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Integrated Pest Management in the Great Lakes Basin Ecosystem: A Review and Evaluation of Agricultural Programs

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University of Guelph

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DISCLAIMER

The statements and views presented in this report are those of Mr. Jeremy Higham and they do not necessarily represent the views or policies of the International Joint Commission, its Great Lakes Science Advisory Board or its committees.

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SUMMARY

The revised Great Lakes Water Quality Agreement of 1978 between Canada and the United States requires the two Parties to strengthen development of their Integrated Pest Management (IPM) programs. A survey of IPM coordinators in Great Lakes jurisdictions was conducted to determine the state of these programs and a select group of producers was surveyed to provide a producer perspective. Definitions of IPM are vague in many jurisdictions and there is inconsistency among states and provinces. Support, in terms of finances and promotion, is generally insufficient for research, education and extension. Further, a lack of nonchemical options for pesticides is viewed as a major obstacle in the development and adoption of IPM. Accomplishments to date, however, are encouraging and have been achieved with meager funding, indicating that significant advances are possible if additional resources are provided.

1.0 INTRODUCTION

1.1 BACKGROUND

In its 1987 biennial report, the Science Advisory Board (SAB) of the International Joint Commission (IJC) outlined the importance of strategies to anticipate pollution problems and ensure prevention (SAB 1987). Whereas typical approaches have focussed on reacting to pollution once it has occurred, a policy of anticipation and prevention is proactive; it eliminates or limits the repercussions of environmental contamination before they arise. Such a policy has gained increasing favour and has been endorsed by organizations such as the World Commission on Environment and Development, Environment Canada, the U.S. Environmental Protection Agency as well as the SAB and the IJC (SAB 1987).

This policy can be applied to agriculture, especially by controlling chemical pesticides in nonpoint pollution through the development of Integrated Pest Management (IPM) programs. Twentieth century agriculture has become increasingly dependent on chemical technology for crop production, while the "on farm" and external costs of this technology have impinged on the economic viability of individual farms (Stinner and House, 1989) and on the integrity of ecosystems. By using pesticides more efficiently and developing nonchemical options, IPM aims to avoid such problems (Dover 1985). A basinwide accounting of pesticide use is unavailable, but certain regions illustrate the degree to which conventional agriculture is dependent on chemical pest control. In the Lake St. Clair region alone an estimated 3.5 million kg of pesticides are applied annually to land in the United States and Canada. This area has great potential to transmit the chemicals via surface runoff, fine particulate matter carried by wind or water, and infiltration to groundwater. Approximately 60% of the Canadian area exhibits a high risk of pollutant transfer to groundwater systems while the potential for surface water contamination is approximately 70% for the same area (Upper Great Lakes Connecting Channels Study 1988).

IPM is subject to broad interpretation and, accordingly, its practice and potential range widely. IPM may be defined as:

> *... the optimization of pest control in an economically and ecologically sound manner, accomplished by the coordinated use of multiple tactics to assure stable crop production and to maintain pest damage below the economic injury level while minimizing hazards to humans, animals, plants and the environment (Dover 1985).*

Simpler definitions can permit programs to focus largely on optimizing pesticide use while retaining conventional pest control strategies. Programs based on this approach can generally attribute substantial reductions in pesticide use to improved training of those applying pesticides. Greater potential for IPM to diminish dependence on chemical pest control and maximize the SAB's goal of reduced discharge of pollutants into the Great Lakes basin could be realized through more comprehensive strategies. In its most advanced state, IPM views agricultural production as the complex interactions of an agroecosystem meshed with the social and economic realities of rural communities. It is apparent that efficient pest control programs must look beyond just the pest to the interrelated aspects of agricultural systems. Pest control that relies solely on chemical measures to eliminate pest populations has proven to be a short-term solution with undesirable results.

The SAB's initiative regarding IPM stems from the mandate designated by the amended Great Lakes Water Quality Agreement (GLWQA) to "develop programs, practices and technology necessary for a better understanding of the Great Lakes Basin Ecosystem and to eliminate or reduce to the maximum extent practicable the discharge of pollutants in the Great Lakes system" (Article II preamble). A Pollution from Land Use Activities Reference Group (PLUARG) report citing an Agriculture Canada study for 1963-1974 noted a rapid increase in pesticide use despite mounting concerns over the potential environmental repercussions (Deutscher 1976). The study further revealed that the decline in pesticide prices relative to other farm inputs had encouraged pesticide use. In 1986 the United States General Accounting Office, in its Report to Congressional Requesters - Pesticides: EPA's Formidable Task to Assess and Regulate Their Risks, described how most of today's pesticides have not undergone complete testing and evaluation in accordance with current requirements. Consequently, risks to human health and the environment cannot be fully determined. Because of scientific and economic limitations, the U.S. Environmental Protection Agency (EPA) does not test the long-term effects of combining two or more ingredients (i.e. synergistic effects) in pesticide formulations.

Conventional agricultural strategies employ significant amounts of pesticide annually to control insects, weeds and other crop pests. More comprehensive management strategies are required in order to minimize agricultural pollution in the Great Lakes basin. *Courtesy of U.S. Environmental Protection Agency.*

From 1963 to 1973, pesticide prices increased by only 8.1% in eastern Canada compared with a total farm input increase of 60.9%. Much of Canada's agricultural chemicals were imported from the United States and as significant expansion of the chemical industry for pesticide production was planned or underway, future pesticide prices were not expected to rise dramatically (Deutscher 1976). Trends in Ontario's fruit production since 1973 reveal that pesticide costs other than herbicides have increased slightly relative to the cost of all farm inputs (McKibbon 1988), thus providing a greater incentive to shift away from pesticide dependence in pest management. Conversely, total farm input costs have greatly exceeded relative increases in herbicide prices (McKibbon 1989). To successfully decrease agricultural dependence on pesticides, the ecology of farming operations must be more comprehensively understood and the qualities of a local ecosystem must be considered to optimize the long-term efficiency of food production (Stinner and House, 1989; Altieri 1987). More complex agroecosystems, such as multiple cropping and conservation tillage systems, require more intensive management than high input monoculture, but because they are more physically and biologically diverse there are more management options. Agroecosystems have interdependent relationships with the larger ecosystems which encompass them such as the Great Lakes basin. Therefore, it is essential that potential damage to the greater ecosystem from agricultural activities be anticipated and averted (Stinner and House, 1989).

Article VI, 1(e)i of the Agreement makes specific reference to agricultural pollutants and calls for a "strengthening of research and educational programs to facilitate the integration of cultural, biological and chemical pest control techniques." In 1976 the same PLUARG study, quoting the U.S. Council on Environmental Quality, discussed the growing attention accorded IPM, noting that "publicly funded, research and multi-university development programs have spurred cooperation among the biological disciplines involved in crop protection," but that "cooperation with the socioeconomic disciplines ... appears to be lagging" (Deutscher 1976). An interdisciplinary approach to pest management has long been recognized as desirable yet academic barriers continue to exist, which will be discussed later in this report. The PLUARG study also points to a technological shift in pest management: nonchemical options are considered the only route to move the agricultural economy away from an "escalating curve of pesticide use" (Deutscher 1976). Best management practices referred to in Article II (c) apply directly to the role of farmers as managers and land stewards, to the importance of their activities as part of a holistic endeavour, and recognize the economic forces at work on the farm and the impact of farm practices off the farm (Hallberg 1987).

Environmental impacts of pesticides are not solely dependent on the quantity used. Factors such as soil conditions, cropping sequences, tillage practices and climate have varying effects on the degree of soil erosion and the amount of water runoff to surface waters and its percolation through the soil into the groundwater. Some pesticides are more likely to adsorb onto organic matter or soil particles, whereas others are highly mobile and leach through the soil or are removed by surface runoff. Shallow, coarse textured soils and those low in organic matter, and landscapes with near surface, fractured bedrock or steep slopes permit more pesticide pollution. Other aspects of agricultural systems that increase the incidence of pollution to water systems include erosion, misapplication of pesticides, improper tillage practices, overabundant precipitation and excessive irrigation (Buhler *et al.* 1985). Thus the abatement of pollution from agricultural pesticides extends beyond the management of pests to the agroecosystem of the farm, the basin ecosystem (in the case of the Great Lakes region) and globally to the biosphere.

1.2 REASONS UNDERLYING ADOPTION OF IPM

Good land use strategies create environmental integrity and directly affect agriculture's economic viability. Farming practices that undermine the structure and fertility of the soil not only pollute water courses, but also reduce yields and make crops more susceptible to pest infestation. A notable example is the prevalence of corn root worm in fields of continuous corn which can be largely avoided through the practice of crop rotation (ICI Americas Inc. 1988).

The 1987 SAB report recognizes the complimentary objectives of ecology and economics in stating that "failure to incorporate sustainability of ecosystems into economic decision making ... is manifested in depletion of both ecological resources and rising economic costs" (SAB 1987). This phenomenon is especially applicable to agriculture where conventional reliance on pesticides has lead to increasing rates of pest resistance (Hammock and Soderlund, 1986; Turnbull, Tolman and Harris, 1988; Harris *et al.* 1982; Carrol *et al.* 1983) and environmental contamination (Castrilli and Vigod, 1987). Both of these conditions will continue to restrict the farmer's chemical options for pest management. As pest populations acquire genetic immunity to pesticides, one option is to increase doses in an attempt to effectively suppress activity. Unfortunately, this strategy speeds up the establishment of resistance in populations. Other methods to cope with pest resistance include mixing or alternating different chemicals to slow its onset (Le Baron *et al.* 1986). As public attention focusses on the environmental toxicity and health implications of pesticides, pressure to ban or to restrict products limits the availability of chemicals for use by farmers. As research and development of new pesticides become more costly, fewer new products and only those associated with major crops and pests have become available to farmers. IPM, conversely, provides farmers with new pest management strategies that lower economic costs by reducing pesticide inputs. The effective monitoring of pest incidence provides information to assess when economic injury occurs and when spraying is recommended. Knowledge and information thus are substituted for chemicals (Bottrel 1979). Nonchemical options further reduce pesticide use and have the potential to switch pest management technology away from predominantly chemical dependence.

The concept of designing integrated systems to manage agricultural pests is not new. IPM has been viewed a rational approach to providing long-term solutions to pest problems for over 30 years. Stern *et al.* (1959) laid the foundations for IPM by introducing the concept of integrated control (a combination of biological, chemical and cultural means) as well as the economic aspects of injury and thresholds. In her book, Silent Spring, Rachel Carson spoke of the research potential for biological controls; however, her vision has only begun to be realized. Developments in agricultural science are starting to place greater emphasis on the interrelated aspects of agricultural systems. As a result, current initiatives and developments in entomology, agronomy and ecology have renewed the attention accorded IPM.

1.3 IPM PROGRAM DEVELOPMENT

The many definitions of IPM as a pest management strategy differ in terms of their levels of sophistication and reflect prevalent attitudes, obsolete spraying technology and a failure of leadership at all levels. Certainly, the capacity for a program to attain its objectives is dependent on the resources at hand, whether human, financial, temporal or level of interest. However, the interpretation of IPM at the outset determines the limits and opportunities for implementation.

In many respects IPM can be viewed as an advancement to conventional strategies. Typically, in conventional programs, weeds, insects, mites, nematodes, fungi and rodents are not tolerated, and scheduled pest control tactics, predominantly chemical pesticides, are employed to eliminate the risk of crop damage. Pesticides are overused to provide assurance of pest eradication (Roberts 1987). Consequently, environmental risks are not minimized and pest control costs to farmers are higher than in systems that are less dependent on chemical control.

IPM is a refinement that attempts to reduce pesticide use while still managing pests. Basin jurisdictions have initiated a first step toward IPM by encouraging less pesticide waste by providing proper disposal of pesticides and empty containers, and sponsoring pesticide training programs that instruct in sprayer calibration, application techniques and proper disposal. Although an important step, these initiatives by themselves do not constitute an integrated approach.

Pest management begins once an understanding of the ecology of agriculture emerges. If particular pests are not present, not only is money wasted by spraying, but a dynamic ecosystem is disrupted as predators disappear and formerly innocuous secondary pests erupt to damaging population levels. Knowledge of the costs associated with spraying and a commitment to a healthy agroecosystem provide incentives to scout for pests and to use pesticides only as a responsive measure.

A further improvement on scouting is the development of economic thresholds for different pests and crops. Pesticides are applied only if pest numbers surpass thresholds based on economic injury levels and thus pest elimination becomes pest population management (Dover 1985). As knowledge of the local ecology increases, protection of beneficial species can be further incorporated into pest management strategies.

Pesticide choices may be based on their toxic specificity, especially as it relates to effects on beneficial species, notably insect and mite predators. Beneficial species are important as a natural control of pests, so an effective short-term solution to a pest problem may prove to be unwise over the long term if it disrupts beneficial populations (Bottrel 1979). Broad spectrum chemicals are harmful in this regard. Therefore, in more advanced forms of IPM their use should be discontinued or rarely employed due to the high value of beneficial species that may be harmed by such use.

Another feature of more highly developed IPM systems is the inclusion of nonchemical options in the form of biological, cultural and varietal controls to reduce dependence on chemicals. As an IPM program becomes more sophisticated, its pest management strategies become increasingly integrated with other farm practices to the point where pest control no longer focusses strictly on the pest, but is part of an increasingly comprehensive knowledge-based approach that views farm organization and management in the constructs of an agroecosystem. Knowledge of regional and local ecology is imperative for successfully implementing nonchemical options, and local research to support such efforts is vital.

2.0 SCIENCE ADVISORY BOARD STUDY OF IPM

Previous to the SAB survey of Great Lakes basin IPM programs, Mr. Wayne Roberts (1987) of the Plant Industry Branch of the Ontario Ministry of Agriculture and Food (OMAF), and later Dr. Richard Frank (1988), Science Advisory Board member and Director of the Agricultural Laboratory Services Branch of OMAF, completed independent studies reviewing IPM in the Great Lakes basin. Mr. Roberts provided a description of various fruit and vegetable IPM programs throughout the basin, focussing on IPM delivery systems, the crops involved, pesticides used, major pests and future plans. A more specific account of implementation in Ontario was also provided that discussed aspects of field delivery, the potential for program expansion to new commodities, pest resistance and obstacles impeding adoption.

Dr. Frank summarized an international study by Wearing (1988), a New Zealand researcher, who had focussed on factors affecting the adoption of IPM in Europe, North America, Australia and New Zealand. Dr. Frank also outlined the state of IPM programs throughout the Great Lakes basin, concentrating on each jurisdiction's goals and objectives, situation, accomplishments and future plans.

In May 1989 the SAB continued this past work by conducting a survey of Great Lakes jurisdictions to review and evaluate the development and potential of their IPM programs. A section on Integrated Pest Management in the Great Lakes Basin Ecosystem was also included in the 1989 SAB Biennial Report under Emerging Issues (Appendix A).

3.0 METHODOLOGY

3.1 IPM COORDINATOR SURVEY (APPENDIX B)

The survey population consisted of state and provincial IPM coordinators of jurisdictions within the Great Lakes basin (Appendix C). The coordinators were identified by referencing Mr. Roberts' and Dr. Frank's studies and the United States Department of Agriculture Directory of State Extension Integrated Pest Management Program Coordinators. Quebec does not conduct a provincially organized IPM program, therefore surveys were mailed to six directors and codirectors of regional IPM programs. After pertinent literature on IPM was reviewed, various professionals associated with IPM were contacted to identify significant issues and to provide a general framework for the survey. Included in the professional network were several IPM coordinators, Ontario IPM regional agents, agricultural scientists and certain producers familiar with IPM. An initial draft of the survey was reviewed by Mr. Peter Boyer, Dr. Richard Frank and Mr. Peter Seidl. Their recommendations were incorporated into a second draft which received a critique from Drs. Larry Olsen and Jim Nugent of the Michigan IPM program. The final draft was translated into French, with assistance from Mr. Michel Slivitzky, for Quebecois respondents. Outside of Quebec all IPM coordinators furnished responses. Quebec's major agricultural regions were represented by Pierre Sauriol in St. Remis, and by Guy Boivin and Luc Brodeur in south Montreal. Where responses to survey questions were insufficient, respondents received followup telephone calls to provide clarification or missing information. Survey responses were then summarized to facilitate the writing of this report.

3.2 PRODUCER QUESTIONNAIRE (APPENDIX D)

A list of producers practicing IPM was established following discussions with coordinators of the New York, Michigan and Ontario IPM programs. These producers were chosen to provide a variety of opinions based on regional and commodity differences (Appendix E). Not all questionnaires were returned by mail; a number of producers responded by phone. This portion of the IPM study was not designed to research a scientifically determined sample, but rather to provide a farmer's perspective to add to that provided by the IPM coordinators.

4.0 RESULTS AND DISCUSSION

4.1 SURVEY OF IPM COORDINATORS

4.1.1 Definition

4.1.1.1 Coordinators

Many agricultural commodities are produced in basin jurisdictions. Consequently, there are different priorities when setting objectives for IPM programs. Feasibility and acceptability govern what can be achieved, and thus the challenges of pest management are perceived differently and the policy initiatives associated with each jurisdiction range widely.

In defining IPM or in outlining the objectives for their programs, jurisdictions generally refer to an efficient pest management system that minimizes environmental impact while optimizing producer profits. A consideration of economic thresholds was common to all respondents. In this initial section of the survey, the availability or development of a variety of different types of pest control were described by all but Ohio, Illinois and Indiana. IPM coordinators in Michigan, Minnesota, Ontario, Quebec and New York specified nonchemical options, such as biological and cultural methods, and Guy Boivin in Quebec was the only IPM coordinator whose program had the stated objective to eventually replace pesticides by these other means. Other objectives worth noting include: Ohio's efforts to involve agricultural chemical dealers in their program and to expand multidisciplinary research; New York's attention to farming systems and multidisciplinary research; Michigan's use of selective pesticides; Minnesota's desire to foster development of the crop consulting industry; and Ontario, Illinois and Minnesota's designs to provide IPM information and training to farmers. Pest resistance, selective pesticides, the crop consulting industry and information delivery to farmers were found to be of interest in most jurisdictions' IPM programs.

Michigan's IPM program may have progressed much further had the 1985 Strategy for Improved Pesticide Management in Michigan been endorsed by the state government. In response to public concerns about the ramifications of pesticide use on human and environmental health, the Governor requested the Cabinet Council on Environmental Protection to propose a strategy for improving the management and regulation of pesticides within the state. The Council's Pesticide Subcommittee drew many conclusions from its studies and proposed a number of progressive recommendations. Committee members decided that Michigan needed a state pest management policy, in which IPM would feature prominently. Their report stressed the need for an "environmentally and socio-economically sound systems approach to reduce pest damage to tolerable levels through a variety of techniques, including predators and parasites, genetically resistant hosts, natural environmental modifications and, when necessary and appropriate, chemical pesticides."

The report recognized that funding for IPM research, extension and education was insufficient, and recommended that funding to the Michigan Agricultural Experiment Station (AES) and Cooperative Extension Service (CES) be extended to provide for development of comprehensive IPM extension and research programs. The report called for ongoing AES research programs in biological monitoring (scouting), environmental monitoring, pest-site ecosystem dynamics, habitat modification, biotechnology and chemical technology. IPM training for farmers by the Michigan State University CES was to include information on pest identification and biology, IPM procedures, pesticide application techniques and safety, environmental and human health risks, and pesticide disposal. Further recommendations advised that a minimum of one agent trained in IPM be posted at each Michigan CES county office; that IPM become a required component of agriculture, natural resources and urban studies degree programs; and that measures to identify and remedy federal, state and private programs and policies encouraging the overuse of pesticides be undertaken.

To further define these programs, the jurisdictions were asked if IPM exists within conventional pest-control programs or if it is independent. This definition is important since IPM programs developed within the framework of conventional programs may be slowed by the more conventional approaches. Conversely, independent IPM programs may be less accessible to growers and may lack the assurance of well established extension and research that conventional programs may provide. A significant measure of progress would be achieved either when IPM strategies form the heart of pest management, having transformed conventional approaches, or when independent IPM programs have sufficient appeal to enlist conventional pest control adherents to ascribe to IPM philosophies. Most jurisdictions' IPM programs have taken the former approach and are working within existing pest control efforts in government agencies. Michigan and Quebec's programs are set apart.

4.1.1.2 Perceptions of Environmental and Agricultural Agencies

In New York, the IPM program is coordinated by personnel at Cornell University where the only form of pest management is IPM. Further, it is the state agricultural policy to support IPM. Michigan's Department of Agriculture is strongly supportive of IPM and its program has succeeded in gaining acceptance of particular IPM practices in conventional pest management systems. Similarly, that state's Department of Natural Resources has advocated a reduction in pesticide use. Quebec, on the other hand, has ten regional IPM programs that have relied little on government support and look more toward producers as sources of funding for the implementation of IPM measures. The provincial ministries of Agriculture (MAPAQ) and Environment support the motive of IPM practitioners in bringing a more ecological focus to agriculture and reducing pesticides. MAPAQ is trying to coordinate the efforts of these district programs under its auspices.

In Ontario, IPM has developed into an important component of traditional programs, significantly altering the old philosophy. Increased public concern over environmental contamination has prompted the Ontario Ministry of Agriculture and Food (OMAF) to increase its emphasis on environmental management, especially in maintaining soil and water resources. The concept of sustainable agriculture is gaining prominence and increased pest resistance and greater importance placed on training of pesticide applicators, combined with public environmental concern, have resulted in a perfect climate for the development and implementation of IPM principles.

Minnesota's IPM program is an outgrowth of traditional programs that depend on existing extension services to deliver IPM information. As in Ontario, the effect of public concern over the environment, along with health and food quality issues, are bringing IPM and the Minnesota Department of Agriculture closer together to improve pest management strategies. Minnesota has adopted a strong environmental position, stressing a reduction in nonpoint sources of pollution to encompass the issues of pesticide use because of its impact on non-target organisms and risk to water and food quality. IPM is recognized for its role in ensuring minimal pesticide impact.

The Ohio IPM program attempts to deliver IPM education via traditional Cooperative Extension programs cooperating with state agencies when multiagency interest is expressed on a given issue or commodity. At the county level, Extension personnel often work closely with state Soil, Water and Conservation District personnel on field crop IPM programs. The State University's IPM Program and the Ohio Department of Agriculture jointly support and implement IPM and pest survey activities serving Ohio nurseries.

Wisconsin IPM coordinators, although lacking funds, perceive that their program is making an impact, noting that the state Departments of Agriculture and Natural Resources have similar objectives to those of the IPM organizers. In Indiana, basic program objectives for more effective pest management, fewer environmental problems and the use of economic thresholds also correlate with those of the environment and agriculture departments. Illinois reports that their program does have linkages with various state regulatory agencies.

Acceptance of IPM objectives by state agricultural and environmental agencies is essential to widespread adoption and ongoing development of advanced pest management.

4.1.1.3 Justification for IPM Programs

The impetus for initiating IPM programs and maintaining their development was varied. Of prime importance has been the political initiatives that have provided funding. Also, pest resistance has been a significant motivation to modify conventional strategies. The destruction of beneficial species was originally viewed as an important reason to institute IPM and it is still a key factor, but farm economics, pollution and consumer pressure have come to the forefront as bases for sustaining IPM. Financial conditions in agricultural communities have pressured farmers to implement cost-cutting measures to increase profitability, and as pesticide costs have increased, so has the motivation to limit their use. As the public becomes increasingly concerned about pollution and food quality, IPM arouses more political attention as a viable way to reduce pesticide use.

4.1.2 Program Support

4.1.2.1 Financial

In the United States, all IPM programs receive federal funds through the United States Department of Agriculture (USDA), but only Minnesota and New York have successfully generated supplemental funding. IPM personnel in Minnesota are hopeful that two years of assistance through the Comprehensive Water Quality Protection Act will become a permanent source of funding. Minnesota also derives 2% of its budget from user fees. In New York, the IPM program has received state funding since 1986 and support has been increasing. Cornell University also has helped to finance the program since its inception. Michigan may be the next jurisdiction to acquire state assistance. A proposal has been submitted to the state legislature outlining budgetary requirements for $2 million entirely for IPM, to be shared equally between research and extension.

Wisconsin is now in the process of drafting a funding initiative for IPM research (Appendix F). A bill is being drafted for the legislature at the request of the Wisconsin Potato and Vegetable Growers Associations. If fully funded, approximately $4.8 million would be directed to IPM research during the next five years. If approved, this will be the first funding earmarked for IPM research in Wisconsin; if successful at the end of five years, the state will continue the investment.

Federal and provincial funds are provided for research in Ontario and Quebec, but budgets for implementation and delivery in Ontario are derived from provincial sources, whereas producers provide the majority of funding in Quebec. A breakdown of financial and personnel resources is provided in Table 1.

New York and Pennsylvania respondents were unable to provide program support information, citing that resources to support IPM were derived from too many areas and there was no realistic way to estimate resource totals.

TABLE 1. FINANCIAL AND HUMAN RESOURCES FOR GREAT LAKES INTEGRATED PEST MANAGEMENT PROGRAMS

(K=1,000)

	JURISDICTIONS							
	IN	IL	MI	MN	ON	WI	OH	QC
RESOURCES							1*	2*
Person/ Years	5.6	6.5	2.45	6.3	18	5	3.4	1 F/T, 15 P/T	6
Annual ($) Budget	178K	232K	167K	387K	590K	138K	200K	200K	180K

*IPM programs on regional basis: 1 = Luc Brodeur and Guy Boivin representing south Montreal; 2 = Pierre Sauriol representing St. Remis.

All jurisdictions except New York had reservations about the level of political support for IPM. Public pressure to move politically on environmental and health issues is building support, but it has yet to translate into dollars. In most states, real funding has decreased with inflation; often budgets are sufficient only to maintain existing projects in select commodities. Regardless of this restriction, politicians want continual program development. Current funding, though, is generally insufficient to permit expansion into new commodities or to implement new nonchemical technologies.

4.1.2.2 Research

Research communities in all regions are generally supportive of IPM, but financial constraints have limited their involvement. While IPM may have lost much of its profile as a major agricultural issue, in terms of research, there are possibilities to increase emphasis on biological and cultural controls, as well as decrease use of chemicals through initiatives in the sustainable agriculture movement. Biotechnology is also an important scientific area where opportunities for IPM development exist.

Priorities in research vary throughout the basin, but overall economic thresholds have received the most attention (Table 2). Michigan is the only jurisdiction that does not have at least moderate funding for this aspect of IPM. Although considered a critical area of IPM, Michigan has been unable to obtain funds for this area of study.

Varietal resistance, crop rotation and genetic engineering are research areas generally associated with nonchemical approaches to pest management, and while they all attract medium levels of attention throughout the basin, all the jurisdictions claim that efforts to develop and promote options for pesticides are insufficient. Biological products have received even less attention basinwide, but Luc Brodeur's program in Quebec and New York's program appear to be giving this topic significant study.

TABLE 2. LEVEL OF RESEARCH FUNDING ALLOTTED FOR RESEARCH AREAS (1–5, Highest – Lowest)

RESEARCH AREAS	AVG.	TOTAL	PA	IN	IL	MI	MN	ON	QC A[2]	QC B[3]	QC C[4]	WI	NY	OH[1]
Economic thresholds	2.3	25	2	1	3	5	2	2	3	2	1	3	1	
Varietal resistance	2.6	29	2	2	2	3	1	2	2	5	4	2	4	
Environmental monitoring + forecast	2.7	30	4	2	4	4	3	3	2	2	2	3	1	
Genetic engineering	2.9	32	2	3	3	2	3	2	3	2	5	2	5	
Biological products	3.1	34	5	4	4	2	3	4	1	3	4	3	1	
Crop rotation	3.1	34	5	2	3	2	3	3	3	2	4	4	3	
Predator–pest relations	3.2	35	5	3	5	3	3	3	2	4	3	3	1	
Implement development	3.5	38	3	4	3	2	5	3	2	3	5	4	4	
Micro–environments	3.6	40	5	2	5	5	4	3	3	4	4	2	3	
Organic agriculture	3.9	43	3	4	5	4	3	5	3	2	4	5	5	
Mulching	4.4	48	4	5	5	5	4	4	4	4	5	5	3	
Companion planting	4.5	49	3	5	5	4	4	5	5	4	5	5	4	
Intercropping	4.7	52	4	5	5	5	5	4	5	5	5	5	4	
Pest sampling											1			
Pesticide efficacy						1	2							
Expert systems			2											

[1]Ratings not provided.
[2]A = Luc Brodeur; [3]B = Guy Boivin; [4]C = Pierre Sauriol.

An Ontario peach grower lays straw mulch to inhibit weed growth. Living mulches or cover crops are also used for pest control. Often they are legume crops which fix nitrogen and conserve soil in addition to controlling weed establishment and growth. ***Credit: Peter C. Boyer***

Overall, environmental monitoring and forecasting received a fair rating, while New York again accorded it important status. Similarly, agricultural meteorologists at the University of Guelph, Ontario have focussed attention on environmental monitoring and forecasting. This practice refers to the use of environmental and predominantly climatological information to predict pest incidence. Quebec and Indiana also indicated an interest in such information. Illinois and Ohio noted that they had not found climatological information to be particularly useful in predicting pest outbreaks.

In Canada, research is viewed as the key to development and implementation of IPM programs and two key players, Agriculture Canada and the Ontario Ministry of the Environment (through the Ontario Pesticides Advisory Committee), work cooperatively to complete such research. For example, Agriculture Canada maintains an internationally recognized interdisciplinary research team at its London Research Centre, which concentrates its research effort on integrated pest management and environmental fate of pesticides. In addition, laboratories at Harrow and Vineland also devote much of their effort to IPM. OPAC has funded IPM and environmental fate research for 16 years, primarily at the University of Guelph.

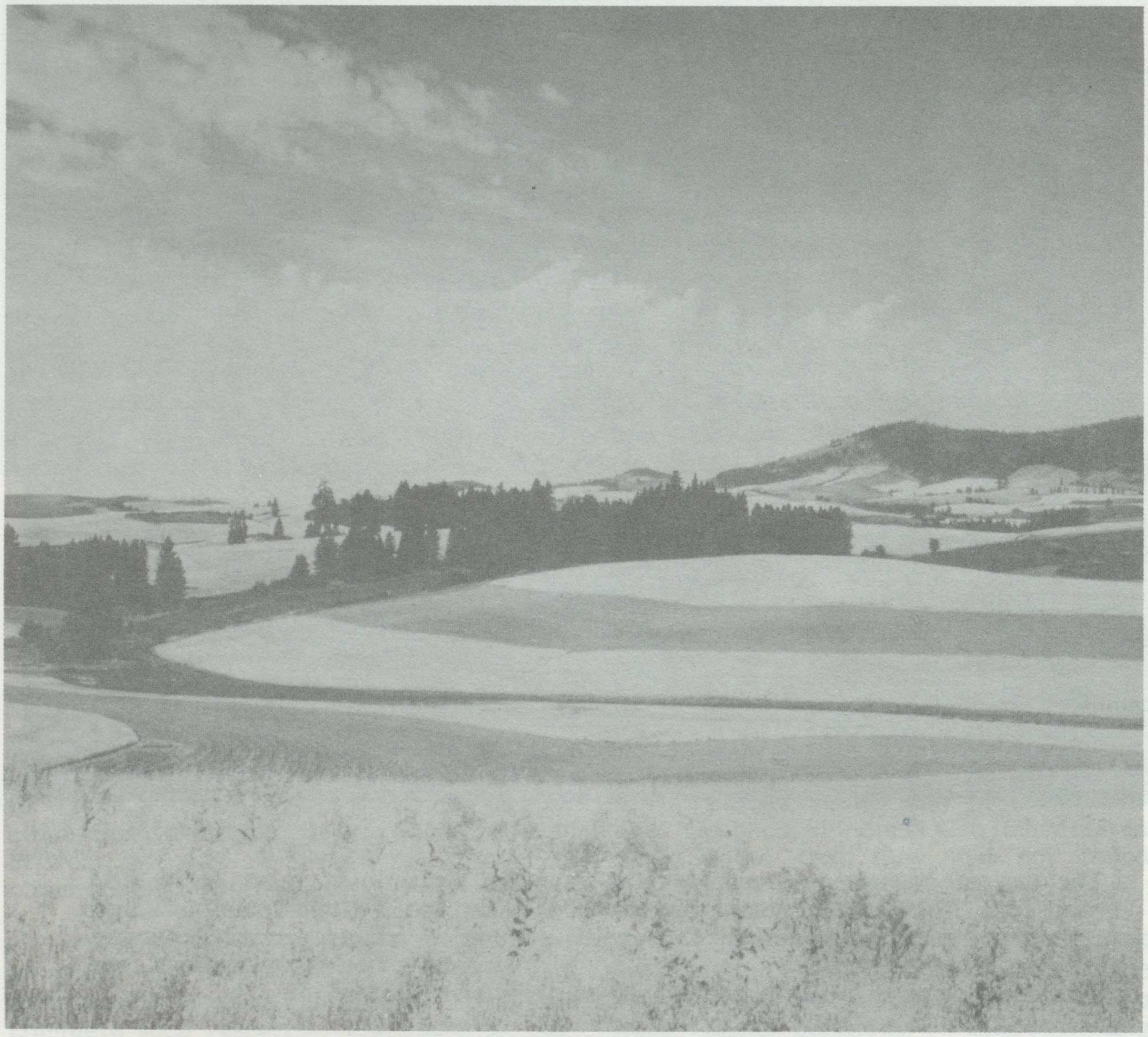
Research areas generating the least interest include micro-environments, organic agriculture, mulching, companion planting and intercropping; all focus heavily on the ecological interactions of agriculture. Although they have traditionally received little attention in North America, significant research is ongoing in developing countries (intercropping, micro-environments, companion planting) (Harrison 1987) and in Europe (organic agriculture) (Vogtman 1988). Because these strategies do not focus on pesticides as the principal tool in pest management, significant nonchemical technologies may arise from their study. For example, there is potential for substantial herbicide reductions in intercropping systems employing cover crops and allelopathic plants (Samson 1988; Altieri 1987).

The use of economic thresholds is a standard feature of most basin IPM programs. Here, a pheremone lure is checked for spotted tentiform leafminer (*Phyllonorcyter blancardella*). Only when population counts exceed economic thresholds are pesticides employed. Significant pesticide reductions are attainable using this IPM technique. *Credit: Peter C. Boyer.*

It is important to recognize that the progress made during the past 15 years in implementing IPM has been due largely to the development of pest monitoring programs. Pest monitoring is only the first stage of IPM — the easy stage — and most of the obvious steps have been taken. Progress through subsequent stages will be much more challenging and will require intensive, expensive research efforts.

4.1.2.3 Drawbacks to Pesticide Use

The limited long-term capacity of pesticides to meet pest control requirements has become increasingly obvious with the onset of pest resistance and increasing legislative restrictions. Strategies to cope with these problems still largely depend on chemicals as the main focus for pest control, despite this approach becoming more limited capacity to provide adequate assurance of crop protection. Jurisdictions have responded more effectively to these problems by using fewer chemicals, but this approach is not necessarily a feasible long-term strategy. Some jurisdictions refer to use of crop rotations, resistant varieties and biological controls, but little seems to be happening in these areas. There is unanimous agreement throughout the basin that more nonchemical research is required. Lack of this technology is described by some jurisdictions as IPM's major weakness.



Agroecosystem development is dependent on interdisciplinary research education and policy formation that coordinates pest management with land and water management, resource conservation, environmental protection and socioeconomic development. ***Courtesy of Soil and Water Conservation Society.***

4.1.2.4 Interdisciplinary Research

Effective pest management must take account of an array of interrelated factors in a farming system (Bottrel 1979). Consequently, research driving an IPM program must have an interdisciplinary focus on experimentation and development. Typically, promotion and tenure practices, traditional funding criteria and researcher reluctance have impeded this type of research. Such is the case for IPM research in the Great Lakes basin as well. Other obstacles listed included strong single discipline university departments (New York), the long-term commitment required for IPM research (Minnesota), and determination of publication by professional societies (New York).

The respondents cited various examples of interdisciplinary research projects contributing to their IPM programs. Although many of these projects bring researchers together from different specializations, few incorporate disciplines to explore what effect pest management has on other components of agricultural systems and vice versa. Exceptions included tillage impacts on weed populations (Wisconsin, Indiana and Illinois); effects of crop rotations on production, pest incidence and soil fertility (Illinois, Wisconsin and Guy Boivin in Quebec); plant nutritional status in relation to weevil infestations (Luc Brodeur in Quebec); and groundwater management (Wisconsin). Other examples tend to isolate pest management as a single objective to be attained without regard to potential variance in other farming practices. Minnesota's IPM research has focussed on specific components at the expense of farming systems study. Minnesota is currently exploring the potential crop consultants could have in grain cropping systems. Agriculture Canada maintains an interdisciplinary research team at its London, Ontario Research Centre that concentrates its research efforts on IPM and the environmental fate of pesticides.

4.1.2.5 Coordination of Agriculture Programs

An extension of the interdisciplinary concept of research is also vital at the information delivery stage. The various government departments and offices responsible for providing agricultural programs to farmers must be harmonious in their efforts, capable of coordinating the activities of distinct programs, and jointly developing and administering comprehensive, multi-issue programs. In linking IPM efforts with other programs, survey respondents are generally satisfied with existing structures for communication, such as informal contacts, co-representation on different program committees and regularly scheduled meetings of program directors to discuss joint programming efforts. Ontario, however, finds that each program "operates in a vacuum providing only lip service to joint program coordination." Pennsylvania also reports that little communication takes place, although the situation is improving.

4.1.2.6 Interjurisdictional Communication

Interstate communication of IPM information is conducted through newsletter exchanges (including electronic mail), telephone contact, USDA-APHIS (Animal and Plant Health Inspection Service), regional pest projects and the USDA-CSRS (Cooperative Soil Research Service). APHIS is conducting migrating insect projects for black cutworm, potato leafhopper and corn earworm. The CSRS sponsors technical committees that exchange research results. Pennsylvania was dissatisfied with efforts to date. To improve communication further, Minnesota suggests an annual regional IPM or extension conference is needed.

4.1.2.7 Linking Agriculture Sectors

Various methods of linking the research, educational, extension and farming sectors of agriculture were also listed. New York has working groups and committees with representation from the various sectors. State and county level committees with representation by commodity and interest groups in Minnesota provide input into the direction of research. Commodity groups in Ontario have provided input into research while maintaining strong communication with extension. Commodity groups in Wisconsin have funded research, some directed toward IPM. If the Wisconsin program is successful in its funding requests for IPM research, an external advisory board will be established with representation from commodity groups, consumers and environmentalists. Quebec programs maintain formal contact with agricultural institutions and the Union des Producteurs Agricoles (UPA). Generally, however, jurisdictions do not provide formal bodies where all sectors can discuss pertinent issues. Instead, communication to the farming sectors is maintained through the information delivery mechanisms discussed later (Table 3). Pennsylvania describes coordination between these agricultural sectors as poor, finding that communication results only from initiatives by individual program leaders.

Wisconsin has strong commodity linkages with IPM. Commodity groups provide checkoff dollars for research, some of which focuses on IPM. For example, funding is available from the Food Processors Association, Lime and Fertilizer Association, Cranberry Growers, Carrot Growers, Potato Board, and Mint Growers. Wisconsin reports that with state funding for IPM research it plans to form an External Advisory Board of representatives of commodity groups, consumers and environmentalists with an active interest in fostering the development of new pest and crop management methodology.

4.1.3 Implementation

4.1.3.1 IPM Promotion

The benefits of IPM are widespread and affect every aspect of the agricultural industry. More effective use of pesticides at reduced rates is in the interest of farmers, the scientific community, educators and policy makers, but to attain the support of these groups the IPM concept must receive adequate promotion.

Farmer lobbying in Quebec brings IPM to the attention of government. In Michigan IPM personnel are communicating directly with the governor's staff and legislative aids to promote their program proposal. IPM's role in water quality legislation (CWQPA) has enabled Minnesota's IPM personnel to forge links with the state government. Ontario and Indiana provide IPM updates, but formal contact does not exist in Ontario and is not mentioned for Indiana. In Wisconsin, legislators are invited to field days and winter meetings, and private field tours are conducted. Illinois has depended on the media for promotion in all agricultural sectors. If funding levels provide some indication of the adequacy of such promotional efforts, it appears such efforts are not sufficient in most jurisdictions.

Promotion of the concept in research and education takes the form of seminars, intercommittee meetings, departmental interaction and conference presentations. IPM research in interdisciplinary contexts may encounter resistance in Michigan, Minnesota, Ontario and Quebec; these jurisdictions noted a reluctance on behalf of researchers as a major impediment to performing interdisciplinary work. Ontario has also found it difficult to actively involve educators in their IPM program.

4.1.3.2 Information Delivery

Table 3 outlines the emphasis the jurisdictions have placed on different mechanisms to deliver information to farmers. Extension visits, workshops, newsletters and farm tours are all popular; all are standard extension tools. Even though recorded telephone messages (phonelines) are recent developments, they are employed in all jurisdictions. This development has been used extensively to disseminate information rapidly on pest incidence and to recommend control strategies based on economic thresholds. Ontario, Michigan, Illinois, Wisconsin and Indiana stressed use of this method the most.

TABLE 3. EMPHASIS ON INFORMATION DELIVERY METHODS
(1–5, Highest – Lowest)

DELIVERY METHODS	AVG.	TOTAL	JURISDICTIONS PA	IN	IL	MI	MN	ON	QC A[1]	QC B[2]	QC C[3]	WI	NY	OH
Newsletter	1.8	22	1	1	1	1	1	2	3	5	2	2	2	1
Phonelines	2.0	24	5	1	1	1	3	1	2	2	2	1	2	3
Workshops	2.1	25	2	1	1	2	2	4	1	1	2	1	4	4
Extension visits	2.3	28	3	3	1	2	4	1	1	3	2	2	3	3
Farm tours	2.6	23	2	2	2	3	2	3	——n/a——			2	5	3
Data bases	3.1	37	4	3	4	3	4	2	2	2	4	2	3	4
Electronic mail	3.5	42	1	2	5	4	4	4	2	5	5	3	5	2
Expert systems	4.8	57	1	4	5	5	5	5	4	5	5	5	5	4
Software applications												1		
Farm demon-strations												2	1	
Scout training			1									1		

[1]A = Luc Brodeur
[2]B = Guy Boivin
[3]C = Pierre Sauriol

Of the newer computer related delivery methods, only data bases have been accorded much support. As Pennsylvania's apple and maize expert systems have reached the producer evaluation stage, this delivery method has been rated highly. Besides the methods listed in Table 3, various forms of mass media (radio, television, newspapers) were also used to bring IPM information to producers.

4.1.3.3 Education

There is general agreement among IPM coordinators that insufficient resources are committed to IPM education in academic institutions. In Minnesota applied IPM courses deal with the separate components of IPM, but an integrated multidisciplinary course is not available. Declining enrollment at the undergraduate and graduate levels of agricultural institutions has frustrated IPM adoption, as there is a shortage in trained personnel. Although excellent employment opportunities are available to graduates of the Wisconsin M.Sc. degree program in pest management, enrollment is also low. A similar situation is apparent in Ontario, where few IPM-specific courses are available. In courses that do include IPM as a pest control option, little emphasis is placed either on the philosophy behind it or the requirements necessary for field application. Improvements could be made by providing core courses in IPM; improving the coordination between horticulture, ecology, crop protection and other disciplines; and by instituting a well rounded Master's program in pest management at the Ontario Agriculture College, University of Guelph. Michigan and New York report that more resources would become available if more students were interested in IPM. Unfortunately, until IPM is viewed as an important or viable pest management approach in the agricultural sector as a whole, interest could remain low. IPM requires a big promotional push to gain support from the various sectors of agriculture.

4.1.3.4 IPM Consultants

IPM farmer consultations throughout the basin are conducted by government agents and private consultants. Private consultants are not numerous in Ontario. Certain jurisdictions, notably Minnesota and Wisconsin, are making overtures to various sectors of industry to become more involved. Minnesota has a statewide campaign to promote the crop consulting industry, and a state crop consultant directory will be issued next year. In Wisconsin and Michigan processing companies are hiring field staff to consult farmers on fertilization, planting, harvesting and pest management strategies. More emphasis is put on final food quality than on the balance of economic costs, however, and thus field staff have tended to be more cautious than IPM farmers since the direct financial costs of pesticides are not their prime consideration. Nevertheless, it is an innovative step to increase industry involvement in IPM. Many of the jurisdictions have only enough resources to develop IPM for a few commodities at a time. Wisconsin's IPM program has attempted to deal with this situation by transferring scouting in a particular crop over to the private sector after an introductory period of three to four years.

4.1.3.5 Pests and Beneficial Species

The prevalence of pest and beneficial species monitoring and the encouragement of beneficial species differs considerably despite similar responses, but a positive response at least suggests a willingness to incorporate greater environmental considerations into an IPM strategy. All jurisdictions acknowledge that pest populations are monitored in their programs. New York, Wisconsin, Quebec, Michigan, Illinois, Pennsylvania and Indiana indicate that at least some monitoring of beneficials also occurs.

At the very least, deliberate use of pesticides to limit disruption of predatory insects and mites is a measure to encourage beneficial species. Other efforts may include aspects of habitat manipulation where plant species providing shelter or breeding spots for beneficials are maintained or planted in hedge rows, in nearby fields, or with a crop. New

York, Wisconsin, Quebec, Ontario, Minnesota, Michigan, Pennsylvania and Indiana all have developed some sort of strategy. However, the advocacy of nonchemical controls and the selective use of pesticides are specifically mentioned.

4.1.3.6 Climate

Climatological information is often used to predict when pest incidence will exceed economic thresholds. An important part of IPM, most jurisdictions relay climate information as related to pest incidence through information delivery systems listed earlier. There is limited recording of climate information by individual farmers to assess the factors at work in their own micro-environments. Ontario and Wisconsin listed specific applications of climate data on a local level. Wisconsin has software available to potato growers that helps predict disease development, such as early and late blight, predicts emergence, provides irrigation scheduling and manages insect problems. A weather-timed disease program in southern Ontario is experiencing limited use by tomato processing companies. Minnesota has implemented two climate-based disease progression models: cercospora leaf spot on sugar beets and rust on edible dry beans.

4.1.3.7 Farmers Practicing IPM

To achieve greater adoption of IPM practices some jurisdictions have fostered development of the crop consulting industry, but all jurisdictions have indicated they are encouraging farmers to conduct their own IPM. Unfortunately, this approach may extend only as far as watching for pests, without assessing whether populations are high enough to worry about economic injury. While some farmers are not using economic thresholds or any means of nonchemical control, they are still classified as IPM practitioners. This situation may give a highly distorted view of the success of different IPM programs. Ontario has advocated monitoring and the use of thresholds by farmers, but has encountered resistance as these activities can be time consuming and difficult.

To encourage greater participation, the jurisdictions have provided various learning opportunities. Ontario conducts training schools, information days and pest diagnostic clinics. Grower meetings and field days give producers hands-on experience in Pennsylvania. Indiana provides a diagnostic training and crop management workshop. Training programs of varying duration are available in Michigan. IPM training in Minnesota is incorporated into county and regional crop production meetings and crop pest management short courses. IPM education is available at some Quebec colleges, and regional IPM programs provide a number of training sessions throughout the year. Wisconsin and Michigan have scout schools, meetings and field days that deal with detailed information, grower problems and research, respectively. Meetings are well attended and result in scouting application in the field. Training programs in New York are conducted both in class and in the field and numerous audio-visual materials and publications are available. In Ohio IPM is taught in pesticide application courses, regional field sessions are periodically conducted for field scout training, and county Extension programs often hold twilight tours to train growers in IPM self-scouting techniques. Illinois did not specify which programs provide IPM training for farmers.

4.1.3.8 Related Programs

Essential to a balanced assessment of the benefits and costs of pesticides is an accurate accounting of their use and disposal. Under Great Lakes Water Quality Agreement Article 6(e)i, the Great Lakes basin jurisdictions agreed to maintain pest control product inventories. All jurisdictions conduct periodic pesticide use surveys. In Wisconsin, the IPM program monitors pesticide use on specific crops to establish baseline use levels prior to IPM and after IPM programs become operational. Ontario also monitors pesticide use where IPM is implemented.

To protect against pollution from pesticide disposal, Michigan and Minnesota have started to set up programs to collect unused pesticides and containers. In Illinois only illegal dumping is of concern to government agencies. Ontario also has few active monitoring measures for disposal, but encourages good practices such as double rinsing of containers, safe storage and proper disposal of unused pesticides through the issuance of technical bulletins to farmers.

Another important consideration for the jurisdictions is the availability of a mandatory or optional pesticide applicator training program. The training is conducted throughout the basin, but mandatory licensing is limited to commercial applicators and users of restricted pesticides. Restricted pesticides may be more toxic than other pesticides as measured for a single application, but general use pesticides are far more heavily used and concern must be shown for the quantity of these chemicals that is being released into the environment by incompetent applicators. Ontario has recognized this condition as a critical issue on pest management and expects licensing of all applicators to be mandatory by 1991.

4.1.3.9 Program Evaluation

To avoid repeating mistakes or adopting inappropriate strategies for development, any program requires a comprehensive evaluation. Because many IPM programs are required to work with constrained budgets, evaluations are valuable. However, funds for a thorough evaluation process usually do not exist. Illinois uses a rather simple assessment of its IPM program by comparing pesticide use over time and by recording the scouted acreage. Ohio maintains records on all acreage scouted directly by Cooperative Extension field scouting programs and on personnel receiving an IPM newsletter circulated at state and county levels. Since IPM education efforts, pesticide certification training programs and general pest management education are often integrated, identification of all growers and dealers impacted by IPM program efforts is difficult to achieve. Quebec evaluations vary, but some techniques used are field tours, daily assessments and post season meetings with producers.

More extensive evaluations are conducted in the other jurisdictions. In Indiana consultant and farmer surveys, in addition to a fairly extensive impact study on IPM for corn, have provided insight into program development. Program agents in Ontario base their evaluations on crop quality, including injury levels and comparisons of profitability in various pest management systems. In Minnesota an annual IPM practitioner survey is conducted and each component of the program is evaluated according to program objectives. Also, an impact study is underway to establish a benchmark for future evaluations of the program and adoption at the farm level. Wisconsin growers are surveyed prior to the start of IPM in a particular commodity and again after three years for pest problems, control measures and the number of sprays. In New York pest pressures are measured in pilot projects along with weather factors, crop quality and the use of biocontrol agents and other IPM methods.

4.1.4 Adoption

4.1.4.1 Obstacles

The final test for basin IPM programs concerns the degree to which they are accepted by farmers. IPM organizers face many obstacles to adoption, but several are more common or significant than others (see Table 4). The lack of alternatives to chemicals is consistently ranked by the jurisdictions as a major impediment to the adoption of IPM. As dependence on chemical means of pest control has increased this century, traditional nonchemical strategies have been abandoned and research into biological and cultural technologies has been neglected. Options to chemicals in basin IPM programs are notably lacking. Crop rotations and resistant or tolerant cultivars are mentioned by some

TABLE 4. OBSTACLES TO IPM ADOPTION
(1–5, Highest – Lowest)

OBSTACLES	AVG	TOTAL	JURISDICTIONS PA	IN	IL	MI	MN	ON	QC A[1]	QC B[2]	QC C[3]	WI	NY	OH
Lack of nonchemical options	1.7	19	1	2	3	1	1	1	1	2	3	1	3	n/a
External costs	2.1	23	1	3	2	4	2	2	1	2	n/a	3	1	2
Cosmetic standards	2.3	27	2	2	3	2	5	1	1	3	4	1	1	2
Grower on recognition of IPM long term	2.3	27	2	2	1	2	1	3	1	2	5	4	1	3
Lack extension funds	2.3	27	2	1	2	2	1	3	4	1	4	1	4	2
Farmer resistance	2.3	28	2	2	2	3	1	3	2	2	3	4	1	3
Lack simple thresholds	2.3	28	3	3	2	2	1	1	2	3	2	3	3	3
Lack political support	2.5	30	2	2	3	1	3	3	1	1	3	3	5	3
Lack selective chemicals	2.7	32	2	2	5	3	2	2	1	2	2	3	4	4
Bioproducts marketing	2.8	33	5	2	1	2	4	2	3	1	4	3	3	3
Chemical industry resistance	2.9	32	5	2	1	3	4	n/a	5	4	3	3	1	1
Lack IPM for key pests	3.0	33	5	4	n/a	1	4	3	4	3	2	3	1	3
Lack simple monitoring	2.9	35	3	3	2	4	3	2	1	4	2	4	3	4
Lack interdisciplinary	3.0	36	1	4	4	1	4	2	3	4	3	4	3	3
Pesticide registration	3.3	40	5	3	5	4	2	2	5	3	1	3	4	3
Academic reluctance	3.4	41	3	4	3	2	3	4	4	4	2	4	4	4
Administrative problems	3.4	41	3	4	5	2	3	4	3	4	4	3	3	3
Lack training of specialists	3.7	44	5	4	5	2	3	4	2	2	4	5	5	3

[1]A = Luc Brodeur
[2]B = Guy Boivin
[3]C = Pierre Sauriol

respondents, but little else appears to be available except possibly in New York, where biological and cultural control methods are noted; in Michigan where IPM manuals, newsletters, radio programs and education programs provide information on alternatives to pesticides; and in Quebec, where information days, personal contact and journal articles are used to disseminate this information. Quebec plans to develop these endeavours further.

The incorporation of nonchemical options into IPM systems was viewed with scepticism by some respondents, especially in relation to the expansive nature of field cropping. Corn and soybean crops have not experienced the problems of pesticide resistance and restrictions to the same degree as horticultural crops, nor are there strong concerns about environmental contamination. Pesticides are viewed as an inexpensive, effective pest management tool. Consequently, the development of alternative strategies has been largely forsaken (Fawcett 1987). The University of Minnesota, like other agricultural institutions, has unfortunately gained a reputation as a promoter of pesticide use; to lend IPM more credibility, more emphasis is being planned to consider options other than chemicals, beginning with a publication format change. None of their programs deal solely with nonchemical approaches, and to increase the stature of these choices new publications will be developed. Further, Minnesota's respondent suggests that a more critical evaluation of the positive and negative aspects of pesticides and nonchemical alternatives is required, with economics as the sole consideration in pest management no longer being assumed.

Many of the social, economic and environmental costs associated with pesticides are not the responsibility of the user. As a result, such external costs may be ignored by producers and an excess of chemical control may be favoured as a simple short-term solution to pest problems. Most respondents ranked external costs as fairly high.

Other important considerations include cosmetic quality standards, growers' lack of recognition of IPM's long-term advantages and their consequent resistance to change, insufficient political support, lack of extension funds, and the external factors associated with social and environmental costs and risks. All jurisdictions had at least moderate concern about a lack of thresholds. With regard to the issue of political support, all jurisdictions viewed it as important with the exception of New York, the only jurisdiction with permanent state funding, and thus New York respondents considered political support of minor importance. Ontario and Minnesota have received more funding than other jurisdictions with Food Systems 2002 and the Comprehensive Water Quality Protection Act, respectively, but the support in Minnesota is currently slated for only two years. Both respondents feel IPM merits still more political attention. Again, a lack of extension funds is usually due to limited political support and New York does not view this limitation as a major problem for its program. Luc Brodeur and Pierre Sauriol are both more concerned about political support than the actual extension funding; perhaps they have limited their programs so as to work effectively within their financial constraints.

Growers' lack of understanding of IPM's long-term advantages was also perceived as a problem by most. Unless producers are familiar with benefits accrued over time in an IPM program, it is unlikely that they will wish to change their strategies, invest in scouts and accept more risk by using economic thresholds instead of calendar techniques to establish spray times. Wisconsin did not rate lack of recognition highly as they have had much success in informing growers about IPM's benefits at well attended meetings and through other extension media. Sauriol also gives this item little importance as an obstacle to IPM adoption, perhaps because extension efforts in his region have also been favourably accepted. Cosmetic food quality standards are viewed as major impediments by most respondents. Although Ostlie from Minnesota thought quality standards were too high, he did not think they were limiting acceptance of Minnesota's IPM program. Perhaps this situation can be attributed to the type of commodities produced in his state. In Minnesota food production is concentrated on grain and other field crops (potatoes, sugar beets, soybean) that are not required to pass as stringent quality standards as horticulture crops.

Of less prominence, but still of concern to respondents, was the lack of selective chemicals, farmer resistance to change, and resistance from the chemical industry. In Illinois, Ohio and Indiana food production is largely devoted to field crops, where herbicides predominate. A lack of selective chemicals was not a concern relative to these jurisdictions because herbicides represent a significant market opportunity and, therefore, great effort is expended in their development and distribution by industry through research and marketing. New York also rates the resistance problem as low, even though its production is more diverse than just field crops. The question of farmer resistance is similar to their understanding of the long-term benefits of IPM and has received a similar response. Resistance by the chemical industry is a significant factor impeding adoption in some jurisdictions (Illinois, Indiana, New York, and Ohio), but other areas (notably Quebec) have encountered fewer problems and are working with industry to expand the adoption of IPM.

4.1.4.2 The Chemical Industry

Jurisdictions other than Quebec have little positive to say about the chemical industry's association with IPM. Minnesota commends the industry for its support of research on pesticide performance and use, but also notes that it is not as enthusiastic about other IPM tenants such as thresholds, tailoring rates and selective pesticides. Further, they feel the chemical companies expound biased information that competes with IPM for attention. Illinois claims that company support for IPM is merely a public facade and their only real objective is to sell pesticide. Similar sentiments exist in Michigan, where the chemical industry is increasing its influence in research as it becomes more involved in funding. As a result, researchers are directed away from work developing nonchemical options. The Ohio Extension and research programs recognize the significant role of the chemical industry in agriculture, but maintain an effort to develop and advocate nonchemical options where applicable. Maintaining an influential role in chemical dealer education is considered a priority in Ohio's IPM Program efforts. In New York chemical dealers have also been accused of advocating increased rather than responsible pesticide use. New York also notes that while chemical companies do have some influence on research, it is less than commonly thought. Indiana acknowledges that the chemical industry could influence research, but does very little in this regard. In the field, IPM personnel try to limit the effect dealers might have through training, newsletters and news releases to the farmers. In Wisconsin, sceptical farmers go to the University of Wisconsin for unbiased information while others may rely completely on pesticide dealers. Chemical companies support their dealer network and maintain dominance in the field by conducting their own research and evaluation of new pesticide products. Some of these involve the development of IPM technologies, such as biological products, indicating the recognition by industry that new market opportunities exist for nonchemical approaches.

4.1.4.3 Farm Size

Concerning the implications of farm size on IPM adoption, Illinois and Pennsylvania respondents do not know if there is a correlation, while in New York no observable difference is seen. Michigan also did not see a direct relationship, but noted that large farms may have difficulty waiting until pests reach threshold levels before initiating controls. At the same time, though, they may be more apt to apply only border sprays. In Indiana large farms tend to adopt IPM, but well educated small farmers are responsive as well. Large farms in Minnesota may have insufficient personnel to scout, although they may be more likely to hire private consultants for the same reason. Large growers in Ontario also cite time constraints for their lack of interest, while small farmers also lack the time or are perhaps simply uninterested, dependent on a pesticide prescription.

Consequently, growers with medium sized farms are the innovators. Quebec's large farmers have seen an advantage in their size as predictions are more precise as acreage increases. Also, large farms gain a greater return from investments in private consultations. In Wisconsin large farms growing more commodities are able to better accept risks. Ohio reports that adoption is dependent on individual growers. However, there is a greater tendency for chemical use by larger farms.

4.1.4.4 IPM Acreage by Commodity or Crop Sector

Respondents were also asked to indicate the degree to which IPM has been adopted in different crop sectors or for the production of specific crops (Table 5). Although these figures do not necessarily give a reliable or consistent account of the acceptance of IPM throughout the basin, they do illustrate how definitions of IPM vary between jurisdictions. For example, the report from Illinois that 100% of its corn, wheat and soybean growers are conducting IPM can be qualified by their definition, i.e. the "intelligent use of pest control actions ensuring favourable economic, ecological and sociological consequences." This definition does not provide an obvious distinction between IPM and conventional pest control, and implementation cannot be measured through the use of economic thresholds, application of nonchemical techniques, or scouting activity, or other objective criteria. Such optimistic assessments do not necessarily indicate a highly advanced IPM program, but may instead reflect insufficient critical evaluation. By comparison, most other jurisdictions report adoption at less than 10% for field crops, a value more likely to reflect actual practices.

Pennsylvania bases its adoption rate for grains, vegetables and potatoes on farm operations that are involved in the state IPM programs, and are using economic thresholds. Acres under contract for consulting provide the figures for IPM acreage in Minnesota, but farmers who conduct their own monitoring are not included. Therefore, the IPM percentages for grains and potatoes are low estimations. IPM adoption in sugar beets is so high because practically all producers of this commodity belong to cooperatives that hire fieldmen to scout the crops. Indiana corn, soybeans, small grains and alfalfa IPM acreage is determined by those producers' participation in organized IPM programs. The state coordinator estimates that 90% of the acreage in corn, soybeans and small grains is farmed using IPM information, although not necessarily coordinated with an IPM program. Ontario IPM estimates for grains, fruits and vegetables arise from the farm sites that are visited by government and private scouts. Criteria for Wisconsin's IPM include: acreage in field corn, carrots, onions, sweet corn and cranberries; dependency on the use of economic thresholds in concert with field scouting; the presence of consultants; or estimations of who may be influenced by IPM recommendations. Farms enrolled in pilot programs, hiring private scouts, or belonging to a cooperative employing IPM personnel comprise New York's IPM acreage. Michigan estimates its IPM acreage on similar criteria.

4.1.4.5 Long-Term Effectiveness of Existing Programs

The final question of the survey asked the jurisdiction's IPM coordinators to assess their program's potential to reduce pesticide use while ensuring efficient agricultural production. Illinois' respondent cites declines in insecticide use without losses in productivity as an indicator of the Illinois program's potential. Until widespread pest resistance or an environmental catastrophe threatens crops, though, it is unlikely that major changes in conventional practices will occur quickly. Despite the long-term risks involved, little is being done to significantly alter popular pest management strategies.

In Indiana and other corn producing areas, corn rootworm insecticide could be reduced 100% if farmers practiced crop rotations. The use of soil insecticide has decreased from 36% to 19% of corn acreage in Minnesota due primarily to a shift from continuous corn to corn-soybean rotations. Unfortunately, subsidization of corn production in the United

States encourages producers to eliminate rotations. The economic return is greater even when the direct financial cost of the insecticide is included in the farmer's costs. The external costs of pollution to ground and surface waters are not included, nor are the long-term costs associated with erosion and declining soil fertility inherent to systems of continuously cropped corn. The four crops toward which most American agricultural support programs are directed (corn, soybeans, cotton and wheat) also account for 65% of pesticide use. To receive full support eligibility, at least half of a farmer's base acreage must be planted in crops covered by support programs. Consequently, farmers practicing crop rotations of three or more years are often penalized. Also, support payments are based on production levels, a condition that intensifies production by increasing the break-even price of chemical inputs. Qualification for federal support programs also often requires that farmers idle a certain percentage of their cropland, thereby reducing commodity inventories, raising market prices, and reducing government spending when commodity prices are low. Farmers may idle their least productive cropland only to intensify chemical inputs to primary cropland. The risk of a transfer of pesticides to ground and surface water increases with increasing amounts of chemical input relative to acreage size (Fleming 1987). Further, an increase in weed pressure and, to a lesser extent, insect problems may occur in subsequent years if idle land is not managed while fallowed. Better federal programs would focus attention beyond just market planning, encouraging producers to include forage grasses and legumes in crop rotations, thereby suppressing growth of annual weeds (Liebman and Janke, 1989). The impact of federal support programs is substantial, affecting the management decisions of a large portion of the farming community.

Before the advent of herbicides, weeds were controlled by crop rotations and cultivation. Although crop rotation is often an essential feature of efficient agroecosystems, cultivation leaves the soil exposed to erosion by wind and water. Most agricultural agencies throughout the basin support conservation tillage to alleviate the tremendous soil loss occurring on agricultural lands. However, conservation tillage generally demands increased amounts of herbicide, at least in the first few years that it is employed. Differences in chemical quantities may result in part because of farmer unfamiliarity with this new practice and also because of changes in weed species. Over time rates of herbicide application in such production systems are minimal (Fawcett 1987).

New York is very positive about its IPM program and maintains that the potential is excellent, given that researchers can continue to find funding for applied research and their extension organizations receive sufficient resources to educate and reassure growers that IPM adoption is not a risk. In addition to decreasing pest management costs of \$95.00 ha^{-1} $yr.^{-1}$, the apple IPM program also has developed a system that depends on 30% less insecticide, 47% less miticide, and 10% less fungicide.

With current levels of what it regards inadequate funding, Michigan's IPM program has achieved a 3–5% $yr.^{-1}$ pesticide reduction. With modest funding increases, expectations are that a 10% reduction could occur. In terms of profitability IPM is estimated to save growers 50% on pest control costs. With the issues of pest resistance, pesticide restrictions and banning, tight economics, and mounting public awareness of environmental and health concerns, support for IPM should increase dramatically. It is essential to remember, though, that ecosystems are not static. Pest complexes are dynamic and variable over time, thus universal IPM formula is available to replace chemical recipes.

Wisconsin has also achieved a great deal with meager funding. Given time and more money new pest resistant cultivars, biological control measures, improved (safer) pesticides and better information delivery can be developed, thus reducing pesticide use considerably. For potatoes, savings generated from pest monitoring amount to \$3.41 – \$7.12 ha^{-1}.

TABLE 5. PERCENTAGE OF CROP ACREAGE WHERE IPM IS CONDUCTED IN GREAT LAKES JURISDICTIONS (PAGE 1 OF 2)

Crop/Sector	Jurisdiction[1]	Acreage (State/Province Total)	IPM (%)
Grains	MN	23,000,000	3.5
	ON	8,143,000	2
	PA	2,545,000	5
Corn	IL	10,000,000	100
	IN	4,800,000	6
	WI	3,500,000	25 ± 10
	MI	3,000,000	15
Small Grains (wheat, oats, rye)	IN	1,4000,00	<1
Wheat	IL	1,000,000	100
Field and Forage	NY	750,000	4
Forage	M	1,500,000	10
Alfalfa	IN	380,000	<5
Soybean	IL	9,000,000	100
	IN	4,300,000	<1
	MI	1,000,000	5
Dry Beans	MI	450,000	5
Snap Beans	WI	82,000	100
Sugar Beets	MN	300,000	100
	MI	100,000	75
Vegetables	ON	179,000	10
	NY	154,000	11

TABLE 5. PERCENTAGE OF CROP ACREAGE WHERE IPM IS CONDUCTED IN GREAT LAKES JURISDICTIONS (PAGE 2 OF 2)

Crop/Sector	Jurisdiction[1]	Acreage (State/Province Total)	IPM (%)
Vegetables, cont'd.			
	QC[2]	50,000	15
	PA	44,500	1
Carrots	WI	4,000	90
Onions	WI	2,500	90
Sweet Corn	WI	125,000	100
Cranberries	WI	8,000	60
Potato	MN	75,000	10 – 20
	WI	68,000	75
	QC	40,000	5
	PA	22,000	1
Fruit	ON	72,800	50
	NY	56,700	15
Apples	MI	55,000	75
Ornamentals	NY	33,000	3

[1]Ohio did not provide this information as definitions of IPM vary. Ohio Cooperative Extension programs continue to directly service over 12,000 acres of field crop acreage and a significant proportion of the state's nursery and sweet corn industry. Private consultants service an equivalent acreage of which acreage estimate may vary depending on the definition of IPM that one accepts. In addition, indirect influences of the state's agriculture by Cooperative Extension's IPM Program is widespread via numerous channels of mass communications, especially weekly radio programs delivered at state and county levels. Since the indirect influence is virtually impossible to measure, acreage estimates are not provided.
[2]Reported by Pierre Sauriol.

Ohio believes their program has influence in agriculture, but personnel and resources are insufficient to affect general trends. According to the respondent, a five to tenfold increase in funding would be required for IPM to have a major impact on pesticide use.

Pierre Sauriol of Quebec thinks IPM is the best solution to pest management. In Luc Brodeur's Quebec program, insecticides have been reduced up to 90% for carrots, celery and onions. Decreases in herbicide use are dependent on cultivation, which farmers refuse to employ. Fungicide use is more dependent on climate. IPM can only minimize pesticides so far. Future reductions will depend on biological controls and other nonchemical strategies. Guy Boivin considers a 50-60% reduction in pesticide use is attainable before other technologies must be employed.

Because IPM is information and management intensive, Minnesota does not expect rapid adoption rates. IPM has great potential, but will depend on a long-term educational effort supported by the necessary funds and dedication at the federal, state, university and farm level. The relevance of IPM has become increasingly obvious as the issues of water quality, sustainable agriculture and health have gained prominence.

These concerns along with pest resistance, changing pest dominance, fewer new pesticides, and a lack of nonchemical options has prompted the Ontario government to initiate Food Systems 2002. This 15-year plan focusses on increasing pesticide residue monitoring, testing and modification of new sprayer technology as well as development and implementation of nonpesticide options such as biological controls, cultural practices, crop rotations and pest resistant crop varieties. In addition, the Ontario Pesticide Education Program (OPEP) will be expanded to train more growers and vendors concerning the safe handling and application of pesticides. To further develop IPM programs and expand their adoption, more pest management specialists have been employed. Ontario expects to reduce pesticide use by half by the program's end, saving growers more than $100 million, while maintaining the viability of agricultural production.

4.2 PRODUCER QUESTIONNAIRE

4.2.1 Definition

As with researchers, policy makers and educators, farmers' interpretations of IPM vary. In most cases, agricultural systems have not advanced beyond scouting, then economic thresholds to reduce pesticide use, yet recognition of the interrelated aspects of the farming environment has become increasingly apparent to those practicing IPM. A sterile, pest-free farm is increasingly viewed as an impracticality as producers learn how their resources can be used more efficiently to monitor pest populations, thereby initiating control measures only when numbers exceed economic thresholds. Although not the major emphasis in most IPM programs, nonchemical strategies are seen to have great potential.

4.2.2 Motivation

The economic advantage IPM provides over conventional pest control is often the driving motivation to adopt IPM techniques. Generally, savings in pesticide costs far outweigh monitoring costs. Unfortunately, farmers are often not sufficiently trained to know how to assess pest populations to determine when economic thresholds are reached. In areas where scouting services are unavailable or below demand, IPM adoption may be limited to few farms. Knowledge of pest life cycles and the effects of climate can also lead to higher quality harvests as management tactics are specifically timed to address pest problems.

Chemical dealers are often the prime source of advice for farmers, but some producers do not trust recommendations from chemical dealers and may, therefore, look to IPM programs for unbiased, reliable sources of information. Ethical considerations regarding potential harm to the environment or human health are also often important to farmers practicing IPM. Conventional pest control typically operates without consideration of beneficial species. Consequently, IPM has gained the favour of producers for the attention it accords natural controls in an agroecosystem.

4.2.3 Effectiveness of Nonchemical Pest Management

Economic thresholds and predator-pest relationships are important in any IPM system. Generally, economic thresholds and the acceptable level of pests are greatest in field crops and lowest in fruits and vegetables. Until pests do enough harm to field crops that the yield is reduced, control measures are not required.

Horticultural crops, on the other hand, will withstand a much lower infestation before cosmetic quality standards require control measures to be used (Frank 1989). The producers indicated that economic thresholds and predator pest relationships are moderately effective (Table 6) in meeting their pest management needs. That they are not "most" effective for all respondents indicates that more work is needed to refine their usefulness in IPM programs.

TABLE 6. TACTIC ASSESSMENT BY GROWERS
(Most 1; moderate 2; least 3)

IPM Tactics	Average	Total	Leech	Campbell	Jackson	Tennes	Shankula
Environmental monitoring and forecast	1.4	7	1	1	3	1	1
Thresholds	1.6	8	2	2	1	2	1
Predator-pest	1.6	8	2	2	1	2	1
Varietal resistance	1.8	9	2	3	1	2	1
Genetic engineering	1.8	9	2	2	3	1	1
Rotation	2.0	10	2	3	1	2	2
Bioproducts	2.0	10	2	3	3	1	1
Intercropping	2.2	11	3	3	1	2	2
Micro-environment	2.5	10	2	3	3	-	2
Implement development	2.6	13	2	3	2	3	3
Companion planting	2.8	14	3	3	3	2	3
Mulching	3.0	15	3	3	3	3	3

Varietal resistance has received greater attention in vegetable and potato crops as more varieties with resistance are available to growers than in other commodities. Various scab resistant varieties of apples are available to growers, but because consumers are not familiar with them, growers have been reluctant to abandon well-known cultivars such as MacIntosh and Red Delicious (Roberts 1989).

Environmental conditions (mostly climate) are monitored to indicate future pest levels. Apple and vegetable growers rated this item most highly, as fungal and insect infestations can often be gauged by temperature and precipitation forecasts. Indications of weed infestations are less clearly associated with such weather factors. As a result, this information is less valuable to field crop producers (Roberts 1989).

Although their use varies among farms, crop rotations have significant potential for reducing or eliminating disease, weed and insect infestations (Bottrel 1979). As fruits are perennial crops, there are fewer opportunities for rotations, but concerns over nematode damage to new trees in old orchard soil may convince growers to intercrop the orchard trees with grasses that inhibit nematode populations (Leuty 1989).

Disease resistant apple varieties are assessed at the New York Agriculture Experimental Station. Because they are very resistant to apple scab, and resist powdery mildew, cedar apple rust and fire blight, these cultivars generally do not require fungicide applications. *Courtesy of New York State Agricultural Experiment Station.*

Shankula and Tennes did not specify which biological products they found useful, but *Bacillus thuringiensis* (Bt) is the most common biological product used for horticultural crops. Bt is a spore-forming bacterial pathogen that can survive in dormancy until consumed, along with vegetation, by insects which soon die due to a paralyzed gut (Bottrel 1979). Bt is not registered in Ontario for apples (Roberts 1989), which probably explains the ratings given to biological products by Campbell.

4.2.4 Pest Resistance and Pesticide Restrictions: Future Pest Problems

In the survey of IPM coordinators, respondents were asked how state and provincial IPM programs were developing adequate pest management options in the face of increasing pest resistance and pesticide restrictions. In the Producer Questionnaire respondents listed pests they expected to cause problems as a result of these two factors. In a period characterized by disappearing chemical options and insufficient research into nonchemical alternative, producers have identified certain pests as posing future problems. The Colorado potato beetle has in many potato growing areas acquired high levels of resistance to insecticides from a variety of different chemical families, including the organochlorine, organophosphorus, carbamates and pyrethroids (Turnbull *et al.* 1988; Boiteau *et al.* 1987; Harris and Turnbull, 1986). Helmut Shankula listed the onion maggot as a significant concern to vegetable growers; in Ontario it can cause from 20% to 40% crop loss. Resistance to cyclodiene insecticide developed quickly and there are indications that the beetle may be resistant to organophosphorus and carbamate insecticides in some areas of Ontario and Michigan (Carrol *et al.* 1983; Harris *et al.* 1982). Larry Leech identified velvet leaf and lamb's quarters as pests of greatest concern in his soybean and corn crops, while Ann Tennes listed European red mites as a major problem for apple growers. An outbreak of harmful mite species is a classic indication of ineffective management of an agroecosystem. Typically, natural control provided by predacious mites is destroyed by improperly timed or overused broad spectrum pesticides. Mireya Campbell did not specify a particular pest problem in apples, but pointed out that large acreages of apples would be nearly impossible to grow without using chemical thinning agents because labour costs would be prohibitive and current prices would not support the increase in costs. Unfortunately, the external costs associated with chemical thinning agents, although difficult to quantify, may be significant as well, requiring either a reduction in the intensity of cultivation or the development of a nonchemical strategy.

4.2.5 Coordination of Agricultural Programs

As with the IPM coordinators, farmers surveyed in the Producer Questionnaire did not agree on whether coordination between IPM and other agricultural programs was sufficient. Anne Tennes and Larry Leech found coordination to be inadequate, while Helmut Shankula and Mareya Campbell were satisfied. Campbell found that many of the programs did not relate directly to each other and, consequently, did not demand substantial coordination. Often, though, policies and actions in one agricultural area can have great implications for one or many other agricultural concerns. For instance, commodity support programs that encourage monoculture row-crop cultivation may also encourage increased pesticide and fertilizer use as well as erosion (Fleming 1987).

4.2.6 Farm Level Constraints on IPM

Three of the five producers listed the lack of professional consultants as the major limitation facing their IPM program. Helmut Shankula depends on students to scout his crops through the growing season, but critical periods in the second and third weeks of September are not monitored since the students have returned to school. Ann Tennes has had trouble finding a well-trained consultant, while Larry Leech said that it is hard to find a scout who is capable of handling all of his acreage. Furthermore, the cost is limiting. Mireya Campbell noted that the size of the Whaley Orchard also poses problems, but the major concern was with timing pesticide applications on such a large scale. Because of orchard size, the spray program is quite staggered. For Dale Jackson, fewer available chemicals leave him unable to counter the development of resistance against the insecticides he does use.

All farmers but Ann Tennes are satisfied with the availability of IPM information. Ratings for the different methods of information delivery are listed in Table 7. Ratings by producers are similar to those of the IPM coordinators, except that newsletters are ranked somewhat lower and phone lines slightly higher. Computer applications of information delivery are not viewed as effective by any respondent at this time.

TABLE 7. EFFECTIVENESS OF INFORMATION DELIVERY (Most 1; moderate 2; least 3)

IPM Tactics	Average	Total	Leech	Campbell	Jackson	Tennes	Shankula
Extensive visits	1.2	6	2	1	1	1	1
Phone lines	1.4	7	2	1	1	2	1
Consultants	1.4	7	1	2	2	1	1
Workshops	1.6	8	3	2	1	1	1
Newsletter	1.8	9	2	2	1	2	2
Farm tours	2.0	19	2	3	2	1	2
Computers	3.0	15	3	3	3	3	3

4.2.7 Responsibility for IPM Tasks

The limited number of farmers surveyed here indicates that pest monitoring is the most commonly performed IPM activity as listed in Table 8. Generally, pest monitoring appears to be the responsibility of professionals who have been sufficiently trained to interpret information in the field to design a pest management program. Scouts and consultants are hired to specifically look at the pest-predator complex. For farmers this relationship is probably not well understood, is less of a priority, and consequently does not receive attention. Depending on the region and the commodity, government agents may or may not be available for IPM consultations. Typically, monitoring of beneficial species occurs less frequently than pest monitoring. If the former activity is undertaken, it is usually by private or government scouts. The encouragement of beneficial species in an agroecosystem can take different forms. Habitats can be managed to provide shelter and breeding space for predators and parasites of pests, but a simpler, more common approach is to limit or discontinue the use of broad spectrum chemicals that destroy nontarget beneficial species in an attempt to eliminate the target pest population.

TABLE 8. RESPONSIBILITY FOR IPM TASKS
(Often 1; periodic 2; incidental 3; never 4)

IPM Tactics	Average	Total	Leech	Campbell	Jackson	Tennes	Shankula
Pest monitoring							
° Private consultants/scouts	1.6	0	1	1	1	4	1
° Government extension	2.2	11	2	3	1	4	1
° Grower	2.4	12	3	4	1	2	2
Beneficial Monitoring							
° Private consultants/scouts	2.8	14	1	4	1	4	4
° Government extension	3.2	16	3	3	2	4	4
° Grower	3.2	16	4	4	2	2	4
Encouraging Beneficial Populations							
° Private	3.3	13	3	2	*	4	4
° Government extension	3.0	13	3	2	*	4	4
° Grower	3.0	12	4	4	*	2	2

*Difficult as heavy-duty pesticides kill beneficials

4.2.8 Climate

Pesticide applications must be effectively timed to control target pests, yet climatic conditions can inhibit a producer's flexibility in enacting these controls. Rain, high winds and hot temperatures must be taken into account, for much pesticide is wasted under these conditions; it is washed off, blown away or volatilized, respectively. Climate information is available from television, radio, newspapers and government publications, such as the Crop Advisory Team (CAT) alerts from the Michigan State University.

4.2.9 IPM Benefits

All producers surveyed, except Mireya Campbell, had been successful in reducing farm costs by reducing pesticide use. Larry Leech added that he had also attained higher yields and higher quality produce. Mireya Campbell reported that chemical use had not decreased, instead higher quality produce had been harvested as a result of a more effectively timed spraying program. On the whole, the producers found IPM to be more effective and less costly than conventional pest control.

An astronaut operating a lunar probe or a farmer spraying his crops? IPM substitutes information technology for chemical technology. *Courtesy of American Fruit Grower Mazagine.*

4.2.10 Obstacles to Adoption of IPM

Despite the fact that IPM systems are often less costly than conventional pest control, farmers may be unwilling to invest in unfamiliar techniques, such as scouting. Further, by not spraying regularly, farmers might feel they are risking both harvest quality and yield. Financial risk is the most important factor impeding producers from adopting IPM (Table 9), but IPM is also more management intensive and depends on knowledge more than the simple chemical solutions of conventional pest control. More than simply discovering a new pest management option, successful adoption of IPM is dependent on a willingness to learn new concepts and implement new techniques. IPM is a new approach that involves different time commitments and a re-evaluation of other components in agricultural systems.

The importance of retail standards, in relation to IPM adoption, varies among commodities. Cosmetic quality standards are lowest in field crops and highest in fruits and vegetables. Dale Jackson does not rate retail standards as significant constraints in carrying out IPM for potato production; his major pest problem is the Colorado potato beetle, which attacks the plant foliage, not the tuber.

Although Ontario and New York have made significant progress in IPM, Shankula and Jackson still view a lack of political support as a major impediment to IPM adoption. While they may have a good understanding of IPM's potential, their dissatisfaction could indicate much work is left to be done and government must increase its efforts to develop IPM.

TABLE 9. OBSTACLES TO ADOPTION
(Most 1; moderate 2; least 3)

IPM Tactics	Average	Total	Leech	Campbell	Jackson	Tennes	Shankula
Financial risk	1.2	6	2	1	1	1	1
Farmer acceptance	1.8	9	3	2	1	1	2
Political support	2.0	10	3	3	1	2	1
Retail standards	2.0	10	3	1	3	1	2
Access to information	2.4	12	2	2	3	2	3
Scouts carrying disease						1	

Helmut Shankula also pointed out how farmers were unwilling to adopt IPM as they were concerned that scouts would transport disease (especially white rot in onions) between farms. Scouts in his area have responded to this problem by cleaning their boots between farms and retaining a pair solely for farms where white rot or other particular diseases are known to exist.

On a final note, Shankula added that substantial pesticide reductions were attainable if all producers practiced IPM. In his IPM program, spraying occurs infrequently; insecticides have not been needed in carrot and onion crops for three and seven years, respectively. The use of economic thresholds and the prevention of the disruption of beneficial species that control pests avoids the risks and costs of pesticides.

5.0 RECOMMENDATIONS

5.1 INTERNATIONAL JOINT COMMISSION

5.1.1 ***Basinwide guidelines outlining development goals for IPM programs should be established under the Agreement and evaluated periodically by the Commission in its role of providing advice and recommendations to governments. Evaluations of basin IPM programs should be combined with pesticide use surveys and conducted using the guidelines to assess development and implementation over time.***

° Although guidelines would provide basic standards for jurisdictions to attain, they should not form a static definition of what IPM must become, but rather identify a dynamic process from which to measure progress. Such an outline might begin with pesticide reduction as an initial parameter, and would range to indicators of agricultural approaches that increasingly operate within the constructs of ecosystem thinking – a policy of the International Joint Commission supported by Canada and the United States through the Great Lakes Water Quality Agreement. Such a framework would help to coordinate short- and long-term budget requirements of maturing IPM programs.

5.2 GOVERNMENTS

5.2.1 ***Governments at all levels need to increase short, medium and long-term funding for all aspects of IPM development. Support for existing commodity programs must be enhanced and funds should be provided to expand IPM to new commodities.***

° A much stronger resource base is required for IPM progress. A lack of political support is preventing expansion of existing programs to new crops and discouraging the development and implementation of nonchemical approaches. In real terms, funding for IPM is declining, yet programs are facing increasing demands to reach more farmers in more commodities. IPM is an investment in long-term efficiency in food production and environmental health. Increased financial support of IPM will assist in the development of a comprehensive network of research, education and extension, but it must also be accompanied by the philosophical support of IPM principles by government through adoption and promotion of IPM as official agricultural policy.

5.2.2 ***All basin jurisdictions need to adopt IPM as their official state or provincial pest management policy. All government agencies that manage pests must implement IPM policies and practices and apply them to their own operations.***

° Whether in research or public service related activities, agencies responsible for agriculture, the environment, natural resources, forestry and transportation are required to use varying forms of pest management to carry out their respective mandates. Pest management is an important consideration at agricultural research stations and farms, regardless of the direct focus of specific projects. Transportation departments are often responsible for maintaining roadsides and ditches, employing pest management techniques to reduce plant growth. Forestry and natural resource agencies use pest management to manage forests for recreation and harvesting.

It is unlikely that individuals will be convinced of the benefits of IPM when governments are not confident enough to use it themselves.

5.2.3 ***Basin jurisdictions should investigate methods to improve communication and coordination among agricultural sectors and jurisdictions.***

° IPM programs require a high level of coordination among farmers, researchers, industry, policy makers, and educators to ensure that good intentions are achieving results on the farm. Enhanced communication between jurisdictions will be required to disseminate knowledge and expertise throughout the basin, and break down any misinformation associated with myths and stereotypes.

5.2.4 ***Agricultural support programs and economic factors that encourage the overuse of pesticides should be identified and eliminated.***

° The jurisdictions and Parties must reassess support programs to the agricultural industry that undermine the resource base through the indiscriminate use of pesticides. Economic factors encouraging the overuse of pesticides such as atrazine should be related to external costs and reflected in the price of the chemical. This could be accomplished through a tax or surcharge.

5.2.5 ***To enhance adoption, economic mechanisms should be applied that benefit farmers willing to practice IPM techniques.***

° Although IPM reduces input costs and therefore is inherently more profitable than conventional approaches, many producers remain averse to risk, or do not perceive the economic benefits. Programs that would maintain and introduce beneficial species, renew old orchards with disease resistant varieties, utilize economic thresholds, encourage crop rotation and replace chemicals with biological products would benefit from economic incentives. Economic mechanisms could include disincentives for conventional practices, market supports, price incentives, transfer payments, investment in infrastructure, and enhanced tax allowances for IPM-related expenditures.

5.3 PROGRAM DEVELOPMENT – AGENCIES AND RESEARCH INSTITUTIONS

5.3.1 ***Research into IPM should concentrate on interdisciplinary efforts that develop options to chemical controls and reconcile the development of the agroecosystem with related concepts such as sustainable and organic agriculture, multiple cropping, conservation tillage, and low input farming.***

° Recognizing the ramifications of pesticide use and the pressures which producers face from pesticide restrictions and pest resistance, IPM coordinators have identified nonchemical approaches as essential, but relatively undeveloped components of IPM systems (Table 2). Coordinators describe the lack of such strategies as the fundamental impediment to IPM adoption by the farming community (Table 4). Interdisciplinary research will be instrumental to provide nonchemical solutions to pest management, for dependence on many chemicals will not be alleviated through direct replacement by other products but by development of agricultural systems that coordinate pest management with land and water management, resource conservation, environmental protection, and socioeconomic development (Altieri 1987). This approach appears to be the general goal of the Sustainable Agriculture movement in the United States, which has attained increasing funding from the Low Input Sustainable Agriculture (LISA) program.

Reference to the term ecosystem may infer the existence of pristine natural environments; however, the largest single land use in the basin comprises a highly diverse agroecosystem. It is important to recognize agriculture as managed manipulations of natural components of the environment, and it is essential that human influences respect the integrity of the Great Lakes Basin Ecosystem. Agricultural systems that are modeled on ecological processes are more likely to achieve integration with the natural ecosystem, and are more likely to be sustainable.

5.3.2 ***Food quality standards that have no nutritional basis, focussing solely on cosmetic appearance, should be eliminated.***

- A great deal of pesticide used on horticultural crops is required not to maintain production or nutritional quality, but to provide cosmetically perfect food. Traditionally the agricultural industry has justified the use of agrichemicals for cosmetic purposes by claiming that consumers will purchase only visually perfect food. Consumers are becoming aware that significant levels of pesticides are required to provide for their tastes, and their concern for food quality has extended beyond cosmetic factors; the presence or possibility of pesticide residues is now a significant consideration. Also, the public has expressed considerable concern over farming practices that may have detrimental impacts on the environment.

5.3.3 ***The agencies should assess educational opportunities currently available for farmers, scouts, students, extension agents and others requiring training in IPM and provide it for general and restricted chemicals together with mandatory applicator training programs for all pesticide users.***

- IPM coordinators generally view academic teaching of IPM as inadequate. A comprehensive focus on IPM is often difficult as IPM is not taught as independent core courses. The coordinators are very optimistic about the role of farmer training programs in expanding IPM adoption; however, the responsibilities of pesticide use need to extend beyond the technical aspects of proper disposal and efficient application. Increasing knowledge of the ecology of pest management should be a required objective of applicator training programs, including such aspects as the study of entomology and weed life cycles.

5.3.4 ***More research should be focussed on alternate technology in order to reduce herbicide use in field crops, and a study should be undertaken to assess the role of industry in the development of IPM programs.***

- Notwithstanding the trend towards reduction of active ingredient rates and decrease in the use of insecticides and fungicides, the increasing amount of pesticide being applied each year is attributed to the use of herbicides and is heavily promoted by industry through advertising.

Weed science and the application of chemical technology appears more directed towards developing crops resistant to herbicides than to crops resistant to weeds, or the nonchemical management of weed pests.

Chemicals are appearing increasingly in ground and surface water, indicating that their use is a threat to valuable and irreplaceable water resources. One of the most commonly used herbicides, atrazine, has been detected in drinking water sources in concentrations exceeding U.S. EPA guidelines (Mittner *et al.* 1989). This chemical is of particular concern, as its high solubility enables it to readily leach into groundwater and flow to surface water. Although it is quickly degraded in soil by photolytic and microbial processes, recent information indicates it is far more stable in aquatic environments, thereby risking contamination of human sources of water (U.S. EPA 1988).

For many farmers the chemical industry is a primary source of information for pest control recommendations, however, the industry has a vested interest in promoting proprietary technology. The role for the market and for industry to identify opportunities associated with IPM technology and services needs to be better defined in order to promote IPM development.

6.0 CONCLUSION

Anticipation and prevention of detrimental human activities are the essential features of International Joint Commission and Great Lakes Water Quality Agreement policy that will enable the Governments of the United States and Canada to fulfill their mandate to "maintain the chemical, physical and biological integrity of the Great Lakes Basin Ecosystem." IPM represents agricultural technology and wisdom that presage the ramifications of widespread chemical use by developing alternative strategies today so remedial measures will not be required in the future. IPM is reducing chemical dependence not only by direct replacement of pesticides, but more importantly, by designing agroecosystems. These are farming systems that look beyond short-term economics; they incorporate the principles of sustainable agriculture; the long-term ecological viability of the system is an economic goal unto itself. By changing pest management from conventional methods to processes that are more compatible with natural ecosystems, external costs are minimized or eliminated.

Jurisdiction IPM programs have suffered from underfunding, but a lack of clarity in IPM objectives has also hindered their development. Basin programs require a structure for development. The jurisdictions have a general goal of reducing pesticides through the use of economic thresholds. This strategy is limited in its ability to diminish pesticides. Further reductions will depend on the availability of alternatives to chemicals. In fact, coordinators claim that options are required now, and the lack of such alternatives is the major obstacle facing grower acceptance of IPM.

Funding and overall support for IPM is inadequate and basin programs have not attained a significant level of sophistication. Despite jurisdiction anomalies in criteria, Table 5 shows that IPM has attracted a small proportion of producers in basin jurisdictions. Progress to date merely indicates that significant advances are attainable in the future.

The recommendations illustrate just how comprehensive action must be to bring mainstream agricultural attitudes to develop the potential attributes of IPM. A re-thinking of the fundamental basis of agriculture is in order. Agriculture is not simply production in a vacuum, nor is it a wholly naturally system, but manipulations in the Great Lakes Basin Ecosystem must be constructed to prevent damaging impacts, such as those brought by the current agricultural dependence on pesticides.

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APPENDIX A

INTEGRATED PEST MANAGEMENT

IN THE GREAT LAKES BASIN ECOSYSTEM:

COMMENTS CONTAINED IN THE

1989 REPORT OF THE GREAT LAKES SCIENCE ADVISORY BOARD

INTEGRATED PEST MANAGEMENT IN THE GREAT LAKES BASIN ECOSYSTEM COMMENTS CONTAINED IN THE 1989 SCIENCE ADVISORY BOARD REPORT OF THE GREAT LAKES

The adoption of anticipatory, preventive and adaptive strategies was addressed by the Board in its 1987 Report, and is a policy endorsed by the Commission, U.S. EPA and Environment Canada. The challenge of moving from policy, good intentions and common sense to specific actions becomes apparent when addressing the anticipation and prevention of pollution. Integrated Pest Management (IPM) is one such initiative; it represents a major opportunity to reduce the widespread dependence on chemicals, and their indiscriminate use in agriculture, through applied science and research.

Integrated Pest Management is addressed in the Great Lakes Water Quality Agreement (GLWQA) under Article VI, 1(e)(i), and provides for the Parties to develop and implement research and educational programs to facilitate the integration of cultural, biological and chemical pest control techniques.

The concept of designing integrated systems to manage agricultural pests is not new. IPM has been viewed as a rational approach to providing long-term solutions to pest problems for over 30 years. In her book Silent Spring, Rachel Carson spoke of the research potential for biological controls; however, her vision has only begun to be realized. Developments in agricultural science are starting to place greater emphasis on the interrelated aspects of agricultural systems. As a result, current initiatives and developments in entomology, crop science, land resource science and ecology have renewed the attention accorded IPM.

IPM employs many different biological, cultural and chemical techniques, combined with climatological information; however, it is effective only when it is applied in an integrated fashion. The use of chemicals, if required, is determined by pest-population thresholds, based on levels of economic injury. Pesticides must be used selectively in order that beneficial species such as predatory insects and their host plants are not affected, thereby contributing to the control of pest outbreaks. Other IPM methods that focus directly on pests in an agroecosystem include pheremones (both attractants and repellents), sterilants and biological products (usually bacterial, viral or fungal) such as Bacillus thuringiensis. A multitude of cultural techniques are also important, including ridge and conservation tillage, mulching, crop rotations and intercropping. These techniques directly suppress pest populations, encourage beneficial species, and enhance soil structure and fertility in order to support more vigorous pest-resistant crops. The particular strategies used by farmers depend on the crops grown and the locale.

In the simplest of IPM programs, attention has focussed largely on optimizing pesticide use, while retaining conventional pest control strategies. In these programs, substantial reductions in pesticide use have been achieved by better timing of chemical spraying and improved training of those who apply pesticides. For IPM to diminish dependence on chemical control and to contribute to the reduced discharge of pollutants into the Great Lakes Basin Ecosystem necessitates that farmers and the jurisdictions move beyond conventional approaches to comprehensive strategies which view farming in the context of agroecosystems.

Notwithstanding the opportunities and progress to date, it is apparent from a preliminary review of basin programs, that a renewed commitment to IPM goals is required. Resources have been lacking to build the information needed to implement IPM programs successfully and to facilitate increased grower acceptance and implementation. While the scientific and ethical importance of integrated approaches to pest management has developed wider public acceptance, it would appear that well developed extension and education programs are not adequately supported by ongoing research.

Pest resistance and public pressure to ban and restrict pesticide use could severely limit chemical control options. This limitation could impinge on the economic viability of agricultural systems. Biological and cultural options developed as a result of IPM can reduce agricultural reliance on pesticides and avoid a reactionary or irrational response to perceived problems. As well, the financial and temporal costs of proving pesticides safe can be reduced if dependence on them is lessened and new strategies are adapted to fit the needs of agriculture. In terms of the maintenance of ecosystem integrity, IPM anticipates potential problems arising from the use of chemicals as more is learned about the long-term and synergistic effects of pesticides in the environment.

A survey assessing the focus and progress of the IPM programs in the basin is currently underway and the Board will be presenting recommendations based on this work.

APPENDIX B

IPM IN THE GREAT LAKES BASIN: COORDINATOR SURVEY

DEFINITION

1. How is IPM defined in your program?

2. Is IPM independent from or a part of traditional pest management programs?

3. What are the objectives of your IPM program?

   (1) ______________________________
   (2) ______________________________
   (3) ______________________________
   (4) ______________________________

4. How do they correspond with the objectives of your state/provincial agriculture program?

5. How do they correspond with your state/provincial environmental policy concerning pesticide use and pollution?

6.

Program justification (Check appropriate box)	Why was your IPM program developed?	What has kept it going?
• Political initiative	☐	☐
• Consumer pressures	☐	☐
• Scientific findings		
– medical	☐	☐
– pesticide resistance	☐	☐
– destruction of beneficials	☐	☐
– pollution	☐	☐
• Farming economics	☐	☐
• Other	☐	☐

7. What priority are the following agricultural pests given (high, medium or low) in each crop sector?

Pests	Fruit	Vegetables	Grains	Oilseeds	Other	
	Crop Sectors					
Insects						
Weeds						
Nematodes						
Fungi						
Bacteria						
Viruses						

PROGRAM SUPPORT

1. Where does funding for IPM originate?

2. Describe the resources committed to your IPM program in:

- Person years ______
- Budget ______
- Percent of agricultural budget ______
- Percent of pest control budget ______

3. Is there adequate political support for IPM regarding:

- Funding ☐Yes ☐No
- Legislation ☐Yes ☐No

Comment on this situation as it relates to the implementation and development of your IPM program.

4. Does the research community support the principals of IPM? ☐Yes ☐No

5. From 1-5 (highest-lowest) rate the level of research funding allotted for:

_______ Economic thresholds
_______ Predator - pest relationships
_______ Mulching
_______ Varietal resistance
_______ Intercropping
_______ Crop rotation
_______ Farm implement development
_______ Genetic engineering
_______ Micro-environments
_______ Environmental monitoring and forecasting
_______ Organic agriculture
_______ Biological products
_______ Companion planting
_______ Other ____________________
_______ ____________________

6. Give some examples of interdisciplinary research that contribute to your IPM program.

(1) ____________________
(2) ____________________
(3) ____________________

7. What do you feel are the common barriers to interdisciplinary IPM research? (Check appropriate box)

☐ Promotion and tenure
☐ Traditional funding criteria
☐ Researcher reluctance
☐ Other ____________________
☐ ____________________
☐ ____________________

8. In considering possible future limitations of available pesticides (due to legislative restrictions and pest resistance) what steps is your program taking to maintain adequate pest control strategies?

9. Is more emphasis on nonchemical pest control research required? ☐Yes ☐No

10. Briefly summarize the communication and coordination that exists between:

- IPM and other agricultural programs (erosion control, ground and surface water pollution, sustainable agriculture, etc.)

- States/provinces especially regarding monitoring and forecasting of climate, pests, and beneficial species.

- Farming, education, extension, and research.

11. Are sufficient resources committed to IPM education in college and university programs? ☐Yes ☐No

<u>IMPLEMENTATION</u>

1. Briefly describe how your IPM program is promoted to the following groups:

- Farmers

- Politicians

- Researchers and educators

2. Rank from 1-5 (highest-lowest) the emphasis placed on different methods of information delivery to the farming community.

_______ Newsletters
_______ Phone lines
_______ Workshops
_______ Farm tours
_______ Extension visits
_______ Expert systems
_______ Electronic mail
_______ Data bases
_______ Other _______________________________
_______ _______________________________

3. Who provides services and delivers IPM information (extension) to farmers? (Check appropriate box)

☐ Private sector
☐ Public sector
☐ Both

4. Are pest populations monitored? ☐Yes ☐No

5. Are beneficial predators monitored? ☐Yes ☐No

6. Has your program developed strategies for encouraging the population growth of beneficial insects, plants, etc? ☐Yes ☐No

7. How is climatological data as it relates to pest incidence made available to farmers?

8. Are farmers encouraged to conduct their own IPM? ☐Yes ☐No

9. List the training programs and type of information on IPM made available to farmers?

10. What information on nonchemical means of pest control is produced for the farmer?

11, What measures exist in your state/province for monitoring the use and disposal of pesticides?

12. Briefly describe the evaluation procedure that has been developed for your IPM program.

ADOPTION

1. Rank from 1-5 (highest-lowest) the importance of the following obstacles that impede adoption of your IPM program.

    ________ Lack of simple monitoring methods
    ________ Lack of simple action thresholds
    ________ Lack of selective chemicals
    ________ Lack of IPM control for key pests
    ________ Lack of political support
    ________ Lack of extension funds
    ________ Insufficient training of IPM specialists
    ________ Grower nonrecognition of long-term advantage of IPM
    ________ Lack of participation from general agricultural academic community
    ________ Farmer resistance to change
    ________ External nature of social and environmental costs and risks of pesticides
    ________ Difficulties in marketing biological techniques and products
    ________ Cosmetic quality standards
    ________ Pesticide registration
    ________ Resistance from chemical industry
    ________ Administrative problems
    ________ Lack of alternatives to pesticides
    ________ Lack of interdisciplinary coordination
    ________ Other ______________________________
    ________ ______________________________

2. How does farm size reflect on IPM adoption?

3. Are food quality standards, especially those evaluating visual quality, too high? ☐Yes ☐No

4. Is there a pesticide applicator training program in your state/province? ☐Yes ☐No

    Is it mandatory? ☐Yes ☐No

5. Has your state/province maintained an inventory of Pest Control Products? ☐Yes ☐No

6. Estimate the amount of acreage in different crops or crop sectors (grains, fruit, vegetables, etc.) and give the percentage currently practicing IPM.

Crop/Sector	Acreage	IPM (%)

7. Also, please choose an insecticide, a herbicide, and a fungicide and estimate/guesstimate the quantity used in conventional production vs. IPM for crops of your choice.

	Crop	Conventional (Units: ______)	IPM (Units: ______)
Insecticide			
Herbicide			
Fungicide			

8. Could you provide any information comparing the costs or profitability of IPM to that of conventional practices?

ADDITIONAL COMMENTS

1. What role does the chemical industry play in IPM?

- Influence on research, as well as government programs and legislation?

- Chemical company information delivery (extension) services affect on farming practices.

2. What is the potential of your IPM program in reducing pesticide use and ensuring efficient agricultural production considering the long-term goals of the program?

Are you satisfied with the survey? Please feel free to include additional comments and suggestions. Thank you for your time and expertise.

Reply before July 5, 1989:
Jeremy Higham
International Joint Commission
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Windsor, Ontario N9A 6T3
or: P.O. Box 32869
Detroit, Michigan 48232-2869
(519) 256-7821 Cdn. line
(313) 226-2170 U.S. line

APPENDIX C

IPM COORDINATORS AND AGRICULTURAL COMMODITIES IN BASIN JURISDICTIONS

IPM COORDINATORS AND AGRICULTURAL COMMODITIES IN BASIN JURISDICTIONS (PAGE 1 OF 2)

ONTARIO Mr. Wayne Roberts Plant Industry Branch Ontario Ministry of Agriculture and Food Guelph Agriculture Centre Guelph, ON N1H 6N1 (519) 767-3173	• Corn, soybeans, winter wheat, apples, tender fruits and vegetables
ILLINOIS Dr. Donald E. Kuhlman Extension Entomologist University of Illinois 172 Natural Resources Building Champlain, IL 61820 (217) 333-6653	• Corn, soybeans and wheat
MICHIGAN Dr. Larry Olsen Pesticide Education/IPM Coordinator Michigan State University Room 11, Agriculture Hall East Lansing, MI 48824 (517) 355-0117	• Corn, soybeans, forage, apples, cherries, sugar beets and dry beans
NEW YORK Dr. James P. Tette Director, IPM Program IPM House New York State Agricultural Experiment Station Division of the NY State College of Agriculture Statutory College of the State University Cornell University Geneva, NY 14456 (315) 787-2206	• Corn, soybeans, apples, grapes, forage and vegetables
OHIO Dr. Harold R. Wilson IPM Program Coordinator and Extension Entomologist Ohio Cooperative Extension Service The Ohio State University IPM Office 1991 Kenny Road Columbus, OH 43210 (614) 292-8358	• Corn, soybeans, forage, small grains, apples, vegetables, and ornamentals

IPM COORDINATORS AND AGRICULTURAL COMMODITIES IN BASIN JURISDICTIONS (PAGE 2 OF 2)

WISCONSIN Dr. Walter R. Stevenson Department of Plant Pathology University of Wisconsin 1620 Linden Drive Madison, WI 53706 (608) 262-6291	• Corn, soybeans, forage, cherries, vegetables, apples, cranberries, and potatoes
INDIANA Dr. C. Richard Edwards Extension Entomologist Department of Entomology Purdue University Entomology Hall West Lafayette, IN 47907 (317) 494-4562	• Corn, soybeans, small grains, forage, apples and peaches
MINNESOTA Dr. Kenneth R. Ostlie Extension Entomologist Department of Entomology University of Minnesota St. Paul, MN 55108 (612) 624-9272	• Corn, soybeans, wheat, forage, sugar beets and potatoes
PENNSYLVANIA Dr. Dennis D. Calvin Assistant Professor of Entomology Extension Pennsylvania State University 103 Patterson Building University Park, PA 16802 (814) 863-4640	• Corn, soybeans, small grains, forage, apples, vegetables, potatoes and mushrooms
QUEBEC M. Pierre Sauriol Ministère de l'Agriculture des Pêcherie et de l'Alimentation 118, rue Lemieux Saint-Remi, PQ J0L 2L0 (514) 454-3904	• Vegetables, apples, potatoes, corn, soybeans and forage
M. Guy Boivin Agriculture Canada Station de Recherche 430 Coin St. Jean sur Richelieu, PQ J3B 3I6	• Same as above
M. Luc Brodeur Réseau de Dépistage at de Recherche du Sud de Montréal 539 Boulevard Edouard VII St. Jacques le Mineur, PQ J0J 1Z0	• Same as above

APPENDIX D

IPM IN THE GREAT LAKES BASIN:

PRODUCER QUESTIONNAIRE

DEFINITION

1 HOW DO YOU DEFINE IPM?

2 WHAT ARE THE REASONS FOR IMPLEMENTING AN IPM PROGRAM ON YOUR FARM?

3 HOW WOULD YOU RATE THE FOLLOWING AS EFFECTIVE MEASURES OF BIOLOGICAL AND CHEMICAL PEST CONTROL?

	EFFECTIVENESS		
	LEAST	MODERATE	MOST
ECONOMIC THRESHOLDS	□	□	□
PREDATOR - PEST RELATIONSHIPS	□	□	□
MULCHING	□	□	□
VARIETAL RESISTANCE	□	□	□
INTERCROPPING	□	□	□
CROP ROTATION	□	□	□
FARM IMPLEMENT DEVELOPMENT	□	□	□
GENETIC-ENGINEERED TECHNOLOGY	□	□	□
MICRO-ENVIRONMENTS	□	□	□
ENVIRONMENTAL MONITORING AND FORECASTING	□	□	□
BIOLOGICAL PRODUCTS	□	□	□
COMPANION PLANTING	□	□	□
OTHER	□	□	□

4 WHAT AREAS OF IPM REQUIRE GREATER RESEARCH?

5 IN CONSIDERING POSSIBLE FUTURE LIMITATIONS OF AVAILABLE PESTICIDES (DUE TO CONSUMER PRESSURES AND PEST RESISTANCE) WHAT PEST, AND WHAT CROP WILL BE MOST ADVERSELY AFFECTED IF PRACTICAL NON-CHEMICAL ALTERNATIVES ARE NOT DEVELOPED?

6 DO YOU FEEL THERE IS SUFFICIENT COORDINATION BETWEEN IPM AND OTHER AGRICULTURAL PROGRAMS (EROSION CONTROL, GROUND AND SURFACE WATER POLLUTION, SUSTAINABLE AGRICULTURE, COMMODITY SUPPORT, DROUGHT RELIEF, ETC.)?

IMPLEMENTATION

1 WHAT WOULD YOU DESCRIBE AS THE MAJOR LIMITATION OF IPM ON YOUR FARM?

2 IS IPM INFORMATION EASILY ACCESSIBLE AT LOW COST?

3 HOW WOULD YOU RATE THE EFFECTIVENESS OF THE FOLLOWING METHODS IN DELIVERING IPM INFORMATION TO YOU?

	EFFECTIVENESS: LEAST	MODERATE	MOST
NEWSLETTERS	☐	☐	☐
PHONELINES	☐	☐	☐
WORKSHOPS	☐	☐	☐
FARM TOURS	☐	☐	☐
EXTENSION VISITS	☐	☐	☐
CONSULTANTS	☐	☐	☐
COMPUTERS	☐	☐	☐
OTHER	☐	☐	☐

4 HOW ARE THE FOLLOWING TASKS ACCOMPLISHED ON YOUR FARM?

		NEVER	INCIDENTAL WITH SOME OTHER FARM ACTIVITY	PERIODIC ON A REGULAR BASIS	OFTEN AS PART OF AN ONGOING TASK
MONITORING FOR PESTS:	PRIVATE CONSULTANTS/SCOUTS	☐	☐	☐	☐
	GOVERNMENT EXTENSION	☐	☐	☐	☐
	YOU	☐	☐	☐	☐
MONITORING FOR BENEFICIAL SPECIES:	PRIVATE CONSULTANTS/SCOUTS	☐	☐	☐	☐
	GOVERNMENT EXTENSION	☐	☐	☐	☐
	YOU	☐	☐	☐	☐
ENCOURAGING THE POPULATION GROWTH OF BENEFICIAL INSECTS AND PLANTS:	PRIVATE CONSULTANTS/SCOUTS	☐	☐	☐	☐
	GOVERNMENT EXTENSION	☐	☐	☐	☐
	YOU	☐	☐	☐	☐

5 PLEASE INDICATE YOUR USUAL SOURCE OF CLIMATOLOGICAL INFORMATION

6 DOES YOUR IPM PROGRAM REQUIRE SPECIFIC CLIMATOLOGICAL DATA, IF SO INDICATE WHAT TYPE?

7 WHAT PROGRESS HAVE YOU MADE WITH IPM FROM YOUR FARM PRACTICES OF FIVE YEARS AGO?

- ☐ LITTLE DIFFERENCE
- ☐ REDUCED COSTS
- ☐ REDUCED PESTICIDE USAGE
- ☐ HIGHER YIELDS
- ☐ HIGHER QUALITY PRODUCE
- ☐ ALL OF THE ABOVE
- ☐ OTHER (SPECIFY)

A D O P T I O N

1 WHAT PREVENTS IPM FROM BEING MORE WIDELY ADOPTED?

	IMPORTANCE		
	LEAST	MODERATE	MOST
POLITICAL SUPPORT	□	□	□
FARMER ACCEPTANCE	□	□	□
ACCESS TO INFORMATION	□	□	□
FINANCIAL RISK	□	□	□
RETAIL STANDARDS	□	□	□
OTHER	□	□	□

2 HAVE YOU FOUND IPM TO BE MORE EFFECTIVE AND LESS COSTLY THAN CONVENTIONAL PEST CONTROL PROGRAMS?

THANK YOU FOR YOUR TIME AND ASSISTANCE.
IF YOU HAVE ANY ADDITIONAL COMMENTS OR SUGGESTIONS, PLEASE FEEL FREE TO INCLUDE THEM.

G E N E R A L C O M M E N T S

NAME

PLEASE REPLY -- BEFORE JULY 10, 1989 (IN ENVELOPE PROVIDED) TO:

Jeremy Higham
International Joint Commission, Great Lakes Regional Office

CANADA: 100 Ouellette Avenue, 8th Floor
Windsor, Ontario N9A 6T3

UNITED STATES: P.O. Box 32869
Detroit, Michigan 48232-2869

APPENDIX E

IPM PRODUCERS AND CROPS

IPM PRODUCERS AND CROPS

Ms. Ann Tennes Country Mill Orchards 4648 Otto Road Charlotte, MI 48813 (517) 543-1019	• Apples
Mr. Larry Leech 14302 East O.P. Avenue Climax, MI 49034 (616) 746-4648	• Corn and soybeans
Mr. Dale Jackson Jackson Farms Road #1 Savannah, NY 13146 (315) 365-2411	• Potatoes and vegetables
Mr. Helmut Shankula R. R. #1 Queensville, ON L0R 1R0 (416) 476-5589	• Vegetables
Ms. Mareya Campbell c/o George Whaley & Sons R. R. #2 Ruthven, ON N0P 2G0 (519) 326-9330	• Apples

APPENDIX F

SUMMARY: A PROPOSAL FOR A FIVE-YEAR RESEARCH INITIATIVE FOR INTEGRATED PEST MANAGEMENT IN WISCONSIN

SUMMARY: A PROPOSAL FOR A FIVE-YEAR RESEARCH INITIATIVE FOR INTEGRATED PEST MANAGEMENT IN WISCONSIN

I. **Purpose**: Wisconsin agriculture is as diverse as it is unique, with crops ranging from potatoes to cranberries and alfalfa to ginseng contributing heavily to the state's economy and the well-being of its citizens. Production in a manner that is environmentally safe requires the availability of technical information on crop and pest management for grower use. During the past decade, Wisconsin received federal funding for educational initiatives related to Integrated Pest Management (IPM). Growers of numerous crops received training in the use of IPM technology and there have been many success stories related to adoption of IPM where growers have reduced pesticide use, improved food safety, reduced environmental exposure to pesticides, improved profitability and improved pest control. As we reach the end of the 1980s, it is widely recognized that research in IPM has not kept pace with delivery of information. Numerous gaps in our knowledge of pest and crop management strategies are apparent and growers wanting to apply more refined IPM techniques are frustrated in their attempts to acquire this information. This proposal develops a statewide research initiative on IPM that will significantly increase our ability to respond to the complex crop and pest management needs of Wisconsin agriculture.

II. **Description of the Problem**: The production of safe food supplies for the consumer that are profitable for the producer and environmentally benign presents a challenge to Wisconsin farmers. Questions related to environmental quality, production efficiency, pesticide use, food safety and quality, worker safety and control of pest problems must be answered with factual information based on sound research. New rules, regulations and consumer concerns related to pesticide use will undoubtedly change the way farmers grow their crops. If growers continue to produce the crops they are familiar with, there must be alternative methods of crop and pest management that maintain profitability and reduce pesticide use. We must build on our small base of IPM knowledge with intensive research if we intend to maintain the viability of agriculture in Wisconsin.

III. **Proposed Description**: The proposed research initiative in IPM will focus on the development of new information related to pest and crop management. Areas of research related to the IPM effort will include improved weather and pest monitoring techniques, development of new or improved economic thresholds for crop pests, development of effective biological control strategies, improved methods of pesticide delivery leading to reduced pesticide and environmental risk, alternatives to pesticides, analysis of economic and environmental impact of IPM activities, crop and pest growth models, development of computer software for problem diagnosis and decision tools, and selection of pest resistant plant materials resistant to pest problems. This research initiative facilitates an interdisciplinary and interagency cooperation necessary to achieve the increased adoption of IPM methodology in Wisconsin agriculture.

IV. **Budget**:

	1990-91	1991-92	1992-93	1993-94	1994-95	Total
State IPM Research	$ 865,000	908,250	953,663	1,001,346	1,051,412	4,779,671
Federal IPM Extension	$ 138,000	138,000	138,000	138,000	138,000	690,000
Total	$1,003,000	1,046,250	1,091,663	1,139,346	1,189,412	5,469,671

Figure 1

Wisconsin Integrated Pest Management Program