**. Once next year's beta test is complete, we will announce a formal launch including with press releases and an inaugural newsletter focused on PRiME for users and potential users.
- **Collaboration with NRCS**. We will continue to work closely with the NRCS WIN-PST group and with NRCS state and county staff to explore opportunities to use PRiME to support NRCS's mission.
- **Internationalization.** We will continue to develop and implement our plan for internationalization to facilitate use in any country worldwide, including the addition of legacy chemicals no longer in use in the US.