

DESIGN AND DEVELOPMENT OF AN INSTRUCTIONAL UNIT ON
INTEGRATED PEST MANAGEMENT (IPM): USING THE GYPSY MOTH
(*Lymantria dispar* [L.]) PROBLEM TO TEACH IPM

by

Belinda Stone Carroll

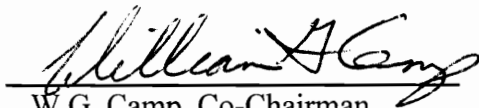
Thesis submitted to the Faculty of the
Virginia Polytechnic Institute and State University
in partial fulfillment of the requirements for the degree of

MASTER OF SCIENCE

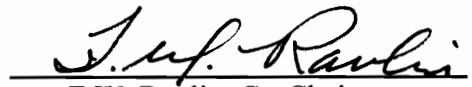
in

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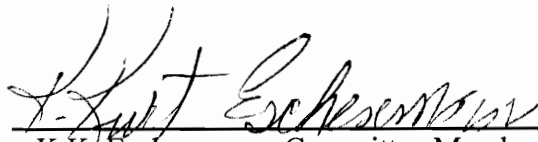
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August, 1996
Blacksburg, Virginia

Key Words: Instruction, Integrated Pest Management, IPM, Gypsy Moth

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(ABSTRACT)

An instructional guide for high school science and agricultural education courses was designed around the topic of integrated pest management (IPM) and the gypsy moth (*Lymantria dispar* [L.]) problem in Virginia. Construction of the guide followed three phases—design, development, and evaluation—of the Instructional Development Institute (IDI) model of instructional design. Lessons were developed using information from Virginia agricultural education course competencies, national science standards, a conceptual model of IPM, and gypsy moth management references and contacts. A validation panel consisting of two educators and two gypsy moth managers provided a review of the guide.

Dedication

This effort is dedicated to two persons who were most influential in the progress and completion of my degree program—my co-advisor, Dr. F. William Ravlin, and my husband David F. Carroll. Dr. Ravlin spent countless hours advising my direction with this program as well as provide considerable gems of knowledge and opportunity where my professional development and well-being were concerned. It is difficult to express how honored I feel to know and work with a person of such great integrity and genuine concern for others.

My husband has demonstrated in other ways what it means to be committed to the interest, well-being and happiness of another. I will never be able to repay him for the meals he prepared, the household chores that were magically done in my absence, the vacations I missed, and the kind and encouraging words he consistently gave. Nor can I begin to express how grateful I am to have such an incredible husband. However, I can acknowledge here that I believe some people purposefully exist to bring happiness and joy to others, and I am lucky enough to share a life with one of these special people.

With heartfelt gratitude and an eternity of indebtedness, I dedicate this effort to Dr. Ravlin and David.

Acknowledgments

I would like to extend my utmost appreciate to Drs. F.W. Ravlin and W.G. Camp of my graduate committee for their commitment to helping me complete my degree program. Dr. Ravlin, state IPM specialist with the Department of Entomology and Virginia Cooperative Extension, provided a significant amount of time and expertise regarding the topics of integrated pest management and gypsy moth management, during which he offered ideas, resources, contacts and reviewed lesson drafts. Dr. Camp has extensive experience in instructional materials development via his work with teacher training and professional development and has published several instructional textbooks and handbooks for agricultural education and environmental science courses at the secondary level. He provided important insight and expertise regarding lesson structure and development. I am indebted to Drs. Ravlin and Camp for the expertise they shared, the patience they bore, and the worlds they shared in science and education.

I owe thanks to my associates in the Agricultural Education Program and especially my friends and coworkers in the Department of Entomology for their plentiful moral support and caring. Special thanks also go to Brenda Diehl, Frederick County Gypsy Moth Program, and George Anderson, Virginia Department of Agriculture and Consumer Services, for their help throughout this project. I also want to thank the following people for their assistance and advice:

Kim Bowling-Largen, Prince William County Gypsy Moth Program
Dave Carroll, Pulaski County High School
Mike Cox, Pulaski County High School
Joe Hunnings, Montgomery County Extension
Jay Jarrett, Stonewall Jackson High School
Ed Leonard, Slow-the-Spread Gypsy Moth Project, U.S. Forest Service, Blacksburg
Ranger District
Gary McAninch, Virginia Department of Agriculture and Consumer Services

Darla Miller, Agricultural Education Program, Virginia Tech
Kathy Nies-Hepner, Shenandoah County Gypsy Moth Program
Kathy Sevebeck, Natural Resources Education Program, Department of Forestry,
Virginia Tech

Finally, I greatly appreciate the assistance the validation panel members offered in evaluating the instructional guide:

George Anderson, Slow-the-Spread Gypsy Moth Project, Virginia Department of
Agriculture and Consumer Services
Tom Bolles, Agricultural Education Program, Virginia Tech
Brenda Diehl, Frederick County Gypsy Moth Program
Kraig Kelican, Fauquier High School
Dan Swafford, Christiansburg High School

I would also like to thank my friend, Thresa Vinardi, for supporting my initial efforts to pursue an advanced degree and introducing me to the Agricultural Education program at Virginia Tech.

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Chapter 1:

Introduction & Literature Review

Education is a key component in integrated pest management (IPM) programs (Fitzner, 1993), and any number of audiences are targets for educational efforts. High school level instructors and students, collectively, represent one target audience, reached through the avenue of formal public education. As such, this audience may be one of the most appropriate to introduce IPM education through a prepared instructional guide instructors can use as part of course curricula.

IPM is a system of optimizing effects of pest control measures in an economically and ecologically sound manner. Optimization is accomplished by using multiple control tactics in an effort to assure stable crop production and to maintain pest damage below a level that results in economic loss while minimizing hazards to humans, animals, plants and the environment (National Research Council, 1991). IPM is multidisciplinary in its scope but is often regarded as a singular, whole topic. Consequently, some of the more recently published instructional guides treat IPM as a whole topic which addresses the subject of pest problems, a decided change from older materials which handle the topic of IPM in a more accessory manner within the subject of pest control. The scope and depth of IPM instruction has changed in keeping with the science surrounding it, yet few instructional guides emphasize social interactions that are important considerations in real decision-making situations involving IPM. These social interactions, or the human component, involve many economic, political and environmental factors which contribute to a more complex understanding of IPM. This added level of complexity may

complicate efforts to present IPM in a comprehensive yet relevant manner at the high school level of instruction.

The gypsy moth (*Lymantria dispar* [L.]) problem is often referred to as a people problem because it directly affects those living in urban, suburban and rural areas. Because gypsy moth populations in Virginia affect a diverse public and generate considerable public interest, gypsy moth management is a good example of how social factors like economics, politics and the environmental influence IPM decision-making. Public interest often translates into educational interests; educators in Virginia want to learn more about gypsy moths and how they can apply new information in their instruction. While excellent guides exist which provide instruction on gypsy moths within a general entomology framework, none specifically use the gypsy moth to teach IPM. Additionally, a secondary-level instructional guide which provides up-to-date information specifically on the Virginia gypsy moth problem does not currently exist. Gypsy moth management represents an ideal example for teaching IPM because it provides a more comprehensive perspective to basic IPM concepts and is a relevant topic from the standpoint that gypsy moths affect a significant number of Virginians.

Purpose and Objectives of this Study

This study took the form of an instructional development project designed to provide a supplemental guide to coursework in high school science and agricultural education in Virginia. The purpose of the project was to design and develop an instructional guide on IPM, using gypsy moth IPM as an example. The objectives of the instructional guide were to provide

- instruction on the main concepts of IPM using gypsy moth management as a model for instructional activities;

- a series of activity-oriented lessons modeling real-life applications and using case studies;
- historical and background information as well as current, accurate information on Virginia gypsy moth research and management; and
- suggestions for professional contacts, Internet resources, other instructional sources, supportive literature, and student project suggestions.

The goal of this study was to address a need for an educational initiative targeted for high school level audiences and, more generally, to address the need for support and development of educational efforts in Virginia gypsy moth IPM programs.

IPM Education and Instruction in Public Schools

The Educational Component of IPM Programs

IPM is an important philosophy in agriculture and natural resources management contexts from the standpoint that the science surrounding it strives not only to understand ecological systems but also social interactions with these systems. Social interactions stem from a wide array of environmental, political, and economic interests and concerns, all of which can present themselves as constraints to IPM practices and add to the complexity of IPM systems. To provide a link between the biological science and social influences behind IPM, a comprehensive IPM program contains a well-planned public awareness and education component tailored to a broad range of audiences (Fitzner, 1993). Awareness and education provide opportunities for audiences to become more informed, knowledgeable, and accepting of IPM practices.

High School Audiences and the Topic of IPM

Whether formal or informal, any number of avenues exist to reach audiences targeted for IPM awareness and education, and public schools represent one of these avenues. Public school students are significant from the standpoint that they represent future consumers, homeowners, voters, and decision-makers. Moreover, they are an easily targeted group, captured in a formal educational arena. Our public schools are an obvious place to include IPM education.

Likewise, IPM is an appropriate topic in high school. As an excellent model of science and scientific applications in agriculture and natural resources management, IPM fits appropriately in a number of high school courses. Its multidisciplinary nature, disciplines of which include biology, chemistry, earth science, and mathematics, makes it a fitting topic in basic and applied science courses. Examples of these courses include environmental science, biology, and agricultural education courses; a number of instructional guides for agricultural education courses actually include special sections on IPM.

Instructional Approaches

Topic Relevancy

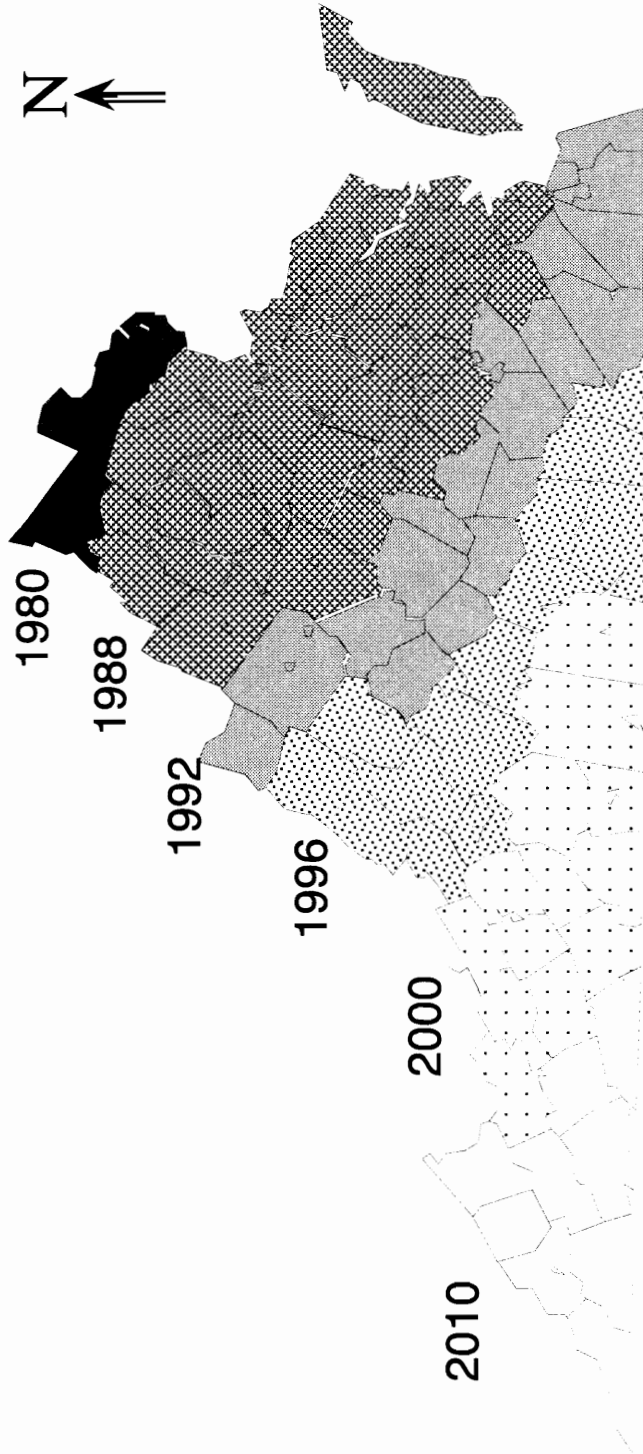
Whether the process involves designing and developing materials or teaching, a basic consideration should address student (learner) needs (Finch & Crunkilton, 1989). As such, making a topic relevant and interesting to the student is an important priority. Zipko (1982) emphasized that his greatest successes in teaching came from those experiences where the subject matter provided individual significance to the student. In the case of IPM, many students cannot easily relate to its agricultural contexts because they do not have agricultural backgrounds. What they can more readily understand is an

experience they have had or likely will have. The gypsy moth is a significant forest and landscape tree pest that infests approximately one-half of Virginia (Laub & Ravlin, 1993). Figure 1.1 shows the years when Virginia counties were or are projected to be generally-infested with gypsy moth populations. Generally-infested means that all life stages (egg, larva, pupa, adult moth) have been detected, reproducing populations are in the area, and defoliation is common (USDA Forest Service and Animal & Plant Health Inspection Service, 1995). As seen from the projections, infestations will occur throughout the entire state by the year 2010, consequently, many Virginians have experienced or will experience gypsy moth infestations and participate in local, state and federal management efforts. Teaching IPM using the gypsy moth problem as a model may reach more students by providing the relevancy they need to understand and apply general IPM concepts to other agricultural and natural resource pest management examples as well as other residential examples.

Using Field Activities and Case Studies to Teach IPM

The nature of gypsy moth management lends itself well to an applied approach to teaching IPM because it involves a great deal of field work. Managers spend time sampling for gypsy moths to determine population status and to provide information for control decisions. The techniques these managers use in field work are well-documented through agencies like the U.S. Forest Service (USFS), Animal and Plant Health Inspection Service (APHIS), and the Virginia Department of Agriculture and Consumer Services (VDACS), and are easily modified for instructional purposes. For example, the Appalachian Integrated Pest Management (AIPM) gypsy moth project sponsored development of a series of field exercises for youth groups, in an effort to simulate the types of work managers did (USFS, 1991). In a more general context, Guthrie (1988)

Observed and Predicted Spread of the Gypsy Moth in Virginia



Source: Laub & Ravlin, 1993, p. 45

Figure 1.1 Observed and predicted spread of gypsy moth populations in Virginia counties from 1980-2010.

ascertained that students should get involved with field experiences because applied instruction was the most effective way to teach IPM.

Field experiences are ideal, but they are not always practical or realistic in a public school setting, nor do they present a complete picture of other factors involved with making pest management decisions in an IPM system. Case studies can fill in the gaps a field experience alone cannot, and they provide a link to students who cannot participate in an applied learning situation outside the physical boundaries of the classroom. A case study as it refers to a teaching methodology is "...a partial, historical, clinical study of a predicament..." (Wassermann, 1993) that a person or group must confront and resolve. As part of their jobs in implementing IPM, gypsy moth managers must face a number of social issues which constrain their management decisions. Drawing from their experiences, particularly those at the local-level, managers are an exceptional source of information for creating and documenting cases to use in the classroom.

Using field experiences and case studies within the context of gypsy moth management is the approach adopted in this study to develop an instructional guide on IPM. Yet other guides currently exist. Specifically, three published instructional guides provide a good basis for comparison to other approaches used to teach IPM or to provide instruction on the gypsy moth. Each is briefly described in the next section.

Review of Existing Instructional Materials on IPM and the Gypsy Moth Problem

The Gypsy Moth in the Classroom

The Gypsy Moth in the Classroom (Mollenhauer, 1990) targets elementary-level instructors and students, although the material can be modified for secondary-level classes. This guide is designed to provide basic science instruction to students through experimentation activities which involve rearing gypsy moths from eggs to adults.

Twenty separate experimentation activities, all of which have been tested in the classroom, give the student experience in understanding the gypsy moth life cycle, gypsy moth control and rearing. Each activity includes a description which specifies learning objectives and time needed to complete the activity in class. Each activity is supported with background content for the instructor, transparency masters, lab instructions and reading material for students.

Entomology for Agricultural Science II Core Curriculum (DeFelice, 1991)

Instructors and students in high school agricultural education courses are the target groups for this guide on entomology which includes seven lessons: Introduction to Entomology, Insect Collection, Insect Identification, Control Methods, Chemical Control Methods, Safe Use of Insecticides, and Integrated Pest Management. IPM is described within its biological and economic confines and within an agricultural context. Steps in an IPM plan are outlined.

Instructors and students each have separate instructional guides. The instructor's guide outlines lesson competencies, objectives, and teaching procedures. Also included are transparency and student handout masters; short answer and multiple choice evaluations; and content references. The student's guide provides background reading for each lesson and a glossary of terms.

Legacy of a Pest (Case, Wissmann & Jeffords, 1988)

Instructors and students in grades 5-10 are targeted for this guide on entomology, ecology, and IPM, all of which are framed within the context of the gypsy moth problem in Illinois. IPM is described as a comprehensive management plan which includes considering chemical, biological, and cultural control options in response to economic

damage. The description also emphasizes the role of decision-making and the types of decisions involved in IPM.

Each of fifty activities includes an instructional objective, skills and processes involved in the activity, a vocabulary list, materials and methods for the activity, and a suggested evaluation.

Chapter 2: Methods & Materials

Design and Development of an Instructional Guide on Integrated Pest Management

The purpose of a model is to bring order and function to a task or problem that may be ambiguous or complex. In an instructional design, the context of the task or problem may make one model more appropriate than another. Table 2.1 outlines a generic instructional design model of five unique steps and associated questions involved with each step. While the generic model gives a very basic understanding of an instructional design process, other models serve to elaborate upon the generic steps and to address particular considerations for a design (i.e. target audiences, instructional content, media). The Instructional Development Institute (IDI) model (Figure 2.1) outlines specific tasks within three general phases: defining the instructional problem, developing an instructional product, evaluating the product. The IDI model takes a linear approach to a sequence of tasks within and between each phase, making it easier to understand and follow. Likewise, it is relatively general with respect to the fact that it places no special constraints on design considerations like target audiences. Because it is easy to follow and generally adaptable to many design scenarios, the IDI model was adopted for the design and development process of the IPM Instructional Guide (IPMIG). The next sections describe the methods used to develop the IPMIG in each IDI phase.

Table 2.1. Five steps and general questions to be addressed in each step of a generic instructional design model (Seels & Glasgow, 1990).

General Step	Questions Addressed in Each Step
1. Analysis	What is the problem? Who is the learner?
2. Design	What is the specific content? How are the objectives classified? How should the content be organized? What media should be used?
3. Development	
4. Implementation	Does the material work in an applied situation?
5. Evaluation	Are the objectives achieved?

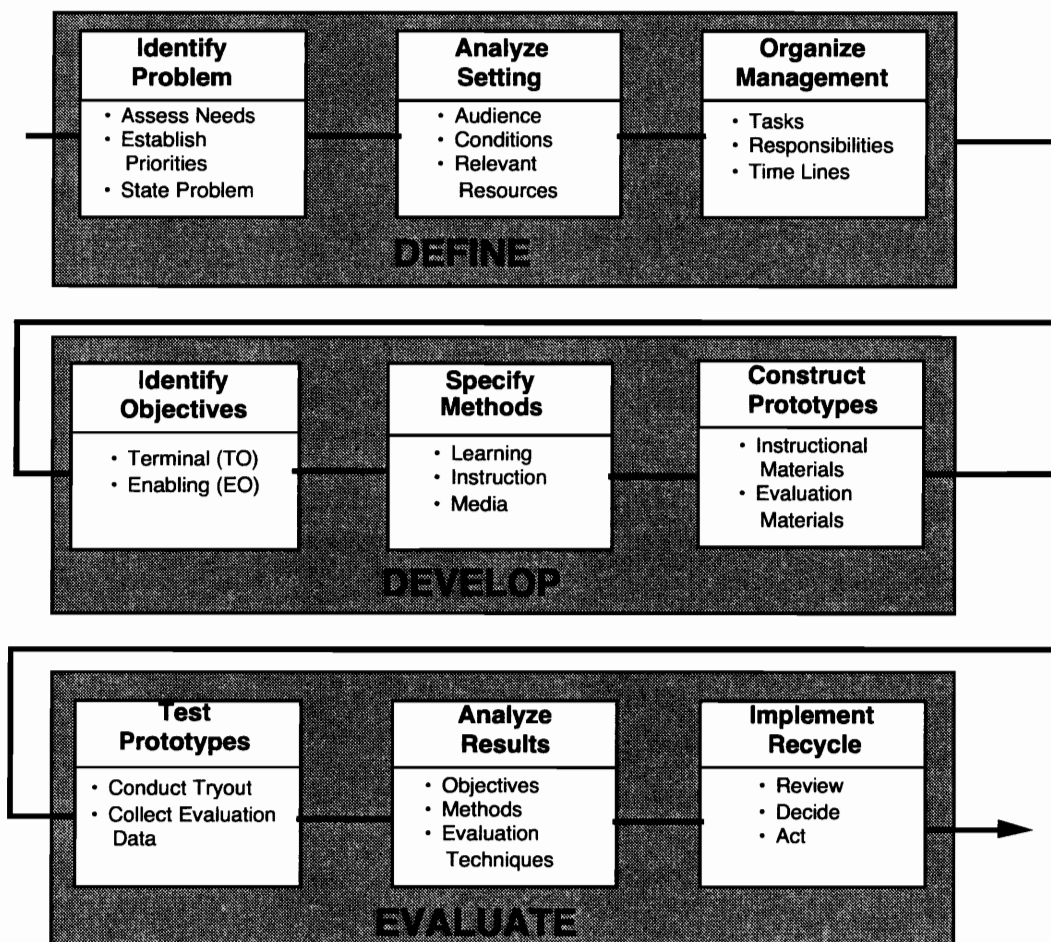


Figure 2.1. Three phases and associated tasks within each phase of the Instructional Development Institute (IDI) model of instructional design (Seels & Glasgow, 1990).

Defining an Instructional Problem

The definition phase involves identifying the instructional problem, determining an appropriate target audience, and gathering information about the audience and specific learning conditions and resources unique to it.

The Focus Group as a Tool to Help Identify Target Audiences and Their Informational Needs as Part of Gypsy Moth IPM Programs

Since the model for development of the IPMIG was the gypsy moth problem in Virginia, a focus group composed of representatives involved with gypsy moth education was assembled. The group consisted of a county gypsy moth manager, a county Extension agent, a state gypsy moth program manager, a high school instructor, a state IPM specialist, and an education specialist in agricultural education. The group met in one afternoon session to determine

- the target audiences for gypsy moth IPM programs, and
- methods to deliver informational materials and educational programs.

With regard to the IPMIG, two additional purposes of the focus group discussion were to verify that high school level instructors and students were a viable audience for gypsy moth IPM education and to determine the types of information appropriate for this audience. Appendix 1 is the agenda group members used to structure the meeting discussions.

Gathering Information about the Learner and Available Learning Conditions and Resources

Review of learning competencies. After targeting the high school instructor-student audience, the next step in the design process was to collect more information about high school courses, instructors, and students. Before deciding upon specific courses to gather information, a review of learning competencies for all Virginia high

school agricultural education courses (Virginia Department of Education, 1990) was conducted to help target courses for IPM instruction. Following the review, arrangements for classroom visits were made with instructors teaching target courses to obtain information about the instructor-student audience.

Class observations and instructor interviews. Two instructors, one at Pulaski County High School and one at Stonewall Jackson High School in Shenandoah County, agreed to classroom visits. Both instructors were acquaintances from the 1994 Virginia Agricultural Education Teacher's Conference, sponsored by the Virginia Tech Agricultural Education Program, and had expressed interest in the topic of gypsy moth management. Pulaski County currently does not have significant gypsy moth infestations while Shenandoah County has been infested for a number of years. Schools within different infestations level were selected purposefully to determine if instructors' attitudes differed regarding their interest and willingness to teach a unit on IPM and gypsy moth. Table 2.2 summarizes three classes used for collecting learner and instructor information.

Seels and Glasgow (1990) noted that examples of data variables which provide a general profile of learner characteristics include age, sex, educational and achievement levels, socioeconomic background, learning style, verbal ability, relevant learning experiences, attitudes towards the subject matter, role perceptions, and perceived learning needs. Using these suggested variables in addition to variables specific to the IPMIG development project, learner and classroom environment profile data sheets were constructed to provide structure to class observations and instructor interviews (Tables 2.3 and 2.4); observations and interviews are two commonly used methods for collecting learner information (Seels & Glasgow, 1990). The observation activity included recording notes on the class observations data sheet while observing the class from an uninvolved

Table 2.2 Classes observed as part of constructing a profile of learner (student) and instructor characteristics.

Class Date	Course Observed	Course Description	Grade Level Observed	School/ County in Virginia
10/13/94	Agricultural Mechanics and Basic Animal Science	second of a two year program; introductory course where students continue study of basic science and economic principles in applied agricultural contexts	10	Pulaski County High School/Pulaski County
10/25/94	Natural Resources Management IV-V		11-12	Stonewall Jackson High School/Shenandoah County
11/15/94	Agricultural Mechanics and Basic Plant Science	first of a two year program; introductory course where students begin study of basic science and economic principles in applied agricultural contexts	9	Pulaski County High School/Pulaski County

Table 2.3. Points noted in class observations as part of constructing a profile of learner (student) and instructor characteristics.

CLASS OBSERVATIONS

POINT	NOTES
Class Size	
Class Makeup: % males to females	
Classroom/lab Set-up and Environment	
Grade Level	
Culture Mix	
Socioeconomic Background	
Maturity Level (time instructor spent on discipline)	
Time on Task (attention span)	
Interest Level; Interest in Subject Matter	
Attitudes about Learning	

Table 2.3. (continued) Points noted in class observations as part of constructing a profile of learner (student) and instructor characteristics.

POINT	NOTES
Learning Styles	
Role Perceptions (student's perceived role in learning)	
Expressions of self-concept (confidence)	
Teaching styles employed by instructor	

CLASS: _____ **INSTRUCTOR:** _____ **DATE:** _____

Table 2.4. Points noted in the instructor interview as part of constructing a profile of learner (student) and instructor characteristics.

INTERVIEW WITH INSTRUCTOR

POINT	NOTES
Average Class Size	
Class Makeup: % males to females	
Classroom/lab Set-up and Environment Do you always teach in this room?	
Grade Level/Reading Level	
Culture Mix	
Socioeconomic Background	
Student's Experience: prior agriculture/science courses, work-study, FFA before this course	
Maturity Level •time instructor spends on discipline •use of guest speakers?	
Time on Task (attention span)	
Interest Level Interest in Subject Matter Topics which Interest Students	
Attitudes about Learning	

Table 2.4. (continued) Points noted in the instructor interview as part of constructing a profile of learner (student) and instructor characteristics.

POINT	NOTES
Learning Styles	
Role Perceptions (student's perceived role in learning)	
Expressions of self-concept (confidence)	
Teaching styles employed by instructor	
Use of prepared lesson plans/guides?	
What do you look for in prepared lesson plans?	
Do you work with science teachers?	
What do you think about integration and the best way to do it?	
How do you evaluate you students? (i.e. daily/weekly quizzes and tests)	
Does the block schedule work for you?	
How do you typically use student aids? Do you get aids every semester?	
Do you have problems with safety? Theft?	

CLASS: _____ **INSTRUCTOR:** _____ **DATE:** _____

position in the classroom. To prevent disruptions, no attempt was made to actively interact with students or instructors during class time. An instructor interview immediately followed the end of the class period, during the instructor's scheduled break. The purposes of the interview were to verify observation notes and to get a better sense of the instructor's teaching styles, methodologies, and topic interests.

Developing the Instructional Product

The second phase of an instructional design process involves identifying the specific content to be taught, terminal and enabling learning objectives, content organization, and the media which best serves to capture all of these. With this information, prototypes of instructional and evaluative materials are developed.

Instructional Content

To determine a specific instructional approach, content information about IPM and gypsy moth management was needed. It is important to note that the origins and development of IPM come principally from dealing with insect pests (Smith, Apple, & Bottrell, 1976). With this in mind, consultations with an academician specializing in insect IPM, along with a review of literature on IPM, helped in the development of a simplified IPM model whose purpose was to provide a framework for lessons and their content in the IPMIG. Additionally, a model was developed to

- graphically represent the idea of IPM;
- illustrate IPM as a system, made up of component parts which relate to one another; and
- break up the topic of IPM into manageable sections (lessons) so that instructors and students could gain a clearer, more detailed understanding of IPM.

Specific information about gypsy moth IPM was obtained from the Gypsy Moth Information Systems Group¹ and from other professional contacts involved with gypsy moth IPM in Virginia.

Learning Objectives

A review of competencies for Virginia agricultural education courses (Virginia Department of Education, 1990), as well as proposed national science learning standards, provided direction for both general and specific learning standards addressed in the IPMIG. The proposed national science learning standards were those of Project 2061, a project addressing educational reform in science, mathematics and technology (American Association for the Advancement of Science [AAAS], 1993). Referencing specific learning competencies from agricultural education courses and national science learning standards provided information for the Concepts and Skills sections prefacing each lesson in the IPMIG.

A terminal learning objective states the way a student must perform to show that he or she has learned intended concepts or skills (Finch & Crunkilton, 1989). In lesson development, terminal learning objectives are basic building blocks for the lesson's structure. The operational portion of the terminal learning objective is the task statement, which directly specifies the expected student behavior. A list terminal objective task statements were compiled for the IPMIG as follows:

The student will be able to

- describe social, environmental, and economic issues surrounding pests and pesticide use in agriculture, natural resources management, and the home environment;
- describe IPM, give examples of strategies used in IPM, and describe its relevance to agriculture, natural resources management, and human health;

¹Department of Entomology, Virginia Tech

- describe how gypsy moths entered the U.S. and Virginia, the types of damage they cause, and why they are an important pest in Virginia;
- determine the potential effects of gypsy moth defoliation and damage on a site based upon measurements of tree species composition and site condition observations;
- make effective and economical control choices for specific gypsy moth management cases and justify these choices; and
- apply other decision criteria to make appropriate control decisions for specific gypsy moth management cases.

Content Organization and Media

Since principles behind IPM involve problems stemming from pesticide use, it was appropriate to begin the topic of IPM with a lesson on pesticide usage and the issues raised from misuse and overuse of pesticides. This lesson provided a lead-in to the next lesson on pesticide problem solutions and an introduction to IPM. These two lessons constituted the first section of the IPMIG, IPM Introduction. Instructors could choose this section to teach the general concepts of IPM then proceed to their own separate examples, or they could continue with the second section.

The second section, Gypsy Moth IPM, was organized so that instructors could use each lesson to teach a different component from the IPM model using the gypsy moth problem and gypsy moth management in Virginia to provide real-world context and examples. For each lesson, the general organizational approach involves a focus on one component of IPM and a gypsy moth management application. For example, the lesson on the sampling component of gypsy moth IPM involves an activity where students survey trees in an area and collect, analyze, and draw conclusions from the data they collect. The lesson activity closely resembles survey work of gypsy moth managers.

Survey work is one example of how gypsy moth management lends itself well to an applied approach to learning IPM because it involves field-oriented activities. As an alternative to field activities, using case studies in instruction is another viable approach to applied learning (Christensen, 1987). Drawing from the experiences of gypsy moth managers, case studies can be designed to incorporate the social interactions of IPM processes and events that are more difficult to capture in a field experience. The IPMIG uses both field-oriented activities and a case study problem as ways to give students experience in applying the biological and social aspects of IPM.

The IPMIG was produced as a written instructional guide because it could be produced easily, relatively cheaply, and with fewer developmental constraints compared to media like videos and compact disks (CDs). Likewise, a written guide could be easily and cheaply reproduced by instructors and would not require special equipment. This is not say that other forms of media to supplement the written guide are not appropriate; the Discussion section in Chapter 4 suggests ideas for further development in the area of media changes and enhancements.

Prototype Development

Finch and Crunkilton (1989) suggested that while formats for structuring an instructional product vary according to specific situations and individual preferences, a cover page, table of contents, directions for use, technical content and a bibliography help provide direction for the format. In terms of how to organize learning events for the technical content, Johnson (1985) suggested a series of seven learning events that should take place in a segment of instruction. The *introduction* draws the student's attention to the learning task, provides reasons why it is important to achieve the learning objectives and connects previous learning with the new learning task. The *presentation* involves introducing the new material to the student, followed by *transitional practice* where the

student gets opportunities to practice his or her understanding of the new material.

Criterion practice allows the student to practice his or her understanding of the new material under the same conditions as a final test. In both practice phases, the student receives *feedback* and *guidance* from the instructor or other means of feedback. Finally, the *criterion test* measures the student's mastery of the learning objectives. In the IPMIG, reading assignments, study questions, and instructor's guides for lecture-discussion serve the introduction and presentation functions of the lessons; study questions serve as transitional practice. The field and case study exercises provide criterion practice; the instructor provides feedback and guidance during both practice events. Suggested quiz items serve the criterion test phase.

A review of instructional guides² provided ideas on how other lessons had been structured and developed. Using these ideas, the parts of the lesson for the IPMIG included the lesson purpose and objectives, skills, concepts, background information for the instructor, lesson activities, transparency masters, students handouts, reading assignments, glossary of terms, and appendices of suggested additional resources. To get an overall sense of what instructors look for in prepared instructional materials, an informal discussion was held with a high school science instructor having nine years of teaching experience. This discussion revealed a number of qualities instructors think are important (D. Carroll, personal communication, April 20, 1995):

- easily executable
- simple and easy to understand
- complete
- aesthetically-pleasing
- inexpensive and easily-obtained
- lessons follow logical flow
- accurate and up-to-date content
- self-contained lessons that can be used apart from the entire guide
- efficient
- original
- provides a variety of lesson activities
- fits within curriculum

²see *Review of Existing Instructional Materials on IPM and the Gypsy Moth Problem* in Chapter 1

This list provided helpful guidelines during lesson development.

First Phase Evaluation of the Instruction: Using the Internal Review

Evaluation of an instructional product generally involves three phases—internal review, small group tryout, and operational tryout (Seels & Glasgow, 1990).

Instructional designers are primarily interested in the formative aspects of evaluation, that is, those aspects which assist in developing and improving the product. Seels and Glasgow (1990) pointed out that summative evaluations, those that provide information about the “summed” effects of the instruction, assist administrators and other key decision-makers regarding issues like instructional materials adoption and other curricular changes. Consequently, summative evaluations typically are not part of a design process since the information provides little in the way of improving the instructional product.

A full formative evaluation was beyond the scope of the design for the IPMIG, but imposing the instruction to the first evaluation phase will help with future plans for a more full-scale evaluation. After the first full iteration of the guide development, a validation panel was used to validate the instructional guide for educational value and content accuracy.

The Validation Panel

A validation panel identifies problem areas and make suggestions for improvements, and its members can represent those in any of the following areas of expertise or viewpoints: teaching, content, instructional design, media, community issues, sponsoring agency, and former students (Seels & Glasgow, 1990). Four members comprised the validation panel for the IPMIG—two educational specialists represented by Virginia agricultural education instructors and two content specialists represented by

Virginia gypsy moth managers. Both instructors had several years of teaching experience, had experience or were interested in instructional development and the topics of IPM, and wanted more information about the gypsy moth problem in Virginia. One instructor teaches in Fauquier County, which is generally-infested with gypsy moths. The other instructor teaches in Montgomery County, which lies outside of the leading edge of gypsy moth infestation. Both gypsy moth managers had extensive experience in gypsy moth management and were interested in promoting the educational aspects of gypsy moth programs. One manager had experience in gypsy moth management at the county level, had a background in environmental education, and had developed several educational products for extension purposes. The other gypsy moth manager worked with state-level programs; had experience in large-scale, multi-state projects; and had an advanced degree in entomology.

The Review Process

Although reviewers provide different types of feedback, Geis (1987) suggested that they answer at least three main questions:

- What needs to be fixed or changed?
- What is the cause of the problem?
- What can be done to correct the problem?

Providing guidelines for the reviewers to answer these questions and more specific items of interest makes for a more efficient review process. In the case of the IPMIG review, two questionnaires were designed, one for the educational specialists and one for the content specialists, to provide guidelines as each member reviewed the draft and to get feedback on strengths and weaknesses of and suggestions for improvements to the instructional guide. Tables 2.5 and 2.6 show each type of questionnaire used in the review.

Table 2.5 Questionnaire completed by the educational specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Advisory Committee Review

Review Guidelines for the Educational Practitioner

Please answer the questions and/or comment on each item.

Part 1

For which courses would this guide be most appropriate? Specify particular agricultural education or science courses.

Which Standards of Learning does the guide address?

Is this guide applicable to your curriculum?

Would you use the entire guide or parts of it? Which parts?

Table 2.5 (continued) Questionnaire completed by the educational specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Part 2

Is the reading level of the reading assignments appropriate for your students?

Do lesson activities fit within a reasonable time frame?

Do the activities address the lesson's purpose and objectives?

Is the guide easy and clear for you to read and follow?

What do you like most about the guide? Least?

Part 3

Do you presently use the types of lesson approaches used in this guide (i.e. case studies, field exercises)? Do your peers?

What do you presently do in your classes that resemble the lesson approaches in this guide (i.e. reading assignments, study questions, library assignments)?

Is the gypsy moth an interesting topic to you, your peers or students?

Table 2.5 (continued) Questionnaire completed by the educational specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Part 3 (continued)

What is your opinion of using case studies as a teaching method?

Part 4

Please comment on other points not addressed in the preceding questions.

Table 2.6 Questionnaire completed by the content specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Advisory Committee Review

Review Guidelines for the Content Specialist

Please answer the questions and/or comment on each item.

Part 1

Is the information about integrated pest management (IPM) correct and current?

What do you think the most important concepts of IPM are? Are they explained and interrelated in this guide?

Are the field exercises and/or case study an effective approach to teach IPM?

Part 2

Is using the gypsy moth problem in Virginia an appropriate and effective way to teach IPM?

Table 2.6 (continued) Questionnaire completed by the content specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Part 2 (continued)

Is the information about the gypsy moth problem in Virginia correct and current?

Do the field exercises reasonably represent field work done by gypsy moth managers?

After completing this guide, do you think students would have a better understanding of IPM and how the gypsy moth problem in Virginia is a prime example of how IPM is used?

Table 2.6 (continued) Questionnaire completed by the content specialist during the first draft review of an instructional guide on IPM and the gypsy moth.

Part 3

Are the terms defined accurately?

Is the information clear and easy to read?

Are the references reasonable representations of the literature and expertise used by gypsy moth management specialists now?

Part 4

Please comment on other points not addressed in the preceding questions.

Chapter 3: Results

Design and Development of an Instructional Guide on Integrated Pest Management

Defining an Instructional Problem

The Focus Group as a Tool to Help Identify Target Audiences and Their Informational Needs as Part of Gypsy Moth IPM Programs

The purpose of the focus group meeting was to identify and define key components in a comprehensive gypsy moth education program, namely the target audiences, the types of information common to these audiences, and methods of information dissemination and delivery. Table 3.1 summarizes input from the focus group regarding these three areas. The focus group verified that high school level instructors and students were a viable audience to target for IPM education and that the types of information appropriate for the general public were also appropriate for students.

Gathering Information about the Learner and Available Learning Conditions and Resources

Review of learning competencies. A review of learning competencies for Virginia high school agricultural education courses revealed that the topics of IPM and gypsy moth management fit well within the state's agricultural education curriculum (Virginia Department of Education, 1990). Table 3.2 lists courses and learning competencies that fit within the context of the IPMIG.

Table 3.1. Educational delivery systems in state and local gypsy moth programs.

Target Audiences				
Industry <ul style="list-style-type: none"> • Health Care • Horticultural Services • Christmas Tree Growers • Forest Products • Private Chemical Applicators • Real Estate 	Government Officials <ul style="list-style-type: none"> • Local • State 	General Public <ul style="list-style-type: none"> • Homeowners • Landowners • Special Interest Groups • Media 	Public Schools <ul style="list-style-type: none"> • Instructors • Students 	Local & State Natural Resources Managers <ul style="list-style-type: none"> • Gypsy Moth Managers • Extension Agents • State Forestry Personnel • State & Local Parks & Recreation Personnel
Topics of Interest	Information is Disseminated			
	Through		By	
<ul style="list-style-type: none"> • Historical Information • Gypsy Moth Physiology • Management & Control • Natural Predators • Ecological & Sociological Concerns • Health & Safety • Design & Implementation of Local Programs • Budgeting & Planning • Local Policy-Making • Tax Considerations • Legal Implications 	<ul style="list-style-type: none"> • Informational Materials • Exhibits • Public Speaking Engagements • Media • Class Instruction • Interpretative Programs 		<ul style="list-style-type: none"> • Gypsy Moth Managers • Extension Agents • Master Gardeners & Other Volunteers • Public School Instructors • Parks & Recreation Personnel • Forestry Personnel 	

Table 3.2. Learning competencies of Virginia agricultural education courses (Virginia Dept. of Education, 1990) for which an instructional guide on integrated pest management and the gypsy moth was applicable.

Course	Grade Level	Competency	Lessons in Guide Which Address Competencies *
Agricultural Mechanics and Basic Plant Science	8-9	<ul style="list-style-type: none"> demonstrate effective communication skills demonstrate a decision-making process identify Virginia forest trees measure forest trees 	IPM Introduction Site Susceptibility Study Gypsy Moth Control, Part I Gypsy Moth Control, Part II
Agricultural Mechanics and Basic Animal Science	9-10	<ul style="list-style-type: none"> identify current issues in agriculture identify the gypsy moth describe gypsy moth control methods 	Pest & Pesticide Issues Intro. to Gypsy Moth Site Susceptibility Study Gypsy Moth Control, Part I
Agricultural Production Technology III	10	<ul style="list-style-type: none"> describe how agriculture and the environment are interrelated identify tree species native to the region by their common names inspect plant for insects 	Pest & Pesticide Issues IPM Introduction Site Susceptibility Study
Agricultural Production Technology IV	11	<ul style="list-style-type: none"> develop plans for pesticide needs develop a plan for homestead improvement 	Site Susceptibility Study Gypsy Moth Control, Part I Gypsy Moth Control, Part II
Agricultural Production Technology V	12	<ul style="list-style-type: none"> interpret maps 	Site Susceptibility Study
Natural Resources Management III	10	<ul style="list-style-type: none"> plan laboratory project demonstrate effective communication skills demonstrate knowledge of the environment, its pollution problems, and possible solutions identify by common name tree species native in region 	Pest & Pesticide Issues IPM Introduction Site Susceptibility Study

* Pest & Pesticide Issues
 IPM Introduction
 Intro. to Gypsy Moth

Site Susceptibility Study
 Gypsy Moth Control, Part I
 Gypsy Moth Control, Part II

Table 3.2. (continued) Learning competencies of Virginia agricultural education courses (Virginia Dept. of Education, 1990) for which an instructional guide on integrated pest management and the gypsy moth was applicable.

Course	Grade Level	Competency	Lessons in Guide Which Address Competencies*
Natural Resources Management IV	11	<ul style="list-style-type: none"> demonstrate effective communication skills describe how agriculture and the environment are interrelated make linear measurements by pacing list the uses of surveys 	Pest & Pesticide Issues IPM Introduction Site Susceptibility Study Gypsy Moth Control, Part I
Natural Resources Management V	12	<ul style="list-style-type: none"> make a decision using a decision-making process describe federal and state agencies responsible for protecting the environment interpret land-use maps select method to control insects in camping areas determine field area of specific plots of land in acres identify and list the natural resources of a given site identify, by common and scientific name, the common grasses and plants found in Virginia 	IPM Introduction Intro. to Gypsy Moth Site Susceptibility Study Gypsy Moth Control, Part I Gypsy Moth Control, Part II
Applied Agricultural Concepts	8-12	<ul style="list-style-type: none"> select pesticides for pest control explain the role and function of the Virginia Department of Agriculture and Consumer Services (VDACS) describe the services provided by the Virginia Department of Forestry and the U.S. Forest Service explain the functions of Virginia Cooperative Extension identify personal values develop communication skills 	Pest & Pesticide Issues IPM Introduction Intro. to Gypsy Moth Gypsy Moth Control, Part I

* Pest & Pesticide Issues
 IPM Introduction
 Intro. to Gypsy Moth

Site Susceptibility Study
 Gypsy Moth Control, Part I
 Gypsy Moth Control, Part II

Table 3.2. (continued) Learning competencies of Virginia agricultural education courses (Virginia Dept. of Education, 1990) for which an instructional guide on integrated pest management and the gypsy moth was applicable.

Course	Grade Level	Competency	Lessons in Guide Which Address Competencies*
Ecology and Conservation	8-12	<ul style="list-style-type: none"> • define environment • explain the importance of the environment • describe how agriculture and the environment are interrelated • describe how agriculture and the ecosystem are interrelated • identify local, state and national environmental problems and issues • describe sources of environmental pollution • identify the economic concerns of environmental problems • describe the benefits of solving environmental problems • describe environmental problems • debate environmental issues 	Pest & Pesticide Issues IPM Introduction

* Pest & Pesticide Issues
IPM Introduction
Intro. to Gypsy Moth

Site Susceptibility Study
Gypsy Moth Control, Part I
Gypsy Moth Control, Part II

Class observations. The most notable points from the class observations are summarized below.

Class size, sex ratio, culture mix. Agricultural Mechanics and Basic Plant Science had 19 students, 2 of whom were female. All students were Caucasian. Agricultural Mechanics and Basic Animal Science had 17 students, 5 of whom were female. Natural Resources Management had 12 students, 3 of whom were female. All students were Caucasian except for one African-American student.

Classroom/Lab setup and environment. Agricultural Mechanics and Basic Plant Science was observed on a lab day. Class was held in a work shop area, equipped with workstations and a tool room. The other two classes were observed during classroom days. Rooms were enclosed with work tables arranged around the periphery of the room, and the instructor's desk was at the front of the room. Students sat together in groups, females and males separated into different groups.

Maturity level, attention span, interest level. Students in the Agricultural Mechanics and Basic Plant Science class were attentive and interested as long as they were occupied. One student supported this observation by commenting that the class was very interesting as long as they were doing something. After splitting into work groups, students knew exactly how to get started with the day's work. As the class progressed, they asked more questions. Based on observations of attention span and interest level, students in Agricultural Mechanics and Basic Plant Science displayed a lower level of maturity while students in Natural Resources Management displayed the highest.

Attitudes, learning styles, role perception. Students' attitudes about learning were generally positive as long as they were engaged in work. The 9th and 10th graders seemed to benefit most from a high level of structure and guidance from the instructor based upon

the number of questions they asked during class time. More independence and self-assurance was observed in the 11th and 12th graders. All students seemed to benefit from a variety of class activities, particularly since the observed classes spanned ninety minutes.

Teaching methodologies and strategies employed by instructor. The instructor of Agricultural Mechanics and Basic Plant Science used class discussion and a game activity to teach material. Students received reading assignments. The same instructor teaching Agricultural Mechanics and Basic Animal Science used small group and individual instruction in the lab class. The instructor in Natural Resources Management used lecture-discussion and small group work. Students were assigned reading materials, a quiz to test their understanding of the reading, and a daily current events issue to report and discuss in class. In all classes, the instructors planned a minimum of four activities.

Instructor interviews. Although the instructors verified much of what was observed in the classes, other notable points are summarized below.

Class size, sex ratio, culture mix. At Pulaski County High School, agricultural education courses typically have 15-20 students. At Stonewall Jackson High School, the same courses average around 18 students, 10% of whom are female. Likewise, 50% of these same students attending Stonewall Jackson High School live in rural areas. The other 50% live in more suburban areas.

Maturity level, attention span, interest level. The instructor at Stonewall Jackson High School verified that there is a big difference in maturity level between the 9th-10th grade students and the 11th-12th grade students. Students at the 11th-12th grade level have more opinions and can express themselves more effectively in class; the 9th-10th grade students generally are too immature. The instructor teaching Agricultural Mechanics and Basic Plant Science and Agricultural Mechanics and Basic Animal Science

noted that ninety-minute class periods are too long for the younger students even during lab days; they lose interest after approximately an hour. However, ninety-minute periods work well for the Natural Resources Management instructor.

Attitudes, learning styles, role perception. Instructors verified that students' maturity level affects their attitude about learning, learning styles that most benefit them, and perception of their personal role in learning. For example, the younger students need a high level of structure and heavily depend upon the instructor for guidance. Because students are uncomfortable working independently, the Pulaski County instructor intentionally breaks up the class into working groups so that students can practice problem-solving on their own. Older students take more responsibility for their learning, reflected by the fact that they perform better in independent working groups.

Teaching methodologies and strategies employed by instructor. The instructors typically employ all of the teaching methodologies observed in the classes. Additionally, they like to invite guest speakers and schedule outdoor labs. The instructor at Stonewall Jackson High School schedules an average of two field trips per year, which are most often related to Future Farmers of America (FFA) activities. The instructors try to vary activities, especially during classroom time, and two to three activities for a ninety-minute period is typical.

Use of agricultural education course competencies and prepared lesson plans. One instructor follows course competency guidelines for Virginia agricultural education courses, but the other does not. While both said they typically did not use prepared lesson plans from another source, they were interested in obtaining current topic information to help them design their own lessons.

Developing the Instructional Product

Instructional Content

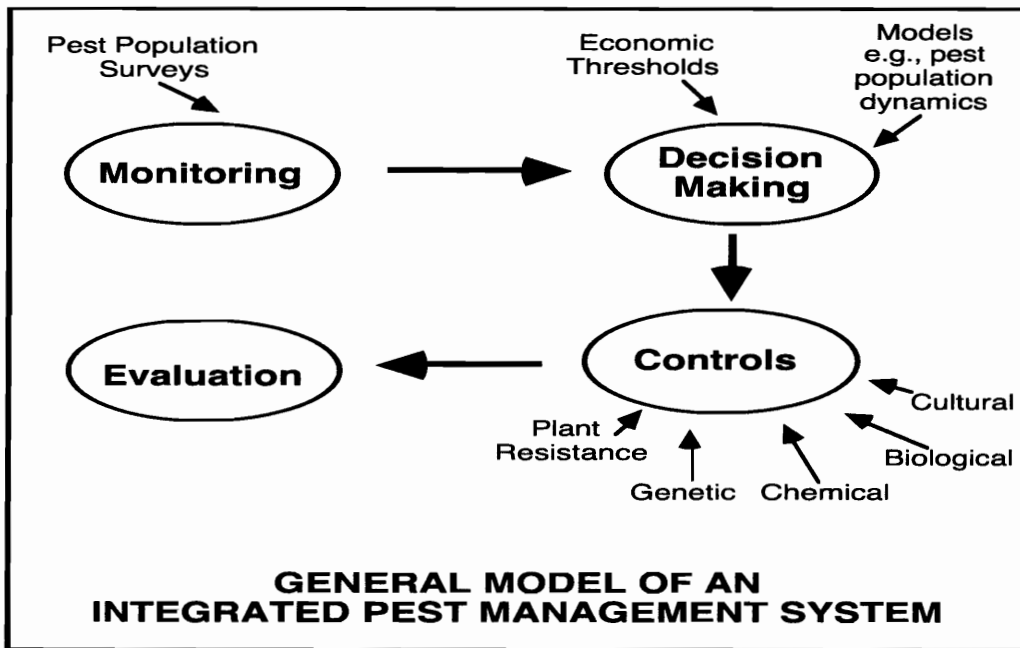
Figure 3.1 illustrates the IPM model and defines its components. Each component of the model was used to structure a lesson. A gypsy moth management example provided context to the significance of each component.

Learning Objectives

Table 3.2 lists those learning competencies in agricultural education courses which were judged the most likely to be addressed in the IPMIG. Table 3.3 summarizes the proposed national science learning standards judged most likely to be addressed in the IPMIG. Terminal learning objectives are noted in the Purpose section of each lesson in the IPMIG.

Content Organization, Media and Prototype Development: A General Description of the IPMIG

The IPMIG (Appendix 2) is a product designed for instructors' use. Explanations of how to use the entire guide (at the beginning of the guide) and each lesson (throughout the guide) are included. The guide is divided into two parts. Section 1: IPM Introduction provides two lessons to introduce the topic of IPM. Section 2: Gypsy Moth IPM provides lessons which illustrate different components of IPM using Virginia gypsy moth management as a real-world example. New terminology is defined at the end of each lesson and is also collated into an appended glossary. An Additional Resources list assists instructors and students in locating alternative sources of information and provides ideas for class projects.



<p>biological control parasites, predators, or pathogens that regulate another organism's population density at a lower than average level</p>	<p>genetic control altering the genes of</p> <ul style="list-style-type: none"> • plants to make them more pest-resistant, • microbes to make them more effective in microbial insecticides, and • biological control organisms to make them more effective in controlling a pest
<p>chemical control use of a chemical substance to reduce a pest infestation below a damaging level</p>	<p>models decision-making tools used to mimic a system that represents reality. For example, by mimicking the dynamics of a population, a pest population model can help predict the actions of a real population</p>
<p>cultural control manipulation of the environment to make it unfavorable for a pest</p>	<p>monitoring a process of measuring variables that help predict pest outbreaks</p>
<p>decision-making an on-going process of decisions regarding status and distribution of a pest, control measures, and evaluation of the success of these decisions</p>	<p>pest population survey a monitoring strategy used to study the geographic distribution and abundance of a pest</p>
<p>economic threshold the pest density above which control measures should be used to prevent the population from reaching a level that causes economic damage</p>	<p>plant resistance an effort in genetic control to alter characteristics of a plant to restrict, retard, or overcome pest infestations</p>
<p>evaluation assessment and interpretation of prior actions and experience. Evaluation results provide updates to information needed for future monitoring and control activities.</p>	

Figure 3.1. Simplified model of an IPM system and definitions (Dent, 1991; Doane & McManus, 1981) of its component parts.

Table 3.3. National learning standards for 9th-12th grades (AAAS, 1993) addressed during the development of an instructional guide on integrated pest management and the gypsy moth.

Scientific Domain	Learning Benchmark <i>By the end of 12th grade, students should know that:</i>	Lessons in Guide Which Address Competencies*
The Living Environment Interdependence of Life	<ul style="list-style-type: none"> • ecosystems are relatively stable over time; a population of organisms is held in check by: food supply, nesting & breeding sites, predators, parasites • humans are part of the earth's ecosystem and influence its equilibrium 	Intro. to Gypsy Moth
Human Society Social Trade-offs Social Conflict	<ul style="list-style-type: none"> • benefits and costs of proposed choices include long- and short-term, direct and indirect consequences • when deciding among alternatives, the major question to answer is who will benefit and who will not • conflict between people or groups happens because of differences in ideas, resources, power and status 	Gypsy Moth Control, Parts I and II Gypsy Moth Control, Part II
The Designed World Agriculture	<ul style="list-style-type: none"> • agricultural technology requires trade-offs between increased production and environmental harm and between efficient production and social values 	Pest & Pesticide Issues IPM Introduction

*Pest & Pesticide Issues
IPM Introduction
Intro. to Gypsy Moth

Site Susceptibility Study
Gypsy Moth Control, Part I
Gypsy Moth Control, Part II

Table 3.3 (continued). National learning standards for 9th-12th grades (AAAS, 1993) addressed during the development of an instructional guide on integrated pest management and the gypsy moth.

Scientific Domain	Learning Benchmark <i>By the end of 12th grade, students should know that:</i>	Lessons in Guide Which Address Competencies*
The Mathematical World Symbolic Relationships	<ul style="list-style-type: none"> • tables, graphs, and symbols are alternative ways to represent data and relationships that can be translated from one to another 	Site Susceptibility Study Gypsy Moth Control, Parts I & II
Uncertainty	<ul style="list-style-type: none"> • the larger a population sample is, the better it estimates population summary statistics. The size of a sample is more important than the size of the population. Samples are selected randomly to avoid bias. • a physical or mathematical model can be used to estimate the probability of real world events. 	Site Susceptibility Study
Models	<ul style="list-style-type: none"> • the usefulness of a model can be tested by comparing its predictions to actual observations in the real world 	Site Susceptibility Study
Constancy and Change	<ul style="list-style-type: none"> • graphs and equations are useful for depicting and analyzing patterns of change • in many physical, biological, and social systems, changes in one direction tend to produce opposing influences, leading to repetitive cycles of behavior 	Site Susceptibility Study Gypsy Moth Control, Parts I & II

*Pest & Pesticide Issues
IPM Introduction
Intro. to Gypsy Moth

Site Susceptibility Study
Gypsy Moth Control, Part I
Gypsy Moth Control, Part II

Table 3.3 (continued). National learning standards for 9th-12th grades (AAAS, 1993) addressed during the development of an instructional guide on integrated pest management and the gypsy moth.

Scientific Domain	Learning Benchmark <i>By the end of 12th grade, students should know that:</i>	Lessons in Guide Which Address Competencies*
Habits of Mind Values and Attitudes Computation and Estimation Communication Skills	<ul style="list-style-type: none"> • view science and technology thoughtfully, being neither categorically antagonistic nor uncritically positive • compare data for two groups by representing averages and spreads graphically • consider the effects of measurement errors on calculations • make and interpret scale drawings • choose summary statistics to describe group differences, indicating data spread as well as central tendencies • participate in group discussions on scientific topics • use tables, charts, and graphs in making arguments and claims in oral and written presentations. 	Pest & Pesticide Issues Site Susceptibility Study Gypsy Moth Control, Parts I & II Pest & Pesticide Issues Site Susceptibility Study Gypsy Moth Control, Parts I & II

*Pest & Pesticide Issues
 IPM Introduction
 Intro. to Gypsy Moth

Site Susceptibility Study
 Gypsy Moth Control, Part I
 Gypsy Moth Control, Part II

Each lesson begins with a purpose statement, a list of concepts and skills the student will gain and practice throughout the lesson, a set of lesson objectives and background information for the instructor. Each lesson provides the instructor with descriptions for each activity and resources to carry out the activity. Examples of resources include sample discussion questions and answers, student handouts such as reading assignments and study questions, and overhead transparency masters to assist lectures. Suggestions for evaluating student performance include sample quiz items and group reports. References at the end of the lesson document lesson content and provide instructors with a source for locating other teaching materials.

In lieu of a discussion of the structure and contents of each lesson, refer to Appendix 2 for a complete copy of the instructional guide.

First Phase Evaluation of the Instruction: Using the Internal Review

The Validation Panel

Each member of the validation panel spent approximately four to six hours reviewing the IPMIG and completing the questionnaire. Each member completed and returned the questionnaire and copy of the IPMIG (with written comments) within two weeks. The members were requested not to spend an inordinate amount of time, in the interest of their convenience and willingness to complete the review. Moreover, the purpose of the internal review was to address general concerns rather than elicit detailed, editorial comments.

The Review Process

The educational practitioners and content specialists responses to the questionnaires are summarized below.

Educational Practitioners

For which courses would this guide be most appropriate? Specify particular agricultural education or science courses. This guide would be appropriate for Natural Resources Management, Ecology, Agricultural Production, Horticulture, Environmental Science, and Biology.

Which Standards of Learning does the guide address? In the case of agricultural education courses, the more correct term is “competencies.” Members responses to this question were general: ecology, environmental science, biology, chemistry, geometry, general math, English, social studies.

Is this guide applicable to your curriculum? Yes. The instructor in Fauquier County further mentioned that because this county was infested with gypsy moths, the guide was very much applicable to the curriculum.

Would you use the entire guide or parts of it? Which parts? One instructor would use the entire guide, but would concentrate on the areas of gypsy moth identification and control. The other said that because the high school curriculum does not concentrate on natural resources and forestry, the second section of the guide would be most useful for students doing special projects or independent studies. However, the first section would be most useful to the existing curriculum.

Is the reading level of the reading assignments appropriate for your students? The reading level is most appropriate for 11th and 12th graders; 9th and 10th graders would experience difficulty with some of the vocabulary.

Do lesson activities fit within a reasonable time frame? Yes. Some activities may require more than one block period (90 minutes), but the instructor can get around this with advanced planning.

Do the activities address the lesson's purpose and objectives? Yes, the activities do a good job of addressing the lesson purpose and objectives.

Is the guide easy and clear for you to read and follow? Some areas are confusing to follow. Adding graphics will help the material flow better.

What do you like most about the guide? Least? Most: interest approaches to introducing lesson content; use of current events, study guides, charts, graphics, prepared overheads; use of higher order thinking skills and integration of content and skills from other disciplines (i.e. math, social studies); appearance and organization. **Least:** definitions have too many words, content needs to be more applied.

Do you presently use the types of lesson approaches used in this guide (i.e. case studies, field exercises)? Do your peers? Approaches used include field studies, case studies, journal writing which includes finding news articles, cause-effect-solution exercises, and group projects.

What do you presently do in your classes that resemble the lesson approaches in this guide (i.e. reading assignments, study questions, library assignments)? Similar lesson approaches include lecture-discussion, supplemental reading assignments from sources other than textbooks, videos, library research, field trips, group projects, managing a twelve-acre outdoor lab, and occasional small research projects.

Is the gypsy moth an interesting topic to you, your peers or students? Many agricultural education instructors are interested in the topic, and the science instructors probably would be interested as well. On the other hand, many students think learning

about the gypsy moth is boring. Those who would be most interested include the brighter students and those interested in natural resources management careers.

What is your opinion of using case studies as a teaching method? Case studies provide a way to illustrate real-world situations that help engage and motivate students. They provide an excellent way to show students first hand the purpose of the lesson. Students tend to understand and retain material if they can see a correlation between classroom learning and personal experiences. Case studies help form this correlation. On the down side, case studies require considerable time and research for the instructor who is trying to put one together.

Please comment on other points not addressed in the preceding questions.

Strengths: appendices, glossary of terms, reading assignments, overheads, use and explanation of new terminology, creative ideas and interesting ways to introduce a subject

Weaknesses: definitions to terms are too long; information on biological controls and gypsy moth population monitoring is unclear; lack of graphics

Suggestions: add a guide, overhead, or reference of common Virginia pests; add an activity on population monitoring (male moth trapping, egg mass surveying); add more graphics

Content Specialists

Is the information about integrated pest management (IPM) correct and current? Yes.

What do you think the most important concepts of IPM are? Are they explained and interrelated in this guide? The most important concepts are identifying the pest problem and considering all available strategies for control, especially alternatives to pesticides. The guide did a good job of emphasizing both of these points.

Are the field exercises and/or case study an effective approach to teach IPM? Yes.

Is using the gypsy moth problem in Virginia an appropriate and effective way to teach IPM? The gypsy moth problem is one of the most relevant examples. It is a contemporary, highly visible problem and will continue to affect more areas of Virginia in the future. IPM has been used very effectively in gypsy moth management.

Is the information about the gypsy moth problem in Virginia correct and current? The information is correct for the most part. Changes are noted within the guide.

Do the field exercises reasonably represent field work done by gypsy moth managers? Yes.

After completing this guide, do you think students would have a better understanding of IPM and how the gypsy moth problem in Virginia is a prime example of how IPM is used? Yes. Also, students who are interested in pursuing a science career will gain valuable exposure to survey techniques used for data collection and evaluation.

Are the terms defined accurately? The terms are defined accurately for the most part. Recommended revisions are noted within the guide.

Is the information clear and easy to read? Yes.

Are the references reasonable representations of the literature and expertise used by gypsy moth management specialists now? Yes.

Please comment on other points not addressed in the preceding questions.

Strengths: The *Glossary of Terms* is a good appendix. The entire guide provides a balanced perspective of the decision-making process involved in gypsy moth control, which includes serious consideration of all control measures—chemical and non-chemical. The cost of using the guide might be minimal, which would be an attractive feature for educators.

Weaknesses: A list of terms after each lesson seems redundant considering the glossary contains terms from all lessons, but including them as part of each lesson may be necessary if instructors only use certain parts of the instructional guide. In the discussion of host plant preferences of the gypsy moth, terms “resistant” and “immune” can be misinterpreted if they are not defined explicitly. Consider changing these words.

Chapter 4: Discussion

Design and Development of an Instructional Guide on Integrated Pest Management

Selecting and following a design model provides order and management to a complex process like instructional design (Seels & Glasgow, 1990). For the IPMIG, selecting and following guidelines from a generic approach in combination with the IDI model assisted the design process tremendously and underscored the importance of using a model. While evaluating the effectiveness of design models was not an objective of this project, it is worth mentioning several realizations concerning the generic and IDI models. First, adopting a model upon immediate knowledge that one has an instructional task or problem greatly focuses and simplifies the effort to proceed with potential solutions. Next, the simplicity of the generic approach is helpful but it does not provide enough detail and is best used in combination with another model. Finally, the IDI model provides step-wise detail, but it is not explicit about the feedback and interaction loops inherent in the process, particularly between the development and evaluation phases.

Defining an Instructional Problem

The Focus Group as a Tool to Help Identify Target Audiences and Their Informational Needs as Part of Gypsy Moth IPM Programs

The focus group activity provided useful insight into what comprises the educational component of gypsy moth programs and how these programs fit with more formal avenues of public education. The group identified public school instructors and

students as an important audience and concurred that an instructional development project targeting Virginia high school audiences would be a useful and interesting addition to the educational component of gypsy moth IPM programs.

Gathering Information about the Learner and Available Learning Conditions and Resources

Review of learning competencies. Reviewing course competencies for Virginia agricultural education courses and guidelines for science learning standards was a useful activity from the standpoint that it helped further define the audience for the IPMIG and provided direction for the purpose, skills, concepts, and objectives of each lesson.

Class observations and instructor interviews. The classroom observations and instructor interviews were extremely beneficial activities because they provided firsthand knowledge about several important points including

- resources and constraints inherent in public schools;
- differences in curricular focus among schools;
- differences in students' learning capabilities at each grade level; and
- instructors' opinions of prepared instructional guides.

Guidelines for observations and interviews outlined by Seels and Glasgow (1990) were useful, but it was still difficult to know what points to observe in the classroom and discuss with the instructor. Moreover, instructors and students may behave differently during observations, making the observations inaccurate to varying degrees. To address some of these inaccuracies and deficiencies, the follow-up interview with the instructor helped clarify points noted in the class observations and added important pieces of information. Given the informal nature of the classroom visits along with the instructors' experience and confidence in teaching, the information collected from the observations and interviews was probably a fair representation of daily classroom behavior and learning

activities. Visiting classes in other parts of the state—for example, central and northern Virginia—may have provided more perspective and strengthened the learner and instructor information.

Developing the Instructional Product

Instructional Content

A strong network of content specialists and resources provided strength to the instructional content and helped the period of lesson development proceed extremely smoothly and with assurance that information was accurate and up-to-date. The content specialists on the validation panel verified that most of the material, with a few minor changes, was current and accurate, and that the guide presented a realistic picture of IPM and its application in gypsy moth management.

Learning Objectives

The learning competencies and standards lists provided general guidelines, but they did not serve as checklists during lesson development. During the interviews, one instructor reported following learning competencies and standards, while another did not use them. Based on these reports, one might assume that following learning competencies and standards is at the discretion of the instructor. Yet, a potential weakness of the guide is that competencies and standards are not explicitly referenced, and whether instructors consciously follow them should not affect the instructional design effort to satisfactorily incorporate competencies and standards.

The terminal learning objective task statements were essential to begin lesson development, and they were modified during the course of the development process. The validation panel verified that the lessons seemed to address the objectives, but clarifying task statements as they address state learning competencies would strengthen the guide.

Content Organization and Media

The validation panel verified that the guide was, for the most part, well-organized, although some parts needed more clarification. Panel members were not questioned on the effectiveness of the media choice because it was not a significant issue in the design. However, one member reported that the cost of using the guide would be minimal, thus educators might be more inclined to use it. This comment concurred with the original reason to develop a written instructional guide.

Prototype Development

Because the guide has not undergone the next phases of evaluation—small group and operational tryouts—it is difficult to address the effectiveness of the guide as a whole and of each lesson. One panel member commented that using only Part 1: IPM Introduction was a reasonable option; this lends support to the guide’s ability to be sectioned into self-contained parts or lessons. Yet, until instructors and students try the guide in the classroom, there is no information to support whether or not it is a usable product in its present form.

First Phase Evaluation of the Instruction: Using the Internal Review

The Validation Panel

Members of the validation panel provided good insight and useful recommendations to improve the guide. Overall, the internal review process worked well and the members were responsive and enthusiastic. Two members from each of the areas, instruction and content, may not have been enough; three or four from each area possibly could have strengthened the process by providing additional viewpoints. Likewise, close

professional associations with the content specialists may have biased questionnaire responses to one degree or another.

The Review Process

The questionnaires served to collect more general than specific information about content accuracy and instructional effectiveness. The questions may have been phrased in a manner that focused more on the guide's strengths rather than its weaknesses and they may not have provided ample structure for suggestions. Moreover, some of the questions may have been more appropriate for evaluators conducting small group tryouts rather than for the validation panel. Panel members were not prompted for an opinion of the questionnaire itself, and this may have been an oversight. Yet, the questionnaire was an extremely useful tool since it provided structure for the panel members and written feedback about the instructional guide.

Recommendations for Further Development and Classroom Use

The next step in making the guide a usable product is to submit it for a sample tryout. Instructors who have been involved with the project development thus far, in addition to others who are interested in teaching IPM and gypsy moth management, are good candidates for testing the guide. Students in the Agricultural Education Program at Virginia Tech who are seeking prepared lessons to use during their student teaching experience may be good candidates as well.

Once subjected to a more thorough evaluation which includes field testing of the lessons, the IPMIG will be published and offered as a printed guide for general distribution. To take advantage of computer technology, the guide will be modified for World Wide Web (WWW) access through the Internet.

Computer access could be advantageous for a number of reasons:

- it provides instructors the option to print out and use only the parts they want;
- it saves reproduction costs if instructors and students have ready access to computer equipment;
- students can complete assignments on school or home computers;
- the WWW version of the guide will be enhanced to include color graphics, an often-times cost prohibitive option for printed materials; and
- instructors and students can communicate electronically with the authors about concerns, questions, and suggestions regarding the guide.

Project Goal and Objectives Revisited

The purpose of this project was to design and develop an instructional guide on IPM using gypsy moth IPM as an example. The objectives were to

1. teach the main concepts of IPM using gypsy moth management as a model for instructional activities;
2. provide historical and background information as well as current, accurate information on Virginia gypsy moth research and management;
3. provide a series of activity-oriented lessons modeling real life applications and using case study learning; and
4. provide suggestions for professional contacts, Internet resources, other instructional sources, supportive literature, and student project suggestions.

The design and development process addressed all of these objectives. Further evaluation will reveal whether these objectives benefit student learning of IPM.

Literature Cited

- American Association for the Advancement of Science (AAAS). (1993). Benchmarks for science literacy. Project 2061. New York: Oxford University Press, Inc.
- Case, L. J., Wissmann, J. L., & Jeffords, M. R. (1988). Legacy of a pest: a science, technology, and society curriculum guide for understanding and dealing with biological problems. Illinois Natural History Survey, Special Publication 9. Champaign, IL: Illinois Natural History Survey.
- Christensen, C. R. (1987). Teaching and the case method. Boston: Harvard Business School Publishing.
- DeFelice, K. L. (1991). Entomology for agricultural science II core curriculum. Instructor guide and student reference. Columbia, MO: University of Missouri-Columbia.
- Dent, D. (1991). Insect pest management. Oxon, UK: C·A·B International.
- Doane, C. C. & M. L. McManus (Eds). (1981). The gypsy moth: Research toward integrated pest management. Tech. Bull. 1584. Washington, DC: U.S. Department of Agriculture.
- Finch, C. R., & Crunkilton, J. R. (1989). Curriculum development in vocational and technical education (3rd ed.). Boston, MA: Allyn and Bacon, Inc.
- Fitzner, M. S. (1993). The role of education in the transfer of biological control technologies. American Chemical Society, 382-387.
- Geis, G. L. (1987). Formative evaluation: Developmental testing and expert review. National Society for Performance and Instruction Journal, 26(4), 1-8.
- Guthrie, M. L. (1988, January). How to get started teaching IPM. The Agricultural Education Magazine, pp. 21-22.
- Johnson, V. (1985). Module 13. Principles of learning: Student resource book. Contract No. F41689-83-C-0048. Randolph AFT, TX: USAF Occupational Measurement Center (ATC).
- Laub, C. & F. W. Ravlin (Eds). 1993. Virginia integrated pest management. Blacksburg, VA: Virginia Polytechnic Institute and State University.

- Mollenhauer, E. (1990). The gypsy moth in the classroom. Broomall, PA: USDA Forest Service.
- National Research Council. (1991). Toward sustainability: A plan for collaborative research on agriculture and natural resource management. Washington, DC: National Academy Press.
- Seels, B. & Glasgow, Z. (1990). Exercises in instructional design. Columbus, OH: Merrill Publishing Company.
- Smith, R. F., Apple, J. L., & Bottrell, D. G. (1976). The origins of integrated pest management concepts for agricultural crops. In J.L. Apple & R.F. Smith (Eds.), Integrated pest management (pp. 1-16). New York: Plenum Press.
- USDA Forest Service. (1991). Appalachian integrated pest management (AIPM) gypsy moth demonstration project, fiscal year 1991. In Carroll, B.S. & Ravlin, F.W. (Eds.), The gypsy moth in Virginia, 1990. Publication 444-030, (pp. 11-18). Blacksburg, VA: Virginia Cooperative Extension, Virginia Tech.
- USDA Forest Service and Animal & Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement. Washington, DC: USDA Forest Service and Animal & Plant Health Inspection Service.
- Virginia Department of Education, Vocational Program Services. (1990). Completion requirements for vocational programs: agricultural education. Richmond, VA: Virginia Department of Education.
- Wassermann, S. (1993). Getting down to cases: learning to teach with case studies. New York, NY: Teachers College Press.
- Zipko, S. J. (1982). Get to know your neighborhood pest: an interdisciplinary project for middle schools students. Science and Children, 9-12.

Appendices

Appendix 1. Agenda used in a focus group meeting to discuss education in gypsy moth IPM programs.

Gypsy Moth Education Focus Group Meeting Agenda

June 25, 1992

Present: **Kim Bowling-Largen**, Prince William County Gypsy Moth Program
Bill Camp, Agricultural Education Program, Virginia Tech
Belinda Carroll, Agricultural Education Program, Virginia Tech
Joe Hunnings, Virginia Cooperative Extension, Montgomery
County
Gary McAninch, State Gypsy Moth Programs, Virginia Department
of Agriculture and Consumer Services
Bill Ravlin, Department of Entomology, Virginia Tech

Absent: **Christy Williams**, Fauquier County High School

Purpose of this meeting: to identify the components of a comprehensive gypsy moth education program

- I. Introduction to Members of Focus Group
 - II. Brief Overview of the Status of an Instructional Development Project and Explanation of the Development Process
 - III. Gypsy Moth Impacts on the Southeast and Correlation to Educational Needs
 - IV. Discussion of the Needs of Recipient Groups
Who are the targeted audiences?
What kinds of information do these audiences need?
 - V. Concluding Remarks
-

Appendix 2. Integrated Pest Management Instructional Guide (IPMIG)

INTEGRATED PEST MANAGEMENT AND THE GYPSY MOTH

**LESSON GUIDE
AND REFERENCE
FOR INSTRUCTORS**

Using this Guide

This instructional guide is divided into two sections. Section 1: IPM Introduction introduces the general concept of integrated pest management (IPM). This section answers several fundamental questions:

- What is a pest?
- What is a pesticide?
- What are the issues surrounding pesticide use?
- How do we address these issues?
- What is IPM?

Section 2: Gypsy Moth IPM is an application of IPM principles using the gypsy moth (*Lymantria dispar* [L.]) problem as an example. The purpose of this section is to more fully answer the question of what integrated pest management is by engaging students in decision-making exercises to solve pest problems. The gypsy moth problem is used as the example here because gypsy moth populations infest over half of Virginia and affect more people directly than other pests. However, the instructor and students may choose to design an IPM plan using a different pest and apply the same principles discussed in this unit. Students in southeastern Virginia, for example, may be interested in IPM for peanut and soybean crops. Southwestern Virginia students may want to design IPM plans for tobacco pests. Students may be interested in designing a cockroach, earwig, or rodent IPM plan to address more immediate concerns of their school site.

Lessons in Section 2 provide instruction on the components of an IPM system: monitoring, decision-making, controls, and evaluation. As students progress with each lesson, they will work on a field or case study for which they will design an IPM plan. The exercises are the basis for evaluation of the students' understanding of the concepts presented in the unit.

If you live in an area that has established gypsy moth populations (refer to the infestation map), an ideal time to teach this unit is in the spring when you can observe egg masses, egg hatch, caterpillars, feeding, and defoliation.

Section 1: IPM Introduction

Lesson: Pest & Pesticide Issues

This lesson provides students the opportunity to explore personal attitudes about pests, pesticides and pesticide use and to compare these with attitudes of the general public.

PURPOSE

This lesson will enable students to describe some of the social, environmental and economic issues surrounding pests and pesticide use in agriculture, natural resources management, and the home environment.

OBJECTIVES

Upon completion of this lesson, students will be able to:

- define pest and discuss ideas about pest control
- define issues related to pests and pesticide use
- categorize the types of issues
- develop solutions for dealing with problems pests and pesticide use present

CONCEPTS

- advantages and disadvantages of pesticides
- public perception of pests and pesticides and its influence on personal attitudes
- definition of a pest
- the pest-pesticide dilemma

SKILLS

Students will

- practice oral and written expression of personal beliefs
- conduct library research
- practice problem-solving and critical thinking skills

BACKGROUND FOR INSTRUCTOR

The purpose of this lesson is to introduce the student to public issues surrounding pests and pest control, namely pesticide use. It sets the stage for why issues of pesticide use are important and why individuals should be informed about the social, environmental, and economic contexts of these issues. This lesson will give the student a sense of tradeoffs; for example, using pesticides for food and fiber increases production but may compromise human and environmental well-being. After developing a better understanding of issues, particularly as they affect the individual, the student will begin thinking about potential solutions to pest and pesticide use problems.

Part I includes an exercise to help students determine how they feel about pests and pesticides. Students will discuss their definition of a pest and pesticide. This section also provides an activity to research current issues published in popular press.

Part II encourages students to think about potential solutions to the problems pests and pesticides pose as a way of leading into the next lesson on integrated pest management.

PART I

Attitude Survey

This survey helps determine students' attitudes towards pesticides and pesticide use and tests their knowledge of pesticides and integrated pest management. Give each student a copy of **Handout: Survey of Attitudes About Pesticides and Pesticide Use** and instruct them to complete it. For each statement, they should circle the number of the phrase (strongly disagree, disagree, undecided, agree, strongly agree) which best represents their opinion. Remind students that this is a survey, not a test, and they should record their first response.

Instruct students to total the numbers circled in each column, then add across the columns for a total score. This is their attitude score.

Plot the class scores on **Overhead: Class Attitudes About Pests and Pesticides**. Plot number of students, counted with a show of hands, who had a score between 10-20, 21-30, 31-40, 41-50, 51-60, 61-70, 81-90, 91-100. Draw bars for each increment to make a bar graph.

Higher scores represent attitudes which are generally against pesticide use and the lower scores represent favorable attitudes. Ask the class to make general conclusions about the attitudes of the class and how their individual scores compare with classmates.

Objective: Define Pest and Discuss Ideas About Pest Control

Establish a definition for a pest and ideas about pest control. Give each student a copy of **Handout: Study Questions about Pests and Pesticides**. Organize the class into small discussion groups of 3-5 students each to brainstorm answers to each of the questions. Have groups report their results and lead a discussion to develop answers. Sample answers are indicated by 🗨️.

What is a pest? Give examples.

🗨️ Anything that is harmful or is a nuisance to humans. Examples include insects, rodents, diseases, and weeds. Stress to students that a pest is often defined in terms of its effects on humans.

What are some problems that specific pests cause and what types of problems are these?

🗨️ As with pesticides, pests pose a number of problems for human health and safety, economic health and the environment. For example, rats carry disease organisms which threaten human health. Roaches and fleas present similar problems. Gypsy moths damage tree resources and can pollute streams.

How do you deal with pests in the home, garden, or farm? Give examples.

🗨️ sanitation, pesticides, pest-resistant plant varieties, traps, do nothing

How do we control pests in agriculture and natural resources management?

🗨️ pesticides, pest-resistant plant varieties, natural enemies

What is a pesticide?

🗨️ Any chemical control for a pest—insecticide, fungicide, rodenticide, herbicide

What are some benefits and drawbacks of using pesticides?

🗨️ Benefits include controlling pest populations quickly, efficiently and inexpensively compared to other control measures. Drawbacks include environmental pollution (pesticide runoff to surface water, wildlife and habitat degradation), negative effects on human health and safety, and, in some cases, high costs to apply them.

Objective: Define Pest and Pesticide Issues

As a library or take-home assignment, instruct students to find one newspaper or magazine article related to pest and pesticide use problems and to write a brief summary of the article identifying

- the topic (ex. fish kills in the James River)
- who or what was affected (ex. the fish, the fishing industry, the water quality, the outraged citizens)
- type of problem or issue (economic, environmental, social) specific to the article.

Use Handout: Pests and Pesticides-Defining the Issues. Suggested search terms to use at the library include pest, pesticides, pesticide overuse, pesticides and the environment, pesticide regulation, pesticides and wildlife, and pesticide pollution.

Most issues will involve environmental and wildlife habitat degradation, negative effects on other organisms, pesticide resistance, human health hazards, pesticide bans, and accidents involving pesticides. Examples on page 2 of the handout illustrate types of issues.

Objective: Categorize Types of Pest and Pesticide Issues

The following day or when you assign the article summaries to be completed, record results from the assignments. Fill in the chart on **Handout: Types of Pest and Pesticide Issues** and instruct students to fill in their own copy. Use tic marks in the TYPE OF PROBLEM columns. See example on the first line.

Look at the results of the class tally.

- What category(s) received the most marks?
- What categories were most consistently represented across all articles?
 - ☞ Answers will vary here, partly due to students' interests, but many of the issues and problems addressed will deal with the environment and human health and safety.

Discuss some of the articles. As part of the discussion, ask students:

Do you think the issue you researched is really a problem? Why or why not?

- ☞ Answers will vary and most students will likely agree that the issue is a problem, but the point of this question is to emphasize to students that we live in a global community and that what happens in other parts of the state or country can affect them (ex. higher prices on citrus because of ban on a popular pesticide used to control citrus insects). See the next question.

On the other hand, students should learn to be critical of information published in newspapers and magazines or broadcast on television. Often times information is not based on fact or scientific evidence and caters to public emotions. They should not believe everything they read or hear from a single source.

Why should you be concerned about something like an accidental chemical spill in a small, rural town of Maryland or Delaware?

☞ These chemicals can make their way to groundwater or end up in the Chesapeake Bay through surface water runoff. The Bay provides numerous interests like fishing and boating as well as provides jobs to people in Virginia. Water pollution threatens these interests.

How could some of the issues and problems discussed in class affect you directly?

☞ Answers will vary. See example above.

PART II

Objective: Develop Solutions for Dealing with Pest and Pesticide Problems

Ask students to think about how they deal with pest and pesticide problems. In class or as a take-home assignment, have them write two or three possible solutions to the problem in their article. Students should record their solutions on the summary handout.

Example:

- ☞ In the Massey article about gypsy moth, solutions could include
- planting trees unfavorable for gypsy moth feeding
 - spraying only certain areas
 - cutting trees for timber before they are damaged by gypsy moth
 - homeowner inspections for presence of gypsy moth on property.

Prompt students to think about ways to deal with pest populations and pesticide misuse as a way to introduce the concept of integrated pest management. Begin with a discussion of their ideas about solutions. To get the discussion started, outline ideas from an article that you found or in one of the sample articles from the last lesson. **See the sample solutions from the last lesson.** Record your ideas on the board or on **Overhead/Handout: Solutions to Pest & Pesticide Problems.** Discuss some of the students' solutions and record their ideas. Keep this list.

Continue with the next lesson, **Integrated Pest Management: An Introduction.**

EVALUATION

Suggested quiz items are at the end of the next lesson.

REFERENCES

Latane, L. (July 1992). Pesticides believed cause of bird kills. Richmond Times-Dispatch.

Laub, C. & F.W. Ravlin (Eds). (1993). Virginia integrated pest management. Blacksburg, VA: Virginia Polytechnic Institute and State University.

Massey, J. (December 1991). Gypsy moths threaten state, board warned. Milwaukee Journal.

Orndorff, B. (March 1989). Food scares. Richmond Times-Dispatch.

INSTRUCTOR'S NOTES

Study Questions

- 1.** What is a pest? Give examples.
- 2.** What are some problems that specific pests cause and what types of problems are these?
- 3.** How do you deal with pests in the home, garden, or farm? Give examples.
- 4.** How do we control pests in agriculture and natural resources management?
- 5.** What is a pesticide?
- 6.** What are some benefits and drawbacks of using pesticides?

Attitudes About Pests and Pesticides

Circle the number that best describes your opinion of the statements below.

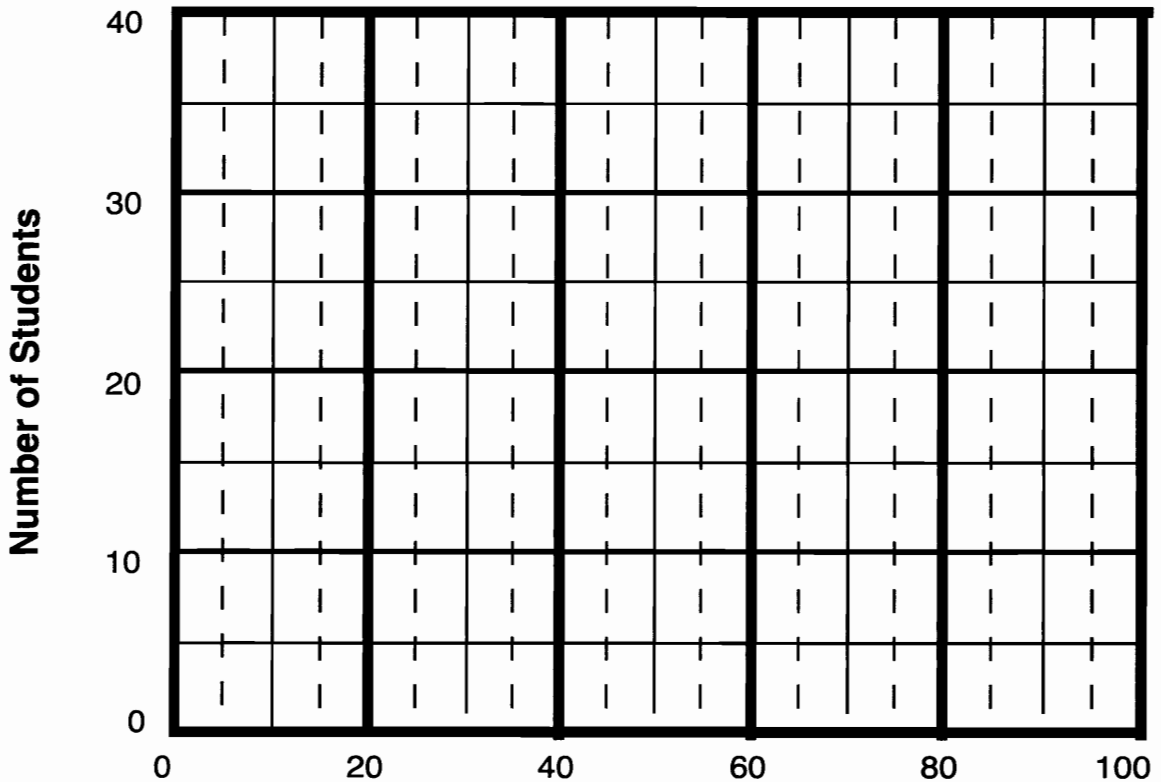
	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
Pesticides benefit people.	5	4	3	2	1
We should focus our research on developing new pesticides to kill pests resistant to old ones.	5	4	3	2	1
Overuse and misuse of pesticides is a big problem.	1	2	3	4	5
Environmental concerns are the main considerations when making a decision to use a pesticide.	1	2	3	4	5
Pesticides are extremely dangerous.	1	2	3	4	5
We must use pesticides for growing crops and protecting trees.	5	4	3	2	1
Our country should ban pesticide production and focus efforts on alternative ways of pest control.	1	2	3	4	5
The U.S. should produce all crops organically (without chemicals).	1	2	3	4	5
Feeding the country is more important than worrying about pesticide pollution.	5	4	3	2	1
Banning use of pesticides in the U.S. is a big mistake.	5	4	3	2	1
The U.S. should produce all crops organically (without chemicals).	1	2	3	4	5

Attitudes About Pests and Pesticides

Circle the number that best describes your opinion of the statements below.

	Strongly Disagree	Disagree	Undecided	Agree	Strongly Agree
A pesticide product should not be used if it affects organisms other than the one causing problems.	1	2	3	4	5
Our country should ban pesticide production and focus efforts on alternative ways of pest control.	1	2	3	4	5
Developing new, more powerful insecticides is a waste of time and money.	1	2	3	4	5
Growers cannot make money unless they use pesticides on their crops.	5	4	3	2	1
The first thing to think about to get rid of a pest is what type of pesticide to use.	5	4	3	2	1
Using insecticides at planned, scheduled times is the most efficient way to kill bugs.	5	4	3	2	1
Pesticides cause great harm to living organisms and the environment and should not be used.	1	2	3	4	5
Applying a pesticide is better than doing nothing about a pest problem.	5	4	3	2	1
Using alternative pest control measures, like natural predators, is a waste of time and money.	5	4	3	2	1
Total:					
Grand Total:					

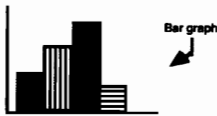
Class Attitudes About Pests and Pesticides



Attitude Scores

Instruct students to total the numbers circled in each column, then add across the columns for a total score. This is the attitude score.

Now, plot the class scores. Use the graph as an overhead. Plot number of students (counted with a show of hands) who had a score between 10-20, 21-30, 31-40, 41-50, 51-60, 61-70, 71-80, 81-90, 91-100. Draw a bar graph.



Now, tell the students that the higher scores represent attitudes which are generally against pesticides and the lower scores represent favorable attitudes. Ask them to draw general conclusions about the attitudes of the class and how their individual scores compare with their classmates.

PESTS & PESTICIDES: DEFINING THE ISSUES

Name: _____

Date: _____

Find one newspaper or magazine article related to pests or pesticide use and write a brief summary of the article identifying

- the topic (ex. fish kills in the James River)
- who or what was affected (ex. the fish, the fishing industry, the water quality, the outraged citizens)
- type of problem or issue (economic, environmental, human health and safety) specific to the article

Suggested search terms to use at the library include pest, pesticides, pesticide overuse, pesticides and the environment, pesticide regulation, pesticides and wildlife, and pesticide pollution.

Summary:

Solutions:

GENERAL CATEGORIES OF ISSUES AND EXAMPLES OF EACH

HUMAN HEALTH & SAFETY

involves threat to short and/or long term well-being

Richmond (Virginia) Times-Dispatch March 15, 1989

Food scares

Relevance of Alar data is at issue

By Beverly Orndorff
Times-Dispatch science writer

The current stew about apples and Alar, a growth control chemical, has arisen in recent years because of what's been happening, or suspected of happening, in some laboratory rodents.

The concern has led several Virginia school systems, including Richmond, Newport News and Henrico and Fairfax counties, to ban apple products from their school lunch programs recently until such foods can be shown to be Alar-free. School systems in other parts of the country, including Chicago, Los Angeles and New York City, have taken similar actions.

"We don't think the data warrant this kind of reaction," Al Heier, a spokesman for the Environmental Protection Agency, said yesterday.

An environmental group's claim that the risks are greater than EPA studies show has led to the current concerns.

Alar has been used by the apple industry to promote even growth of apples and to reduce spoilage. But it has been used less and less, Heier said. "From all of the data we can gather," he said, "it appears it was used on only about 5 percent of the total volume of apples

systems in the state that have temporarily stricken apples from the menu. Why?

"We don't often include apple products anyway," said Jacquelyn Lindsey, acting school superintendent. "So it doesn't hurt to go ahead and discontinue it until we know what's going on."

The banning spurt started Thursday when schools in Fairfax announced they would not sell apples, and escalated Monday when Richmond and Henrico schools followed suit. Anxiety over the potential

health hazard continued to rise yesterday as schools in James City, Albemarle, Stafford, Newport News and Culpeper adopted the no-apple policy.

Dr. Jane R. Logan, associate director of school food service for the Virginia Department of Education, said the department is not recommending the ban.

"Certainly, it's a local decision as to what they do," she said. There is no proof that Alar is present in apples in quantities that would harm students, she said.

The wave of apple-banning is partially the result of the schools' fear of criticism from parents, Dr. Logan said.

Indeed, New Kent County School Superintendent Burton F. Alexander Jr. said, "You have to be concerned about the problem and what the parents perceive. Until we know that the products are not contaminated, we will not be serving them."

Other school systems are taking a wait-and-see approach.

"I'm not too alarmed right now, but we don't want to do anything detrimental to the children," said Bill Towne, superintendent of Charles City County Schools. "They do come first, but I'm not going to jump on the bandwagon until I hear from the EPA or the USDA, and then we will follow their direction."

Brunswick Superintendent J. Grady Martin said, "We're not doing anything until we hear word from state authorities."

"Certainly we're trying to find out all we can," said Halifax County Superintendent Paul H. Jones.

In the heart of apple-growing country, there are no plans to bar apples from school cafeterias, according to officials in Winchester and Frederick County.

"We've not culled apples from our menus. We've not been advised by the state people or our [federal] commodities people to do that," said Thomas Malcolm, assistant Frederick County school superintendent.

Education officials throughout the state are awaiting the results of a Department of Agriculture test for Alar. Researchers have collected 80 samples of apples, from both in-state and out-of-state sources, from stores and wholesalers.

Results should be available by the end of the week, said Arthur D. Dell'Arta, supervisor of the Bureau of Food Inspection.

"We don't expect to find anything that's over the established tolerance," he said.

Dr. Benjamin F. Zambrana, a Richmond pediatrician, said he supports the wide-prevalent banning of apples.

"They should have been banned a long time ago," he said.

Others disagreed. "I think people are reacting too hastily," said C. Wayne Ashworth, Virginia Farm Bureau president.

A report by the Natural Resources Defense Council broadcast on "60 Minutes" last month alarmed the public about the potential effects of Alar on children. The truth, Ashworth said, is that the average person would have to eat more than 2,000 pounds of Alar-treated apples every day for 70 years in order to reach hazardous levels.

Besides, most farmers have stopped using the chemical, he said. Officials estimate that Alar is used on about 5 percent of all Virginia-grown apples.

GENERAL CATEGORIES OF ISSUES AND EXAMPLES OF EACH

ECONOMIC: involves gains and losses in money or assets

Milwaukee (Wisconsin) Journal December 26, 1991

Gypsy moths threaten state, board warned

Pests could devastate paper, timber industries if they aren't eradicated

By JIM MASSEY
Special to The Journal

Madison, Wis. — The gypsy moth, which could have a devastating impact on Wisconsin's paper, timber, nursery and tourism industries, must be eradicated soon to prevent widespread damage in the state, the state Board of Agriculture, Trade and Consumer Protection was told earlier this month.

Steve Krause, director of the gypsy moth program at the state agriculture department, said the moths were spreading into Wisconsin from Michigan and other states, and were especially prevalent in Door, Kewaunee, Manitowoc and Sheboygan Counties along Lake Michigan. The damaging pests, which last year defoliated 7 million acres of trees in the United States, will spread across the state if an eradication program is not implemented, Krause said.

"If nothing is done against this insect on a large scale, it will certainly spread, and we'll fall into a suppression mode here in Wisconsin," Krause said. "Other states spend millions of dollars once they concede they're in a suppression mode just to spray to keep part of the leaves hanging on a tree."

State Agriculture Secretary Alan Tracy said the agency was "trying to sound a bit of a wake-up call" about how much damage the insect could cause. He said the paper, nursery, timber and tourism industries "have an awful lot at stake here, and they don't know what's coming."

Homeowners in the area of an infestation should also be concerned, since defoliation of trees can significantly reduce property values, Tracy said.

"We've dealt with other insects, but this state has never seen anything like the gypsy moth," he said. "Now's the time to do something about it. There is general agreement that eradication is still possible in this state."

100,000 ACRES NEED SPRAYING

Experts say about 100,000 acres should be sprayed in Wisconsin in an attempt to kill the insect, a task that would cost about \$3.5 million. The US Forest Service will provide half of the money for the eradica-

tion effort, Tracy said.

Spending \$1.75 million of state and private funds to eradicate the gypsy moth would be "an extremely cost-effective thing to do," Tracy said. Unfortunately, a decision must be made within a matter of weeks if officials are going to gear up to spray the pests in the spring of 1992.

A Gypsy Moth Working Group composed of specialists from the agriculture department, Department of Natural Resources, US Forest Service, USDA Animal and Plant Health Inspection Service and the University of Wisconsin, has been meeting in recent weeks to plan a strategy to battle the insect. However, Tracy said it would take a special appropriation from the Legislature to tackle the job.

The gypsy moth is considered the most damaging leaf-eating insect in the US. The insect has invaded states from Massachusetts to Michigan and south to Virginia, causing an estimated \$500 million in damage per year.

The larvae feed on trees, and can defoliate and kill them rapidly. In Michigan, they stripped leaves from trees on only five acres in 1980. By 1991, defoliation had exploded to 694,000 acres.

GENERAL CATEGORIES OF ISSUES AND EXAMPLES OF EACH

ENVIRONMENTAL: involves conditions affecting the development and well-being of living organisms and their surroundings

Richmond (Virginia) Times-Dispatch July 3, 1992

Pesticides believed cause of bird kills

Findings of dead birds widespread; diazinon may be poisoning them

BY LAWRENCE LATANE III
TIMES-DISPATCH STAFF WRITER

Pesticides are believed responsible for a flurry of bird kills around the state that have taken a toll on several species, including robins, bluebirds and a peregrine falcon.

Findings of dead birds have been widespread, with reports coming from Richmond and Roanoke and an area bounded by Hampton Roads to the east and Tazewell to the west.

"A lady from Fredericksburg told us she had 20 birds die on her lawn after she had applied diazinon, which is a lawn-care pesticide," said Betsy Stinson, a biologist with the state Department of Game and Inland Fisheries.

"If a homeowner has a choice, they should not use diazinon if they care about wildlife," she said. "It's deadly to birds."

The product, available at most lawn and garden centers, has been

banned for use on golf courses and turf farms, but remains legal for home use.

In another case, about a dozen birds were found dead at a home

TO REPORT

STONE: Dead birds in a plastic bag on ice or in the freezer.

CALL: Wildlife agents at (703) 231-6253.

where "a gentleman said he let liquid Furadan flow into a puddle," she said. The state banned the use of granular Furadan last year after it was linked with numerous kills of birds feeding in freshly planted fields. The use of liquid Furadan is legal.

The game commission got its first report of bird kills in March. They have continued through this week, with the latest report coming from Westmoreland County, Ms. Stinson

said.

She is the head of an informal network of wildlife agents working with the U.S. Fish and Wildlife Service to document the reports and investigate what has caused the deaths.

The group is investigating about 20 incidents. Several of them are linked to pesticide contamination, according to necropsies performed on the birds.

"We really need to know what is killing these birds," said Don Patterson, chief of law enforcement for the Fish and Wildlife Service in Richmond.

"Nationwide, I know of major kills in Idaho, Indiana and North Carolina." He said the service has made it a national priority to investigate the

bird kills.

A dead peregrine falcon, a federally protected endangered species, was discovered in the eastern part of the state. Patterson declined to discuss the incident because it is under investigation.

Other birds found dead include "bluebirds, finches, bluejays, red-winged blackbirds, several species of sparrows, mourning doves, you name it," he said.

Ms. Stinson said she would report her findings later to the State Pesticide Control Board, the agency which banned granular Furadan last year.

"I don't know if a ban" of diazinon is necessary, she said. "The main thing is to make homeowners aware that when they use a product like diazinon it has a potential to kill birds."

TYPES OF PEST & PESTICIDE ISSUES

TOPIC	WHO/WHAT AFFECTED	TYPE OF PROBLEM		
		Environmental	Economic	Health & Safety
Gypsy moth infestations and damage in Wisconsin	Tyber, nursery, paper and tourish industries, Wisconsin forests, homeowners			/
TOTAL:				

TYPES OF PEST & PESTICIDE ISSUES

TOPIC	WHO/WHAT AFFECTED	TYPE OF PROBLEM		
		Environmental	Economic	Health & Safety
TOTAL:				

**SOLUTIONS TO
PEST & PESTICIDE PROBLEMS**

THE PROBLEM	SOLUTIONS

SOLUTIONS TO PEST & PESTICIDE PROBLEMS

THE PROBLEM	SOLUTIONS

Lesson: Introduction to Integrated Pest Management

This lesson introduces the concept of integrated pest management as a solution to the pest—pesticide dilemma and gives examples of IPM practices in Virginia.

PURPOSE

This lesson will enable students to describe integrated pest management (IPM), give examples of strategies used in IPM, and describe its relevance to agriculture, natural resources management and human health.

OBJECTIVES

Upon completion of this lesson, students will be able to

- describe IPM
- outline strategies used in IPM systems
- outline the evolution of IPM in the United States (optional)
- discuss the relevance of IPM practices
- give examples of IPM practices in Virginia

CONCEPTS

- solutions to pest control and pesticide problems
- understanding IPM as a system made up of different processes

SKILLS

Students will

- practice oral and written expression of personal beliefs
- practice problem-solving and critical thinking skills
- practice abstract thinking (the IPM concept)

BACKGROUND FOR INSTRUCTOR

This lesson introduces the student to integrated pest management (IPM)-what it is and how it is relevant to contemporary pest control. The student should obtain a good understanding of the main components of IPM. These components will be broken up in the following lessons and applied as part of case study exercises where students practice IPM for gypsy moth management.

Included in this lesson is the section, Evolution of IPM and Current Relevance of IPM Practices. Its purpose is to give students historical background on the concept and practice of integrated pest management. It is important for students to develop perspective concerning current thinking about pest management using historical information. However, it is not necessary to their understanding of integrated pest management and how it we use it today, so you may choose to omit this section and continue to the next section.

Objective: Describe IPM

We want to get rid of pests, so we use pesticides to kill them. Yet, pesticides cause other problems which may be more long-term and expensive. Pests and pesticides each have unique sets of problems, and knowing how to minimize these problems is the conflict faced by many of us. This is the pest—pesticide dilemma.

Ask the students how they would address this conflict by instructing them to think of strategies they would use to control a pest while minimizing pesticide use at the same time. Record key words or phrases on the board or overhead. Use the solutions from the solution chart of the last lesson as guides because these solutions likely will illustrate a number of strategies to control pests and minimize pesticide misuse and overuse.

Now ask students:

- Do you have to use just one of these strategies for good control?
- Do you think using different strategies—like sanitation, predators and pesticides—is a good plan? Why or why not?

If they responded that combining strategies is a good plan, tell them that they now understand a basic meaning behind **integrated pest management** (IPM for short), that is, combining or **integrating** strategies to manage a pest. Use **Overhead: IPM Definition** to give the class a textbook definition:

Integrated pest management (IPM) is a pest population management system that uses all suitable tactics, like introducing natural enemies, using pest-resistant plants, and applying pesticides, in an effort to anticipate and prevent the population from reaching damaging levels.

Objective: Outline Strategies Used in IPM

IPM involves the use of decision-making tools, pest population monitoring, multiple control tactics and evaluation of controls to manage a pest.

(**Overhead: General Model of IPM**). Refer to the terminology list (**Handout: IPM Terms**). These are general terms describing tools and tactics used in IPM. Instruct students to study and use this list in their reading assignments.

Objective: Outline the Evolution of IPM and Discuss Current Relevance of IPM Practices

Use **Overhead/Handout: Evolution Chart** to illustrate the types of pest controls used over the centuries and important milestones in the evolution of IPM . Note that the use of organic pesticides increased dramatically after World War II, and brought with it many environmental and health hazards. Provide students with **Handout: Evolution of IPM** as a summary.

☞ An important milestone in the IPM movement was Rachel Carson's book *Silent Spring*. It raised public awareness and concern about the pitfalls of pesticides. If you can obtain a copy of *Silent Spring*, read the introduction to give students a sense of the rising public concern for pesticide misuse and overuse beginning in the early 1960s. Ask them if they are concerned that contemporary pest management threatens their health or environment. Do they think the scenario described by Rachel Carson is or could be a reality today?

Now, ask students why we should practice IPM today.

Objective: Give Examples of IPM in Virginia

At the end of this lesson, give students **Handout: IPM and Virginia**, which briefly reviews what IPM is and some applications in Virginia. Instruct them to use the terminology list as they read the handout.

EVALUATION

At the end of this section, quiz students on content from the pesticides and IPM lessons. Below are suggested quiz items and sample answers (indicated with the symbol ☞).

Suggested Quiz Items

From the articles discussed in class, give two (2) examples of pest control issues and the types of problems they pose.

☞ Example:

1. Use of Alar on apples: human health concerns (social); apple bans in school cafeterias (economic)*
2. Gypsy moth in Wisconsin: widespread defoliation produces losses in timber quality/recreational value to area forests and residential landscapes (social, environmental, economic concerns).

Describe your interpretation of integrated pest management. Use drawings if you want.

☞ Refer to the definitions described in class, the textbook definition and the model. The student's response should include using multiple control tactics to anticipate and prevent pests from reaching damaging levels.

Give three examples of strategies used in IPM and a brief description of each.

☞ Example:

1. plant resistance: use of plants that can avoid, tolerate or recover from pest injury
2. sampling: technique to collect information about the presence, density and change in density of a pest population
3. economic threshold: the pest population level above which control measures should be used to prevent economic damage

How are IPM practices important?

☞ Example:

- can save money by decreasing pesticide use
- can help decrease pesticide misuse and overuse by providing other control options (ex. predators/parasites, resistant plants)
- alternatives may provide solutions to insect resistance problems

Give one example of how IPM is used in Virginia?

☞ Examples:

- weathering monitoring helps eastern Virginia peanut farmers predict when to spray fungicides to control peanut leaf spot
- sampling gypsy moth populations provides information about where they are and the population density throughout Virginia
- biological controls help reduce herbicide use on thistles

* Alar is a hormone growth regulator, not a pesticide. However the Alar issue is an excellent example of how the public reacts (or over reacts) to chemicals in food.

Extra Credit Items

- Why should you care if a local farmer, forester, orchardist, nursery grower, or even your gardening neighbor does not practice IPM?

☞ Example:

I am concerned that if these people are not using IPM, they may be using too much pesticide, the wrong pesticides, or the wrong ways to apply them. I am concerned that this misuse may affect water quality, wildlife and their habitat, my food and air, and may cause insects and diseases to become resistant to these pesticides.

- Think about an organism that you consider a pest (non-human!). Suggest ways that you could use IPM to control this pest.

☞ Example:

You have a problem with mice and rats at home. IPM strategies that you can use include storing food in tightly-wrapped containers, regular cleaning, disposing waste in containers with tight lids, patching holes in windows/doors or anywhere that creates access from the outside.

REFERENCES

Camp, W.G. and R.L. Donahue. (1994). Ch. 11, Integrated pest management. Environmental Science. Albany, NY: Delmar Publishers, Inc.

Dent, D. (1991). Insect pest management. Oxon, UK: C·A·B International.

Kogan, Marcos. (1975). Ch. 4, Plant resistance in pest management. In Introduction to Insect Pest Management, R.L. Metcalf & W.H. Luckmann (Eds). New York: John Wiley & Sons Inc.

Ravlin, F.W. (1993). Integrated pest management in Virginia. In Virginia Integrated Pest Management, C. Laub & F.W. Ravlin (Eds). Blacksburg, VA: Virginia Polytechnic Institute and State University.

Twardus, D.B. and H.A. Machesky (Eds). (June 1994). Gypsy moth news, #35. USDA Forest Service, Northeastern Area.

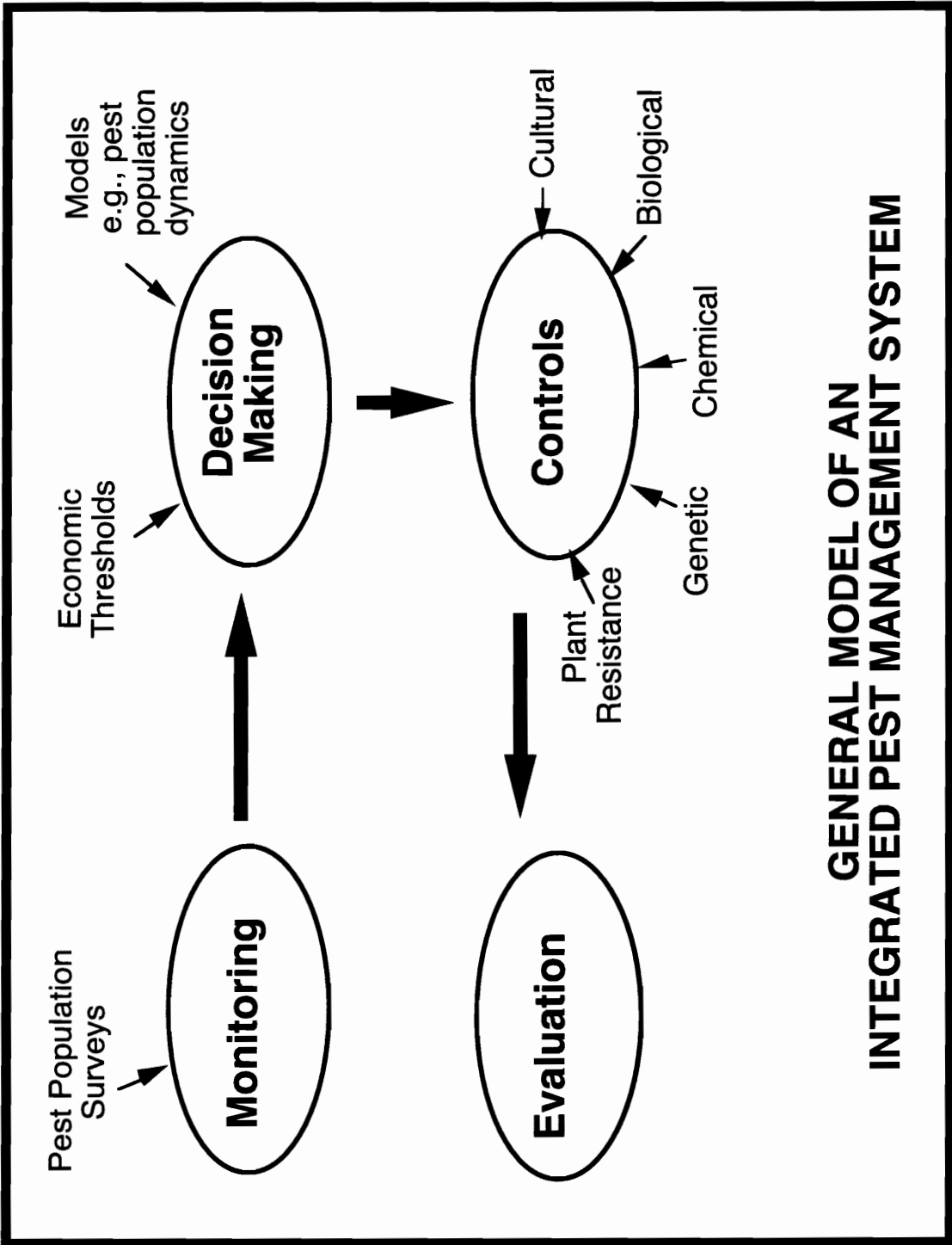
Ware, G.W. (1989). The pesticide book. Fresno, CA: Thomson Publications.

INSTRUCTOR'S NOTES

INTEGRATED PEST MANAGEMENT



Integrated pest management (IPM) is a pest population management system that uses all suitable tactics, like introducing natural enemies, using pest-resistant plants, and applying pesticides, in an effort to anticipate and prevent the population from reaching damaging levels.



**GENERAL MODEL OF AN
INTEGRATED PEST MANAGEMENT SYSTEM**

Terms

biological control

use of an organism that is a predator of a pest or can out-compete it for food, water, or shelter
Example: Greenhouse managers release ladybird beetles to feed on aphids that damage greenhouse plants.

chemical control

any chemical substance used to control pests
Example: Pet owners use insecticides to kill fleas on their pets.

cultural control

managing the environment to make it unfavorable for a pest. Cultural control includes practices that

- improve the health of a plant (ex.: fertilization, watering, pruning, and mulching)
Example: Homeowners care for trees to improve their health and decrease chances for insect or disease attacks;
- decrease favorable habitat for the pest (ex: sanitation, airtight storage containers)
Example: Restaurants and grocery stores store waste in tightly latched containers to help keep the area clean and to discourage rodents; and
- decrease availability of the host (ex: planting before or after the damaging stage of the life cycle, planting pest-resistant varieties, planting multiple crops, and rotating crops in the fields)
Example: Gardeners plant annual vegetables and flowers in different spots each year to avoid a buildup of disease organisms in the soil.

economic threshold

the pest density above which control measures should be used to prevent the population from reaching a level that causes economic damage to the crop. The economic threshold is an important decision-making tool of integrated pest management, using information about the pest population density and economic damage of the crop.

Example: Managers control gypsy moths when the area has over 200 egg masses per acre. Egg mass counts over 200 indicate a gypsy moth population that can cause economic damage.

forecasting

a process of predicting when a pest attack will occur, how long it will last, and how severe it will be. Forecasting is extremely important to managers as they plan how to control pests.

Example: Foresters remove trees that are susceptible to gypsy moth attack and they improve growing conditions of standing tree several years before the forecasted infestations.

genetic control

altering the genes of a pest to make it less successful in reproduction

Example: In the lab, scientists genetically alter gypsy moth females to make them sterile. The sterile females are released in a forest where they mate with the natural population of adult males but produce sterile offspring. The next generation cannot reproduce.

integrated pest management (IPM)

a pest population management system that uses all suitable tactics, like introducing natural enemies, using pest-resistant plants, and applying pesticides, in an effort to anticipate and prevent the population from reaching damaging levels.

Example: Schools use IPM to control roaches and rodents, which spread diseases to humans. Sanitation is important, especially in and around cafeterias, so cleaning staff play a very important role in IPM. Maintenance staff use traps to kill roaches and rodents and to get information about size of the populations. They also use pesticides when populations are large and extensive.

monitoring

a process of collecting information that helps predict pest outbreaks (ex. weather conditions, plant growth stages)

Example 1: In the spring, gypsy moth managers sample new leaves to determine the stage at which they have opened and expanded. Leaves must expand a certain degree before insecticide applications begin.

Example 2: Peanut growers in southeast Virginia use a weather monitor which provides information about temperature and humidity. The monitor alerts growers to weather conditions which are favorable for peanut leaf spot disease and they can plan fungicide applications on peanut fields at the correct time.

pest

any organism judged by humans to cause harm or nuisance to humans, crops, animals or property

Example: Most people think that roaches are pests because they spread disease and are a nuisance.

pesticide

any substance, often a chemical, used to control unwanted pests

<u>This pesticide:</u>	<u>controls these pests:</u>
Insecticide	insects
Fungicide	fungi
Rodenticide	rodents
Herbicide	weeds
Avicide	birds
Miticide	mites
Nematacide	nematodes
Bactericide	bacteria

plant resistance

a plant's ability to avoid, tolerate, or recover from pest injury

Example: Gardeners plant varieties which are resistant to common garden diseases.

sampling

any technique used to collect information about the presence, density and change in density of a pest population

Example: Corn growers in Virginia hire scouts to get information about corn rootworms, which cause significant damage to corn crops if not controlled. Scouts set traps in sample areas of cornfields to catch the adult beetles. Beetles caught in the traps indicate presence of corn rootworm and the severity of infestation.

EVOLUTION OF IPM:

Historical Pest Management Practices & Important Events

1700-1985

<p>1700's</p> <ul style="list-style-type: none"> □ Sanitation □ Tillage □ Removal of alternate hosts □ Crop rotation □ Timing of planting □ Pruning □ Slacked lime and powdered tobacco □ Plant materials □ Animal manures □ Soot □ Dry ashes □ Sea water □ Urine □ Soap □ Turpentine □ Alcohol □ Farmyard drainage 	<p>1870</p> <p>Paris green for Colorado potato beetle</p>	<p>1882</p> <p>"Bordeaux mixture" (quicklime & copper sulfate)</p>	<p>1900</p> <p>Host plant resistance</p> <p>Chemical controls begun</p>	<p>1920</p> <p>1940</p> <p>Chemical controls & pesticide application technology</p>	<p>1945</p> <p>1972</p> <p>Organic pesticides, DDT and others</p>	<p>1962</p> <p>Silent Spring written by Rachel Carson</p>	<p>1972</p> <p>1985</p> <p>"Huffaker Project" IPM</p>	<p>1985</p> <p>Bio-technology and Bacillus thuringiensis (Bt)</p>
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Source: F. W. Ravlin, Department of Entomology, VA Tech

EVOLUTION OF IPM

1700-1985

This list describes general practices and important events in each century as they relate to the history of pest management. They also provide perspective about the development of integrated pest management.

1700's

Farmers used a variety of control methods for crop diseases, insects and weeds during this time, many of which involved cultural control like sanitation of crop residues, crop rotation and pruning.

1870

Common use of Paris green to control Colorado potato beetle (*Leptinotarsa decemlineata*) began during this time. Paris green was the first commonly used arsenical (Ware, 1989). It is a powdery substance made by combining sodium arsenite, copper sulfate and acetic acid, and has a bright green color because of the copper content. Paris green was used as a stomach poison, ingested by insects.

1882

"Bordeaux mixture", a mix of lime, water and copper sulfate, was discovered by the French to be toxic to insects and fungi.

1900

Research on pest-resistant plant varieties occurred in the early 1900s. For example, United States Department of Agriculture (USDA) scientists conducted research on cotton plants resistant to cotton boll weevil attacks. However, the emphasis on pesticide research was growing during this time.

1920-1940

Research on chemical controls and pesticide application technology were areas of major emphasis during this period.

1945-1972

World War II began the Chemical Era and the introduction of synthetic organic insecticides. It also began the "Era of Optimism" in pest management, particularly with regard to the introduction of DDT. From a public health view, DDT was extremely effective in lice, mosquito and flea control. Agricultural benefits included effective control of potato, apple, tobacco, and cotton and vegetable crop insects.

EVOLUTION OF IPM

1700-1985

1962

Problems related to reliance on chemical controls became more important in the early 1960s. Included among these problems were insect resistance to insecticides, environmental and wildlife habitat degradation, accidental poisoning and spills, and occupational exposure to pesticides. Rachel Carson's book, *Silent Spring*, was a cornerstone of the "Era of Doubt" from 1960-1976 when the public became increasingly concerned about the negative effects of pesticide use.

1972-1985

Relying too much on chemical controls and problems with pesticide overuse and abuse prompted a change in thinking about pest management. A concept of integrated control emerged, integrating multiple controls tactics as part of a whole management plan. The term integrated pest management (IPM) came into popular use during the late 1960s.

The first major U.S. IPM program, the Huffacker Project, received federal funding in the mid-1970s. This was a 6-year, multi-state project involving collaboration of 18 universities, over 300 researchers and research on most of the major U.S. crops. The "Era of IPM" began in 1976 and continues today.

1985

Research emphasis on genetic, biological and cultural controls from the mid-1980s until today supports the importance of multiple control tactics and careful use of chemical controls when appropriate. Use of the bacteria *Bacillus thuringiensis* (Bt) as a biological insecticide is a good control option for some lepidopterous insects (butterflies and moths) like cabbage loopers and gypsy moths.

Pest control today is an accumulation of many important past contributions. With obvious enhancements and improvements, today's pest management has many of the qualities of the 1700s.

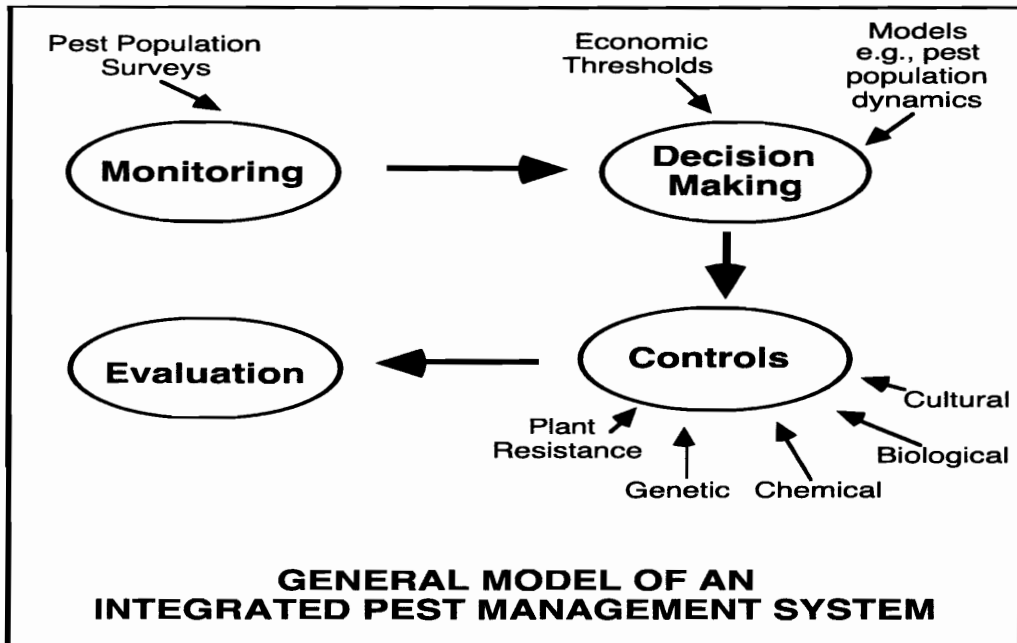
Reference

Ware, G.W. (1989). *The pesticide book*. Fresno, CA: Thomson Publications.

IPM AND VIRGINIA

Pests and Integrated Pest Management

Pests like insects, diseases, weeds, and rodents affect virtually every aspect of our lives, our economy and our environment. In agriculture, pests reduce productivity by an average of 30% and are responsible for the complete loss of many crops. In urban areas, pests promote the use of excessive amounts of pesticides that can adversely affect humans, pets, turf, landscape plants, other organisms and our environment. Pests cause economic and environmental problems for our natural resources and recreational areas. For these reasons, integrated pest management (IPM) is an important and necessary part of agriculture, urban life, natural resource management and recreation. Pests must be controlled in ways that are affordable, safe for human health and the environment, and generally accepted by our society. Historically, pesticides have been the control of choice. Yet, many of the reasons to use IPM today result from the adverse effects many pesticides have on management costs, food safety, the safety of workers applying pesticides, pest resistance to pesticides, water quality and other organisms.



What is IPM?

Integrated pest management (IPM) is a pest population management system that uses all suitable tactics, like introducing natural enemies, using pest-resistant plants, and applying pesticides, in an effort to anticipate and prevent the population from reaching damaging levels.

IPM involves the use of pest population monitoring, decision-making tools, multiple control tactics and evaluation of controls to manage a pest. The model above illustrates different parts of a whole IPM system.

IPM in Virginia

Many agencies in Virginia work together to develop and use IPM programs.

These agencies include

- The Virginia Agriculture Experiment Station at VPI & SU
- Virginia Cooperative Extension
- Virginia Department of Agriculture and Consumer Services
- Virginia Department of Conservation and Recreation
- Division of Soil and Water Conservation
- Virginia Department of Forestry
- USDI National Park Service
- USDA Forest Service

EXAMPLES OF

Virginia IPM Programs	IPM Technology Under Development
<ul style="list-style-type: none"> ● a peanut leaf spot and thrips IPM program that reduced pesticide applications by over 120 tons and saved farmers approximately \$2.5 million dollars in a single year 	<ul style="list-style-type: none"> ● a new control tactic that uses natural "attractants" to disrupt mating and control insect pests in apple orchards without insecticides
<ul style="list-style-type: none"> ● an alfalfa IPM program that returns an average of almost \$13 per acre 	<ul style="list-style-type: none"> ● computer programs for agriculture and gypsy moth management that help make decisions and reduce negative environmental effects associated with pest management programs
<ul style="list-style-type: none"> ● a soybean IPM program that in 1992 saved a remarkable \$1.85 million dollars on insect control alone 	<ul style="list-style-type: none"> ● beneficial diseases and insects that are able to naturally control weeds in pasture lands
<ul style="list-style-type: none"> ● the Chesapeake Bay IPM program that assisted farmers and landowners to develop IPM plans on almost 20,000 acres and maximize the use of environmentally friendly pest control tactics 	<ul style="list-style-type: none"> ● sampling procedures that will save Virginia counties thousands of dollars every year in gypsy moth management programs
<ul style="list-style-type: none"> ● a biological control program for thistles that can eliminate the need for herbicides on thousands of acres of Virginia's pasture lands 	<ul style="list-style-type: none"> ● environmentally safe chemicals that will replace extremely toxic materials used to control weeds, diseases, and insect pests in many Virginia crops
<ul style="list-style-type: none"> ● an IPM program that maintains gypsy moth populations within acceptable levels on approximately 10 million acres of Virginia's urban, forested and recreational lands 	<ul style="list-style-type: none"> ● naturally produced chemicals called "antifeedants" that will replace highly toxic pesticides in Christmas tree plantations
	<ul style="list-style-type: none"> ● beetles that can control scale insects on ornamental plants

SOURCE: Ravlin, F.W. (1993). Integrated pest management in Virginia. In Virginia Integrated Pest Management, C. Laub & F.W. Ravlin (Eds). Blacksburg, VA: Virginia Polytechnic Institute and State University

Section 2: Gypsy Moth IPM

Lesson: Introduction to the Gypsy Moth

This lesson introduces the gypsy moth problem in Virginia, a problem which will be used as an example of integrated pest management for the next lessons.

PURPOSE

This lesson introduces the gypsy moth problem in Virginia and the United States. Students will describe how gypsy moths entered the U.S. and Virginia, the types of damage they cause, and why they are an important pest in Virginia.

OBJECTIVES

Upon completion of this lesson, students will be able to

- estimate when the gypsy moth will enter their county and infest the entire state
- list ways that gypsy moths spread to uninfested areas
- describe types of gypsy moth damage
- draw and explain the gypsy moth life cycle and describe how to identify them at different stages
- explain how gypsy moths and their damage might affect them personally either through role-playing (skits), writing, or art

CONCEPTS

- insect life cycles
- pest-host relationship
- gypsy moth effects

SKILLS

Students will practice

- oral and written reading comprehension
- problem-solving and critical thinking skills
- creative expression of a gypsy moth-related topic

BACKGROUND FOR INSTRUCTOR

Objectives: Reading Assignment and Study Questions

Distribute **Handout: Introduction to the Gypsy Moth** as a take-home reading assignment and instruct students to complete the study questions at the end. Discuss these questions during the next class period. Sample answers are indicated with 🗨️.

1. **When will gypsy moths enter your county? If gypsy moths are already in your county, when did they enter? Do you have infestations near your home or school?**

🗨️ Answers will vary but make sure students study the projection map in the reading assignment.

2. **What are the two ways gypsy moths spread to uninfested areas? Give examples. At what stages in the life cycle do they spread?**

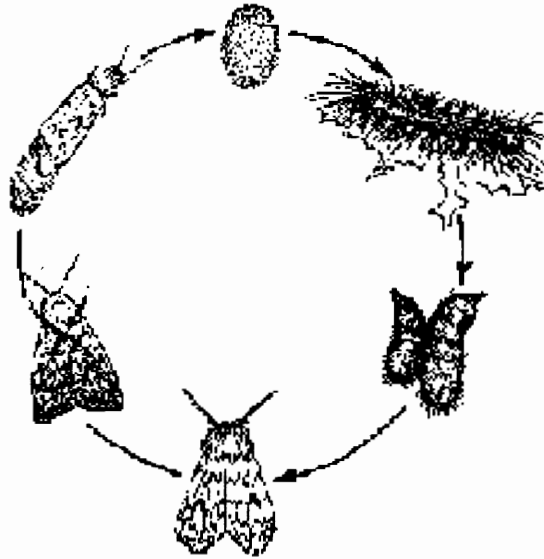
🗨️ Gypsy moths spread naturally and by artificial means. Wind catches the silken strands of the early instar larvae and moves them to new locations. This way of natural spread is called ballooning. A more important way that they spread is by humans. In infested areas, adult female moths lay eggs in any number of places—yard and garden equipment, dog houses, lumber, vehicles. People unknowingly transport egg masses to uninfested areas when they travel, move, and haul cargo.

3. **List at least three effects from gypsy moths and their damage.**

🗨️

- tree stress and possible death
- increased forest and stream temperatures in defoliated areas
- change in wildlife habitat and activity
- nuisance and safety problems in residential areas: crawling larvae; dead, dying, and squished larvae which cause hazardous walking and road surfaces; allergies to gypsy moth hairs; dead trees which might fall and cause damage
- lost value to timber, recreation, landscape, tourist resources

4. Draw and explain the gypsy moth life cycle and describe how to identify them at each life stage.
☞ refer to the illustration in the reading assignment



5. Explain why knowing how to identify a gypsy moth and about its life cycle helps in their control.
☞ The most important first step in any kind of pest management is to identify the pest. In the case of gypsy moths, you want to know that what you are seeing is actually a gypsy moth and not Eastern tent caterpillar or fall webworm, two insects often confused with gypsy moths. Identifying the pest will help tell you **how** to control it.

Once it has been identified, you can get information about its life cycle to know the best times to take control action. Knowing the life cycle will help tell you **when** to control it.

Objective: Explain How Gypsy Moth Damage Might Affect You Personally Through a Creative Interpretation of a Gypsy Moth Topic or Experience

After students have background knowledge of the gypsy moth problem, challenge them to create their own interpretation of how gypsy moths have or will affect them personally. Their interpretation can take form in writing, art, or acting.

Written Interpretation

Encourage students to write about a gypsy moth experience or an anticipated experience. The following are ideas to suggest:

- a journal entry
- short story
- poem
- newspaper or magazine article
- a speech to the local town council expressing concern about gypsy moths
- book or video review of a gypsy moth topic

Art or Craft Interpretation¹

Have students make sketches, models, collages, or take photographs.

Suggested topics:

- detailed sketches of the gypsy moth life cycle to be published in a scientific textbook
- visual interpretation of defoliation and damage in a forest
- model of a life cycle using materials of choice

Skits

Students, alone or in groups, can act out a short skit.

Suggested topics and scenarios:

- the public's reaction to Trouvelot's mistake in the late 1800's
- campers visiting a gypsy-moth infested campground
- a speech to the local town council expressing concern about gypsy moths
- an Extension agent discussing gypsy moth controls to a homeowner
- a high school teacher teaching the gypsy moth life cycle

EVALUATION

Use the study questions and/or the creative expression activity. Use factual references and originality as grading criteria for the activity.

¹Encourage computer generated products if students have computer access at home or school.

REFERENCES

Publications

Carroll, B.S., Virginia Tech. (1993). What about...the gypsy moth? The Virginia Gardener Newsletter. Volume 12, Number 6. Department of Horticulture, Virginia Cooperative Extension Blacksburg, VA: Virginia Tech.

Elkinton, J.S. and A.M. Liebhold. (1994). The dynamics of gypsy moth predators, parasites and pathogens. Gypsy Moth News, #34. USDA Forest Service, Northeastern Area.

Hajek, Ann E. and Amy L. Snyder. (1992). Field identification of the gypsy moth fungus, *Entomophaga maimaiga*. USDA Forest Service, Northeastern Area. NA-PR-02-92.

Liebhold, Andrew; Victor Mastro and Paul W. Schaefer. (1989). Learning from the legacy of Leopold Trouvelot. Bulletin of the Entomological Society of America.

Ravlin, F.W. (1995). Gypsy moth feeding preferences and the homeowner. Publication 444-250. Department of Entomology, Virginia Cooperative Extension. Blacksburg, VA: Virginia Tech.

Twardus, D.B. and H.A Machesky (Eds). (1994). Spraying the gypsy moth. Gypsy Moth News, #35. USDA Forest Service, Northeastern Area.

USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C: U.S. Department of Agriculture.

USDA Forest Service, Northeastern Forest Experiment Station. (October 1990). Gypsy moth research and development program.

Virginia Department of Agriculture and Consumer Services. (1988). Gypsy moth suppression insecticides fact sheet. Richmond, VA: Virginia Department of Agriculture and Consumer Services.

Internet (through World Wide Web)

USDA Forest Service. (1996). Gypsy moth in North America. <http://gypsy.fsl.wvnet.edu:80/gmoth/>. Morgantown, WV: USDA Forest Service, Forest Sciences Laboratory.

INSTRUCTOR'S NOTES

Introduction to the Gypsy Moth

Terms to Know & Use: ballooning, B.t., DDT, defoliation, Dimilin, Entomophaga maimaiga, eradication, frass, host, larvae, metamorphosis, NPV, parasitoid, pheromone, photosynthesis, population, predator, pupae, silviculture, slow-the-spread, sterile insect technique, suppression, transpiration, treatment, VDACS, VDF

European gypsy moths (scientific name: *Lymantria dispar* [L.]) are the most destructive forest insect pests in the eastern United States and are probably among the worst nuisance insects in residential areas. Each year gypsy moths affect millions of acres of land in the U.S. and have affected hundreds of thousands of acres in Virginia since 1980.

Many people who are unfamiliar with gypsy moths often ask these questions:

- How did they get here and why?
- What do they look like?
- How do they cause so much damage?
- What types of damage do they cause?
- What do they feed upon?
- Does anything kill them?
- Can we get rid of gypsy moths?

The following sections provide some basic information about gypsy moths and answer these questions.

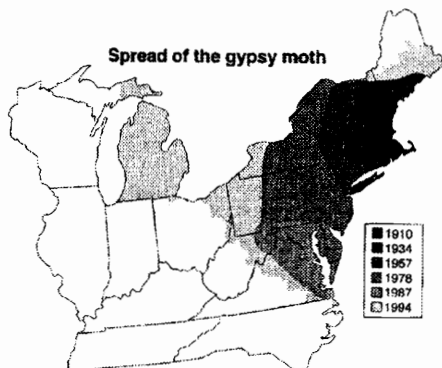
History of Gypsy Moth Introduction in the United States

The next time you wear something made from silk, you might think about how the gypsy moth got to North America. Throughout the nineteenth century, many business-minded Americans tried to find ways to produce silk and promote a lucrative silk industry in this country. A scientist named Étienne Léopold Trouvelot (pronounced tru-ve-lo) believed that the best way to promote such an industry was to find a superior silkworm. Disease killed many of the silk-producing moths in Europe and had a devastating effect on their silk industry. Trouvelot performed experiments with different species of native American silkworms and decided that breeding these species with a disease-resistant species, like gypsy moths, would produce an ideal silkworm for commercial silk production.

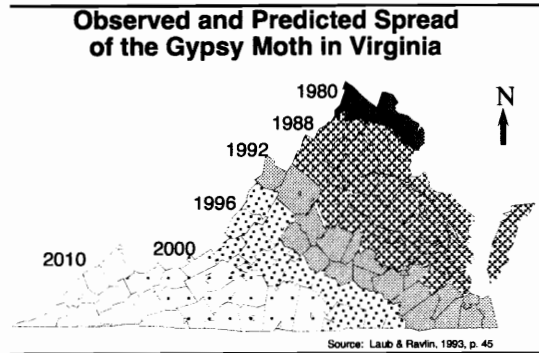
During the late 1860s Trouvelot brought from Europe a shipment of live gypsy moth eggs which he reared in his laboratory in Medford,

Massachusetts. Sometime in 1868 or 1869 a few of the gypsy moths escaped from his house and within ten years the escaped **population** grew enough that it was **defoliating** trees in the neighborhood. By 1890 gypsy moths had spread throughout the area and state officials attempted to **eradicate** them, but their attempts were unsuccessful.

Since their introduction in the late 1860s, gypsy moths have spread throughout the northeastern U.S. and continue to expand their range in Ohio, Michigan, West Virginia, Virginia, and North Carolina. Isolated, smaller populations have been detected as far south as Florida and Texas, throughout the Midwest and along the West coast.

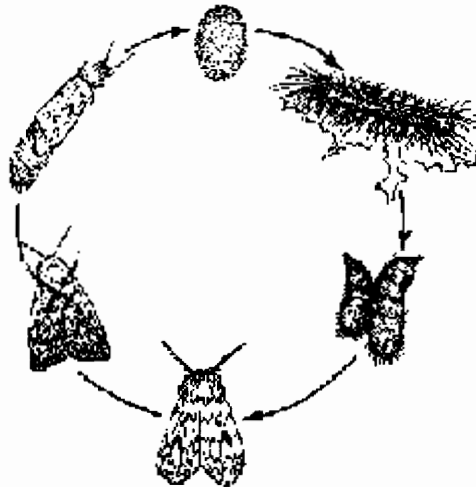


Gypsy moths eventually spread into Virginia around 1980 and have continued moving south and west. As of 1995, over two-thirds of the state was infested and by the year 2010, the entire state probably will be infested.



Identification of the Gypsy Moth

Gypsy moths belong to an order of insects called Lepidoptera. All butterflies and moths belong to this order. Like all insects, gypsy moths go through different developmental stages. These stages make up an insect life cycle. Moths go through several stages in their life cycle-egg, caterpillar, pupae and adult moth.



Gypsy moth eggs are round to oval, buff-colored mounds on tree trunks, logs, cars, rocks or anywhere a femal moth finds a protected, accessible spot to lay eggs. The masses are about the size of a quarter and contain 500-1000 eggs. The eggs themselves are small, round balls that look something like

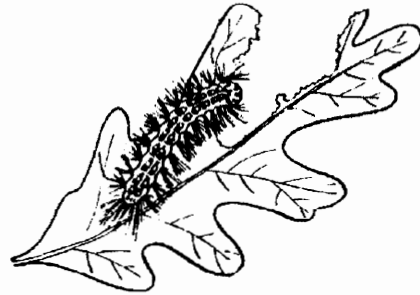
clear gunshot pellets. The female covers the mass of eggs with fuzzy, tan-colored hairs from her abdomen. The coating of hairs provides protection from weather and predators. Gypsy moth eggs hatch from mid-April to mid-May depending on the area of Virginia.

Caterpillars, also called **larvae**, emerge from the hatched eggs and go through six stages of development, increasing in size during each stage. During the last larval stages, the caterpillars assume a brown or gray color with distinguishing red and blue dots extending along the back. Gypsy moths feed on trees and cause the most damage during the larval stage.

Larvae develop into **pupae** or cocoons around June and go through **metamorphosis** where they change into adult moths. Adults emerge from the pupal cases in June or July, again depending upon where in Virginia they are. The adult female of the European gypsy moth does not fly and is very light tan to almost white with dark, jagged markings on the wings. The male is smaller and dark brown with similar wing markings. The male also has feathery antennae, used to detect and locate a female emitting a sex-attractant chemical called a **pheromone**. Adults mate and the females lay egg masses; after mating and egg laying, the adults die. Eggs lie dormant over the winter until the next spring when the cycle continues.

Feeding Preferences

Gypsy moths feed on trees and shrubs during the larval stage. Their preferred **hosts** are species of oak and aspen trees, but they will feed on other species depending upon the size of the caterpillars.

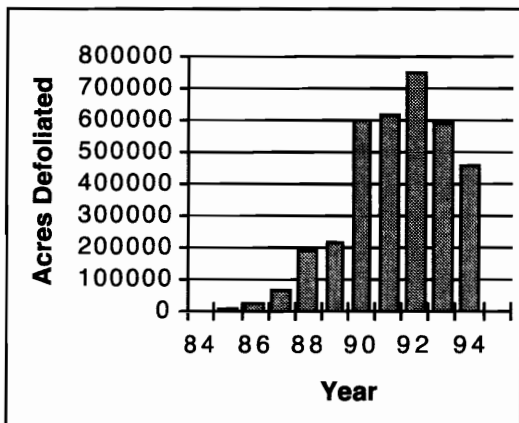


If you live in an area of Virginia where gypsy moths are present, observe gypsy moth feeding and their preferences for food first hand. Collect some of the later-stage larvae in May or June. Put them in a jar or aquarium filled with oak leaves and leaves or needles from another tree (ex. pine, sycamore, maple, poplar). Observe which leaves the larvae prefer to feed upon.

Defoliation

Defoliation involves removing some or all of the leaves from a plant. Gypsy moths defoliate trees by feeding upon leaf tissue, creating holes in the leaves, and by chewing off the leaf petiole, the small stalk at the leaf base. The petiole breaks and the leaf falls to the ground. Defoliation weakens the tree by reducing its ability to manufacture food through **photosynthesis** and to regulate gas and water exchange through **transpiration**.

Early stages of gypsy moth larvae feed mostly at night. As they become larger, they feed more heavily and throughout the day and night. Late-stage larvae will eat up to a square foot of foliage per day. As gypsy moth populations build in an area, they often affect a larger area. Gypsy moths have been spreading in Virginia since their introduction in 1980 and have caused more defoliation every year. The Virginia Department of Forestry (VDF) estimates the amount of gypsy moth defoliation from calculations using aerial photographs of forested areas. Three hundred seventy four (374) acres were defoliated in 1984 and by 1992 over 700,000 acres were defoliated.



Other Damage and Effects

Besides defoliating trees, gypsy moths cause other problems. If trees are defoliated in multiple years, they can become so stressed that they will die. This may not be desirable, particularly in areas like parks, camp sites and urban and suburban settings where people value trees for their shade and aesthetic qualities. Tree damage

causes economic losses to landowners and foresters who manage trees for wood production.

Defoliation can affect the forest. Air temperature increases during the spring while at the same time, trees leaf out and cool the forest.

Defoliation serves to offset this cooling effect by decreasing shade. Increased forest temperatures can stress vegetation on the forest floor, disrupt animal activity and increase stream temperatures. As an example, research shows that increased stream temperatures in gypsy moth defoliated areas can have negative effects on trout, which rely on colder waters to live and breed.

In more suburban and urban settings, the caterpillars themselves cause great nuisance problems. In large numbers, caterpillars can cover the outside of houses and other structures. They will crawl on decks, patios, and roadways and smashed and dead caterpillars create slippery and sometimes dangerous surfaces. Some people are allergic to caterpillar hairs and caterpillar excrement, called **frass**.

Gypsy Moth Success

Since gypsy moths are not native to this country, they have no known natural predators or parasites that significantly reduce and control their numbers. This fact makes them extremely successful in establishing populations. Gypsy moths disperse and become established through natural and artificial means. As caterpillars hatch and begin their ascent up trees to find food, they make thin silken strands from which

they hang on the outside of branches. Wind catches the strands and carries the small caterpillars to new locations, from a few feet to several miles. This process of natural dispersal is called **ballooning**.

Artificial spread normally means accidental introduction by humans. Adult gypsy moth females find many protected places to lay eggs, including the undersides of doghouses, firewood, building materials lying outside and beneath automobiles. Eggs are transported to new, uninfested areas of the state by unsuspecting motorists traveling from infested areas. Officials from the U.S. Forest Service and the Virginia Department of Agriculture and Consumer Services (**VDACS**) found a small infestation in Giles County in 1987, an area of the state thought to be prime gypsy moth habitat because of large expanses of mixed-hardwood forests. Because the area offers good hunting and fishing opportunities, officials think campers from the north accidentally brought gypsy moth eggs to the area.

In subsequent years, additional small infestations were detected in Giles County, probably the result of ballooning from the initial infestation. Eradication efforts have been successful at some of these sites, but residual populations are still present. Other counties experiencing recent artificially introduced infestations include Bland, Carroll, Craig, and Floyd.

Gypsy Moth Control

Once managers determine that control is necessary, they select from a number of **treatments** appropriate for the area's control strategy. Treatments fall into four main categories: biological, cultural, genetic, chemical. Gypsy moths have no known natural controls that will eradicate a population. However, there are **predators**, **parasitoids** and disease organisms that help reduce gypsy moth numbers. Likewise, diseases play an important role in natural control of gypsy moth populations. A virus called **NPV** has been present in building populations in the eastern U.S. for many years. More recently, scientists have discovered a fungus called **Entomophaga maimaiga** and are investigating its potential use as a control.

Silviculture is a type of cultural control used in woodlots and forests. Types of mechanical control include removing and destroying egg masses, wrapping barriers around trees to trap larvae and prevent them from climbing, trapping adult moths, and preventing adult moths from mating. A genetic control used in gypsy moth management involves releasing sterile male into an area. **Sterile insect technique** serves to reduce the number of moths capable of reproducing thus reduces the population.

Chemical controls are extremely important in gypsy moth management. Aerial application of insecticides is the main treatment used in state and federal management programs to control

gypsy moths. Diflubenzuron (trade name Dimilin®) and *Bacillus thuringiensis* (B.t.) are the insecticides of choice. Newer insecticides which may be more specific to gypsy moth and pose fewer environmental side-effects have been tested in small areas. Gypchek is one of these insecticides, a powder manufactured from dead larvae infected by NPV virus.

Can We Get Rid of Gypsy Moths?

An important question that many ask is "Can we totally get rid of gypsy moths?" In today's terms the answer is "No." Some believe that gypsy moths might have been **eradicated** by aggressive spray programs using **DDT** in the 1950s. But overuse of DDT and rising public concern

about pesticide use beginning in the late 1950s and early 1960s prompted government agencies to stop using DDT.

Since the early 1960s large-scale pest control programs have met with increasingly critical and complicated public opinion issues. Gypsy moth management has become more complex, and control decisions are primarily based upon the level of infestation. In areas where gypsy moths are well-established, **suppression** tactics are used. In areas where gypsy moths are becoming established, **slow-the-spread** tactics are used. In areas experiencing small, isolated infestations, **eradication** is still attempted and is sometimes successful.

Terms

ballooning

a term used to describe a way gypsy moths spread to different areas. Larvae climb to tree tops where they hang from the silken threads they have attached to branches and leaves. Wind breaks the fine threads and carries the larvae to another location, from several feet to several miles. Larvae continue this ballooning process until they find suitable food.

Bacillus thuringiensis (B.t.)

scientific name for a bacterium that kills the larvae of many lepidopterous insects (moths and butterflies)

DDT (dichloro-diphenyl-trichloroethane)

a powerful, synthetic chemical used for insect control after World War II. DDT use for gypsy moth control began in the 1940's and ended in the late 1950's, after much public controversy concerning its safety to humans and the environment.

defoliation

foliage loss on a tree. Leaf-eating insects like gypsy moth larvae are one of numerous causes of defoliation on a tree.

diflubenzuron (Dimilin®)

an insect growth regulator that interrupts chitin production and prevents gypsy moth larvae from completing the molting process. It is the active ingredient in insecticides sold under the trade name Dimilin®.

Entomophaga maimaiga

scientific name for a fungus that kills gypsy moth larvae

eradication

a control strategy whose primary goal is to get rid of a pest population. Eradication is most often used on small, isolated gypsy moth infestations. See **strategy**.

frass

fecal excrement from insects

host

a living organism that provides food and/or shelter for another organism. Oaks are the preferred host tree for gypsy moths.

larva (plural—larvae)

the immature, caterpillar stage of an insect; the stage between the egg and pupa

metamorphosis

change in an insect's form, structure or function during its life cycle. Changes from egg to larva, larva to pupa, and pupa to adult represent metamorphosis.

nucleopolyhedrosis virus (NPV)

a naturally occurring group of viruses causing tissue breakdown and death of many moth and butterfly larvae. The NPV specific to gypsy moth is the active ingredient in the biological insecticide Gypchek.

parasitoid

a parasite that eventually kills its host. Certain species of flies and wasps are parasitoids of gypsy moths.

pheromone

a chemical produced and emitted by an organism to communicate with individuals of the same species. Gypsy moth females emit a sex-attractant pheromone to attract males.

photosynthesis

the chemical process in green plants of converting light into organic substances (sugars)

population

all organisms of a species inhabiting a specified area

predator

an organism that feeds upon and likely kills another organism. Small mammals and birds are predators of gypsy moths.

pupa (plural—pupae)

the immature stage between larva and adult, providing a resting period for the insect.

silviculture

the part of forest management which involves applying treatments (cultural, chemical, biological, genetic) that help maintain and improve the forested area

Example: Before gypsy moths infest the area, foresters may decide to remove weak, stressed, dying and defoliation-prone trees to help improve growing conditions for standing trees. Removing problem trees is a type of cultural treatment which may lower the risk of future gypsy moth attacks.

slow-the-spread

a control strategy whose primary goal is to slow the natural spread of gypsy moths to uninfested areas by preventing low-density populations (in infested areas) from increasing in size. During the 1990s, managers are testing new methods of slowing the spread of gypsy moths in sample management areas to see if these methods can be used on a national scale. See **strategy**.

sterile insect technique

a treatment method used to reduce insects' ability to reproduce.

Example: Gypsy moth sterile insect technique involves releasing genetically altered pupae or eggs into a management area. These altered individuals develop and mate normally, but they produce no offspring or sterile offspring. As a result, the next and subsequent generations of gypsy moths decrease.

suppression

a control strategy whose primary goal is to reduce outbreaks in established populations in an effort to prevent or minimize damage to tree resources. See **strategy**.

transpiration

the process of water transport throughout a plant and release of water vapor to air through openings in leaves and stems

treatment

a specific action to control pest populations

Example: In gypsy moth management, managers use chemical, cultural, genetic, and mechanical treatments to control populations.

VDACS

an acronym for the Virginia Department of Agriculture and Consumer Services. In gypsy moth management programs, VDACS assists counties with treatment efforts to manage gypsy moth populations and their spread.

VDF

an acronym for the Virginia Department of Forestry. In gypsy moth management programs, VDF collects defoliation information which is useful in determining how effective previous treatments were. This is a type of post-treatment survey.

Study Questions

- 1.** When will gypsy moths enter your county? If gypsy moths are in your county, when did they enter? Do you have infestations near your home or school?
- 2.** What are the two ways gypsy moths spread to uninfested areas? Give examples. At what stages in the life cycle do they spread?
- 3.** List at least three effects from gypsy moths and their damage.
- 4.** Draw and explain the gypsy moth life cycle and describe how to identify them at each life stage.
- 5.** Explain why knowing how to identify a gypsy moth and about its life cycle helps in their control.

Lesson: Site Susceptibility Study

This lesson describes the host plant preferences of gypsy moth and provides exercises for determining if defoliation and damage are imminent for an area.

PURPOSE

Students will be able to determine the potential effects of gypsy moth defoliation and damage on a site based upon measurements of tree species composition and site condition observations.

OBJECTIVES

Upon completion of this lesson, students will be able to

- explain reasons for conducting a site susceptibility study
- explain the role of sampling in this study and in other IPM systems
- identify tree species by general groups—i.e., oaks, maples, hickories, pines, hemlock—and give examples of tree species that are susceptible, resistant and immune to gypsy moth feeding
- distinguish between overstory and understory trees
- list examples of tree and shrub species found in local habitats and explain how these plants are indicators of the site and of possible gypsy moth defoliation damage
- describe site characteristics of a susceptible, resistant, and immune site
- assign a susceptibility and damage rating to plot samples
- discuss short- and long-term prognoses of gypsy moth defoliation and damage for the study site and throughout the area based upon data collected and analyzed in the study
- develop general management recommendations for the study area

CONCEPTS

- pest/host relationships
- tree composition/habitat associations
- forest dynamics (regeneration, stress factors, mortality, succession)

SKILLS

Students will

- work in teams
- apply basic tree identification in field work
- record observations of local habitats
- apply sampling to collect data
- apply basic math to calculate percentages
- analyze data and make general conclusions based on the analyses
- report team results in an oral presentation

BACKGROUND FOR INSTRUCTOR

Pest-Host Relationship

Preferred food sources for the European gypsy moth are species of oaks. As with the gypsy moth, many insects have evolved to feed on particular plants or plant parts, thus developing a pest-host relationship. This pest-host relationship is a primary consideration for determining the likelihood of insect damage—a farm manager need not worry about losing a corn crops to gypsy moth feeding but will be concerned about the property's mixed oak stands which provide supplemental timber income.

The percentage of trees susceptible to gypsy moth feeding is, indeed, an important consideration for predicting damage in an area, yet a combination of factors generally affects the likelihood of gypsy moth defoliation and damage. Status of the gypsy moth population in the area, general tree conditions, site characteristics, and weather patterns and conditions contribute significantly to defoliation and damage potential.

Site Susceptibility Study

IPM programs in Virginia rely heavily on the sampling component to provide needed information for management decisions. Preliminary data about an area provides managers with information to make tactical decisions for the short-term and to apply predictive models for future decisions. Models range in complexity, but most field surveys require quick and simple data collection in the interest of covering large management units.

This lesson focuses on a field exercise which presents a very simple model for measuring susceptibility and damage. The model considers the percentage of trees susceptible to gypsy moth feeding, general tree conditions and inherent site characteristics. Weather patterns and conditions are more difficult to measure, so for these purposes, are not part of the study. However, encourage students to speculate about the role weather plays on gypsy moth populations and tree and site conditions. Upon completing the exercise, students can make general conclusions about an area's potential for defoliation and damage,

which provide a good basis for the management decisions they will make in the next lessons.

Information Concerning the Field Exercise

The field exercise gives students experience in tree identification, sampling, data collection and data analysis. Field teams are often used in applied situations because they are more efficient at data collection and provide an element of safety in remote areas. The exercise recommends group work but can be adapted for individual work especially in residential areas.

Spring, summer or early fall are the best times to conduct this exercise since tree identification is easier when the leaves are out. The instructor should make allowances for winter tree identification if s/he is teaching the unit in the winter months.

Contacts

A letter or phone call to property owners is one way to make contact. Instructors and students may choose to contact owners a different way, but please do contact participants one way or another. Do not trespass on private property.

Study area

The field exercise probably will be best executed if the instructor visits the study area beforehand. Avoid sampling in orchards and tree plantations since these situations represent monocultures and do not allow students practice in identifying trees. Parks, wooded lots, area forests, wildlife management areas, and residential areas are good choices.

Leaf samples

Students will be better prepared for the exercise if they familiarize themselves with local tree species and how to identify them. Collecting leaves and twigs from representative trees is one way to prepare them. Pressed leaf mounts studied in the classroom is another way. If time permits, take the class to the study area for a mini-lesson on tree identification. Use field guides. Three recommended guides are listed at the end of the field exercise. In any case, study the overstory trees in the area because most damage occurs in larger, more prominent trees.

Susceptibility chart

The susceptibility chart (Attachment B) is a compilation of trees and shrubs common in Virginia and having important economic and/or aesthetic value. Susceptible host species are those most favorable for gypsy moth feeding with potential for greater than 60% defoliation. Oaks are among the most susceptible. Resistant host species are those less favored for gypsy moth feeding with potential for 30-60% defoliation. Immune species are those non-preferred food sources with less than 30% defoliation. Students should refer to this chart when categorizing trees in the study area.

Overstory versus understory

An overstory tree includes any tree that makes up the main canopy and receives full sunlight on all or a portion of its crown. Overstory trees are the tallest trees in the area and have larger-diameter trunks. In residential situations, overstory trees include large shade trees.

Understory trees are smaller trees below the main canopy, including young overstory tree species as well as mature tree species that do not extend to the overstory. In this study, saplings 4-5 feet and above should be considered part of the understory. Understory trees in residential areas include many smaller ornamental trees like dogwood, redbud, crabapple, and cherry.

Sampling methodology

A grid of sample plots allows even coverage and systematic data collection of an area. The tightness of a grid often depends upon the type of data collection and management objectives. The exercise suggests plots every 30 feet along a sampling line. Students can approximate 30 feet by pacing.

The typical size of an individual plot is 1/40th of an acre, which measures as a 18.6 foot radius circle. This measure allows managers to make calculations on a per acre basis. Although students do not need to calculate results per acre, 18.6 feet is a standard field measure and recommended for this exercise. Likewise, sampling entire yards is a convention used in many residential surveys.

Take-Home Messages: IPM Principles

- insects have evolved to feed on particular plants, called host plants. The preferred hosts of gypsy moths are oak species. As part of collecting information about an IPM system, one must learn the pest-host relationship.
- **collecting preliminary data** about a site or area helps to determine potential problem areas and assists proactive management.
- defoliation and damage are site and area specific, therefore, management must be specific as well. This is a major point in IPM—treating areas that need treating rather than broad-scale treatments which waste time and money and needlessly affects non-problematic areas.

Lesson Objectives

All lesson objectives are incorporated into the field exercise and discussion following the exercise. Students who participate in the field activity, complete the data sheets and their associated questions, and discuss results from the exercise will meet all of the objectives..

EVALUATION

Each team will complete and turn in their data sheets sets and will be assigned a team grade for their field work/classroom presentation. Consider using peer evaluations for a portion of the grade. Discussion questions outlined in the field exercise can be used for quiz or test questions.

REFERENCES

- Dirr, Michael. (1993). Manual of woody landscape plants: their identification, ornamental characteristics, culture, propagation and uses. Third edition. Champaign, IL: Stipes Publishing Company.
- Doane, C.C. & M. L. McManus (Eds). (1981). The gypsy moth: research toward integrated pest management. Technical Bulletin 1584. Washington, D.C.: U.S. Department of Agriculture.
- Petrides, G. A. (1972). A field guide to trees and shrubs. The Peterson field guide series. Second edition. Boston: Houghton Mifflin Company.
- USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C: U.S. Department of Agriculture.
- USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Appendix G: ecological risk assessment. Final environmental impact statement. Washington, D.C: U.S. Department of Agriculture
- Virginia Department of Forestry. Forest trees of Virginia. Publication #26.

INSTRUCTOR'S NOTES

Field Exercise

Field Instructions—Wooded Areas

Equipment Needed (per team)

plot stakes (1)
18.6' length of heavy string or twine (1/stake)
data sheets (1/plot)
pencils
clipboard(1)
susceptibility chart—Attachment B (1/student)

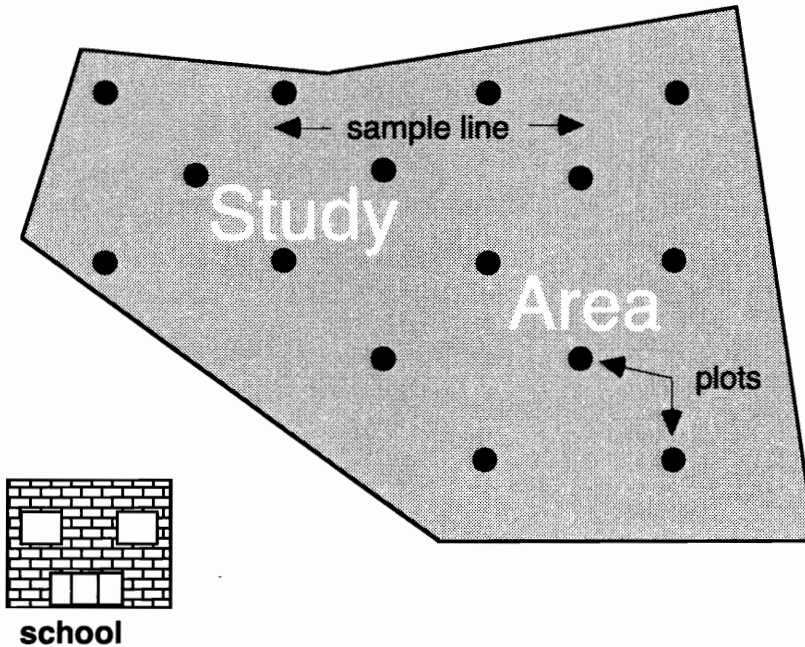
Optional

plastic bags for collecting leaf/twig samples
survey flagging for pre-marking sample lines
plant identification aids (i.e. field guides, pressed-leaf mounts)
binoculars (1)
compass (1)
calculators

Setting Up

1. Select the study area: a wooded area near the school, a park or a forested area. Get necessary permission from owners of private property (see sample letter, **Attachment A**).
2. Within the study area but prior to the field exercise, collect and/or have students collect twig and leaf samples from representative overstory trees in the three susceptibility categories—susceptible, resistant, immune. Refer to **Attachment B**. Examples can include oaks, sweet gum, pines, spruces, beeches, elms, hickories, maples, walnuts, ashes, locusts, sycamores and yellow poplars. Put the twigs and leaves in airtight plastic bags and refrigerate if possible. In class, use the collected material to help familiarize students with the different tree species growing in your area.
3. Sketch a map of the study area. Use **Attachment C**. Instruct students to sketch the same map on their handout because they will use it to fill in class data results.
4. Divide the class into teams of 4-5 students/team. Each team needs a plot stake, 18.6' length of string or twine tied to the stake, set of data sheets, clipboard or other writing surface, pencils, calculator, tree identification aids and a susceptibility chart.

5. Set up a sampling grid that covers the entire area or a representative section. A grid consists of sample points (plots) along measured intervals as shown:



Sample lines for each team can be assigned one of several ways:

- assign each team a land feature to follow (i.e. creek, ridgetop, road, trail). The team will use the land feature to follow a sample line.
 - if students know how to use compasses, assign each team a starting point and have them set up samples along a line following an assigned compass bearing.
 - set up sample lines beforehand and mark sample points with flagging approximately every 30 feet. Assign each team a line.
6. Each team will sample along one or more lines depending upon how many teams are available and the size of the area to cover.

Collecting Data

- Appoint a team member to record data. Note general observations about the study area: what type of land it is (ex. mountain, valley, coastal, floodplain) and how it's used (ex. farming, timber harvesting, recreation), natural and man-made features (rivers, streams, swamps, powerline cuts, roads), general description of vegetation cover (ex. conifer, mixed hardwood, conifer/hardwood). Record on the **Area Summary** sheet.

2. Establish the first plot. Walk 10-15 steps along the sample line to get away from the edge. Drive the stake into the ground to set the plot center.
3. Record general notes about the sample plot (ex. dry, wet, rocky, creek bottom, ridgetop, steep slope, flat). Record on the **Plot Summary** sheet.
4. Pull the string taut and walk a circle around the stake. All trees within the circle are in the plot sample.
5. Identify all overstory trees in the plot circle. An overstory tree will be a larger diameter tree whose top reaches the upper part of the general tree canopy. To aid in identifying large overstory trees, search the ground for flowers, fruits and fallen leaves. Use binoculars to look at leaf shapes and characteristics. Use field guides to aid identification.
6. Total all overstory trees within the plot circle and record the number on the data sheet.
7. Count the number of overstory trees for each susceptibility category (susceptible, resistant, immune). Refer to the susceptibility chart.
8. List the general understory tree species within the plot. For this study, an understory tree includes a tree which is at least 4-5 feet above the ground but does not reach general overstory height.
9. Use one data sheet per plot. Complete the data sheet as shown in the example.
10. Walk another 30 steps along the sample line and establish the next plot. Complete a new data sheet.
11. Teams will continue sampling until they reach the end of their assigned lines/areas.

Optional: assign each field team a susceptibility category (susceptible, resistant, immune) and instruct them to collect leaves/twigs from 2-3 species within each category and to make brief notes about how to identify the plants (use **Additional Notes** section on the Plot Summary sheet). Reconvene teams at the study site. Instruct each team to present to the class their collected plant material, indicating the species they identified. If time permits, have the team point out the plants at the site.

Field Instructions—Residential Areas

Equipment Needed (per team)

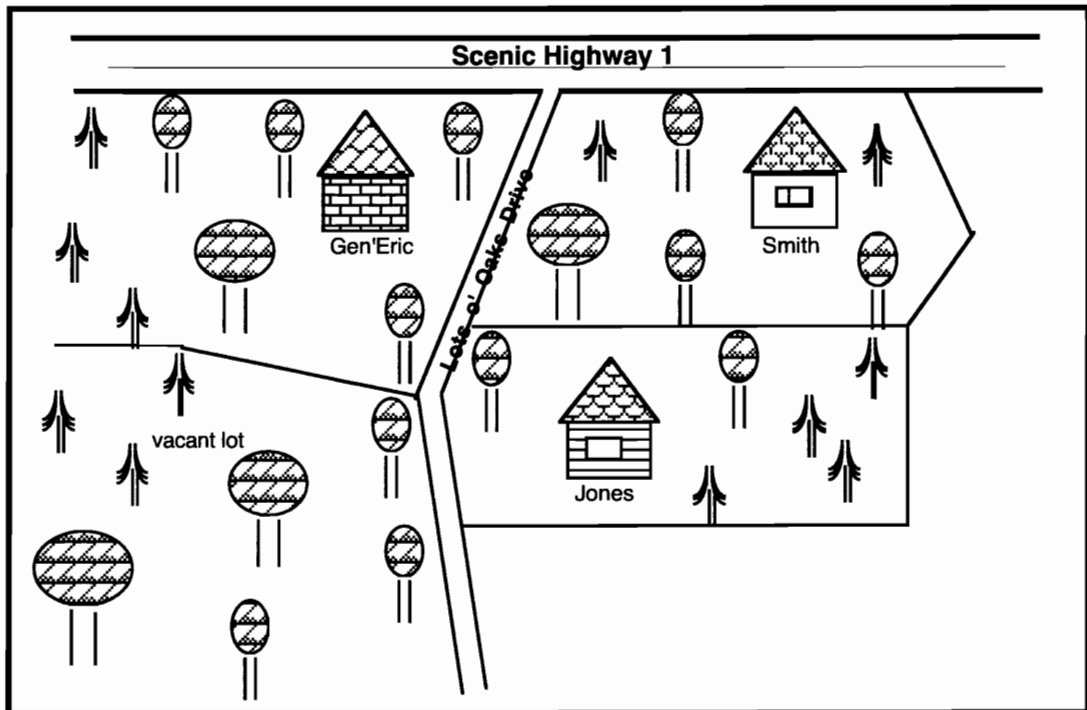
data sheets (1/plot)
clipboard (1)
pencils
susceptibility chart—Attachment C (1/student)

Optional

plastic bags for collecting leaf/twig samples
plant identification aids (i.e. field guides, pressed-leaf mounts)
binoculars (1)
calculators

Setting Up

1. Select the study area: get necessary permission from owners of private property (see sample letter, **Attachment A**).
2. Within the study area but prior to the field exercise, collect and/or have students collect twig and leaf samples from representative overstory trees in the three susceptibility categories—susceptible, resistant, immune. Refer to **Attachment B**. Examples can include oaks, sweet gum, pines, spruces, beeches, elms, hickories, maples, walnuts, ashes, locusts, sycamores and yellow poplars. Put the twigs and leaves in airtight plastic bags and refrigerate if possible. In class, use the collected material to help familiarize students with the different tree species growing in your area.
3. Sketch a map of the study area. Use **Attachment C**. Instruct students to sketch the same map on their handout because they will use it to fill in class data results.
4. Divide the class into teams of 4-5 students/team. Each team needs a set of data sheets, a clipboard or other writing surface, pencils, calculator, tree identification aids and a susceptibility chart.
5. A sampling grid probably won't be practical in residential areas, so instruct each field team to sample a yard (front and back). A yard equals one sample plot. Each team should sample at least three adjacent properties or as many as it takes to cover the study area.



Collecting Data

1. Appoint a team member to record data. Note general observations about the study area: what type of land it is (ex. mountain, valley, coastal, floodplain) and how it's used (ex. residential, businesses), man-made and natural features (roads, powerline cuts, rivers, lakes, streams, swamps), general description of vegetation cover (ex. wooded: conifer, mixed hardwood, conifer/hardwood; landscaped with ornamental plants). Record on the **Area Summary** sheet.
2. Establish the first plot (a yard). Record general notes about the yard (ex. dry, wet, rocky, open, steep, flat). Record on the **Plot Summary** sheet.
3. Identify all overstory trees in the yard. An overstory tree will be a larger diameter tree whose top reaches the upper part of the general tree canopy. To aid in identifying large overstory trees, search the ground for flowers, fruits and fallen leaves. Use binoculars to look at leaf shapes and characteristics. Use field guides to aid identification.
4. Total all overstory trees in the yard and record the number on the data sheet.
5. Count the number of overstory trees for each susceptibility category (susceptible, resistant, immune). Refer to the susceptibility chart.

6. List the general understory tree species in the yard. For this study, an understory tree includes a tree which is at least 4-5 feet above the ground but does not reach general overstory height. Many ornamental trees like dogwoods and redbuds are considered understory trees.
7. Use one data sheet per yard. Complete the data sheet as shown in the example.
8. Continue to the next assigned yard. Complete a new data sheet.
9. Teams will continue sampling until they complete their assigned yards.

Optional: assign each field team a susceptibility category (susceptible, resistant, immune) and instruct them to collect leaves/twigs from 2-3 species within each category and to make brief notes about how to identify the plants (use **Additional Notes** section on the Plot Summary sheet). Reconvene teams at the study site. Instruct each team to present to the class their collected plant material, indicating the species they identified. If time permits, have the team point out the plants at the site.

Calculating and Interpreting Results

1. Return to the classroom where teams can complete data calculations.
2. Instruct teams to complete the **Area Summary** sheet.

Questions on the Area Summary sheet

1. Across all plots, are there more trees susceptible, resistant or immune to gypsy moth defoliation?
 2. Across all plots, which damage potential category do most of the trees fall within (high, moderate, low)?
 3. If you observed understory tree species, what general statements can you make about future susceptibility to defoliation and damage?
3. Instruct teams to make a short presentation to the class about their plot results. Each team should give a general description of the plots, the susceptibility and damage rating across all plots, and a prediction of susceptibility based on understory species observed.
 4. On the study area map, code each team's defoliation and damage potential. This will be a two-letter code: susceptible(S), resistant(R), immune(I); high(H), moderate(M), low(L). Teams will use their answers from questions on the Area Summary sheet.

5. After all teams have reported, discuss the following questions:
- What is the general susceptibility to gypsy moth defoliation and damage for the entire area?
☞ Answers will vary
 - Are all sites equally susceptible to gypsy moth defoliation and damage?
☞ Answers will vary, but it is likely that the area does not have homogeneous site conditions, especially in a forested area, thus the sites will not be equally susceptible.
 - Based on the class data and observations, what characteristics of a site might make it more susceptible to defoliation and damage? Less susceptible?
☞ More susceptible typically means dry, rocky, or poorly drained sites with signs of tree stress (insect damage, holes, decay, dead trees). Less susceptible means well-drained, moister sites with fewer signs of tree stress.
 - Why make observations of understory plants?
☞ These observations provide predictive information about the site. Understory trees indicate what will succeed in the area and what the composition of overstory trees will look like in the future. Although not discussed in this exercise, they also can give an indication of the growing conditions (site conditions) of the area.
 - Why sample an area?
☞ Sampling allows the observer to collect information about an area without having to look at the entire area. Sampling is an important management practice in integrated pest management systems.
6. End this exercise by asking students to think about the answers to these questions to prepare for the next lesson on controls:
- Will all sites in the study area be managed the same way?
 - Will land use affect a treatment decision?
 - What other considerations affect treatment decisions?
-

Attachment A: Sample letter to property owner

October 5, 1995

Mr. and Ms. Gen'Eric
100 Lots o' Oaks Drive
Somewhere, Virginia 00000-000

Dear Mr. and Ms. Gen Eric,

My Agriculture I class at Somewhere High School is studying the gypsy moth this semester. As part of the lessons, the class must study trees in an area to see if gypsy moth defoliation and damage are possible or have occurred. We want to study the trees in your area and would like permission to work on your property for a few hours next April.

After we complete the unit on gypsy moth, we will provide you a summary of our results and will make general management recommendations to control gypsy moth on your property.

Please respond directly to me at the address below. If you grant the class permission, I will follow up with a phone call closer to the time of our scheduled work. Thank you for your time and we hope to work with you next spring.

Sincerely,

Joe or Josephine Instructor
Agricultural Education Department
Somewhere High School
1 East Main Street
Somewhere, VA 00000-0000

Attachment B: Select Virginia Trees and Shrubs— Susceptibility to Gypsy Moth Defoliation

Susceptible (> 60% defoliation)

Overstory	Understory
apple	alder
basswood (linden)	firethorn (pyracantha)
bigtooth aspen	hawthorn
birch: European white, paper, river	hazelnut (American hazelnut, American filbert, wild hazelnut)
boxelder	hophornbeam (eastern hophornbeam, ironwood)
larch	rose
mountain-ash: American and European	serviceberry (Allegheny serviceberry, shadbush, shadblow)
oak	smoketree (American smoketree)
poplar: most species	sumac
sweetgum (redgum)	witch-hazel
willow	

Resistant (30-60% defoliation)

Overstory	Understory
ailanthus (tree of heaven)	spruce
beech: American and European	walnut:: white (butternut) and black
birch: black and yellow	
black gum: sour gum, swamp black gum	
buckeye: Ohio and yellow (sweet)	
cedar: Atlantic white, atlas, deodar	
cherry: most species	
chestnut (American chestnut)	
coittonwood (eastern or southern coittonwood, eastern poplar)	
cucumber tree (cucumber magnolia)	
elm: most species	
fir: white	
hackberry (American hackberry, sugarberry)	
hemlock (eastern hemlock)	
hickory	
maple: most species	
peach: most species and plum species	
pear (common)	
pine: most species	
plum: most species	
poplar: silver	
	Allegheny chinkapin
	bayberry (southern bayberry, southern waxmyrtle)
	blueberry, huckleberry, deerberry, cranberry
	butternut
	camellia: mountain, silky
	euonymus (burningbush, wahoo)
	fringe-tree (old-mans-beard)
	gooseberry
	hibiscus
	hornbeam (American hornbeam, blue beech)
	paw paw
	persimmon (simmon)
	quince (flowering quince, Japanese quince)
	redbud (eastern redbud, Judas-tree)
	sassafras
	sourwood
	sweetfern

Attachment B: Select Virginia Trees and Shrubs— Susceptibility to Gypsy Moth Defoliation

Immune

(<30% defoliation)

Overstory	Understory
arborvitae: Northern white cedar, oriental arborvitae	abelia (glossy abelia)
ash	azalea
catalpa	blackberry, dewberry, raspberry
cypress (baldcypress)	buckthorn
fir: balsam and Fraser	ceanothus (New Jersey Tea, wild snowball)
ginkgo	devilwood (wild olive)
horsechestnut	dogwood
Kentucky coffeetree	elderberry (American elder, common elder)
Leyland cypress	grape
locust: black (yellow locust) and honey	greenbrier
mulberry	holly
princess-tree (royal paulownia)	juniper
redcedar (eastern redcedar)	magnolia: most species
sycamore (American sycamore, buttonwood)	maple: mountain and striped (moosewood)
yellow poplar (tulip tree, tulip poplar)	mimosa
	laurel: mountain and sheep
	osage-orange
	rhododendron
	Russian olive
	sarsaparilla (devils walkingstick, Hercules-club)
	spicebush (common spicebush)
	sweetshrub (common sweetshrub, Carolina allspice, hairy allspice)
	viburnum

Sources: Gottschalk, Kurt. (1995). Table 2-2. European gypsy moth host susceptibility. In Appendix G: Ecological risk assessment. Gypsy moth management in the United States: a cooperative approach. Environmental impact statement (draft). United States Department of Agriculture: Forest Service and Animal and Plant Health Inspection Service.

Liebold, et al. (1995). Appendix D: Plant list. Gypsy moth management in the United States: a cooperative approach. Environmental Impact Statement (draft). United States Department of Agriculture: Forest Service and Animal and Plant Health Inspection Service.

Virginia Tech Horticulture Department. (1995). Consumer horticulture fact sheets: trees and shrubs. Virginia Cooperative Extension Gopher, <http://gopher.ext.vt.edu:70/11/vce-data/hort/consumer/factsheets>.

Attachment C: Sketch Map of Study Area



PLOT DATA SUMMARY

Plot # _____

General Plot Description:
(ex. dry, rocky, steep, flat, moist)

General Description of Tree Condition:
(ex. bark furrows, holes, crooked growth, lots of dead branches, straight growth, no dead branches or trees)

Total Number of Overstory Trees _____

Number of Overstory Trees in each Susceptibility Category	% of Overstory Trees in each Susceptibility Category
Susceptible	
Resistant	
Immune	

List General Understory Species:

Additional Notes:

AREA SUMMARY (Across Plots)

Team Members (names):

General Description of Study Area:

(type of land, land use, natural and man-made features, general description of vegetation cover)

Check the boxes that apply for each plot.

Plot #	Does the plot have > 60% susceptible trees?	Is the site dry, steep, rocky or swampy (wet)?	Are there signs of tree stress?	What is the damage potential? (H, M, L)

**3 boxes/plot = high (H)
2 boxes = moderate (M)
1 box = low (L)**

Questions

- 1.** Across all plots, are there more trees susceptible, resistant or immune to gypsy moth defoliation?
- 2.** Across all plots, which damage potential category do most of the trees fall within (high, moderate, low)?
- 3.** If you observed understory tree species, what general statements can you make about future susceptibility to defoliation and damage?

Lesson: Gypsy Moth Control, Part 1

This lesson describes the types of measures managers take to control gypsy moth populations and the criteria they use to make control decisions.

PURPOSE

Students will be able to make effective and economical control choices for specific gypsy moth management cases and justify these choices.

OBJECTIVES

Students will

- apply action thresholds in control decisions
- differentiate between control strategies
- choose an appropriate treatment(s) for an assigned study area and justify the choices

CONCEPTS

- control strategies
- action threshold
- economic threshold
- treatment decisions

SKILLS

Students will

- work in teams
- analyze data
- make control and treatment decisions using scientific data and management guidelines
- report team results orally and in writing

BACKGROUND FOR INSTRUCTOR

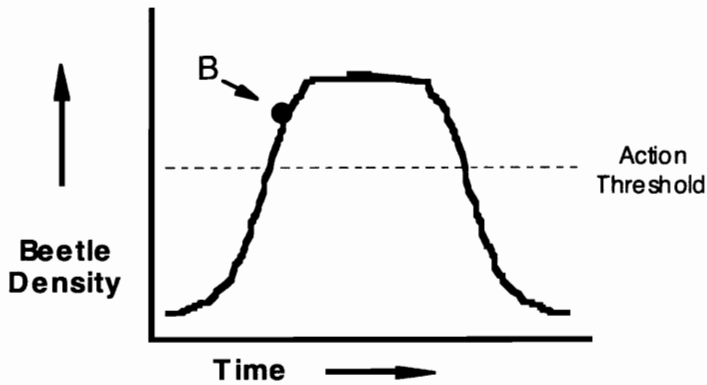
- Objectives:**
- apply action thresholds in control decisions
 - differentiate between control strategies

Instruct students to read **Gypsy Moth Integrated Pest Management: Surveys, Action Thresholds and Types of Control** as an out-of-class assignment prior to this lesson. Study questions are at the end of the reading so that they can prepare for the next case study activity.

Review the concepts of infestation status, action threshold, and types of control and treatment decisions. Check the students' understanding of these concepts by reviewing the study questions in class.

Study Questions

1. In which infestation zone do you live in Virginia?
☞ Answers will vary. Refer to Figure 1.
2. Can we get rid of gypsy moths?
☞ It depends. Management strategies are based upon infestation level. In areas where gypsy moths are well-established, suppression tactics are used. In areas where gypsy moths are becoming established, slow-the-spread tactics are used. In areas experiencing small, isolated infestations, eradication is still attempted and is successful. History proves that we will not get rid of gypsy moths in the United States; they are permanent residents as defoliating pests and will continue to spread.
3. Which infestations zones are most appropriate for silvicultural treatments?
☞ The transition and uninfested zones are most appropriate. Areas in these zones, particularly uninfested areas, would benefit from tree health improvement and removal of stressed and dying trees, especially those susceptible to gypsy moth damage.
4. Which type of treatment would benefit most from a site susceptibility study? Why?
☞ Silvicultural treatments benefit from site susceptibility studies. Data from these studies indicate potential problem areas and help managers prioritize management activities.
5. You have been sampling Japanese beetles in your neighbor's yard and have plotted the progress of the population (see the graph). The population is at Point B. Using only this information, should you control the beetles?



☞ Point B lies above the economic threshold line, meaning that the beetle population is at a point where the cost of injury to your neighbor's plants is more than the cost of treating the population. Your neighbor should control the beetles.

6. The same neighbor wants to know your results from #5. If he has to treat, he wants to use B.t.k. What do you advise him to do?

☞ You advise your neighbor to control the beetles but tell him you do not recommend B.t.k. as a treatment. B.t.k. is *Bacillus thuringiensis* var. *kurstaki*, a bacterial control for lepidoptera species (moths and butterflies). Tell your neighbor to contact the local Cooperative Extension office, nursery or garden center concerning recommended treatments for Japanese beetles.

7. Your other neighbor hears that Dimilin is a good treatment for gypsy moth egg masses. She want to use it in her yard. What do you tell her?

☞ Dimilin is a restricted-use pesticide, which means she cannot buy or use it for residential purposes. Furthermore, Dimilin targets gypsy moth larvae in the spring and is not effective on egg masses. You recommend that she scrape and destroy the egg masses in her yard or spray them with a soybean oil preparation sold in garden centers.

8. Your parent sees a cockroach in the kitchen one night and immediately wants to call an exterminator to treat the whole house. Explain how to best handle this situation using your current knowledge of integrated pest management.

☞ You might want to think about the problem as a series of questions to be answered:

- Is the insect actually a cockroach? Make a positive identification first thing.
- Assuming it is a cockroach, how many are in the house? Sample the area using traps.

- What is a recommended threshold for cockroaches? Obtain guidelines from Cooperative Extension or home improvement centers.
 - Does your infestation exceed the recommended threshold? Use your sample data.
 - If the infestation is above threshold, what control options do we have? Check it out. Contacting the exterminator maybe a wise decision.
 - If the infestation is below threshold, what other control options do we have? A cultural treatment like sanitation or an insecticide treatment like roach baits will work. One roach deserves a very simple mechanical treatment—stomp it to death!
 - What can we do to prevent or manage cockroach infestations in the future? Consider treatments like sanitation, baits, and spot applications of a cockroach insecticide.
-

Objective: choose an appropriate treatment(s) for an assigned area and justify the choices

Lesson Activity

Case Study Option: Part II

Each team will review the information described in Part II of their assigned case. Using this information, they will complete the preliminary treatment recommendation report.

Field Study Option: Part II

Each team will use data gathered from their field plots.

Completing the Treatment Recommendation Report

Area Type: explained on report. Use appropriate letter.

Problem Determination: use tables and figures provided and data results from the field work

Infestation Level: explained on report

Control Strategy: refer to Table 1

Budget Allowance: each team is assigned up to \$500 for treatments

Treatment Choice(s): refer to Tables 1 and 2

Take-Home Messages: IPM Principles

Control decisions take into account:

- susceptibility of an area to defoliation and damage
- infestation level
- an acceptable or unacceptable population level in an area (action threshold)
- an appropriate treatment option or combination of options

EVALUATION

Each team will complete and turn in their treatment recommendation report and will be assigned a team grade for their report/classroom presentation. Consider using peer evaluations for a portion of the grade.

You may also choose to assign individual grades for the study questions in the reading assignment.

REFERENCES

- USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C: U.S. Department of Agriculture.
- Virginia Department of Agriculture and Consumer Services (VDACS). (October 1994). Virginia cooperative gypsy moth suppression program. 1994 guidelines for participation in aerial treatments. Richmond, VA: VDACS.

INSTRUCTOR'S NOTES

Gypsy Moth Integrated Pest Management: Surveys, Action Thresholds & Types of Control

Terms to Know & Use: action threshold, B.t., Dimilin, economic threshold, egg mass survey, *Entomophaga maimaiga*, eradication, generally infested zone, male moth survey, mass trapping, NPV, parasites, predators, silviculture, slow-the-spread, sterile egg technique, suppression, transition zone, treatment, tree banding, uninfested zone

The U.S. Forest Service and APHIS are currently proposing a national gypsy moth management policy based upon infestation status.¹ The information in this lesson closely follows a portion of these federally proposed guidelines.

The proposed guidelines characterize three infestation zones in the U.S.: generally infested, transition and uninfested (see Table 1). The **generally infested zone** includes areas where European gypsy moth populations are permanently established—all life stages are present and defoliation is common. Areas between the generally infested and uninfested areas are within the **transition zone**, where populations become established in smaller, discontinuous pockets and adults male moths are most commonly

found. Defoliation is uncommon in the transition zone. Areas ahead of the transition zone are within the **uninfested zone**, where occasional male moths are found but no established populations exist. Figure 1 shows the infestation zones in the U.S. as of 1994.

Based upon infestation level, managers consider three control strategies: **suppression**, **eradication** and **slow-the-spread**. The objectives for each strategy are outlined in Table 1.

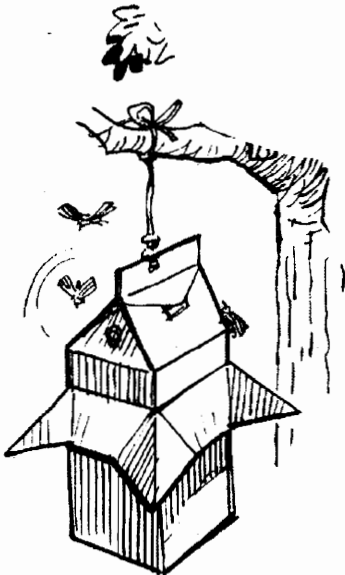
Sampling allows managers to collect a wide range of information about a pest as well as about the **biotic and abiotic** characteristics of an area. Sampling provides vital information about pest distribution—where pest infestations are located—and density, or the number of pests infesting an area. Thus, insect surveys are an extremely important part of integrated pest management for insect pests. Once managers have an idea of the pest's

¹ *Gypsy Moth Management in the United States: a Cooperative Approach*. 1995. Final Environmental Impact Statement. USDA Forest Service, Animal and Plant Health Inspection Service.

distribution and density, they can make decisions about whether the pest is truly a problem and what actions they will take to control it.

GYPSY MOTH SURVEYS

Two types of surveys, the male moth survey and egg mass survey, provide information about gypsy moth distribution and density. **Male moth surveys** involve sampling an area using pheromone-baited traps. Surveyors set traps along a pre-determined grid and count the number of adult male moths caught in the traps throughout the summer trapping season.



Data from these surveys help managers locate new, isolated infestations as well as verify existence and distribution of small, established infestations. For these reasons, male moth surveys are reserved for areas within the transition zone.

Managers conduct **egg mass surveys** in the generally infested zones to determine the health of established populations. Surveyors count egg masses within sites along a sampling grid and inspect the size of egg masses which gives an indication of the health of the population; larger, less numerous masses indicate healthy, building populations while smaller, more numerous masses indicate stressed, declining populations.

ACTION THRESHOLD

Armed with information about the pest population, managers can then compare existing conditions with guidelines set by the management agency. The action threshold is the driving force behind control decisions in IPM, making it a primary consideration in management guidelines. Specifically, an action threshold is most often based upon economic consequences. **The economic threshold for gypsy moths is the highest level of defoliation an area can maintain without losing economic benefits.** For example, forest managers measure economic threshold as the highest level of defoliation a forest can maintain without loss in timber productivity and harvest value. Park managers measure economic threshold as the highest level a recreation area can maintain without loss in park visitors.

How do managers set thresholds? One way is through use of historical survey data. Logically, the number of male moths or egg masses gives an indication of the potential defoliation in an area. Managers

compare the population density with the amount of defoliation it causes to arrive at acceptable and unacceptable population levels.

Figure 2 shows a graph of the economic threshold concept. The shaded lines represent the threshold. Population levels above the threshold are unacceptable and require control while levels below the threshold are acceptable in terms of economic damage and do not require control.

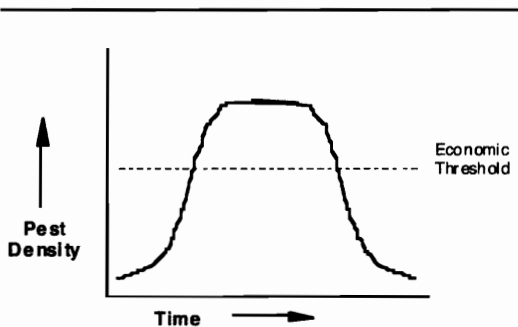


Figure 2. Economic threshold concept

TYPES OF TREATMENT

Once managers determine that control is necessary, they select from a number of treatments appropriate for the area's control strategy. Treatments fall into four main categories: biological, cultural, genetic, chemical.

Biological or Natural Treatments

Gypsy moths have no known natural controls that will eradicate a population. However, there are **predators**, **parasitoids** and disease organisms that help reduce gypsy moth numbers.

Predators

Twenty known species of mammals feed on gypsy moths. One example, the white-footed mouse, feeds upon pupae and can be important in reducing gypsy moth numbers in low-density populations.

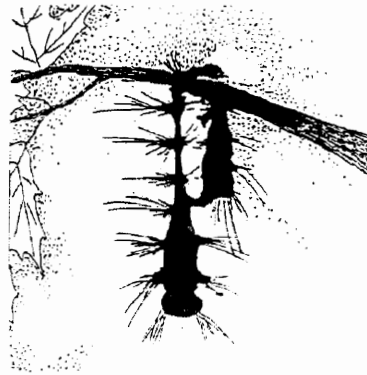
Approximately 50 species of birds include gypsy moth caterpillars and adult moths in their diets. Blue jays, towhees, tanagers, catbirds, American robins, black-capped chickadees and woodpeckers are among these species. Beetles, spiders, ants and squirrels are other examples of predators.

Providing habitat to encourage predators is a treatment practice managers can use in forested and residential situations. Dead trees and bird boxes attract cavity-nesting birds like woodpeckers; wood and brush piles attract small rodents. Planting trees and shrubs that bear edible fruit and establishing feeding and watering stations are good measures for attracting birds.

Parasitoids

Beginning in the early 1900s, parasitoids were introduced into North America from Europe and Asia in an effort to control building populations in the northeastern U.S. Of approximately 40 species introduced, ten are established. Several species of wasps and flies are gypsy moth parasitoids. They attack the gypsy moth host at the egg, pupae or caterpillar stage by laying their eggs on or inside the host. The parasitoid eggs hatch, then the small larvae begin feeding on the gypsy moth and kill it.

Despite extensive research on the effectiveness of parasitoids as gypsy moth controls, most findings reveal that they generally do not cause significant reduction of gypsy moth populations. In specific instances, parasitoid releases may cause minor reductions in the population, but gypsy moth managers do not use artificial release of parasitoids in large management programs.



Disease organisms

Diseases play an important role in natural control of gypsy moth populations. A virus called NPV has been present in building populations in the eastern U.S. for many years. More recently, scientists have discovered a fungus called *Entomophaga maimaiga* and are investigating its potential use as a control.

NPV

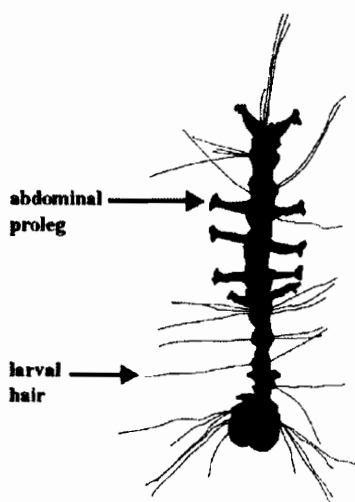
NPV (nucleopolyhedrovirus) occurs naturally and specifically infects gypsy moths—it does not affect other animals or humans. Virus particles enter a gypsy moth caterpillar as it feeds on leaves. The particles infect the gut and other organs and tissues, causing internal breakdown and buildup of tissue fluids. The caterpillar normally dies 10-14 days after it is infected. A distinguishing characteristic of an NPV-infected caterpillar is its limp, inverted-V appearance, which is why NPV is often called “wilt disease.”

NPV outbreaks, called **epizootics**, are dependent upon the density of gypsy moths; more dense gypsy moth populations cause a more intensive epizootic. Gypsy moth populations in northern Virginia have experienced NPV epizootics. For example, park officials with the Shenandoah National Park observed NPV outbreaks in the late 1980's when gypsy moth populations were high.

Entomophaga maimaiga

E. maimaiga is a naturally-occurring fungus disease that affects gypsy moths and a few related lepidopterans. It gained attention after a widespread epizootic throughout New England in 1989 and has since been observed and studied in much of the North American gypsy moth range. Small caterpillars pick up the spores as they crawl on trees, forest litter and soil. The fungus enters through the caterpillar's skin, assisted by **enzymes** produced by the fungal spores. The fungus quickly grows inside the caterpillar, killing it by drying out the body.

E. maimaiga-infected caterpillars are often confused with those infected by NPV. One difference is that caterpillars infected by *E. maimaiga* frequently attach themselves to surfaces facing down and in a vertical position. The bodies are dried-out and the abdominal **prolegs** extend from the body at a 90° angle.



E. maimaiga is found in areas where gypsy moths are well-established and are experiencing declines in their populations—for example, the New England states. It has not noticeably affected gypsy moth populations in Virginia, although studies have been conducted in the George Washington/Thomas Jefferson National Forest to introduce *E. maimaiga*. Because the fungus is a relatively new discovery, researchers are still gathering information that might be used to help develop a new gypsy moth control tool.

Cultural Treatments

Silviculture

Silviculture is the practice of managing woodlots and forests to maintain and improve their productivity and usefulness for any purpose. Examples of silvicultural treatments with respect to gypsy moth management include removing dead, dying and stressed trees; reducing trees most susceptible to gypsy moth feeding; improving predator habitat; and planting trees less susceptible to gypsy moth, which is especially appropriate in urban and suburban areas. Improving tree health and vigor through fertilization, mulching, adequate watering, and pruning are other important cultural practices best suited for residential areas.

The best time to apply silvicultural treatments is at least 2 years before gypsy moth infestations have become established in an area. Newly planted trees, pruned trees, and trees left standing from a timber cutting must all recover from the plant stresses of their respective treatments.

Mechanical Treatments

Scraping and destroying egg masses

Removing egg masses from a surface was one of the first treatments ever used for gypsy moth infestations in New England. However, as populations increase, egg masses are too numerous and it is impossible to remove all of them in a wooded area. Egg mass scraping and destroying is still a good treatment for accessible trees in urban and suburban settings and it is used by regulatory officials to

assist prevention of artificial spread. A common technique is to scrape the masses from a surface into a container of alcohol. Regulatory officials often use this technique when inspecting transportation vehicles and cargo.

A newer method of destroying egg masses in residential situations involves spot treating masses in the fall with a soybean oil solution. The oil coats the outside layer of the mass and essentially suffocates the developing larvae.

Tree bands and barriers

Based on the larvae's habits of migrating and seeking shelter along trees, artificial shelters which serve to capture larvae are practical control treatments only in small areas. Strips of burlap with an overhanging flap are tied around a tree trunk. During the day, larvae crawl underneath the flap and use the hidden area for a resting spot. They are scraped off the burlap flap and destroyed in a container of alcohol.

Tree barriers with a sticky surface also are effective in capturing larvae climbing a tree, but they have no effect on larvae already in the tree canopy. Duct tape covered with a sticky substance called Tanglefoot is wrapped around the tree trunk. Tanglefoot is a thick, glue-type material which very effectively prevents larvae from climbing trees.

Mass trapping

Trapping assists managers in monitoring populations in the transition zone, but it also is an eradication treatment in the

uninfested zone. Mass trapping is similar to male moth surveys in that traps are set in an area along a sampling grid. However, the infested area is much smaller—usually 100 acres or less—and the grid is much tighter so that more traps are placed. The idea behind mass trapping is to lure all male moths to traps so that they will not mate with females.

The best use of mass trapping is in forested areas with small infestations and low population density. Residents ahead of the generally infested can use traps on their property, but they should not depend upon this method to protect foliage from gypsy moth feeding.

Mating disruption

The sex pheromone, disparlure, is the main ingredient in mating disruption treatments. It is manufactured into small beads or flakes and is most often aerially spread over an area. The flakes saturate the area with pheromone, and the male moths become confused and cannot find and mate with females.

Like mass trapping, mating disruption is reserved for areas of low population density but aerial application makes this treatment easier to use; larger areas can be treated. And like mass trapping, populations are reduced the next season but foliage is not protected in the current season.

Genetic Treatments

Sterile insect technique is the only genetic treatment used in gypsy moth management. Sterile insect

technique has two main purposes in gypsy moth management:

1. to reduce the chances of female moths mating with fertile males by releasing sterile males into the infested area; and
2. to increase the number of sterile egg masses when females mate with sterile males, which eventually eliminates the population.

Sterile males are aerially released into an area by plane or helicopter for several consecutive seasons. These releases are best used in low-density infestations within transition and uninfested zones where survey data indicate less than 10 egg masses/acre.

Insecticide Treatments

Aerial application of insecticides is the main treatment used in state and federal management programs to control gypsy moths. Diflubenzuron (trade name Dimilin®) and Bacillus thuringiensis (B.t.) are the insecticides of choice. Newer insecticides which may be more specific to gypsy moth and pose fewer environmental side-effects have been tested in small areas. Gypchek is one of these insecticides, a powder manufactured from dead larvae infected by NPV virus.

Dimilin®

Dimilin is an insect growth regulator that interrupts a gypsy moth larva's ability to produce chitin, which is an important part of the insect's outer skin or **exoskeleton**. Because the larva cannot complete the molting process, internal pressure builds

and ruptures the body wall and the larva dies.

All instars are affected by Dimilin applications, primarily through ingesting leaves coated with the insecticide. Dimilin is very effective in protecting trees from defoliation and reducing the gypsy moth population, making it a choice treatment in all infestation zones. It is a "restricted use" pesticide which means that it can only be used by certified pesticide applicators. Its main disadvantage is that it is toxic to organisms other than gypsy moths. These **nontarget organisms** include aquatic crustaceans and other invertebrates.

B.t.k

B.t. is a naturally occurring bacterium in soil. Numerous varieties exist, but Bacillus thuringiensis variety kurstaki (B.t.k.) affects only species of lepidoterans. B.t.k. has been manufactured into a biological insecticide to control forest defoliating caterpillars. When a larva ingests leaves coated with B.t.k. , it digests the bacteria's spores and protein crystals, which cause cells in the gut to burst. The larva experiences gut paralysis, stops feeding, and dies within a few days.

B.t.k. is the choice insecticide for eradicating isolated infestations, but it is also used for suppression. Its main disadvantage is that it is toxic to other moths and butterflies.

Gypchek

Manufactured from the NPV virus found naturally in gypsy moth populations, Gypchek is a good

treatment choice in moderate to high level infestations (300-5000 egg masses/acre) in the generally infested area. Researchers are still testing its effectiveness in low level populations of the transition area.

Gypchek is a biological insecticide proven very effective in dense populations where the virus transmits more easily. Gypchek can kill a high percentage of the affected population and greatly minimizes defoliation. It only infects gypsy moths, making it a good choice for areas having particular environmental concerns like threatened and endangered species.

Gypchek is not widely available because the production process is time-and labor-intensive and expensive. One treated acre requires 500-1000 infested larvae to produce a sufficient quantity of Gypchek, consequently, the Forest Service and APHIS produce only enough to treat roughly 20,000 acres a year. Its use is reserved for special concern areas in large management projects; it currently is not available for residential use.

Table 2 lists the types of treatments used in gypsy moth management along with factors to consider in using each treatment.

Table 1. Control Strategies and Treatments Based Upon Infestation Level

Infestation Zone	Control Strategy & Objectives	Treatment Type & Options
<p>Generally-infested</p> <ul style="list-style-type: none"> • populations permanently established in a continuous area • outbreaks occur • all life stages present • defoliation is common 	<p>Suppression</p> <ul style="list-style-type: none"> • minimize defoliation and mortality of trees • reduce outbreak populations enough to avoid treatments the next year 	<p>Insecticide</p> <ul style="list-style-type: none"> • B.t. • diflubenzuron • Gypchek
<p>Transition</p> <ul style="list-style-type: none"> • populations established in smaller, discontinuous pockets • outbreaks do not occur • adult male moths common • defoliation is uncommon 	<p>Slow-the-Spread</p> <ul style="list-style-type: none"> • slow natural and artificial spread of low-level populations • prevent low-level populations from reaching outbreak levels 	<p>Insecticide</p> <ul style="list-style-type: none"> • B.t. • diflubenzuron • Gypchek <p>Genetic</p> <ul style="list-style-type: none"> • sterile insect technique <p>Mechanical</p> <ul style="list-style-type: none"> • mass trapping • mating disruption
<p>Uninfested</p> <ul style="list-style-type: none"> • ahead of the transition zone • outbreaks do not occur • occasional male moths • no established populations 	<p>Eradication</p> <ul style="list-style-type: none"> • prevent establishment in new areas by eliminating isolated infestations 	<p>Insecticide</p> <ul style="list-style-type: none"> • B.t. • diflubenzuron • Gypchek <p>Genetic</p> <ul style="list-style-type: none"> • sterile insect technique <p>Mechanical</p> <ul style="list-style-type: none"> • mass trapping • mating disruption

Figure 1. Infestation Zones in U.S., 1994

Infestation status, 1994

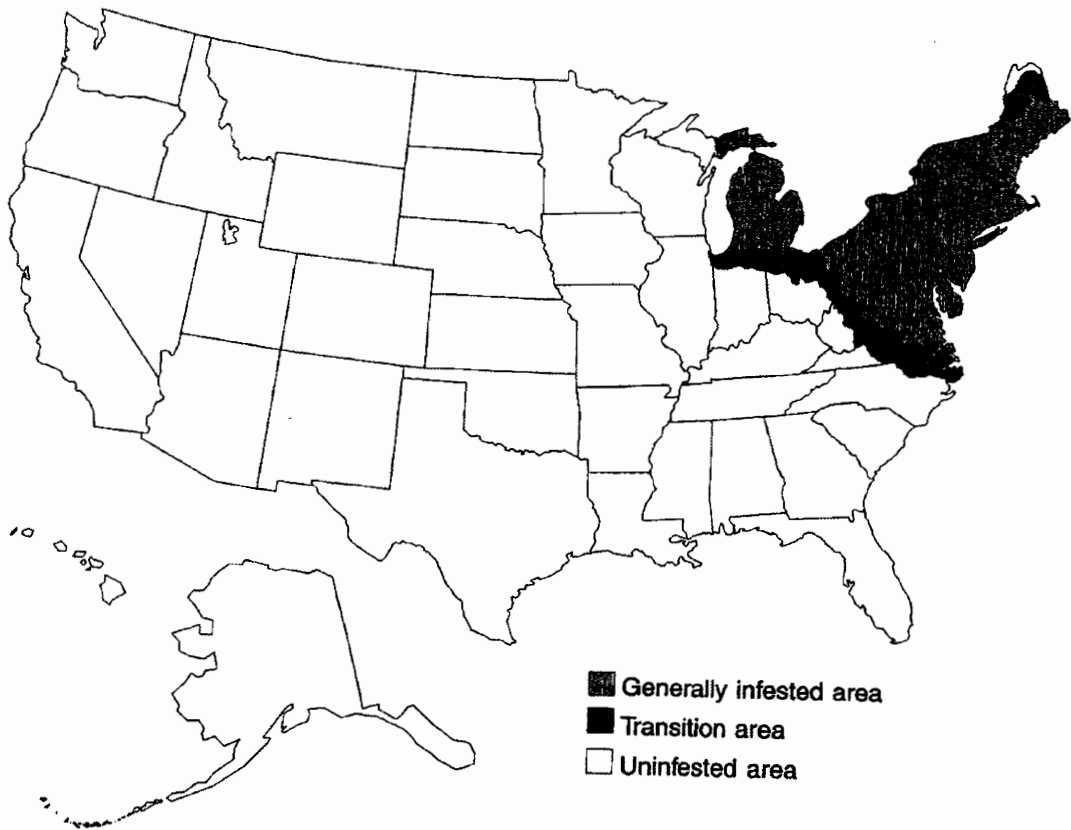


Table 2. Factors to Consider for Each Treatment

Treatment	Cost Per Acre	Availability	Decreases		Best Use Areas	
			Gypsy Moth #s	Defoliation	Residential(R)	Forested(F)
Predators & Parasitoids						
Silviculture						
Removing Egg Masses						
Tree Barriers						
Mass Trapping						
Sterile Insect Release						
Mating Disruption						
Dimilin						
<i>B.t.k.</i>						
Gypchek						

Terms

action threshold

the pest density that justifies using some type of control to manage the pest

Example: According to management guidelines in Virginia, areas having 200 egg masses/acre or more will receive insecticide control using Bt or Dimilin®. 200 egg masses/acre is the action threshold.

Bacillus thuringiensis (B.t.)

scientific name for a bacterium that kills the larvae of many lepidopterous insects (moths and butterflies)

diflubenzuron (Dimilin®)

an insect growth regulator that interrupts chitin production and prevents gypsy moth larvae from completing the molting process. It is the active ingredient in insecticides sold under the trade name Dimilin®.

economic threshold

the pest density above which control measures should be used to prevent the population from reaching a level that causes economic damage to the crop. The economic threshold is an important decision-making tool of integrated pest management, using information about the pest population density and economic damage of the crop.

Example: Managers control gypsy moths when the area has over 200 egg masses per acre. Egg mass counts over 200 indicate a gypsy moth population that can cause economic damage.

egg mass survey

a method used to determine gypsy moth density in an area. Managers set up sample plots throughout the area and count the number of egg masses at each plot.

Entomophaga maimaiga

scientific name for a fungus that kills gypsy moth larvae

eradication

a control strategy whose primary goal is to get rid of a pest population. Eradication is most often used on small, isolated gypsy moth infestations. See **strategy**.

generally infested zone

an area where all life stages of gypsy moth are present and where population outbreaks and defoliation occur. See **transition zone** and **uninfested zone**.

male moth survey

a method used to determine the location and potential population density problems of gypsy moths in an area. Managers set up sample plots throughout the area and count the number of male moths attracted to pheromone-baited traps at each plot.

mass trapping

a treatment method used mostly for eradication purposes. Gypsy moth traps baited with pheromone are placed within an area along a very tight, intensive grid. The pheromone lures the male moths to the traps where they are captured and killed. The purpose of mass trapping is to introduce so much pheromone in the area that the males cannot find females thus cannot mate. See **mating disruption** for a similar method.

nucleopolyhedrosis virus (NPV)

a naturally occurring group of viruses causing tissue breakdown and death of many moth and butterfly larvae. The NPV specific to gypsy moth is the active ingredient in the biological insecticide Gypchek.

parasite

organisms that must live on or within another organism, the host organism, to survive. Parasites provide no benefits to the host.

predator

an organism that feeds upon and likely kills another organism. Small mammals and birds are predators of gypsy moths.

silviculture

the part of forest management which involves applying treatments (cultural, chemical, biological, genetic) that help maintain and improve the forested area

Example: Before gypsy moths infest the area, foresters may decide to remove weak, stressed, dying and defoliation-prone trees to help improve growing conditions for standing trees. Removing problem trees is a type of cultural treatment which may lower the risk of future gypsy moth attacks.

slow-the-spread

a control strategy whose primary goal is to slow the natural spread of gypsy moths to uninfested areas by preventing low-density populations (in infested areas) from increasing in size. During the 1990s, managers are testing new methods of slowing the spread of gypsy moths in sample management areas to see if these methods can be used on a national scale. See **strategy**.

sterile insect technique

a treatment method used to reduce insects' ability to reproduce.

Example: Gypsy moth sterile insect technique involves releasing genetically altered pupae or eggs into a management area. These altered individuals develop and mate normally, but they produce no offspring or sterile offspring. As a result, the next and subsequent generations of gypsy moths decrease.

suppression

a control strategy whose primary goal is to reduce outbreaks in established populations in an effort to prevent or minimize damage to tree resources. See **strategy**.

transition zone

an area situated between generally infested and uninfested areas. Populations are scattered and consist primarily of adult male moths. Defoliation normally does not occur in a transition area. See **generally infested zone** and **uninfested zone**.

treatment

a specific action to control pest populations

Example: In gypsy moth management, managers use chemical, cultural, genetic, and mechanical treatments to control populations.

tree banding

a mechanical treatment option best used in residential settings on individual trees. Strips of burlap wrapped around the trunk provide a hiding and resting spot for gypsy moth larvae as they crawl up a tree. Larvae under the burlap strips are collected and killed, thus this option is effective in reducing numbers on individual trees. A similar treatment involves tree barriers, sticky bands encircling the tree trunk to prevent larvae from climbing up a tree to the canopy.

uninfested zone

an area ahead of the transition zone. Gypsy moth populations do not exist and outbreaks do not occur. Surveys detect occasional adult male moths but rarely other life stages. See **generally infested zone** and **transition zone**.

Study Questions

1. In which infestation zone do you live in Virginia?
2. Can we get rid of gypsy moths?
3. Which infestations zones are most appropriate for silvicultural treatments?
4. Which type of treatment would benefit most from a site susceptibility study? Why?
5. You have been sampling Japanese beetles in your neighbor's yard and have plotted the progress of the population (see the graph). The population is at Point B. Using only this information, should you control the beetles?
6. The same neighbor wants to know your results from #5. If he has to treat, he wants to use B.t.k. What do you advise him to do?
7. Your other neighbor wants to use Dimilin to treat gypsy moth egg masses in her yard. What do you tell her?
8. Your parent sees a cockroach in the kitchen one night and immediately want to call the exterminator to treat the whole house. Explain how to best handle this situation using your current knowledge of integrated pest management.

TREATMENT RECOMMENDATION REPORT (Preliminary)

Study Area _____

Team Members (names):

Area Type _____

- A: publicly owned, forested, recreational (ex. parks, state/national forest)
- B: forested residential area with at least one house/acre
- C: forested residential area with at least one house/5 acres
- D: forested residential area with at least one house/15 acres
- E: uninhabited and undeveloped forest land

Problem Determination

General infestation level (generally infested, transition, uninfested)

Describe the area's susceptibility to gypsy moth defoliation and damage

Population density (egg masses/acre)
(Average this number for all plots)

Estimated defoliation (%)

Infestation Level _____

Low = less than 250 egg masses/acres
Moderate-High = more than 250 egg masses/acre

(over)

Control Strategy
Budget Allowance \$500
Treatment Choice(s)
Additional Comments

Lesson: Gypsy Moth Control, Part 2

This lesson reviews other factors managers include in gypsy moth control decisions.

PURPOSE

Students will be apply other decision criteria to make appropriate control decisions for specific gypsy moth management cases and justify these choices.

OBJECTIVES

Students will

- choose an appropriate treatment(s) for an assigned study area and justify the choices using additional environmental information and public input

CONCEPTS

- influence of environmental factors on management decisions
- influence of human factors on management decisions

SKILLS

Students will

- work in teams
- analyze data
- make control and treatment decisions using scientific data and citizen input
- report team results orally and in writing

BACKGROUND FOR INSTRUCTOR

Instruct students to read **Gypsy Moth Integrated Pest Management: Other Factors in Control Decisions** as an out-of-class assignment prior to this lesson. Study questions are at the end of the reading so that students can prepare for the next case study activity. Students should complete Table 1 as part of the reading assignment. Review the study questions in class before the

lesson activity to check students' understanding of other factors involved with making gypsy moth control decisions and how managers address these factors.

Assemble management groups and instruct them to revise their **Property Owner Reports** based upon the additional information. After groups have completed revisions, instruct each group to report their results to the class.

Study Questions

1. How does a gypsy moth problem differ from an agricultural pest problem like corn earworm?

☞ Agricultural pests typically feed on a single crop. Corn earworm, for example, eats corn. Gypsy moths feed upon numerous tree species, so that damage is more obvious and sometimes devastating to an area.

Agricultural pests directly affect fewer people. Obviously they affect the farmer, but the general public experiences no direct contact or experience with agricultural pests. On the other hand, gypsy moths affect many people, ranging anywhere from the forester to the urban resident. Trees have direct importance for almost everyone in one way or another.

2. Explain how forest condition changes from gypsy moth infestations would affect management of a wilderness area versus a timber area?

☞ The primary objective of a wilderness area is its protection in a natural state. People use wilderness areas for recreation, research, and plant and animal habitat protection. Gypsy moth infestations damage a wilderness area as much as any other area, and in reality, the damage can be more extensive because managers do not treat wilderness areas. Yet, this damage does not significantly compromise wilderness management objectives thus gypsy moth management normally does not play a role in management.

The primary objective of a timber management area is to grow trees for profit. Gypsy moth damage can have a major impact on tree growth and quality, thus managers will adopt rigorous gypsy moth management programs to minimize damage and spread.

3. You live in a gypsy moth infested area and are in the midst of an outbreak. Dead larvae and frass are everywhere and the sidewalks are extremely slippery and hazardous. Your neighbor, who headed an effort to stop gypsy moth treatments in the town, slipped and fell on a sidewalk. She broke her ankle. Now she is suing the town for negligence in maintaining town property.

As a state gypsy moth management consultant, what advice would you offer to the town to prevent future episodes like this?

☞ My advice would be to launch an aggressive education program to inform citizens of the pros and cons of gypsy moth management in their town or county and to assert who takes responsibility for this management.

4. What types of businesses would benefit from a local decision not to treat for gypsy moths?

☞ Tree care companies, landscape and nursery businesses

5. As a local gypsy moth manager, what might be one of your most important contributions to the communities' cooperation in your management program?

☞ A good educational program aimed at a variety of groups (ex. school children, business people, local legislators) is one of the most important functions of a local gypsy moth manager.

6. Suggest ways that managers can help educate the public about eventual gypsy moth infestations in their area.

- ☞
- organize field trips to defoliated areas
 - T.V. and radio announcements
 - public area displays (ex. libraries, town halls)
 - organize and hold public meetings
 - develop informational products for free access (ex. brochures, World Wide Web information)

EVALUATION

Each team will complete and turn in their treatment recommendation report and will be assigned a team grade for their report/classroom presentation. Consider using peer evaluations for a portion of the grade.

REFERENCES

USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C: U.S. Department of Agriculture.

INSTRUCTOR'S NOTES

Gypsy Moth Integrated Pest Management: Other Factors in Control Decisions

Terms to Know and Use: aquatic, buffer zones, entomophobia, invertebrate, microclimate, non-target organism, objector, pH, threatened and endangered species, timber area, transpiration, wilderness area

INTRODUCTION

The practice of integrated pest management (IPM) is complex from the standpoint that it is often time- and information-intensive. Making decisions in an IPM program is equally complex since decisions account for several factors—biological, environmental, and human. Gypsy moth management is an excellent example of how managers must juggle all of these factors when making control decisions and implementing treatment programs. Gypsy moths and their control affect forest conditions, soil, water and non-target organisms in the environment as well as affect public health and safety, the economy, politics, and attitudes and perceptions.

One of the most important considerations in understanding and dealing with gypsy moth problems is realizing that they really are human problems. If we did not perceive them as pests, we would not have gypsy moth problems. Problems posed to humans and their affected environment play a

critical role in gypsy moth management decisions.

To Treat or Not to Treat

Someone unfamiliar with gypsy moths might assume that the benefits of doing nothing about them outweigh controlling them. This person may assume that the expense of treatments as well as public concern for insecticide effects on health and environment are too great. In reality many people believe that the no treatment option is best even when they have experienced gypsy moth infestations. Yet, others feel differently. These people think controlling gypsy moths will benefit the environment as well as public health and well-being.

Treating or not treating an area each has important environmental and human consequences. An informed decision to treat or not to treat includes considering all of these consequences, the next two sections of which discuss them in greater detail.

ENVIRONMENTAL FACTORS

Whether the decision is to allow gypsy moths to naturally infest an area or to control them, both options affect the environment in different ways. Forest conditions, soil and air, water and non-target organisms are among the most important environmental targets of gypsy moth infestations. In deciding whether or not to treat, managers must consider the effects on each of these targets within and outside their management area.

Forest Conditions

Gypsy moth infestations significantly change forest conditions. Untreated areas experience any of several events: increased tree mortality, change in species composition to trees less susceptible to gypsy moth damage, reduced tree growth and fruit production, increased undergrowth, and increased susceptibility to fire. On the other hand, treated areas, especially those within suppression boundaries, experience minimal defoliation and damage which minimizes forest condition changes. In some areas like wilderness, changes in forest conditions make little difference to the success of management goals. Yet, timber management areas require healthy and productive trees.

Soil and Microclimate

Soil and microclimate temperatures increase in defoliated areas. More direct sunlight in defoliated areas decreases humidity, while soil moisture increases as a result of runoff and lower transpiration rates in trees. Forests experience

immediate, short-term increases in soil decomposition and growth of understory vegetation. Along with other forest conditions, soil and microclimate experience fewer changes in treated areas.

Water

Defoliation greatly affects water quality for several reasons. Heavy and widespread defoliation cause increases in water temperature, flow, and nitrogen levels. Increases in fecal bacteria result from gypsy moth frass falling directly into water and washing in from surrounding areas. Defoliation also contributes to decreases in oxygen and pH levels, conditions which may negatively affect populations of fish and other aquatic organisms.

Dead trees and other forest litter from gypsy moth-induced damage fall and buildup over streams. These so-called debris dams create good habitat for fish and provide more food for aquatic organisms which rely upon organic material that has fallen and settled in streams.

Dimilin treatments applied to an area affect water quality. Specifically, Dimilin indirectly decreases oxygen levels in water by reducing the number of aquatic insects and crustaceans that feed upon algae. Decreases in aquatic organisms can cause increases in algae populations, which consume oxygen and further decrease oxygen levels in streams. Dimilin is the only insecticide that causes measurable effects on water quality, and most managers contend that untreated areas have more potential

for water quality degradation than do treated areas.

Non-target Organisms

The change in forest conditions of defoliated and damaged areas means changes in wildlife habitat. Changes in how and where vegetation grows, cover for shelter, food source and availability, and number of prey affect wildlife habitat of numerous birds and mammals. Normally these changes are gradual enough that wildlife adapt accordingly by migrating to other areas or finding new sources of shelter and food within a gypsy moth-damaged area. In many instances, wildlife benefit from these changes. Animals like white-tailed deer find food and shelter in the vigorous undergrowth of areas opened up by tree mortality. Cavity-nesting birds like woodpeckers and owls seek shelter in dead, standing trees. Gypsy moths themselves provide a good supply of food for birds and mammals.

Insecticide treatments affect non-target organisms in the short-term. Dimilin kills invertebrate species other than gypsy moth, of which aquatic invertebrates are of primary concern. B.t.k. kills other lepidopteran species which undergo larval development and feed during the same time as gypsy moths.

To protect non-target organisms, managers establish buffer zones, areas prohibited from any insecticide treatment or certain insecticides. For example, managers use B.t.k. instead of Dimilin near water sources. They may select Gypchek for highly

sensitive areas where threatened and endangered species live.

HUMAN FACTORS

Human interests play dominating roles in any IPM system, and they are especially significant in gypsy moth management because gypsy moths affect resources that provide us business, recreation, and homes. Gypsy moths affect our political and economic health as well as our personal health and safety. They challenge our attitudes, beliefs, and knowledge about pest control with respect to our well-being and environmental well-being. Well-practiced IPM seeks a balance between both.

Human input is a critical part of an IPM process. Not only do gypsy moth managers have an obligation to educate and inform, but they must learn as much as they can about public issues and concerns regarding safety and health, local economic and political views, and personal perceptions. Decisions to treat or not to treat have good and bad points associated with each of the public issues described in the next sections.

Public Safety & Health

Heavily infested areas pose safety problems in some instances. Crawling and dead larvae and frass droppings create slippery conditions on roads, sidewalks, decks, and playgrounds. Dead trees and limbs can fall at any time, damaging property and power lines or threatening individual safety. Some people experience allergic skin

reactions upon contact with gypsy moth hairs. Still others complain of eye and respiratory problems.

Insecticides used in treatments pose no significant short- or long-term risks to humans. B.t.k. and Gypchek may cause skin, eye or respiratory allergies in some people if they come into direct contact with the spray. This is more of a problem for management personnel in treatment operations than it is for the general public. Dimilin poses no risks to humans.

Economic & Political Views

Not treating for gypsy moths is a decision surrounded by numerous and often long-term economic consequences. Maintaining a non-treated area requires money and effort to remove larvae and frass, clean and paint buildings, clear walking areas, remove dead and dying trees, and replant trees. Local economies may lose money from recreation, tourism, and forestry. Property values typically decrease while energy costs increase for air conditioning.

Decisions to treat come with more short-term costs of planning and executing a treatment project. Local and regional businesses contract with federal and state governments to provide equipment, supplies and aerial insecticide applications. For example, independent aviation companies in Virginia contract with the Virginia Department of Agriculture and Consumer Services (VDACS). These business agreements provide business to the companies and local expertise to VDACS.

Federal, state and local governments share costs for treatment projects, the percentage breakdown of which depends upon the area's control strategy. In suppression zones, for example, local and state governments share treatment costs, while state and/or federal agencies fund treatments in slow-the-spread zones. Political pressure from local residents typically arises during the process of deciding whether or not to provide money for treatments. Private citizens, businesses, and organizations pressure their local and state legislators to support or not to support funding for treatment projects. The economic health of a community or region is foremost in the minds of many legislators, so their decisions to provide funding for gypsy moth treatments often come from a commitment to protect the area's economic resources. Yet, government officials must take into account a wide variety of opinions and advice from citizens.

Personal Perception

Education a big factor here—private citizens, local legislators, media, community organizations

Public attitudes toward and beliefs of gypsy moths and their treatment largely depend upon how knowledgeable they are about the gypsy moth as an insect and insecticides. Firsthand experience often plays a big role in the public's perception of gypsy moth as a problem. For example, people in the northern Virginia counties know very well the direct impacts gypsy moths have on their lives, thus they often have strong and definite opinions

about how gypsy moths should be managed. Those living in uninfested areas of the state wonder why gypsy moths are such a big deal.

Generally, people know little about the problems gypsy moths pose until they experience outbreaks firsthand. Their immediate responses include alarm, fear, anger, and frustration. Large numbers of gypsy moth larvae alarm people because they may not know what they are and if they are a health threat. Likewise, defoliation causes concern about property damage. Some people are afraid of insects, a condition called entomophobia, and large numbers of larvae cause them great distress. Others are angry and frustrated by the mess, nuisance, and disruption infestations cause to their business and personal lives.

Government-sponsored treatment projects generate similar responses. Helicopters and planes flying close to houses alarm residents. Some fear that insecticide exposure will harm them, their children and animals, or other property. They fear that insecticides will harm the environment. Treatment projects cause some disruption to business and personal schedules. For example, managers forewarn local schools about when treatments occur in an effort to keep children inside and away from direct exposure to insecticides. Likewise, people postpone recreational activities during treatment projects.

Still others become angry and frustrated with local officials and their neighbors. As part of the

management process, government-sponsored projects include a way for citizens to prevent having their property sprayed. These citizens are called objectors. This creates problems for the neighbors who want their property sprayed yet do not want the objectors' gypsy moths spreading to their property. Conversely, the objectors do not want insecticidal spray drifting to their property. In other cases, people want their property treated, yet management thresholds are too low to justify the treatments; these people become angry and frustrated with local officials and gypsy moth managers for not treating their property.

In areas where government-managed treatments are excluded, people sometimes resort to private companies to treat their property with any number of insecticides. These insecticides and their application pose greater health and environmental risks if they are not used appropriately and correctly. Likewise, residents try a variety of chemicals to get rid of caterpillars on their property, often ignorant of the fact that they are using the wrong chemical at the wrong time in the gypsy moth life cycle.

People's responses to gypsy moth infestations and their willingness to cooperate in treatment projects largely depend upon how informed they are. Probably one of the most important parts of an IPM program is public education. Managers must inform and educate before they can expect people to understand and support gypsy moth management programs.

Finding ways to reach people and increase their knowledge of gypsy moths and IPM challenges managers to this day. It is particularly difficult to interest people ahead of infestations since they have no personal experience. As a result, efforts to educate come as a reaction to public concern and frustration during initial outbreaks. Compounding this problem is the fact that concern and frustration contribute to personal perceptions based upon emotions rather than facts. Changing these perceptions is a most difficult challenge for gypsy moth managers.

Table 1 summarizes the different gypsy moth treatments and the types of effects they may have on the environment and humans.

Table 1. Effects of Each Treatment

Treatment	Effects on the Environment				Effects on Humans			
	Forest Conditions	Soil	Non-target Organisms	Water	Health & Safety	Attitudes	Economy	Politics
Predators & Parasitoids								
Silviculture								
Removing Egg Masses								
Tree Barriers								
Mass Trapping								
Sterile Insect Release								
Mating Disruption								
Dimilin								
B.t.k.								
Gypchek								
No Treatment								

Terms

aquatic

living or growing in water

buffer zones

areas surrounding a resource like a lake, stream, or habitat of endangered species to protect it from effects of treatment operations

entomophobia

general fear of insects

invertebrate

an animal which has no spinal column. Insects, crustaceans, and spiders are examples of invertebrates.

microclimate

unique weather conditions of a local area or habitat, influenced by topography, soil and vegetation. Microclimate differs from the climate of the general area or region.

nontarget organism

a living organism that could be affected by a management practice intended for another organism. For example, other moth and butterfly species can be killed by B.t. treatments used to control gypsy moths.

objector

someone within a treatment project area who does not want property sprayed for gypsy moths

pH

a measure of how acid or alkaline a substance is on a scale from 0 to 14. Lower numbers indicate acidity (0-6), higher numbers indicate alkalinity (8-14). 7 is neutral.

threatened and endangered species

species that may be in danger of becoming extinct in the future (threatened) or are presently in danger of extinction (endangered)

transpiration

the process of water transport throughout a plant and release of water vapor to air through openings in leaves and stems

timber area

an area of wooded or forested land managed for tree production and harvest

wilderness area

undeveloped federal land designated by Congress to remain in its natural state without human intervention. Wilderness areas protect the primeval character and unique qualities of the land by preventing noticeable human influence.

Study Questions

1. How does gypsy moth management differ from management of an agricultural pest like corn earworm?
2. Explain how forest condition changes from gypsy moth infestations would affect a wilderness area versus a timber area?
3. You live in a gypsy moth infested area and are in the midst of an outbreak. Dead larvae and frass are everywhere and the sidewalks are extremely slippery and hazardous. Your neighbor, who headed an effort to stop gypsy moth treatments in the town, slipped and fell on a sidewalk. She broke her ankle. Now she is suing the town for negligence in maintaining town property.

As a gypsy moth management consultant, what advice would you offer to the town to prevent future episodes like this?

4. What types of businesses would benefit from a local decision not to treat for gypsy moths?
5. As a local gypsy moth manager, what would be your most important contribution to the communities' cooperation in your management program?
6. Suggest ways that managers can help educate the public about eventual gypsy moth infestations in their area.

Appendices

APPENDIX A

A Case Study of Gypsy Moth Management in Virginia

Real Estate Deal in Orange County, Virginia Part 1

Background

Amy and Ron Mitchell just retired from a family medical practice in New Jersey. Their retirement plans included buying a nice piece of land in Virginia to build a home and raise horses. After several months of searching, they found a perfect setting in Orange County. The property had 10 acres of open pasture for the horses, with an additional 11 acres of forested land where they intended to build a woodland home.

The Mitchell's signed a purchase contract in November and soon after hired a local forester to examine the wooded area for potential timber value. As part of her report, the forester noted presence of gypsy moth egg masses on the land.

Gypsy moths have been in New Jersey for years and the Mitchell's were well aware of the damage and nuisance they cause. When they read the forester's survey report, they immediately called their attorney asking how they could get out of the contract—they did not want gypsy moths on their land.

The sellers were furious when they heard the Mitchell's wanted to back out of the real estate deal so they decided to seek court action. As part of the evidence presented at the trial, Virginia Tech scientists in the Entomology Department presented their findings about the defoliation and damage potential as well as the population density on the property.

As it turned out, the trial judge ruled in favor of the Mitchell's—a tearful testimony from Ms. Mitchell probably helped—and they got out of the real estate contract. Meanwhile, the sellers begrudgedly admitted that they really did not know that there were gypsy moths on their Virginia property since they lived full-time in the Florida Keys where they operated a very successful chain of snowcone stands and sold Jimmy Buffet paraphernalia. However, they needed to make money from the Orange County property in the event

their snowcone business melted. It was time to get informed about their property.

They consulted with the Virginia Tech entomologists and hired a gypsy moth management firm (**your group**).^{*} The first thing they wanted to know was if gypsy moth defoliation and damage were potential problems.

Recall that the judge ruled in favor of the Mitchell's. What did not surface in the trial was the fact that Ms. Mitchell was extremely afraid of bugs and was receiving psychiatric treatment for entomophobia (extreme fear of insects). The judge felt sorry for her and based the court decision more on Ms. Mitchell's emotional condition than scientific evidence about gypsy moths.

Your task as the management group is to analyze the data gathered from Virginia Tech and provide a series of reports to the landowners. Your first report to the landowners will tell them about the infestation level in the area, and whether or not the property is REALLY susceptible to defoliation and damage. The information that follows describes how the scientists collected data and provides their results.

Sampling and Tree Composition

Two field scientists from Virginia Tech traveled to the property in March to collect data about the area. They set up 21 sample plots over the entire 11 acres, each plot covering 1/40th of an acre. The sample plots allowed the scientists to cover the area more quickly and efficiently and provided information that represented the entire 11 acres without having to study the entire 11 acres. 1/40th of an acre is a standard sample plot size used by land managers. Managers measure 1/40th acre plots by making a plot center with a stake and making a full circle around the stake with a 18.6' length of rope or tape. Everything within the circle is the sample plot. Data collected from the plots are then multiplied by 40 to get per acre values.

The scientists wanted to know the composition of overstory and understory trees growing in the area, so they did a tree survey in each sample plot. Knowing the predominant overstory species helps managers predict if an area can sustain gypsy moth populations throughout the succeeding 10-20 years.

^{*} As part of the compensation for the work your group does, the landowners agree to treat each of you to an all-expense paid trip to the Florida Keys, complete with sun, surf, sailing, free Jimmy Buffet t-shirts, and all-you-can-eat snowcones.

The overstory species composition for the Orange County property looked like this:

Species	Number of Trees	Percentage of Trees	Cumulative Number of Trees
White oak	30	30.9	30
Chestnut oak	23	23.7	53
Tulip poplar	10	10.3	63
Red oak	9	9.3	72
Red maple	9	9.3	81
Pignut hickory	7	7.2	88
American beech	5	5.2	93
Virginia pine	2	2.1	95
Black oak	1	1.0	96
Flowering dogwood	1	1.0	97

The understory species composition includes those tree species which will become dominant under natural conditions in the future. The understory species composition for the Orange County property looked like this:

Species	Number of Trees	Percentage of Trees	Cumulative Number of Trees
American beech	6	28.6	6
Black gum	5	23.8	11
Flowering dogwood	3	14.3	14
Red maple	3	14.3	17
Mountain laurel	2	9.5	19
Virginia pine	1	4.8	20
Tulip poplar	1	4.8	21

The scientists also noted that forested areas surrounding the study area had been cut to different degrees and were primarily dominated by red maples.

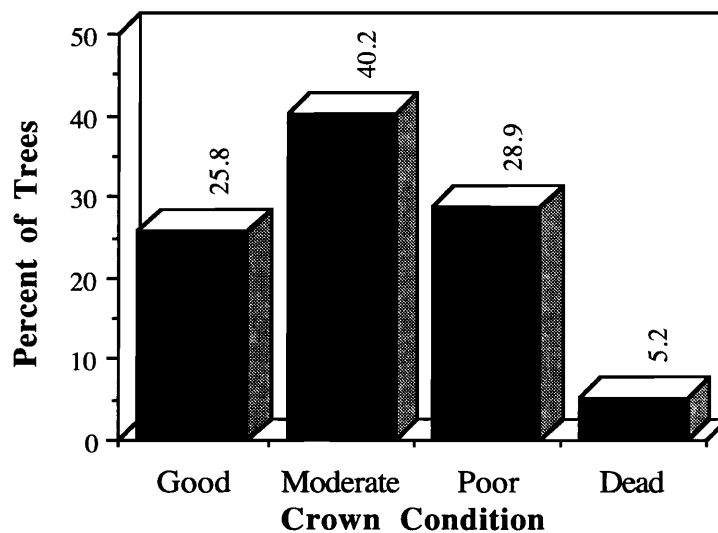
Tree Condition

Observing the physical appearance of a tree is one way to determine how healthy it is. If it is not healthy, it may become severely stressed during and after gypsy moth defoliation events, and the rate at which it dies is very rapid. Trees stressed from gypsy moth defoliation can die 3-5 years after repeated defoliation.

Determining if and how much a tree is stressed includes noting the following signs:

- dead and dying branches with open gaps in the canopy;
- numerous, small sprouting twigs along the trunk;
- loose, peeling bark;
- evidence of bird or animal cavities in branches or along the trunk; and
- evidence of other insect and disease infestations.

The Virginia Tech scientists noted tree condition of overstory trees at each site in the study area and categorized the conditions as good, moderate, poor, or dying. They recorded the following results:



Site Conditions

During their field work, the scientists observed site conditions. Overall, the property was typical Virginia Piedmont land—rolling topography; mature woodlots surrounding open, cultivated land; clay-type soils; small creeks and streams crossing the property. Although most of the soil was well-drained, soil moisture conditions spanned the range from dry to wet—hilltops and steeper slopes had thinner, dry soils; mid- and lower slope soils were well-drained; bottomland sites had wetter, more poorly-drained soils.

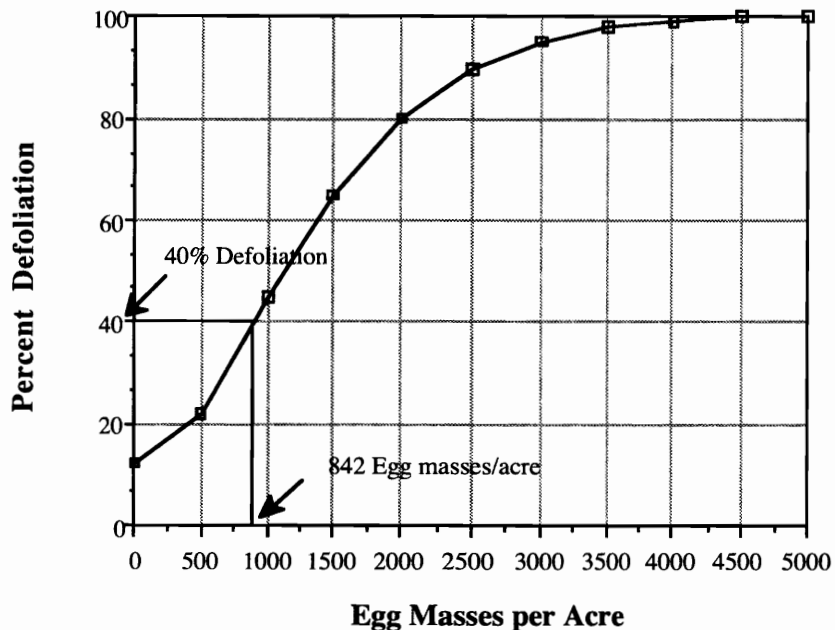
Real Estate Deal in Orange County, Virginia Part 2

Background

As part of their sample plot data, the Virginia Tech scientists searched for and counted egg masses. The number of egg masses in an area gives a good estimation of the density of a gypsy moth infestation. Like the state forester, they found egg masses on the property.

Gypsy Moth Population Density

An egg mass survey of the property revealed an average of 842 egg masses per acre. The scientists used a scientific model¹ which predicts gypsy moth defoliation based upon egg mass counts:



This model estimates that approximately 40% of the area will be defoliated.

¹ Model redrawn from Gansner, D.A., O.W. Herrick, & M. Ticehurst. 1985. A method for predicting gypsy moth defoliation from egg mass counts. *Northern Journal of Applied Forestry* 2: 78-79.

PROPERTY OWNER REPORT: PART 1

Population Status/Defoliation and Damage Potential

Case _____

Name of Gypsy Moth Management Firm:

Team Members (names):

General Description of Study Area:

(type of land, land use, natural and man-made features,
general description of vegetation cover)

General Infestation Level

Gypsy Moth Life Stages Present

Susceptibility to Gypsy Moth Defoliation

Susceptibility Category	% Overstory Trees in each Category	% Understory Trees in each Category
Susceptible		
Resistant		
Immune		

PROPERTY OWNER REPORT: PART 1

Population Status/Defoliation and Damage Potential

Case _____

Damage Potential for Property

Check the boxes that apply for the area

Does the property include sites with >60% susceptible trees?	Does the property have sites that are dry, steep, rocky, or wet?	Are there signs of tree stress?	What is the greatest damage potential for the area? (H, M, L)

**3 boxes/area = High (H)
2 boxes = Moderate (M)
1 box = Low (L)**

PROPERTY OWNER REPORT: PART 1

Population Status/Defoliation and Damage Potential

Case _____

1. Based upon the infestation level and gypsy moth life stages present, what can you say about the status of the population on the property in Orange County?

2. Is the tree species composition on the property or sections of the property favorable for gypsy moth population establishment? Are more trees susceptible, resistant or immune to gypsy moth defoliation? Explain your answer using area summary data.

3. Is the property or are sections of the property vulnerable to defoliation damage? Explain your answer using area summary data.

4. What general statements can you make about the property's future susceptibility to defoliation and damage?

5. What will you tell the landowners about the potential for gypsy moth defoliation and damage on their property?

(Use Back for Additional Comments)

PROPERTY OWNER REPORT: PART 2

Population Density and Preliminary Treatment Recommendations

Case _____

Name of Gypsy Moth Management Firm

Team Members (names):

Area Type _____

- A: publicly owned, forested, recreational (ex. parks, state/national forest)
- B: forested residential area with at least one house/acre
- C: forested residential area with at least one house/5 acres
- D: forested residential area with at least one house/15 acres
- E: uninhabited and undeveloped forest land

Population Density (egg masses/acre)
(average over the entire property)

Estimated Defoliation (%)

Infestation Level for Property _____

Low = less than 250 egg masses/acres

Moderate-High = more than 250 egg masses/acre

Recommended Control Strategy for Area

Treatment Choice(s)

APPENDIX B

Glossary of Terms

A new term is defined within the lesson where it is first introduced. This list is a compilation of terms from all lessons in the unit.

action threshold

the pest density that justifies using some type of control to manage the pest

Example: According to management guidelines in Virginia, areas having 200 egg masses/acre or more will receive insecticide control using Bt or Dimilin®. 200 egg masses/acre is the action threshold.

aquatic

living or growing in water

artificial spread

spread of gypsy moths to uninfested areas by artificial means like transport vehicles and cargo

Example: Gypsy moths often are spread to uninfested areas when cars, trucks and ships travel to these areas. Hidden egg masses on vehicles hatch and larvae spread to new feeding areas. This means of spread is one reason why gypsy moths got their name.

Asian strain

a type of gypsy moth originally from the Far East. Asian gypsy moths are larger, feed on a wider variety of trees and hatch earlier than the European strain. Unlike the European strain, the females fly. See **European strain** and **strain**.

Bacillus thuringiensis (B.t.)

scientific name for a bacterium that kills the larvae of many lepidopterous insects (moths and butterflies)

ballooning

a term used to describe a way gypsy moths spread to different areas. Larvae climb to tree tops where they hang from the silken threads they have attached to branches and leaves. Wind breaks the fine threads and carries the larvae to another location, from several feet to several miles. Larvae continue this ballooning process until they find suitable food.

biological control

use of an organism that is a predator of a pest or can out-compete it for food, water, or shelter

Example: Greenhouse managers release ladybird beetles to feed on aphids that damage greenhouse plants.

buffer zones

areas surrounding a resource like a lake, stream, or habitat of endangered species to protect it from effects of treatment operations

chemical control

any chemical substance used to control pests

Example: Pet owners use insecticides to kill fleas on their pets.

cultural control

managing the environment to make it unfavorable for a pest. Cultural control includes practices that

- improve the health of a plant (ex.: fertilization, watering, pruning, and mulching)
Example: Homeowners care for trees to improve their health and decrease chances for insect or disease attacks;
- decrease favorable habitat for the pest (ex: sanitation, airtight storage containers)
Example: Restaurants and grocery stores store waste in tightly latched containers to help keep the area clean and to discourage rodents; and
- decrease availability of the host (ex: planting before or after the damaging stage of the life cycle, planting pest-resistant varieties, planting multiple crops, and rotating crops in the fields)
Example: Gardeners plant annual vegetables and flowers in different spots each year to avoid a buildup of disease organisms in the soil.

DDT (dichloro-diphenyl-trichloroethane)

a powerful, synthetic chemical used for insect control after World War II. DDT use for gypsy moth control began in the 1940's and ended in the late 1950's, after much public controversy concerning its safety to humans and the environment.

defoliation

foliage loss on a tree. Leaf-eating insects like gypsy moth larvae are one of numerous causes of defoliation on a tree.

diflubenzuron (Dimilin®)

an insect growth regulator that interrupts chitin production and prevents gypsy moth larvae from completing the molting process. It is the active ingredient in insecticides sold under the trade name Dimilin®.

economic threshold

the pest density above which control measures should be used to prevent the population from reaching a level that causes economic damage to the crop. The economic threshold is an important decision-making tool of integrated pest management, using information about the pest population density and economic damage of the crop.

Example: Managers control gypsy moths when the area has over 200 egg masses per acre. Egg mass counts over 200 indicate a gypsy moth population that can cause economic damage.

egg mass survey

a method used to determine gypsy moth density in an area. Managers set up sample plots throughout the area and count the number of egg masses at each plot.

Entomophaga maimaiga

scientific name for a fungus that kills gypsy moth larvae

entomophobia

general fear of insects

enzyme

a natural or synthetic protein that helps speed up a chemical reaction

epidemic

an unusually large, fast spreading pest population

epizootic

a disease organism that occurs widely and spreads quickly throughout an animal population

eradication

a control strategy whose primary goal is to get rid of a pest population. Eradication is most often used on small, isolated gypsy moth infestations. See **strategy**.

European strain

the type of gypsy moth originally from Western Europe and the current established type in North America. Females of the European strain do not fly; females of the Asian strain do fly. See **Asian strain** and **strain**.

exoskeleton

the skeletal structure on the outside of an insect's body

forecasting

a process of predicting when a pest attack will occur, how long it will last, and how severe it will be. Forecasting is extremely important to managers as they plan how to control pests.

Example: Foresters remove trees that are susceptible to gypsy moth attack and they improve growing conditions of standing tree several years before the forecasted infestations.

frass

fecal excrement from insects

generally infested zone

an area where all life stages of gypsy moth are present and where population outbreaks and defoliation occur. See **transition zone** and **uninfested zone**.

genetic control

altering the genes of a pest to make it less successful in reproduction

Example: In the lab, scientists genetically alter gypsy moth females to make them sterile. The sterile females are released in a forest where they mate with the natural population of adult males but produce sterile offspring. The next generation cannot reproduce.

Gypchek

the trade name of a biological insecticide whose active ingredient is a nucleopolyhedrosis virus (NPV) that kills gypsy moth larvae. See **nucleopolyhedrosis virus**.

habitat

the location where an organism lives, consisting of its food, water, shelter and space. Oak-mixed hardwood forests are prime gypsy moth habitat.

host

a living organism that provides food and/or shelter for another organism. Oaks are the preferred host tree for gypsy moths.

infestation

a large number of pests inhabiting an area

instar

a developmental stage of the insect when it increases in size before molting. Gypsy moth larvae go through several instars before pupation.

integrated pest management (IPM)

a pest population management system that uses all suitable tactics, like introducing natural enemies, using pest-resistant plants, and applying pesticides, in an effort to anticipate and prevent the population from reaching damaging levels.

Example: Schools use IPM to control roaches and rodents, which spread diseases to humans. Sanitation is important, especially in and around cafeterias, so cleaning staff play a very important role in IPM. Maintenance staff use traps to kill roaches and rodents and to get information about size of the populations. They also use pesticides when populations are large and extensive.

invertebrate

an animal which has no spinal column. Insects, crustaceans, and spiders are examples of invertebrates.

isolated infestation

a smaller, contained infested area outside of the generally infested area

issue

a public concern or problem

larva (plural—larvae)

the immature, caterpillar stage of an insect; the stage between the egg and pupa

Lepidoptera

the order of insects which includes the butterflies and moths. These insects are distinguished by their four scale-covered wings and coiled, sucking mouth parts.

LD₅₀

the lethal dose of a chemical or other poison that causes death in 50% of a test animal population like laboratory rats

life stage

a period in an insect's life distinguished by physical and functional characteristics. A gypsy moth has four life stages: egg, larva, pupa and adult moth.

Lymantria dispar (L.)

scientific name for the gypsy moth

male moth survey

a method used to determine the location and potential population density problems of gypsy moths in an area. Managers set up sample plots throughout the area and count the number of male moths attracted to pheromone-baited traps at each plot.

management area

an area with common land use goals and objectives. For example, a wilderness area and a timber production area are two separate management areas because their land use goals and objectives differ. See **timber area** and **wilderness area**.

mass trapping

a treatment method used mostly for eradication purposes. Gypsy moth traps baited with pheromone are placed within an area along a very tight, intensive grid. The pheromone lures the male moths to the traps where they are captured and killed. The purpose of mass trapping is to introduce so much pheromone in the area that the males cannot find females thus cannot mate. See **mating disruption** for a similar method.

mating disruption

a treatment method which involves dispersing artificial gypsy moth pheromone in an area to confuse males so that they cannot locate and mate with females. Flakes or small beads containing pheromone are spread aerially over an area.

metamorphosis

change in an insect's form, structure or function during its life cycle. Changes from egg to larva, larva to pupa, and pupa to adult represent metamorphosis.

microclimate

unique weather conditions of a local area or habitat, influenced by topography, soil and vegetation. Microclimate differs from the climate of the general area or region.

molting

the process of shedding the old exoskeleton and forming a new one as the insect grows or changes its shape

monitoring

a process of collecting information that helps predict pest outbreaks (ex. weather conditions, plant growth stages)

Example 1: In the spring, gypsy moth managers sample new leaves to determine the stage at which they have opened and expanded. Leaves must expand a certain degree before insecticide applications begin.

Example 2: Peanut growers in southeast Virginia use a weather monitor which provides information about temperature and humidity. The monitor alerts growers to weather conditions which are favorable for peanut leaf spot disease and they can plan fungicide applications on peanut fields at the correct time.

natural spread

spread of gypsy moths to uninfested areas by natural means like ballooning, crawling larvae, crawling European adult females, and flying females of the Asian strain.

nontarget organism

a living organism that could be affected by a management practice intended for another organism. For example, other moth and butterfly species can be killed by B.t. treatments used to control gypsy moths.

nucleopolyhedrosis virus (NPV)

a naturally occurring group of viruses causing tissue breakdown and death of many moth and butterfly larvae. The NPV specific to gypsy moth is the active ingredient in the biological insecticide Gypchek.

objector

someone within a treatment project area who does not want property sprayed for gypsy moths

outbreak

an increased population of gypsy moths marked by heavy feeding and defoliation

parasite

organisms that must live on or within another organism, the host organism, to survive. Parasites provide no benefits to the host.

parasitoid

a parasite that eventually kills its host. Certain species of flies and wasps are parasitoids of gypsy moths.

pest

any organism judged by humans to cause harm or nuisance to humans, crops, animals or property

Example: Most people think that roaches are pests because they spread disease and are a nuisance.

pesticide

any substance, often a chemical, used to control unwanted pests

<u>This pesticide:</u>	<u>controls these pests:</u>
Insecticide	insects
Fungicide	fungi
Rodenticide	rodents
Herbicide	weeds
Avicide	birds
Miticide	mites
Nematocide	nematodes
Bactericide	bacteria

pH

a measure of how acid or alkaline a substance is on a scale from 0 to 14. Lower numbers indicate acidity (0-6), higher numbers indicate alkalinity (8-14). 7 is neutral.

pheromone

a chemical produced and emitted by an organism to communicate with individuals of the same species. Gypsy moth females emit a sex-attractant pheromone to attract males.

photosynthesis

the chemical process in green plants of converting light into organic substances (sugars).

plant resistance

a plant's ability to avoid, tolerate, or recover from pest injury

Example: Gardeners plant varieties which are resistant to common garden diseases.

population

all organisms of a species inhabiting a specified area

predator

an organism that feeds upon and likely kills another organism. Small mammals and birds are predators of gypsy moths.

proleg

the short limbs attached to the abdomen of certain larvae

pupa (plural—pupae)

the immature stage between larva and adult, providing a resting period for the insect

quarantine

designation given to a generally infested area in an attempt to slow or prevent artificial spread of pests to uninfested areas

sampling

any technique used to collect information about the presence, density and change in density of a pest population

Example: Corn growers in Virginia hire scouts to get information about corn rootworms, which cause significant damage to corn crops if not controlled. Scouts set traps in sample areas of cornfields to catch the adult beetles. Beetles caught in the traps indicate presence of corn rootworm and the severity of infestation.

silviculture

the part of forest management which involves applying treatments (cultural, chemical, biological, genetic) that help maintain and improve the forested area

Example: Before gypsy moths infest the area, foresters may decide to remove weak, stressed, dying and defoliation-prone trees to help improve growing conditions for standing trees. Removing problem trees is a type of cultural treatment which may lower the risk of future gypsy moth attacks.

slow-the-spread

a control strategy whose primary goal is to slow the natural spread of gypsy moths to uninfested areas by preventing low-density populations (in infested areas) from increasing in size. During the 1990s, managers are testing new methods of slowing the spread of gypsy moths in sample management areas to see if these methods can be used on a national scale. See **strategy**.

sterile insect technique

a treatment method used to reduce insects' ability to reproduce.

Example: Gypsy moth sterile insect technique involves releasing genetically altered pupae or eggs into a management area. These altered individuals develop and mate normally, but they produce no offspring or sterile offspring. As a result, the next and subsequent generations of gypsy moths decrease.

strain

a group within a species bearing a physiological difference that makes it unique within the species.

Example: European and Asian are the known strains of gypsy moth (*Lymantria dispar* L.). Asian gypsy moths are larger than the European strain, the eggs hatch earlier, and adult females can fly.

strategy

set of planned, objective-specific actions as part of an overall management plan. Eradication, suppression and slowing-the-spread are examples of strategies used in gypsy moth management.

suppression

a control strategy whose primary goal is to reduce outbreaks in established populations in an effort to prevent or minimize damage to tree resources. See **strategy**.

threatened and endangered species

species that may be in danger of becoming extinct in the future (threatened) or are presently in danger of extinction (endangered)

timber area

an area of wooded or forested land managed for tree production and harvest

toxicity

a chemical's capability to cause harmful effects on a living organism

transition zone

an area situated between generally infested and uninfested areas. Populations are scattered and consist primarily of adult male moths. Defoliation normally does not occur in a transition area. See **generally infested zone** and **uninfested zone**.

transpiration

the process of water transport throughout a plant and release of water vapor to air through openings in leaves and stems

treatment

a specific action to control pest populations

Example: In gypsy moth management, managers use chemical, cultural, genetic, and mechanical treatments to control populations.

tree banding

a mechanical treatment option best used in residential settings on individual trees. Strips of burlap wrapped around the trunk provide a hiding and resting spot for gypsy moth larvae as they crawl up a tree. Larvae under the burlap strips are collected and killed, thus this option is effective in reducing numbers on individual trees. A similar treatment involves tree barriers, sticky bands encircling the tree trunk to prevent larvae from climbing up a tree to the canopy.

uninfested zone

an area ahead of the transition zone. Gypsy moth populations do not exist and outbreaks do not occur. Surveys detect occasional adult male moths but rarely other life stages. See **generally infested zone** and **transition zone**.

VCE

an acronym for Virginia Cooperative Extension. In gypsy moth management programs, VCE assists counties with public awareness and educational efforts.

VDACS

an acronym for the Virginia Department of Agriculture and Consumer Services. In gypsy moth management programs, VDACS assists counties with treatment efforts to manage gypsy moth populations and their spread.

VDF

an acronym for the Virginia Department of Forestry. In gypsy moth management programs, VDF collects defoliation information which is useful in determining how effective previous treatments were. This is a type of post-treatment survey.

wilderness area

undeveloped federal land designated by Congress to remain in its natural state without human intervention. Wilderness areas protect the primeval character and unique qualities of the land by preventing noticeable human influence.

REFERENCES

- Dent, D. (1991). Insect pest management. Oxon, UK: C·A·B International.
- Doane, C.C. and M. L. McManus (Eds). (1981). The gypsy moth: research toward integrated pest management. Technical Bulletin 1584. Washington, D.C.: U.S. Department of Agriculture.
- USDA Forest Service, Southern Region. (1989). Appalachian integrated pest management (IPM) gypsy moth demonstration project. Final environmental impact statement. Management Bulletin, R8-MB 33. Broomall, PA: Northeastern Area State and Private Forestry.
- USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C: U.S. Department of Agriculture.

APPENDIX C

Additional Resources

This guide lists other instructional materials related to integrated pest management and gypsy moths, publication and electronic references that can assist instruction and/or student projects, contacts in Virginia gypsy moth management programs, and suggested student projects related to this unit.



Instructional Materials



Much To Do About Gypsy Moths

This is a collection of project activities designed to demonstrate the many facets of gypsy moth management and the types of tasks local gypsy moth managers have in their daily jobs. Students can learn how to make and use a light trap to collect insects, what is involved with holding a public meeting, and how to use local records to determine the value of a piece of property. It is a good source for high school research projects.

Contact: Ms. Brenda Diehl
Frederick County Gypsy Moth Program Manager
20 North Loudoun Street
Winchester, Virginia 22601
(540) 665-5684

Full citation: Diehl, B. (1996). Much to do about gypsy moths. Unpublished manuscript.

The Gypsy Moth in the Classroom

A premiere source for teaching elementary-level students about gypsy moths. Secondary-level instructors may find useful information to modify for their students. The unit consists of a section on rearing gypsy moth eggs to adult moths in addition to twenty lesson activities about gypsy moth biology.

Contact: Mr. Erik Mollenhauer
Project Director
309 Roosevelt Avenue
Pitman, New Jersey 08071

Full citation: Mollenhauer, E. (1990). The gypsy moth in the classroom. Broomall, PA: USDA Forest Service.

Legacy of a Pest: A Science, Technology and Society Curriculum Guide for Understanding and Dealing with Biological Problems

A curriculum guide designed to teach principles of taxonomy, ecology, and pest management using the gypsy moth as a model. Complete with fifty lesson activities, transparency masters, glossary and references.

Contact: Illinois Natural History Survey

Full citation: Case, L. J., J. L. Wissmann, & M. R. Jeffords. (1988). Legacy of a pest: a science, technology and society curriculum guide for understanding and dealing with biological problems. Illinois Natural History Survey Special Publication 9. Champaign, IL: Illinois Natural History Survey.

Entomology for Agricultural Science II Core Curriculum

Designed as a unit on entomology, this guide includes a section on integrated pest management. Other sections include an introduction to entomology, insect collecting, insect identification, control methods, and use of insecticides. The instructor's guide provides transparency masters, activity outlines, work sheets, and evaluation exercises where appropriate. The student guide provides background reading for each of seven lessons.

Contact: Instructional Materials Laboratory
University of Missouri-Columbia
10 London Hall
Columbia, MO 65211
(314) 882-2883

Full citation: DeFelice, K. L. (1991). Entomology for agricultural science II core curriculum. Instructor guide and student reference. Columbia, MO: University of Missouri-Columbia.

The Gypsy Moth: An Integrative Approach to Laboratory Science

Developed by the Cell and Molecular Biology department at Michigan State University, this guide teaches principles of biotechnology, natural history, molecular and cellular biology and ecology. It provides good suggestions for activities which give students applied practice in laboratory study and procedures.

Contact: Department of Cell and Molecular Biology
Michigan State University
Authors: Kathy Lovgren and Lynda Smith

Full citation: Lovgren, K. & L. Smith. (1992). The gypsy moth: an integrative approach to laboratory science. Department of Cell and Molecular Biology: Michigan State University.



References



These suggested references may assist instructors in finding additional content for lesson plans and will help students with class projects. Note that the references listed at the end of each lesson in this unit may be useful, but were included primarily for the author's documentation purposes.

Gypsy Moth Handbook

This publication, written for the general public, provides a good overview of gypsy moths in the United States—introduction to the U.S., identification and life cycle, and control techniques for homeowners. It also includes directions for building a birdhouse to attract birds that feed on gypsy moths.

Contact: The American Forestry Association
P.O. Box 2000
Washington, D.C. 20013
(202) 667-3300

Full citation: The American Forestry Association. (1989). Gypsy moth handbook. Washington, D.C.

Gypsy Moth Management in the United States: a Cooperative Approach. Final Environmental Impact Statement.

This is an excellent reference which gives a thorough account of the gypsy moth problem as an environmental issue. Environmental impact statements (EIS) in general are good references because their purpose is to educate the general public. This one provides non-technical and technical information in a clear, easy-to-read format and includes separate appendices on human health risk and ecological risk assessments.

Contact: local public library
or
National Gypsy Moth EIS Team
USDA Forest Service
5 Radnor Corporate Center, Suite 200
Radnor, PA 19087-4585
(610) 975-4150

Full citation: USDA Forest Service and Animal and Plant Health Inspection Service. (1995). Gypsy moth management in the United States: a cooperative approach. Final environmental impact statement, Vol. II. Washington, D.C.: U.S. Department of Agriculture.

Virginia Integrated Pest Management

This extension publication is a series of reports written by IPM specialists in Virginia. Reports include summaries of IPM programs in field crops, fruit and vegetable crops, forest crops and resources, ornamentals and urban IPM.

Contact: Virginia Cooperative Extension
Extension Distribution Center
Virginia Polytechnic Institute and State University
Blacksburg, VA 24061
(540) 231-6192

Full citation: Ravlin, F.W. (1993). Integrated pest management in Virginia. In Virginia Integrated Pest Management, C. Laub & F.W. Ravlin (Eds). Blacksburg, VA: Virginia Polytechnic Institute and State University.

Forest Trees of Virginia

Contact: Virginia Department of Forestry, Headquarters
Charlottesville, VA

Full citation: Virginia Department of Forestry. Forest Trees of Virginia. Publication #26. Charlottesville, VA.

The Gypsy Moth: Research Toward Integrated Pest Management

Full citation: Doane, C. C. and M. L. McManus (Eds). (1981). The gypsy moth: research toward integrated pest management. Technical Bulletin 1584. Washington, D.C.: U.S. Department of Agriculture.



World Wide Web (WWW) Sites



Access interesting sites about gypsy moth and integrated pest management on the World Wide Web. Home page descriptions and their Uniform Resource Locators (URLs) are listed.

GYPSY MOTH

Gypsy Moth/IPM Home Page—

<http://www.gypsymoth.ento.vt.edu/Welcome.html>

This site provides some of the most comprehensive information on gypsy moth in Virginia and regionally. It includes topics of general interest as well as more technical information for gypsy moth managers and researchers. Special features include a color slide set of damage and gypsy moth life stages; a directory of gypsy moth agencies, organizations and key contacts in Virginia; and color maps of gypsy moth populations.

Gypsy Moth in North America—

<http://gypsy.fsl.wvnet.edu:80/gmoth/>

This site, supported by the U.S. Forest Service, gives general information about the gypsy moth, including color photographs. It provides information about Forest Service-sponsored management and research programs and provides links to other gypsy moth, pest management and entomology resources.

Gypsy Moth News—

<http://gypsy.fsl.wvnet.edu/gmoth/gmnews/gmnews.html>

This site provides access to a quarterly newsletter which gives updates on management and research activities, technology development, and statistics. The newsletter is a good reference for research papers and projects.

Animal and Plant Health Inspection Service Plant Pests and Diseases gopher—

<gopher://hal.aphis.usda.gov:70/11/AI.d/PPDI.d>

This site provides a gopher menu of fact sheet files published by USDA APHIS. Three specific files provide information on gypsy moth:

- Asian Gypsy Moth
- APHIS Fact Sheet, Don't Move Gypsy Moth (brochure)
- Gypsy Moth: Slow the Spread.

The National Agriculture Library: Agricultural Images from Special Collections—<http://www.nal.usda.gov/speccoll/>

This site provides a source of insect, plant, and disease images in color and black and white.

INTEGRATED PEST MANAGEMENT

Virginia Tech Entomology Extension—

<http://www.ento.vt.edu/Main/ExtensionInfo.html>

This site gives brief facts about Virginia IPM programs and also provides a link to the Department of Entomology at Virginia Tech.

National IPM Network—<http://www.reeusda.gov/ipm/>

Sponsored by the Cooperative State Research, Education, and Extension Service (CSREES) of the U.S. Department of Agriculture, this is a central site for information on urban and agricultural IPM programs. Information for Virginia is found in the Southern region.



Electronic Discussion Groups



BugNet

BugNet is an electronic discussion group particularly geared for educators, students, and insect enthusiasts. Pose questions to professional entomologists. To subscribe, send an email message to

listproc@listproc.wsu.edu

Leave the subject line blank and in the body text type:

SUBSCRIBE BUGNET John Doe

where John Doe is your real name.

Suggested Topics for Student Projects



and Other Learning Activities



Topics

- Effects of *Bacillus thuringiensis* on non-target organisms
- Site susceptibility to gypsy moth damage
- Study of why gypsy moths prefer oak species.
- Field trip to infested area to observe life stages, feeding, defoliation, damage and to report observations
- Population status of Asian gypsy moth in the United States
- Gypsy moth effects on non-target organisms
- Oral/written report to local board of supervisors on status of gypsy moth in the county and what measures they can take to prepare for or manage infestations
- Gypsy moth newsletter or periodic article in student newspaper updating school community on the gypsy moth situation in their area.

Vita

Belinda Stone Carroll was born October 26, 1961 in Newark, Ohio but lived most of her childhood and teenage years in Chesterfield County, Virginia. After graduating from Thomas Dale High School in 1980, she pursued a degree in Forestry and Wildlife at Virginia Polytechnic Institute and State University (VPI & SU). She graduated in 1985 with a bachelor of science degree in Forestry and Wildlife and a minor in Horticulture. Following her degree work, Ms. Carroll worked as a farm manager with a family-owned business in Leesburg, Virginia which specialized in fresh market fruit, vegetable and greenhouse crops. In 1987 she returned to Blacksburg, Virginia where she worked in the Department of Entomology as a database manager for the Gypsy Moth Information Systems Group and as an extension assistant in the Gypsy Moth Integrated Pest Management Program. In 1990 Ms. Carroll began a master of science program in Vocational and Technical Education with a concentration in agricultural education at VPI & SU, where she developed a high school-level instructional guide on integrated pest management and gypsy moth, a project co-directed by the Agricultural Education Program and the Department of Entomology.

