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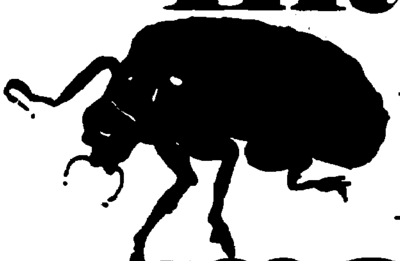
ABSTRACT

This book consists of materials prepared for a conference aimed at developing courses of study in Integrated Pest Management appropriate for use at several levels: secondary schools, MDTA programs, community colleges and technical institutions, baccalaureate programs, and master's and doctoral level programs. The first section (Background Papers) provides concise summaries of particular approaches to pest management and of specific approaches to pest management used in particular locales. The second section (Important Components) includes materials that can be used as a supplement to, or as part of, programs in Integrated Pest Management. The contents include material on career education, core courses or curriculum in environmental education, and a short course in Integrated Pest Management. The third section (Educational Programs) contains outlines for courses of study in Integrated Pest Management appropriate for use at secondary and higher educational levels. (DT)

A CURRICULUM REPORT

integrated pest management



INTEGRATED PEST MANAGEMENT

DEVELOPED PURSUANT TO A CONTRACT AWARDED BY
THE U. S. OFFICE OF EDUCATION
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TO

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The co-editors of this report are: Robert H. McCabe (Introductory Chapters); Jo Ellen Zgut (High School - MDTA); James O'Connor (Community College-Technical Institutes); Arden Pratt (Baccalaureate Programs); and R. F. Mines (Graduate Programs and Coordinating Editor).

INTRODUCTION

This book consists of materials that were developed at a conference held in Berkeley, California, October 21 - 24, 1973, or that were prepared in conjunction with that conference.

The book consists of three sections: I. Background Papers II. Important Components III. Educational Programs. Generally speaking, the contents of the first two sections were prepared outside the conference, either for the guidance of the participants in that meeting or to supplement the materials which they developed.

Since the purpose of each section is briefly described as it begins, it is probably not necessary to repeat such information here. However, it should be stated that the purpose of the conference was to develop courses of study in Integrated Pest Management appropriate for use at several levels: secondary schools, MDTA programs, community colleges and technical institutions, baccalaureate programs, master's level programs, and doctoral level programs.

These courses of study are outlines only: they are by no means fully developed curriculums. However, it is anticipated that they will provide the basis for actual curriculum development. The courses of study developed at the conference are continued in the third section of this book: Educational Programs.

The first section (Background Papers) provides concise summaries of particular approaches to pest management or of specific approaches to pest management used in particular locales. The second section (Important Components) includes material that can be used either to supplement, or as part of, programs in Integrated Pest Management. The contents include material on career education, core courses or curriculum in environmental education, and a short unit or course in Integrated Pest Management which can be used as part of other programs. It also contains material relating to careers in Integrated Pest Management.

An interesting feature of the project which has produced this report is jobs in Integrated Pest Management were identified, sifted out and then rated according to training and competencies required through the use of a Delphi Technique. Most of this activity occurred prior to the meeting itself. The results were then used by participants in developing the outlines of courses considered appropriate for different educational levels.

For the person unfamiliar with the concept of Integrated Pest Management, there is a good deal of explanatory material available in this book. Briefly stated, Integrated Pest Management involves the use of material pest controls, along with a combination of techniques such as biological controls, pathogens, sterilization and selected chemicals as needed. Another way of stating this might be to say that Integrated Pest Management involves the use of any one of a number of controls against a specific pest or class of pests.

At its highest level integrated pest management will take into consideration all classes of pests that might affect the total crops in a given area. Ultimately, it becomes an integrated system of plant protection.

In this regard, a pest is defined as any biological organism whose characteristics have an effect on man and his activities.

Basic to the integrated pest management approach is the concept that the emphasis must be upon pest control, rather than upon pest eradication.

An important point to be made in connection with this report is that a number of persons who contributed to it worked independently of the conference. As a result, they may use job titles and categories which will differ from those decided upon in the conference itself. However, a careful reading of the different sections of this book will make clear exactly what kind of jobs are referred to even when different names are used for them in different sections.

This project was made possible by a grant awarded by the U. S. Office of Education, Office of Environmental Education, to Kirkwood Community College, Cedar Rapids, Iowa.

We would like to express our appreciation to those federal officials who supported and guided us with this project. Most especially we should express our thanks to Mr. Walter Bogan and Mr. George Lowe of the U. S. Office of Education and Dr. Warren Muir of the Council for Environmental Quality.

I. BACKGROUND PAPERS

BACKGROUND PAPERS

INTRODUCTION

This section is comprised of six papers dealing with integrated pest management. They are the work of persons involved in the field. The topics were selected to provide an overview of integrated pest management and to illustrate the scope of application.

The first three papers by Ray F. Smith, C. B. Huffaker and Robert van den Bosch are concerned with the development of integrated pest management and with basic concepts. A description of biological environmental, genetic, behavioral and metabolic approaches to pest control are included. These serve as an excellent introduction to integrated pest management.

The remaining papers by Donald L. Dahlsten, Richard Garcia and Richard Brusuelas deal with integrated approaches to forest pest management, mosquito control and rodent control. These deal with areas that are not usually thought of in this context but which do lend themselves admirably to integrated control practices. They are intended to broaden the readers view of the applicability of integrated pest management.

The authors of each paper are identified as it is their work and not that of the workshop.

INTEGRATED PEST MANAGEMENT

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A century ago pest control in agriculture was largely achieved by natural and cultural measures, sometimes augmented by minimal use of the earliest insecticides and fungicides or by hand picking. Cultural methods were used especially to expose the susceptible stages of the pest organisms to adverse environmental conditions. The control methods then used interfered little with the indigenous parasites, predators and pathogens of the various pest species and these natural enemies undoubtedly served a significant role in control. Crop residue destruction, plowing or harrowing, crop rotation, and early or late planting were commonly utilized as essential parts of pest control. The crop varieties grown in a particular region undoubtedly reflected a past history of selection for resistance or tolerance to the local pests. In this early era, pest control was not always satisfactory or adequate and at times it was a complete failure. Nevertheless, it did not produce the chaos and economic disaster evident in some crop producing areas during the past two decades.

During the late forties and the decade of the fifties, crop protection development proceeded on two quite separate but nevertheless interrelated fronts. On the one hand many new chemical pesticides became available and farmers turned to them because of their effectiveness and ease of use. This dependence on pesticides led to many secondary problems including resistance to pesticides, rapid pest resurgences, and unleashed pest outbreaks. These difficulties and the increased costs of pest control have been detailed many times. On the other hand during this same period, the basic philosophy and tools of integrated pest management were developed and in a few places excellent examples of practical integrated pest management were instituted.

As part of modern concern with the quality of the environment, crop protection activities must be taken into account as they may have both direct and indirect impact on the environment. This is true if for no other reason than that it is almost impossible to do anything within an environment -- whether this environment be the entire biosphere, a restricted agroecosystem, a lovely home garden, or a quiet living room -- without having secondary and often unexpected impact on that environment. Some pest and disease control activities, especially those involving use of pesticide chemicals, often have a significant impact on environmental quality or stability in an agroecosystem. However, the disruptive influences and impact on environmental quality resulting from agricultural pest control are relatively minor as compared to those caused by other activities of man. Nevertheless, these negative aspects of pest control should be examined as one of the many considerations which must be made as better methods are sougnt for managing the environment in man's interest. This more positive approach can contribute to an enhanced environment and, at the same time, to the improved nutrition and health of man.

The insertion of a chemical pesticide into an agroecosystem has as its primary objectives a change in the living conditions of at least two components of the system -- the pests and the crop plants. Insecticides are applied for the purpose of bringing about a reduction in numbers of one or more species of pests so that more favorable conditions can be provided for the growth and development of the crop species. Thus, the environment is changed and as a consequence there occur reactions and adjustments among other components of the agroecosystem. Chain reactions of enormous complexity may be set in motion by the application of biologically active pesticides such as the organochlorine, organophosphorus, and carbamate compounds used during the last quarter-century. These interactions are so complex that it is doubtful that any set has ever been described completely or understood fully.

The environmental disruptions stemming from use of the synthetic organic pesticides have resulted in substantial alteration of the faunal composition of our agroecosystems, especially those that have received intensive treatment, e. g., deciduous fruit orchards and cotton fields. Some of the changes which have been most frequently observed following applications of pesticides have been severe outbreaks of secondary pests and of normally minor species and the rapid resurgence of the treated populations.

The severe and long-lasting depressions of natural enemies compared to pests following exposure to pesticides often is the result of the denial of adequate food for the natural enemies brought about by destruction of their prey (i.e., the pests).

Considerable field experimentation in recent years has produced strong evidence to support the proposition that natural enemy suppression by pesticides is a major cause of change in pest status and resurgence of treated populations. Nevertheless, some evidence is available that shows factors other than the destruction of natural enemies are also involved in these population phenomena. Species-specific response to other mortality factors can be expected to occur just as it does to intoxication by pesticidal chemicals. Therefore, it is likely that other factors often operating in intricate complexity are also responsible for some of the pest "upsets" that have been attributed to the adverse effects of pesticides alone. A better understanding than now exists of the complex interactions taking place in agricultural ecosystems is needed. The interactions among pests and their hosts, natural enemies, and competitors must be better understood in the development of effective integrated pest management systems.

Chemical pesticides remain in many situations a most powerful and dependable tool for the management of pest populations. They can be more effective, dependable, economical, and adaptable for use in a wide variety of situations than many other tools for maintaining pest populations at subeconomic levels. Indeed, use of chemical pesticides is the only known method of control of many of the world's most important pests of agriculture and public health. No other tactic lends itself to such comparative ease of manipulation and none can be brought to bear so quickly on outbreak populations. Narrowly-selective chemicals would appear to offer an almost ideal means of pest control. However, only a very few such chemicals have been discovered and developed for commercial use. Future prospects for many additional narrow-range chemicals is not great.

We are thus presented with a dilemma. Some form of crop protection is absolutely essential in the production of an adequate supply of food and fibre for the world population. Pesticides are a c itical element in the protection of man's crop and also his health. However, when we depend solely on pesticides for this protection or when we use them carelessly many serious problems are encountered often more serious than the original one. Hence, what is needed is a middle course that can take advantage of the great value of pesticides in pest control systems and avoid their disadvantages. The solution to this dilemma is through an ecological approach to pest control which in recent years has come to be called integrated pest management.

DEFINITIONS

The FAO Panel of Experts on Integrated Pest Control as early as 1967 defined "integrated control" as "a pest management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury." The Panel later stated: "This broad definition, implying the fullest use of natural mortality factors complemented when necessary by artificial methods needs no alteration. Implicit in this definition is also that imposed control measures, notably conventional pesticides, should be used only where economic injury thresholds would otherwise be exceeded. Integrated control is not dependent upon any specific control procedure but for each situation coordinates relevant techniques with the natural (regulating and limiting) elements of the environment. The successful development of integrated control depends on adequate understanding of the population dynamics of the pests and of potential pests, of the ecology and economics of the cropping systems, and of possible harmful effects on the general environment." It is in this sense that the term "integrated pest management" is also used.

With respect to the term "pest management," the Panel commented in December 1972 as follows: "Although there has been a widespread tendency to synonymize the terms pest management and integrated control, they are not, in fact, synonymous. Pest management includes all approaches ranging from single component control methods to the most sophisticated and complex control systems. It may include quarantine and other regulatory methods to prevent the introduction of a potential pest species; decisions not to grow a crop in an area subjected to high risk of pest damage, or decrees prohibiting the growing of a crop in a particular place at a particular time; or it may take the form of extreme measures, utilizing all available techniques, to eradicate a pest. Thus, pest management is a general term which applies to any form of pest population manipulation invoked by man, its objective being to optimize control in terms of overall economic, social and environmental needs of mankind."

Pest, as used here, is meant to include insects, mites, nemotodes, weeds and vertebrates; it also includes virus, mycoplasma, bacteria, richettsia and fungi causing infectious disease.

In view of the wide publicity given in many places to the term "integrated control," it is also appropriate to describe what integrated control is not. It is not sole reliance on predators or parasites, although natural enemies are utilized and fostered as much as possible in the system. It is not classical biological control, although this technology is brought into use where possible. It is not the use of the sterile male technique, pheromones, hormones, and other largely untested and unproven biological methods of control, although eventually we may be able to use such techniques in integrated control and are striving to do so. It is not the elimination or banning of DDT or any other chemical pesticide, although in a particular integrated control system it may be necessary to restrict the use of most pesticides and not use others. It is not the development over a long period of time, with much research effort, of a completely new pest control system which then is established in place of the old system; rather the process is a series of incremental steps which gradually modify the old system.

NEED FOR INTEGRATED PEST MANAGEMENT

The world has seen in recent years amazing changes in the race between food production and human population increase. Tremendous gains in food production have occurred in many parts of the world. This widely publicized phenomenon, often termed in the news media the "Green Revolution," has resulted from a combination of many factors; the chief among them are: (1) the introduction of new high-yielding crop varieties, (2) the availability of purchased production inputs, e.g., fertilizers, pesticides, tractors, (3) new crop management technology (including double and multiple cropping), (4) improved irrigation capability and (5) the long-term cumulative effect of development efforts by national governments and international agencies. It should, of course, be recognized that a part of the gains in food production in some years have also been the result of favorable weather. The recent set backs in the Philippines, India, Pakistan and other parts of the world emphasize this last point.

The system of traditional agriculture, which is characteristic of many areas in developing nations, is beginning to give way to modern agricultural technology. Traditional agriculture with its labor intensive, small fields sparsely planted with seeds of mixed genetic types are not as readily exploitable by endemic plant pests as are modern "monoculture" systems. The mixed culture may also provide some protection against climatic adversity and attack by new pests because of its inherent heterogeneity. Furthermore, plants grown under the tillage system of traditional agriculture are generally not as susceptible to some pests as those developed under more favorable conditions for growth. In the developed countries, these patterns started over a hundred years ago and exist today at a more advanced state.

Pressured by a multitude of ubiquitous pests over many centuries, man's crop plants have become adapted through natural selection to the selective pressures of these traditional agricultural systems (agroecosystems). This state is stabilized by an array of genetic factors for high yield combined with tolerance to low fertility, pest attack and other environmental stresses. Moreover, these traditional systems usually represent an efficient allocation of man's available resources and rarely respond to additional investment of resources without accompanying introduction of new technology for increased production. This means that if modern pest management practices are imposed on traditional agroecosystems without also increasing the basic production potential, the investment will not be profitable; on the other hand, new crop protection inputs may be needed most critically where the traditional agriculture has been modified by introduced technology, e.g., new varieties and fertilizers.

As contrasted to traditional agriculture, modern agriculture is a more intensified system that integrates capital inputs with management technology to maximize production per unit of area at minimum cost per unit of production, hopefully on a continuing basis. Many of the practices developed to achieve this goal contributed significantly to increased plant pest problems and thus may prevent achievement of the goal. For example, plant introduction and exchange has resulted in varieties with higher yields, resistance to pests and other desirous qualities; but his plant movement may carry with it new pests and disease pathogens and the introduced plant types may be susceptbile to indigenous pests and diseases. Modern monocultures frequently involve only a single plant variety with a very narrow genetic base thus enhancing their vulnerability to devastation by pests and disease. Plant breeding the selection often places major emphasis on a single or very few qualities, consequently history records many examples of new varieties highly susceptible to previously innocuous pests or to new pest strains. Vegetative propagation, e.g., bananas and potatoes, has the real disadvantage of disseminating serious pathogens through infected or infested stock.

In addition, many cultural practices of modern agriculture may enhance susceptibility to disease or attack by insects. These include (1) fertilization which produces larger and more succulent plants that are often more susceptible to disease or insect damage than plants grown at lower nutritional levels; (2) irrigation which favors many disease and insect pests as contrasted to the fluctuating soil moisture levels under natural rainfall conditions; (3) tillage and other soil manipulations are often an important factor in increasing the incidence of disease as compared to no-tillage or limited tillage cultures: (4) double and triple cropping which promotes rapid increase of pest populations and (5) more dense plant populations with resulting micro-environment changes that favor the development of some pests. These same cultural practices may at times inhibit certain other pests, but in general, the balance is one favoring increased pest and disease incidence.

These practices have been introduced at a very rapid rate, and the rate of the change promises to increase in the future. The rapidity by which new technology is adopted and the increased production which resulted is surprising. However, these modernizing practices, which also enhance the potential for destructive pest attacks, often are being introduced without proper attention to crop protection as a component of agricultural development programs. This is not to question the validity of these developments; but the fact remains that the changed agroecosystems resulting from the introduction of new methodologies produce shifts in and very often an intensification of pest and disease problems. There is mounting evidence indicating that pest and disease problems are becoming more severe, indeed in some cases devastating. Unless measures are taken to protect the food crops against the ravages of pests and disease, the production gains realized from the new technology could vanish. The integrated pest management approach offers a possible solution to these difficult problems. However, this must involve significant effort in the training and retraining of crop protection and pest management specialists, and organization of new types of programs for research at the adaptive and implementation levels, and the education of the general public and farmers as to the significance of crop protection to their welfare.

POTENTIALS AND PRESENT STATUS

The revival of the old era when pest control was to a great extent ecologically-oriented is now firmly established today. This has come about largely as the result of public reactions to problems associated with pesticide chemicals combined with failure of complete dependence on chemicals to give adequate crop protection. There are numerous well-documented examples of the inadequacy of a unilateral chemical approach. Unless a broad ecological approach such as emphasized by integrated pest management programs is initiated, additional "pesticide abuse" situations will arise. Complete dependence on hazardous, broad spectrum pesticides over a period of time not only fails to control the pests in question but acutally aggravates pest problems, endangers human health and threatens environmental quality. Furthermore, pesticide misuse imposes an addtional real cost on food production.

The integrated pest management strategy employs the idea of maximizing natural control forces and utilizes other pest management tactics with a minimum of environmental disturbance and only when crop losses justify action are threatened. Adverse weather factors, while a powerful repressive force for pests in agroecosystems, are not consistent enough to be a reliable suppressor of major pests. Use of natural enemies and plant resistance are basically compatible and supportive in the integrated pest management strategy. Cultural control, a third basically compatible tactic, is commonly used in ways to expose the pests to adverse weather, to disrupt their natural development, to increase the action of natural enemies or to increase the crop's resistance. Chemicals, although not always compatible with the use of natural enemies, often can furnish a reliable immediate solution to a problem. Thus, pesticides are an important and necessary element in integrated control programs. Finally, a basic fund of ecological and biological knowledge is needed to guide decision-making in the integrated pest management strategy.

It is mandatory that scientists, in seeking better crop protection, explore the potentials of pest control with broader perspective than looking to single uncomplicated solutions. The search should include the broadest array of possibilities for control with emphasis in utilizing those forces which nature itself has put foremost; that is, the use of natural enemies, of plant resistance and of manipulations which expose pests to adversities of the environment.

The attainment of resistance in our crop plants to all major pests and diseases is an unrealistic goal. Nevertheless, resistance to key pests and diseases or even partial resistance to some of them can be most useful in integrated pest management programs and at times is an essential element.

In the utilization of natural enemies, consideration must go far beyond the techniques of classical biological control, i.e., introduction of parasites and predators into new areas. Attention should also be given to assessing and understanding the role of indigenous natural enemies, manipulation of the environment to increase efficiency of existing natural enemies, periodic colonization of natural enemies, supplemental feeding of natural enemies, and utilization of the invertebrate pathogens such as viruses.

The horizons suggested by introduction of new invertebrate pathogens and utilization of indigenous ones, such as insect viruses, have hardly been touched. It is highly probably that pathogens selective for certain species or groups of insects and innocuous to vertebrates abound in nature, but too little effort has been made to find them, characterize them, and develop them for practical use. Pathogens have many of the advantages of chemical insecticides and they lack many of their disadvantages; furthermore, the available pesticide application technology is adaptable to them. Some of the known pathogens are quickly and highly effective, specific in activity, safe and biodegradable. In some cases, they can be readily stored. Their cost, lack of proved reliability, patentability, and problems of registration clearance present some of the disadvantages and the barriers to their development.

Considerable progress in the development and implementation of integrated pest management programs for major crops in the United States has been accomplished in the past 10 years and the pace of these activities is increasing each year. In some cases implementation has proceeded far ahead of or without the support of research. We must guard against this because this type of implementation will probably result in chaos and failure with consequent grower and public antagonism to the integrated pest management approach. Crop protection will be most benefited by a balanced program of research, implementation, and education with close coordination and collaboration among the three.

LIMITATIONS

Integrated pest management is not a panacea for all the problems of man in dealing with his pests. One current limitation to the full implementation of integrated pest management systems is the lack of information. Although research in this area has been greatly expanded, much greater effort is needed. These programs develop slowly usually through a step-by-step procedure and the complexity of the program emerges slowly. Another limitation is the lack of adequately trained personnel in both the research and implementation aspects. Many crop protection administrators, researchers, teachers and extension workers received their formal training during the fifties and early sixties when an over-reliance was placed on pesticide chemicals for crop protection. Many of these people will require retraining to be fully prepared to implement integrated pest management programs. Substantial efforts should be made to inform the general public as to the severe food losses caused by pests and diseases and the significance of an ecological approach to crop protection and the preservation of environmental quality. An informed public (including farmers) aś an essential step in the implementation of adequate and effective crop protection programs.

ENVIRONMENTAL, BIOLOGICAL, GENETIC, BEHAVIORAL AND METABOLIC APPROACHES TO PEST CONTROL

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Train et al. (1972) noted that this country and the world faces a dilemma of increasing food production while maintaining environmental quality. Two methods have been undertaken by the Government: (1) comprehensive protection legislation to regulate the use of pesticides and (2) intensive effort to develop other methods than broad-spectrum chemicals to control our pests. This latter is being pursued widely, perhaps most intensively by the International Biological Program's effort on pest management supported by the National Science Foundation, the Environmental Protection Agency, the U. S. Department of Agriculture, many State Agricultural Experiment Stations and, to a degree, sectors of private industry.

The paper of this series by Ray Smith introducing the subject of integrated pest management briefly traced the history of insect pest control in the U. S., the rise of a series of problems associated with the general abandonment of more ecological methods with the extensive reliance upon broad-spectrum insecticides and acaricides following World War II, and the recent revival of the earlier era when natural controls and other non-chemical methods were heavily relied upon. This revival is centered on the philosophy and strategy of integrated pest management, which is, in general, the containment or correction of pest problems (with minimum adverse effects), rather than the prevention or eradication of the pest-organisms concerned. It seeks to manage all the pests and potential pests of a crop by maximizing the natural control forces, by using tactics alternative to conventional broad-spectrum pesticides, where feasible, and resorting to the latter materials only when really needed, in minimal necessary amounts and in ways compatible to the benefits that can be had by use of other methods used against the same or different pest species on the crop.

This paper deals with the potential benefits inherent to employing alternative tactics to the broad-spectrum chemicals, especially the insectcides and acaricides. These tactics can be grouped under the topic comprising the title of this paper. This is not altogether a natural grouping but all these tactics offer real potential for reducing the use of conventional chemicals. All of them are, or appear to be, environmentally sound and most of them have had some marked successes, economically. These tactics, the environmental, biological, genetic, behavioral and metabolic approaches, comprise the direct control tactics. There are, however, a number of indirect or supportive tactics that are equally important in conducting research on, and in developing integrated pest management programs. These embrace the methods required in gaining the necessary biological, ecological and economic insights into the processes involved in the production of the crop, the development of pest populations, the factors tending to favor or retard their becoming troublesome, ways of obtaining reliable information, and the handling, integrating and interpreting of that information to make rational decisions about the employment of specific tactics. In the absence of such a systems analysis a given tactic might pose consequences adverse to the short-term or long-term interest of the producer or society.

The various direct control tactics do not fall exclusively in either the containment or corrective strategy of integrated pest management or in the preventive or eradicative strategy. If used in a prophylactic manner by calendar dates, or very intensively to exterminate a newly established pest species, this is preventive or eradicative strategy.

If used only when pest densities are threatening and in minimal necessary amounts, this is containment or corrective strategy. In the typical preventive approach each insect pest species is treated as an isolated matter and a broad-spectrum chemical is used on a prophylactic basis, thus, hopefully, preventing rise to pest status of other species as well. The trouble is that this method, as is now well known, does not prevent the rise to pest status of all other species, but in fact has itself occasioned the rise to major pest status of many formerly innocuous or minor pest species, primarily by destroying or interferring with their natural enemies, either directly or indirectly. This strategy of containment of all the pests on a crop may indeed well include preventive or eradicative action selectively applied (e.g., by growing a crop or variety on which a key pest cannot develop to pest status, or by eradicating it from the environment), thus making the use of alternative containment tactics practicable for control of the other pests on the crop. An example would be the eradication (short or long term) of codling moth in apples, thus greatly simplifying the control of spider mites, some insects, etc. whose natural control is disrupted by the chemicals commonly used to control codling moth.

The direct control tactics are treated below.

GENETIC APPROACHES

Genetic approaches in pest management are often pursued as an isolated matter, either to develop a crop variety resistant to a given insect or plant disease or to interfere with the reproduction of a single pest insect, usually a key pest. As noted above, these tactics, however, can be most useful, if not a central opening wedge for integrated programs.

Plant Resistance. Over long spans of time, man's crop plants, through non-deliberate selection, have developed a multitude of mechanisms or resistance to insects and disease organisms. They have also developed an adaptation to the traditional patterns of their culture in the regions where they are grown. Thus, when some 10,000 varieties of rice were grown under traditional culture by the International Rice Research Institute in the Philippines, the one that produced best, unprotected from insects and disease organisms and without modern supporting fertilizers, was one already popular among Philippine farmers.

Use of resistant plant varieties is a consideration in pest management. Ideally, resistance factors should be introduced in all our major crop plants. The more pest species that can be handled by incorporation of resistant factors into agronomically desirable cultigens, the easier it becomes to manage the other pests, for chemical or even cultural control methods effective against one pest may favor another.

In the evolutionary sense development of plant resistance has played major role in restricting the phytopagous species that attack given plants.

Many insect species have thus been excluded, although others have become specialists capable of attacking only one species or genus of plant to which they have closely adapted by specialization. Many of the latter are often prevented from severely affecting their host plant populations by their own natural enemies, and the selection pressure for developing intrinsic resistance is thus greatly reduced.

A vast pool of resistance factors exist in plant stocks around the world and these germ plasms can be used in breeding programs to develop insect and disease resistant varieties. Resistance to key pests and diseases or even partial resistance to some of them can be most useful in integrated pest control and at times is an essential element. Insect-resistant varieties form an almost ideal way to control pest insects. The cost is minimal, no insecticide residue is left in food or the environment, natural enemies or otherwise beneficial insects are not harmed, and the method is compatible with biological, chemical, cultural and other control methods (Horber, 1972).

Breeding for pest resistance has been highly successful except in the case of weeds, and here the technique would apply only to weeds that are parasitic on crop plants. The method has long been widely used to solve crop disease problems. More recently, there has been intensified research to develop crop varieties resistant to insects, which was long relatively neglected in spite of some notable early successes, and to nematodes. There are now some 150 varieties of 23 crop plants resistant to nematodes (Good, 1972), over 100 resistant to a total of 25 insects (Luginbill, 1969; Sprague and Dahms, 1972) and at least 150 resistant to various plant diseases (Johnson, 1972). For certain grains (e.g. wheat) 95 to 98% of the total acreage is now planted to resistant varieties. While in 1900 less than 1% of our U. S. crops were planted to develop resistant varieties, in 1965 such usage had spread to more than 3/4 of the total acreage. (Council on Environmental Quality, 1972.)

In general, plant resistance to diseases has been easier to achieve but more easily lost by development of "resistance-breaking" biotypes of the pest organism than has been true in the case of resistance to insects. The former has more commonly been achieved by use of simple or single gene factors, and the latter by use of more complex polygenically controlled resistance. Hessian fly resistance in some varieties of wheat has lasted 30 years, but new sources of resistance have had to be brought in for other varieties and areas. Borlaug (1965) considered the average useful life of a wheat stem rust resistant variety to be only some 5 years in some regions. Introduction of new factors to affect the development of resistance-breaking biotypes of pathogens have also been necessary for powdery mildew on barley and tobacco mosaic virus on tomato (Day, 1972).

On the economic side, the total costs of developing resistant varieties for Hessian fly, wheat stem sawfly, European corn borer, and the spotted alfalfa aphid was about $9.3 million, with the net monetary value of the research over a 10-year period being about $3 billion --- a return for each research dollar of about $300 (Council on Environmental Quality, 1972).

A final caution is necessary. It is highly unlikely that we can develop varieties resistant to the whole complex of pests in an area, rendering other methods unnecessary. Zink and Duffus (1969) found evidence of a genetic linkage in lettuce between susceptability to turnip mosaic virus and resistance to downy mildew, and Fowdon Maxwell (pers. com.) reports several examples of resistance to one insect attacking cotton being associated with susceptability to another or others.

Genetic or Autocidal Insect Control. The highly ingenious method of releasing large numbers of sterile or genetically altered insects into wild populations to control insect pest species was first suggested about 30 years ago. The utility of releasing males sterilized by irradiation was first shown with the literal eradication of the screwworm fly on the island of Curacao and in Florida, and with its adequate suppression in the southwestern United States. This stimulated much enthusiasm about the possibilities not only of the method used in this case, but also of other genetic approaches.

As noted by Proverbs (1969), in the last decade the sterile insect or genetic principle has attracted intense worldwide attention. These methods include not only the sterilization of insects and their release as a means of interfering with natural matings in the field, but also other genetic avenues, such as chromosomal translocations, hybrid sterility (e.g., *Anopheles gambiae* Davidson *et al*. 1967), deleterious genes, and cytoplasmic incompatibility. Use of cytoplasmic incompatability was apparently successful in "eradicating" the mosquito *Culex pipiens quinquefasciatus* in a village near Rangoon, Burma (Laven, 1967). However, little success has been had to date with techniques other than release of sterile insects and even this technique is not viewed as a solution of our agricultural and forest insect problems on a very general basis. The method's great utility rests in its use, where feasible, for eradication or keeping under continuous control a key pest species (e.g., boll weevil or codling moth), the treatments for which lead to rapid pest resurgence and induced outbreaks of formerly minor or negligible species.

The mechanisms are of two kinds: (1) eugenic --- development of better insects, which in pest control would mean better natural enemies and (2) dysgenic (or autocidal).

The eugenic approach has been demonstrated for insects in the improved lines of the honeybee and silkworm. Improved parasites, predators or pathogens may be developed through selection, breeding and heterosis. Altering a parasite species to make it more amenable to mass production for release in the field (assuming no loss in field performance characteristics) or more fit to survive the climatic or pesticide extremes encountered in the field offers possibilities. White *et al*. (1970) was able to develop lines of *Aphytis lingnanensis* more resistant to summer and winter climatic extremes in southern California, and Brian Croft (personal communication) was able to incorporate the gene(s) for pesticide resistance found in a Washington stock of the predatory mite *Metaseiulus occidentalis* into a southern California stock by introducing the resistant stock.

The dysgenic or autocidal mechanisms can be outlined as follows:

(1) Dominant lethality --- males rendered sterile by radiation or chemo-sterilants. This has been by far the most useful method. Most pest species have not had a fair trial, and many failures have apparently resulted from release of too few insects, poor timing, or deficient methods of release.

(2) Chromosome translocations offer promise and could be further explored. Current programs are being developed for Glossina, Lucilia, Musca, Culex and Aedes. This method can be employed even when the genetics of the species is not well-known.

(3) Evolutionary mechanisms (ones already present). Existing sterility barriers which allow mating but inhibit gene flow can be employed --- use of hybrid sterility or inviability, cytoplasmic incompatibility, sex ratio distorters, meiotic drive systems.

(4) Genes modifying the bionomics --- conditional lethality, host choice, ability to diapause (most promising), vectorial capacity.

Some dozen attempts have been made to eradicate insects, other than the screwworm, by use of sterile male releases, particularly tephritid fruitflies in various parts of the world (e.g. Greece, Australia, the small Pacific island of Rota) but only in the latter case has eradication been duplicated. The method has also been used against small segments of large populations or along borders to prevent spread into new areas. Treatment of such segment areas have usually resulted in much suppression of numbers, but these results can be misleading with respect to determining the potential of eradication either in the segment areas, unless isolated or isolatable from surrounding infested areas, or as a clue to utility over the whole infested region. Problems of economic rearing of the required number of insects to be sterilized, the problem of releasing some fertile females along with the sterile males, the physiological limitations of some species to undergo sterilization or laboratory rearing and remain competitive, and especially the difficulty of reaching the last remaining wild females over extensive widely diverse and "rough" environments suggest that we have expected too much from the method. The early successes led to major diversions of funds from research on other needed pest management tactics to support the vastly expensive eradication campaigns. It seems now to be realized that these other tactics cannot be slighted in this way and that such eradication attempts must be carefully appraised and only the very promising and central ones attempted.

NATURAL ENEMIES

Plant resistance has not evolved to the point of accomodation or exclusion of all potentially destructive phytophagous insects. Many of the most highly host specific species of phytophagous insects face relatively little host plant resistance in favorable habitats. Most potentially damaging phytophagous species in natural habitats seem to be commonly held at low densities by their natural enemies (parasites, predators, and pathogens).

Natural enemies in combination with other environmental factors maintain a degree of control and balance among the populations of aminals and plants in such biotic communities. That natural enemies have this important role has been attested to on countless occasions through the disruption of their roles by application of insecticides. Thus usually rapid target pest resurgence and the unleashing of formerly innocuous or minor species to outbreak status has been commonplace. (Huffaker, 1971a, b; van den Bosch and Messenger 1973.) Paul DeBach has termed this the "invisible biological control" which is not recognized until it is disturbed. He estimates that some 85% or so of our potentially damaging pests are commonly under such invisible biological control. Natural enemies have long been accorded a primary role in control of insect pests, and more recently of some weeds and certain soil inhabiting plant pathogens. In general, extended management of the complex of pests on very few crops, even those for which considerable resistance has been built in, is likely unless natural enemies are made a primary consideration.

Use of natural enemies, where applicable, has several distinct advantages over most other tactics. It is cheap, usually long lasting in perennial crops, does not occasion development of resistance or lead to outbreak by minor species, does not adversely affect man or other non-target species, the crop or the environment, and is compatible with all other pest control methods except the use of distrubing pesticides. The latter represents a constraint it places on the choice of chemicals and the method of their application.

In the utilization of natural enemies, consideration must go far beyond the techniques of classical biological control, i.e., introduction of parasites and predators into new areas. Attention must be given to assessing and understanding the role of natural biological control agents, manipulation of the environment to increase efficiency of existing natural enemies, periodic colonization of natural enemies, supplemental feeding of natural enemies, and utilization of the invertebrate pathogens such as the viruses, bacteria and fungi.

Use of natural enemies has commonly been divided into three categories (1) importation of new enemies (2) conservation of already established enemies to improve or maintain their effectiveness by (a) provision of requisites such as alternative hosts, subsidiary food or shelter and (b) elimination or reduction of hazards or adverse environmental factors such as poor cultural practices, use of disruptive insecticides, and (3) augmentation of already established natural enemies by periodic colonization. If a pest is "real" (not induced by pesticides), effective natural enemy action is obviously lacking. The remedy can best be sought, particularly if it is an alien introduction, by importing its natural enemies from its native region. On the other hand, if the pest is an induced one, or if no suitable natural enemies can be established in the former case, then efforts should be made to increase the efficiency of already resident natural enemies. The importation of new natural enemies has been vastly more successful in practice than the improvement of efficiency of resident natural enemies by their conservation or augmentation. We cannot yet make great claims for the latter techniques except in a few instances. However, new insights and breakthrough in technology may soon change this situation.

Van den Bosch and Messenger (1973) list some 100 examples where importations of natural enemies have resulted in substantial or complete control of invertebrate pests and weeds. In many of these instances, the pests concerned were highly destructive ones, and some of them ones whose control was not feasible by any other means. Natural enemies (mostly parasites and predators) have been introduced against some 223 species of insects alone and partial to complete success has been attained for 120, or over half of them (DeBach, 1971; Clausen, in press).

The economic gains from some of the importation programs for California alone have recently been updated. For the following examples, black scale and citrophilus mealybug on citrus, grade leaf skeletonizer, klamath weed, olive parlatoria scale, spotted alfalfa aphid and walnut aphid, some $270 million (conservative estimate) have been saved from natural enemy introduction up to 1973. Other important savings, including that from the introductions against the infamous cottony cushion scale are not included. While much care is necessary in making importations to be sure that unwanted species are not brought in, and this is especially important in importing species to control weeds, the extensive history of making introductions does not contain a significant example of any introduced species becoming a pest, other than such expected cases, as for example where a coccinellid introduced to control mealybugs on a fruit crop also attacked related mealybugs introduced to control prickly pear in South Africa.

The horizons suggested by introduction of new invertebrate pathogens and utilization of indigenous ones have hardly been touched. It is highly probable that pathogens selective for certain species or groups of insects and innocuous to vertebrates abound in nature, but too little effort has been made to find them, characterize them, and develop them for practical use. Pathogens have many of the advantages of chemical insecticides and they lack many of their disadvantages; furthermore, the available pesticide application technology is adaptable to them. Some of the known pathogens are quickly and highly effective, specific in activity, safe and biodegradable. In some cases,they can be readily stored. Their cost, lack of proved reliability, patentability, and problems of registration clearance present some of the disadvantages and the barriers to their developlent.

There is currently a sharply increased interest in use of microbial insecticides. Several companies are doing research on them, and some are producing _Bacillus, thuringiensis_, _B_. _lentimorbus_, _B_. _popilliae_, and the nucleopolyhedrosis virus of _Heliothis zea_ in commercial quantities (Briggs, 1963; Ignoffo, 1967; Martignoni, 1970; Heimpel, 1972). This area of research and development offers a promising, safe, and ecologically-compatible control of insects as a vitally needed substitute for much of the toxic chemicals otherwise required.

It is unfortunate that the establishing of protocols for safety testing and the registration of more potentially valuable pathogens has made little progress in recent years. For some entomopathogenic organisms there is fear that they may affect other organisms than the insects, or they may mutate and become pathogenic for them. Some, however, seem to be quite safe, yet their registration is not yet at hand.

The deliberate importation and establishment of new pathogens for pest control has been little tried. The example of introduction of the myxoma disease to control the European rabbit plagues that once devastated vast areas in Australia is the exception. Two striking highly beneficial results from inadvertent introduction also come to mind, that of the introductions of the virus of the European spruce sawfly into eastern Canada and of the Japanses beetle in the eastern United States. The virus is credited with destroying the spruce sawfly outbreak and saving thousands of square miles of valuable timber. The Japanese beetle's ravages were also distinctly reduced through, in this case, systematic innoculations of appropriate sites over wide areas.

ENVIRONMENTAL MANIPULATIONS

As stated by Dr. Smith, cultural and physical methods provided good control of many pest insects for many years. Timing of planting and/or harvesting to iminmize infestation or to escape periods of great danger, rotating crops (including varieties), manuring, managing water, residue destruction (e.g., plowing, burning) and cultivation were widely practiced. Such environmental methods are used to curtail pest species reproduction or to favor their natural enemies.

Development of organosynthetic insecticides released growers from their reliance on these unspectacular methods of pest control, and they have been much neglected. However, in forests, silvicultural methods are still widely used. Cultural techniques do not commonly give complete control of a complex of pests, yet they present real promise for use as a supplementary tactic in integrated control. They may for the principal means of control in certain situations. The cultural practices, including the mosaic of crop or variety plantings, affect the pest species, their parasites, predators, and pathogens, or alternate prey or hosts.

Adding habitat diversity may be helpful, as indicated by Doutt and Nakata (1965) who used small blackberry patches planted next to grape vineyards in California, as a means of demonstrating the potential of achieving biological control of the grape leafhopper. Stern et al. (1969) also used strip cropping of alfalfa and cotton, again increasing natural enemy effectiveness. A change from tillage to herbicides for weed control, from clean culture to a cover crop, or from selective age-distribution cutting to clear cutting in forests can have far-reaching effects on insect densities.

Recently, it was shown in Louisiana that use of early season planting of a small portion of the eventual plantings of soybeans in an area would concentrate the overwintered adults of the bean leaf bettle, the vector of bean pod mottle virus, on these early beans. Using these as a trap crop and treating the beetle concentrations on this reduced acreage resulted in protection of the major crop without treatments.

Plowing can also provide valuable control of insects by physically destroying them during the soil-inhabiting period of their life cycles. Spring plowing can destroy up to 98 percent of the corn earworn pupae that survive the winter.

Changes in planting and harvesting schedules can make the crop less available as a habitat during critical stages of insect development. Planting cotton seed over as short a time period as possible, for example, allows cotton to mature simultaneously throughout the planted area. This limits the number of boll weevil and pink bollworm generations by minimizing the duration in which mature cotton is available for attack. By destroying the stalk after harvest --- the winter habitat of the boll weevil --- the ability of that pest to survive the winter is reduced.

Lastly, it should not be forgotten that use only of a single source of resistance to a plant disease over vast areas as a monoculture is conducive to massive losses from the disease (or other pest) is a resistance-breaking biotype of the pest develops. Planting of a mosaic of mixtures of appropriate genotypes is indicated.

Much potential rests in the possibilities of rotation in the given field and in shifting the mosaics of planting, in a region, of a group of varieties offering resistance to different species of insects and other pests.

METABOLIC OR HORMONAL APPROACHES

Work on insect hormonal chemicals is still at an early stage of development. None is registered for use except Zoecon's ZR 515 for experimental use against mosquitoes, and the efficiency and feasibility of using these chemicals as a general tactic in control programs is far from established. Sunlight appears to seriously affect their potential when used on crop plants in the field. More success has been had in experiments in granaries and aquatic habitats.

Robbins (1972) notes cautiously that very recent research on hormones has provided many chemical regulators of insect development, metamorphosis, reproduction, or diapause, suggesting it is now possible "...to attempt to bring to realization the prior predicted applications of this horizon in insect pest control." Optimism regarding this approach has been related to: 1) the compounds disrupt processes peculiar to insects (and their near relatives) or the mechanism in insects is very different from that in vertebrates, 2) the insect hormones are structurally different from the hormones of vertebrates; and 3) the view that insects will not be able to develop resistance to their own hormones.

These three points suggest a basis for intensive research to develop hormones, but they are not altogether supported, and, alone are not an adequate basis for appraising this horizon. In fact, there is danger that developments in this field could follow the pattern resulting from the almost exclusive reliance on conventional insecticides, with similar attendant ills. Points 1) and 2) do suggest promise that the method may prove safe for vertebrates, but this does not necessarily follow. Toxic effects on vertebrates or other non-target species could arise through processes other than those with which they are associated in insects. Plapp and Vinson (in press) report that for one --- a juvenile hormone analogue --- cross-tolerance was exhibited with carbaryl in the housefly. This directly disproves point 3) above, that insects could not develop resistance to their own hormones. Furthermore, the exogenous source, method of entry, timing, and application rate could form a basis for natural selection not presented in normal hormone release in the insect itself. Robbins (pers. comm.) has found that some hormonal chemicals, entering an insect from an exogenous source (e.g., ingestion) can undergo change to chemicals hormonally inactive. Development of resistance might be expected in such cases.

There are two principal classes of hormones being studied, the molting hormones (MH) and the juvenile hormones (JH). The former are produced by the prothoracic glands when stimulated by the brain hormone. These MH compounds are steroids or ecdysones, and analogs of them are widely found in some plants, especially the ferns. MH compounds are also found in some plant groups, especially in conifers. Their possible roles in resistance to insects by these plants is not established.

According to Robbins (1972), the JH compounds seem to offer at present the most promise as they readily penetrate insect cuticle, are highly active, and would be the least expensive to produce. They are also biodegradable and exhibit a high degree of specificity. However, since they only block the terminal molt, their use on a given population of larvae would not prevent their decimating the crop. Yet, in the reduction of the population density, they would protect the crop subsequently. The MH compounds do not readily penetrate insect cuticle, and they would be expensive to produce, but because they act at any immature molt, they could be used as an immediate solution, a main value in an insecticide.

BEHAVIORAL APPROACHES

The behavioral chemicals currently under investigation are categorized as attractants, repellents, arrestants, deterrents (feeding and oviposition) and stimulants. To date the practicality, except in isolated instances, of using attractants and repellents as a means of field crop pest control remains to be explored and demonstrated. However, the greatest utility to date has been as a means of survey and detection of insect infestation which has been an invaluable tool to control programs using other methods. Millions of dollars have thus been saved.

Attractants. Successful pest management requires knowledge of the whereabouts and numbers of the harmful and beneficial species involved. A most effective monitoring tool for insect pests is attractants.

Opportunities for improved pest management have been much enhanced by discovery of powerful attractants, especially the sex pheromones. The uniqueness of these substances as regards crop and animal protection through integrated pest management lies in their very ability to attract insects from considerable distances.

An important facet of their use is in the interception and elimination of newly arrived potential pests.

A few examples of successful or promising uses for attractants may be cited. Methyl eugenol is a very strong attractant for male oriental fruit flies, and has been used successfully in combination with an insecticide, naleb, impregnated on fibre wafers dropped from planes in the chemical and sterile male eradication of this pest from the island of Rota. Protein hydrolyzate is attractive to several fruit flies and has been used successfully with toxicants such as malathion to control or eradicate the Mediterranean fruit fly. When used to bait sticky traps, RiBlure® is effective in monitoring for red banded leaf roller in apples and as a control method in mass trapping and in inhibition (and/or confusion) tests in apple and grape plantings. Codlemone© provides an excellent tool for monitoring for codling moth and should make possible appreciable reductions in amounts of pesticide used for its control, and it may be possible to use it for direct control.

Synthetic attractants were the first to be available in quantity, so much of the early work has been done with these. Many of natural origin have now been isolated, and studies are being conducted on them. It is not known why insects find some of these compounds attractive. A natural chemical similar to trimedlure has not been reported. Neither is it known why some compounds attract only males, some both sexes, and some only workers, which are females. While good attractants are highly specific, it is expected that the various chemicals have little in common, except that most of them are esters.

Significant advances looking toward pest control utilizing this biochemical approach remain painstakingly slow because of our primitive understanding of insect behavior as related to such biochemicals, problems associated with mass rearing and with isolation and identification of significant compounds occurring in minute amounts in complex mixtures, synergism and masking effects, synthesis of the materials or suitable substitutes, and lastly, the problems of developing control approaches that can utilize synthetic compounds, some of which are mentioned above. However, with intensive effort along these lines new control horizons should open up. It is imperative, however, that we move cautiously with respect to large-scale field control operations because some of these chemicals may attract certain natural enemies as readily, or more readily, than they do the target species. This could be disastrous or perhaps turned to advantage. Such natural enemies may be crucial in the control, not only of the given target species, but of other species of equal or greater, potential hazard. Also, while some claim that it is unlikely that the target species will develop a strain that will not be susceptible, this is by no means assured (Atkins, 1968).

We know less about the importance of insect movements and how to quantify and predict them than perhaps any other basic principle of comparable significance. Our ability to assess the importance of movements is greatly constrained for the highly mobile species.

Nature's great chemical messengers, the pheromones, present avenues not only to learning a great deal more about pest and natural enemy movements and other behavior, but also as a means by which we can monitor pest populations more accurately and apply insecticides much more wisely as to place and timing. Also the horizon to direct control through pheromone trapping is thus envisioned.

Modern behaviorists are reshaping and refining old concepts of insect movements. Up to about 20 years ago it was considered that big strong fliers like butterflies and locusts could maintain directional flights for hundreds of miles, while the small weak ones like gnats and aphids simply drifted passively with the wind (Kennedy, 1972). While much new evidence is coming to light showing that even such strong fliers as locusts move as swarms with the wind (and this has survival value in taking the locusts to the point(s) of wind concurrence and rain), new studies emphasize the role of behavior in initiating and timing the flights in determining their end (Kennedy and Fosbrooke, 1972; Hagen, 1962). Yet, according to Kennedy (1972) our ignorance of insect movements and behavior is especially well illustrated by developments in pheromone research. It appears that the research chemists have been avidly busy identifying and synthesizing sex pheromones even before they know anything about the behavior involved in mate findings. Kennedy writes that the chemist's expertise and pertinacity, although highly admirable, serves only to "...show up the emptiness on the behavioral side". The work of Shorey (1970) has emphasized that a "sex attractant" may indeed orient an insect to its mate, or under other conditions, signal it to move in the opposite direction by switching on an orientation to wind or light. Thus, while some optimism about the use of pheromones, not only for monitoring, but as a direct control tactic, seems justified, the chemical horse again seems about to run away with the biological wagon unless much more intensive behavioral studies are done. While successes may be had without them; frustration and failures may be averted with them, writes Kennedy.

It is interesting that in an effort to control the gypsy moth, the dropping of 300,000 pieces of paper containing a sex pheromone (Disparlure®) on each of several 40-acre infested regions permeated the area jamming or confusing the males in seeking natural females. Yet, the use of pheromones for control of this insect has not yet proved successful, although Disparlure has been useful in detecting outlying or new infestations.

<u>Repellents</u>. Repellents have been of tremendous practical importance in protecting people, especially our Armed Forces, from insect-borne disease and from the nuisance of a variety of pestiferous insects and other organisms. Several chemicals or mixtures are available for direct use on the skin or on clothing to repel pests. Chemicals are also used to protect domestic animals from insects but these are usually toxicants such as pyrethrins, malathion or methoxychlor.

No insect repellent has yet been found useful for protecting agricultural crops from insect attack. Volatile materials acting as vapors require too frequent applications. Since this paper deals with crop pests, repellents will not be further discussed.

The need for indirect or supportive tactics in pest management was stated above. Among these supportive tactics is the obtaining of adequate biological and ecological knowledge of the system to make effective use either of the direct control tactics or the supportive tactics. The supportive tactics also include sampling and monitoring pest and natural enemy populations, establishing the need to take control action (economic thresholds), and the techniques of pesticide application. I will not deal here with application techniques other than to say that many of the principles of application as regards application of conventional pesticides apply in the use of microbial pathogens, hormones, or pheromones, with appropriate modifications. I will also only treat the other supportive tactics in a general way.

We treat first the necessary background understanding of the crop or commodity pest system.

The insertion of a chemical pesticide into an agroecosystem has as its objective a change in the living conditions of at least two components of the system. Usually insecticides are applied for the purpose of bringing about a drastic reduction in numbers of one or more species of pests providing more favorable conditions for development of the crop species. The environment is changed and there occur reactions and adjustments among other components of the ecosystem. Complex chain reactions may be set in motion by the pesticides (organochlorine, organophosphorus, and carbamate compounds) and it is doubtful that even the simplest is understood fully.

Considerable field experimentation in recent years has produced strong evidence to support the proposition that natural enemy suppression by pesticides is a major cause of change in pest status and resurgence of treated populations. Some evidence is also available that shows that some pesticides have produced an increase in the inherent fecundity of the pest species either directly or in altering its nutrition.

Great need exists for better characterization, both qualitatively and quantitatively of the population dynamics and mobility of our major crop pests, the damage they cause and the various interactions among the many factors just mentioned.

Far too little attention has been paid to the crop itself--how it produces the particular item(s) of yield (quality and quantity), how the various environmental, agronomic or pest control tactics, or the pests themselves, alone and in combinations, affect this yield. Moreover, an allowable cost of a measure to control a pest is dependent upon the market outlook--upon the supply and demand situation.

Thus, to develop the necessary understanding of the pest control system, not only is an analysis of the pest system needed but both crop production and economic analyses are also required. The complexities are too great to handle without the use of modern computer science and simulation modeling. The first stage in this modeling is to develop a model of plant growth (normal, healthy plants not affected significantly by pests). Thus, the efficiency and pattern of cotton boll formation on the cotton plant, and the causes of boll or square dropping must be related to the various major factors affecting these processes. Then an understanding of the relation of insect or other pest attack on such yield productivity must be established and built into the model. One must be able to predict effects over some time period from data obtained earlier in order to take remedial action when required. This requires not only a thorough knowledge of the pest's life cycle and reproductive capability but also of its abundance, mobility and the various factors that affect its capability to do damage (e.g., weather, cultural practices, natural enemies, crop variety (resistance), power of crop plant compensation, etc.). Sub-models of the most significant natural enemies should be incorporated or handled in some way.

Economic analysis is also necessary and must be built into the model for decision-making. This latter is the third phase, but all phases must be utilized in a single over-all model. Moreover, the model itself requires alteration as its testing reveals its flaws. The model itself will point to the most obvious gaps in needed background data and thus direct further research, the two aspects going hand in hand.

For the pests and their natural enemies, much basic information is required and this will vary greatly with the situation. Long-term life table studies are perhaps prohibitive generally, but short-term population dynamics studies in which the causes of mortality and the extend of mobility are tabulated in a life table pattern will often prove useful. Particularly essential is basic information on the potential of natural enemies to fully or adequately control various actual or potential pests in the absence of disruptive effects of agricultural practices (especially pesticides, but may also include, e.g., the manner of crop refuse destruction). Such information can be obtained by experimental studies. These studies will require extensive, detailed and often frequent monitoring and sampling. The influence of pesticides on natural enemy populations as well as on the pest species is required. The methods of application as well as the kinds of materials used may greatly affect not only the pest but the natural enemies. Much basic information on possible differential effects that can be achieved in this way is needed.

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BIOLOGICAL CONTROL

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INTRODUCTION

Simply stated, biological control is the regulation of plant and animal numbers by natural enemies. It is a natural phenomenon, and as such a component of that combination of environmental forces which keep all living organisms (excepting possibly man) under natural control.

NATURAL CONTROL

Natural control is effected by two kinds of factors, those that are (1) density independent and (2) those that are density dependent. A density independent factor effects a degree of mortality that is uninfluenced by the abundance of the species it affects. For example, a freeze will kill a given percentage of a rabbit population regardless of whether the rabbits are rare or abundant. With a density dependent factor, on the other hand, density of the affected population has an important influence on the degree of mortality that is effected. Density dependence can be (1) reciprocal or (2) non reciprocal. The number of tree holes available to a hole nesting bird is an example of a non reciprocal density dependent factor. If a given region has 10,000 tree holes in it, the number of nesting birds will be limited to 10,000 pairs. Excess pairs, unable to find nesting sites, cannot reproduce. Thus, the number of tree holes in the area limits the density of the particular bird species. But this is a one-way relationship, i.e., the number of available nesting sites limits the size of the bird population, but bird density has no influence on the number of tree holes. By contrast, in the reciprocal density dependent inter-relationship each element of the interaction is affected by changes in density of the other. Thus, in the interaction between a parasitic wasp and its aphid host, the wasp takes an increasingly heavy toll on the aphid population as the latter's numbers increase, so that ultimately aphid deaths exceed births. As a result, the aphid population crashes and this in turn affects the wasp which loses efficiency as the aphid numbers decline. Eventually, a point is reached where aphid births exceed deaths and the population begins to increase. But this triggers a response by the parasite which affects a steadily increasing percentage of the rising aphid population until another crash occurs. And so it goes, a continuous waxing and waning of aphid and parasite populations as each in turn is affected by changes in density of the other. In control systems terminology, the reciprocal density dependent agent functions as a negative feed back mechanism much as a governor on an engine or a thermostat in a heat regulating system.

An understanding of the reciprocal density dependence phenomenon is critical to an understanding of biological control, for reciprocal density dependent agents, i. e. parasites, predators and pathogens, are the agents of biological control. We use these agents in two basic ways; (a) by introducing them into situations where pest species are epidemic because they lack effective natural enemies, or (2) by preserving or augmenting them in situations where their disturbance or elimination will lead to pest eruptions.

CLASSICAL BIOLOGICAL CONTROL

Classical biological control is the introduction of natural enemies against pest populations. In practice this has overwhelmingly involved the introduction of exotic natural enemies against invading pest species. The practice has its basis in the fact that many species which accidentally invade new areas, attain epidemic abundance because they have escaped their effective natural enemies. The logical thing to do then is to attempt to reestablish the pest-natural enemy relationship, and this in essence is what is done in classical biological control programs.

Certain steps are required in this process. First, the epidemic pest must be identified as an exotic invader, and its native habitat determined. Then, the native habitat must be searched for the pest and its associated natural enemies, the latter transported to the invaded area where, after careful testing in quarantine, they are passed on to an insectary for mass propagation and eventual field colonization.

In general this type of activity is conducted by a governmental agency such as the U. S. Department of Agriculture or a State Agricultural Experiment Station, but on occasion a grower's association may also be involved, as has the Sugar Planters Association in Hawaii.

Measured in terms of permanent pest suppression, classical biological control ranks as one of our most successful pest control techniques. World wide, approximately 100 pest insects and weeds have been either substantially or completely suppressed by introduced natural enemies. By contrast, chemical control, our most commonly used "artificial" control tactic, has never permanently suppressed any insect pest or weed plant.

Classical biological control has several advantages. In addition to its permanence, it is safe, cheap, and ecologically tenable. But it is not a pest control panacea and should not be looked upon as the total approach to pest control. In actuality, no single tactic, whether it be biological, genetic, cultural or chemical will solve our pest problems. Instead our various techniques and materials along with information can be used most effectively if they are laced together in integrated central systems. Indeed under integrated control, natural enemies and insecticides instead of being antagonistic may well become complementary. It remains to be seen if we can attain this commendable objective in our future pest control strategy.

Classical biological control has existed over the years as a sort of poor sister to each pest control innovation as it has appeared on the scene. This has been particularly true in the post World War II era, when first the synthetic organic insecticides, then the autosterilization technique, next the pheromones and now the third generation insecticides (hormones) have each in turn been accepted with great enthusiasm and inordinate administrative and fiscal support as potential pest control panaceas.

This has created an imbalance in support for research on the full spectrum of pest control tactics (e. g. resistant varieties, biological control, cultural control) and integrated control. A measure of the hinderence that this has caused to the implementation of classical biological control can be gained by comparing results in California and Hawaii, which strongly support natural enemy importation programs, with those attained in the rest of the country where support has been generally feeble. When we do this it turns out that of 38 cases of substantial to complete biological control so far scored in the U. S., 32 (84.2%) have occurred in California and Hawaii. It will be argued that this discrepancy reflects the fact that California is an ecological island and Hawaii an oceanic one. But this argument lacks validity, for Puerto Rico, an oceanic island, and Florida, an ecological island, both with salubrious climates, have enjoyed only limited biological control successes.

The simple truth is that California and Hawaii in supporting vigorous biological control programs have gained commensurate benefits while other parts of the country which have largely neglected classical biological control, have hardly benefited from the tactic. The logical deduction from this, then, is that a substantial increase in the success of classical biological control is to be expected if there is a significant increase in support for the tactic. And, there is every reason to believe that this optimistic view is indeed realistic since most of our major pest insects (and weeds) are exotic species and thus highly amenable to classical biological control.

For example, approximately two-thirds of our 25 most serious pest insects are of exotic origin, as are at least half of our major weed species. Entire pest insect groups such as aphids, mealy bugs and scale insects are almost entirely composed of exotic species. The neglect of classical biological control is no where more striking than with such major pests as the codling moth, boll weevil and green peach aphid upon which tens of millions of research dollars have been spent on conventional controls, but which have never been the subjects of serious natural enemy introduction programs.

American society stands to realize very large gains from an intensified classical biological control effort. It remains to be seen whether public opinion and actions of pest control administrators and politicans can bring this about.

NATURALLY OCCURRING BIOLOGICAL CONTROL

All ecosystems, even crop monocultures, contain food chains and food webs in which carnivorous species (predators and parasites) restrain or completely suppress species that are our competitors or potential competitors. This ubiquitous, ever active, carnivory is nothing other than naturally occurring biological control. As such, it is vitally important to us in our competition with insects. Common sense would seem to dictate that we take full advantage of this "bonusbug kill" in our pest control strategy, but unfortunately this has not always been the case. Indeed our neglect, and even worse, our interference with naturally occurring biological control has been very much at the root of the burgeoning worldwide pesticide treadmill and the frightening problem of pest resistance to insecticides.

We stumbled into this nightmare quite innocently. Our innocence was directly related to the kinds of pesticides that are available before the appearance of DDT. The early insecticides were simply not very good killers, and because of this they had very little impact on the insect foodwebs and food chains in the environments to which they were applied. Consequently, researchers and pesticide users had virtually no experience with target pest resurgences or secondary pest outbreaks in the wake of pesticide usage, because the primitive pesticides had virtually no adverse effect on predators and parasites. As a result there was no pesticide treadmill and pesticide resistance was virtually unknown.

And so, when the new broad spectrum synthetic killers became available in the mid and late 1940's, there was no background experience to warn of impending disaster. The materials were spread over the environment with what, at first bloom, seemed to be miraculous effect. But troubles quickly appeared. Unprecedented outbreaks of spider mites aphids, scale insects and lepidopterous pests soon occurred following the use of DDT and its siblings and successors. Already, by the late 1940's and early 1950's pesticide resistance in the housefly, mosquitoes and other pests had become a major problem. Quickly the pesticide treadmill became a global phenomenon, cropping up wherever the new "miracle" insecticides were brought into major usage.

And at the root of it all was the interference of the synthetic organic insecticides with naturally occurring biological control. The biocides wiped out herbivore and carnivore alike leaving a biotic vacuum in which target pest resurged with a vengeance and previously unnoticed species, liberated from their natural enemies, exploded to damaging abundance.

At its worst the pesticide treadmill is a disaster. This is attested to by the collapse of the massive cotton industry in northeastern Mexico where a secondary outbreak pest, the tobacco budworm, became resistant to all available pesticides and literally ate the cotton industry into extinction.

The ascendancy of spider mites to global supremacy among the pest arthropod groups is an even more distrubing example of the adverse feed back from the pesticide treadmill. And, here again, disruption of biological control by insecticides has been a principal contributor.

The citation of episodes of pest outbreak in the wake of insecticide usage could go on for pages. However, the situations just described are sufficient to outline the gravity of the problem. And, what is of importance here is the lesson that has been learned concerning the role of naturally occurring biological control. The balance of nature is indeed a reality in our forests, pastures, rivers, lakes and ponds and in our croplands. In overall consideration it is the strongest force we have going for us in our conflict with insects. It behooves us, then, to include biological control as a major element in our basic pest control strategy, that is, the strategy of integrated control.

SUMMARY

Biological control is a natural phenomenon, the regulation of plant and animal numbers by natural enemies. Classical biological control involves the introduction of natural enemies into new areas. It is usually practiced against invading exotic species which have escaped their natural enemies.

World-wide, about 100 species of pest insects and weeds have been permanently suppressed following natural enemy introductions. This is one of the best records of permanent pest control effected by any control method, but it can be improved with greater effort. Naturally occurring biological control has become widely appreciated as disruption of natural enemies by modern insecticides has resulted in a global manifestation of the insecticide treadmill. Biological control is a keystone of integrated control, and will be an increasingly important consideration as the integrated philosophy spreads.

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PEST MANAGEMENT IN FORESTRY

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INTRODUCTION

Forest environments present an entirely different situation with respect to marketing, harvesting and insect control than agroecosystems. However, insect outbreaks in forests are often treated the same as insects in cotton, alfalfa or any other agrimonoculture. The fact is that the two situations are totally different ecologically and should be treated as such.

The forest differs from an agricultural field in many ways and these differences should have a strong bearing on insect control practices. A grower in agriculture is responsible for preparing the soil, planting and harvesting his crop. He enters into every phase of crop production and has options in each phase. The situation in forestry is considerable different as the forest manager does not have this kind of control over every phase of timber production. In California, for example, virgin forests are still being cut. In most cases commercial forests are second growth and in the past there was little cost to the forester for stand regeneration as it was mostly natural. Currently more and more attention is being given to stand reestablishment following harvest cuts. The trend is toward establishing stocking levels for various forest types and sites and this may be regulated by law as in California (the new California forest practices act).

Foresters currently are talking of the "third forest" which means more intensive management and more intrusion by man into the system. In the south and north central portions of the United States considerable attention has been given to stand establishment. Large areas have been planted with trees of the same age and often of the same species. These large plantations involve a considerable investment for stand regeneration and therefore a departure from reliance on natural means of regeneration. The trend to monocultures and even-aged management in forestry means that forestry is tending to become more and more like agriculture. Other practices such as increased mechanization, fertilization, increased use of chemicals for insect, disease and weed control, genetic selection, prescribed burning, off-site plantings, and the introduction of exotic species are becoming more common. The desire is to maximize fiber production and intensive management procedures mean more investment. Protection costs will therefore increase. Even though forest practices are tending more to agriculture there are still considerable differences which must be taken into account. These differences are important in developing a pest control strategy.

No matter where timber cutting takes place, a natural stand or a plantation, the harvest doesn't occur on the same plot of ground every year. In agriculture, there is an annual harvest and in some cases several harvests per year. A forest stand is harvested once every 30 to 60 years. Cost of pest control is therefore a critical factor in forestry. Another important difference between agriculture and the forestry is the intended use of the land. In agriculture the only consideration is the harvestable product. The forest, however, is intended to be multiple use resource--timber, wildlife, watershed and recreation. It is questionable in some situations if, in fact, the multiple-use concept can become a reality. Certain logging practices and insect control schemes simply don't fit into this concept.

There are some naturally occurring even-aged stands which should be mentioned here. These stands are considerably different than the monoculture discussed above. Some of these natural stands are due to fire such as those pines with serotinous cones, e.g., Bishops pine, *Pinus muricata*. In other stands insects may play an important role. Possibly the lodgepole needle miner, *Coleotechnides milleri*, is important in lodgepole pine, *Pinus contorta contorta*, regeneration. One need only to look at the dense regeneration of young lodgepoles beneath the Ghost Forest in Yosemite National Park's Tuolumne Meadows to think this. Lodgepole pine is closely related to several fire species, jack pine, *P. resinosa* and Rocky Mountain lodgepole pine, *P. contorta murrayana*. Could it be that insects have replaced fire in maintaining these even-aged stands? The same might be asked about the association between Englemann spruce, *Picea englemanni*, and the bark beetle, *Dendroctonus obesus*, in the Rocky Mountains. Naturally-occurring even-aged stands can be viewed in a different light, particularly those where insects might be involved in the maintenance of such stands. Can these insects actually be considered pests? A naturally-occurring phenomenon as those above must certainly be taken into account in the development of a forest insect control philosophy.

Development of Concepts in Forest Insect Control

Relatively speaking far less chemical insecticides have been applied to our forested regions than to agricultural areas. However, if the same insecticides and methodology are used in controlling insects in both types of environments then something is drastically wrong. In practice both environments are treated similarly. The approach has not been ecological but has been economical, i.e., the forest manager is looking to maximize fiber production solely rather than viewing the stand as a complex forest community. Perhaps the genesis of this problem is our forestry schools where the orientation and curricula are economical and not biological. For example, should not forest pathology and entomology be required courses for forestry students? Such is not the case at my own institution nor are these courses required at many forestry schools. Too often the student of forestry is bogged down with techniques such as fire fighting, road building, timber falling and axe sharpening and he is not exposed to basic forest biology and ecology.

With this as a starting point, how is the forest manager for a private company or those foresters working in timber management with the U. S. Forest Service or other forest agencies going to make intelligent insect control decisions. Scientific insect control is a biological and an ecological matter, it is not totally economics although economics is a vital part of any pest control decision. The origin of the entire problem, then, lies within the educational system that produces the forester.

The problem is not entirely the foresters either. The highly trained, professional forest entomologist will often times not be bothered with such practical matters as an insect control project. To some extent he is shirking his responsibility and the forest industries have every right to complain.

Control decisions, then, are often made by people without adequate training and without an ecological perspective. But, there are other problems in forest insect control which tend to channel control decisions in the wrong direction. The situation in forestry is much different from that in agriculture in that the salesmen and the oversell are not part of the problem.

The Forest Pest Control Act of 1947 (Public Law 110) established a definite pest control policy for United States forested land. Basically this act set up forest insect and disease detection and appraisal in forests across the nation regardless of ownership. The act also permitted the federal government to plan and carry out control measures on state or private lands. As with many federal acts, the states have set up similar laws. In California, the forest insect control law (Public Resources Code, Division 4, Chapter 3, 4451-4459) permits the State Forester to set up a "zone of infestation" and to cooperate with federal and private agencies in controlling insects. These laws are well meaning but have created undesirable side effects.

Probably one of the biggest problems is with the timber owner. This is primarily a psychological factor. The owner, if his land is within a zone of infestation declared by the State Board of Forestry, pays only one-fourth of the cost of the control project. The federal government pays half and the state one-fourth. This gives the owner the impression that he is getting something for nothing. Unfortunately, the application of the provisions of the Forest Pest Control Act has been limited almost entirely to those projects involving the use of chemical insecticides. The forest manager because of his economic orientation and his lack of ecological understanding views all insects as pests. He doesn't worry about the effects of the chemicals on the natural enemies of the target species or of non-target species that are potential pests. He doesn't really have to think in terms of control cost as he would if he had to pay the total bill. Ecologically, the forest manager is not thinking of the forest in terms of multiple use but of timber production alone. He has no appreciation for beneficial forest insects and the work that they are doing for him. The control agencies have not established economic levels for their pest insects and it is never considered whether a particular insect is really a pest or not.

The detection provided for by the Forest Pest Control Act also leaves much to be desired. The various U. S. Forest Service Regions are flown once or twice a year to note for insect damage. This can be misleading in that insect populations tend to be discovered and treated after they have reached their zenith. There is also a difficulty in establishing the boundaries of the area to be sprayed. If this is done by plane with some ground checking in the more accessible areas then much larger areas will be treated than really is necessary. Current trends in insect control are toward spot treatments rather than broad scale application. The broad scale application of insecticides in forests tends toward prophylaxis and this is not desirable in such a complex ecosystem. In fact, prophylatic treatments are passé in most insect control situations.

Current Forest Insect Control Practices

Tussock moth.-- The 1965 Douglas-fir tussock moth (*Orgyia pseudotsugata* McD.) outbreak in California provides an excellent illustration of a typical control project. Cooperative population surveys of tussock moth were made in northeastern California much before the planned spray date (early July). Federal, State and private agencies and entomologists from the University of California helped on this program. Historically, the tussock moth was known to buildup in large numbers but also there were dramatic collapses two to three years following the inception of a buildup (Sugden, 1957; Wickman *et al*. 1973). The infestation was in a checkerboard pattern which is typical for this moth. However, in order for money to be appropriated from the state legislature a "zone of infestation" must be declared. Usually this is an area much larger than the area covered by the infestation. This is not a good means of obtaining money for control as the tendency is to spray many more acres than necessary.

The population survey showed approximately 12,000 acres to fall in the "heavy infestation" category. The decision was made, however, to treat almost 65,000 acres. This included areas in the light to medium infestation grouping, in addition to regions where there was no tussock moth. Further, another survey showed that the population of tussock moth was heavily infected by nucleopolyhedrosis virus as well as by other natural enemies (Dahlsten and Thomas, 1969; Dahlsten *et al*., 1970). This control project is an example of spraying too much too late and is a symptom of a control philosophy that is badly in need of a revamping.

The current (1972-73) tussock moth outbreak in Oregon and Washington has been handled in much the same way. However, there has been widespread publicity of this rather substantial (± 500,000 acres) outbreak because DDT has been banned. The general public has no way of knowing exactly what is happening but can be mislead by such activities as placing embargoes on Christmas trees. This particular outbreak is interesting as it has become more of a DDT issue than a tussock moth issue. Several bills have been introduced into the state legislatures as well as to the House and Senate of the United States with regard to using DDT on the tussock moth in 1974. This is not the way to handle a control decision and the entire program was orchestrated by the forest industries in the Pacific Northwest.

The tussock moth declined in 1973 but there are still some "hot spots" and the final collapse should occur in 1974. This is not the time to spray with DDT or anything lese as the natural control agents should have completed their job. Another vital point is that DDT has only been applied to declining populations and as such has never been shown to be an effective control agent. Finally, there are other chemical insecticides that, if applied properly, could give control. The tendency is to talk of 100 percent control but this is a rarity indeed. In fact, in the modern chemical approaches the trend is to lower dosages and lower desired control effectiveness, as low as 70 to 85 percent.

The tussock moth presents other problems which can lend light to the development of control strategies. From observation it appears that the outbreaks occur on previously high-grade logged land. These stands are often overstocked and heavy to white fir, particularly in California. Many stands in the Pacific Northwest are overstocked but much of the acreage is on poor growing sites (4 and 5). The stand conditions may, in fact, be the reason that the outbreaks occur in such sites to begin with. If such lands do not merit funds for management, and I doubt that they do, does it not follow that a large outlay of money for control is not justified.

DDT was banned as a matter of national policy and in order for the ban to be lifted some value of national importance must be threatened. This is not the case and it is doubtful that anything at the regional or state level is at stake. The annual harvest in the outbreak area is approximately 300 million board feet. Assuming the worst, that 1,500 MMBF (probably 150 MMBF) of mortality results and if this is reflected over a 10 year period, then the loss would be 150 MMBF annually. This would not be significant in the Pacific Southwest region (annual cut around 17,000 MMBF) or in Oregon (9,200 MMBF). There would be a trivial effect on timber supplies. The impact would be most severly felt at the local level. This, however, is not a justification for lifting a national ban.

At most, there would be a 50 percent reduction in the annual harvest. This could be partially compensated for through salvage and other management adjustments. The loss in revenue to the four affected counties might be as much as $50,000 annually which is substantial considering a possible $100,000 - $200,000 operating budget in the same areas. In large part the loss represents the difference in revenues if the timber is sold as "salvage" or as "green." The reduction in sales receipts going to county governments would not be so great if stumpage prices between "salvage" and "green" U. S. Forest Service sales was not so great. There is no reason why defoliated but non-beetle attacked trees could not be sold as green. Actually, in most cases whether attacked secondarily by bark beetles or not, there is no reason why salvage stumpage prices should be so low. Raising stumpage prices on salvage timber would be one means of increasing money flow in the community and Federal subsidy would be another. It may well be that subsidies over a 10 year period would just about equal the costs of a spray application.

This brief analysis illustrates the complexity of control decisions and some of the alternatives that might be taken and only a few factors were discussed. The need for a broad perspective and a systems approach to the solution is obvious.

Bark beetles.--The beetles in the family Scolytidae are the most important pests of forests in the western United States. The damage caused is readily visible even at low population levels as the beetles mass attack trees and kill them. The beetles in the most important genera (Dendroctonus, Ips, and Scolytus) are considered to be primary but it is known now that there is usually a predisposing factor that weakens the trees prior to attack. Such factors as drought, flooding, lightening strikes, root disease, photochemical smog, or mechanical injuries due to road building, logging, or home construction are known to weaken trees, making them susceptible to beetle attack. Poor stand conditions, such as crowding or overmature timber can be responsible for initiating outbreaks as can snow breakage and blow-downs.

All of the evidence seems to indicate that bark beetles are secondary insects. As such, preventative silvicultural procedures such as thinning and risk rating are viable options (Hall, 1958; Hall and Pierce, 1965).

Not only do the beetles kill the trees but they introduce a blue stain fungus which colors the wood. The staining of the wood affects marketability and there is some difficulty in covering the stained timber with paint. One approach is to try and control beetle populations by treating infested trees with lindane. For many reasons the use of this chlorinated hydrocarbon has not been successful in controlling populations (Wickman and Lyon, 1962). The best approach is with stand management procedures. In the east side Sierra Nevada Mountains the California Risk Rating System (Keen, 1943; Salmon and Bongberg 1942) has been shown to reduce stand loss to bark beetles. Using this procedure, trees that are the most likely to be attacked are removed from the stand. Losses can be reduced by 75 to 80 percent while removing only 15 to 30 percent of the volume (Whiteside, 1951). This type of cutting can be done at costs only slightly higher than a standard commercial harvest cut.

Again salvage of insect damaged or killed timber must be encouraged. Knowledge of the beetle biology and that these insects are probably secondary should lead to stand management practices which discourage beetle activity. Although it has been demonstrated primarily with bark beetles that silvicultural procedures can reduce loss, it is no doubt true that these procedures would do the same for insect and disease problems in forests generally.

Diaspine scales. --Scale insects and other sucking insects such as aphids are often good or sensitive indicators of disruption. A common scale insect in California, the pine needle scale (Chionaspis pinifcliae), appears to be an excellent index of disruption.

In a study at South Lake Tahoe a mosquito control program was found to be the cause of dramatic increase in the scale population. A closer look at the situation showed that not only was the fogging program with malathion ineffective in controlling adult mosquitoes but it was disrupting the natural controls of the scale insects (Dahlsten el al., 1969: Roberts et al., 1973). Balance was restored by discontinuing the weekly fogging operations. No further activity was necessary as natural control agents, coccinelids and small parasitic wasps, built up and the scale population collapsed completely within three years.

This type of problem--a relatively innocuous insect becoming a pest--will be more and more common as forests are urbanized or as man's activity increases in these natural areas.

CONCLUSION

Insects will continue to be problems in forests and there will definitely be a need for a control strategy. The current trend in forest management to more intensive systems will certainly increase the problems. Man's activity in the forest environment generally will likewise be an inducement to insect outbreaks. Vulnerable situations can be created by previous logging practices as with the tussock moth or a mosquito control program in a recreational area as with the needle scale, or poor stand management procedure as with bark beetles.

The forest, because of its complexity, probably offers more to the pest manager than any other ecosystem. The current attempts to simplify this system for increased fiber production and efficiency must be weighed very carefully. This is why the increased emphasis on modern pest management procedure comes at an ideal time for forestry as it is in a transition period. It is conceivable that some compromises between the quantity of timber production and the quality of the forest environment can still be made.

The integrated approach to pest management in forestry will have to rely on silvicultural methods and to try and take advantage of natural controls even more so than in other types of insect control. The forest, because it is a multiple use resource, may be more complicated to manage in terms of pest control on one hand but the multiplicity of uses may lead to a more diverse environment on the other. Diversity, theoretically in ecology, should tend toward stability and in the long run fewer pest control problems. The difference with which the forested areas will be put to use means that the pest manager must have an even broader perspective of the environment than pest control practitioners in other areas. However, the holoistic outlook is imperative in pest control in agriculture, forestry or the urban environment.

The forest because it is a multiple use resource offers the pest manager more in terms of options than any other ecosystem. Even so, the pest management strategy must be placed on a foundation of sound biological and ecological principles. Stand management and silvicultural procedures must be the cornerstone of any pest management strategy. Students preparing for careers in this field must have a broad perspective and an appreciation for the systems approach to problem solving.

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STRATEGY OF MOSQUITO CONTROL

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Mosquitoes currently constitute an important annoyance and vector problem to people all over the world. The basic principles underlying the strategy and examples presented in this paper for mosquitoes will apply in many cases to other arthropods of medical and veterinary importance. Mosquito control over the last quarter of a century has depended heavily on synthetic chemical insecticides for control. Dramatic successes were achieved at first, but after years of use, dismal failures became more and more common. This was particularly true in areas of heavy use such as the Central Valley of California.

Currently alternative methods for regulation of these insects are being investigated, however, it is not anticipated that any single method will solve the problem. Successful long term control will depend on the application of new and old techniques integrated with a basic understanding of the biology of the particular species to be controlled.

Biological principles were extremely important in developing early strategies for the control of disease vectors particularly those transmitting malaria. I will borrow a few examples from the history of malaria to demonstrate how an understanding of the biology of the species spearheaded successful attempts to control this disease in certain parts of the world.

Over half a century ago the concept of "species sanitation" was coined by Sir Malcolm Watson, a leader in malaria control in the tropics of Malaya. This concept was based on the fact that only certain Anopheles species were vectors of malaria and that control could be oriented towards a specific vector to control the disease in a particular area. As research progressed specific biological information was accumulated on vector species and this information formulated the concept of naturalistic control. This form of control was based on alterations to the preferred habitat of a particular species by mimicking a natural process which was detrimental to the particular species.

A couple of examples will illustrate the principles of this rather enlightened biological approach. *Anopheles maculatus*, an important malaria vector in Malaysia, is a species, and there are several other important vectors of malaria which have the same attribute, in which the female selects sunlit water sources for oviposition (egg laying). Exposed seepage areas and the open edges of hill streams are important breeding sites. Man's activities in clearing the jungle for lumber, crops and settlements gave an important advantage to this species by exposing numerous water sources for egg laying and larval development. The population of this vector spread and increased in numbers resulting in outbreaks of malaria where little or none existed before. Early malariologists quickly recognized the importance of shade from tree and shrub growth along streams and developed control practices based on subsurface drains, covering seepage areas with palm branches and planting and encouraging growth of trees and shrubs around exposed water. These methods effectively reduced the vector where they were practiced.

In the Philippines another malaria vector which preferred the quiet edges of hill streams was controlled by the use of automatically tripped dams which caused a periodic flushing of the streams. Under these conditions the immature stages would be washed into the deeper pools where fish or other predators consumed them.

In the first example man's activities in removing the jungle resulted in a change of the habitat favorable to *Anopheles maculatus*. The reversal of this change (shading) resulted in an effective control procedure. The second example also denotes a change of the preferred habitat but it is of a different type since it altered a habitat that apparently existed under natural conditions. On close observation of almost all mosquito control practices, one readily sees that a change in the habitat is the most frequently applied mechanism. This is true whether it is the application of a synthetic chemical insecticide, the use of a natural product such as sodium chloride or the planting of trees to produce shade.

The major consideration is how broad the change is, since placing an insecticide into an aquatic habitat for larval control or dispensing small droplets in a fog for killing adult mosquitoes can and often does affect other life occupying the same habitat. This would also be true for draining a swamp or filling a salt marsh since these types of changes are so drastic that they eliminate other communities of living things occupying these systems. Many times elimination of the water source is the best and most permanent method of control in water sources such as those due to improper irrigational practices, clogged drains, etc. In habitats having other desirable attributes, then one should try to apply control techniques with the following in mind (a) that it interrupts a biological requirement of the mosquito without a major affect to other life and/or (b) that the lethal action of applied control agents is a relatively specific mortality factor for mosquitoes.

In recent years there has been some incentive to develop more specific insecticides for pest control. In theory these chemicals would primarily be toxic to the pest and much less or not so to other organisms in the same habitat thus allowing the application of the material as a selective mortality factor. Research in this area is of value, since in principle only the target pest would be affected. Pathogens, parasites, predators, and genetic control techniques offer the potential attribute of specificity and are also important areas for research. However, as mentioned before it is highly unlikely that any single technique will serve all purposes. Indeed, if specific insecticides are developed and if used in the same manner as their broad spectrum relatives were used in the past, then it is almost certain that genetic resistance will be the outcome. A brief review of the resistance problem in California mosquitoes will serve to illustrate this point. Both Culex tarsalis, the major vector of western encephalitis, and the pasture mosquito, Aedes nigromaculis, are now resistant to all commonly used insecticides for mosquito control in parts of the Central Valley. The first widely used synthetic insecticide was the chlorinated hydrocarbon DDT. Mosquito control agencies accepted this material readily because of its ease of application, dramatic insecticidal properties, relative low cost and at the time apparent safety. Within five years after the introduction for control of Culex tarsalis resistance had developed in populations to a point where DDT would no longer reduce populations effectively, and it was phased out in parts of the Central Valley. The year of the complete failure of the insecticide in the Bakersfield area was also a year of abnormal flooding which resulted in a large uncontrolled vector population. These events coincided with the largest outbreak of western equine encephalomy-elitis in the State's history. Thus dependency on a single mortality factor in this case, DDT led to a breakdown in control of an important vector when it was most needed. In subsequent years other insecticides were used in the same manner and one by one they failed after a few years of use because of genetic resistance. This left a situation where none of the commonly used insecticides were available for control. Reliance on insecticides has had other disadvantages because more basic control systems, such as source reduction and naturalistic control, were no longer used or further developed. These techniques should form the backbone of mosquito control with insecticides in reserve for emergency situations such as flooding or the introduction of a "new" disease agent.

I would now like to move from generalities to more specific examples of mosquito control. An urban environment and salt marsh environment have been selected to illustrate some points regarding mosquito control.

URBAN ENVIRONMENT

An important group of mosquitoes in urban environments are members of the Culex pipiens complex. Members of this group are the most widely distributed mosquitoes in the world ranging from the tropics throughout the temperate zones of the world. They are both an important nuisance and vector mosquito and are frequently the cause of restless sleep if one has not become used to their presence during the night. These mosquitoes in general prefer foul water (rich in organic matter) as their breeding source and are therefore frequently abundant in urban areas because of the many suitable breeding sources present. These mosquitoes stay relatively close to their breeding site and when one is bothered by this mosquito, you can usually find the source within a distance of 100 yards or so.

The approach to control of this particular species complex does not require a more intense understanding of the biology of the species for control, since breeding generally occurs in water sources that are frequently unnecessary and usually unwanted. The breeding sources consist of improperly constructed or clogged drains, clogged catch basins, rain barrels, open cesspools, leaky septic tanks, and other retaining devices catching and holding foul water. Control of the species is best accomplished by location and removal or drainage of the site. The most desirable approach is clear, it consists of proper design, construction and maintenance of water conduits, and an educational program instructing the public of how they can participate in elimination of the problem. It should be also pointed out that control procedures based on spraying or oiling, catch basins, etc. does not pose a great hazard to water quality or other organisms, however, it is far more satisfactory to design the problem out of existence rather than to treat the problem after it becomes an annoyance or health hazard. Additional advantages of this approach are that good sanitary and drainage practices eliminate other problems related to the health and well being of the community.

SALT MARSH ENVIRONMENT

The salt marsh environment poses problems of a different nature than the urban breeding sources which are generally the result of entrapments of "unwanted" water. An estuarine marsh in San Francisco Bay will be used as an example of how this complex system can be handled to control mosquitoes and yet preserve with minor change the homogeneity of the marsh. The Marin County Mosquito District deserves full credit for these control techniques. The Petaluma salt marsh lies in the northwest corner of the bay and represents the last great segment of the bay marshes remaining relatively in tact. The biological systems of the salt marsh represent an important cleansing mechanism for bay waters. It converts the various nutrients into the food chains supporting the higher forms of life occupying the salt marsh and the bay waters. The egrets, ducks and shorebirds, which are often seen in these marsh habitats, represent only the tip of the iceberg of this complex biological community. The control of mosquitoes must therefore be handled with great caution to preserve this important system.

Salt marsh mosquitoes, unlike the Culex pipiens complex, are known to move great distances from the breeding source, thus causing annoyance to people and domestic animals living miles from the marsh. The important pest mosquito of this marsh is Aedes dorsalis. Like other salt marsh Aedes, the eggs are laid on the mud surfaces generally in depression areas or potholes that are filled by tidal action. In the spring and summer, conditions are most suitable for this mosquito's development. During this period there are generally about six tides in the bay which fill these mosquito sources resulting in five or six relatively large broods of adult mosquitoes. These pools, which form the principal breeding sites for Aedes dorsalis, are generally located along the upper parts of the marsh. The important point here is that the marsh as a whole is not producing mosquitoes, but only specific areas filled occasionally by the periodic high tides. On examination of the salt marsh, the Marin County Abatement District determined that the majority of these breeding sites were due to man's previous activities such as military uses (practice bombing runs), diversion of streams, etc. Thus under natural condition, the tides would ebb and flow and clear the marsh of most standing water. Besides the small potholes which produce mosquitoes, there are large deeper ponds used by duck clubs to attract water fowl. These retain water continuously between tides and do not present a mosquito problem. This is apparently due to the effects of wave action which are detrimental to mosquito development and the presence of the mosquito fish, Gambusia affinis, which had adapted to this brakish water. In addition, the permanency of the water in larger ponds would not be attractive to ovipositing females with the possible exception of the exposed mud margins during intertidal periods.

The approach to control of Aedes dorsalis by the abatement district is centered on elimination of the breeding sources without undue disturbance or drastic alteration of the marsh habitat. This was effectively accomplished by the use of a wide tracked vehicle fitted with front and rear ditching attachments. By working with the natural drain of the marsh towards the bay, a series of interconnecting ditches were established between the major mosquito producing potholes and the main canals of the marsh. After completion of a ditch, the exposed mud from the operation at the margin of the ditches is carefully rolled down by the broad tracks of the vehicle to allow the marsh vegetation (pickleweed) to recover and encroach quickly over the area. The area appears relatively undisturbed after a few months. In conjunction with preserving the marsh, the Aedes dorsalis control has proven to be excellent and superior to former practices. Besides providing excellent long term mosquito control, this approach has proven to be more economical as well. Previous control practices centered on the application of five or six treatments of parathion applied by aircraft after each of the spring and summer high tides, a technique employed year after year with variable results. The elimination of the handling and use of this highly toxic chemical by the operators and the elimination of its broad spectrum impact on the marsh communities are equally major benefits provided by this program.

In conclusion, the remarks stated in this paper obviously do not encompass all mosquito problems but only emphasize the types of approach which have yielded favorable results. The most obvious theme that runs through the examples given in this paper is the alteration or change in the habitat which eliminates a necessary requirement for the species to complete its life cycle. Since many urban sources of mosquito production occur in "unwanted" water sources, it is removal of such sites by design which offers the best opportunity for long term control. This would also be true for many rural breeding sites such as those produced by improper irrigation practices, improperly constructed drains, etc.

When the breeding sources are intermeshed or part of other desirable habitats such as a salt marsh or forest mountain region, the problem requires a more intricate biological approach to reduce the mosquitoes and yet preserve the qualities of the system. This is where the challenge lies for future research and training.

RODENT CONTROL - AN INTEGRATED APPROACH

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INTRODUCTION

Rodents comprise more than one third of all living species of mammals, and exceed every other mammalian order in numbers of individuals. They number 1400 species and 2! families. The five common species which attract the most attention are:

1. House Mouse - or <u>Mus musculus musculus</u>
2. Norway Rat - or <u>Rattus norvegicus</u>
3. Black rat - or <u>Rattus rattus rattus</u>
4. Roof rat - or <u>Rattus rattus alexandrinus</u>
5. White belly rat - or <u>Rattus rattus frugivorus</u>

The Norway rat and the house mouse are man's main concern. Rodents transmit over 35 diseases to man and animals. They also carry 18 different kinds of lice, ticks, fleas and mites. Disease is spread by the parasites they harbor, their excreta and by their bites. Among the diseases they spread are plague, typhus fever, infectious jaundice and food poisoning. The most dramatic of these diseases is "Plague" which devasted Europe in the 15th Century, taking over 25 million lives or one-fourth of the population at that time. In a period from 1898 to 1923 Plague killed 11 million people in India. Rat borne diseases have taken more lives than all the wars in history. In modern times we are more concerned with the rat bite, typhus, food poisoning and economic impact of rat destruction. However, in the past few years there have been several cases of bubonic plague that have resulted in deaths. In public health terms, rats and mice are undesirable pests.

From an economic standpoint, it is estimated that there is at least one rat per person in the U.S. and that the cost of feeding it is approximately one half to one cent per day. Since rodents destroy 10 to 20 times what they consume and damage property in other ways, the annual damage is estimated at 6 billion dollars. It is further estimated that rats destroy 200 million bushels of grain each year.

Rats will take almost any food either man or domestic animals can eat, which explains the ease in which they have adapted themselves to almost any environment. In a survey conducted in one state rodent hairs were found in 43 different brands of canned products. In addition, rats and mice can start fires by damaging insulation on electrical wiring.

<u>CURRENT CONTROL TECHNIQUES</u>

The most frequently used method of rat control is poisoning. There are "permanent" techniques such as rat proofing of buildings in their original design, or rat proofing of older structures to prevent entry of rodents. In addition a primary technique is the elimination of rodent harboring areas such as trash, wood piles, and abandoned structures. Secondly, there are temporary measures which include fumigation with gases like cyanide and chlorine, or poisoning with anti-coagulants such as warfarin or pival. Anti-coagulants are the most widely used today because of their relative safety to man and his pets. However, resistance to them has been noted in the U. S. and Europe. Other poisons include red squill, used primarily against the Norway rat; zinc phosphate and sodium flouroacetate (1080).

Trapping is also used extensively; however, its usefulness is limited to small infestations of rodents or in determining species and ectoparasites present.

Biological controls which utilize natural forces to suppress rodent population can also be used. For example, natural enemies such as cats, dogs, skunks, snakes and predatory birds may be useful. In addition bacterial agents such as "Ratite" and "Azoa" have both been used, but both contain living cultures of salmonella. These organisms are also dangerous to man and in view of rodent contamination of food products should not be recommended as a control measure. Deterrents have sometimes been employed, however, their efficacy is questionable.

Although poisons are effective and fast acting they are expensive to use because they only have a temporary impact on rodent populations. The use of poisons in a rat control campaign which is carefully and systematicall carried out will wipe out about 3/4 of a rodent population. The remaining fourth, however, will be able to restore the population to its original level or carrying capacity of the environment in about six months. Some investigators believe that temporary control mechanisms such as poisoning and trapping may serve to maintain the reproductive rate at its most efficient level.

As previously mentioned we are beginning to see resistance to the anticoagulants in rodent populations. The problem of rodents developing resistance to rodenticides is a recurring one, which can be avoided by emphasis on managing the habitat rather than relying on chemicals for the extermination.

Another technique that has recently been considered in rodent control is the use of chemosterilants. The purpose of the chemosterilant is to sterilize the rodent without harming him in any other way. Sterile rodents are then released into the environment to compete with normal rats for available food and shelter. If enough sterile rats are released into the environment the birth rate will become lower than the death rate. Ideally, the species will die out. The use of chemosterilants has many pitfalls in that some of them cause bait shyness or require daily ingestion to maintain effectiveness.

If the chemosterilants can overcome problems such as bait shyness and temporariness, they may become a promising control technique in areas where environmental improvement is difficult. However, even if made more effective, chemosterilants are not the answer to rodent infestations. Even under the best circumstances it would take between six months to one year to decimate a rodent population.

Of all the control techniques environmental improvement is the most effective. Poisoning, trapping, and the use of chemosterilants are directed at the rat rather than the conditions which support him. For this reason these methods are not always successful.

The superiority of environmental improvement over the use of poisons as a rat control technique is well proven. The hardiness of the rodent species, their numbers and ability to multiply quickly to the carrying capacity of most environments, requires an integrated approach to their control.

INTEGRATED PEST CONTROL

It is quite evident in the literature that we now have sufficient knowledge about the biological principles of rodent populations and therefore control strategy should be based on these principles. One glance at the literature will show many references related to strategies for controlling rodents as well as studies that have been conducted on rodent populations.

By understanding the dynamics of rodent populations a proper balance of temporary and permanent techniques can be used to bring about the control. The most effective strategy to control rodents or any other pests is to manage the habitat so that the carrying capacity is reduced and the population is kept at an acceptable level.

Again, the most permanent control measures are the elimination of harborage and the accessibility of food supply. In order to do this in an urban setting the emphasis must frequently be placed on programs that have social and economic impacts. Housing code enforcement along with an effective refuse collection and disposal program are the most effective means of reducing rodent populations in an urban area.

Extensive studies conducted in Baltimore (1943-1947) showed that rat populations will increase to the capacity of the environment and then level off for an indefinite period of time and increase or decrease as the environment changes. The Baltimore study also showed that after poisoning, the rodent populations promptly returned to approximately the original level.

When an extensive program of poisoning, trapping and gassing is implemented the populations can be kept at a low level, but eventually they will return to the environmental carrying capacity even after subsequent treatment with poisoning.

The Baltimore figures show that when a rodent population was reduced 50 to 70% the population recovery was rapid. Even when a reduction of 90% was achieved, the return was slower but nevertheless the return proceeded towards the maximum carrying capacity of the habitat. The study further emphasized that areas which had been made completely rat free for a period of 2.5 years developed large populations in a period of six months and exceeded the carrying capacity of the environment. Spontaneous reduction factors occurred during which time the population eventually leveled to the capacity of the habitat.

A feedback mechanism has been described by Davis where aggressive behavior brought about by competition for food and shelter stimulates hormonal production of the adrenal glands. This causes an increased susceptability to disease and increased physiological disease of the heart and kidney. In addition, both size of litters and fertility are reduced. This points out that for any population a homeostatic mechanism exists which will adjust the population to the carrying capacity of the habitat. Understanding how chomeostatic mechanism adjust the population to the capacity is an important part of control strategy. Predation of rodent populations and the use of temporary measures will actually maintain the breeding capacity of a given rodent population at a higher level. Consequently when temporary measures are stopped, rodent populations have had tendencies toward explosive growth.

The use of rodenticides can be effective and quick acting, but they must be used in combination with a program to alter habitat or the programs will result in wasted efforts. Further, the residual population will possibly develop a resistence to the poisons thus making chemical control even more difficult.

Rodenticides play an important role in the management of pests, and their role has been of undeniable value to the welfare of man. There use must however be kept in perspective. Since the pest control industry depends on sales of chemicals for profit, merchandising promotes the use of their products on a continued basis. Modern pest control technology has produced effective poisons which we must continue to use but should not replace or discourage environmental management.

In the urban environment, sanitation techniques in housing rehabilitation are primary environmental management tools. The same principles apply to the agricultural setting where protection of stored grains, prevention of excess spilling of food products or proper crop rotation can be significant factors in adjusting the carrying capacity for rodent populations.

Urban rodent controls strategies can only be successful if environmental management capabilities exist. These include:

- Public work activities like street maintenance or weed clearance programs.

- Community and beautification and anti-litter programs.

- Public education programs designed to inform neighborhood residents on the do's and don'ts for rodent control.

- Enforcement of sanitary refuse disposal practices.

From a total community standpoint public works-community sanitation programs will have more impact on rodent populations than specific control measures.

Pest control management requires that a diversified approach be taken to bring about the population balance or control desired.

Successful rodent control programs have relied on a combination of techniques. The mainstays of a balanced control program, is to destroy rodent habitats and starve them. Temporary measures of trapping and poisoning are also necessary in any effort to get quick results and to prevent migrations of rodents to other areas. In many cases poisoning provides the only possible relief.

Administration of rodent control programs must include program planning to evaluate program direction, enforcement effectiveness, efficient personnel use and community needs. A concentrated effort to coordinate programs of community sanitation, housing code enforcement and solid waste management is more difficult to achieve especially since it is easier to take the easy way out and use chemicals. The use of chemicals is encouraged by quick short-term results. Also, there is a well established pest control industry in the U.S. which offers a ready solution to a problem few people care to deal with. Rodent control supplies are available to consumers in a variety of choices in retail establishments ranging from the local grocery store to specialty houses. Both of the above contribute to dependence on chemical use rather than more difficult to achieve environmental management.

Program planning involves determining what the problem is, what is being done and what should be done. It serves to establish priorities for control programs. The program planning process should consider those community programs that impact on the rodent problem such as refuse collection and based on that consideration, develop an acceptable program justified both technically as well as politically.

Urban rodent control programs must consider a variety of factors such as social and economic situations in addition to environmental management and improvement. The highest rodent populations are found in areas which are physically or economically depressed, generally over-crowded and have inadequate refuse storage and collection practices. These areas generally reflect the greatest conflicting land use patterns and poorest environmental sanitation practices. For example, it is not uncommon to find within one block an automobile repair shop with numerous abandoned automobiles, a commercial establishment with poor refuse disposal, weed covered lots, poorly maintained fences or out structures and high density poor quality housing. These conditions provide the ingredients for a large rodent population: a ready supply of food, and a lack of external control; consequently rodents are maintained at the maximum capacity of the environment. It can readily be noted that rodent control programs within a "slum area" will not accomplish their task if they rely solely on poisons or traps.

Integrated rodent control programs in an urban area must use innovative tactics that provide for the maximum use of available personnel to meet a specific need. For example, it has proven successful to use indigent health workers who are familiar with their own neighborhoods and their neighbors to bring about practices that significantly reduce rodent populations. While the indigent health worker or rodent control specialist is not necessarily an expert in the scientific aspects of rodent control, he is effective in dealing with the social, political structure in his neighborhood. In addition to providing rodent control, the availability of an employment opportunity also provides some social benefits. This type of program has long term benefits such as the development of community pride and understanding of rodent control methods.

Program management programs must maximize the use of permanent measures. A list of measures can include the following:

- Housing code enforcement program.

- The initiation of an effective residential and commercial refuse collection program combined with adequate enforcement.

- An abandoned vehicle and appliance pickup program.

The list of related activities could go on. However, the point is that many other factors other than specific biological principles must be considered in conducting rodent management.

IN SUMMARY

Rodents are a major concern for Americans. Their numbers are used as an indicator of urban decay. Proven principles that reduce the carrying capacity of the environment represent the best control methods. The use of chemicals can bring quick relief; however, it is temporary unless a community undertakes an environmental sanitation and improvement program.

It cannot be over emphasized that control strategy is political as well as biological. Without political support community programs to clear slums and provide better refuse collection, rodents will flourish.

The goal of a rodent control program is obviously to eliminate or reduce the potential public health hazard from rodents or their ectoparisites, and, to reduce rodent population levels so that damage is not of economic interest. Because of the public health significance of rodents that live in close contact to humans we have a wealth of information on control tactics for urban rats - the principles also applying to the control of rodents in agricultural areas. The tactics for control of rodent population do not favor the use of predation (poisoning, trapping and predators) to maintain low levels of rodents. While predation does play a role it is not of significance unless combined with habitat management.

II. IMPORTANT COMPONENTS

IMPORTANT COMPONENTS

INTRODUCTION

As the title of this section indicates, it is concerned with units, modules or courses which can play an important role in educational programs related to Integrated Pest Management.

The three components of this kind outlined in this section are Career Preparation, an Environmental Education Core, and a unit entitled Introduction to Integrated Pest Management.

Since the concept of Career Education is still in the process of development --- and since Career Preparation is a defined phase of this --- this particular component receives the most detailed attention in this section. There are three chapters devoted to it: Introduction to Career Preparation; Career Preparation: The Teacher's Role; and Career Preparation for Integrated Pest Management.

These chapters are followed by a chapter entitled An Introduction to Integrated Pest Management. This title actually is the name of a short course which is outlined in this chapter. Because there will very probably be a demand for a unit or course which can overview this field, this course outline has been included at this point. Depending upon the depth in which each topic is explored, the course can be adapted for use in secondary schools, community colleges or technical institutes, or baccalaureate programs.

Similarly, the course can involve two weeks, a month, six weeks, a quarter or a semester. Again this will depend upon the study and investigation applied to each of these topics.

Moreover, this outline may be used to develop a unit on Integrated Pest Management as part of quarter or semester course. As such, it may be covered in only two weeks, although it can be extended to greater length should this be desired.

Finally, this section includes two chapters entitled The Environmental Education Core for High School and MDTA Integrated Pest Management Programs and The Environmental Education Core for College Integrated Pest Management Programs. As is stated in each of these chapters: "Integrated pest management personnel must acquire the specialized skills necessary to deal with problems relating to crops and pests. However, it is important that they understand fundamental environmental concepts that will allow them to view their work and decisions in the broadest context of global environmental impact."

The chapters in this section were writted by Mr. Edward Petrie of the Ohio State Department of Education, Dr. George M. Barton of Nova University, and Dr. Robert H. McCabe of Associated Research Corporation. Each of these persons has contributed two chapters to this section.

INTRODUCTION TO CAREER PREPARATION

The general purpose of this chapter is to provide basic information about career preparation to teachers, administrators, counselors and others concerned with preparing students for careers in integrated pest management. It is intended to be a guide to the overall goals and purposes of career preparation as a phase of career education.

AN OVERVIEW OF CAREER EDUCATION

Career education provides for a broad approach to preparation for citizenship; provides job information and skill development; and also helps individuals develop attitudes about the personal, psychological, social and economic significance of work in our system. It develops and fosters a vocational and recreational interest in individuals to help them prepare for well-rounded living in a world in which leisure time is increasing and greater opportunity for self-expression through creative production is available.

Dr. S. P. Marland, Jr., then the U. S. Commissioner of Education, observed that: "Educators must be bent on preparing students either to become properly and usefully employed immediately upon graduation from high school or to go on to further formal education. The student should be equipped occupationally, academically, and emotionally to spin off from the system at whatever point he chooses - whether at age 16 as a craftsman apprentice, or age 30 as a surgeon, or age 60 as a newly trained practical nurse."

In citing the need for career education, Dr. Marland has referred to it as eliminating the artificial separation "between things academic and things vocational."

Programs in career education offer a response to this challenge since the fundamental concept of career education is that all education and experiences - curriculum, instruction, and couseling - should be geared for economic independence and an appreciation for the dignity of work.

GOALS OF CAREER EDUCATION

1. To make <u>all</u> educational subject matter more meaningful and relevant to the individual through restructuring and focusing it around a career development theme.

2. To provide <u>all</u> persons with the guidance, counseling, and instruction needed to develop their self-awareness and self-direction; to expand their occupational awareness and aspiration; and to develop appropriate attitudes about the personal and social significance of work.

3. To assure the opportunity for all persons to gain an entry level marketable skill prior to their leaving school.

4. To prepare all persons completing secondary school with the knowledge and skill necessary to pursue further education or to become employed.

5. To provide services for placing every person in the next step in his development whether it be employment or further education.

6. To build into the educational system greater utilization and coordination of all community resources.

7. To increase the educational occupational options available to all persons through a flexible educational system which facilitates entrance and re-entry either into the world of work or the educational system.

CAREER EDUCATION AS A COMPREHENSIVE EDUCATIONAL PROGRAM

Career education is a comprehensive educational program which begins in kindergarten or earlier and continues through the adult years. Implementation of the career education concept includes a restructuring of basic academic subjects around the theme of career development, and including in them information on opportunities and requirements in the world of work. With this restructuring the basic academics, such as mathematics, science, social studies and language arts will become more relevant because the student is helped to see their relationship to future career goals.

Career education is essentially a program of four (4) ordered phases; Phase I - Career Awareness, Phase II - Career Orientation, Phase III - Career Exploration and Phase IV - Career Preparation.

Phase I, Career Awareness, begins with pre-schoolers and extends into the early elementary school years. Career awareness is the process of providing the child with information necessary for him to understand the need for all people to function in the world of work and form the desire to do so. The child should also gain a respect for all work and for people who work.

Phase II, Career Orientation, normally occurs in the late elementary and early junior high years. In this phase students are informed about the wide range of jobs in our economy and the associated societal roles. Students are assisted in orienting themselves to the world of work through a process of self assessment of their talents, aptitudes and interests. They will receive information as to the structure of the fifteen career clusters, including the entry level jobs available within each and the career ladders to promotion within each occupational group.

In junior high and early high school (Phase III, Career Exploration) students explore specific jobs and/or job families within the various career clusters through hands-on experiences and field observation, as well as classroom instruction. This intensive, hands-on, in-depth exploration is intended to lead to an intelligent, well reasoned choice of a career for which to prepare.

Phase IV, Career Preparation, is intensive skill, technical knowledge, work habit, attitude and safety judgement training in one job or job family preparatory to job entry. This preparation may be gained in high school cooperative or in-school vocational programs, private and public post-high school programs, correspondence courses, adult education programs, technical institutes and community colleges, four-year colleges and post-graduate university programs.

The grade level designations noted here are intended to show only the normal time occurrence of each phase in a student's educational career. To provide for individual differences, grade level indications must not be interpreted as being restrictive. Extensive guidance and counseling activities assist the students in developing self-awareness and in matching their interests and abilities against potential careers allowing them to move from phase to phase, and backwards as well, as each individual case warrants.

The grade level indications also should not be interpreted as meaning that career education is available only to young people in school. Career education recognizes that adults will require upgrading for career advancement or even counseling, career exploration and preparation for a new and different career.

CAREER PREPARATION

Education for career preparation develops in the student entry level job skills and knowledge. By the time secondary education has been completed -- which may or may not involve completing the twelfth grade -- the student should be prepared to enter the world of work or further education. In the latter case, this will usually be an institution of the type described as post-secondary -- a college, junior college, technical institute, or private or public vocational training center.

In career preparation, the student should have the opportunity to enjoy actual work experience. This will be accomplished through cooperative arrangements with industry, business, public institutions, or other employers.

In developing objectives or goals for the career preparation program, the assumption can be made that prior to entering career preparation, the student will have already made a decision to pursue a career in integrated pest management based upon counseling and previous experiences in Career Awareness, Career Orientation, and Career Exploration.

Initiating a career preparation program should include a review of the objectives or activities of the earlier phases of career education. This will ascertain just what point students should have reached before coming into the program.

It will be valuable to review at this juncture what the student should have achieved as a result of completing the Career Exploration phase -- since this is the one that should be completed just before coming into career preparation. The objectives of career exploration should have included (and this is not an exhaustive list):

1. Developing a knowledge of integrated pest management and its relationship to the entire world of work. This will include knowledge of career possibilities as well as knowledge of its contribution to the prosperity and success of this country.

2. Reviewing the major occupational groups in integrated pest management, including entry levels within each group, while considering the student's own interests, attitudes and aptitudes.

3. Gaining a knowledge of changing employment patterns, future growth predictions, career lattices and other opportunities in the occupational groups chosen for exploration.

4. Determining the education or training necessary for entry-level positions in the jobs/job families chosen for exploration, giving the student the means to design his educational/training plans for the future.

A student who has experienced even a part of the career exploration phase will have already been exposed to a program which has involved considerable contact with personnel officers, industrial trainers, vocational counselors, guidance officers, and so on. The student will, in fact, have learned to "explore" careers to a considerable extent through self initiative. Thus, the student will be prepared for an arrangement in which the instructor functions as an educational manager rather than as a teacher in the traditional sense. In fact, the student may very likely experience marked disappointment at finding something other than this.

In all this, it should be noted that some kind of instrument or technique will be needed to determine where each student stands in readiness for the career preparation program. This can be by a multiple choice questionnaire, an open-ended survey, or a personal interview. If a personal interview is the device used, it should be undertaken in considerable depth. The results of any instrument or technique should be evaluated in conjunction with school records and other materials relating to the student's past achievements.

OVERVIEW OF PROGRAM OBJECTIVES

The career preparation program objective is to qualify the student for an entry level position in the integrated pest management industry. It will be apparent from the foregoing statement that this is career "preparation" in the truest sense of the word and to many students will represent the culmination of the career education process. While these students may be involved in a career education continuing throughout their lives, this is where preparation for a career is most emphasized, focused and intensified.

Prior to entering this phase of career education, the student should have evaluated personal interests, abilities, values and needs as they relate to occupational goals. Students who have not dealt with these matters to the extent required, should be brought up to the point where career preparation opportunities can be handled. Whatever elements may have been missed in prior phases of career education, the goal of career preparation is to qualify the student for an entry level position. In addition, an overall objective of career preparation is to provide the student with an overview of integrated pest management and its impact on our national economy, as well as upon such important facets of our national life as the environment and our social and political systems.

Since the student may not remain in the particular area of integrated pest management represented by the entry level job, a further objective of career preparation is to help the student understand the broad aspects of agriculture in the United States, the wide variety of career patterns involved with it, and the interdisciplinary aspects of integrated pest management activities. All of these will form a basis which the student may ultimately use in firming up career objectives.

OVERVIEW OF STUDENT GOALS

As a consequence of participation in a program in preparation for a career in integrated pest management the student should have developed and be able to demonstrate:

1. A knowledge of the agriculture industry and its relationship to the entire world of work. This will include knowledge of specific areas in integrated pest management as well as knowledge of the contribution of each to the prosperity and success of this country.

2. A knowledge of basic problems and issues that must be dealt with in integrated pest management -- in such categories as labor-management relations, equal employment opportunity and community relations.

3. An awareness of the social, economic and political impact of integrated pest management on society.

4. A knowledge of, and the ability to use the communications skills required in the world of work. Communications skills will include oral and written skills as applied to integrated pest management.

5. A knowledge of, and the ability to use the mathematics and science skills required to succeed in the job or job family for which career preparation is undertaken.

6. The ability to function socially based upon information gained from social studies instruction.

7. That immediate social objectives and career goals are clearly established at the time of entering the world of work or further education.

CAREER PREPARATION: THE TEACHER'S ROLE

Career preparation is distinguished from the previous stages of career development (awareness, orientation and exploration) in that it represents a narrowing of interests, abilities, aptitudes and potentials; all of which are brought to one focal point -- the occupation or family of occupations for which the individual has chosen to prepare. Career preparation teachers work with students who are either preparing for immediate job entry or who are preparing to pursue further education requisite to eventual job entry, or both. The goal of the career preparation teacher, then, should be to assist students in obtaining adequate skills and knowledge to facilitate successful job assimilation or advancement to the next level of education or training. The roles of career preparation teachers will be as varied as the individual career aspirations of students and the progress they have made toward realizing these aspirations.

Career preparation, like the other phases of career development, should be keyed to individuals who should be directing many of their own activities and making many of the decisions involved in these activities. Students should expect to experience a certain amount of failure in this self-directed process (just as they will in their chosen careers) as well as the eventual success that a thoroughly and systematically planned career search and preparation will produce.

The teacher's role throughout the preparation process should be essentially that of a coordinator of the overall learning experience. The teacher will be called upon to provide guidance and direction whenever appropriate to: offer continuous feedback to students as well as to others involved in the career preparation process; evaluate progress; provide encouragement and motivation; be a bridge between school and community, especially in fostering community involvement in the career preparation process; and provide assistance with the definition, selection and procurement of sources of occupational and other information. The successful activation of these functions will be dependent upon the flexibility and resourcefulness of the teacher. This flexibility and resourcefulness must permeate the entire career preparation process, both within the school and without, to insure maximum effectiveness for the individuals involved. The teacher will fulfill an all-important function as coordinator-communicator of the overall preparation experience for each individual/participant. This will necessitate constant communication to keep students, as well as others (i.e., parents, administrators, employers, co-op supervisors, guidance counselors, etc.) involved in their preparation, informed. All parties involved in this process should be aware of individual students' progress as well as their shortcomings and future needs. In this regard the career preparation teacher is a vital link in the whole process of career development.

Career preparation implies the <u>total</u> development of the individual toward an occupationally oriented goal. This will necessitate the teacher's involvement in the students' development of communicative skills, acquisition of a working knowledge of integrated pest management and its relationships to the entire world of work, ability to assess changing career patterns and job opportunities, educational and training requisites for occupational advancement, applicability of lifestyle to occupational choice, etc., as well as skill development for a particular occupation or family of occupations.

The teacher's role is thus a multifarious one at this critical stage in the individual's career development. It may involve a re-thinking of traditional concepts, a restructuring of curriculum, new focuses of time and energy, additional assistance from various sources and a variety of other changes, all of which will probably involve more work. Whatever changes are necessary, the end product -- a curriculum geared to the individual needs, aptitudes, interests and aspirations of students -- is certainly worth the effort.

While this chapter is concerned primarily with teachers whose responsibilities deal with the skills and knowledge directly related to career preparation, the role of the academic teacher should not be overlooked. The fact that the basic goal of career education is to restructure our educational system by focusing all subject areas around a career development theme implies a definite role in career preparation for teachers of the language arts, sciences, mathematics and social sciences. To assume this role the academic teacher must abandon teaching only in the abstract and move toward an emphasis on practical application. This will enable students to find meaning and relevance not only in preparing for a career but in all other school work as well.

The academic teacher assumes this role by cooperating with the career preparation teacher in such things as observations, joint assignments, providing practical examples, etc. For instance: A written report could be both a career preparation and an English assignment with both teachers assisting the student; an assignment in the chemical composition of pesticides could be done in conjunction with a project in chemistry; the speech teacher may assist with oral reports the students may do to pass along information to other interested students; the social value of integrated pest management may be discussed in social science classes as it relates to the environment; and many practical examples from integrated pest management can be provided for mathematics classes.

THE VOCATIONAL TEACHER

Vocational education is generally assumed to be career preparation that is undertaken at the secondary level (high school) of our educational system. Because career preparation represents the culmination of the career education process, the role of the vocational teacher is of exceptional importance. Primary emphasis is placed upon the students' acquisition of skills and related knowledge directed toward an entry level position in the world of work immediately upon graduation from high school. The vocational teacher will have the responsibility for this skill and related knowledge training.

Within the secondary school, vocational teachers must meet certain state vocational certification requirements. Normally they are required to have obtained appropriate work experience in the vocation to be taught, as well as a considerable amount of college teacher preparation. Since integrated pest management falls under the cluster of agriculture occupations, teachers may be required to have a degree in vocational agriculture education. The combination of work experience and education is to be preferred, however, since it provides the teacher with the most appropriate background relating to the role that is to be assumed. It also means that the teacher will have the peer recognition, both within the school and throughout the community, that is necessary to make the most effective contribution to this kind of program.

There will be two types of programs used in the high schools to prepare students for careers in integrated pest management. One type is referred to as "in-school" where all of the skill and related knowledge training is undertaken in the school, in a laboratory set up for this purpose. The other type is called a "cooperative" program where the student acquires related knowledge in the school and skill training on released time in a real job setting. The roles of the teachers in both types of programs are delineated below.

THE IN-SCHOOL VOCATIONAL TEACHER

This vocational teacher will need to assume complete responsibility for the students' acquisition of job skills and related knowledge in the school setting. The primary responsibilities will be those of instructor, coordinator of student learning activities and occupational guidance.

The in-school vocational teacher will also serve as a manager of the educational program; as a coordinator of the activities of others who will be contributing to the program; as a liaison between and among students, parents, counselors, other faculty, administrators, business and industry representatives and the community; and as the primary evaluator of the on-going program as a whole and of its various components.

In order to be really effective, the in-school vocational teacher will need to have close relationships with employers in the field for which the students are preparing. The vocational teacher must maintain ties with industry and the community at large that will be helpful in obtaining materials, equipment, information and most important of all, placement assistance for graduates of the program.

THE VOCATIONAL COOPERATIVE TEACHER

The teacher-coordinator of a cooperative vocational education program is usually given the total responsibility for coordinating the on-the-job training and in-school related instruction of a group of students preparing for careers in a single occupational group or in a single occupation within integrated pest management. Smaller schools may combine more than one occupational group, or even more than one cluster of occupations, into one class to make the program economical to operate.

One of the major roles of the teacher-coordinator is placing the students in on-the-job training positions for skill development and then assisting them in adjusting to their work environment. The teacher must enlist participation of cooperating employers and maintain good relations with them. Students will require assistance in preparing for job interviews, dealing with job problems and evaluating job training progress. Since it is virtually impossible to be continually on the job with every student, the teacher-coordinator must train and place considerable trust in the on-the-job training supervisor who is a regular employee of the cooperating firm.

While the in-school vocational teacher normally has a class where all students are studying in a single occupation or family of occupations, the teacher of a cooperative program usually has students in many occupations. The teacher-coordinator must be flexible enough to coordinate and correlate his in-school related instruction with each student's on-the-job training. The students must be encouraged to accept a certain amount of responsibility for their own training and then be depended upon to do it.

The vocational cooperative teacher also will serve as a manager of the educational program; as a coordinator of the activities of others who will be contributing to the program; as a liaison between and among students, parents, counselors, other faculty, administrators, business and industry representatives and the community; and as the primary evaluator of the on-going program as a whole and of its various components.

THE PRE-PROFESSIONAL TEACHER

Larger high schools will no doubt provide a preparatory course for post-secondary career education in integrated pest management for those students whose career choice includes a decision to pursue further education after graduation. Some schools may establish a program with both pre-professional and vocational students doing their career preparation in school, on cooperative jobs, or both. Smaller schools may even combine integrated pest management with other agriculturally related programs in a general post-secondary preparatory course.

This means that the teacher assigned to this program needs to have a varied background. Since the students will be preparing for post-secondary education, the teacher should have had post-secondary education, more than likely in agriculture or an agriculturally related field. The fact that the program is career oriented means that the teacher also needs to have had practical work experience in integrated pest management, or some agriculturally related area, as well.

Since students in this type of program will be desirous of pursuing a variety of different careers it will be necessary for this teacher to make extensive use of all available individualized instruction techniques. Students will need direction to initiate an individualized learning plan by selecting objectives and planning activities and experiences necessary to assist them in carrying out the plan. The teacher's greatest assistance to the students will be in helping them interpret their experiences to see if the intended objective has been met. It will probably also be necessary to coordinate a number of students' experiences to see if they may be done together, in groups, to conserve time and resources.

THE PARA-PROFESSIONAL TEACHER

Employability is the key to the preparation of individuals for para-professional careers in integrated pest management. Whether program participants enter the world of work directly upon completion of para-professional level education and training or continue into professional level education, they must exit this stage with a high level of technical competence and a concentration of knowledge ranging from the broad based principles of pest management to the specific applications of these principles. Much of the knowledge previously gleaned by students from courses in pest management should be given practical application here through the development of skills indigenous to specific occupations or families of occupations within the area of integrated pest management. This critical need to augment knowledge with employable skills necessitates a high level of teacher involvement and individualization of programming. Para-professional teachers must, therefore, possess sophisticated skills inextricably linked to specific technician level occupations. These skills should have been developed through actual on-the-job experience as this direct experience will give the teacher an important perspective from which to impart many of these skills to students who will usually face employment, or possibly continuing education, or even both, at the culmination of para-professional education.

Essentially, the para-professional teacher's role is tied directly to these objectives:

1. The graduate should be prepared to take an entry level job as a technician and perform successfully in all occupational capacities.

2. The education and training, when combined with a reasonable amount of work experience, should facilitate the graduate's advancement to positions of increasing responsibility.

3. The foundation provided by the education and training should be broad enough to allow the graduate to pursue further educational and training opportunities at a later date.

The emphasis on specific skills development should be complemented by continued exposure to the modes and methods of utilization of these skills as well as by a heightened awareness of the applicability of these and other skills to other occupations both within and without integrated pest management. An appreciation for the roles these occupations and others play in the overall strategy of pest management should be developed, as well as a synergistic view of the discipline itself.

A number of occupations exist for which appropriate para-professional level education and training can be developed. These include positions on the advisory (field sweeper or scout, laboratory technician, plant science technician, meteorological technician, etc.), supervisory (application supervisor) and applicator (aerial, ground, water and structure applicators) levels. Training for these occupations should be based upon skills and knowledge requisite to successful occupational assimilation. These can be determined by students during exploratory exercises prior to actual skill development. The teacher should have employment experience adequate to the task of overseeing job analysis, as well as skill preparation, on the part of students.

The teacher should also possess enough familiarity with integrated pest management to insure that students augment skill development with coursework which will provide knowledge and aptitude in techniques and procedures for reporting data and results, field and laboratory sampling techniques, crop systems, biological systems, chemical principles and pests.

Essentially, the teacher's role continues to be that of a coordinator of the individual student's career preparation experience. However, just as the career preparation process continues to narrow, so too will the role of the teacher within that process. The teacher will need to begin acting as a manager of the preparatory experience, imparting numerous specific skills to the student, overseeing each student's total preparation program and guiding the student toward the objective of employability. Indeed, the teacher's role as manager should not end with this objective. Skills and knowledge requisite to occupational advancement should be available to para-professional students even after they have exited the educational process for entry level employment. The para-professional program should remain open for re-entry in order to facilitate advancement on the various career ladders within integrated pest management.

THE PROFESSIONAL TEACHER

The role of the professional teacher in career preparation for integrated pest management is definitely more varied and less easily defined than the roles of vocational, pre-professional and para-professional teachers. The teacher of the prospective professional in integrated pest management will, more than likely, be responsible for only one segment of that student's curricular necessities. Nonetheless, the professional level teacher must endeavor to remain cognizant of two ingredients which should permeate all of career preparation along the ladder from vocational to professional level training -- individualization and occupational relevancy.

The teacher's primary concern should be the preparation of students who can approach the problems of pest management and plant protection with a comprehensive and integrated point of view. The urgency of environmentally cogent approaches to pest control and crop management is expected to create a variety of new jobs in pest management, in addition to the numerous opportunities which presently exist in private enterprise and governmental agencies already concerned with plant pest control, crop protection and environmental protection. These opportunities will demand an increasing number of graduates who possess an understanding of the crop ecosystem as related to the management of all groups of pests through the application of biological, chemical and integrated systems compatible with a quality environment.

In general, courses of study which fall within the domain of integrated pest management at the professional level should facilitate students in their understanding of the following:

1. The philosophy and nature of, and the need for, pest management and plant protection.

3. The environmental interactions of plants, pests, crops, and protection measures.

4. The abnormalities of plants incited by both abiotic and biotic agents.

5. How plant protection enhances economic and aesthetic values of plants and environmental quality.

The specific knowledge and skills imparted to students will, of course, vary according to their occupational aspirations. Opportunities are available in such occupations as agricultural chemical sales, plant protection technician, county agent, extension specialist, researcher, teaching integrated pest management, and governmental and industrial advisor. In addition, the principles elucidated above should be of invaluable assistance to persons performing many occupations outside of pest control and crop management -- persons who need to nurture a professional concern for the environment in their day-to-day work, such as landscape architects, farmers, highway engineers and so on. Whatever the individual's occupational aspirations, the professional level teacher should define all elements of pest management applicable to that individual and attempt to communicate the correlation of theory to practice and equip the individual student with skills requisite to the wise application of theory to pest control and crop management. The professional level teacher should encourage a high degree of self-initiative among students, since the development of such refined aptitudes as conceptualization and problem solving are paramount to the production of able professionals in this interdisciplinary field of study.

THE ENVIRONMENTAL EDUCATION CORE FOR HIGH SCHOOL AND MDTA INTEGRATED PEST MANAGEMENT PROGRAMS

Man is interdependent with the environment. It is imperative that all men recognize this interdependence and the accompanying responsibility of man toward the environment. This is especially important for those in careers which allow greater impact on the environment --- as those in integrated pest management.

Integrated pest management personnel must acquire the specialized skills necessary to deal with problems relating to crops and pests. However, it is important that they understand fundamental environmental concepts that will allow them to view their work and decisions in the broadest context of global environmental impact.

The core program is comprised of study modules from the environmental studies program for high schools developed in 1972 by the National Association for Environmental Education through a grant from the Office of Environmental Education, the United States Office of Education.

CURRICULUM OBJECTIVES

To promote on the part of the student an awareness, concern and knowledge regarding the following concepts;

1. The biosphere is a closed system in which there are many complex interrelationships;

2. Man has environmental problems;

3. Man's endeavors are interrelated with all aspects of his environment.

4. Environmental problems are not limited to any one group and affect all of us, no matter how subtly or at what point in time;

5. Unlimited growth of living species will have important consequences on the future of the environment;

6. The student is in a position to propose and effect changes in the environment;

7. As members of an affluent society and because of their value systems, Americans can have a disproportionate effect upon the environment;

8. Most environmental problems are extremely complex, do not lend themselves to easy solutions, and may involve only such identifiable solutions as will create new problems;

9. Environmental control may involve some relinquishing of individual freedom;

10. The earth's resources are finite.

THE MAN-ENVIRONMENT SYSTEM

Overview

The planet Earth is a closed system, an oasis perhaps, spinning and whirling within a larger galaxy known as the Milky Way. The resources of the earth remain constant. Similar to a closed aquarium-terrarium, the Earth's only input from outside the system is the daily infusion of sunlight and the occasional invasion of a meteor. Natural cycles circulate and recirculate matter and energy in a continuous transfer from place to place, from one form to another.

For 4.6 billion years there has been a continuous inter-reaction of the Earth's organic and inorganic matter. While these great cycles are global in nature, their delicate balance can be upset by man's intervention. All forms of life including man are encompassed and involved within the organic whole of the planet. Because all forms of Earth life are interrelated and interdependent, the survival of all life forms are intimately connected with the continuing existance of each life form. Ecological diversity is one of the essential global truths of our finite environmental system.

Concepts

A. The Universe: its vastness; probability of other solar systems; distance and time factors indicate there is "nowhere to go".

The Solar System: its origin

The Earth: its formation as a unique planet; formation of physical and living organisms; the Earth as a closed system.

B. First ecological crisis in primordial times: entry of photosynthesis.

C. The delicate balance of life.

D. Evolution of life to man. The "Web of Life".

E. Second ecological crisis: Now.

ENVIRONMENT: GOVERNMENT, LAW & SOCIAL ASPECTS

Overview

Just as there is a natural or biophysical aspect of the environmental ecosystem, so is there a human or politico-social aspect, each affecting and being affected by the other. Two themes run throughout this module: first, the extent to which environmental concerns are involved in the functioning of the American political process today; secondly, an interpretation of the development of social concepts. the problem situations that selected actions were intended to meet, the reasons why we chose these rather than alternate solutions, and the continuing stresses today. We look at man and society as organized - or not organized - to deal with environmental problems today through the formal executive, legislative and judicial departments of government at all levels, through the conflict-oriented phases of political processes, and through a variety of voluntary eco-action organizations.

The student is introduced to political and social strategies for influencing public opinion and governmental decisions regarding the environment. This module is the practical "civics" of environmental studies.

Concepts

A. Man can learn to manipulate, control and effect change within the political arena.

B. The law is an instrument to effect and/or impede environmental change.

C. The function of government: is it to lead or serve?

D. Judicial, executive, legislative areas of government are interrelated but each can promote or obstruct progress toward a good environment.

E. Establishment of governmental priorities create conflict and militate against environmental change.

F. Social-economic-environmental concerns and law priorities overlap.

G. Political environmental conflicts are reflections of varying value systems which in turn are the extension of individual life styles.

POPULATION AND THE ENVIRONMENT

Overview

The world ecosystem is a dynamic system. Populations within this system are constantly changing in numbers, compositions, and distribution due to the influence of both natural and man-made factors. Increased human population growth has created many personal, social and ecological problems, and has complicated the solutions of many others. Action to stabilize the world's population has given rise to a number of controversial issues involving the fundamentals of life itself. Yet, the present rate of population growth, unprecedented in history, has reached the point where future alternatives for population change must be mapped in order to preserve the existence and quality of life on this planet.

Concepts

A. Demographic data provides information and methodology for understanding concepts of population changes.

B. A knowledge of population trends in the United States and international communities helps man to understand past and present population changes.

C. Human and other populations within the earth's ecosystem are constantly changing in numbers, composition, and distribution. Factors producing these changes emerge from both natural and man-made systems.

D. Man should understand the implications of population trends and determine alternative plans for the future. By pooling human resources, man is capable of developing realistic and operational solutions to problems of population change.

THE INDIVIDUAL AND WHAT HE CAN DO

Overview

Learning about the environment should be an active process in which students participate in the solution of specific environmental problems which are related to the resolution of the global environmental dilemma. This approach is recommended for two reasons: first, educators believe that the inquiry method is a superior learning technique, and secondly, critical environmental problems lend themselves easily to this approach. However, student involvement should be responsible and intelligent, and it should lead to sensitivity about the environment, individual growth, self-esteem and commitment.

Such a learning process not only facilitates the student's current learning, but provides a model for future study and action, both as an individual and as a member of voluntary citizen groups.

What can the individual do? He can become <u>informed</u> about environmental problems, he can accept <u>responsibility</u> for the quality of his environment, he can become <u>involved</u> in individual and group programs to improve the environment, and he can develop a <u>sensitivity</u> to the world in which he lives.

Concepts

A. The individual should become <u>informed</u> about his environment. This is a process of identification of problems, gathering data and synthesizing information. Underlying this concept are the presuppositions that each individual is a member of many ecosystems and that the aesthetic quality of life is a good in itself.

B. The individual should be <u>involved</u>. Involvement is contingent upon a person's being informed and responsible. The person who wants to be involved should develop a positive self-image, remain flexible to change, be open to interdisciplinary learning approaches and recognize that group involvement and cooperative effort are good and necessary in today's world.

C. The individual should be <u>responsible</u>. The responsible person is one who acts from rational motives, chooses a responsible life-style, is open to continuous evaluation and feed-back, and chooses wisely his educational, occupational and life goals.

D. The individual should be <u>sensitive</u> to the environment. Sensitivity is the ultimate result of being informed, involved and responsible.

THE PAST AND PLANNING FOR THE FUTURE

Overview

The purpose of this module is to give the student an understanding of the biological and behavioral nature of man. Man is dependent on his ever-changing environment for his own development, and as the dominant species in the biosphere his attitude and behavior toward the environment can determine its quality and future usefulness. Man is a complex being, often dynamic and resourceful, but sometimes short-sighted in his solution to problems. This module is intended to give the student the long-range view toward the environment and help him form proper attitudes and behavior patterns for the future.

Concepts

A. Man in his behavior, life styles and structural system is a complex organism.

B. Man's behavior changed initially as a result of natural selection pressures and is continuing to change now as a result of artificial (man-created) selection forces.

C. Man has attempted to solve problems for short-term gain without considering the long-term implications of his decision.

D. Man's present actions, behavior, and values will determine his future but he can mold the future through planning.

E. The sum total of man's experience, including his cultural heritage and his socio-economic beliefs, influences his formulation of solutions to problems.

F. Man must structure new modes of thought in order to plan for the future.

G. Man must learn to differentiate between that which has substantial worth and that which has transient value; the former he must respect and preserve.

H. Exponential growth and resource consumption ultimately affects man's ability to preserve and plan his life on earth.

I. Man is able to transcend his own environmental experiences in order to plan for the future.

FOODS, ADDITIVES, PESTICIDES, HERBICIDES, DRUGS AND THE ENVIRONMENT

Overview

Ingenious and revolutionary changes have occurred in methods of mass-producing, transporting, storing, packaging and marketing of food for modern man. However, in these changes there are inherent dangers and threats to man's health and survival. Artificial hormones, antibiotics, dyes, flavorings and preservatives have been added to food; remnants of fungicides and pesticides are found in agricultural products; wastes, poisons and refuse are sometimes included in large-scale food production.

Further, man's ignorance of basic food and nutritional requirements has made him the object of exploitation and profiteering by advocates of food fads, vitamins, etc. As a consequence, his diet is often not only inadequate but harmful.

The purpose of this module is to build an understanding of sound nutrition and an awareness of the problems inherent in mass-production and distribution of food.

Concepts

A. The composition of food is complex.

B. The composition of food varies as a result of manipulation and contamination.

C. The composition of food is modified to enhance its quality and quantity and for the sake of convenience.

D. Food additions and deletions are the result of production and processing practices.

E. Certain food and feed additives may constitute an immediate or long-range health hazard for organisms.

F. Certain food and feed contaminants may constitute an immediate or long-range health hazard for organisms.

G. The individual must recognize his responsibility and work cooperatively with other persons and agencies to ensure the proper production and distribution of food.

WILDLIFE

Overview

The concept of wildlife should not be limited to what is sometimes known as wildlife but should include all varieties of living things. Wildlife is a precious resource because once the species is extinguished it cannot be recreated by any means presently available. Protection of wildlife is important for a variety of reasons, both aesthetic and utilitarian.

Efforts to preserve wildlife should not be concentrated merely on direct preservation of species and habitats but should look also to those human activities which affect the preservation of species.

Population growth and increased technology throughout the world are threatening wildlife on a global scale. Wildlife management, therefore, should be presented to students so that they will have a realistic and balanced view of the current situation.

Concepts

A. All wildlife species and varieties of life deserve protection from extinction, for a number of reasons:

   1. aesthetically, diversity of species makes earth an interesting, stimulating habitat for people of all tastes;

   2. ethically, man must recognize that non-human entities have their place in the ecosystem.

B. Man's endeavors are related to the survival of wildlife species.

C. An affluent society's increased growth, mobility, land use and power needs infringe on and destroy wildlife and its habitats.

D. Earth's wildlife resources are finite.

E. Wildlife has sometimes been mismanaged or exterminated because either man was threatened by nature or he miscalculated the abundance of life.

F. Man must assume the responsibility for the continued existence and balance of all species.

G. Certain species are currently in danger of extinction.

H. Wildlife management requires international cooperation.

I. The quality of wildlife is an effective environmental barometer for all species.

J. A species' ability to change may not be equal to the demands placed upon it by man's manipulation of the environment.

K. Native species may be better adapted to a habitat than introduced species, e. g. the native large game animals of Africa may produce more protein and less environmental damage than the cattle, goats, and sheep which have been widely introduced there.

L. On the other hand, some introduced species may thrive and become pests due to lack of natural enemies.

ENVIRONMENTAL ETHICS

Overview

This module is designed to introduce the student to ethical standards of the past and present regarding the environment and to facilitate the formulation of a personal ethic.

Man must share the bounty of the planet Earth with all its present inhabitants and preserve it for future generations. He should be concerned about both living and non-living things which are part of this bounty and contribute to its variety.

Man must respect, too, the various cultures of his civilization. Some cultures are deteriorating because their values and customs have not kept pace with progress of technology. Cultures and technologies can produce reasonable material satisfaction and can preserve the diversity of life on the planet, but they must be modified when they infringe on the rights of present or future inhabitants of the Earth.

The overriding responsibility of societies and individuals is their stewardship of the Earth's resources.

Concepts

A. The environmental ethic is derived from a continuous process of examination of all available sources of information.

SOIL POLLUTION AND EROSION

Overview

Although the soil is merely a thin film that covers a small part of the Earth's surface, it is essential to life. The soil has many uses; it is the medium and the participant in essential ecological processes.

The cultural, social and economic development of different regions are related to the variations in soil from locale to locale. Man's future and the future of all life are dependent on the wise management of the soil both locally and internationally. The population increase makes it even more imperative that an intelligent conservation ethic regarding soil be developed.

Concepts

A. Soil is an essential commodity with various uses: biological, sociological, chemical, and physical (nature and man-made).

B. Soil is the result of chemical and physical and biological changes. Some are natural, others are caused by man.

C. The physical and chemical composition of soil varies, e. g. physically, in stratification and water-holding capacity; chemically, in its organic or inorganic composition.

D. Soil is both a medium of and a participant in ecological processes, e. g. medium: decomposition, anchorage of plants, and habitat; participants: nutrients cycles, food chains, water cycles, and water purification.

E. Man is capable of managing the soil in both positive and negative ways, e. g. cultivation, irrigation, mining, industrial landfill, construction, etc.

F. Effective soil management in the future will require a soil conservation ethic which will govern management practices.

THE ENERGY CRISIS AND THE DEPLETION OF NATURAL RESOURCES

Overview

Increased world population in conjunction with increased per capita demand has raised the consumption levels of energy and natural resources to an alarming level. Research and applied technology have not yet discovered solutions to this environmental crisis.

It is essential that man understand the basic principles and interactions of matter and energy and examine closely the use and abuse of energy and natural resources in the past and present.

This module is designed to make the student aware of this environmental crisis and to provide a framework within which he might plan future use and management of natural resources. Such planning will include economic, political and sociological factors.

Concepts

A. Energy is found in several forms. The form of energy can change but efficiency is lost in the process.

B. Within an ecosystem the recycling of matter and flow of energy are interrelated.

C. Due to increased growth and consumption patterns, there is an increasing demand for resources that are limited.

D. Increased resource demands have an increasingly profound impact upon the environment of the world.

E. Resource use and development affects and is affected by economic, political, and technological systems.

F. Solutions to this environmental crisis will require new technology, change in life styles and both short-and long-range planning.

THE ENVIRONMENTAL EDUCATION CORE FOR COLLEGE INTEGRATED PEST MANAGEMENT PROGRAMS

Man is interdependent with the environment. It is imperative that all men recognize this interdependence and the accompanying responsibility of man toward the environment. This is especially important for those in careers which allow greater impact on the environment --- as those in integrated pest management.

Integrated pest management personnel must acquire the specialized skills necessary to deal with problems relating to crops and pests. However, it is important that they understand fundamental environmental concepts that will allow them to view their work and decisions in the broadest context of global environmental impact.

The core program is comprised of study modules selected from the college general education environmental education course developed nationally in 1970. Considerable support materials are available for these modules.

COURSE OBJECTIVES

Over-all Objective: To have students recognize man's interdependence with his environment and his responsibility for it.

General Objectives: To develop awareness and understanding of:

1. Self: Need for optimum psychological and social satisfaction
2. Nature: Psycho-bio-cultural
3. Environment: External; internal; natural; man-made
4. Change in the environment: Social institutions
5. Interdependence in the environment
6. Interaction in the environment: Psycho-bio-cultural
7. Consequences of change: Man as an ecological dominant
8. Man's responsibility for the environment: Individual, group, governmental
9. Our ecological past
10. Our obligation to future environment: Survival; the human dimension
11. Rational knowledge and the function of habits, emotions, values
12. Belief systems
13. Environmental problems

14. Alternative courses of action toward the solution of environmental problems

15. Individual involvement

THE MODULES

Ecological Imperatives

Objectives

1. To acquaint the student with ecology at four levels of involvement: personal, regional, national, international, through the use of several well defined case histories.

2. To help the student recognize his responsibility for participation at all levels.

3. To realize that environmental interrelationships are not easily quantifiable but can be subtle and complex.

4. To demonstrate to the student that adverse environmental changes have immediate impact and/or cumulative effect on the well being of the individual.

5. To help the student understand the nuances of regional regulations, laws, statutes, and local ordinances.

Overview

This module would convey (1) a clear understanding that man is an inseperable part of a system composed of men, culture and the natural environment, and that man's technology alters the interrelationships of this system; (2) an appreciation of the environment, both natural and manmade; (3) a fundamental knowledge of the problems confronting man, ways to solve these problems, and the need for citizen and governmental partnership in working out solutions, and (4) attitudes, ethical standards, and behavioral patterns which will foster citizen commitment and action to overcome the environmental crisis and to improve the quality of life in the 70's and 80's.

THE NATURE OF MAN

Objectives

1. To develop a knowledge and awareness of man's biological nature.

2. To recognize that man is not unique with respect to his use of energy, and employment of physical, biological and chemical processes.

3. To accept that man is the ecological dominant. By virtue of this, he is the greatest single modifier on the environment.

4. To develop a knowledge and awareness of man's social behavior.

5. To recognize the interrelationships between man's biological and social nature as they pertain to the environment.

6. To understand that success of behavioral models is determined by compatibility with environment.

Overview

This module provides an understanding of the biological and behavioral nature of man. Having evolved as a product of a unique environment which has continually changed, the importance of man's relationships to his environment (habitat) is emphasized. Because man is the ecologically dominant species, his attitude and behavior towards the use of the environment are crucial to his future success.

VALUE SYSTEMS --- ECOLOGICAL PRIORITIES

Objectives

1. To show that man is a part of the biosphere.

2. To illustrate contemporary examples of the chaotic present.

3. To identify historical antecedents of the chaotic present.

4. To suggest alternative paths to an ecologically sound future.

5. To recommend humane priorities which might lead to a desirable alternative future.

6. To suggest alternative learning situations where the student and teacher together might discover insights into ecological awareness --- past, present and future.

Overview

This module is designed to show that at the base of our present chaotic world situation there lies a deeper crisis --- a value crisis. In order to describe and make this relevant to the present generation of students, it is necessary to begin where they and we are (in the chaotic present), and illuminate or highlight pertinent examples of this chaos and then to search for historical antecedents, relating these to the present and suggesting alternative paths toward an ecologically sound future.

BELIEF SYSTEMS

Objectives

1. To recognize man's traditionally anthropocentric view of his environment.

2. To illustrate contemporary examples of the chaotic present.

3. To identify historical antecedents of the chaotic present.

4. To suggest alternative paths to an ecologically sound future.

5. To recommend humane priorities which might lead to a desirable alternative future.

6. To suggest alternative learning situations where the student and teacher together might discover insights into ecological awareness --- past, present and future.

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BELIEF SYSTEMS

Objectives

1. To recognize man's traditionally anthropocentric view of his environment.

2. To identify man's historical rationale concerning his unrestricted utilization of his environment.

3. To explore the attitudes of those societies exhibiting a compatability with environment.

4. To examine the alternative to those beliefs which are presently incompatible with a harmonious ecosystem.

Overview

The tradition of man as the ecological dominant characterizes the views of many societies. Much of this is predicated on the historical direction taken by man in his formulation of institutions to deal with his environment.

THE MYTHS OF TECHNOLOGY

Objectives

1. To define technology and relate it to such areas as science, industry, government and family unit.

2. To identify and examine examples of "myths".

3. To enable existing myths to be discovered and identified in the community.

4. To define growth and identify examples of it.

5. To develop a questioning attitude and a critical faculty for analysis of myth and reality in the modern industrial - technical society with respect to environmental problems.

6. To study how to use some of the existing myths in our society for the improvement of the environment.

Overview

This Module presents a definition, discussion, examination and analysis of myths of technology. It attempts to develop a questioning and an analytical attitude toward statements which are indeed "myths". Strategies of using technology and the myths in a positive way with regard to environmental problems are considered.

Economic growth increases material wealth, but it has a growing number of unfortunate side effects --- each individual tries to increase his own benefits within an increasingly crowded environment. Growth is as deeply entangled in our economic thinking as rain dancing is in other societies.

Too often progress has been equated with growth, change, exploration rather than a real improvement in the quality of life.

Technology has the wherewithall to reduce the degradation of the environment. How industry can be made to do this with least disruption to mankind is the question.

CONCEPTS OF CHANGE

Objectives

1. To attempt to identify any unchanging condition in the following:

   a. Himself
   b. His family
   c. Society
   d. The world
   e. The universe

2. To observe two or more kinds of change.

3. To make a comparative systematic analysis of the rate and predictability of change in one of the kinds of change mentioned in Objective 2.

4. To identify the consequences of change.

5. To study the rationale of human resistance to change.

Overview

This module is designed to demonstrate to the student the inconstancy of the physical and the living environment. He is expected to identify some of the types of change and to select one of these types for an in-depth comparative study of the factors effecting change and the consequences to be expected from such change.

EARTH AS AN ENERGY SYSTEM

Objectives

1. To consider the Earth as an open or closed energy system.
2. To appreciate the implications of the laws of thermodynamics as they relate to ecosystems.
3. To understand the rapid use of our potential energy source (fossil fuels) --- the rate of energy expended exceeds the energy accumulation.
4. To consider and understand that pollution is a consequence of energy expenditure.
5. To consider the need of man to explore new energy sources and the possible consequences resulting from this usage.
6. To understand the wise use of available energy.

Overview

The following is a direct quote from: Resources and Man, Committee on Resources and Man, Natural Academy of Sciences, Natural Research Council, W. H. Freeman & Company, 1969, Page 157.

"Into and out of the earth's surface environment there occurs a continuous flux of energy, in consequence of which the material constituents of the earth's surface undergo continuous or intermittent circulation. By far the largest source of this energy flux is solar radiation, a small fraction of which is captured by the leaves of plants and stored as chemical energy. This chemically stored solar energy becomes the essential biological energy source for the entire animal kingdom. In particular, it supplies the energy required as food for the human population.

During geologic history, a minute fraction of the organic matter of former plants and animals became buried in sedimentary sands, muds, and limes, under conditions of incomplete oxidation. This has become the source of our present supply of fossil fuels --- coal, petroleum and natural gas."

CONSERVATION OF VITAL RESOURCES

Objectives

1. To develop an awareness of the fact that "conservation" implies maintenance, preservation and regeneration of vital resources.

2. To define what constitutes a vital resource.

3. To identify principal categories of vital resources.

4. To identify those vital resources which are non-renewable (non-living).

5. To identify those vital resources which are renewable (non-living).

6. To identify those vital resources which are self-regenerative (living).

7. To illustrate the interrelationships between categories of vital resources (since substances vital to life often occur in cyclic or other relationships between the living and non-living aspects of the environment).

8. To observe man's role in the total conservation pattern --- including sociological, technological, biological, political, and economic aspects of vital resources management.

Overview

Vital resources may be categorized as being either renewable or non-renewable. This represents a continuum rather than a dichotomy. If man is to survive as a species with a life style commensurate with todays standard of living, he must be aware of the resources essential to himself. These resources may be living or non-living; renewable or non-renewable; regenerative or reusable. When making an intelligent decision regarding the conservation of a vital resource, man must be able to recognize the inter-relationships of the vital resources in the terms mentioned above. In addition, man must also be aware of the many social, political, economic, and healthful implications involved when he makes a decision of this kind.

POPULATION DYNAMICS

Objectives

1. To make the student aware that overpopulation is the underlying cause of our environmental problems.

2. To give the students an overview of the history of human population growth.

3. To determine the limiting factors of population dynamics.

4. To determine the human constraints to effective population regulations.

5. To suggest effective measures for limiting populations.

Overview

The world's population, which was approximately 3.5 billion in 1969, increases about 2% every year. If it continues at this rate, the world population will double by the year 2000. Our present population increases by 180,000 daily --- or more than 65 million a year. Half of the population now living on earth has been born since the end of World War II (1945).

The magnitude of the problem arising from this unprecedented multiplication of the human species has stirred the concern of thinking people everywhere. The expansion in world populations, projected for the remainder of this century, is staggering. The impending disaster, foretold by these statistics, decries the immediate concern of the world's approximate 3.6 billion.

WATER --- SUPPLY, DEMAND AND POLLUTION

Objectives

1. To define the problem of water supply, demand and pollution.

2. To develop an awareness of and concern for the problems involved in the above item.

3. To identify the natural water cycle.

4. To identify man's uses of --- and thereby, his effect on --- the natural water cycle.

5. To develop an ability to recognize and define local problems.

6. To develop an awareness of various means of eliminating the problems identified in this module.

Overview

This module deals with water --- supply, demand and pollution. It is designed to bring into awareness the factors causing the problem; methods of defining the problem; the scope of the problem; and the means of alleviating the problem.

The module is so structured that instructor and students progress as follows: (1) The problem identified; (2) Presentation of basic information for understanding the problem; (3) A commitment engendered in and by the student that the problem must be solved; (4) Appropriate involvement on the part of the student in which he translates his concern into action.

AIR POLLUTION

Objectives

1. To develop an awareness of and concern about air pollution.

2. To give the student an insight into the biologic role of normal atmospheric components.

3. To identify atmospheric pollutants.

4. To understand the meteorologic conditions influencing pollution.

5. To understand the effects of air pollution and their mechanisms.

6. To understand methods of control.

7. To involve the students in the recognition of air pollution problems and the implementation of various courses of action.

Overview

The acute effects of urban air pollution are well documented by extensive studies of air pollution disasters. The intermittent and sub-threshold effects await further evidence, however air pollution control should be immediately pressed and not await full illumination of pollutant effects and mechanisms of action.

Community pollution control eminates from individual concern and individual action. The student should be made aware of the necessity for his participation in the implementation of air pollution control.

FOOD AND DRUG POLLUTION

Objectives

1. To acquaint students with the accelerated abuses of food by the inclusion of additives, adulterants, preservatives and pesticides.

2. To explain the detrimental implications of these pollutants through natural food chains.

3. To inform the students of the biocultural implications of medication abuse.

4. To investigate various points of view in regard to the issue of food and drug pollution.

5. To investigate and evaluate methods of control.

6. To involve the students in the recognition of food and drug pollution problems and the implementation of various courses of action to deal with these problems.

Overview

Certain chemical additions are generally considered prerequisite to obtaining efficient crop yields and insuring proper preservation of our food. However, other chemical additions are strictly consumer-oriented and their inclusion in our foods in questionable at best, and may indeed constitute a real health hazard. Remedial measures will involve not only experimental identification of the toxic agents, but certainly will require reconstruction of consumer attitudes with regard to the marketing and merchandizing of his foods and drugs.

WILDLIFE AND MAN

Objectives

1. To define the meaning of the term "wildlife".

2. To understand the interrelationship between wildlife and the environment.

3. To recognize the misuse of wildlife.

4. To recognize the misuse of wildlife habitat.

5. To determine social factors causing misuse of wildlife and wildlife habitat.

6. To determine the effects of man's activities on wildlife.

7. To determine the effects of man's wildlife activities on man himself.

8. To recognize man's efforts to conserve wildlife.

Overview

This module seeks to determine wildlife's place in the environment with respect to man. It is intended to show that wildlife is an integral part of man's environment, and that this activities affect the wildlife around him either negatively or positively. This module attempts to point out some of the errors that man has made in the past, and some of the losses and disasters that have occurred as a result of man's ignorance, greed, or thoughtlessness.

An attempt is made to show how man can profit from his past mistakes and strive to protect endangered species, regional and local wildlife populations, and the natural woldlife balances.

FORESTS AND MAN

Objectives

1. To define the meaning of the terms "forests" and "forest resources".

2. To identify different forest types of the United States.

3. To understand the interrelationships within the forest communities.

4. To understand the interrelationship between the forests and the surrounding environment.

5. To recognize the misuse of forests.

6. To determine social factors causing use and misuse of forests.

7. To determine the effects of man's activities on forests.

8. To determine the effects of man's forest activities on man himself.

9. To recognize man's efforts to conserve forests.

Overview

This module attempts to point out the significance of forests as a major part of man's environment.

Man has been and is now greatly influenced by the various types of forests and he, in turn, has a profound effect on forest communities. This module attempts to point out both the positive and negative aspects of this profound effect.

Also examined in this module is how man may avoid mistakes in utilizing forest recources by learning from past experiences and how man can enhance the forest communities by careful scientific planning and implementation of sound forestry practices.

GRASSLANDS AND MAN

Objectives

1. To define the meaning of the term "grasslands".

2. To identify different grassland types in the United States.

3. To understand the interrelationships within the grassland communities.

4. To understand the interrelationship between the grasslands and the surrounding environment.

5. To recognize the misuse of grasslands.

6. To determine social factors causing misuse of grasslands.

7. To determine the effects of man's activities on grasslands.

8. To determine the effects of man's grassland activities on man himself.

9. To recognize man's efforts to conserve grasslands.

Overview

This module is built around the premise that the grassland areas of the United States (and the world) constitute a major part of the earth's environment.

Man has been, and is now, greatly influenced by the various types of natural grasslands and the cultivated farms which have replaced them. He, in turn, has had a profound effect on the grassland areas.

This module attempts to point out both the positive and negative aspects of man's conversion of natural grasslands to agriculture. Also considered in this module are man's mistakes in utilizing grassland resources and their effects on soils, waters and the American society.

The present scope of agricultural use of grassland areas and the resources, products and services provided are discussed, together with the history of land-use practices in the nation.

With increasing demands for food and other products of grassland animals by an expanding population, the emphasis is placed on maximizing use and productivity of grassland and former grassland areas, minimizing losses to insects and disease, and minimizing losses of soil and water resources.

SOIL AND MAN

Objectives

1. To define soil resources.
2. To investigate soil types.
3. To investigate interrelationships within soil communities (with plants, animals, micro-organisms).
4. To investigate the interrelationships between soil communities and environment.
5. To recognize soil uses.
6. To recognize misuse of soils.
7. To determine social, economic, political, familial, ethnic, cultural, religious and individual factors.
8. To relate knowledge developed above to problems of immediacy as they relate to local, regional, national and global concerns; (move from local to global concerns).
9. To relate soil concerns to the urban-suburban-rural environments.
10. To point out that the urban student (as well as the non-urban student) is intimately dependent upon soils.
11. To recognize principal efforts to conserve (use wisely) local, state, regional, national and global resources.

Overview

The student will investigate local soils through personal experience in the field, or samples and examples which have been prepared for the classroom. This gives him a background for understanding the definition of soil, and prepares him for determining the constituents of soil. After investigation and experience with local soils, the student may then study and compare world soil classes and types, and how they affect him personally, as well as the impact they have on various world cultures.

With this background, he may better understand the relationships within the soil community, and the interrelationships with surrounding environments. Value judgments can be developed by investigation of local and world uses of soils and soil products. Through a contemporary and historical approach, the student develops an awareness and understanding of the abuses and misuses of soil resources. Personal involvement may be put into perspective by attaining an awareness of the citizen's role with respect to social, governmental, economic, ethnic and religious factors.

The most significant concept arrived at in this module might be that of developing and implementing conservation practices in our multi-use of soils. This might come about through using a basis of the historical approach, and in turn leading to an investigation of contemporary soil conservation practices and their impact on man.

ROCK AND MINERAL RESOURCE MANAGEMENT

Objectives

1. To define rock and mineral resources.

2. To develop in the student an understanding of the origin and occurence of various rock and mineral resources.

3. To develop in the student an understanding of some of the processes involved in mineral exploration and recovery.

4. To understand the various uses of mineral resources.

5. To make the student aware of the significance of rock and mineral resources in the world affairs and socio-economic concerns.

6. To bring about an awareness of the problems of effects of exploration mining, processing, using and disposing of the resources on our environment.

7. To bring about an awareness of the need for intelligent management of rock and mineral resource reserves.

8. To recognize and understand local rock and mineral resources, requirements and associated environmental problems.

9. To develop an understanding of the processes involved in planning and implementing of rock and mineral resource conservation and environmental control.

Overview

Rock and mineral resources are necessary to satisfy many of man's physical, biological and cultural needs, and are of great significance in world affairs. Resource demands are increasing both in among and variety, and have produced concomitant supply and environmental problems. These associated environmental problems occur at every stage of rock and mineral resource utilization. Consideration is given to the alternative measures available for problems of supply, and to methods of controlling the various effects. The student should become aware of local rock and mineral resource utilization and involved with local problems.

INDIVIDUAL INVOLVEMENT

Objectives

1. To survey specific environmental problems.

2. To study existing environmental conditions, and evaluate the quality.

3. To plan and evaluate theoretical models related to appropriate courses of action.

4. To implement the plan of action.

5. To evaluate the effectiveness of the actions taken.

Overview

This Module is intended to present the student with the guidelines by which he addresses himself to a specific problem and charges him with applying the knowledge acquired in this segment of the course, in our effort to improve the environmental condition. He is directed in such a way as to apply the scientific method to the problem, thus providing a logical frame of reference in which to work.

CAREER PREPARATION FOR INTEGRATED PEST MANAGEMENT

This was written independently of the Integrated Pest Management Conference at which course outlines for this book were developed. Thus, job titles used here may differ from those decided upon at the Conference.

INTRODUCTION

The United States, like other nations, faces a dilemma of increasing food production on the one hand and maintaining environmental quality on the other. In an attempt to deal with this dilemma, there has been a rapidly emerging program of investigation into new methods of more effective and environmentally desirable pest control. As a result there are increasingly more employment possibilities available in the field of integrated pest management.

The implementation of an integrated pest management program is crucial as the federal government and private industry attempt to discover methods to control pests which result in a minimum of adverse effects on the environment. There are a variety of jobs available in integrated pest management ranging from behind the scenes developmental work to activities that require direct contact with the consumer.

Many of the jobs associated with integrated pest management exist in only limited numbers at the present, or in some instances scarcely exist at all. These jobs are defined, however, because they have been identified by a group of experts as being necessary to the development and implementation of an integrated pest management program.

Jobs in the field of integrated pest management are divided into three major categories --- applicators, advisors and supervisors. The educational requirements for these jobs range from high school programs to graduate education in a university.

DEFINITION OF INTEGRATED PEST MANAGEMENT SERVICES

In this occupational group the workers are involved in methods of controlling specific pests through the maximum use of natural pest population controls, combined with techniques such as biological controls, pathogens, sterilization and selective chemicals when required.

The workers are concerned with the classes of pests that have the potential of affecting the total crops in specific geographic areas. Thus, the jobs include those which directly relate to the physical application of pest control products, those which are involved in assisting the consumer in defining a pest management problem and to identify, propose and recommend solutions to that problem and those jobs that deal with the supervising of a major function or the work activities of other people employed in integrated pest management programs.

SCOPE OF INTEGRATED PEST MANAGEMENT SERVICES

This occupational group includes jobs at all levels of complexity and responsibility. During the development of the integrated pest management concept, many jobs will be associated with developmental and consulting services. As decisions are made concerning the application of selected chemicals, additional jobs will become available.

At the highest level, the talents required of the people employed include a high degree of understanding and knowledge about various techniques available in pest management. In addition, these persons are often required to interact with collegues and consumers on a regular basis. A personal commitment to improve the methods of pest management, to minimize the adverse affects will help the worker to be successful in this field.

At the lowest level, the talents required of the people employed include skills such as driving heavy equipment, piloting an airplane and knowledge of application techniques. Assistants, here, must engage in loading, unloading and mixing. This work requires a willingness to follow directions and an ability in manual skills.

SOCIETY AND INTEGRATED PEST MANAGEMENT SERVICES

Persons employed in integrated pest management programs are performing jobs which have been developed because of the dissatisfaction of society with traditional methods of pest control. As a result, society's increased awareness of the need to protect the quality of our total environment has led to legislative restrictions on the use and application of the many chemicals used for plant protection. It has also led to the establishment of certain standards that must be met by individuals involved in making plant protection recommendations or the application of agricultural chemicals. Thus, demands are being established in government and private industry for persons broadly educated and trained in the ecological approach to pest management and plant protection.

The controls and limitations of pests which affect man and his environment are of primary concern to those who produce, process and market the food and fiber of the nation. Since the control methods used have broad implications for the entire ecosystem, society in general is actively involved in the development of constraints which shape the broad parameters of pest management.

People employed in the field of pest management, then, are answering a plea from society to solve one of the most crucial problems faced by the nation. Truly, workers in this field are engaged in timely and worthwhile activities.

INTEGRATED PEST MANAGEMENT CURRICULA

Training for jobs in integrated pest management is developed on the basis of proficiencies related to the various employment opportunities. Training programs may exist in four levels of education: (1) the high school; (2) the MDTA skills center; and (3) the community college.

This section contains proficiency based curricula that may exist in each of these educational levels. The jobs included are those for which either complete or partial training could appropriately be offered by the specific educational institution.

THE HIGH SCHOOL

The list of jobs below has been developed with the idea in mind of the secondary school as it exists in most communities today. There are some jobs, however, such as a "technclogist" that are sometimes seen as inappropriate for today's secondary school. There are certain "technology" jobs that are included in the list that partial training can be offered in the secondary school and for that reason are listed.

The jobs in this list cover a remarkably broad range. This being the case, it is difficult to identify common basic proficiencies for all jobs. However, the following five common elements seem to apply to all of these jobs:

1. Basic communication skills
2. Appreciation of the need for pest control
3. Receptiveness to the philosophy of control through integrated pest management
4. General knowledge of the pest universe
5. Sensitivity to the environment

Major Job Clusters

Because these jobs vary so widely, their scope may very probably be better described by dividing them into clusters. The jobs, for which training is available in the high school, appear to lend themselves to being divided into three major clusters:

Cluster I: Applicator Jobs

This category includes jobs which directly relate to the physical application of pest control products. Jobs performed under supervision with a certain amount of controlled or limited decision making responsibility. Most applicators must possess skills in the operation of some type of vehicle in addition to a knowledge of application techniques. (These vehicles might include a plane, helicopter, truck, tractor, boat, etc.).

The applicator's decision making responsibility requires an elementary knowledge of crop production, growing cycles, weather conditions and precautionary procedures needed in application of pest control products. This person ultimately makes the final decision whether or not to apply the pest control product --- based on his evaluation of the conditions in existence at the time of the examination. If for any reason he does not believe a pest control product should be applied at that time, it is his responsibility to make this decision and then immediately discuss it with his supervisor. His decision might be based on wind conditions, specific crop characteristics, content of adjoining areas, etc.

Job opportunities of this type appear to be plentiful at this time. However, the person engaged in this type of work would be expected to travel as dictated by the growing seasons in various parts of the country. Less travel would be required if the individual was skilled in a wide variety of application techniques and as a result, could work on different crops in any locality.

The general proficiencies that the student should possess at the end of a training program are as follows:

1. Be aware of acute hazards of chemicals and biologic agents and take all precautionary measures for protection.

2. Possesses knowledge of proper operation and safety of application equipment.

3. Knows the procedure used in maintaining simple field records.

4. Has a sound knowledge of the kind of chemicals and biologic agents used, their formulation and their general characteristics, efficacy and potential adverse effect on non-target organisms.

5. Possesses basic knowledge of the pest species being controlled.

6. Knows the crop system and the role of chemicals and biologic agents in relation to that system.

7. Possesses knowledge of application principles in relation to meteorological conditions.

8. Must be aware of laws and regulations which govern his operational procedures.

9. Possesses ability to follow directions carefully and be concerned with accuracy in operation.

<u>Cluster II: People Oriented Jobs</u>

People oriented jobs are generally those positions contained under the designation, Advisors. Advisor positions in integrated pest management are involved in some manner with assisting the consumer to define a pest management problem and subsequently identifying, proposing or recommending alternative solutions to that problem.

All of the jobs in this area involve direct contact with the consumer.

Advisors depend on the supportive personnel to make recommendations about integrated pest management that the advisor can pass on to the consumer.

Advisory personnel will be required to possess an increasing level and breadth of educational experience to be adequately prepared for job entry as well as continuation in the field. At the present time entry into people oriented jobs can be through on-the-job training as well as the customary educational route. It is expected that increasingly, post secondary educational programs will be required for entry into these positions. In many cases, completion of an associate degree may be required.

The general proficiencies for people oriented jobs are:

1. Possesses elementary knowledge of botany, of how plants grow and of environmental effects on plant growth.

2. Possesses knowledge of the chemical product and its effect on living systems and the environment.

3. Possesses basic knowledge of chemical and biological principles.

4. Possesses knowledge of chemical products and pest management procedure.

5. Possesses elementary knowledge of soils and nutrient requirements of plants.

Cluster III: Technician Jobs

Technician jobs are supportive functions that fall in the advisory category. Technician jobs do not involve direct contact with the consumer. By being supportive to the integrated management system, they enable the professional advisor to make recommendations to the consumer based on the most accurate and most appropriate information available.

The jobs included in this area may, to a slight degree, overlap with those in the applicator area. The degree of overlap should, however, be quite limited and occur only in the areas of research and testing.

In all technician jobs it is required that personnel are highly trained in the chemical or biological sciences and are able to apply basic reasarch and analysis techniques in the laboratory. Increasingly, the higher level technology jobs will require education beyond the high school. These are, however, positions from which secondary school training is adequate.

The general proficiencies for technician jobs are as follows:

1. Possesses an elementary knowledge of a specific scientific and mathematical procedures.

2. Knows the procedures used in field and laboratory techniques.

3. Knows the techniques and procedures used in reporting data.

4. Possesses a knowledge of safety procedures.

THE MDTA SKILLS CENTER

The Manpower Development and Training Act provides funds through the Department of Labor and the Department of Health, Education and Welfare to train unemployed or underemployed individuals for job entry. Programs of study related to integrated pest management are appropriate for MDTA skills center, as there is a reasonable expectation of employment in this field.

MDTA training must enable the student to reach the job entry level in the shortest period of time possible. The program in integrated pest management must be developed to enable the participant to enter whenever his need for training is recognized and exit when he has mastered the tasks and skills which make him employable. Student evaluation is critical at all times because the program must provide the individual with the means to progress at his own rate.

It appears that there are seven job entry level positions for which MDTA training programs can be developed. All of these programs exist in varying numbers depending upon the part of the country involved. The training period may be from two weeks to one year in duration.

Training can be provided for the following integrated pest management jobs through MDTA programs:

1. Applicator

2. Applicator Assistant

3. Field Sweeper or Scout

4. Laboratory Assistant

5. Insectary Technician Assistant

6. Field Equipment Technician

7. Inspector Trainee

The following job elements are common in differing degrees to all of the jobs for which MDTA training programs can be developed:

1. Skill in communication with the farmer; interpersonal relations.

2. A skill in practical entomology; how to identify pests and control them, how to identify weeds and control them, how to identify nematodes and control them, etc.

3. An environmental awareness.

4. Skill in visually recognizing and identifying a problem.

5. Ability to perform arithmetic skills and to report quantitatively.

6. Ability to work in the field of chemistry and biology, a practical application of techniques and an understanding of the problems and principles involved.

7. General knowledge of crop production.

8. General knowledge of economic implications of this field.

9. General knowledge of safety procedures and practices.

10. Knowledge of products and their effects.

11. General knowledge of regulations for use of pesticides.

THE COMMUNITY COLLEGE

Within the present context of higher education, the community college and other similar level institutions such as technical institutes are responding to educational needs not previously fulfilled. These institutions for the most part now offer a multiple educational program of transfer, career and continuing education, as well as the supportive services to make the programs effective. Increasing percentages of students are enrolling in career education programs which lead to job entry in a variety of fields.

Preparation for a number of jobs identified in the integrated pest management system would be most appropriate for these career programs within community colleges, technical institutes and similar institutions. This would include jobs in all categories within the integrated pest management system.

All positions in which community college programs are appropriate do not require the same proficiencies. Certain of them, however, are common to a majority of the jobs. These include:

1. Techniques and procedures in reporting data and results.

2. A knowledge of field and laboratory sampling techniques.

3. Knowledge of crop systems.

4. Knowledge of biological systems.

5. Knowledge of chemical principles.

6. Basic knowledge of pests.

The jobs for which community college preparation is appropriate can conveniently be grouped into four areas:

1. Data Collecting Jobs
2. Laboratory Jobs
3. Field Jobs
4. Sales Jobs

JOBS IN THIS FIELD

Regarding jobs in this field, what of estimates of the probable demand for persons with appropriate training for these? In a report of this length, it is not possible to include documentation or statistics regarding this. Persons interested in obtaining more detailed information along these lines should consult such publications as those issued by the United States Bureau of Labor Statistics.

Certain jobs listed in this report exist in only limited numbers at the present or may scarcely exist at all. They are included wherever authorities believed them to be of a type that will develop in substantial numbers as a result of foreseeable new state and federal legislation and regulations.

A significant point which should certainly not be overlooked is that the availability of supervisory personnel is likely to be a pivotal factor in job availability for persons at lower levels in the career scheme. While parts of this report may give considerable emphasis to technician, applicator and assistant roles in integrated pest management, there will also be a concurrent requirement for supervisors of whom many will be holders of the baccalaureate or master's degree.

CAREER LADDERS

A ladder exists within many of the job categories in integrated pest management. The various training programs provided through the different educational institutions provided individuals with the initial opportunity to enter the field of integrated pest management. Any individual entering the field through these routes has unlimited possibilities to improve the position in any of several directions. Those individuals who wish to try a different area of work can do so by taking supplementary training related to that new kind of position or through service improve in performance and build on the common elements of the jobs.

Since so many of the jobs in integrated pest management are of the on-the-job training type, vertical movement is possible through experience in jobs at many levels.

ACTIVITIES AND EXPERIENCES

According to the degree of involvement which they provide for the students, activities and experiences in Career Preparation are classified as either Vicarious, Simulation or Experimental. Most activities and experiences in Career Preparation are of the Simulation or Experimental level.

The following activities are samples only of what might be attempted:

Vicarious Level

1. In order to have the student become acquainted with job descriptions and employment opportunities in the field of integrated pest management the students may:

   A) Locate specific job titles within the field using the latest publications on jobs in integrated pest management, interviews with representatives of private industry and governmental officials.

   B) List the skills required for specific jobs and job families (both entry level skills and those skills required for career mobility within the field) found in the most recent publications and through personal interviews with representatives of private industry and government.

2. In order to have your students become aware of the changing employment opportunities within the ingegrated pest management system, have them:

   A) Have them refer to the latest publications as they become available from private industry or the federal government.

   B) Have them contact farmers in the area and inquire as to what jobs are available in local integrated pest management programs.

   C) Have the students trained in the systematic use of available audio-visual aids by having them use the Educators Guide to Free Filmstrips and the access to all other audio-visual formats such as 16mm, 35mm Filmstrips, 8mm Cartridges, etc.

Simulation Level

1. In order to expose your students to the entry level requirements and job operations within the integrated pest management system the students may:

   A) Visit private industries, governmental offices and farms that are concerned with the development or continued use of integrated pest management procedures.

B) Attempt to duplicate some of the observed activities in the same setting.

Experimental Level

1. In order to have students become interested in careers in Integrated Pest Management and familiar with specific job "tools" have them: plan a program that points out the need for Integrated Pest Management and that describes the value to society of the various available or projected jobs.

2. In order for your students to receive actual experience in the field of Integrated Pest Management, the students may: arrange for part-time after school or summer jobs for themselves within the various agencies or farms that are involved with Integrated Pest Management.

SOURCES OF MATERIALS

At the time of this writing material in this field is not plentiful. However, write the following Federal Agencies for any listings they have of materials in this field, including publications of their own:

U. S. Environmental Protection Agency
Washington, D. C.

Superintendent of Documents
U. S. Government Printing Office
Washington, D. C.

Council on Environmental Quality
Washington, D. C.

Two of the best publications along these lines are published by the Council on Environmental Quality. These are entitled "Integrated Pest Management" and "Toxic Substances."

AN INTRODUCTION TO INTEGRATED PEST MANAGEMENT

INTRODUCTION

This is a short course or unit, the purpose of which is to introduce the student to the field of integrated pest management.

No prior exposure to --- or knowledge of --- pests, pest management, or integrated pest management is required of the student undertaking this unit. In fact, this short course or unit will be appropriate to introduce this field to the secondary school student, the post-secondary student, or the adult seeking greater awareness of this field --- either for general knowledge or for career interest.

This course of ten major topics, each of which is briefly described in the following pages. At a minimum, the course can be conducted in ten sessions of one hour each, or, if these are undertaken daily during the school week,over a period of two weeks. This outline is also designed so that it may be undertaken either (a) as a unit provided as part of a longer course or (b) as a short course related to, but still independent of, others being offered by any given institution.

Just how deeply students will become involved with each major topic included here will depend upon such factors as the total time available for the course, the educational and age levels of the students involved, the objectives of the students taking this course, and the resources which any institution can bring to this particular program.

The major topics outlined below realistically may be regarded as "modules" --- topic areas which can stand by themselves where required, re-arranged in sequence, varied as to length of time provided for each module (according to the particular requirements of such an individual introductory course), or even where single topics are concerned modified, combined or omitted to meet such constraints as time, curriculum requirements, or student interest.

As a final point, it should be emphasized that the outline which follows is solely a curriculum guide. While it outlines a carefully thought-out table of contents appropriate to this field --- and one based upon consultation with a number of authorities in integrated pest management --- it does not attempt to provide the content that will be involved. In fact, it will be up to the individual instructor to obtain for the program the required content data and information, other relevant materials, identification of resource persons and agencies, and the various other kinds of support required for any program of this kind.

Fortunately, this is a field about which there is a high level of public awareness and concern at this time, most especially perhaps among young people.

WHAT IS PEST MANAGEMENT?

Perhaps this is one topic in this outline which requires expansion beyond the usual: what is integrated pest management?

Pest management is an attempt to control the insect pests and potential insect pests through the use of environmental, biological, genetic, behavioral, metabolic and chemical pesticide controls. In some detail:

Environmental Approaches

The manipulation of the physical environment in an attempt to curtail pest species reproduction or to favor their natural enemies.

A. Crop residue destruction

B. Plowing, harrowing and burning

C. Crop rotation

D. Time of planting

E. Advantages and disadvantages

Biological Approaches

The maximum use of natural enemies in the control of pest insects.

A. Importation of new natural enemies

B. Conservation of already established natural enemies

  1. Provision for alternative hosts, food or shelter

  2. Elimination of hazards or adverse environmental factors

C. Augmentation of already established natural enemies through colonization

D. Advantages and disadvantages

Genetic Approaches

The development of a crop variety resistant to insect or plant disease or to interfere with the reproduction of the pest insect.

A. Plant resistance

  1. Resistance factors existing in plant stocks

  2. Breeding for pest resistance

  3. Advantages and disadvantages

B. Insect Control

  1. Eugenic approach

     The development of better insects, which would mean better natural enemies

a. Selection

b. Breeding

c. Heterosis

2. Dysgenic approach

The physical alteration of the pest insects

a. Dominant lethality

b. Chromosone translocation

c. Evolutionary mechanisms

d. Genes modifying the bionomics

C. Advantages and disadvantages

Behavioral Approaches

The introduction of behavioral chemicals that provide the stimulus for the desired reaction of the insect pests.

A. Attractants

B. Repellents

C. Arrestants

D. Deterrents

E. Stimulants

F. Advantages and disadvantages

Metabolic Approaches

The attempt to control insect pests through the introduction of harmonal chemicals.

A. Molting harmones (MH)

B. Juvenile harmones (JH)

C. Advantages and disadvantages

COURSE OR UNIT OUTLINE

The following are the ten major topics suggested for a short program in Integrated Pest Management. Each is outlined in sufficient detail to make apparent what should be included, but no attempt has been made to provide the actual content material or to indicate the depth in which each topic should be explored. The latter especially will depend upon the particular objectives of the program and the students involved with it, as well as the time and resources available.

These ten major topics or modules are:

I. WHAT IS A PEST?

The pest defined as any biological organism the characteristics of which have an effect on man and his activities.

II. WHAT IS PEST MANAGEMENT?

Pest management studied as an attempt to control insect pests --- and potential insect pests --- through the use of:

1. Environmental approaches
2. Biological approaches
3. Genetic approaches
4. Behavioral approaches
5. Metabolic approaches
6. Chemical pesticide approaches

III. PROBLEMS IN PEST MANAGEMENT

Consideration of the advantages with, and problems and resistances to, pest management as it has been undertaken in this country over the past quarter century --- with emphasis upon the ways in which the use of many pesticides has resulted in unintended side effects which create environment problems or reduce their own effectiveness.

These effects may be categorized as:

1. Contamination of the environment:
   a. Persistence
   b. Biomagnification
   c. Toxicity to man
   d. Toxicity to non-target organisms
2. Ecological disruption:
   a. Pest resistance to chemical pesticides
   b. Effect of chemical pesticides on natural pest enemies

IV. WHAT IS INTEGRATED PEST MANAGEMENT?

Integrated pest management considered in terms of:

1. A definition of integrated pest management
2. A review of the need for an integrated approach
3. The scope of integrated pest management
4. A realistic evaluation of the potential of integrated pest management
5. A similar evaluation of the limitations of integrated pest management
6. Public expectations relating to integrated pest management
7. Major factors and influences involved in implementation of integrated pest management programs

V. OBJECTIVES OF INTEGRATED PEST MANAGEMENT

The objectives of integrated pest management considered from such points-of-view as:

1. Control of pests
2. Protection of the environment as a whole
3. Protection of man
4. The potential and limitations of this approach

VI. RELATIONSHIP OF FEDERAL, STATE AND LOCAL AGENCIES TO INTEGRATED PEST MANAGEMENT

Integrated pest management studied in terms of government and other agencies involved, controlling and regulating legislation, and the current and potential influence upon this field of such agencies as:

1. Federal agencies
    a. United States Department of Agriculture
    b. Environmental Protection Agency
    c. Council for Environmental Quality
    d. U. S. Department of Health, Education & Welfare
    e. National Science Foundation

2. State agencies

   a. State Departments of Agriculture

   b. State university extension services

   c. State environmental agencies

   d. State Departments of Public Health

3. Regional and local agencies

   Agencies of the county, city and voluntary level concerned with:

   a. Extension services

   b. Agricultural programs

   c. Environmental programs

   d. Public health programs

   e. Other approaches to pest control or environmental protection

These agencies should be studied not only in light of their individual activities but in terms of their relationships to each other.

VII. INDUSTRY AND ITS RELATIONSHIP TO INTEGRATED PEST MANAGEMENT

The study of the role of industry in pesticide development, pest control and integrated pest management and its relationship to such groups as farmers, government agencies and others:

1. The relationship of industry to federal, state and local agencies

2. The relationship of industry to legislative groups

3. The relationship of industry to agrobusiness and agriculture

4. The role of the industry representative as a consultant to agriculture

5. The role of industry in identification of goals and expectations for integrated pest management programs

VIII. THE PUBLIC AND INTEGRATED PEST MANAGEMENT

A study of the role of the general public, citizen groups, legislative bodies and voluntary agencies with relationship to integrated pest management:

1. The development of public concern about pest management

2. The role of various media in the development of public awareness

3. The role of various crises in the shaping of public attitudes

4. Prevalent concepts of integrated pest management

5. Sources of resistance to integrated pest management

6. The role of compromise in the shaping of integrated pest management programs

IX. THE TOOLS OF INTEGRATED PEST MANAGEMENT

The study of how various approaches to pest management may be integrated into a coordinated approach. Emphasis may be upon:

1. Environmental techniques

2. Biological techniques

3. Genetic techniques

4. Behavioral techniques

5. Metabolic techniques

6. Chemical pesticide techniques

7. Public awareness and pressures

8. Local or other specific adaptations

X. CAREERS IN INTEGRATED PEST MANAGEMENT

A study of the probable careers which will result from the growing concern about integrated pest management, investigated most especially in terms of competencies involved, responsibilities, career ladders and educational entry requirements --- the latter categorized as follows:

1. Secondary school

2. MDTA or other skills center programs

3. Community college or technical institute

4. Baccalaureate programs

5. Graduate programs

SCOPE AND OBJECTIVES

This is an introductory course (it might be referred to as a survey) relating to integrated pest management. As such, its over-all goal is to provide students with the opportunity to acquire needed or desired awareness of this field. It is not intended to develop specific competencies or any sophisticated degree of awareness related to integrated pest management.

Traditionally pest management has been thought of as the management or control of pests through any available means, without any particular consideration of man-environmental consequences and usually through the use of one --- or a single group of --- control techniques.

Then what is integrated pest management? One definition of integrated pest management is that it involves the maximum use of natural pest population controls, along with a combination of techniques such as biological controls, pathogens, sterilization and selective chemicals as needed. Another way of stating this might be to say that integrated pest management involves the use of any one of a number of controls against a specific pest or class of pests.

Thus, integrated pest management is concerned with all classes of pests that have the potential of affecting the total crops in a specific geographic area. As a result, it becomes an integrated system of crop and plant management. In utilizing the integrated pest management approach, the emphasis is upon pest control, rather than upon eradication.

At the completion of this ten unit short course, the student will have a knowledge of:

1. How a pest is defined
2. What is meant by pest management
3. What is meant by integrated pest management
4. Why we have moved from pest management to an integrated approach to pest management
5. The objectives of integrated pest management
6. The relationship of federal, state and local agencies to integrated pest management
7. The relationship of industry to integrated pest management
8. The role of the public in integrated pest management
9. The tools of integrated pest management
10. Careers in integrated pest management

SAMPLE ACTIVITIES

The following activities are representative of those which may be utilized in a unit or course such as this.

It is hoped that they will stimulate ideas concerning other activities which will help the student and teacher to realize the objectives of this module:

1. There are a variety of effective films available dealing with insect pests. A student committee might review several such films and select one to be shown to the entire group.

2. An official of the local extension service or state agency could be invited to speak to the class about pest management.

3. Student groups, through their realistic and previous class experiences should consider specific approaches to pest management and report to the class the problem associated with it. A summary should be prepared and be made available to the students.

4. A panel discussion should be held, made up of a representative from the appropriate state agencies, a representative from the appropriate county agency and a farmer. This panel will be able to present the scope, limitation and potential of IPM.

5. The students should be able to state many of the objectives of IPM as a result of the first four sessions. A summary should be prepared and be made available.

6. Should be covered during four and be discussed and summarized in class.

7. A representative from industry should speak to the group about recent developments and activities of industry in relation to IPM.

8. The group should discuss and react conclusions about the role of the public in relation to IPM. The results should be summarized and distributed to the students.

SOURCES OF MATERIALS

At the time of this writing material in this field is not plentiful. However, write the following Federal Agencies for any listing they have of materials in this field, including publications of their own:

U. S. Environmental Protection Agency
Washington, D. C.

Superintendent of Documents
U. S. Government Printing Office
Washington, D. C.

Council on Environmental Quality
Washington, D. C.

Two of the best publications along these lines are published by the Council on Environmental Quality. These are entitled "Integrated Pest Management" and "Toxic Substances."

III. EDUCATIONAL PROGRAMS

EDUCATIONAL PROGRAMS

INTRODUCTION

At the very beginning of this section it needs to be emphasized that the outlines which it contains are program and course outlines only; they are not curriculums. Persons taking part in this conference identified certain competencies which students should possess in order to attain certain kinds of jobs; then they cited sequences of courses which would permit students to obtain these defined competencies. In certain instances, they identified important elements which should be contained in identified courses. But actual curriculums are not provided here.

Obviously the reason for this is that this conference involved only a few days, although each participant had done considerable preparation for it before attending the conference itself. Once at the conference, participants were divided into four groups, with each person being assigned to a group according to his particular specialty and the kind of educational institution or programs with which he was most familiar.

The four groups worked on these levels of programs: those appropriate for secondary schools and MDTA programs; those appropriate for community colleges and technical institutes; those appropriate for baccalaureate programs; and those appropriate for graduate programs. Each group devoted its time and attention exclusively to one of these levels.

Since these groups had very little time in which to review each other's materials --- or even to communicate with each other --- a certain amount of duplication, overlapping and even conflict is bound to be apparent in these outlines. The latter will be apparent mostly with regard to competencies identified as being necessary for certain jobs, the titles given to the jobs themselves, and the kinds of educational institutions or programs most appropriate for preparing people for these jobs. However, there actually is relatively little of this in evidence in this report, most probably a reflection of the fact that there is a good deal of commonality in the thinking which people concerned with this field have done about the jobs and careers involved with it.

The participants who developed these outlines came from all parts of the United States and from a variety of educational settings, among them MDTA programs, secondary schools, community colleges, technical institutes, undergraduate and graduate college and university programs.

It was the considered opinion of these participants that certain categories could be combined because of the similarities in the programs which they would offer. As a result, secondary school and MDTA programs are discussed in a single section and so are programs appropriate for community colleges and technical institutes.

HIGH SCHOOL AND MDTA

INTRODUCTION

Integrated pest management is duscussed in this outline as an approach in which techniques, methods, practices, materials, knowledge and information are integrated to accomplish the management of pest populations in the most economically sound and environmentally and sociologically desirable ways.

Under integrated control, man acts as but one of the elements of the common ecosystem and functions with minimum impact upon the environment. Conversely, under conventional pest control practice, the role of man if often highly disruptive and economically and sociologically costly.

INTEGRATED PEST MANAGEMENT - AN INTERDISCIPLINARY APPROACH

DESCRIPTION

A strong program in integrated pest management is a disciplinary in that it must cross disciplines and be multi-disciplined. The goal of the high school integrated pest management program should be to make each student aware of the role man plays in integrated pest management and concerned enough about this role to become involved in actions and programs to improve the environment through this ecological approach.

The materials presented here were developed for flexible use by a wide variety of teachers and schools. It is not expected that they will be used in any predetermined order. The individuality of the teacher, the ability and cultural historyof the students, needs and problems of the community and geographic area involved should all operate to determine the patterns of instruction. The program is designed to facilitate active teacher-student relationships. An interdisciplinary approach should be the ultimate objective.

OBJECTIVES

The following objectives point out the specific needs of students who wish to enter into a job in the field of integrated pest management as well as those who wish to obtain a general familiarity with this field for the purpose of broadening their scope of knowledge and in order to be a well rounded citizen.

The objectives may be met in presently existing courses in a variety of disciplines or in a program designed specifically for the field of integrated pest management.

I. Social Sciences

A. Primary Objectives

1. The student will understand the set of conditions which brought about the unilateral use of synthetic pesticides and their ramifications.

2. The student will be able to understand how the implementation of integrated pest management programs have been affected by general farm policy over the past thirty years.

3. The student will understand the vital contributions of the various social sciences and related disciplines (History/Government/Political Science/International Affairs/Sociology/Anthropology/Psychology/Environmental Ethics) to integrated pest management by placing it in its historical context, showing how it relates to and is effected by politics and governmental policies and its implications for international trade and foreign policy, and impact upon the societal patterns, individual life styles, personality and ethical-moral values and beliefs.

B. <u>Secondary Objectives</u>

The student will:

1. <u>Become aware of the historical development of farm policy</u>.

   a. Know what impact farm policies have on supply and demand.

   b. Know the principles of market elasticity and when it does and does not apply.

   c. Know the implication of farm policy on foreign markets.

2. <u>Become aware of the present status of farm policy</u>.

   a. Know the effect of U. S. farm policy on foreign and domestic markets. Include such things as the common market, bilateral trade agreements, balance of payment.

   b. Know the effect of U. S. farm policy upon production base and technology.

3. <u>Understand the post harvest transportation, marketing and storage of farm products</u>.

4. <u>Become aware of consumer demands for perfection of farm products and its effect on the economics of integrated pest management</u>.

5. <u>Be able to recognize the influence of mass pesticide marketing practices and their effect upon the economy</u>.

6. <u>Be aware of market characteristics which force the development of "volume based" pesticides.</u>

7. <u>Be able to analyze the cost of crop production rationalizing the value of integrated pest management</u>.

8. Be able to put integrated pest management into its historical context.

   a. Become aware of historical milestones in the history of integrated pest management, agriculture and its implications for integrated pest management and life today, and the environmental movement from 1890 to present.

   b. Be able to trace the growth of rural U. S. to urban U. S.

   c. Be able to describe the massive mechanization of American farms.

9. Become aware of the impact of agriculture policy on such things as the rural to urban shift, amount of farm production, farm production organization, change of legislative representation in government, governmental decisions and decision making, and land grant college system.

10. Become aware of the impact on cultural change, change of product production, living patterns, support mechanisms, mobility and public health of advanced science and technology being transferred to underdeveloped nations in pest management.

11. Be aware of the part integrated pest management plays in the environmental philosophy especially life style, the land use ethic and the stewardship of land vs. its exploitation.

12. Understand the importance of positive and well developed interpersonal to an individuals success in integrated pest management.

II. Science

A. Primary Objectives

1. The student will have a familiarity with the general concepts of ecology and biology (eco-biology) to understand integrated pest management as this concept deals with the management of populations within ecosystems.

2. The student will be aware of the vast array of ecological and biological processes and inter-relationships which come into play in the development and implementation of integrated pest management.

3. The student will understand how the physical factors of environmental interplay determine the abundance and distribution of plants and animals.

4. The student will understand the importance of the structure of the physical factors of environmental interplay and how they set the limits of ecosystems.

5. The student will understand the basic principles of practical physics and how to apply them for a better understanding of integrated pest management.

6. The student will understand the applied aspects of chemistry as they relate to integrated pest management looking at chemistry as encompassing the role of the servant to the ecosystem and man.

B. Secondary Objectives

The student will:

1. Understand biology at the population and eco-community level (ecosystems).

   a. Be able to define different types of biologies such as carnivores, herbivors, and reducers.

   b. Be able to define ecosystem.

   c. Be able to identify and describe food chains and food webs.

   d. Understand the principle of biomagnification.

2. Be able to identify and describe the different types of communities including aquatic, terrestrial, arboreal, monoculture vs. polyculture and cropping systems.

3. Understand genetics in terms of inter and intra specific relationships such as population genetics, gene pools, hereditary traits, selection, resistance-resistant varities, and predator-prey relationship.

4. Be able to describe the characteristics of growth.

5. Understand phenology, timing of events, light and photosynthesis, nutrients-plant and animal, insect growth stages and plant distribution.

6. Be able to describe the general concepts of biological behavior and theories.

7. Be able to show the applied utility of behavioral concepts including attractants, pheromones, repellents, traps and selected habitats.

8. Be able to demonstrate the application of nutrition basics to baits - selective, synthetic diets, malnutrition and metabolism.

9. Be able to define morphology and describe its relationship to integrated pest management.

10. Be able to show how genetics relates to morphology by identifying and describing some examples of physical barriers.

11. Understand the basics of evolution such as contempory evolution, eco-types, genetic divergence, parallel paths and selection.

12. Be able to thoroughly understand the basic concept of the balance of nature including natural control, biological control, physical factors and diversity vs. simplification.

13. Have a rudimentary understanding of physiology such as mode of action of pesticides, detoxification mechanisms, synergism, pathogenicity, bioassay techniques, internal biochemistry, anti-biosis, repellency, tolerance, translocation, enzyme system and hormones.

14. Understand the components and dimensions of the atmosphere.

15. Understand the atmosphere as a transport system.

    a. Have an acquaintance with weather patterns; e.g., inversion, lapse rate, relative humidity, barometric pressure.

    b. Have a working knowledge of respiratory precautions when using pesticides.

16. Understand the water cycle.

17. Understand the geographical variations of the water cycle as it relates to distribution and abundance of plants and animals.

18. Become familiar with natural water systems; their characteristics, their manipulation, their use.

19. Be able to recognize the effect of water flow on soil fertility.

20. Understand the effect of water management on public health problems in pest control.

21. Understand the purpose, use, and implications of man-made geological structures; e.g., dams, levies, drain tiles, drainage ditches, canals, etc.

22. Recognize the various societal uses of water and the management techniques necessary for its compatable.

23. Understand the composition, formation and variations of soil including its chemical balance, physical properties and content of living organisms.

24. Understand the nutrient availability from soil to plants.

25. Understand soil conservation methods and techniques; e.g., rotations, contours, terracing.

26. Know what creates flow and how to change its direction and volume.

27. Understand the components of a complete electrical circuit.

28. Understand the measurement of electricity.

29. Be able to identify hazards connected with electricity.

30. Understand gas laws in their role in the environment.

31. Be able to identify principles of phase change; solid, liquid, gas.

32. Understand how gravity effects the behavior of particles with designated size and density.

33. Understand the principles of stress and their practical application.

34. Be able to demonstrate the practical application of the principles of friction for efficient use of energy.

35. Understand that there are various forms of energy which are interchangeable and they have a variety of uses; mechanical to electrical; chemical to mechanical; solar to chemical.

36. Be able to identify the light spectrum and illustrate its role.

37. Understand the principles of friction for efficient use of energy.

38. Be able to identify the light spectrum and illustrate its role in the growth cycle.

39. Understand the dimensions of frequency and intensity of sound.

40. Have a basic understanding of the principles of atomic theory.

41. Understand the basic concepts of physical chemistry; e.g., valance, ph, etc.

42. Be able to describe the chemical components of soil and their interaction; e.g., adhesion, absorption, systemic pesticides, salinity, microclimate, degradation process, etc.

43. Be aware of the analytical techniques used in pesticide detection in the environment.

44. Understand the problem and dimension of pesticide residue.

45. Be aware of intoxication analysis.

46. Be aware of the techniques used for testing for pesticides in the field.

47. Be aware of the positive and negative effects of the environment - (sun, wind, rain, etc.) - on pesticides.

48. Understand the nature of toxicity on plants and animals; e.g., acute, chronic.

49. Be aware of the range and variation of integrated pest management chemicals.

    a. Pesticides

        1. Kinds of Pesticides - Conventional Pesticides
        e.g., insecticides, herbicides, fungicides, rodentcides, avicides, malacacides, piscicides, germicides, nematacides, predacides.

        Non-Conventional Pesticides
        e.g., inert dust, fumigants.

        2. Chemical Nature of Conventional Pesticides

        Inorganic - e.g., mercury, arsenic, cyanide
        Organic - e.g., organo chlorine, organo phosphates, carbonates, growth hormones, botanicals, anticoagelants, phenoxy acetic acid.

3. Mode of Entry of Conventional Pesticides
e.g., stomach, contact, respiratory

b. Other Integrated Pest Management Chemicals

1. Behavioral Chemicals - e.g., pheromones, hairomones, repellents, attractants, antiferdants, nutrients

2. Growth Regulators

3. Chemosterilants

III. Mathematics

A. Primary Objective

The student will be able to use applied mathematics as an essential tool in problem solving associated with integrated pest management.

B. Secondary Objectives

The student will:

1. Be able to practice all of the basic arithmetic skills with accuracy and skill.

2. Be able to recognize, use, and convert standard units weights and measures.

3. Have a clear understanding of the use of percentages, fractions, proportions, and ratios in problem analysis.

4. Have a working knowledge of elementary statistics; e.g., mean, mode, median, random distribution, probability.

5. Be able to interpret and calculate time-rate problems and understand the significance of this principle in integrated pest management.

6. Be able to understand and calculate geometric problems related to area and volume measurements.

7. Be able to practice basic skills in the use of business machines.

IV. Communications

A. Primary Objectives

1. The student will be exposed to, gain an understanding

of, and be able to use various medial and communication techniques.

2. The student will become familiar with the literature of the environmental, conservation and integrated pest management movements.

B. Secondary Objectives

The student will:

1. Become familiar with the potential uses of modern media techniques as a means of fostering local, state, regional, and national acceptance and understanding for integrated pest management.

2. Become familiar with methods and techniques used to obtain needed material related to integrated pest management in libraries, private business, government agencies, etc.

3. Be able to interpret various integrated pest management materials, concepts, and ideas including the various positions of trade, industry, agency, pressure groups, lobbies, etc.

4. Be able to use integrated pest management materials to reach and communicate with target groups.

5. Have a mastery of the basic communications skills of reading and writing.

6. Be able to communicate effectively in speaking to large and small groups as well as individuals.

JOB TITLES AND DESCRIPTIONS

EQUIPMENT OPERATOR - OTHER THAN AERIAL

A person who operates equipment that is utilized in integrated pest management; e.g., application of agri-chemicals, biological agents, and the implementation of other techniques implicit to this type of strategy.

1. General Skills

(a) Practices interpersonal relations with supervisors, clients, and residents in the area.

(b) Knows the precautionary measures which must be taken for protection from acute hazards of the materials and equipment he is using.

<u>EQUIPMENT OPERATOR - OTHER THAN AERIAL</u> (continued)

(c) Operates equipment properly and safely.

(d) Maintains simple field records accurately.

(e) Is able to recognize the pest being controlled.

(f) Is able to identify and differentiate target and non-target substrate.

(g) Is able to practice application principles in relation to weather.

(h) Has a sound knowledge of his equipment and what can be expected of it.

(i) Possesses the ability to take basic decontamination procedures in case of error or accident.

(j) Knows how to use elementary first aid.

(k) Must be aware of laws and regulations which govern his operational procedures.

(l) Possesses knowledge of and is aware of the reasons for re-entry regulations and precautions.

(m) Can follow and apply employer policies for the development of the business.

(n) Possesses ability to follow directions carefully and be concerned with accuracy in operation.

(o) Possesses the ability to make minor on-the-job decisions and call the supervisor when decisions are major.

(p) Practices proper radio-telephone and telephone skills.

(q) Must follow instructions on disposal of excess pesticides and the containers.

(r) Implement proper maintenance of equipment.

(s) Knows how to use an operators manual and other direction-giving material.

(t) Knows how to calibrate application equipment accurately.

(u) Has basic knowledge and understanding to make practical application of the principles of chemicals and biological agents, their formulation and their general characteristics, efficacy and potential adverse effect on non-target organisms.

OBJECTIVES

The objectives included under 'Integrated Pest Management, An Interdisciplinary Approach" are a necessary part of the training for Equipment Operators. In addition, the following objectives dealing with mechanical skills must be met.

The student must:

1. Know how to operate a vehicle that contains or pulls a tandem.
2. Know how to regulate pump flow.
3. Know how to clean, care for and change nozzles and other spray devices.
4. Know how to operate specific equipment applicators such as fog machines, hydraulic sprayers, mist blowers, field fumigators and knife applicators.
5. Knows how to make minor repairs in order to maintain peak performance.
6. Know exactly what the equipment being used is capable of.
7. Be aware of laws and regulations which govern his operational procedure.
8. Know how to develop and implement a regular maintenance schedule.
9. Be able to interpret and practice directions given in the operators manual.
10. Be able to mix pesticides with accuracy.
11. Be able to practice precautionary measures appropriate to pesticide application and disposal.

RELAVENT COURSES

1. First Aid
2. Drivers Education

PROGRAM PREPARATION

These items have been incorporated into the objectives through indicated levels of expertise where appropriate.

CLASSROOM ACTIVITIES AND FIELD EXPERIENCES

(a) Participate in Earth Week projects and community service operations of an environmental nature.

(b) Visit museums and view films, slides, video-tapes, which depict the change of America from an agricultural to an industrial society.

(c) Observe legislative sessions, community meetings, courtroom hearings, and the like, which deal with integrated pest management.

(d) Visit the offices of government agencies dealing with integrated pest management and discuss their programs.

(e) Listen to guest lecturers who are working in the field of integrated pest management.

(f) Role play an actual meeting between farmers and integrated pest management officials with opposing views.

(g) Visit organic gardens, health food stores and communes.

(h) Experiment with integrated pest management in a controlled demonstration in a greenhouse.

(i) Sweep a portion of a field near the school and analyze the results.

(j) Develop a project utilizing weather maps showing weather movement in order to show the principle of transference.

(k) View man-made geological structures and natural water systems.

(l) Conduct experiments illustrating the gas laws.

(m) Conduct experiments which show how by changing its environment, a gas, a liquid and a solid will change its physical characteristics.

(n) Develop field projects which will utilize various mathematical principles and statistical methods used in integrated pest management.

(o) Speak to a school or civic group about integrated pest management.

(p) Observe a field being treated or livestock being sprayed.

(q) Produce a video-tape which can be presented to interested groups on some phase of integrated pest management.

(r) Write news articles for the school paper or the community newspaper on integrated pest management.

(s) Accompany an equipment operator on his daily duties.

(t) Construct a display of pests for classroom use.

(u) Collect container labels showing integrated pest management chemicals.

SPECIAL NOTE ABOUT MDTA PROGRAMS

It was the opinion of the participants that the development of training programs for jobs requiring fewer skills than those needed by the equipment operator was inappropriate. The function of assistants to operators consists primarily of following directions given by the operator and being aware of the consequences which result if these directions were not followed.

Initial training through MDTA would most appropriately begin at the equipment operators level. Emphasis should be placed on the mechanical skills needed in the operation of equipment properly and safely. The extent of training can be most appropriately ascertained at the local level when employment opportunities are determined. Larger business establishments will have a greater number of levels of employment and would be the ones most likely to have jobs available for individuals prepared through MDTA training programs. In smaller business establishments the equipment operator will have other responsibilities and it would be therefore necessary for him to have greater expertise in, and knowledge of, integrated pest management.

COMMUNITY COLLEGE - TECHNICAL INSTITUTE

INTRODUCTION

This part of the curriculum guide is developed for community colleges, vocational-technician institutes, and similar institutions. These institutions offer multi-faceted programs of transfer education, occupational education, continuing education, and supportive services.

The proposed curricula give direction for the implementation of a two year associate program, a one to two year certificate program, or programs for in-service training. In this section are those units of instruction which are designed for educating Laboratory Service Technicians, Application Service Technicians, and Supply Service Technicians.

A. INTEGRATED PEST MANAGEMENT - LABORATORY SERVICES

1. PROGRAM DESCRIPTION

This program is one of three options offered at the community college - technical institute level and is designed to prepare students for an occupation in Integrated Pest Management. The three Integrated Pest Management programs available to community college - technical institute students are: Laboratory Services, Application Services, Supplies and Services.

This program prepares the student for an occupation in the area of Laboratory Services. Within the area of Laboratory Services, the student has five choices. The five occupational choices and respective descriptions are:

Laboratory Technician-Biological: works with many types of biological agents including microbial and virus organisms.

Laboratory Technician-Chemical: engages in sampling procedures and assists in analytical procedures relating to pesticides and other chemical agents.

Insectory Technician: raises, and assumes responsibility for, insects.

Laboratory Assistant: performs laboratory duties as assigned by a laboratory supervisor or a technician.

Environmental Monitoring Technician: samples specific components of the environment, to assure the integrity of pest management programs.

Scout-Field Sweeper: acts as a data collector in field situations.

Each of the technician choices, including the Scout, involves a two year program. The Laboratory Assistant requires a one year program.

2. PROGRAM OBJECTIVES

   a. To prepare individuals for occupations in Integrated Pest Management.

   b. To develop an understanding of the judicious use of selective pesticides in combination with biological agents and cultural methods.

   c. To prepare individuals in the area of Integrated Pest Management Laboratory Services.

3. JOB TITLES AND DESCRIPTIONS

   a. Laboratory Technician - Biological

      A person who works with many types of biological agents including microbial and virus organisms.

      1. General Skills

         (a) Possesses elementary knowledge of, and applies, chemical procedures.

         (b) Possesses elementary knowledge of, and applies, biological procedures.

         (c) Possesses an elementary knowledge of mathematics procedures as applicable to the job description.

         (d) Possesses a knowledge of safety procedures.

         (e) Possesses the ability to collect and report data accurately.

         (f) Possesses a knowledge of field and laboratory sampling techniques.

         (g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

         (h) Possesses a command of the metric system.

         (i) Possesses general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Knows biological principles including sterile techniques, and elementary microbiology.

(b) Knows how to use laboratory instruments such as: microscopes, balances, autoclave, environmental chambers, dissection scopes, incubators, electric pH meter, ovens, refractometer, microscope filters, colony counters, hydrometer, thermometers, etc.

(c) Recognizes pests common to his area.

(d) Uses appropriate nutrient media.

(e) Has basic knowledge of staining techniques.

(f) Can report data in graph form.

b. Laboratory Technician - Chemical

A person who engages in sampling procedures and assists in analytical procedures relating to pesticides and other chemical agents.

1. General Skills

(a) Possesses elementary knowledge of, and applies, chemical procedures.

(b) Possesses elementary knowledge of, and applies, biological procedures.

(c) Possesses an elementary knowledge of math procedures as applicable to the job description.

(d) Possesses a knowledge of safety procedures.

(e) Possesses the ability to collect and report data accurately.

(f) Possesses knowledge of field and laboratory sampling techniques.

(g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

(h) Possesses a command of the metric system.

(i) Possesses general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Elementary knowledge of quantitative and qualitative analyses.

(b) Knows how to use laboratory instruments such as: analytical balances, electric pH meter, ovens, refractometer, sol-u-bridge, muffle furnace, baths, polarizing microscope, hydrometer, burners, etc.

(c) Prepares and standardizes laboratory solutions.

(d) Can construct specialized pieces of laboratory glassware.

(e) Can set up and use distillation and extraction apparati.

(f) Has knowledge of chemical symbols, formulae and equations.

(g) Can report data in graph form.

c. Insectory Technician

A person who raises and assumes responsibility for insects.

1. General Skills

(a) Possesses elementary knowledge of, and applies, chemical procedures.

(b) Possesses elementary knowledge of, and applies, biological procedures.

(c) Possesses an elementary knowledge of math procedures as applicable to the job description.

(d) Possesses a knowledge of safety procedure.

(e) Possesses the ability to collect and report data accurately.

(f) Possesses knowledge of field and laboratory sampling techniques.

(g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

(h) Possesses a command of the metric system.

(i) Possesses general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Knows how to use laboratory instruments such as: analytical balance, ovens, pH meter, refractometer, hydrometer, etc.

(b) Possesses knowledge of sterile techniques, elementary microbiology and entomology.

(c) Uses appropriate nutrient media.

(d) Possesses knowledge of insect life and rearing techniques.

(e) Can design and construct specialized laboratory equipment drawing upon carpentry, plumbing and electrical skills.

(f) Can interpret graphs.

d. Laboratory Assistant

A person who performs laboratory duties as assigned by a supervisor or technician.

1. General Skills

(a) Possesses elementary knowledge of, and applies, chemical procedures.

(b) Possesses elementary knowledge of, and applies, biological procedures.

(c) Possesses an elementary knowledge of math procedures as applicable to the job description.

(d) Possesses a knowledge of safety procedures.

(e) Possesses the ability to collect and report data accurately.

(f) Possesses knowledge of field and laboratory sampling techniques.

(g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

(h) Possesses a command of the metric system.

(i) Possesses a general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Is familiar with laboratory glassware and cleaning techniques.

(b) Knows how to use laboratory instruments such as: analytical balances, pH meter, ovens, refractometer, autoclave, muffle furnace, baths, microscopes, illuminators and light filters, colony counters, hydrometer, thermometers, etc.

(c) Can prepare and standardize solutions.

(d) Prepares nutrient media properly.

(e) Is familiar with ordering laboratory material and equipment.

(f) Is familiar with weight and temperature conversions.

(g) Can interpret graphs.

e. Environmental Monitoring Technician

A person who is assigned to sampling specific components of the environment to assure the integrity of pest management programs.

1. General Skills

(a) Possesses elementary knowledge of, and applies, chemical procedures.

(b) Possesses elementary knowledge of, and applies, biological procedures.

(c) Possesses an elementary knowledge of math procedures as applicable to the job description.

(d) Possesses a knowledge of safety procedures.

(e) Possesses the ability to collect and report data accurately.

(f) Possesses the knowledge of field and laboratory sampling techniques.

(g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

(h) Possesses a command of the metric system.

(i) Possesses general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Knows how to use laboratory instruments such as: analytical balances, ovens, autoclave, pH meter, refractometer, sol-u-bridge, microscopes, illuminators, hydrometer, thermometers, etc.

(b) Possesses knowledge of insects and their life cycles.

(c) Can report data in graph form.

(d) Possesses knowledge of crop to be monitored.

(e) Possesses exceptional field-observation acuity.

(f) Has knowledge of the environmental factors which impinge upon crop monitoring efforts.

f. Scout-Field Sweeper

A person who acts as a data collector in field situations.

1. General Skills

(a) Possesses elementary knowledge of, and applies, chemical procedures.

(b) Possesses elementary knowledge of, and applies, biological procedures.

(c) Possesses an elementary knowledge of procedures as applicable to the job description.

(d) Possesses a knowledge of safety procedures.

(e) Possesses the ability to collect and report data accurately.

(f) Possesses knowledge of field and laboratory sampling techniques.

(g) Possesses the ability to operate laboratory instrumentation, relative to his job description.

(h) Possesses a command of the metric system.

(i) Possesses general knowledge of animal and plant pests and elements of their control.

2. Specific Skills

(a) Possesses a general knowledge of cropping systems.

(b) Has the ability to follow detailed instructions and to make minor on-the-job decisions.

(c) Recognizes and reports secondary effects of control measures.

(d) Possesses the ability to operate a motor vehicle.

(e) Has the ability to monitor populations of both pests and biological organisms.

4. RELEVANT COURSES

a. Laboratory Technician - Biological

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Techniques	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

4. RELEVANT COURSES (continued)

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Applied Biology	4		x		
(b) Applied Botany	4			x	
(c) Introduction to Field Biotechniques	1	x			
TOTAL Specialty	9				

4. Elective

	CREDITS
(a) Psychology - Human Relations	3
(b) American Governmental System	3
(c) Conversational Spanish	3
(d) Basic Mechanic Skills	3
(e) Personal Typing	2
(f) Microbiology	4
(g) Soils	3
(h) Humanities	3
(i) Plant Nutrients	3
TOTAL Electives	10

b. Laboratory Technician - Chemical

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

RELEVANT COURSES (continued)

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Technique	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Applied Chemistry	4			x	
(b) General Physical Science	4				x
TOTAL Specialty	8				

4. Elective

	CREDITS
(a) Psychology - Human Relations	3
(b) American Governmental Systems	3
(c) Conversational Spanish	3
(d) Basic Mechanic Skills	3
(e) Personal Typing	2
(f) Microbiology	4
(g) Soils	3
(h) Humanities	3
(i) Plant Nutrients	3
TOTAL Electives	11

4. RELEVANT COURSES (continued)

c. Insectory Technician

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Technique	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Economic Entomology	4			x	
(b) Insectory Operations	4		x		
TOTAL Specialty	8				

4. Elective

	CREDITS
(a) Psychology - Human Relations	3
(b) American Governmental Systems	3
(c) Conversational Spanish	3

4. RELEVANT COURSES (continued)

4. Elective (continued)

	CREDITS
(d) Basic Mechanic Skills	3
(e) Personal Typing	2
(f) Microbiology	4
(g) Soils	3
(h) Humanities	3
(i) Plant Nutrients	3
TOTAL Electives	11

d. Laboratory Assistant

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Technique	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

4. RELEVANT COURSES (continued)

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) No specialty courses	0				
TOTAL Specialty	0				

4. Elective

	CREDITS
(a) Psychology - Human Relations	3
(b) American Governmental Systems	3
(c) Conversational Spanish	3
(d) Basic Mechanic Skills	3
(e) Personal Typing	2
(f) Microbiology	4
(g) Soils	3
(h) Humanities	3
(i) Plant Nutrients	3
TOTAL Electives	9

e. Environmental Monitoring Technician

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

4. RELEVANT COURSES (continued)

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Technique	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Introcution to Field Biotechnique	1	x			
(b) Environmental Conservation	3		x		
(c) Physical Geography	3		x		
(d) Meteorology	3			x	
(e) Environmental Monitoring	3				x
TOTAL Specialty	13				

4. Elective

	CREDITS
(a) Psychology - Human Relations	3
(b) American Governmental Systems	3
(c) Conversational Spanish	3
(d) Basic Mechanic Skills	3
(e) Personal Typing	2
(f) Microbiology	4
(g) Soils	3
(h) Humanities	3
(i) Plant Nutrients	3
TOTAL Electives	5

4. RELEVANT COURSES (continued)

f. Scout - Field Sweeper

1. General Education

Course	CREDITS	1	2	3	4
(a) English	3	x			
(b) General Biology	4	x			
(c) Elementary Chemistry	4			x	
(d) Elementary Algebra	3		x		
(e) Agriculture and the Environment	3	x			
(f) Social Science I	3				x
TOTAL General Education	20				

2. Occupational Core

Course	CREDITS	1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Laboratory Instrumentation + Technique	4	x			
(c) Technical Report Writing	2			x	
(d) Agricultural Pest Control	5				x
(e) Applied Math	3			x	
(f) Supervised Occupational Practice	4		x		
TOTAL Occupational Core	21				

3. Specialty

Course	CREDITS	1	2	3	4
(a) Pest Identification	3	x			
(b) Plant Science	3		x		
TOTAL Specialty	6				

4. RELEVANT COURSES (continued)

4. Elective

		CREDITS
(a)	Psychology - Human Relations	3
(b)	American Governmental Systems	3
(c)	Conversational Spanish	3
(d)	Basic Mechanic Skills	3
(e)	Personal Typing	2
(f)	Microbiology	4
(g)	Soils	3
(h)	Humanities	3
(i)	Plant Nutrients	3
	TOTAL Electives	13

5. PROGRAM PREPARATION

a. High school diploma

b. High school college preparation program

c. High school science core with emphasis on advanced placement in the area of special interest.

d. Science club membership

e. Work-study experience in both laboratory and field settings.

6. EXAMPLES OF CLASSROOM ACTIVITIES

a. Practice in using laboratory instrumentation and equipment.

b. Laboratory experiences should deal with pesticidal compounds wherever possible.

c. Laboratory experiences should emphasize analytical procedures and techniques.

d. Students should be exposed to relevant technical articles.

e. Students should write technical reports based on field data.

6. EXAMPLES OF CLASSROOM ACTIVITIES (continued)

f. Design and equip a simulated laboratory.

g. Design a laboratory safety program.

h. Prepare standardized laboratory solutions.

i. Work with animal and plant pathogens.

j. Experiences in a wide variety of laboratory sample preparation and analytical procedures and techniques.

k. Bring in resource persons from relevant areas of the scientific community.

l. Construct specialized pieces of laboratory equipment.

7. EXAMPLES OF FIELD EXPERIENCES

a. Experiences in a wide variety of field sampling procedures and techniques.

b. Visits to government and private laboratories to observe practical application of instruments.

c. Work experience in a government or private laboratory.

d. On-site observations of crop damage caused by pests (insects, mites, plant disease, nematodes, weeds, etc.).

e. Visit environmental agencies involved in monitoring activities.

f. Observe and participate in various types of commercial application of pesticides (air, ground, soil, seed).

g. Inspection of large commercial pesticide distribution center - formulation, labelling, containers, safety procedures, etc.

B. INTEGRATED PEST MANAGEMENT - APPLICATION SERVICES

1. PROGRAM DESCRIPTION

This program is one of three options offered at the community college - technical institute level and is designed to prepare students for an occupation in the Integrated Pest Management System. The three Integrated Pest Management programs available to community college - technical institute students are: Application Services, Laboratory Services, Supplies and Services.

This program prepares the student for an occupation in the area of Application Services. Within the area of Application Services the student has four occupational choices. The four occupations and respective descriptions are (each is a two year program):

Integrated Pest Management Foreman: uses the disciplines required to perform the tasks of Integrated Pest Management and to supervise the application of pesticidal materials and biological agents.

Field Equipment Technician: advises and/or develops, adopts, maintains, tests, operates and calibrates equipment used in Integrated Pest Management.

Aerial Applicator: applies pesticides and/or bio-control agents for pest control in structures.

Structural Applicator: operates equipment designed for pest control in structures

2. PROGRAM OBJECTIVES

a. To prepare individuals for occupations in the Integrated Pest Management System.

b. To develop an understanding of the judicious use of selective pesticides in combination with biological agents and cultural methods.

c. To prepare individuals as Integrated Pest Management Technicians in application services.

3. JOB TITLES AND DESCRIPTIONS

a. Integrated Pest Management Foreman

A person qualified to use the disciplines required to perform the tasks of Integrated Pest Management and to supervise the applications of pesticidal materials and biologic agents.

1. General Skills

(a) Possesses an elementary knowledge of mathematics and communication.

(b) Possesses a knowledge of Integrated Pest Management Programs.

(c) Possesses a knowledge of application equipment including operation, maintenance, calibration and decontamination.

(d) Possesses a comprehensive knowledge of the State and Federal laws relating to pesticidal materials and their application.

(e) Possesses the ability to maintain records and report accurately.

(f) Possesses an understanding of the potential environmental consequences of the use and misuse of pesticides.

(g) Possesses a practical understanding concerning toxicity, hazards, and precautions to be taken in using pesticides.

(h) Possesses the ability to identify pests and know the importance of the biology of pests relevant to the area of operation.

2. Specific Skills

(a) Understands the role of such factors as climatic conditions, types of terrain, soil and substrata and the presence of various non target organisms.

(b) Understands the cultural practices and the related problems involved in the successful growing of plants or animals.

(c) Has the ability to supervise and effectively communicate with employees.

b. Field Equipment Technician

A person who advises and/or develops, adopts, maintains, tests, operates, and calibrates equipment used in Integrated Pest Management.

1. General Skills

(a) Possesses an elementary knowledge of mathematics and communications.

(b) Possesses a knowledge of Integrated Pest Management Programs.

(c) Possesses a knowledge of application equipment including operation, maintenance, calibration and decontamination

(d) Possesses a comprehensive knowledge of the State and Federal laws relating to pesticidal materials and their application.

(e) Possesses the ability to maintain records and report accurately.

(f) Possesses an understanding of the potential environmental consequences of the use and misuse of pesticides.

(g) Possesses a practical understanding concerning toxicity, hazards, and precautions to be taken in using pesticides.

(h) Possesses the ability to identify pests and know the importance of the biology of pests relevant to the area of operation.

2. Specific Skills

(a) Has the ability to design, construct, service, repair, regulate, test, evaluate, calibrate, and operate pesticide application equipment.

(b) Possesses a knowledge of application equipment such as: dusters, seed treaters, spray rigs, slurry applicators, injectors, and fumigators.

(c) Understands the cultural practices and the related problems involved in the successful growing of plants or animals.

c. Aerial Applicator

A person who applies pesticides and/or bio-control agents by aircraft.

1. General Skills

(a) Possesses an elementary knowledge of mathematics and communications.

(b) Possesses a knowledge of Integrated Pest Management Programs.

(c) Possesses a knowledge of application equipment including operation, maintenance, calibration and decontamination.

(d) Possesses a comprehensive knowledge of the State and Federal laws relating to pesticidal materials and their application.

(e) Possesses the ability to maintain records and report accurately.

(f) Possesses an understanding of the potential environmental consequences of the use and misuse of pesticides.

(g) Possesses a practical understanding concerning toxicity, hazards, and precautions to be taken in using pesticides.

(h) Possesses the ability to identify pests and know the importance of the biology of pests relevant to the area of operation.

2. Specific Skills

(a) Possesses a practical knowledge of the types, maintenance, use, and calibration of aerial application equipment.

(b) Possesses an understanding of how to apply pesticides in various formulations.

(c) Possesses knowledge of meteorological conditions and their impact upon aerial applications.

(d) Possesses a license to operate and fly an aircraft in a safe manner and understands the parameters of his equipment under given conditions.

d. Structural Applicator

A person who operates equipment designed for pest control in structures.

1. General Skills

(a) Possesses an elementary knowledge of mathematics and communications.

(b) Possesses a knowledge of Integrated Pest Management Programs.

(c) Possesses a knowledge of application equipment including operation, maintenance, calibration and decontamination.

(d) Possesses a comprehensive knowledge of the State and Federal laws relating to pesticidal materials and their application.

(e) Possesses the ability to maintain records and report accurately.

(f) Possesses an understanding of the potential environmental consequences of the use and misuse of pesticides.

(g) Possesses a practical understanding concerning toxicity, hazards, and precautions to be taken in using pesticides.

(h) Possesses the ability to identify pests and know the importance of the biology of pests relevant to the area of operation.

2. Specific Skills

(a) Possesses a knowledge of safety practices in relationship to food, utensils, food processing equipment, sleeping quarters, and food preparation areas.

(b) Possesses a knowledge of the elements of construction such as location of vents and drainage systems, in relation to the work being done and the habits of the pest.

(c) Possesses a knowledge of surfaces on which pesticides are applied such as vinyl or asbestos floors, wax finish, etc.

(d) Possesses the ability to operate equipment designed for pest control in structures.

4. RELEVANT COURSES

a. Integrated Pest Management Foreman

1. General Education	CREDITS	SEMESTER 1	2	3	4
(a) Basic Communications	3	x			
(b) General Biology	3		x		
(c) General Chemistry	4			x	
(d) Agriculture and the Environment	3	x			
(e) Social Science	3				x
TOTAL General Education	16				

4. RELEVANT COURSES (continued)

2. Occupational Core

		CREDITS	SEMESTER 1	2	3	4
(a)	Basic Agricultural Mechanics	3	x			
(b)	Agricultural Chemicals	3				x
(c)	Technical Report Writing	2			x	
(d)	Crop Ecology	3			x	
(e)	Farm Equipment	3			x	
(f)	Crop Production I	3	x			
(g)	Agricultural Pest Control	5				x
(h)	Supervised Occupational Practice	4	x	x	x	x
(i)	Agricultural Computations	2	x			
	TOTAL Occupational Core	28				

3. Specialty

		CREDITS	SEMESTER 1	2	3	4
(a)	Supervision in Agriculture	2			x	
(b)	Crop Production II	3		x		
(c)	Farm Records and Analysis	2		x		
(d)	Farm Management	3				x
	TOTAL Specialty	10				

4. Elective

		CREDITS
(a)	Humanities	3
(b)	Plant Nutrition	3
(c)	Soils	4
(d)	Agricultural Economics	3
(e)	Personal Typing	2
(f)	Conversational Spanish	2
(g)	Irrigation and Drainage	3
(h)	Speech	3
	TOTAL Electives	6

4. RELEVANT COURSES (continued)

b. Field Equipment Technician

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Communications	3	x			
(b) General Biology	3		x		
(c) General Chemistry	4			x	
(d) Agriculture and the Environment	3	x			
(e) Social Science	3				x
TOTAL General Education	16				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Agricultural Mechanics	3	x			
(b) Agricultural Chemicals	3				x
(c) Technical Report Writing	2			x	
(d) Crop Ecology	3			x	
(e) Farm Equipment	3			x	
(f) Crop Production I	3	x			
(g) Agricultural Pest Control	5				x
(h) Supervised Occupational Practice	4	x	x	x	x
(i) Agricultural Computations	2	x			
TOTAL Occupational Core	28				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Technical Drawing	2		x		
(b) Farm Tractors	2		x		
(c) Farm Welding	2		x		
(d) Farm Power	3		x		
(e) Agricultural Fluid Power	3				x
TOTAL Specialty	12				

4. RELEVANT COURSES (continued)

4. Elective

	CREDITS
(a) Humanities	3
(b) Plant Nutrition	3
(c) Soils	4
(d) Agricultural Economics	3
(e) Personal Typing	2
(f) Conversational Spanish	2
(g) Irrigation and Drainage	3
(h) Speech	3
TOTAL Elective	4

c. Aerial Applicator

1. General Education

		SEMESTER			
	CREDITS	1	2	3	4
(a) Basic Communications	3	x			
(b) General Biology	3		x		
(c) General Chemistry	4			x	
(d) Agriculture and the Environment	3	x			
(e) Social Science	3				x
TOTAL General Education	16				

2. Occupational Core

		SEMESTER			
	CREDITS	1	2	3	4
(a) Basic Agricultural Mechanics	3	x			
(b) Agricultural Chemicals	3				x
(c) Technical Report Writing	2			x	
(d) Crop Ecology	3			x	
(e) Farm Equipment	3			x	
(f) Crop Production I	3	x			

4. RELEVANT COURSES (continued)

2. Occupational Core (continued)

	CREDITS	SEMESTER 1	2	3	4
(g) Agricultural Pest Control	5				x
(h) Supervised Occupational Practice	4	x	x	x	x
(i) Agricultural Computations	2	x			
TOTAL Occupational Core	28				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Flight Training and Ground School as required F.A.A. for pilot licensing	13		x	x	
(b) Meterology	3				x
TOTAL Specialty	16				

4. Elective

	CREDITS
(a) None	0

d. Structural Applicator

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Communications	3	x			
(b) General Biology	3		x		
(c) General Chemistry	4			x	
(d) Agriculture and the Environment	3	x			
(e) Social Science	3				x
TOTAL General Education	16				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Agricultural Mechanics	3	x			
(b) Agricultural Chemicals	3				x
(c) Technical Report Writing	2			x	

4. RELEVANT COURSES (continued)

2. Occupational Core (continued)

	CREDITS	SEMESTER 1	2	3	4
(d) Crop Ecology	3			x	
(e) Farm Equipment	3			x	
(f) Crop Production I	3	x			
(g) Agricultural Pest Control	5				x
(h) Supervised Occupational Practice	4	x	x	x	x
(i) Agricultural Computations	2	x			
TOTAL Occupational Core	28				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Structural Pest Control Techniques	4		x		
TOTAL Specialty	4				

4. Elective

	CREDITS
(a) Humanities	3
(b) Plant Nutrition	3
(c) Soil	4
(d) Agricultural Economics	3
(e) Personal Typing	2
(f) Conversational Spanish	2
(g) Irrigation and Drainage	3
(h) Speech	3
TOTAL Elective	12

5. PROGRAM PREPARATION

(a) High school diploma.

(b) Completion of a high school vocational-agriculture basic sciences and mechanics.

(c) Field experience.

6. EXAMPLES OF CLASSROOM ACTIVITIES

(a) Collect and identify weeds, insects, and diseased plant materials.

(b) Write sample reports to include tables and graphs.

(c) Apply for a pesticidal use permit.

(d) Calculate sample problem on pesticide dosages and unit cost.

(e) Analyze integrated pest management techniques and propose solutions to sample pest problems.

(f) Role play labor-management situations.

(g) Have guest speakers such as county agents, public health officers, industry consultants, etc.

(h) Trouble shoot farm engines and application equipment.

(i) Disassemble and reassemble farm engines and application equipment.

7. EXAMPLES OF FIELD EXPERIENCES

(a) Operate farm equipment.

(b) Calibrate, adjust, and test application equipment.

(c) Sample pest populations and record abundance.

(d) Observe crop damage and losses.

(e) Maintain demonstration plots.

(f) Apply pesticides, collect and record results.

(g) Practice problems in safe handling of pesticides and container disposal.

(h) Visit local pesticide plants, farm machinery dealers, and farmers.

(i) Practice equipment decontamination.

(j) Maintain meteorlogical records.

(k) Work in the related occupation to gain experience.

C. INTEGRATED PEST MANAGEMENT - SUPPLIES AND SERVICES

1. PROGRAM DESCRIPTION

This program is designed to prepare a student to become a retailer, sales person, or technical sales person in the integrated pest management industry. Supplies and Services is one of three program options. The other two are Laboratory Services and Application Services. This program contains many field experiences, and, "hands-on" activities to give the student practical, relevant skills used in the pest management industry. The individual will be enrolled in business, sales, agricultural, environmental, and pest management courses. Upon completion, individuals will be able to sell all types of pesticides, interpret product labels in accordance with local conditions and current Federal and State recommendations. The graduate will be able to recognize and provide solutions for local pest problems; demonstrate proficiency in particular application techniques; and provide follow up sales contact to insure proper product utilization to insure customer satisfaction.

2. PROGRAM OBJECTIVES

(a) To prepare individuals for occupations in Integrated Pest Management.

(b) To develop an understanding of the judicious use of selective pesticides in combination with biological agents and cultural methods.

(c) To prepare individuals as Integrated Pest Management retailers, sales people and technical sales people.

3. JOB TITLES AND DESCRIPTIONS

a. Retailer

A person who provides the consumer with supplies and material necessary for pest management.

1. General Skills

   (a) Possesses knowledge of the product and its effect on living systems and the environment.

   (b) Possesses basic knowledge of pests in this person's trade area.

   (c) Possesses basic understanding of Integrated Pest Management.

   (d) Possesses interpersonal skills.

3. JOB TITLES AND DESCRIPTIONS (continued)

a. Retailer (continued)

(e) Recognizes Federal, State, and local rules and regulations pertaining to pesticides merchandise.

(f) Able to tell the safety precautions to follow with pesticide merchandise.

(g) Has basic knowledge of pesticide application equipment used in his trade area.

(h) Competent in basic mathematics, sales ticket completion, figuring discounts and taxes, pricing merchandise, and using business machines.

(i) Be able to practice sales techniques.

2. Specific Skills

(a) Possesses basic skills in business and pesticide terminology, inventory control, credit control, advertising and promotion, merchandise display; and business law in the Integrated Pest Management industry.

(b) Competent in personnel management.

(c) Be able to recommend possible cultural, biological, and chemical control for local area pests.

b. Salesperson

A person who provides the customer supplies and material necessary for pest management upon request.

1. General Skills

(a) Possesses knowledge of the product and its effect on living systems and the environment.

(b) Possesses basic knowledge of pests in this person's trade area.

(c) Possesses basic understanding of Integrated Pest Management.

(d) Possesses interpersonal skills.

(e) Recognizes Federal, State, and local rules and regulations pertaining to pesticides merchandise.

3. <u>JOB TITLES AND DESCRIPTIONS</u> (continued)

b. <u>Salesperson</u> (continued)

(f) Able to tell the safety precautions to follow with pesticides merchandise.

(g) Has basic knowledge of pesticide application equipment used in his trade area.

(h) Competent in basic mathematics, sales ticket completion, figuring discounts and taxes, pricing merchandise, and using business machines.

(i) Be able to practice sales techniques.

2. <u>Specific Skills</u>

(a) Possesses basic knowledge of the product inventory.

(b) Be aware of store delivery systems.

(c) Be able to follow written and oral instructions.

(d) Know the storage recommendations and shelf life of products.

c. <u>Technical Salesperson</u>

A person who advises the customer about material and supplies necessary for pest management.

1. <u>General Skills</u>

(a) Possesses knowledge of the product and its effect on living systems and the environment.

(b) Possesses basic knowledge of pests in this person's trade area.

(c) Possesses basic understanding of Integrated Pest Management.

(d) Possesses interpersonal skills.

(e) Recognizes Federal, State, and local rules and regulations pertaining to pesticides merchandise.

(f) Able to tell the safety precautions to follow with pesticides merchandise.

(g) Has basic knowledge of pesticide application equipment used in his trade area.

3. JOB TITLES AND DESCRIPTIONS (continued)

c. Technical Salesperson (continued)

(h) Competent in basic mathematics, sales ticket completion, figuring discounts, and taxes, pricing merchandise, and using business machines.

(i) Be able to practice sales techniques.

2. Specific Skills

(a) Competent in field sampling techniques.

(b) Competence in problem solving techniques.

(c) Be able to identify those organisms harmful to his environment.

(d) Be able to recommend possible biological, cultural, and chemical control for local area pests.

(e) Possesses a knowledge of pesticide terminology.

4. RELEVANT COURSES

a. Retailer

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Communication	3		x		
(b) General Biology	3	x			
(c) Agriculture and the Environment	3	x			
(d) Public Speaking	3			x	
(e) Human Relations	3	x			
TOTAL General Education	15				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Crop Production I	3	x			
(c) Basic Agricultural Mathematics	3	x			
(d) Agricultural Record Keeping	3		x		

4. RELEVANT COURSES (continued)

a. Retailer (continued)

2. Occupational Core (continued)

	CREDITS	SEMESTER 1	2	3	4
(e) Agricultural Pest Control	5			x	
(f) Crop Ecology	3				x
(g) Farm Equipment	3		x		
(h) Salesmanship	3			x	
(i) Supervised Occupational Experience	3			x	
(j) Pesticide Law	1				x
TOTAL Occupational Core	30				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Soil Science	3			x	
(b) Agribusiness Management	3				x
(c) Crop Production II	3	x			
TOTAL Specialty	9				

4. Elective

	CREDITS
(a) Office Machines	3
(b) Bookkeeping	3
(c) Economics	3
(d) Psychology	3
(e) Personal Health	3
(f) Personal Finance	3
(g) Personal Typing	2
(h) Business Law	3
(i) Conversational Spanish	2
TOTAL Elective	6

4. RELEVANT COURSES (continued)

b. Salesperson

1. General Education

	SEMESTER				
	CREDITS	1	2	3	4
(a) Basic Communications	3		x		
(b) General Biology	3	x			
(c) Agriculture and the Environment	3	x			
(d) Public Speaking	3			x	
(e) Human Relations	3	x			
TOTAL General Education	15				

2. Occupational Core

	SEMESTER				
	CREDITS	1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Crop Production I	3	x			
(c) Basic Agricultural Mathematics	3		x		
(d) Agricultural Record Keeping	3		x		
(e) Agricultural Pest Control	5			x	
(f) Crop Ecology	3				x
(g) Farm Equipment	3		x		
(h) Salesmanship I	3	x			
(i) Supervised Occupational Experience	3			x	
(j) Pesticide Law	1				x
TOTAL Occupational Core	30				

3. Specialty

	SEMESTER				
	CREDITS	1	2	3	4
(a) Salesmanship II	3		x		
(b) Field Experience in Sampling Techniques	3			x	
TOTAL Specialty	6				

4. RELEVANT COURSES (continued)

b. Salesperson (continued)

4. Elective

	CREDITS
(a) Office Machines	3
(b) Bookkeeping	3
(c) Economics	3
(d) Psychology	3
(e) Personal Health	3
(f) Personal Finance	3
(g) Personal Typing	2
(h) Business Law	3
(i) Conversational Spanish	2
TOTAL Elective	9

c. Technical Salesperson

1. General Education

	CREDITS	SEMESTER 1	2	3	4
(a) Basic Communications	3		x		
(b) General Biology	3	x			
(c) Agriculture and the Environment	3	x			
(d) Public Speaking	3			x	
(e) Human Relations	3	x			
TOTAL General Education	15				

2. Occupational Core

	CREDITS	SEMESTER 1	2	3	4
(a) Agricultural Chemicals	3				x
(b) Crop Production I	3	x			
(c) Basic Agricultural Mathematics	3		x		
(d) Agricultural Record Keeping	3		x		

4. RELEVANT COURSES (continued)

2. Occupational Core (continued)

	CREDITS	SEMESTER 1	2	3	4
(e) Agricultural Pest Control	5			x	
(f) Crop Ecology	3				x
(g) Farm Equipment	3		x		
(h) Salesmanship I	3	x			
(i) Supervised Occupational Experience	3			x	
(j) Pesticide Law	1				x
TOTAL Occupational Core	30				

3. Specialty

	CREDITS	SEMESTER 1	2	3	4
(a) Salesmanship II	3		x		
(b) Field Experience in Sampling Techniques	3			x	
TOTAL Specialty	6				

4. Elective

	CREDITS
(a) Office Machine	3
(b) Bookkeeping	3
(c) Economics	3
(d) Psychology	3
(e) Personal Health	3
(f) Personal Finance	3
(g) Personal Typing	2
(h) Business Law	3
(i) Conversational Spanish	2
TOTAL Elective	9

5. PROGRAM PREPARATION

(a) High school vocational agriculture and business education courses would be very helpful.

(b) Occupation experience in sales, agriculture or pesticides would enable the student to advance at a more rapid rate.

(c) High school diploma.

6. EXAMPLES OF CLASSROOM ACTIVITIES

(a) Students will bring to class examples of insects and disease damaged crops.

(b) Students will make a collection of common insect pests.

(c) Discuss cultural practices, natural predators of insects, and inheritable insect resistance bred in crop varieties.

(d) Students select varieties from yield trial results, which are resistant to, or tolerant to, many diseases of that particular crop.

(e) Students will trace the life cycle of the major plant diseases.

(f) Students will estimate the economic effect of a widespread disease. Could use past history such as Southern corn blight in the mid-west in 1970.

(g) Students develop a set of cultural and chemical practices for disease control on a given form.

(h) Interpret and apply the information found on a chemical container seal.

(i) Determine the application rate per acre that is required and calibrate the output of the sprayer.

(j) Students determine labor and machine requirements of cultural pest control.

(k) Discuss safety equipment and procedures required for the safe handling and use of chemicals.

(l) Explain the procedures needed for the safe storage of pesticides and for the safe disposal of empty containers and unused chemicals.

(m) Determine the cost per acre of chemical pest control.

6. <u>EXAMPLES OF CLASSROOM ACTIVITES</u> (continued)

(n) Estimate the yield increases in recent years that are due primarily to chemical pest control.

(o) Review pesticide control regulations that apply to the chemical effects of man and the environment.

(p) Two people from local business speak to the class concerning opportunities in insect pest management selling.

(q) Using a successful sales person, select those traits which might contribute to a successful sales person.

(r) Students role-play desirable and undesirable selling personalities.

(s) Students take "Self-Analysis of Interest in Sales Work" (test) and determine their individual scores.

(t) Describe how to meet new people.

(u) Invite a successful farmer to discuss his relationship with a salesman to the class.

(v) Students prepare a demonstration to show how to appeal to a customer who would be motivated by the "ease and convenience" motive, the "safety" motive, or the "profit" motive.

(w) Students bring chemical labels to class and discuss product information.

(x) Students develop a visual aid designed to overcome objections.

(y) Video tape a student traying to make a sale and then have the class critique the tape.

(z) Students take pre-test to determine ability to solve written problems which occur on the job.

(aa) Prepare a chart of the four ways of doing business, comparing the features of: who owns the business, how is voting conducted, who manages the company, who gets the profits, how are profits distributed and how are taxes paid?

(bb) Students operate a cash register. Each student should take the part of cashier and make change. Other students act the part of customers. Use real money.

7. EXAMPLES OF FIELD EXPERIENCES

(a) Using a collection net, students will determine the number and kinds of insects present in a crop field.

(b) Students will visit a crop improvement station or plant breeder and discuss inheritable resistance to diseases.

(c) Students will conduct a periodic field survey to determine insect infestation, stage of development, and optimum time for chemical control application.

(d) Visit a test plot and evaluate the effectiveness of various pesticide treatments.

(e) Visit an organic farmer who uses only cultural methods of pest control.

(f) Visit with farmers and determine pest control methods used by them before chemicals became widely available.

(g) Conduct a test plot showing the effect of resistant and susceptible varieties of plants.

(h) Survey a field after chemical treatment to determine the chemical's effect on non pests as well as pests.

(i) Drench, spray, dust, or treat animals for specific pests with specific controlling agents.

(j) Student interviews three farmers to determine the dollar cost/acre for insect pest management.

(k) Students bring to class throughout the time salesmanship is studied examples of good and poor selling techniques.

(l) Practice methods of remembering names and pronouncing them correctly.

(m) Students in groups of two to four attend specific community meeting for the purpose of compiling a list of prospective customers for a pesticide sales center. Assume the roles of salesmen, discovering the potential customer without divulging the purpose. Each student reports the experience and presents a list of prospects, giving pertinent data about each.

(n) Visit a local store. Without interfering, try to identify and record the motives that prompted customers to buy.

7. <u>EXAMPLES OF FIELD EXPERIENCES</u> (continued)

(o) Student rides with a salesman for one day.

(p) Survey a business to determine the incidence of common types of errors. Report them to the class.

(q) Students bring examples to class of desirable and undesirable completed sales tickets from local businesses.

(r) Visit local agricultural businesses and observe types of inventory systems used.

BACCALAUREATE LEVEL PROGRAMS

INTRODUCTION

Demand continues for abundant high quality agricultural and forest products, superior standards of health, and freedom from nuisance pests. These demands, when combined with widespread concern for the quality of our environment, have placed new requirements and constraints on those involved in pest control. During the 1950's and 1960's the scient of plant and animal protection experienced gains as well as setbacks. These have helped to set the stage for the appearance of a new kind of professional -- the pest management specialist. Enactment of state and national legislation, particularly in regard to pesticides, demands that this practitioner be trained in a broad, ecologically-oriented way in order to confront the new challenges of the 1970's and the years beyond.

For decades we have depended heavily on chemicals to suppress pests of importance to our agriculture, forests, home grounds, recreational lands, and man himself. Attention now is focused on pest population management through integrated control systems. Traditional pest control and eradication has attempted the reduction or elimination of noxious species without full regard to the economic, biologic, or environmental consequences of such activities. Pest Management, however, implies the use of various methods of pest reduction, compatible with and in combination with one another, with full awareness of pest and damage levels and of ecological considerations. Thus demands are being established in government and private industry for persons broadly educated and trained in the ecological approach to pest management and plant protection.

To provide for the education of these individuals, it is necessary for a new orientation and integration of the pest-oriented disciplines into one common program of education and training based upon the concepts of biotic and abiotic interactions as viewed from the systems approach. One important objective of the recommended program is to impart to the student the philosophy that pest management and plant protection is based on the integration of all known control measures designed to maintain pest densities below economical thresholds and to have a minimal impact on the environment.

Pest Management Specialists must have an understanding of parasites, predators, pathogens, and other natural control agents operating in the ecosystem. Knowledge of the economics of the crop or other commodity system, pest phenology, ecology and behavior, and the spectrum of available artificial control methods, including pesticides, all will be important to the Pest Management Specialist. The plant disease, weed, and nematode situations and many other factors must be considered before making the important action decisions required of him. Properly trained Pest Management Specialists are in short supply today and the outlook for employment in this important field is bright.

In addition to preparing individuals for jobs in the field, the goals of the integrated pest management program should facilitate the student in his understanding of the following:

1. The philosophy and nature of and need for pest management and plant protection,

2. The responsibilities of an individual to society when conducting plant protection programs,

3. The environmental interactions of plant pests, crops and protection measures,

4. The abnormalities of plants incited by both abiotic and biotic agents, and

5. How plant protection enhances economic and aesthetic values of plants and environmental quality.

INTEGRATED PEST MANAGEMENT PROGRAM

To prepare individuals to fulfill these needs a broad Integrated Pest Management Baccalaureate program has been developed. This single program with five options is designed to prepare individuals to enter the field of pest management and plant protection in a total of thirteen specializations.

The program's design is based on a common required core of educational elements and courses in general education, mathematics, and science as well as in pest management and plant protection. Additional educational elements are recommended for each option and many of the specializations.

The recommended B.S. program in Integrated Pest Management and the recommended options and appropriate specializations follows:

(a) Regulatory Option with specializations in:

- (1) Regulatory Technologist
- (2) Regulatory Specialist
- (3) Environmental Monitoring Specialist

(b) Pest Management Option with specialization in:

- (1) Integrated Pest Management Specialist
- (2) Plant Protection Technologist
- (3) Research Assistant in Pest Management

(c) Support Services Option with specialization in:

- (1) Application Supervisor
- (2) Insect Rearing Specialist
- (3) Field Laboratory Supervisor

(d) Education-Information Option with specialization in:

- (1) Education Training Specialist
- (2) Information Specialist

(e) Business-Marketing Option with specialization in:

- (1) Agricultural Chemical Sales Representative
- (2) Market Development Specialist

B.S. INTEGRATED PEST MANAGEMENT

- REGULATORY OPTION
  - REGULATORY TECHNOLOGIST
  - REGULATORY SPECIALIST
  - ENVIRONMENTAL MONITORING SPECIALIST
- PEST MANAGEMENT OPTION
  - INTEGRATED PEST MANAGEMENT SPECIALIST
  - PLANT PROTECTION TECHNOLOGIST
  - RESEARCH ASSISTANT IN PEST MANAGEMENT
- SUPPORT SERVICES OPTION
  - APPLICATION SUPERVISOR
  - INSECT REARING SPECIALIST
  - FIELD LABORATORY SPECIALIST
- EDUCATION-INFORMATION OPTION
  - EDUCATION/TRAINING SPECIALIST
  - INFORMATION SPECIALIST
- BUSINESS MARKETING OPTION
  - AGRICULTURAL CHEMICAL SALES REPRESENTATIVE
  - MARKET DEVELOPMENT SPECIALIST

RELATED JOBS

Many additional jobs which are supportive to the concept of integrated pest management may also be prepared at the baccalaureate degree level. Most of these already have curricula unique to their area. However, it is recommended that some information on integrated pest management specifically and environmental consideration and awareness be included in these curricula. Examples of such programs include:

Meteorological Technologist

Wildlife Biologist

Chemist

Farm Manager

Forest and Park Manager

Soil Analyst

B.S. IN INTEGRATED PEST MANAGEMENT - REGULATORY OPTION

Specialization for Regulatory Technologist

DESCRIPTION

A person who collects samples and observational data for determining regulation compliance, prepares reports and recommendations relating to compliance and makes decisions in the field relating to compliance. A person who:

1. Samples agricultural products and agricultural chemicals.

2. Makes inspections in the field and takes appropriate action.

3. Makes linkages and pursues observed problems to the source, utilizing investigations and observational skills.

4. Determines compliance to all regulations affecting Integrated Pest Management and recommends appropriate action.

OBJECTIVES

The regulatory technologist specialization within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics).
4. Have a general understanding of the interaction among biological, social, and physical system (ecology).
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Know details of all regulations affecting integrated pest management.
14. Have a general knowledge of and the ability to identify economically important pests of the region.
15. Have a knowledge of information sources on pest identification and product analysis.
16. Have a general understanding of plant protection, integrated pest management, and crop ecosystems.
17. Possess knowledge of products and pest management procedure to be inspected.
18. Posses good observational and investigative skills.
19. Possess knowledge of field and laboratory sampling techniques.
20. Have abilities of collecting and reporting data procedures.
21. Possess knowledge of pertinent safety precautions.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses in a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities, and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)	8	Semester	Hours
Chemistry -- Inorganic, Organic and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics -- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science -- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles -- this integrated block should include: 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects. *	15	"	"

*See Recommendations

		SEMESTER HOURS	
Pesticides in the Environment -- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or Regulatory Procedures, or Federal and State Regulations -- Environmental Business Law	3	"	"
Sampling Procedures and Applied Statistics	3	"	"

OPTIONAL COURSES

Wildlife Ecology**	3	"	"
Agricultural Meterology***	3	"	"

** If not included in the core, this course is recommended for all specializations in the regulatory system and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specialization in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology	Plant Pathology	Nematology
Weed Science	Basic College Physics	Systems Analysis Principles and Techniques

ELECTIVES (continued)

Organic Chemistry	Biochemistry	Diagnostic Chemical Experience
Vertebrate Pest Control	Business Law and Contracts	Plant Taxonomy
Computer Science and Modeling	Agricultural Economics Courses	Animal Science (integrated) courses
Microbiology	Agricultural Marketing	Forestry Courses
Range Management Courses	Personnel Management	Population Ecology
Soil Fertility and Plant Nutrition	Agricultural Engineering Courses	Insect Nutrition
Insect Behavior	Insect Pathology	Oral and Written Communications
Educational Materials and Methods	Business Management	

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25

Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Bio-chemistry	6
Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of these programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slide and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisors to individual students.

8. Case studies or special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization include an internship or cooperative work experience in off campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

II. Intermediate Concepts (continued)

a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

a) Biologically sound control programs require knowledge of the cycles.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

Objectives:

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a) Nutritional problems including deficiencies and excesses of mineral nutrients.

    b) Drought, heat, cold, etc.

    c) Air pollution.

4. Biotic factors influencing agricultural crops (agroecosystems).

    a) Man

    b) Vertebrates

    c) Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

a) Insects as vectors of viruses, bacterial, nematodes, etc.

b) Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

c) Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

    a) life cycles

    b) body systems and behavior

    c) biotic interactions

    d) role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a) role in the global ecosystem

    b) place in the animal kingdom

    c) body systems and behavior

    d) role in plant protection

    e) life cycles

    f) interactions with plant production systems

    g) control

<u>COURSE OBJECTIVES FOR THE FINAL CONCEPTS</u>

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - REGULATORY OPTION

Specialization For Regulatory Specialist

DESCRIPTION

A person who monitor sales and use of pest control media chemicals in accordance with laws or public policy. A person who:

1. Makes appropriate disposition of samples from the field and takes appropriate action based on the analysis of the samples.

2. Interprets standards and public policy.

3. Conducts hearings on regulations and compliance.

4. Applies federal and state regulations relating to specific products and activities (e.g., pesticides, herbicides.)

OBJECTIVES

The specialization for preparation of regulatory specialists within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics).

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology).

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

OBJECTIVES (continued)

13. Know all specific details of laws and regulations relating to specific products and activities (e.g., pesticides, herbicides).

14. Make inspections in the field and takes appropriate action.

15. Make linkages and pursues observed problems to the source utilizing investigations and observational skills.

16. Determine compliance to all regulations affecting integrated pest management and recommends appropriate action.

17. Possess general knowledge of judicial, legislative, and governmental processes.

18. Have an appreciation of the integrated approach to pest management, including environmental protection.

19. Display the ability to interpret and apply these laws and regulations.

20. Display the ability to effectively supervise others.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)	8	"	"
Chemistry -- Inorganic, Organic and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics -- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science -- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"

	SEMESTER HOURS		
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles -- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects. *	15	"	"
Pesticides in the Environment -- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"
Personnel Management	3	"	"
Optional Courses			
Wildlife Ecology**	3	"	"
Agricultural Meteorology***	3	"	"

* See Recommendations

** If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specialization in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internships or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics Courses
Microbiology
Forestry Courses
Population Ecology
Insect Nutrition
Insect Behavior
Insect Pathology
Business Management

Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (Integrated courses)
Range Management Courses
Soil Fertility and Plant Nutrition
Oral and Written Communications

Nematology
Systems Analysis, Principles and Techniques
Computer Science and Modeling
Agricultural Marketing
Personnel Management
Agricultural Engineering Courses
Educational materials and methods

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

THE HIGH SCHOOL (continued)

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities.	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry (Organic or Biochemistry)	6
Physics	4
Economics	3
Agricultural Courses	8-16
TOTAL TRANSFER CREDITS	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM (continued)

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies or special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

I. <u>Introductory Concepts</u> (continued)

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. <u>Intermediate Concepts</u>

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

    a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

    b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

    a) Biologically sound control programs require knowledge of the cycle.

    b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the eco-system, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with disease, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

Objectives

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a) Nutritional problems including deficiencies and excesses of mineral nutrients.

    b) Drought, heat, cold, etc.

    c) Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a) Man

    b) Vertebrates

    c) Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

    a) Insects as vectors of viruses, bacteria, nematodes, etc.

    b) Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

    c) Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystems.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.
2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.
3. Apply the concept of disease to pathogenesis with and without parasitism.
4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.
5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.
6. Recognize major types of nematodes and describe their:
    a) life cycles
    b) body systems and behavior
    c) biotic interactions
    d) role in plant protection
7. Understand when and why a plant is considered a weed.
8. Know why the major weeds in their area are important.
9. Identify the major types of weeds and describe their morphology, growth and reproduction.
10. Identify the major insects and other arthropod pests and describe their:
    a) role in the global ecosystem
    b) place in the animal kingdom
    c) body systems and behavior
    d) role in plant protection
    e) life cycles

f) interactions with plant production systems

g) control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - REGULATORY OPTION

Specialization for Environmental Monitoring Specialist

DESCRIPTION

A person who assumes responsibility for assessing the potential impact and monitoring the effects of pest control practices on various components of the environment. A person who:

1. Maintains surveillance on appropriate elements of the environment; e.g., air, water, soil, biota.

2. Makes linkages and pursues observed problems to the source utilizing investigations and observational skills.

3. Applies all regulations pertaining to environmental protection.

4. Maintains credibility with the various groups and individuals who are "environmentally concerned."

5. Writes environmental impact statements.

OBJECTIVES

The specialization for preparation of environmental monitoring specialist within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics).

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology).

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

13. Possess sampling techniques to assist in maintaining surveillance on appropriate element of the environment.

14. Know details of all regulations affecting environmental protection.

15. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.

16. Have a general knowledge of ecology of the region and its crops.

17. Possess knowledge of data collection and the ability to write technical reports.

18. Have training in oral communications.

19. Possess basic knowledge of common pests.

20. Have the ability to recognize and report secondary effects of control measures.

OBJECTIVES (continued)

21. Displays environmental sensitivity.

22. Possess basic knowledge of the effects of pest management on the environment including living systems in air, soil and water.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 SEMESTER HOURS

MATHEMATICS AND GENERAL SCIENCE CORE

Biology (Botany and Zoology)	8	"	"
Chemistry -- Inorganic, Organic and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics -- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science -- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles -- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

*See Recommendations

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)	SEMESTER HOURS		
Pesticides in the Environment -- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"
Sampling Procedures and Applied Statistics	3	"	"
Optional Courses			
Wildlife Ecology**	3	"	"
Agricultural Meterology***	3	"	"

** If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics Courses
Microbiology
Forestry Courses
Population Ecology
Insect Nutrition
Insect Behavior
Insect Pathology
Business Management
Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (Integrated courses)
Range Management Courses
Soil Fertility and Plant Nutrition
Oral and Written Communications
Nematology
Systems Analysis, Principles and Techniques
Computer Science and Modeling
Agricultural Marketing
Personnel Management
Agricultural Engineering Courses
Educational materials and methods

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12

Chemistry, Inorganic	6
Chemistry, Organic or Bio-chemistry	6
Physics	4
Economics	3
Agricultural Courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomodation will have to be made for the graduates of these programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.
2. Part-time work experience which is related to the program.
3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.
4. Use of guest speakers either from other disciplines or practitioners in the field.
5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.
6. Student participation seminars.
7. Assignment of special faculty advisers to individual students.
8. Case studies or special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.

EXAMPLES OF FIELD EXPERIENCES (continued)

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest mananagement and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control programs require knowledge of the cycle.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Biotic factors influencing agricultural crops (agrosystems).

    a) Man

    b) Vertebrates

    c) Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds.

6. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

    a) Insects as vectors of viruses, bacteria, nematodes, etc.

    b) Weeds as hosts for insects and agents of diseases and as reservoirs for viruses.

    c) Nematodes and fungi as vectors of viruses.

7. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

8. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

9. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

10, An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

11. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecase the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

    a) Life cycles

    b) Body systems and behavior

    c) Biotic interactions

    d) Role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a) Role in the global ecosystem

    b) Place in the animal kingdom

    c) Body systems and behavior

    d) Role in plant protection

    e) Life cycles

    f) Interactions with plant production systems

    g) Control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles Integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used on the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - PEST MANAGEMENT OPTION

Specialization for Integrated Pest Management Specialist

DESCRIPTION

A person who is qualified to use the many disciplines required to perform the tasks of integrated pest management, which entails specifically the broad use and understanding of biological-cultural-chemical methods to enhance the most economically and ecologically sound practices for the management of pests. This individual could have a baccalaureate background plus extensive experience. (It should be noted that advanced degree work may be expected in the future.) A person who:

1. Operates as pest manager on a specific group of farms.

2. Concentrates his activities on the pest problem of one geographic area.

3. Acts as manager or organizer for a district or company.

4. Supervises such workers as field checkers and scouts.

5. Interprets and verifies data in the field and makes recommendations on what should or should not be done.

OBJECTIVES

The specialization for preparation of integrated pest management specialists within the baccalaureate degree in integrated pest management will prepare individuals who:

OBJECTIVES (continued)

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics).

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology).

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

13. Are able to identify pests in a selected agroecosystem.

14. Know pesticides and methods of application.

15. Know specific sampling techniques for the pests in the selected agroecosystems.

16. Understand cultural and biological control including host plants resistance in the selected agroecosystem.

17. Understand the significant component parts of the agroecosystems and their interaction.

18. Have a general knowledge of State and Federal regulations.

19. Have an understanding of elementary business management skills.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 SEMESTER HOURS

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)	8	"	"
Chemistry -- Inorganic, Organic and Chemistry of Living Things	10	"	"
Mathematics	3	"	"
Statistics -- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science -- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles -- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"
Pesticides in the Environment -- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"

*See Recommendations

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)	SEMESTER HOURS		
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"
Population Ecology	3	"	"
Systems Analysis Principles and Techniques	3	"	"
Advanced Pest Management	9	"	"

This is to be a series of integrated, multidisciplinary or single disciplinary courses to insure student flexibility. Examples of areas of specialization include:

- Soil Fertility and Plant Nutrition
- Computer Science
- Advanced Entomology, Plant Pathology, Nematology and Weed Science
- Microbiology

OPTIONAL COURSES

Wildlife Ecology**	3	"	"
Agricultural Meteorology***	3	"	"

** If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

INTERNSHIPS (continued)

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics Courses
Microbiology
Forestry Courses
Population Ecology
Insect Nutrition
Insect Behavior
Insect Pathology
Business Management

Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (Int-
egrated courses)
Range Management Courses
Soil Fertility and
Plant Nutrition
Oral and Written
Communications

Nematology
Systems Analysis,
Principles and
Techniques
Computer Science and
Modeling
Agricultural Marketing

Personnel Management
Agricultural Engin-
eering Courses
Educational materials
and methods

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

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Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

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THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
Physics	4
Economics	3
Agricultural Courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of these programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.
2. Part-time work experience which is related to the program.
3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.
4. Use of guest speakers either from other disciplines or practitioners in the field.
5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.
6. Student participation seminars.
7. Assignment of special faculty advisers to individual students.
8. Case studies or special courses.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization include an internship or cooperative work experience in off campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control progr[illegible] require knowledge of the cycles.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Biotic factors influencing agricultural crops (agroecosystems).

    a) Man

    b) Vertebrates

    c) Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

6. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

    a) Insects as vectors of viruses, bacteria, nematodes, etc.

    b) Weeds as hosts for insects and agents of diseases and as reservoris for viruses.

    c) Nematodes and fungi as vectors of viruses.

7. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

8. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

9. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

III. Final Concepts (continued)

10. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

11. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

    a) Life cycles

    b) Body systems and behaviors

    c) Biotic interactions

    d) Role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a) Role in the global ecosystem

    b) Place in the animal kingdom

    c) Body systems and behavior

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

d) Role in plant protection

e) Life cycles

f) Interactions with plant production systems

g) Control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - PEST MANAGEMENT OPTION

Specialization for Plant Protection Technologist

DESCRIPTION

A person who conducts large scale action programs in plant protection publicly sponsored either by governmental agencies or by special interest groups. A person who:

1. Designs and conducts action programs in plant protection; e.g.,

   a) Area control programs
   b) Area suppression programs
   c) Area eradication programs
   d) Quarantine

2. Monitors, conducts surveilance and detects infestations.

DESCRIPTION (continued)

3. Maintains a public communication and public information service.

4. Writes environmental impact statements.

OBJECTIVES

The specialization for the preparation of plant protection technologists within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics).

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology).

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

13. Are able to identify pests in a selected agroecosystem.

14. Know pesticides and methods of application.

15. Know specific sampling techniques for the pests in the selected agroecosystem.

OBJECTIVES (continued)

16. Understand the significant component parts of the agroecosystems and their interaction.

17. Have a general knowledge of State and Federal regulations.

18. Have an understanding of elementary business management skills.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

	20-26	Semester	Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry -- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science -- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles-- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

*See Recommendations

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

			Semester Hours
Pesticides in the Environment -- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"
Population Ecology	3	"	"
Systems Analysis Principles and Techniques	3	"	"
Advanced Pest Management	9	"	"

This is to be a series of integrated, multi-disciplinary or single disciplinary courses to insure student flexibility. Examples of areas of specialization include:

Soil Fertility and Plant Nutrition
Computer Science
Advanced Entomology, Plant Pathology
Nematology and Weed Science
Microbiology

OPTIONAL COURSES

			Semester Hours
Wildlife Ecology**	3	"	"
Agricultural Meteorology***	3	"	"

** If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

- Advanced Entomology
- Weed Science
- Biochemistry
- Business Law and Contracts
- Plant Taxonomy
- Animal Science (integrated) courses
- Range Management Courses
- Soil Fertility and Plant Nutrition
- Insect Behavior
- Educational Material and Methods
- Plant Pathology
- Basic College Physics
- Diagnostic Chemical Experience
- Computer Science and Modeling
- Microbiology
- Personnel Management
- Agricultural Engineering Courses
- Insect Pathology
- Business Management
- Nematology
- Organic Chemistry
- Vertebrate Pest Control
- Agricultural Economics Courses
- Forestry Courses
- Agricultural Marketing
- Sampling Procedures and Applied Statistics
- Insect Nutrition
- Oral and Written Communications

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

- Biology
- Chemistry
- Earth Science
- College Preparatory Math
- Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
Physics	4
Economics	3
Agricultural Courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of these programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM (continued)

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies or special courses.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization include an internship or cooperative work experience in off-campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

I. Introductory Concepts (continued)

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

II. <u>Intermediate Concepts</u> (continued)

a) Biologically sound control programs require knowledge of the cycles.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. <u>Final Concepts</u>

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host, but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Biotic factors influencing agricultural crops (agro-ecosystems).

   a) Man

   b) Vertebrates

   c) Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

6. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

   a) Insects as vectors of viruses, bacteria, nematodes, etc.

   b) Weeds as hosts for insects and agents of diseases and as reservoirs for viruses.

   c) Nematodes and fungi as vectors of viruses.

7. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

III. Final Concepts (continued)

8. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

9. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

10. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

11. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

    a) Life cycles

    b) Body systems and behaviors

    c) Biotic interactions

    d) Role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a) Role in the global ecosystem

    b) Place in the animal kingdom

    c) Body systems and behavior

    d) Role in plant protection

    e) Life cycles

    f) Interactions with plant production systems

    g) Control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequences are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - PEST MANAGEMENT OPTION

Specialization for Research Assistant in Pest Management

DESCRIPTION

A person who assists extension specialists and researchers in the conduct of their programs in integrated pest management. A person who:

1. Identifies plant pests
2. Collects and reports data relating to pest management.
3. Follows instructions involved in assigned tasks.
4. Uses research techniques.
5. Supervises research technicians.

OBJECTIVES

The specialization to prepare research assistants in pest management within the integrated pest management baccalaureate degree program will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics).
4. Have a general understanding of the interaction among biological, social, and physical systems (ecology).
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Are able to identify pests in a selected agroecosystem.
14. Know pesticides and methods of application.
15. Know specific sampling techniques for the pests in the selected agroecosystem.

16. Understand cultural and biological control including host plants resistance in the selected agroecosystem.

17. Understand the significant component parts of the agroecosystems and their interaction.

18. Have a general knowledge of State and Federal regulations.

19. Have an understanding of elementary business management skills.

20. Possess ability to identify plant pests.

21. Possess the knowledge of data collection and reporting.

22. Have the ability to follow instructions for involved task assignments.

23. Possess the proficiency in knowledge and use of current research techniques.

24. Ability to supervise research technicians.

25. Have the knowledge of pertinent safety precautions in the use of agricultural chemicals and equipment.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry -- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"

Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

*See Recommendations

Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"
Population Ecology	3	"	"
Systems Analysis Principles and Techniques	3	"	"
Advanced Pest Management	9	"	"

This is to be a series of integrated, multi-disciplinary of single disciplinary courses to insure student flexibility. Examples of areas of specialization include:

Soil Fertility and Plant Nutrition
Computer Science
Advanced Entomology, Plant Pathology
Nematology and Weed Science
Microbiology

OPTIONAL COURSES	Semester Hours		
Wildlife Ecology**	3	"	"
Agricultural Meteorology***	3	"	"

OPTIONAL COURSES (continued)

* See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

*** If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Biochemistry
Business Law and Contracts
Computer Science and Modeling
Microbiology
Agricultural Marketing
Personnel Management
Agricultural engineering courses
Insect Nutrition
Educational materials and methods
Plant Pathology
Basic College Physics
Diagnostic Chemical Experience
Agricultural Economics courses
Forestry courses
Sampling Procedures and Applied Statistics
Insect Behavior
Business Management
Nematology
Organic Chemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (integrated) courses
Range Management courses
Soil Fertility and Plant Nutrition
Insect Pathology
Oral and Written Communications

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

PROGRAM PREPARATION (continued)

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

- Biology
- Chemistry
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- Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

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Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM (continued)

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special facu ' / advisers to individual students.

8. Case studies or special courses.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

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2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

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4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

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7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

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1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control programs require knowledge of the cycle.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

Objectives

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

    c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

    a. Insects as vectors of viruses, bacteria, nematodes, etc.

    b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

    c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

   a. life cycles

   b. body systems and behavior

   c. biotic interactions

   d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS (continued)

a. role in the global ecosystem

b. place in the animal kingdom

c. body systems and behavior

d. role in plant protection

e. life cycles

f. interactions with plant production systems

g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - SUPPORT SERVICES OPTION

Specialization for Application Supervisor

DESCRIPTION

A person who supervises, coordinates and evaluates integrated pest management control procedures in the field. A person who:

1. Makes effective product utilization.

2. Uses chemical application techniques and equipment.

3. Applies an indepth knowledge of safety theory and practices.

4. Uses a variety of mechanical skills including operation of agricultural equipment.

OBJECTIVES

The specialization to prepare application supervisors within the baccalaureate program in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics)
4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Have the ability to get along with others.
14. Possess a knowledge of all application techniques and equipment.
15. Possess a knowledge of effective product utilization and chemical control.
16. Have the ability to schedule work projects.
17. Possess the ability to utilize inventory procedures.
18. Have the ability to utilize effective training techniques.
19. Possess a knowledge of safety theory and practices.
20. Display skill in negotiating customer complaints.
21. Possess the ability to improvise procedures.
22. Have a general knowledge of and the ability to identify major pests of the region.

23. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.

24. Possess knowledge of Federal and State regulations which apply to the application of agricultural chemicals.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

	20-26	Semester	Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry -- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

*See Recommendations

Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

Soils	3	"	"
Economics	3	"	"
Economic, Legislative and Social Consideration in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulation - Environmental Business Law	3	"	"
Agricultural Engineering (material handling and Mechanics)	6-9	"	"
Personnel Management	3	"	"
Business Law and Contracts	3	"	"

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

There will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U.S. Department of Agriculture, U. S. Environmental Protection Agency, U.S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology	Plant Pathology	Nematology
Weed Science	Basic College Physics	Systems Analysis Principles and Techniques
Organic Chemistry	Biochemistry	Plant Taxonomy
Diagnostic Chemical Experience	Vertebrate Pest Control	Animal Science (integrated)
Computer Science and Modeling	Agricultural Economics courses	Range Management courses
Microbiology	Forestry courses	Insect Behavior
Agricultural Marketing	Samping Procedures Applied Statistics	Insect Pathology
Economic, Legislative and Social Considerations in Pest Management	Insect Nutrition	
Soil Fertility and Plant Nutrition	Educational materials and methods	
Oral and Written Communications		
Business Management		

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant progection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6

Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.
2. Part-time work experience which is related to the program.
3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.
4. Use of guest speakers either from other disciplines or practitioners in the field.
5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.
6. Student participation seminars.
7. Assignment of special faculty advisers to individual students.
8. Case studies or special courses.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.
2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

a) Biologically sound control programs require knowledge of the cycle.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants: and to acquaint the student with integrated control measures and their effects on man's environment.

Objectives:

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

    c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

OBJECTIVES (continued)

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

   a. Insects as vectors of viruses, bacteria, nematodes, etc.

   b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

   c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

<u>COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS</u>

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

a. life cycles

b. body systems and behavior

c. biotic interactions

d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

a. role in the global ecosystem

b. place in the animal kingdom

c. body systems and behavior

d. role in plant protection

e. life cycles

f. interactions with plant production systems

g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection principles integrated undergratuate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST TECHNOLOGY - SUPPORT SERVICES OPTION

Specialization for Insect Rearing Specialist

DESCRIPTION

A person who is an expert in mass production of insects and other anthropods. A person who:

1. Prevents diseases through knowledge of insect pathology; uses sterile techniques.

2. Utilizes knowledge of insect biology, reproduction and behavior.

3. Provides adequate diets through understanding nutrition of insects.

4. Understands production live technology with involvement of both people and materials.

OBJECTIVES

The specialization to prepare insect rearing specialists within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics)

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

OBJECTIVES (continued)

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

13. Have good knowledge of insect nutrition.

14. Have good knowledge of insect pathology.

15. Have good knowledge of insect biology, genetics, and behavior.

16. Understand techniques for rearing insects and other anthropods.

17. Possess greenhouse management skills.

18. Possess insectary management skills.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"

Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"
Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Microbiology	3	"	"
Insect Nutrition	3	"	"
Insect Behavior	3	"	"
Insect Pathology	3	"	"

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

- Advanced Entomology
- Weed Science
- Organic Chemistry
- Diagnostic Chemical Experience
- Business Law and Contracts
- Agricultural Economics courses
- Forestry courses
- Range Management courses
- Economic, Legislative and Social Considerations in Pest Management
- Agricultural engineering courses
- Educational materials and methods
- Plant Pathology
- Basic College Physics
- Biochemistry
- Vertebrate Pest Control
- Plant Taxonomy
- Animal Science (integrated) courses
- Personnel Management
- Samping Procedures and Applied Statistics
- Oral and Written Communications
- Nematology
- Systems Analysis Principles and Techniques
- Computer Science and Modeling
- Agricultural Marketing
- Population Ecology
- Soil Fertility and Plant Nutrition
- Business Management

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12

THE COMMUNITY COLLEGE (continued)

Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomoda-tion will have to made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdis-ciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is in-dividually scheduled and which also includes an intro-duction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.

2. Field trips to such places as residue laboratories, commercial

insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal

of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control programs require knowledge of the cycle.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

FINAL CONCEPTS (continued)

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural corps (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

FINAL CONCEPTS (continued)

   c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

   a. Insects as vectors of viruses, bacteria, nematodes, etc.

   b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

   c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber,and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

<u>COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS</u>

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

    a. life cycles

    b. body systems and behavior

    c. biotic interactions

    d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a. role in the global ecosystem

    b. place in the animal kingdom

    c. body systems and behavior

    d. role in plant protection

    e. life cycles

    f. interactions with plant production systems

    g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - SUPPORT SERVICES OPTION

Specialization for Field Laboratory Supervisor

DESCRIPTION

A person who supervises the activities of a field laboratory serving as an adjunct to an integrated pest management program. A person who supervises and coordinates the activities of personnel in such a laboratory centering about pests such as nematodes, weeds, diseases and insects. A person who:

1. Analyzes or identifies biological materials.
2. Handles and analyzes statistical data.
3. Supplies staff support for integrated pest management programs.
4. Prepares maps of infestation or travel charts.
5. Supervises workers in the field.

OBJECTIVES

The specialization to prepare field laboratory supervisors within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics)
4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

OBJECTIVES (continued)

13. Possess thorough knowledge of analytical and identification procedures, e.g., chemical, biological, physical.

14. Can apply statistical procedures.

15. Know how to prepare technical reports.

16. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

Pesticides in the Environment --- Development and

classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Personnel Management	3	"	"
Sampling Procedures and Applied Statistics	3	"	"
Advance Pest Management	9	"	"

This is to be a series of integrated, multi-disciplinary or single discipline courses to insure student flexibility. Samples of areas of specialization include:

Soil Fertility and Plant Nutrition

Computer Science
Advanced Entymology, Plant Pathology, Nematology, and Weed Science Microbiology

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics courses
Agricultural Marketing
Forestry courses
Population Ecology
Agricultural engineering courses
Insect Nutrition
Insect Pathology
Educational materials and methods
Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (integrated) courses
Range Management courses
Soil Fertility and Plant Nutrition
Insect Behavior
Oral and Written Communications
Nematology
Systems Analysis Principles and Techniques
Computer Science and Modeling
Microbiology
Economic, Legislative and Social Considerations in Pest Management
Business Management

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6

Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.
2. Part-time work experience which is related to the program.
3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.
4. Use of guest speakers either from other disciplines or practitioners in the field.
5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.
6. Student participation seminars.
7. Assignment of special faculty advisers to individual students.
8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies.
2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements ot pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

a) Biologically sound control programs require knowledge of the cycle.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves

assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

    c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in pro-

OBJECTIVES (continued)

ducing disease in crop plants and/or reduced crop yield or quality.

a. Insects as vectors of viruses, bacteria, nematodes, etc.

b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

a. life cycles

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS (continued)

b. body systems and behavior

c. biotic interactions

d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

a. role in the global ecosystem

b. place in the animal kingdom

c. body systems and behavior

d. role in plant protection

e. life cycles

f. interactions with plant production systems

g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MAMAGEMENT - EDUCATION-INFORMATION OPTION

Specialization for Education/Training Specialist

DESCRIPTION

A person skilled in the theorectical and applied techniques and approaches involved in integrated pest management. Equipped by formal education and experience to give the leadership and inspiration necessary to train individuals in the philosophy or/and skills needed to integrated pest management. A person who:

1. Trains para-professionals, pre-professionals and technicians to work in integrated pest management.
2. Communicates well both verbally and in written form.
3. Uses latest educational technology.

OBJECTIVES

The specialization to prepare education/training specialists within the baccalaureate program in integrated pest mamagement will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics)
4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Have a philosophical commitment to the integrated pest management approach.
14. Possess competency in the certain plant protection fields.

OBJECTIVES (continued)

15. Possess a knowledge of how to use the latest educational technology.

16. Have the ability to work with people.

17. Can apply the ability to communicate well both verbally and in writing.

18. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

	20-26	Semester	Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soil	3	"	"
Economics	3	"	"
Oral and Written Communications	3	"	"
Educational Materials and Methods	3	"	"
Basic Journalism, including news reporting and feature writing	6	"	"

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U.S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology　　Plant Pathology　　Nematology

ELECTIVES (continued)

Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics courses
Microbiology
Forestry courses
Personnel Management
Samping Procedures and Applied Statistics
Agricultural engineering courses
Insect Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (integrated) courses
Range Management courses
Economic, Legislative and Social Considerations in Pest Management
Insect Nutrition
Business Management
Systems Analysis Principles and Techniques
Computer Science and Modeling
Agricultural Marketing
Population Ecology
Soil Fertility and Plant Nutrition
Insect Behavior

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6

Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduate of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies. For this specialization one of the work periods should be with an employer such as an extension information specialist.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and

beneficial influence within biological systems.

a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

a) Biologically sound control programs require knowledge of the cycle.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. <u>Final Concepts</u>

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

   a. Nutritional problems including deficiencies and excesses of mineral nutrients.

   b. Drought, heat, cold, etc.

   c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

   a. Man

   b. Vertebrates

   c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

OBJECTIVES (continued)

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

   a. Insects as vectors of viruses, bacteria, nematodes, etc.

   b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

   c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

   a. life cycles

b. body systems and behavior

c. biotic interactions

d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

a. role in the global ecosystem

b. place in the animal kingdom

c. body systems and behavior

d. role in plant protection

e. life cycles

f. interactions with plant production systems

g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT EDUCATION-INFORMATION OPTION

Specialization for Information Specialist

DESCRIPTION

A person who interprets and adapts research findings and evaluates progress in integrated pest management and converts these into a usable form for dissemination to the public. A person who:

1. Writes informational pieces on integrated pest management.

2. Develops visuals aids and displays related to integrated pest management.

3. Uses the mass communications media for dissemination of information of integrated pest management.

OBJECTIVES

The specialization to prepare information specialists within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.

2. Have a general understanding of living systems (biology).

3. Have a general understanding of physical systems (chemistry and physics)

4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)

5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.

6. Have an understanding of how plants function and reproduce.

7. Have an ability to recognize a pest problem and its etiology.

8. Have a knowledge of the principles of plant protection.

9. Understand the economic systems as related to agricultural production.

10. Understand elementary statistics and sampling.

11. Understand and practice interpersonal skills.

12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.

13. Have ability to interpret research findings and evaluate trends.

14. Possess skills and expertise in writing, visual aid development and use of mass communications media.

15. Possess a general understanding of plant protection, integrated pest management and crop ecosystems.

16. Have an environmental sensitivity which includes biological, social and economic implications.

17. Have a general knowledge of the Federal, State and local laws and regulations governing pest control.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies	20-26	Semester	Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"
Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

Soils	3	"	"
Economics	3	"	"
Oral and Written Communications	3	"	"
Educational Materials and Methods	3	"	"
Basic Journalism, including news reporting and feature writing.	6	"	"

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Business Law and Contracts
Agricultural Economics courses
Microbiology

Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Plant Taxonomy
Animal Science (integrated) courses

Nematology
Systems Analysis Principles and Techniques
Computer Science and Modeling
Agricultural Marketing

ELECTIVES (continued)

Forestry courses
Economic, Legislative and Social Consideration in Pest Management
Soil Fertility and Plant Nutrition
Agricultural engineering courses
Insect Pathology
Range Management courses
Sampling Procedures and Applied Statistics
Insect Nutrition
Business Management
Personnel Management
Population Ecology
Insect Behavior

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
Physics	4
Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accomodation will have to be made for the graduates of those programs to enter the baccalaureate program with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies. One period of this experience should be with an employer as an extension information specialist or in a practice teaching situation.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

   a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

   b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control programs require knowledge of the cycle.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It

is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

    c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.

    a. Insects as vectors of viruses, bacteria, nematodes, etc.

    b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

OBJECTIVES (continued)

c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

   a. life cycles

   b. body systems and behavior

   c. biotic interactions

   d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

    a. role in the global ecosystem

    b. place in the animal kingdom

    c. body systems and behavior

    d. role in plant protection

    e. life cycles

    f. interactions with plant production systems

    g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - BUSINESS-MARKETING OPTION

Specialization for Agricultural Chemical Sales Representative

DESCRIPTION

A person who provides the formulator, retailer, or farmer with supplies, materials and information necessary for pest management and plant protection. A person who:

1. Supplies information on agricultural chemicals and related materials.

DESCRIPTION (continued)

2. Offers suggestions to formulators, retailers, and farmers relating to use of agricultural chemicals.

OBJECTIVES

The specialization to prepare agricultural chemical sales representative within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics)
4. Have a general understanding of the interaction among biological, social, and physical systems. (ecology)
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Possess ability to communicate with the public.
14. Have knowledge of agricultural chemicals and their use.
15. Possess an environmental sensitivity.
16. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.
17. Know pesticides and methods of application.
18. Have knowledge of merchandising and marketing.
19. Have general knowledge of products.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies

	20-26	Semester	Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology) Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"
Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Business Management	3	"	"
Business Law and Contracts	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

Agricultural Marketing	3	"	"
Oral and Written Communications	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"

OPTIONAL COURSES

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

INTERNSHIPS

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U. S. Department of Agriculture, U. S. Environmental Protection Agency, U. S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

ELECTIVES

Advanced Entomology	Plant Pathology	Nematology
Weed Science	Basic College Physics	Systems Analysis Principles and Techniques
Organic Chemistry	Biochemistry	Agricultural Economics courses
Diagnostic Chemical Experience	Vertebrate Pest Control	
Plant Taxonomy	Computer Science and Modeling	

ELECTIVES (continued)

Animal Science (integrated) courses
Range Management courses
SamplingProcedures & Applied Statistics
Soil Fertility and Plant Nutrition
Insect Nutrition
Insect Behavior
Microbiology
Personnel Management
Population Ecology
Agricultural engineering courses
Insect Pathology
Forestry courses
Economic, Legislative and Social Considerations in Pest Management
Educational materials & methods

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
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Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
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Economics	3
Agricultural courses	8-16
TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.

2. Part-time work experience which is related to the program.

3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.

4. Use of guest speakers either from other disciplines or practitioners in the field.

5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.

6. Student participation seminars.

7. Assignment of special faculty advisers to individual students.

8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies. One of the work periods should be in a residue or chemistry laboratory, manufacturing or formulation or product development plant.

2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

    a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

    b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

   a) Biologically sound control programs require knowledge of the cycle.

   b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds, prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It

is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).
2. Agricultural fields and forests as specialized ecosystems and the relation of these agroecosystems one to another.
3. Abiotic factors influencing agricultural crops (agroecosystems) and their importance in the diagnosis of "abnormal" plant growth.
   a. Nutritional problems including deficiencies and excesses of mineral nutrients.
   b. Drought, heat, cold, etc.
   c. Air pollution
4. Biotic factors influencing agricultural crops (agroecosystems).
   a. Man
   b. Vertebrates
   c. Invertebrates - including nematodes, insects, mites, fungi, bacteria, mycoplasms, viruses and weeds
5. Interrelations among various biotic factors in producing disease in crop plants and/or reduced crop yield or quality.
   a. Insects as vectors of viruses, bacteria, nematodes, etc.
   b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

OBJECTIVES (continued)

   c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probable progression of the disease.

6. Recognize major types of nematodes and describe their:

   a. life cycles

   b. body systems and behavior

   c. biotic interactions

   d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS (continued)

10. Identify the major insects and other arthropod pests and describe their:

    a. role in the global ecosystem

    b. place in the animal kingdom

    c. body systems and behavior

    d. role in plant protection

    e. life cycles

    f. interactions with plant production systems

    g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

B.S. IN INTEGRATED PEST MANAGEMENT - BUSINESS-MARKETING OPTION

Specialization for Market Development Specialist

DESCRIPTION

A person who develops data for agricultural chemicals market analysis to be utilized to make management decisions for product development and sales relative to integrated pest management. A person who:

1. Gathers and analyses data.

2. Conducts interviews to collect information.

DESCRIPTION (continued)

3. Maintains flow of information between the agricultural and business communities.

OBJECTIVES

The specialization to prepare market development specialists within the baccalaureate degree in integrated pest management will prepare individuals who:

1. Are able to communicate - written, oral, mathematically.
2. Have a general understanding of living systems (biology).
3. Have a general understanding of physical systems (chemistry and physics)
4. Have a general understanding of the interaction among biological, social, and physical systems (ecology.)
5. Have a general understanding of methods and systems of production of man's food and fiber and their relation to agroecosystems.
6. Have an understanding of how plants function and reproduce.
7. Have an ability to recognize a pest problem and its etiology.
8. Have a knowledge of the principles of plant protection.
9. Understand the economic systems as related to agricultural production.
10. Understand elementary statistics and sampling.
11. Understand and practice interpersonal skills.
12. Know impact of pesticides on pests, their natural enemies, plants, humans, wildlife, soil, air, water and relevant safety practices.
13. Have awareness of new pest problems and changes in agricultural technology.
14. Develop awareness of competing products.
15. Possess competency in the use of statistical techniques.
16. Possess a general understanding of plant protection, integrated pest management, and crop ecosystems.
17. Have general knowledge of agri-business.
18. Possess expertise in basic economic theory.

RELEVANT COURSES

The courses recommended for inclusion in a program preparing for this specialization may be categorized into four groups (with each of the course or groups of courses is a suggested number of semester hours.)

GENERAL EDUCATION CORE

Courses including English, communications, social sciences, humanities and environmental studies.

20-26 Semester Hours

MATHEMATICS AND SCIENCE CORE

Biology (Botany and Zoology)			
Chemistry --- Inorganic, Organic	8	"	"
and Chemistry of Living Systems	10	"	"
Mathematics	3	"	"
Statistics --- through analysis of variance	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE

Plant Science --- an introduction to the plant sciences, scientific principles and technologies used in the culture of agronomic, biocultural, forest and range crops; an integrated introductory crop management course.	3	"	"
Genetics or Plant Breeding	3	"	"
Plant Physiology	4	"	"
Ecology, Principles of Applied	3	"	"
Pest Management and Plant Protection Principles --- this integrated block should include 1) the interrelationship of the various components of the crop ecosystem and 2) the effects of the major plant pests (insects, diseases, nematodes, weeds) on the ecosystem. Emphasis is placed upon management of these plant pests in the context of and understanding of all factors in this ecosystem and how they interact. This block includes fundamentals of morphology, taxonomy and biology of insects.*	15	"	"
Pesticides in the Environment --- Development and classification of pesticides, programs of use, metabolism, and environmental pathways.	3	"	"
Pesticide Application, Problems and Techniques	3	"	"
Soils	3	"	"
Economics	3	"	"
Business Management	3	"	"
Business Law and Contracts	3	"	"

PEST MANAGEMENT AND PLANT PROTECTION CORE (continued)

Agricultural Marketing	3	"	"
Oral and Written Communications	3	"	"
Economic, Legislative and Social Considerations in Pest Management, or			
Regulatory Procedures, or			
Federal and State Regulations - Environmental Business Law	3	"	"

<u>OPTIONAL COURSES</u>

Wildlife Ecology **	3	"	"
Agricultural Meteorology ***	3	"	"

*See Recommendations

**If not included in the core, this course is recommended for all specializations in the regulatory option and the education-information option as well as that of the field laboratory supervisor.

***If not included in the core, this course is recommended for all specializations in the pest management option and those of environmental monitoring specialist, application supervisor, and field laboratory supervisor.

<u>INTERNSHIPS</u>

It is strongly recommended that all specializations in integrated pest management include periods of internship or cooperative education in which alternative work and academic periods are scheduled for the individual students.

These will provide practical experiences in pest management and plant protection in action agencies and companies. Public agencies such as the U.S. Department of Agriculture, U.S. Environmental Protection Agency, U.S. Department of Interior, and their counterparts at the state level offer possibilities for such opportunities. The integrated pest management companies offer similar opportunities in the private sector.

It is recommended that academic credit be granted to individuals who are enrolled in internship or cooperative education programs.

<u>ELECTIVES</u>

Advanced Entomology
Weed Science
Organic Chemistry
Diagnostic Chemical Experience
Plant Taxonomy

Plant Pathology
Basic College Physics
Biochemistry
Vertebrate Pest Control
Computer Science & Modeling

Nematology
Systems Analysis Principles and Techniques

ELECTIVES (continued)

Agricultural Economics courses
Forestry courses
Personnel Management
Sampling Procedures & Applied Statistics
Soil Fertility & Plant Nutrition
Agricultural engineering courses
Insect Behavior

Animal Science (integrated) courses
Economic, Legislative & Social Considerations in Pest Management
Insect Pathology

Microbiology
Range Management courses
Population Ecology
Insect Nutrition
Educational materials & methods

PROGRAM PREPARATION

The following courses in the high school and community college are recommended for students planning to take baccalaureate degrees in pest management and plant protection:

THE HIGH SCHOOL

Students should follow a college preparatory program. If there is a science oriented option, this would be the preferable alternative. Such an option should include such courses as:

Biology
Chemistry
Earth Science
College Preparatory Math
Physics

It is assumed that college preparatory programs also include courses in English, Social Science and Humanities.

Vocational Agriculture is not a prerequisite since it is not offered in all high schools. Where offered, Vocational Agriculture can provide a valuable learning experience, complementary to those basic sciences required to enter a baccalaureate program.

THE COMMUNITY COLLEGE

Students wishing to transfer to the baccalaureate program in integrated pest management should complete a program including the following:

General Education Includes English and Communication, Social Science and Humanities	20-25
Biology (Botany and Zoology)	8-12
Chemistry, Inorganic	6
Chemistry, Organic or Biochemistry	6
Physics	4
Economics	3

THE COMMUNITY COLLEGE (continued)

Agricultural courses		8-16
	TOTAL TRANSFER CREDIT	55-72

At the present time few two-year post-secondary programs are offered in the pest management field, however, as soon as they are implemented accommodation will have to be made for the graduates of those programs to enter the baccalaureate programs with advanced standing.

EXAMPLES OF CAMPUS SUPPORT OF PROGRAM

In addition to the usual lectures and laboratories, the delivery system for the baccalaureate specializations in integrated pest management should use the maximum possible number of the following:

1. Individualized instruction, particularly in interdisciplinary courses and those being newly organized.
2. Part-time work experience which is related to the program.
3. Honors programs in which the senior year program is individually scheduled and which also includes an introduction to a research program.
4. Use of guest speakers either from other disciplines or practitioners in the field.
5. Diagnostic clinics using real materials or simulated materials, including models, slides and mock-ups.
6. Student participation seminars.
7. Assignment of special faculty advisers to individual students.
8. Case studies on special studies.

EXAMPLES OF FIELD EXPERIENCES

1. The courses recommended for this specialization includes an internship or cooperative work experience in off-campus agencies or companies. One of the work periods should be in a residue or chemistry laboratory, manufacturing or product development plant.
2. Field trips to such places as residue laboratories, commercial insectories, wildlife refuges and laboratories, quality control laboratories, monitoring laboratories, agricultural experiment stations, and formulating laboratories.

RECOMMENDATIONS

The Pest Management and Plant Protection Principles courses should constitute an integrated block. One recommended plan of implementation is to divide the concepts to be presented into an introductory, an intermediate and a final course.

I. Introductory Concepts

1. Plant protection is necessary for a healthy, compatible society.

2. Plant pests cause world-wide economic, social and medical problems which significantly influence world peace and the future of mankind.

3. A multiplicity of abiotic and biotic factors affect plants, pests and their interactions.

4. Effective plant protection requires an understanding of the plant-pest ecosystem.

5. Elements of pest management and plant protection include prevention, exclusion, eradication and suppression.

6. Biotic populations possess genetic plasticity which allows them to adapt to environmental changes.

7. Control practices must integrate alternative approaches and interactions in order to maximize the benefits and minimize the adverse reactions.

8. The potential ramifications of any pest control practice, particularly those involving pesticides, necessitates regulation for protection of the general public.

9. Socio-economic-political forces may profoundly influence pest management programs for plant protection.

II. Intermediate Concepts

1. Effective control of pests requires an understanding of their individual biology and dynamic interactions with other organisms.

2. The major types of pests - insects, mites, weeds, fungi, bacteria, viruses, nematodes, etc. - must be recognized and classified.

3. Growth, physiology, reproductive potential, and dispersal of pests must be considered when devising control procedures.

4. Weeds exert a detrimental influence through competition with desirable plants, harbour other pests, and present obstacles to man's health, activities, and comfort.

5. Insects and related arthropods exert deleterious and beneficial influence within biological systems.

a) They are detrimental as direct destructive agents, as vectors of disease agents, and as factors reducing aesthetic appeal.

b) They are beneficial as pollinators, predators, parasites, and as convertors of biological wastes.

6. Nematodes are both beneficial as predators and pest parasites, but are harmful as inducers of disease, as viral and bacterial vectors, and as associates with cryptogamic parasites.

7. Many common plant pathogens, nematodes, and arthropods induce characteristic suscept responses which make ready diagnosis possible; however, similar suscept responses may be induced by different types of pathogens, by the combined action of two or more different agents acting simultaneously or in succession, or by direct action of adverse environments rendering diagnosis difficult or impossible at our present state of knowledge.

8. Many plant disorders progress through an orderly sequence of events, or cycles, which may be annual, biennial, or perennial. During epidemics, the disorder tends to increase according to geometric progressions.

a) Biologically sound control programs require knowledge of the cycle.

b) Control usually is aimed at attacking the weakest link of the cycle.

III. Final Concepts

1. Every integrated pest control program should undergo a cost-benefit analysis covering not only the pest and host but also all related organisms and systems.

2. Pest management systems involve an understanding of the ecosystem, and of necessity the approach is usually interdisciplinary; it is complex and quantitative.

3. Pest management is the reduction of pest problems on a continuing basis by applying principles of ecology in an economically sound manner.

4. Proper pest management for plant protection must involve proficient analysis of pest situations, the place and effect of pesticides, and the impact of management practices on interacting subsystems of the ecosystem.

5. Implementation of management systems at the applied level involves assessment of tolerance thresholds,

prediction of population levels, determination of economic levels of pest density and the necessity for induced or manipulated reduction of density below such levels with the least possible changes to other life systems.

6. Improved environmental quality is an important identifiable result of proper pest management. It is assured through a knowledge of chemical-biological dynamics and the recognition and assessment of disrupting factors arising out of control activities.

COURSE OBJECTIVES FOR THE INTRODUCTORY CONCEPTS

This course is designed to introduce the ecological, economical, and social complexes centered around man, his crops, forests and domestic animals as related to pest management and plant protection; to acquaint the student with diseases, insects, nematodes, weeds and other factors affecting plants; and to acquaint the student with integrated control measures and their effects on man's environment.

OBJECTIVES

1. The relation of agriculture to man's environment and his total well-being (including some history of pest control).

2. Agricultural fields and forests as specialized eco-systems and the relation of these agroecosystems one to another.

3. Abiotic factors influencing agricultural crops (agro-ecosystems) and their importance in the diagnosis of "abnormal" plant growth.

    a. Nutritional problems including deficiencies and excesses of mineral nutrients.

    b. Drought, heat, cold, etc.

    c. Air pollution

4. Biotic factors influencing agricultural crops (agroecosystems).

    a. Man

    b. Vertebrates

    c. Invertebrates - including nematodes, in-sects, mites, fungi, bacteria, mycoplasms, viruses and weeds

5. Interrelations among various biotic factors in pro-ducing disease in crop plants and/or reduced crop

OBJECTIVES (continued)

yield or quality.

a. Insects as vectors of viruses, bacteria, nematodes, etc.

b. Weeds as hosts for insects and agents of diseases and as reservoirs for viruses

c. Nematodes and fungi as vectors of viruses

6. Introduction to concept of the economic threshold as related to yield, quality, overproduction, etc.

7. Basic principles of pest control stressing the common nature of the methods and the effects of these methods on both harmful and beneficial organisms in the ecosystem.

8. Introduction to the use of chemicals in pest control, basic nature of chemicals involved, application methods, problems of environmental pollution, residues in food and fiber, and social, political, economic, and legal implications.

9. An introduction to control procedures, other than chemical (biological, cultural, physical, mechanical, legal, and plant protection).

10. A brief introduction to systems approach to pest management integrating all pest control procedures.

COURSE OBJECTIVES FOR THE INTERMEDIATE CONCEPTS

The intermediate course/s shall enable students to:

1. Recognize the various types of abiotic agents that incite disease and the accompanying symptoms.

2. Recognize biotic factors of varying complexity that incite disease and the accompanying symptoms.

3. Apply the concept of disease to pathogenesis with and without parasitism.

4. Describe typical annual, biennial, and perennial disease cycles and relate them to specific control mechanisms.

5. Measure disease incidence and, by appropriate analysis, forecast the probably progression of the disease.

6. Recognize major types of nematodes and describe their:

a. life cycles

   b. body systems and behavior

   c. biotic interactions

   d. role in plant protection

7. Understand when and why a plant is considered a weed.

8. Know why the major weeds in their area are important.

9. Identify the major types of weeds and describe their morphology, growth and reproduction.

10. Identify the major insects and other arthropod pests and describe their:

   a. role in the global ecosystem

   b. place in the animal kingdom

   c. body systems and behavior

   d. role in plant protection

   e. life cycles

   f. interactions with plant production systems

   g. control

COURSE OBJECTIVES FOR THE FINAL CONCEPTS

The objectives of the "final" or "capstone" course of the Pest Management and Plant Protection Principles integrated undergraduate course sequence are to teach:

1. The principles of the systems analysis approach and its application to pest control.

2. The principles of cost-benefit analysis and their application to the use of specific management practices.

3. The incorporation of practices used for the control of all pests into a single management system and the incorporation of this system into the total environment with the least possible changes to life systems other than those directly involved.

It is recommended that the case study method could best be used in the development of this course.

GRADUATE PROGRAMS: MASTER'S LEVEL

JOB TITLES

The following jobs will require preparation of the master's degree level. These are broadly defined jobs and somewhat more specific titles may be given to them in particular situations.

These jobs are seven in number:

(1) Extension Specialist for Pest Management

(2) Research Specialist in Pest Management

(3) Teaching Specialist in Pest Management

(4) Pest Management Advisor or Consultant

(5) Regulatory Specialist

(6) Monitoring Specialist

(7) Manager/Supervisor in Pest Management

BRIEF JOB DESCRIPTIONS

The following are brief descriptions of each of these seven jobs:

(1) Extension Specialist for Pest Management:

This is a specialist in Pest Management who works in the field of adult education. This person transmits information about pest management to producers, processors and the general public, develops projects to demonstrate the value of new and/or useful technology; furnishes guidelines to regulatory programs, and otherwise carries out education functions in pest management directed toward producers, processors and the general public.

(2) Research Specialist in Pest Management:

This is a specialist who designs and/or conducts research in pest management, interprets the results of such research, and communicates these results for the purpose of implementation. Such a specialist may concentrate in either entomology, vertebrate pests, plant pathology or weed science.

(3) Teaching Specialist in Pest Management:

This is a specialist in pest management who instructs in all aspects of this field including its environmental consequences! This person will be a faculty member in a post-secondary institution such as a community college or technical institute.

(4) Pest Management Advisor or Consultant:

This is a specialist in pest management who advises or guides growers, municipalities, industry and others regarding discussions in pest control. This acting may be on an over-all basis. Concerned with only specific phases of pest management.

(5) Regulatory Specialist:

This is a specialist in the regulatory aspects of pest management who may be either a government official or an industry employee or consultant who interprets relevant federal, state and local laws and offers guidance concerning them. If employed by a government agency, this person may also enforce such laws and regulations involving quarantine, eradication and other regulatory functions.

(6) Monitoring Specialist:

This is a specialist in pest management whose functions involve monitoring and sampling pest populations and other environmental phenomena for population trends for providing essential data to other specialists in pest management.

(7) Manager/Supervisor in Pest Management:

This is a specialist in pest management who either manages a broad program in this field or supervises some segment or specialized activity. Positions in this category may range from the middle-management to the very senior level.

JOB COMPETENCIES

These competencies are outlined in terms of specific skills which these specialists should possess upon completion of the particular program which leads to a specific kind of job.

General Skills

The following are competencies, skills or levels of knowledge which a person should possess at the completion of <u>any</u> master's program relating to the general field of integrated pest management:

(1) Be able to identify pest species;

(2) Have knowledge of pesticides;

(3) Have knowledge of pest management techniques;

(4) Have knowledge of genc [illegible] and pest ecology;

(5) Have knowledge of biometry;

(6) Have knowledge of economics and sociology;

(7) Have knowledge of crop and livestock production;

(8) Have knowledge of man and environment;

(9) Possess and maintain a good knowledge of one's field

In the following items specific skills are outlined for each job. It should be kept in mind that these are <u>in addition to</u> the general skills outlined above.

<u>Extention Specialist --- Specific Skills</u>
Should possess:

(1) Communication and media skills;

(2) Ability to prepare reports addressed to producers, processors and the public;

(3) Knowledge of group dynamics (attitudes, receptionism, resistances)

(4) Advanced knowledge of agricultural economics;

(5) Ability to design or manage demonstration plots

<u>Research Specialist --- Specific Skills</u>
Should possess:

(1) Ability to participate in research projects and assume responsibility for the design and execution of specific phases of them;

(2) Knowledge of etatistics appropriate for the design of research projects and interpretation of results;

(3) Ability to prepare research reports and publications;

(4) Advanced knowledge of either entomology, plant pathology, vertebrate pests or weed science.

<u>Teaching Specialist --- Specific Skills</u>
Should possess:

(1) Communication and media skills;

(2) Knowledge of group dynamics;

(3) Knowledge of principles of education;

(4) Ability to evaluate research and explain research techniques.

Pest Management Advisor - Consultant --- Specific Skills
Should possess:

(1) Communication skills;

(2) Advanced knowledge of crop production or animal husbandry;

(3) Knowledge of population sampling and monitoring;

(4) Knowledge of systems analysis;

(5) Ability to prepare periodic assessment and evaluations of pest management programs;

(6) Advanced knowledge of economics and business management

Regulatory Specialist --- Specific Skills
Should possess:

(1) Knowledge of federal, state and local laws and regulations relating to pest management;

(2) Ability to communicate and interpret these laws and regulations;

(3) Prepare reports addressed to producers, processors and the public;

(4) Public relations skills

Monitoring Specialist --- Specific Skills
Should possess:

(1) Knowledge of population sampling and monitoring techniques (including appropriate environmental data);

(2) Knowledge of population dynamics and epidemiology;

(3) Prepare periodic assessments and evaluations of population trends;

(4) Knowledge of statistics appropriate to the analysis of population trends;

(5) Ability to work with predictive models

Manager/Supervisor of Pest Management --- Specific Skills
Should possess:

(1) Communication skills;

(2) Advanced knowledge of crop production or animal husbandry

(3) Knowledge of population sampling and monitoring;

(4) Knowledge of systems analysis;

(5) Ability to prepare periodic assessments and evaluations of pest management programs;

(6) Advanced knowledge of economics and business management;

(7) Management and personal administration skills

PROGRAM OBJECTIVES

In accordance with the job skills outlined in the foregoing paragraphs, the following objectives have been identified for master's level programs preparing people for these jobs.

General Objectives

At the conclusion of any such program, there are certain objectives which should have been met by a student.

A successful graduate of such a program:

1. Identifies common insects, weeds, vertebrate pests and plant diseases and assesses their threat to crops, livestock and man, fully considering natural control factors.

2. Ascertains effectiveness of the various pesticides, the proper formulations and dosage, application techniques for control of pests, and potential side-effects to a crop system and man and his environment.

3. Makes decisions regarding combinations of pest management techniques for a complex of pests.

4. Assesses the benefits and costs of these decisions relative to crop and livestock production, and, society and the environment.

The following objectives apply to successful graduates of these programs preparing for specific jobs and are in addition to those just outlined.

Extension Specialist

1. Prepares reports and otherwise communicates information addressed to producers, processors and the public.

2. Works with groups to educate them in pest management, including the costs and benefits to crops, livestock, man society and the environment.

3. Designs and/or manages demonstration plots.

Research Specialist

1. Identifies research needs.

2. Plans and executes research studies or portions of them.

3. Uses appropriate statistical techniques in design, conduct and interpretation of research data.

4. Assesses and evaluates research findings and prepares recommendations, reports and publications.

Teaching Specialist

1. Prepares instructional materials in Pest Management and its environmental consequences.

2. Conducts classes, labs and field exercises.

3. Counsels students and conducts individual instruction.

4. Evaluates research publications for the preparation of instructional materials.

5. Evaluates and uses media for educational purposes.

Pest Management Advisor or Consultant

1. Develops with agreement of the client or employee an overall plan of pest management to protect crops, livestock, man and/or the environment.

2. Assesses continually pest populations and other relevant environmental factors to make appropriate decisions regarding control techniques.

3. Communicates as needed with the client concerning actions and recommendations.

Monitoring Specialist

1. Samples and monitors pest populations and other relevant environmental factors.

2. Selects and applies appropriate statistics.

3. Employs appropriate predictive models.

4. Assesses and evaluates monitoring data and makes predictions on pest population and other environmental factors and consequences.

Regulatory Specialist

1. Interprets federal, state and local laws and regulations applying to pest management.

2. In certain instances, enforces such laws and regulations and in others, offers guidance concerning them.

3. May plan and implement aspects of these programs.

4. Prepares interpretive communications for producers, processors and the public explaining such programs.

Pest Management Manager/Supervisor

1. The same as for Pest Management advisor - consultant.

2. The same as for Pest Management advisor - consultant.

3. The same as for Pest Management advisor - consultant.

4. Directly manages or supervises a broad program or particular activity including personnel.

DEFINITIONS:

When we speak of man we mean his direct response to the effects of applicators and the protection of the public health.

By environment we mean direct and indirect effects on the agricultural eco-system, non-target species and other components of the general environment.

RELEVANT COURSES

These courses are outlined in terms of those that are considered essential or highly desirable for all persons preparing for these jobs through master level programs and those that come within this category only for specific jobs.

It should be recognized that the courses listed for specific jobs are in addition to the core courses listed first:

Core Courses

1. Entomology

2. Plant Pathology

3. Weeds

4. Vertebrate Pests

5. Pesticide Chemistry and Toxocology

6. Pest Management (techniques and systems)

7. General Ecology (including man and environment)

8. Pest Ecology (including natural control factors)

9. Biometry

10. Economics

11. Sociology

12. Crop Production

13. Livestock Production

Research Specialist

1. Thesis Research

2. Advanced courses in either:

   a. Entomology

   b. Plant Path

   c. Weed Science

Extension Specialist

1. Mass communication

2. Media communication

3. Social Psychology (group dynamics)

4. Agricultural economics

5. Project where he practices his special skills (in place of thesis in the field (internship).

Teaching Specialist

1. Educational media (communication)

2. Social Psychology

3. Principles of Higher Education

4. Field practice project

Pest Management Advisor and Consultant

Advanced biometry (sampling)

Advanced crop production or advanced animal production

Systems Analysis

Agricultural economics

Business Management

Field practice project (Replaces thesis)

Regulatory Specialist

Laws and regulations relating to Pest Management (Federal, State and local)

Communication Arts or Public Relations

Business Law or Environmental Law

Field practice project (Replaces thesis)

Monitoring Specialist

Advanced Biometry (Sampling)

Population dynamics and epidemiology

Model building and computer models

Field practice project (Replaces thesis)

Supervisor of Pest Management

Advanced biometry (Sampling)

Advanced crop production or advanced animal production

Agricultural economics

Business and personnel management

Field practice project (Replaces thesis)

LABORATORY ACTIVITIES AND FIELD EXPERIENCES

About all that need be said about this at the master's level is that each student should have personal exposure to pests, crops or other aspects of this over-all field with which his studies involve him. To the greatest extent possible, he should observe these where they actually exist, make his own observations and draw his own conclusions. Where this is not possible in the field, the laboratory should be used to duplicate these circumstances to the greatest extent possible. Laboratory experiences have their own role in such programs and they should provide the student with the kinds of opportunities for personal observation and evaluation as are offered to him in field experiences.

GRADUATE PROGRAMS: DOCTORAL LEVEL

INTRODUCTION

The following outline was developed in conjunction with the outline on graduate programs of the master's level. The reader is referred to it for expansion or clarification of a number of items outlined below. Because of this, this outline is relatively brief.

JOB TITLES

The following jobs will require preparation of the doctoral level. Again these are broadly defined job titles:

1. Extension Scientist

2. Research Scientist in Pest Management

3. Professor of Pest Management

4. Senior Systems Analyst

BRIEF JOB DESCRIPTIONS

The following should be read in conjuncion to any job of similar titles described under master's degree programs:

KNOWLEDGE AND COMPETENCIES

The following are statements of the major competencies and knowledge which persons holding these jobs should possess. Therefore, the objectives of relevant programs will be related to enabling students to acquire these competencies and these kinds of knowledge.

Common Elements

(1) All common competencies listed at the master's level

(2) Knowledge of biological controls

(3) Knowledge of population ecology

(4) Knowledge of four and specialized knowledge of one of them

(5) Knowledge of systems analysis & computer science

(6) Advanced knowledge of research techniques

Extension Scientist

(1) All of the competencies listed for the extension specialist at the master's level

(2) All of the competencies listed for the research specialist at the master's level

(3) Additionally, knowledge and abilities involved in identifying research needs, initiating research, and planning and designing research projects

(4) Knowledge and abilities involved in carrying out other high level or broadly defined studies and projects

Research Scientist

(1) Items 1 through 5 listed as competencies required of the research specialist

(2) Additionally, knowledge and abilities involved in identifying research needs, initiating research, and planning and designing research

Professor of Integrated Pest Management

(1) Items 1 through 3 listed as competencies required of the teaching specialist at the master's level

(2) All of the competencies listed for the research specialist at the master's level

(3) All of the competencies listed for the research scientist

Systems Analyst

(1) Knowledge of differential equation mathematics

(2) Knowledge of matrix algebra

(3) Knowledge of advanced statistics

(4) Knowledge of sensitivity analysis

(5) Knowledge of systems analysis and design

(6) Knowledge of relevant kinds of computer programming

RELEVANT COURSES

In addition to the core courses recommended at the master's level, the following are recommended for doctoral students in this field (if they have not already been taken at the master's level):

Biological Controls

Population Ecology

Systems Analysis

Computer Science

Advanced Research Techniques

A course in Entomology

A course in Plant Photography

A course in Weeds

Because an extensive research project and a thesis will be required at the doctoral level, no other courses are seen as being essential for the extension scientist, the research scientist or the professor of integrated pest management. However, additional advanced courses in relevant kinds of computer programming and systems analysis and design are recommended for the systems analyst.

LABORATORY ACTIVITIES AND FIELD EXPERIENCES

The statement under this heading relating to master's level programs will also apply at the doctoral leve, except that more should be offered to the student in the way of independent field and laboratory study. Similarly, more should be expected of him in the way of independent observations, conclusions and recommendations.

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