PROCEEDINGS

OF THE TWENTY-FOURTH ANNUAL

WESTERN FOREST INSECT WORK CONFERENCE

Tucson, Arizona

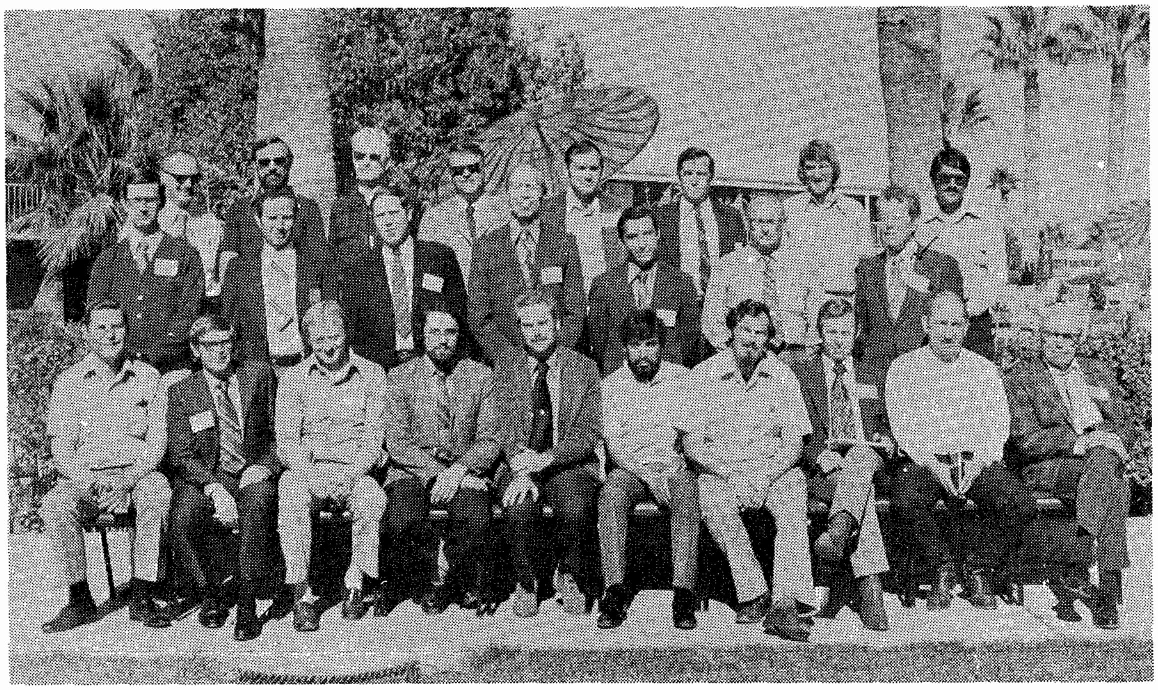
March 6-8, 1973

<u>Not for Publication</u>

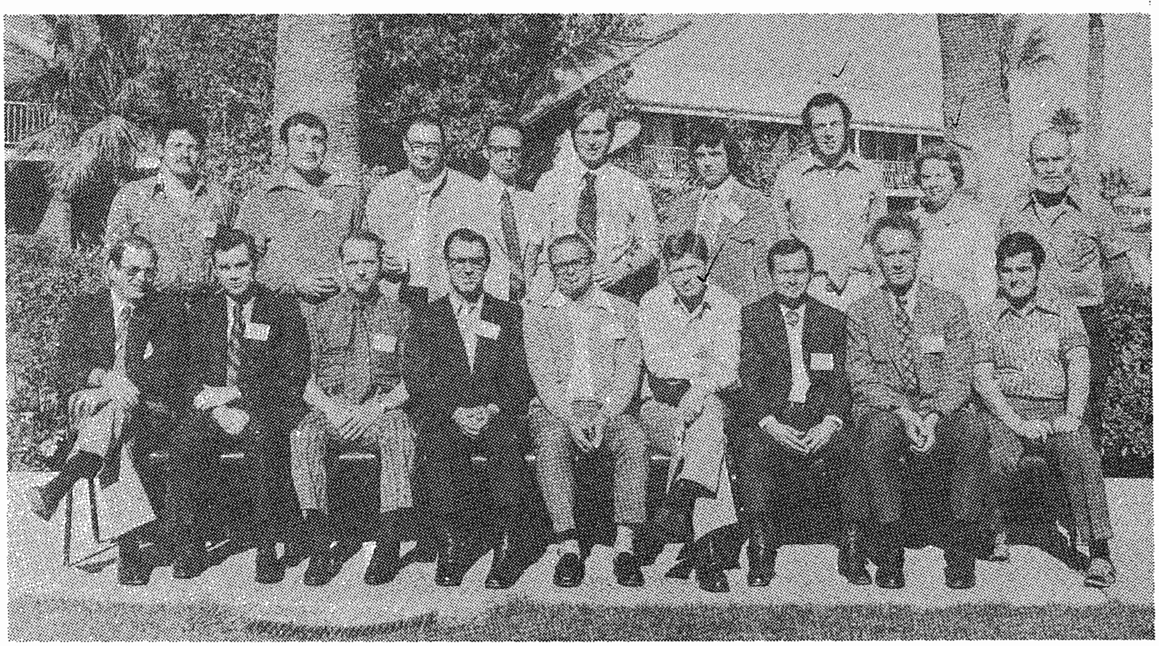
(For information of Conference Members only)

Prepared at

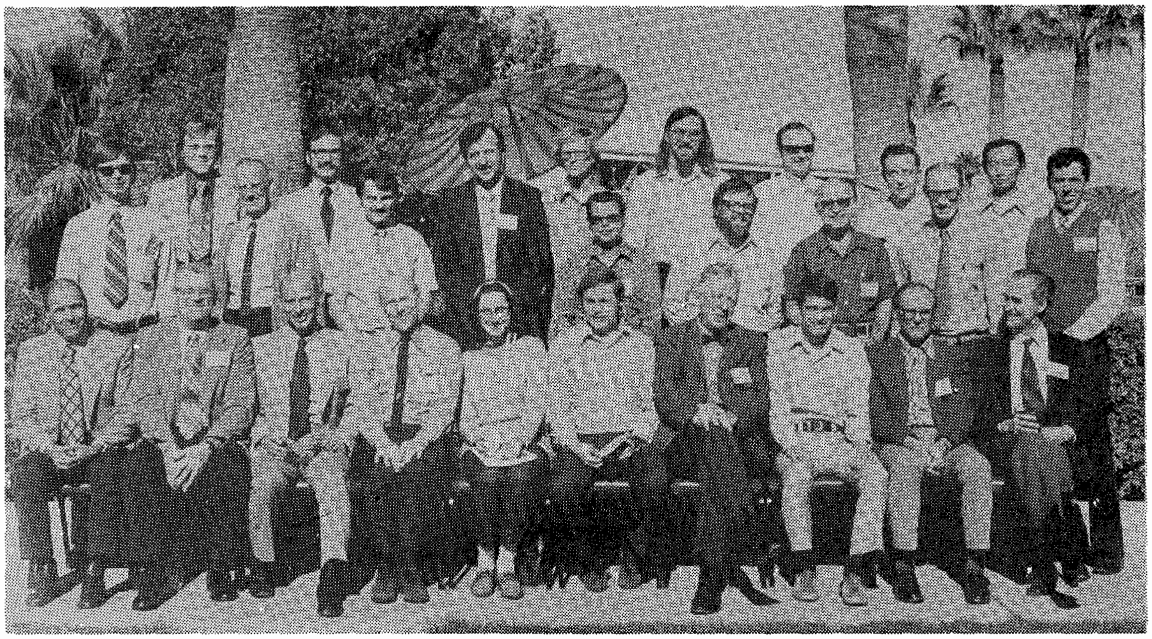
Shelterbelt Laboratory
Rocky Mountain Forest and Range Experiment Station
U.S.D.A. - Forest Service
Bottineau, North Dakota



Front row (L to R): Don Lucht, Wayne Brewer, Bob Stevens, Pete Murtha, Mel McKnight, David Cibrian, Lyne Marsalis, Grant Kinzer, John Schmid, Es Lampi; Middle row: Bob Acciavatti, Jed Dewey, Steve Kohler, Gerry Lanier, Steve Mata, Clifford Myers, Hec Richmond; Back row: Dick Washburn, Boyd Wickman, John Wear, Dan Jennings, Bob Loomis, John Laut, Lew Edson, Mike Chavez.



Front row (L to R): Bob Dolph, Ladd Livingston, Bill Kearby, Royce Cox, Stan Meso, Brian Dillistone, Pat Kennedy, Karel Stoszek, Ed Kettela; Back row: Charlie Russell, Jules Cayler, Dennis Hart, John Borden, Don Ostaff, Alan Cameron, Gordon Miller, Thelma Finlayson, N. Rae Brown.



Front row (L to R): Fred Honing, Harold Lembright, Galen Trostle, Tom Koerber, Judy Bodenham, Pete Johnson, Barney Flieger, Larry Yarger, George Downing, Doug Ross; Middle row: Arden Tagestad, Bob Fisher, Bob Frye, Bill Klein, Mike Atkins, Dave Wood, Rick Johnsey, Rod Carrow, Harold Osborne; Back row: Bruce Baker, Ken Lister, Larry Wright, Bob Bordasch, LeRoy Klein, John Schenk, Nit Kirtibutr.

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WESTERN FOREST INSECT WORK CONFERENCE
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EXECUTIVE COMMITTEE (Twenty-fourth Conference)

R. E. Stevens, Fort Collins	Chairman
D. L. Wood, Berkeley	Immediate Past Chairman
M. E. McKnight, Bottineau	Secretary-Treasurer
W. E. Cole, Ogden	Councillor (1970)
B. E. Wickman, Corvallis	Councillor (1971)
W. G. H. Ives, Edmonton	Councillor (1972)

R. H. Frye, Albuquerque — Program Chairman

EXECUTIVE COMMITTEE ELECT

R. E. Stevens, Fort Collins	Chairman
D. L. Wood, Berkeley	Immediate Past Chairman
M. E. McKnight, Bottineau	Secretary-Treasurer
B. E. Wickman, Corvallis	Councillor (1971)
W. G. H. Ives, Edmonton	Councillor (1972)
R. G. Cox, Lewiston	Councillor (1973)

D. L. Parker, Ogden — Program Chairman

Prepared by the Secretary-Treasurer from summaries submitted by panel and workshop moderators.

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PROGRAM

TWENTY-FOURTH ANNUAL WESTERN FOREST INSECT WORK CONFERENCE
Hilton Inn, Tucson, Arizona, March 6-8, 1973

<u>Monday, March 5</u>

4:00-8:00 p.m.	Registration
8:00 p.m.	Executive Committee Meeting

<u>Tuesday, March 6</u>

8:00-9:00 a.m.	Registration
9:00-10:00 a.m.	Initial Business Meeting
10:00-10:30 a.m.	Coffee
10:30-11:30 a.m.	The U. S. Forest Service Gypsy Moth Research and Development Program Speaker: Jim Bean, Northeastern Forest Experiment Station, Hamden, Conn.
11:30 a.m.-1:00 p.m.	Lunch
1:00-3:00 p.m.	<u>Panel</u>: Net Impact of Forest Insects Moderator: Bill Klein, U. S. Forest Service, Ogden, Utah Panelists: Bill Klein, Mountain Pine Beetle-Lodgepole Pine Bill Ciesla, U. S. Forest Service, Missoula, Mont., Spruce Budworm-Douglas-fir, True fir Dennis Hart, U. S. Forest Service, San Francisco, Calif., Western Pine Beetle-Ponderosa Pine Robert Dolph, U. S. Forest Service, Portland, Ore., Douglas-fir Tussock Moth-Douglas-fir George Downing, U. S. Forest Service, Denver, Colo., Spruce Beetle-Engelmann Spruce Karl Stoszek, Weyerhaeuser, Klamath Falls, Ore., Western Pine Shoot Borer in Plantations
3:00-3:20 p.m.	Coffee
3:20-5:00 p.m.	<u>Concurrent Workshops</u>: 1. Methods of Measuring Impact Moderator: Cliff Myers 2. Urban Forest Insect Problems Moderator: Wayne Brewer 3. Effect of Host on Insect Populations Moderator: Alan Berryman 4. Technician's Role in Forest Entomology Moderator: Arden Tagestad
6:00-7:30 p.m.	Social Hour

Wednesday, March 7

8:30-10:00 a.m.	Panel: International Biological Program Moderator: Dave Wood, University of California, Berkeley Panelists: Ron Stark, University of Idaho Bob Coulson, Texas A&M Alan Berryman, Washington State
10:00-10:20 a.m.	Coffee
10:20-12:00 m.	Concurrent Workshops: 1. Pros and Cons of the Trend Toward Large Pest Management Research and Development Programs Moderator: Boyd Wickman 2. Cacodylic Acid Moderator: Ken Lister 3. Problems in Insect Identification Moderator: Mel McKnight 4. Uses and Applications of Infrared Photography Moderator: Pete Murtha
12:00 m.-1:30 p.m.	Lunch
1:30 p.m.	Choice of Bus Tours 1. Arizona-Sonora Desert Museum and Saguaro National Monument 2. Southern Arizona and Nogales, Mexico

Thursday, March 8

8:30-10:00 a.m.	Panel: Forest Lepidoptera Pheromones Moderator: Al Cameron, Pennsylvania State Panelists: Iain Weatherston, Insect Pathology Research Institute, Sault Ste. Marie, Ontario, Canada Daniel Jennings, U. S. Forest Service, Albuquerque, N. Mex. Boyd Wickman for Gary Daterman, U. S. Forest Service, Corvallis, Ore.
10:00-10:20 a.m.	Coffee
10:20-12:00 m.	Concurrent Workshops: 1. Forest Insect Pheromones Moderator: John Borden 2. Seed and Cone Insects Moderator: Jed Dewey 3. Value of Visual Aerial Detection Surveys Moderator: George Downing
12:00 m.-1:00 p.m.	Lunch
1:00-3:00 p.m.	Concurrent Workshops: 1. Preventive Sprays and Individual Tree Protection Moderator: Galen Trostle 2. Ground Survey Methods for Bark Beetles Moderator: Bill Klein 3. Eastern and Western Spruce Budworm Suppression Moderator: Dick Washburn
3:00-3:30 p.m.	Coffee
3:30-4:30 p.m.	Final Business Meeting

MINUTES OF EXECUTIVE COMMITTEE MEETING
March 5, 1973

The Executive Committee was called to order by Chairman Bob Stevens in Room 151, Hilton Inn, Tucson, at 8:30 pm.

Present were McKnight, Woods, Wickman, Ives, Frye, Laut, Trostle, Lucht, and Wilford.

The minutes of the final business meeting of the 1972 Work Conference were read. The Treasurer reported a balance of $949.51 on hand.

The site of the 1974 Work Conference was discussed. Trostle provided details on the tentative meeting site in the Salt Lake City area and Douglas Parker was named as Program Chairman.

The proposed meeting with the Western International Forest Disease Work Conference was discussed. Wickman extended an invitation to hold the meeting in the Portland area. It was the consensus of the Executive Committee that Chairman Stevens should negotiate with the Executive of the Western International Forest Disease Work Conference with regard to date, place, and program co-chairman.

Boyd Wickman reported for Roy Sheperd that nothing can be accomplished regarding the publication of the Bibliography in the revision of "Insect Enemies of Western Forests" until after July 1, 1973. Stevens appointed Wickman to keep in touch with Furniss's work and report to the Work Conference.

A discussion followed concerning payment of travel expenses for keynote speakers. The Executive Committee recommends that it be authorized to pay travel expenses of keynote speakers within the limits of its resources.

There being no further business the meeting was adjourned at 10:00 pm.

MINUTES OF INITIAL BUSINESS MEETING
March 6, 1973

The 1973 Western Forest Insect Work Conference was called to order by Chairman Bob Stevens at 9:15 am in the Williamsburg Room, Hilton Inn, Tucson, Arizona.

Harold Flake welcomed the Work Conference to the Southwestern Region. New members of the Work Conference were introduced and welcomed.

The minutes of the final business meeting of the 1972 Work Conference were read and accepted. The minutes of the Executive meeting of March 5, 1973 were read. The treasurer reported a balance of $949.51 on hand before the opening of Registration.

Boyd Wickman reported that the first draft of Furniss's revision of "Insect Enemies of Western Forests," is expected about July 1, 1973.

A discussion of payment of travel expenses for keynote speakers followed. Alan Berryman suggested that reduction of registration fees would be an alternative use of the present Treasury. Galen Trostle made the point that publication of the Proceedings is sometimes a potential cost to the Work Conference.

Tom Koerber reported that the 1971 and 1972 Proceedings should be distributed in a couple of months.

Jim Bean alerted SAF members to a forthcoming request for suggestions to strengthen the Fire, Insects, and Diseases Section of SAF.

Program Chairman Bob Frye made announcements concerning arrangements for the 1973 meeting and suggested that Rich Johnsey serve as chairman of the Ethical Practices Committee as replacement for Paul Buffam.

There being no further business the meeting was adjourned at 10:00 am.

The USDA Forest Service
GYPSY MOTH RESEARCH AND DEVELOPMENT PROGRAM

James L. Bean, Northeastern Forest Experiment Station
Hamden, Connecticut

THE UNITED STATES Department of Agriculture has identified the gypsy moth as a priority insect pest and, with funds provided by Congress plus reprogramming within the Forest Service, has undertaken a 5-year research and development (R&D) program designed to develop, demonstrate, and provide the technology needed to minimize the gypsy moth problem. This program is scheduled to end in 1976.

First I will give you a brief birds-eye-view of the gypsy moth itself and some of the major reasons why we have a gypsy moth R&D Program.

A Direct Threat

The gypsy moth was introduced into the United States in the vicinity of Boston, Mass., in 1869 or thereabouts. Since that date, it has spread, over the years, until it now generally infests all the states in the Northeast and is spreading west and south through western Pennsylvania, West Virginia, Maryland, and Delaware (fig. 1). Infesta-

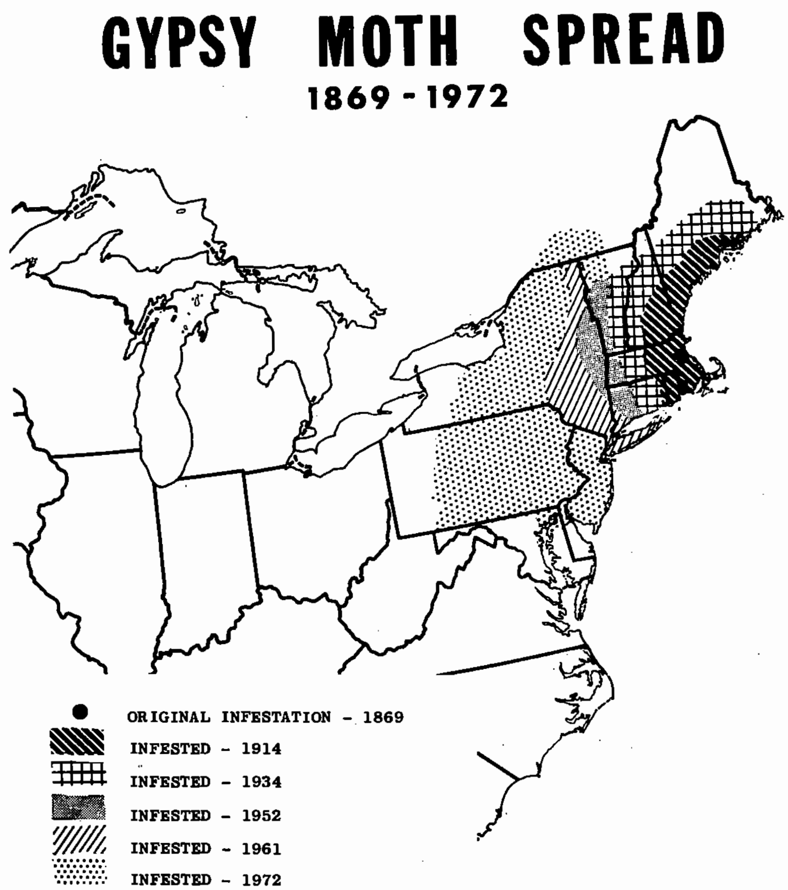

Figure 1.--Gypsy moth defoliated areas, 1972

tions have also been found in southern Ontario along the Vermont-New York border. The forest resources of the entire eastern United States are directly threatened by this pest. Attempts to control and prevent spread of this insect were begun in the late 1800's and have continued to the present time with varying degrees of success.

The gypsy moth larvae feed on the foliage of more than 500 species of plants in the Northeast alone, including coniferous species and shrubs. However, the favored foods are the oaks. Tree mortality may be initiated with one defoliation. Oak mortality of 50 percent or greater can be experienced after two or three consecutive years of defoliation.

Data taken during outbreaks of the gypsy moth between 1911 and 1931 showed that stand composition can be greatly modified because of tree mortality induced by gypsy moth defoliation. Defoliated trees, when not killed outright, are more susceptible to attack by secondary insects and diseases.

In addition to the direct effects of the gypsy moth on trees, the presence of the larvae has several social and economic ramifications. Yards, playgrounds, and other recreational areas such as parks and picnic areas cannot be used when large numbers of gypsy moth larvae are present. The sight of so many hairy caterpillars is revolting, and the larval hairs may have an allergenic effect on some people.

In wooded communities during severe outbreaks, the larvae will crawl over the walls of houses, seeking places to pupate. As they crawl, they deface the house with frass, strands of silk, and later with pupal cases and egg masses. People living in these wooded communities of the Northeast face the problem and expense of removing or treating dead and weakened trees in and around their yards. Communities throughout the infested area hold meetings annually to decide whether to take community action to control the gypsy moth.

During each of the past two summers, noticeable to heavy defoliation has occurred on more than 2 million acres throughout the Northeast. Both natural spread and man-caused spread of the gypsy moth on recreational vehicles and commodities makes it critical that new ways to manage this pest be developed within the next few years if we are to minimize its spread and reduce its impact on people and on the environment.

Approach to the Problem

Early in 1968, because of the public controversy that raged over ways to cope with the gypsy moth problem, a group of concerned state officials formed the Gypsy Moth Advisory Council to seek Congressional support for a scientific approach to the problem. The current gypsy moth R&D Program is the outgrowth of this action.

Four USDA agencies participate in this program: the Forest Service (both Research and Forest Pest Management); Animal and Plant Health Inspection Service; Agricultural Research Service; and the Extension Service. In addition, the Department has appointed a Program Coordinator who is responsible for the coordination of all gypsy moth R&D activities that are funded entirely or in part with Federal funds.

The Department, in cooperation with state and private agencies, is now involved in a comprehensive, flexible, and ecologically sound R&D program aimed at an integrated management system for the control of the gypsy moth.

The objective of this program is to provide the knowledge and technology for an integrated management system to minimize the spread of the insect and reduce its impact to tolerable levels. The major effort is directed at biological and other alternative controls that will have minimal adverse effects on non-target organisms and the environment in general.

The gypsy moth R&D program is both multiproject and multifunctional in scope and complexity. It will require the judicious use of the people, money, time, and facilities that are and will be available if we are to meet the program objective by 1976. The ARS/FS gypsy moth R&D funding for 1972-76 is as follows:

Integrated control elements	Estimated 5-year totals
Assessing and predicting population & impacts	$2,430,000.
Chemicals:	
Toxicants	410,000.
Disparlure	955,000.
Chemostimulants	955,000.
Microbials:	
Virus	1,235,000.
Bt	290,000.
Parasites	1,200,000.
Predators	715,000.
Sterile-male release and mass rearings	700,000.
Total	$8,890,000.

The Northeastern Forest Experiment Station's input into the Department's R&D program will be mainly in the following elements: assessing and predicting population trends and impact; field-testing chemical toxicants for efficacy data; microbials, mainly viruses and Bt; and vertebrate predators. We will also have limited input into some of the other research elements. The Station's contribution to the program is as follows:

Fiscal-year	
1971	
Base	$431,000.
Reprogrammed ARS monies	443,100.
Total	$874,100.
1972	
Base	$725,000.
Reprogrammed ARS monies	435,000.
Total	$1,160,000.
1973 (estimated)	
Base	$879,000.
Reprogrammed ARS monies	493,000.
Total	$1,372,000.

Program Manager Appointed

The Northeastern Station has committed the entire Hamden, Conn., laboratory facility and staff to this effort. Five research work units with a total of 20 scientists and 16 technicians plus support personnel have been assigned to work full-time on this Program. Individual scientists from other work units, from other Stations, and from the Washington Office can and have been called on for their expertise on segments of the problem when and as needed.

A Program Manager has been appointed to provide the administrative and technical leadership a program of this magnitude requires. Also to permit the maximum flexibility in combining Forest Service funds, scientists, and facilities, and to change these combinations when and as the program needs dictate.

Fortunately, or unfortunately, this is where I enter the picture. As Program Manager, I am responsible for planning, executing, and coordinating all Forest Service research on the gypsy moth.

The complexity of the management problems that make up this program of operation is illustrated by the flow diagram (fig. 2). The operational system shown here can be modified with time to reflect the current state of knowledge and relations among team members and with our public and external cooperators.

Let me quickly cover some of the components of this operational system. The functions of the Station Director, Program Manager, NA, S&PF Forest Pest Management and Projects should be readily apparent (fig. 3). However some of the others may need some explanation:

USDA Coordinator.--The Department has appointed a special Coordinator (Leo Iverson) who will be responsible for the coordination of all Department R&D programs and for determining whether the programs meet the proposed objective of the Department's gypsy moth R&D effort. He is also in the position to determine if Federal funding for the R&D program is adequate and properly allocated.

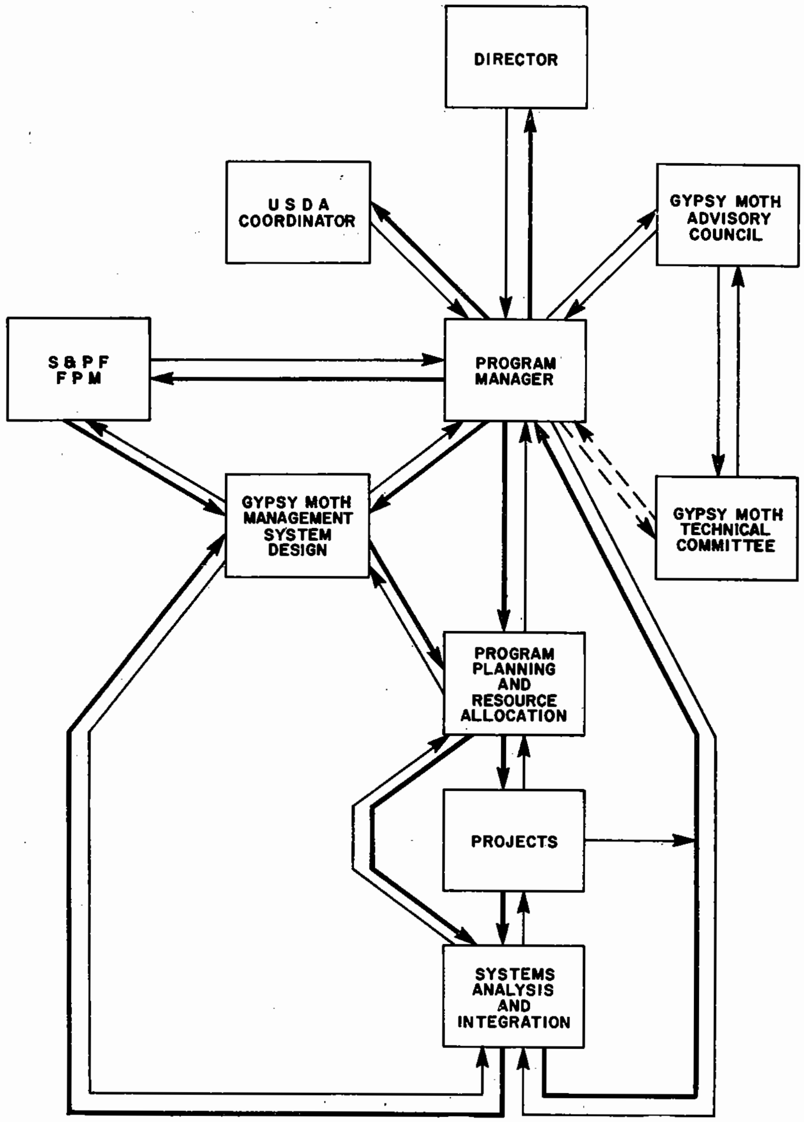

Figure 2.--Operations system for the Hamden Laboratory gypsy moth R&D program.

Gypsy Moth Advisory Council and Technical Committee.--The Advisory Council was formed by a group of citizens, public and private, who were concerned over the rapid spread of the gypsy moth. The Council was primarily responsible in getting the current R&D program off and running.

The Technical Committee provides the Advisory Council with technical reviews of current and planned R&D programs.

Gypsy Moth Program Coordination within NEFES

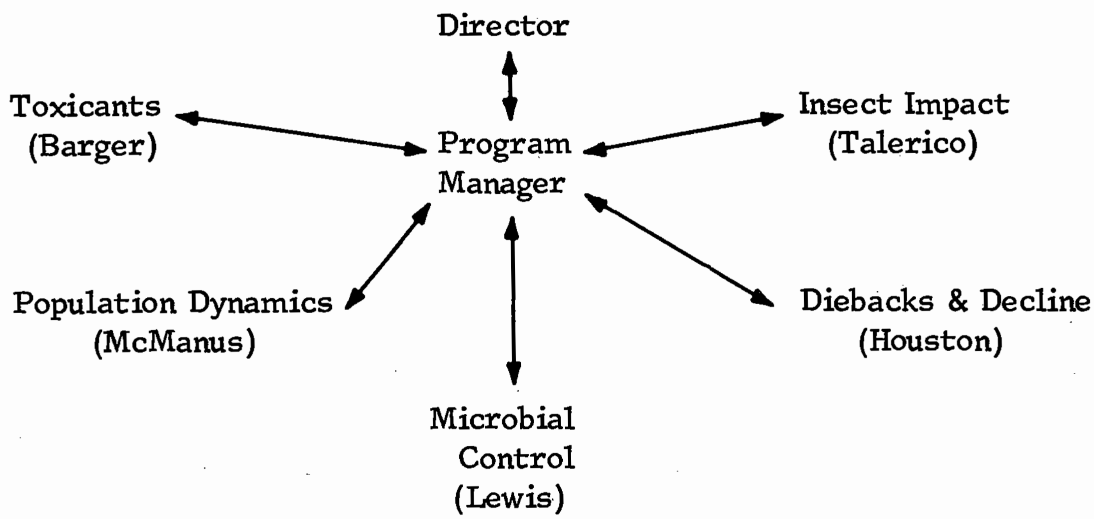

Figure 3.--Research work units and project leaders assigned to the R&D program.

Program Planning and Resource Allocation Team.--The Program Manager, project leaders (4), systems analyst, and the administrative officer (RSS) form this team. The responsibility of this team is to maintain and up-date the Station's master research plan, determine additional research needs, and allocate resources (funds, equipment, and manpower) to get the required research completed as planned.

Systems Analysis and Interpretation Team.--The systems analysis and the Programmer, along with two other project scientists, with background and experience in systems design and modelling, make up this team. They are responsible for analysis of research results and simulation of forest/gypsy moth systems from these data, and for comparison and evaluation of the preliminary management systems design.

Management Systems Design Team.--This team will be composed of representatives from Forest Pest Management--both NA and SA, NE Forest Pest Council (State), private timberland owner, National Forest System, project leader (2201), our systems analyst, and myself. This team will be instrumental in development of the preliminary design of the integrated gypsy moth management system. They will provide input on state and federal policies related to treatment methods, pest management requirements for suburban areas as well as for commercial timber and recreational and other use areas, and how the final management system may be carried out.

In general, the Northeastern Station's R&D program can be separated into the following broad categories:

1. Acquisition of a data base on population dynamics.
2. Development of alternative controls for integrated approach.
3. Measuring of impact.
4. Continuing laboratory research on biology and behavior.

Plot Systems

The gypsy moth is known to exhibit an extraordinarily wide range in population trends from a given set of preconditions. In essence, any population level can result from any prior population level. Therefore a prediction system that is based upon data from one restricted area--and may work well within that area--may have little operational value in other areas. This emphasizes the need for obtaining population-dynamics data simultaneously over a broad geographical area, for a period of years.

To achieve this goal, we need to integrate data about the gypsy moth, the hosts, and the ecosystem so that we can:

1. Predict trends in gypsy moth population.
2. Predict resulting damage or impacts on the environment.
3. List the benefits to be achieved by a variety or combination of treatments, or no treatment at all.

To acquire this data base in a meaningful way, we have established a system of plots in several of the Northeastern states. The extensive plot system is one of these.

Between 1911 and 1931, the Melrose Highlands Gypsy Moth Laboratory (operated by the old B.E. & P.Q.) established a number of plots along the seaboard of eastern New England from Massachusetts to Maine, to observe trends in gypsy moth populations and to record damage resulting from this defoliation.

Recently, these data were rediscovered by Bob Campbell. They were processed along with weather data; and a series of predictive equations were developed for forecasting, on an annual basis, the following variables: (1) trend in egg mass numbers, (2) defoliation, (3) tree condition, (4) tree mortality, and (5) annual increment.

In cooperation with FPM and State agencies, the extensive plot system was established in the New England States, New Jersey, New York, and Pennsylvania, where field data are collected annually to test the validity of Campbell's prediction system when applied to current data. This will be a 5-year study.

The intensive plot system is the second plot system. In 1972, six study areas were established, one in each of these locations: Cape Cod and Ludlow, Massachusetts; Whitehall and Cobleskill, New York; and Pittstown and New Lisbon, New Jersey. These areas were chosen because of their geographical and plant diversity; Cape Cod and the Pine Barrens of New Jersey simulate southern penetration. Data on the following will be collected from permanently established study sites within each area over the next 5 years.

(1) Life table data, to elucidate the various mortality-causing factors and to determine survivorship; (2) mortality data, the proportion of the gypsy moth killed by parasitoids, predators, and disease complex, individually and collectively; (3) predator data, to obtain an index of the relative densities of vertebrate and invertebrate predators within and between plots; and (4) weather data, to characterize the areas climatically, and to provide a data base for ecological interractions.

Finally, the suburban plot system. Data from a variety of sources indicate that the dynamics of a system of gypsy moth populations may be profoundly influenced by human activities in the suburban environment. Conversely, human concern with the consequences of gypsy moth activities has been far more intense in the suburban communities than in either rural or urban areas--at least in recent years.

Considering the above with the unpublished observations of virtually everyone who has watched gypsy moth densities change from year to year in suburban areas, and we find that most agree that gypsy moth densities are much higher, during incipient outbreak periods, in and near people's yards than they are in adjacent woodlands. These facts and observations suggest that gypsy moth survival rates may be directly related to human activities. Consider, for example, that in new developments, tree-clearing for homes in wooded areas usually results in the removal of understory trees (often non-preferred hosts) in favor of the large mature or overmature oaks (preferred hosts), which are more likely to have many natural resting locations for late-stage larvae. Also, in the Northeast, stone walls and and woodpiles are associated with homesites, and these are perfect natural hiding places for the late-stage larvae and resultant egg masses. Furthermore, suburban dwellings have populations of domestic animals, which play a big role in holding down some of the important gypsy moth predators.

Methods of Control

What about our R&D program on alternate methods of control? The Hamden Laboratory is currently involved in three study areas on microbials, in search for potential pathogens: evaluation of Bt in gypsy moth control, development of the nuclear polyhedrosis virus of the gypsy moth as a potential control agent, and determination of the natural disease complex of the gypsy moth.

Bacillus thuringiensis has been around for a long time and has been used on a variety of agricultural crops. However, its use in forest situations is still being evaluated. The evaluation of Bt when applied from the ground for the gypsy moth was completed in 1971. Forest Service, ARS, and the states of New Jersey, Massachusetts, and Pennsylvania cooperated and, based on results, Bt is now registered for ground application to achieve foliage protection.

During 1972, we evaluated aerial applications of different formulations of Bt for gypsy moth. Analysis of results are not complete, but Bt should soon be registered for aerial applications.

Although Bt will protect foliage, it does not seem to effect much of a population reduction. In addition, two sprays are often required to achieve a level of protection comparable to that achieved with Sevin or Dylox. This creates a cost factor because a single application of Bt is more expensive than that of currently used pesticides. In Connecticut, the average comparison is $30 to $35 for Sevin, and $60 + for Bt.

Gypsy moth nuclear polyhedrosis virus has been recognized in infestations since 1900 and was commonly called "wilt disease" because of the collapse of the larvae on the host trees. There are recognized strains of the virus, and the virulence of the strains is variable. The Russian and U.S. strains are the most potent. [Even the gypsy moth is getting involved in world politics.] There is an 80 to 90 percent reduction in virulence of the U.S. strain within 24 hours of application. The Hamden Lab has the responsibility of developing and producing a more virulent U.S. strain.

One of the most important aspects of our virus studies is registration. Few or no protocol have been established for registration of viruses. The most advanced are those for the Heliothis virus.

A total of 2 or 3 years is required for safety tests and efficacy data. The 2-year carcinogenic test alone will cost $35,000. We are currently waiting for guidelines from the EPA on establishing a protocol for virus testing. When this occurs, about one additional year of tests will be required. From start (isolation) to finish (registration), a virus will cost about $1-1/2 million and will take 5 to 8 years. For comparison, it is estimated that a new pesticide would cost around $15 million.

How can we best use viruses in an integrated management system? Based on present knowledge, it may be better to find alternatives to broadcast spraying. For example, the virus may be disseminated by using parasites as vectors, or it may be introduced in a gypsy moth population via diseased insects (larvae).

With regard to Bt and the virus, we must eliminate the idea of dramatic suppression as was characteristic of pesticide application. Foliage protection is the immediate goal, but microbials can be used in combination with other techniques; i.e. true integrated control. However, there must be greater emphasis on timing and methods of applying microbials.

This past summer a massive screening of diseased insects collected from the intensive plot system was conducted by the Hamden Lab. The objectives of this study were to find out what natural pathogens are active in diverse populations, to isolate those that exhibit pathogenicity, and to evaluate these through feedback trials.

More than 43,000 diseased individuals were collected in the study plots and were intensively autopsied.

Although the virus is commonly found, the importance of bacteria in larval mortality is obvious and probably underrated. The protozoa are relatively unimportant. During this study a cytoplasmic polyhedrosis was isolated for the first time in this area.

<u>Parasites and Predators</u>

For many years, parasites have been introduced into the U.S. for gypsy moth control. Several species are now established. Part of the problem has been the evaluation of parasite effectiveness.

The objectives of our parasite studies are:

1. To develop methodology for sampling gypsy moth life stages in the field for parasitoid recovery.
2. To evaluate parasitoid activity within the intensive plot system.
3. To develop taxonomic keys for parasite immatures in cooperation with the U.S. National Museum.
4. To conduct detailed behavioral studies on the most promising species of parasitoids.

This past season, more than 113,000 gypsy moth larvae, pre-pupae, and pupae were collected within the plot system and reared for parasite emergence. Analysis of these data is still pending.

The lack of suitable keys for parasite immatures, especially dipterous larvae, required that gypsy moth larvae be reared until parasite development was complete. This was time-consuming and reduced overall effectiveness.

One of our major concerns is the mass release of native exotic species of parasites without proper evaluation of their effectiveness. New Jersey has been rearing and releasing parasites for almost 10 years. Now, as the gypsy moth spreads south, many other states are actively going into the parasite rearing and releasing business, but we still lack the most basic tool for evaluating the results of these introductions.

Some of the early spectacular successes of biological agents such as parasites set high standards so that ultimate control is expected. This is unfortunate. We should recognize the importance of partial control, which could reduce the frequency, duration, or severity of damage. Complete control by a single biological agent is not compatible with our increasing knowledge of population dynamics.

Unlike the parasitoids that usually have a relatively restricted range of types of prey, most forest invertebrates consume a wide array of food material. They are also, in general, highly discriminate in their choice of food, and their choice may not always be in the interests of controlling a specific noxious pest. On the other hand, they may respond to population increases of a specific insect to the advantage of the forest managers. What is required is a much wider description of the foods and feeding habits of as many invertebrates in the ecosystem that may be of importance to the management of the gypsy moth. This we are attempting to do.

Our research on other predators of the gypsy moth is directed to the evaluation of vertebrates, especially the white-footed deer mouse (Peromyscus) and birds.

Life-table data from sparse gypsy moth populations in Connecticut revealed that the white-footed deer mouse was primarily responsible for maintaining the gypsy moth at low levels. When the mice were excluded from the test area, the trend in numbers of the insect increased dramatically. Our research effort here is designed to monitor mouse populations; i.e. to determine the population dynamics of the white-footed deer mouse and to elucidate the mortality factors that affect its abundance in natural situations.

To obtain this data, a transistorized thermal switch was developed that can be implanted in the mouse. When the mouse dies, either from natural causes or as a result of a mortality agent, the body temperature is lowered, activating the thermal switch and then producing a signal that can be picked up with a portable receiver. This procedure was tested on a small island with multiple mouse releases, and all the test individuals were recovered and analyzed, and cause of death was determined. Laboratory tests have also been run concurrently on evaluating the behavior, activity, and development of implanted individuals and their progeny.

The occurrence of bird species and their importance as gypsy moth predators is also being evaluated. Ten specimens each of 11 species were sampled during the 1972 season, and their stomach contents were analyzed for presence of various gypsy moth life stages.

Although the presence of the larval stages in birds' stomachs can be readily determined, estimating the volumes or percentages of the components is difficult. This study is continuing.

Impacts

Although gypsy moth larvae feed on a variety of plant species, they cannot survive on some species such as white ash and yellow-poplar. A research grant has been awarded to a biochemist at Ohio State University to isolate fractions from foliage of these and other plant species for possible inhibitory effects. These fractions are sent to our Hamden Lab, where they are bioassayed against the larvae.

One problem inherent to this type of study is to determine if the lack of feeding is a result of a real inhibitory effect or the lack of a suitable feeding stimulant.

Four categories of plants have been identified: (1) those that stimulate feeding (oaks, black locust, and honeylocust); (2) those that lack feeding stimulants (ash, which seems more like a deterrent); (3) a synergist, mulberry, (which has no effect by itself but increases feeding when mixed with oak diet); and (4) a deterrent, true inhibition such as yellow-poplar and catalpa. We are currently including southern tree species in these studies.

Pesticides have been the mainstay in the battle against the gypsy moth and will continue to play a role in any integrated management schemes for this insect. APHIS and the Forest Service are cooperating in the screening and field-testing of candidate compounds for use against the gypsy moth. More than 75 materials were screened during this past year; and only one, Zectran, seems to be promising. Lack of funds prevented us from field-testing Zectran this season.

Disparlure, the synthetic sex attractant of the gypsy moth, was isolated by Dr. Morton Beroza of ARS. It is an excellent mimic of the natural material emanated by the flightless female to attract the male moth. This is a potentially effective tool, but a lot of research remains to be done to make practical use of it. Extreme caution must be exercised and emphasized. Dr. Cameron is currently involved in research on this material.

Measuring impact is another of our major R&D efforts.

Pests affect the uses, values, and productivity of forests in many ways. With a defoliator such as the gypsy moth, we usually consider defoliation and tree mortality as impacts. However, the gypsy moth, like many forest pests, has ecological, economic, and sociological impacts on all aspects of private and public forest resources.

These may range from timber loss to missed recreation time to aesthetics (fall color) to the cost of tree removal on private lands. There is a general lack of data and methodology for predicting changes in impact--and this depends on having knowledge of what the impact would be if no control were applied. Our lack of information about impact became evident during the preparation of the environmental statement for anticipated control projects. We are moving to correct this situation.

Forest Service researchers and pest management specialists are combining to quantify aspects of socio-economic impacts.

Cooperative studies on the two-lined chestnut borer, historically a major cause of oak mortality in the Northeast following defoliation, are being conducted at the State University of New York College of Forestry at Syracuse.

The objective is to understand and predict decline and mortality of oaks based on a knowledge of the population of *Agrilus bilineatus* and its mechanism of attack in weakened trees.

Effects of Defoliation

The effects of defoliation on the vigor or physiological condition of trees are being evaluated by our Forest Pathology Project. There are two broad objectives within the scope of these studies. One is to evaluate the ecological effects of defoliation by the gypsy moth; the other is to determine the physiological effects of gypsy moth defoliation on trees.

The ecological evaluation consists of comparing forests in Massachusetts (old gypsy moth country) that have experienced recent severe defoliation with similar stands in New Jersey and Pennsylvania (new infestations) to determine if and why tree mortality differs in these diverse areas.

Old areas such as the Melrose, Mass., plots that were intensively studied and for which we have good records, will be examined to determine the long-range (successional) effects of severe gypsy moth defoliations.

One of the most promising aspects of the defoliation studies is the use of root starch reserves as an indicator of the physiological condition or vigor of forest trees. When trees are defoliated, they respond by refoliating or putting out a second flush of leaves in mid-summer. This process apparently reduces the starch reserves in the roots and weakens the tree, making it more susceptible to secondary invaders such as *Armillaria* root rot and the two-lined chestnut borer. This indicator would be an invaluable tool for predicting tree decline and mortality after defoliation.

In conjunction with this, scientists at the University of New Hampshire are using electronic devices as a non-destructive technique for measuring the response of trees to defoliation. Defoliation initiates several and often massive biochemical changes in stems and roots of trees. This study is designed to relate the electrical properties of trees to their physiological responses to defoliation by measuring the biopotential and resistivity of tissues known to change biochemically following defoliation. It entails both remote continuous monitoring and spot measurements of these changes in different trees.

Similar studies have shown great promise for a non-destructive method of determining the degree of discoloration and decay in living trees.

Supporting our overall R&D program are a number of on-going research activities on the biology and behavior of the gypsy moth. I'll quickly outline a few of these.

A dispersal model is being developed by Dr. McManus for predicting the projected pattern of spread of newly hatched larvae from a known source population (fig. 4). This is being done in cooperation with the IBP aerobiology program.

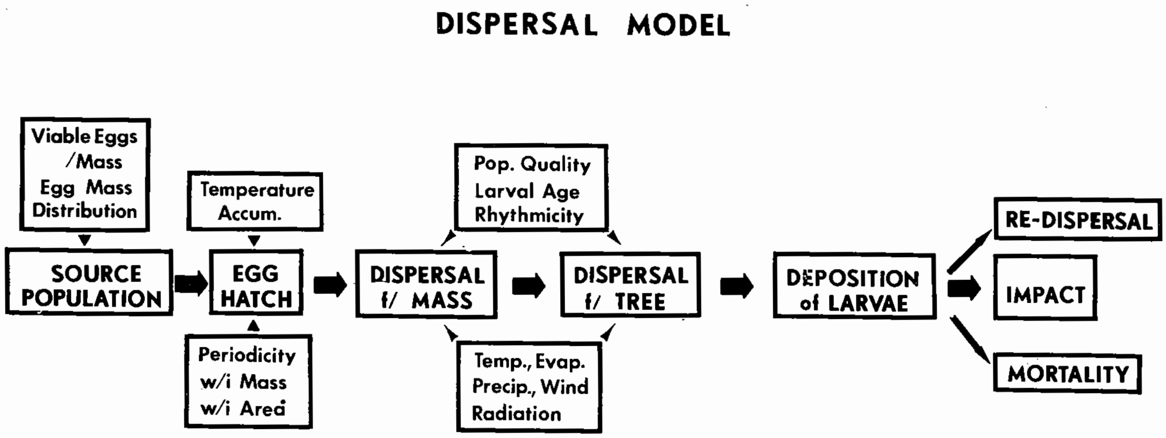

Figure 4.--A dispersal model for predicting the spread of newly hatched larvae.

Laboratory studies to determine the responses of the larval instars to regimes of temperature, evaporation, and light will be initiated in the near future. Data on this are essential to our understanding the effects of weather on population dynamics of the gypsy moth.

An improved sampling scheme for the gypsy moth is being developed by researchers at Pennsylvania State University through a Forest Service cooperative agreement. Our procedures of sampling egg masses alone have not resulted in accurate predictions of either insect abundance or resultant defoliation. We hope, a design that incorporates sampling multiple life stages will be developed.

And finally, to wrap up the R&D program, comes the compilation of all field and laboratory data into a management system model--our ultimate R&D goal.

Mathematical models are really mathematical statements that make biological sense, that attempt to mimic the numerical changes that occur in natural populations, and by which quantitative predictions can be made.

These models are based on life-table data (or knowledge of population dynamics) and are used to predict pest population densities and trends. The observed population densities and trends are compared to those that were predicted, and the accuracy of the model is evaluated. This is the only scientific way of demonstrating how much or how little is understood about the population dynamics of the pest species.

Another main use is to calculate and test the best tactics or strategy for pest management.

In short, these models are the only way we can evaluate the effects of a multitude of environmental factors and their interactions.

We have on our staff a systems analyst who will be responsible for the development of our R&D systems model. The overall concept of our proposed gypsy moth management system design may best be illustrated by figures 5, 6, 7, and 8.

SYSTEMS MODELS DEVLOPMENT
OVERALL CONCEPTS

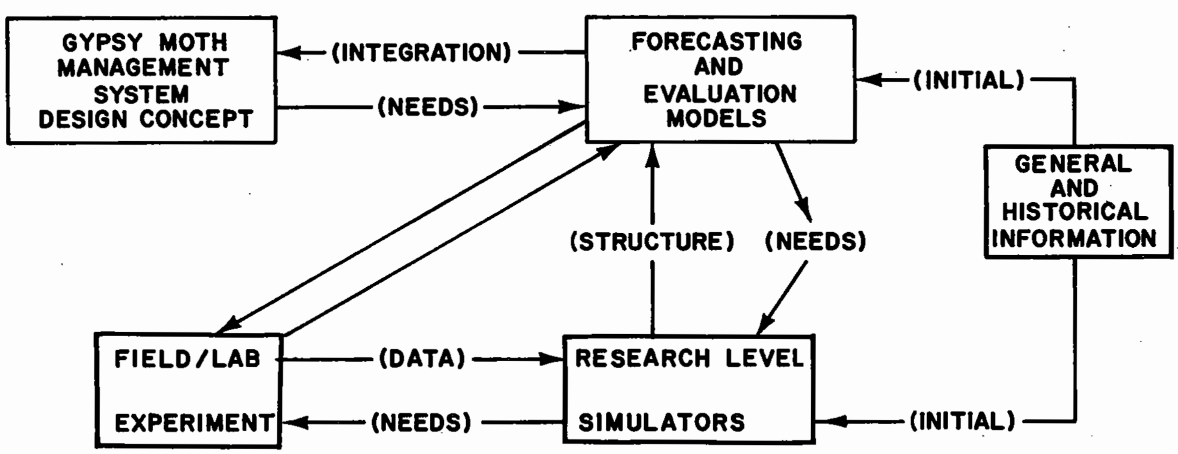

Figure 5.--Overall concept of systems models development.

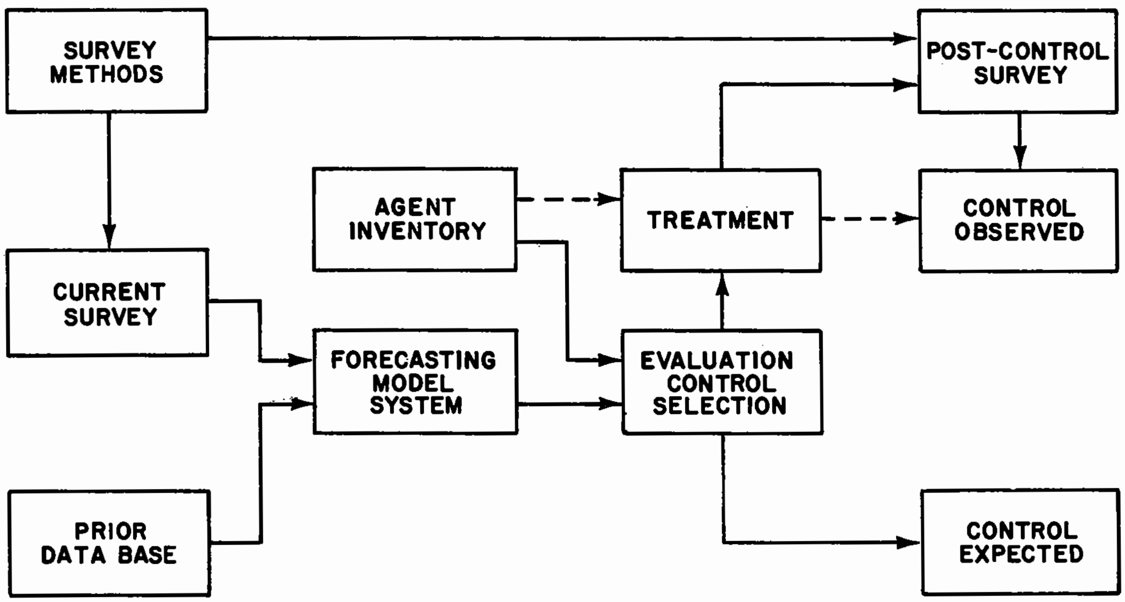

Figure 6.--Management process concept, basic cycle.

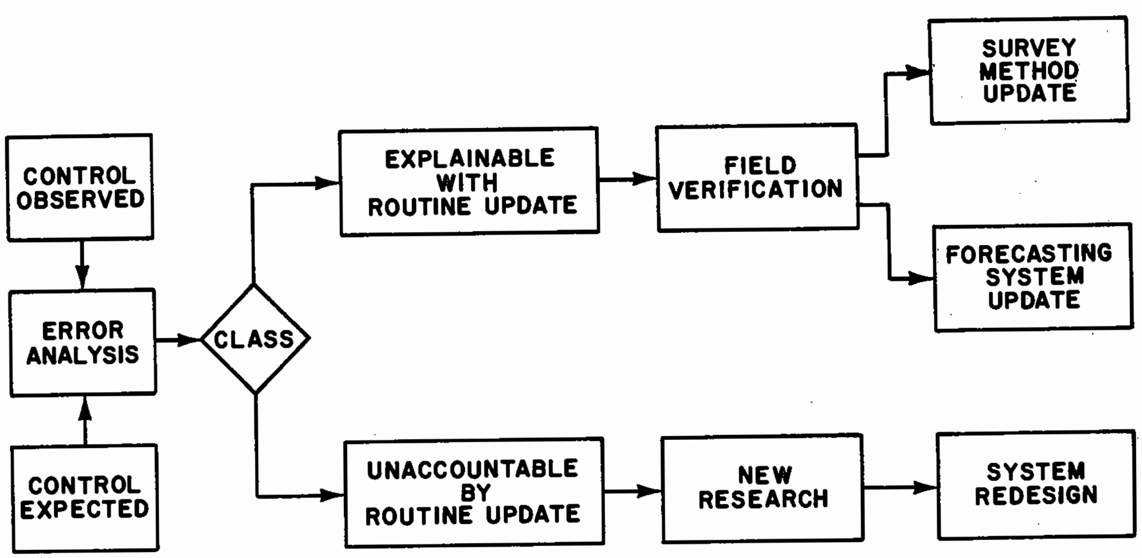

Figure 7.--Management process concept, feedback.

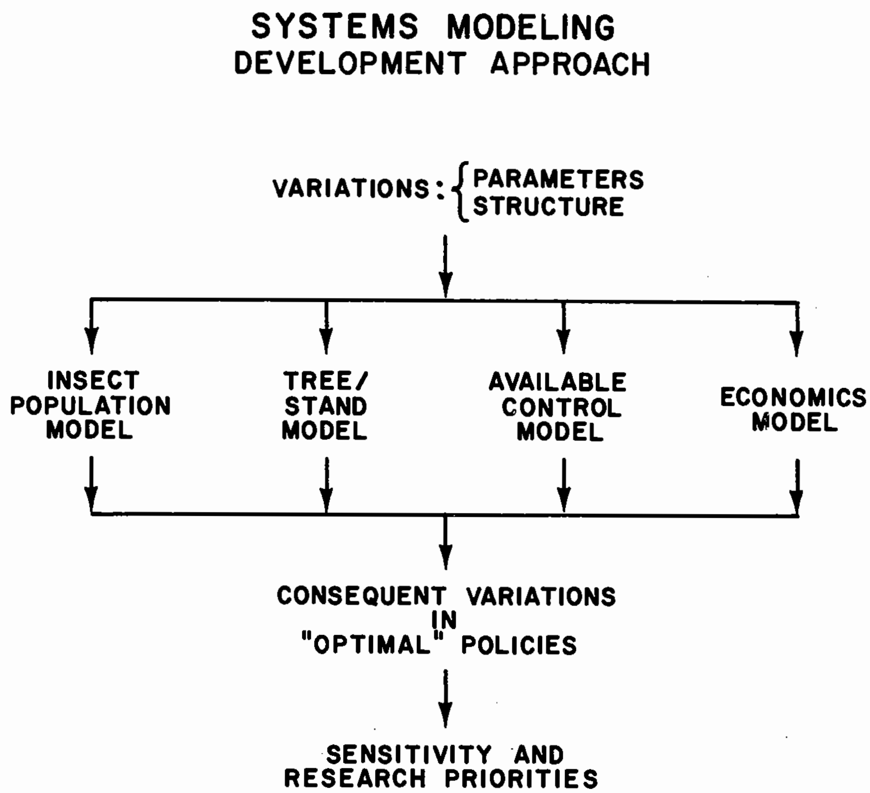

Figure 8.--Systems modeling development approach.

Some tentative conclusions from the first pass of our 1972 data are evident: First, it will be necessary to incorporate sex-and-stage-specific survival rates in the models; this has serious implications in the research data-collection problems. Second, trend variations substantially smaller than natural fluctuations cause gross changes in the optimal policy. This means the models must incorporate mechanisms that model or explain these fluctuations. Finally, it must be anticipated that any realistic management survey design will include feedback channels for adapting the models and survey methods to actual current field conditions. The feedback will interact with natural fluctuations. The interaction can cause the management or control system to be unstable, possibly amplifying the fluctuations. The risk of having this happen can be controlled by developing the survey methods, the models, and the management system design as a complete and coherent package.

PANEL: NET IMPACT OF FOREST INSECTS

Moderator: Bill Klein

Panelists: Bill Klein, George Downing, Robert Dolph, Karel Stoszek, Dennis Hart, Jed Dewey.

Introduction: William H. Klein

My introduction is going to be short and sweet. As many of you know, a workshop on Forest Insect and Disease impacts was held in this area--Marana Airpark--about this same time just one year ago. The objective of the workshop and of the various working groups was to define impact, develop ideas and concepts as to the type of data to be taken, and to suggest ways that these data can be analyzed and integrated into a workable management plan. These working groups, I might add, consisted of entomologists, pathologists, mensurationists, educators, and systems analysts. The concepts generated at this meeting helped set the stage for the procurement of meaningful impact information.

One thing that the workshop did not do, however, was to spell out methodology. This was not the intent; the insect-host problems were too complex and geographical areas were too diverse for that. The task was left up to the Regions and Areas. Some work is already underway and it is the status of these efforts that will be discussed by this distinguished panel. Impact problem areas we will cover are the spruce budworm, Engelmann spruce beetle, Douglas-fir tussock moth, a composite survey in California, the western pine shoot borer in plantations, and last but not least, the mountain pine beetle in lodgepole pine.

I won't even bother to define impact for it means different things to different people. Instead, I will mention a few initial problems that most of us have already encountered in the implementation of impact surveys. The first is area. How large an area do we sample and how representative is it of the whole? How do you sample for impact in an endemic situation compared to an epidemic one--or in between? Do you measure things when the infestation is in progress or do you wait for it to recede? How do you put meaningful, tangible values on an intangible resource, such as recreation or water yield? Simpler yet, how do you put tangible values on a tangible product such as timber? What if this timber is in a wilderness area or in the water and travel influence zone; i.e., timber that will probably never be cut. How do you assign a value to public attitude?--if there is one. Or the emotional rationale of public opinion-- or foresters for that matter. I can go on and on, but these are just a few examples of the interpretation problems we all face. Perhaps some meaningful suggestions will emerge from the forthcoming presentations.

A survey to determine the impact of the mountain pine-beetle in lodgepole pine: William H. Klein

Introduction.--The mountain pine beetle in lodgepole pine is the single-most important and damaging forest insect problem in the Intermountain Region today. During the past decade, several million trees have been killed in outbreaks stretching from northern Utah to western Wyoming and southern Idaho. Control efforts utilizing every conceivable technique-fall and burn, fall and spray, standing spray, standing burn, and logging--have been attempted on massive scales, and, other than affecting localized suppression in some areas and slowing the rate of tree killing in others, they have, for the most part, been unsuccessful.

Cruise data taken in stands where the infestations have run their course indicate that stand losses range from 10 to 50 percent of the trees 5 inches d.b.h. and larger and loss of merchantable volume (8 inches d.b.h. and larger) runs as high as 60 percent in some areas. Tree losses have gone as high as 50 to 120 per acre. Trend plot data have shown that the larger trees are killed first, disproportionate to their occurrence in the stand. Overall losses and/or gains or the net effect of this dead timber on the stand and other resource values and uses are unknown.

Purpose.--The purpose of this survey is to determine the net effect of mountain pine beetle depredations on all resource uses and values, including people. In effect - impact. The survey will be divided into two phases. The first phase will be to measure impact in a lodgepole pine stand already depleted by the mountain pine beetle. The second phase will be to monitor the same stand to determine its recuperative ability and characteristics, the physical changes during this period, and the time taken to regain its former character (if it does) and susceptibility to future mountain pine beetle attacks.

Area.--The impact area, approximately 100,000 acres in size, is on the Ashton Ranger District of the Targhee National Forest, Idaho. Roughly, the boundaries run from Cave Falls road and the southern boundary of Yellowstone National Park on the north, south to the North Fork of the Teton River, east to the Divide, and west to the Forest boundary (see appended map).

The survey area has been under attack by the mountain pine beetle since 1963 but has since declined. Some tree killing is now underway but only in the high elevations. Control work, using the standing spray method, was started in 1964, continued for three consecutive years, and then stopped. Logging for both control and salvage was undertaken along the western portion of the area.

Elevations range from 5,700 feet in the west to 7,500 feet in the east.

Time of Survey.--The field portions of the first phase and the initial stage of the second phase began during the first week of June 1972 and will terminate by fall of 1973. In the event the fieldwork is not completed this year (1973), it will continue through the 1974 field season. Follow-up surveys for the continuation of the second phase will continue at 2- to 3-year intervals. A special survey to determine impact in a high-use recreation area will be initiated in Grand Teton National Park during 1973.

Personnel.--A Regional entomologist from the Division of Timber Management has planned, organized, and supervised the study. Field personnel includes a part-time entomologist and two forestry aides. Personnel from Soil and Water Management and Range Management have provided on-the-ground training for obtaining data of their respective functions. The Regional Plant Pathologist has trained field personnel in mistletoe classification.

Cooperation.--This is an interdisciplinary study. A meeting was held in April 1972 to (1) outline the purpose of the impact study, (2) suggest tentative survey procedures, (3) request advice on survey methodology, and (4) solicit for active participation of all of the affected disciplines. In some instances, individuals felt that the type of timber data that we planned to take was sufficient for their interpretation and analysis. Others, such as Range Management and Soils, felt that we should take additional data, and went as far as to volunteer advice and their services in on-the-ground training.

Methods.--The survey area was systematically sampled by 25mm color aerialphotography at a scale of 1:5000 during fall of 1971. Sixty-three stereo triplets were taken from a light aircraft in a grid pattern one and one-half miles apart. A four square-acre area was delimited in the center of the work area of the first stereo pair then examined stereoptically for dead (snags and faders) lodgepole pine. The location of each dead tree was marked on a transparent overlay for future reference.

For the purpose of determining the effectiveness of the photographic method, approximately one-third of the photo plots will be randomly selected by the PPSORT[1/] method and visited on the ground. Ground truth will be compared to photo counts and adjusted by regression.

[1/] Stage, Albert R. 1971. Sampling with probability proportional to size from a sorted list. USDA Forest Service Research Paper INT-88, 16 p.

This photo plot network, randomly located throughout the impact area, will provide a basis for all other measurements. A multi-stage sampling scheme with a common plot center will be used.

Green Stand, Mortality, and Site

The center of the 4-acre photo plot is the common center of a 10 BAF variable plot, a 1/250-acre circular plot, and a 50 x 100' site study plot. Instructions and procedures for establishing the plots and for making observations and taking data follows:

Photo Plots

1. Locate photo plot and record route to plot (steps 2 through 5 will be followed only for the first 15-20 plots).

2. Locate plot corners

3. Measure horizontal ground distance between any two corners.

4. Run string line from corner to corner, around entire plot.

5. Working in a systematic pattern, locate and count all snags and faders 5.0 inches d.b.h. and larger.

   A. Record diameter and mark with plastic flagging or paint.
   B. Record all spike tops and note whether tree is suppressed (not visible on photo).

6. Locate plot center of 4-acre photo plot. Drive stake and mark stake with plot number.

   A. Variable plot (BAF 10) - Use Relaskop over jake staff.

      (1) Working in a clockwise direction from north, record all trees, living or dead (faders and new attacks will be considered dead) by one inch diameter class of trees 5.0 inches d.b.h. and larger.

      (2) First five live "in" trees of each tree species.

         a. Drive aluminum nail with numbered tag at d.b.h. in direction of plot center.
         b. Measure d.b.h. to nearest 1/10 inch.
         c. Measure height from 1 chain or 100-foot distance. Drive stake at point of measurement. Record distance and azimuth from tree to stake.
         d. Take increment boring at d.b.h. Label and place in plastic straw.
         e. Classify tree to mistletoe infection using Hawksworth classification system.
         f. Measure live crown ratio.

(3) Drive aluminum nail with numbered tag at d.b.h. in all "in" snags in direction of plot center.

B. Five 1/250-acre circular plots (7.44 ft. radius) in cluster pattern, 1 chain apart.

(1) Record all trees, living and dead, between 1.0-4.99 inches d.b.h.

(2) Record all established seedlings by species 6 inches in height to 0.99 inches d.b.h. If number of trees are excessive, count only those in NE quadrant.

C. Site study (50 x 100') and soil description plots.

(1) Locate corners.

(2) Take color picture from best vantage point. Have man stand at plot center for perspective and for future reference.

(3) Follow procedures outlined in "Site Study Field Notes" in the appendix. To procure this information from all plots, it will be necessary to retrace some plots.

(4) Collect and mount specimens of all plants and grass.

(5) Soil data will be taken as outlined in "Soil Description" from the appendix. Crews will also receive training by a soil specialist in conjunction with above.

Analysis

Most of the tree data taken during the first phase of the study will be compiled and analyzed using existing computer programs. Phase II data will require a new program and/or adapted to a long-range modeling and retrieval system such as RAM.

Survey Continuity

All plots are permanent and will be reexamined at 2-year intervals to determine net changes in stand structure, composition, tree growth, understory composition and succession, fire hazard, water yield, soil, and wildlife and range habitat, to name some. It is anticipated that some plots will be obliterated by cutting, road-building activity, and possibly fire. Hopefully, they will be few.

Reporting

A preliminary report giving general findings will be prepared and issued prior to May 1974. A report on timber losses and the results of the 35mm aerial photography study will be prepared earlier, possibly by February 1974.

Net impact of spruce beetle outbreak on White River National Forest, 1939-1951: George L. Downing

In the winter of 1972, the Washington Office of the Forest Pest Control, U.S. Forest Service, made assignments to each Regional and Area Office to collect and report the net impact of specific insects and diseases. The spruce beetle was assigned to Region 2 and D. B. Cahill was selected to coordinate the effort on determining net impact from this insect. Since it would be too time-consuming to attempt to collect this information from throughout the entire Region, it was decided to concentrate on one area. The area selected was the Buck Creek and Dry Buck drainages on the White River National Forest. This area is part of a 670,000 acre area that was devastated by an epidemic of the spruce beetle in Engelmann spruce between 1939 and 1951. The epidemic started from a buildup of the beetles in trees which were windthrown in 1939. The end of the epidemic coincided with extremely low winter temperatures in 1951.

Estimates of timber loss resulting from the epidemic were made for the entire area shortly after the outbreak subsided. A total of 3 billion board feet of timber were estimated as killed. At today's stumpage values, this amounts to about $120,000,000.

Survey Methods

A determination of net impact involves the many uses that are in one way or another affected by the dying of spruce trees from the bark beetle epidemic. This problem was discussed with representatives of the several resource divisions in the Forest Service Regional Office in Denver. As a result of these discussions, Forest Pest Control arranged to have Region 2 Forest Survey teams obtain State 2 sampling data from the 5,000 acre Buck Creek Study Area. The standard Stage 2 inventory data were augmented by the collection of additional data on range and browse plants and for fire rating assessment. Separate data were taken by Forest Service soils and water personnel.

Forest Survey sampling consisted of four major steps:

1. Range plant density.--This step was taken first to avoid trampling of ground vegetation. From the plot center, 25-foot transects were taken in each cardinal direction. At each foot along the transects, a 3/4-inch range loop was placed on the ground. A total of 100 points was sampled at each plot. Within each range loop all vegetation was identified, at least as to genus.

2. Browse plants inventory.--From the plot center, a 11.8-foot radius circular plot was laid out and all browse species located, identified to species, measured for height and age, and the amount of hedging (browsing) determined.

3. Timber inventory.--From the plot center a variable plot was taken using a 40 basal area gauge. Standard Stage 2 data were taken, including such items as tree species of both green and dead trees, diameter breast height, tree height, cause of death, type of defect, growth rate, crown class, etc. A 1/300-acre plot was taken around the plot center and number and species of forest regeneration were recorded.

4. Fire potential.--All down or standing snags within the 40 basal aread plot were recorded as either sound sapwood or rotten sapwood.

The above four sample steps were taken at each of 189 sampling locations. These sample locations were selected after the entire area was stratified by timber types based on photo interpretation. The number of plots falling in each timber type was based on the number of acres of that type in the study area. Of the 189 sample locations, four were taken outside of the study area in a spruce-fir small sawtimber stand. This stand was sampled as a control, primarily to provide data on ground vegetation under a mature stand.

Results

The results of this impact study are preliminary and incomplete at this time as all of the data have not been completely analyzed.

Stand composition by basal area (BA).--The BA of the control stand is comprised of 80% spruce and 20% fir. This stand represents the approximate species composition of the entire area prior to the spruce beetle epidemic. By contrast, all of the stands sampled within the study area are now primarily fir. Following the epidemic, some of the areas were logged to salvage the dead spruce. These areas have also come back to fir. Basal areas within the study area ranged from 130 for large, well-crowned, spruce-fir sawtimber stands to BA's of about 30 to 50 for the other spruce-fir stand types. The BA of the cutover areas averaged less than 10.

Cubic foot volumes.--It is estimated that stands averaged 6,000 cu. ft. per acre prior to the epidemic. Stand types sampled on the study area averaged less than 1,000 cu. ft. per acre, with the largest sawtimber stand having about 2,800 cu. ft. per acre. The control area averaged 2,000 cu. ft. per acre.

Vegetation by stand types.--The percentage of ground area covered by all vegetation, other than trees, increased dramatically in all study area stand types as compared to the control stand. The control stand had almost no vegetative cover, whereas all stand types within the study area had between 25 and 40 percent of the ground area covered by vegetation.

The amount of vegetative cover is important in considering animal population levels between old-growth stands and the stands that have developed following the beetle epidemic.

Animal population fluctuations.--Animal population changes over time were reconstructed by consulting with wildlife specialists. These specialists made observations in the area and used the vegetative data collected on both the control area and the study area as a basis for their estimates.

Spruce beetle populations increased rapidly following the 1939 blowdown, reaching a peak in the middle and late 1940's, and then crashing to low levels in 1951. The beetle populations have remained low throughout the study area since that time. These beetle populations had an effect primarily on woodpeckers and small mammals which increased in numbers with the increase in bark beetles. Woodpeckers followed the increase and decline curve of beetle numbers with a more gradual increase at the outset of the epidemic and a decline that was not as drastic as the beetles. Small mammal numbers increased gradually with the beginning of the epidemic, reached but moderate levels during the epidemic, declined with the end of the epidemic, and have maintained population levels that were about the same as those prior to 1939. Elk, deer, blue grouse, and large animal predators all increased during the latter stages of the beetle epidemic due primarily to vegetative changes. These animal populations continued a gradual increase for many years with the elk, deer, and grouse populations declining slightly in the last 5 to 10 years. Large animal predators have continued a slight increase to the present time, but may have reached a peak.

Snag density.--About 80 percent of the total study area has 80 or more snags per acre, with snag densities in some areas of 200 per acre. Forty-one percent of the snags had fallen by 1972. Some house logs and mine props are still being utilized from the dead spruce. About 28 percent of the dead spruce is now classed as cull.

Tons per acre of dead spruce.--Over 40 percent of the study area contains at least 55 tons of dead spruce per acre, with about 10 percent of the area containing 85 tons per acre. These data will be used along with other information to determine fire hazard resulting from the spruce beetle epidemic.

White River streamflow data.--The study area and other adjacent areas are part of the White River drainage. Streamflow data have been collected continuously from this drainage since 1902. These data have been combined in several-year increments to minimize annual fluctuations. From 1941 to 1946, acre feet of water exceeded the mean acre feet for the 1902 to 1940 base period by 20,000 acre feet. For the period 1947-1951, streamflow increased and exceeded the base period by 60,000 acre feet. For the period 1952-1957, streamflow declined to about 57,000 acre feet above the base level. This decline continued for 1958-1964 to about 46,000 acre feet above base level and for the most recent period of 1965-1971 the decline was to 30,000 acre feet above the base level.

These streamflow figures are important and show the dramatic increase in water runoff as the spruce tree cover was killed. Likewise, these data show the influence of new vegetative cover. As this vegetative cover has increased, streamflow has decreased. It is estimated that acre feet of streamflow will return to the 1902-1940 base level by 1985. Projections of water yield could be misleading if based on a period following a spruce beetle outbreak.

Man's maneuverability.--Dead spruce that have fallen throughout the area are a hindrance to man in working, hunting, or otherwise utilizing the area. To gain some measure of the effect this downed material has on foot travel, individuals were timed covering 400 feet in distance across ground having various levels of downed material. With no downed material the distance was covered in about 1 minute 15 seconds. Travel over 1 foot of downfall took 1 minute 45 seconds; travel over 2 feet of downfall took a little over 2 minutes; travel over 3 feet of downfall took 2 minutes 15 seconds, and travel over 4 feet of downfall took 2 minutes 30 seconds. Much of the data collected in this spruce beetle impact study has not been fully evaluated or had definitive values assigned. An economist has been consulted on interpretation of the data and it is intended that an economic analysis will be made.

Douglas-fir tussock moth impact on Douglas-fir and grand fir in the Pacific Northwest Region: Robert E. Dolph

During the summer of 1972, a severe Douglas-fir tussock moth outbreak occurred in the states of Oregon and Washington. The largest infestation center was in the Blue Mountains in northeast Oregon and southeast Washington. The outbreak was first observed in fir stands north of La Grande, Oregon, in late June 1972. During the cooperative aerial detection survey made by the Oregon State Department of Forestry, Washington State Department of Natural Resources and the U. S. Forest Service in late July, it became apparent that the caterpillars of the Douglas-fir tussock moth had chewed on vast acreages of Douglas-fir and grand fir. Visible defoliation, ranging from light to concentrated mortality, was mapped in certain areas of the Blue Mountains extending 70 miles northeast of La Grande, Oregon, into areas near Dayton, Washington. A major part of the outbreak was on the Umatilla National Forest.

When the significance of the infestation was realized, helicopters were used to obtain a more accurate map showing the degree of damage and to evaluate the timber losses. Helicopters were used because the aerial observer could move in close to check out each drainage and small islands of timber for classifying the various degrees of visible defoliation. The damage classes used to designate the degree of defoliation were as follows:

Damage Class

1. Tree killing.--Fifty percent or more of the host trees within the area were completely defoliated and the remaining trees had heavy defoliation.

2. Top killing.--Fifty percent or more of the host trees within the area had at least the top quarter of the crown completely defoliated.

3. Defoliation.--The current year's foliage had been removed on most of the host trees within the area, but less than a quarter of the crown was completely defoliated.

The results of this survey showed the infestation encompassed about 174,000 acres in the Blue Mountain area. This included about 11,000 acres of heavy tree killing - Class 1; 60,500 acres of top-kill - Class 2; and 102,500 acres of Class 3.

In addition to the outbreak in the Blue Mountains, localized but severe tussock moth defoliation also occurred at widely scattered locations in north-central Washington. Tussock moth damage was detected on the Colville Indian Reservation, on private lands in Okanogan, Lincoln, Stevens, and Chelan counties and on the Wenatchee and Okanogan National Forests. The damage occurred in relatively small centers and totaled about 23,000 acres. Tree killing was reported on nearly 5,000 acres, top killing on 14,000 acres and light defoliation on about 4,000 acres. Because these centers were widely scattered and the infested areas were small, no helicopter survey was made.

After the aerial and ground surveys were completed, a biological evaluation survey was made in the fall to determine the degree of defoliation that could be expected in 1973 using Dr. Mason's sequential sampling method, and to determine the "old to new egg ratio." The first five new egg masses collected were placed in a paper bag and shipped to Dr. Thompson at the Forestry Sciences Lab in Corvallis, Oregon, to determine the incidence of the native virus disease in the tussock moth population.

During this same period, the biological data was collected, we solicited foresters, fire management personnel, fish and wildlife biologists, recreational personnel, range personnel, watershed personnel, and public health officers from state and federal agencies and industry to participate and report on the impact the tussock moth defoliation had on the various resources in the outbreak areas. The response to our request was excellent.

The information presented here is the summary of the impact data developed by the affected national forests, Colville Indian Agency, various state agencies from Oregon and Washington, and private landowners.

Timber.--The impact of the tussock moth on the timber resource included tree mortality and growth loss. The volume computations for tree mortality and growth loss were based on the latest resource inventory. Tree mortality was calculated only for Class 1. The total number of acres within this class was multiplied by the volume per acre of susceptible type for each working circle. The total volume was then multiplied by the percentage of trees killed per acre - 84 percent. This percentage figure is based upon the results of impact studies by Mr. Wickman. In the Blue Mountains the estimated volume of trees killed by the tussock moth amounted to 87 million Bd. Ft. and 44.5 million Bd. Ft. in North-Central Washington.

Growth loss was calculated for all three classes of defoliation by multiplying the total number of defoliated acres times the annual growth per acre for each working circle. The estimated growth loss in the Blue Mountains amounted to 18.5 million Bd. Ft. and 900,000 Bd. Ft. in the North-Central Washington outbreaks.

Fire.--Another important adverse impact tussock moth defoliation had on the infested area was the increase in fire protection costs due to the change in fuel type. Fire management personnel stated the greatest change of fuel type was in Class 1 infested area where "fire growth rate" had increased from 3.5 acres per hour to 44.5 acres per hour at "high" fire danger rating. The Oregon State Department of Forestry estimates its fire protection costs had increased by $15,000 per year. The Umatilla and Wallowa-Whitman National Forests had estimated an increase of $110,000 per year.

Wildlife.--The tussock moth outbreak in the Blue Mountains occurred in the area where some of the largest deer and elk herds reside. Game and wildlife biologists believe the present impact of the tussock moth on the wildlife habitat was beneficial since the summer range for deer and elk was probably enhanced. Adverse effects appear minimal because of the relatively small size of most areas of mortality, the mixture of species remaining, and the small percentage of range affected. Wherever large areas of tree mortality occurred, the biologists stated there was an adverse effect due to the loss of escape cover and fawning or calving grounds.

Fish biologists reported the impact on fisheries was minimal because most of the insect damage occurred at higher elevations or at the head waters of tributaries of major fishing streams.

Range.--The impact on the range resource appears to be largely beneficial. Grazing values on the affected areas are expected to increase, particularly on those sites where there was definite change in forest type. It is estimated that the short-term effect of the outbreak will result in additional forage amounting to approximately 7,900 animal unit months.

Watershed.--The present effect of the tussock moth infestation on water resources is considered minimal. The direct impact on either water quality and quantity will probably remain relatively slight if the litter layer and understory vegetation is left undisturbed.

Recreation.--Aesthetic impacts is rather difficult to quantitatively measure. However, heavy defoliation has already reduced land development values as much as 50 percent. Heavy defoliation occurred in some of the most heavily used recreational sites along interstate highway 80N in Oregon. Visitors at the state parks and national forest campgrounds complained of dropping frass, defoliated and discolored trees.

Public Health Hazard.--The impact of this outbreak concerning human health became apparent last summer when several woods workers employed to log tussock moth damaged trees filed compensation claims with the state of Oregon Industrial Accident Commission. One contract logger reported his crews were all affected to the point of losing work time or actually forced to quit and seek work in noninfested areas. The Accident Commission investigated these claims and reported some of the men were allergic to the body hairs of the tussock moth which cover the cocoons. Some of the most common reactions reported was an itching rash, swelling of the eyes, respiratorial irritation other than sneezing, and some mouth irritation in the cases of heavy smokers. The loggers reported the problem was most severe when tree falling on dry days. They commented each time they fell a tree, a cloud of hairs would form.

After the biological survey was completed and the 1972 impacts summarized, we then predicted the losses expected in 1973. This information was used to develop our cost/benefit analysis in the environmental statement.

The evaluation of this outbreak demonstrated the need for more precise methods in collecting and analyzing impacts. Researchers have recognized this problem and have established impact and population studies in the outbreak areas. We are currently preparing a sampling plan to measure tree mortality using color infrared film.

Damage to Ponderosa Pine Plantations by the Western Pine - Shoot Borer, *Eucosma sonomana* (Lepidoptera: Tortricidae): Karl J. Stoszek

The Western pine shoot borer, *Eucosma sonomana* Kearfott is a newly recognized pest of ponderosa, lodgepole and Jeffreyi pine under intensive forest management. The larvae mine through the pith of developing terminals stunting and deforming tree growth.

E. sonomana overwinters in the pupal stage in the soil. Adults emerge from mid-April to early June in Southeastern Oregon. The moth fly at dusk; the flight temperature threshold is near 50°F. The attacks appear undeterred by tree size; shoots on terminals seem preferred. The insect passes through five larval stages within a pine shoot. Larvae emerge from shoots to pupate from late June to mid-August. Trees are capable of aborting incipient attacks. Cannibalism appears an important mortality factor, so is parasitism.

Main symptoms of attack and injury: stunted shoot growth, short bottle-brush like needles on distal part of infested shoots, frass-filled larval mine through the center of the pith.

The loss estimate was obtained by subjecting the length of leaders in various (four) damage categories (paired with the length of the longest undamaged internode on the same tree) to regression and co-variance analysis. The results show that larval mining stunts the height of infested leaders and impairs growth of leaders the year following attack.

Length of borer unaltered leaders provided a basis to which the length of borer damaged leaders was compared. The incidence of infested leaders in a particular plantation provided the basis for the estimation of borer caused losses in average annual height increments of the stand. The loss was estimated to reach up to twenty five (25%) percent of borer unaltered increment (in plantations chronically subjected to seventy (70%) percent leader infestation incidence); the height increment loss may result in percentage-wise similar losses in volume yields.

Surveys in young plantations show a trend of increased incidence of infested leaders with increasing xericity of habitat types; Forest Zones and habitat types in Southeastern Oregon are ranked into three borer hazard categories.

Forest Pest Evaluation System: Dennis Hart

Introduction.--Forest managers in California urgently need reliable information on losses caused by insects and diseases. To meet this need on Forest Service land in Region 5, entomologists and pathologists have been developing a system for evaluating the effects of pests in managed forests. In a greatly simplified form we see this problem as an equation in which "loss" is the function of many factors, operating in combination, rather than independently. We see the "causal agent" not as a specific insect or disease, but as a pest complex, in this way resolving the classic question of what killed the tree.

Reduced to its essentials, our equation contains four factors:

(Site Conditions) (Stand Conditions) (Pest Complex) = Insect and Disease Effects

In principle, this evaluation system is a three-part decision-making process:

(1) The input includes information on:

a.) Pest effects.
b.) Conditions of affected stands.
c.) Information on the environmental conditions associated with pest activity.

(2) The second phase will be the evaluation of these data by an interdisciplinary team of specialists which will include:

a.) Entomologists
b.) Pathologists
c.) Silviculturists
d.) Range Analysts
e.) Soil and Watershed Specialists

(3) The third phase will be the development of criteria for making management decisions.

Timber Inventory System.--Before I can talk about the uses of our system it is necessary to refer to the Timber Inventory System. This is a highly-simplified overview of the System. There are three main phases:

(1) The Timber Inventory Survey

(2) The WRIS Map - WRIS stands for - Wildland Resource Information System.

(3) And Timber RAM - RAM stands for the Resource Allocation Model.

The purpose of the Timber Inventory Survey is to collect timber data from the field on the basis of stand types within National Forests.

The WRIS Map is a stand map of each Forest and is used for management planning and the scheduling of the annual cut. Three overlays are prepared for each of these maps. They are:

(1) An overlay delineating property boundaries and sub-divisions.

(2) An overlay showing important multiple use zones such as:

a.) Recreation areas.
b.) Wildlife Feeding Areas
c.) Scenic Zones

(3) A map of timber treatment classes.

Timber RAM is a computer program that is used to calculate the annual cut for each Forest, based on tree growth and yield by treatment class.

Application of Results.--(1) The Pest Evaluation System should enable us to make more accurate statements of tree and volume losses by stand types, and lead to (2) The development of stand life tables and hazard ratings for local areas by stand types. (3) These stand hazard ratings will then be applied to the WRIS Map. (4) This will be used to aid in the scheduling of cultural treatments within management units.

This information will also help us:

(5) Modify marking rules
(6) Modify stand yield estimates, by including pest effects
(7) Help establish pathologic rotations based on stand conditions
(8) Aid in predicting future losses

Procedures.--Four types of surveys are included in this Forest Pest Evaluation System. They are:

(1) Tree Mortality Survey
(2) Pest Conditions Survey
(3) Growth Evaluation Survey
(4) Pest Incidence Survey

These pest surveys will be made in conjunction with the Region's Timber Inventory Survey, which is the primary source of information on which timber management plans for the 17 National Forests of California are based. When fully operational, these pest surveys will cover the Region on a 5-year cycle.

The tree mortality and pest conditions surveys will be done at the same time. The pest conditions survey is a more intensive subsample of the groups included in the tree mortality survey. These surveys are described as follows:

Phase I. Tree Mortality Survey. The purpose of this survey is to measure the mortality caused by insects and diseases, and to list this mortality by stand type.

Using current aerial photography, photo interpreters will detect tree mortality groups, and estimate the species, size class and number of dead trees per group.

Stand types will then be delineated on the photos. Then, selected mortality groups will be examined on the ground to check the accuracy of the photo estimates and to calculate a correction factor for the photo sample.

Results from this tree mortality survey will be expressed as annual mortality by stand class, which is the basic land unit for the WRIS program. As this survey continues, and as data accumulates for the stand classes that are most seriously affected, these mortality estimates will become increasingly precise.

Phase II. Pest Conditions Survey. As I mentioned before, this survey will be made concurrently with the Mortality Survey. Essentially, it will provide for a more in depth analysis of a subsample of the groups included in the Tree Mortality Survey.

The purpose of this pest conditions survey is to determine the nature of the Pest/Stand/Site Conditions, which are associated with pest activity for each mortality group examined. At this point we are not trying to estimate which pest killed the tree, but to rate the pests that are associated with tree death according to the part of the tree they affect, their density, and the area over which they occur. We should be able to make estimates on site deterioration as we collect more information.

The results of these surveys will be used directly in the Timber Inventory System primarily in scheduling the cutting of infested and pest-free stand classes.

Phase III. Growth Loss Survey. The two phases of the system described above deal with loss resulting from trees being killed and to a great extent with old-growth stands; however, some pests also cause losses by reducing the growth rate of affected trees. In managed stands, growth-reduction losses may be great or small with respect to mortality losses -- very little is known of this at present. A supplementary survey designed to measure effects on tree growth will be added to the system at a later time when the overall insect and disease problem in managed stands in California is better understood. We intend to start this survey within two years.

Phase IV. Pest Incidence Survey. The purpose of this survey is to detect occurrence of important pests. This would include non-lethal pests. We plan on coordinating this survey with the Timber Inventory Survey so that the data required for making these estimates can be collected from their inventory plots. We plan to start this survey during the summer of 1974.

Other Studies. The Forest Pest Evaluation System will utilize information from other sources, especially biological evaluations that are made by the Division, and cooperative research and evaluation projects carried out with the Pacific Southwest Forest and Range Experiment Station, and the University of California at Berkeley. With special reference to the stand sampling component of the International Biological Program (Ponderosa Pine - Western pine beetle).

Survey Results.--During the summer and fall of 1972 we conducted a survey to assess insect and disease effects on the Moore Creek Compartment of the Stanislaus National Forest. This survey was made in cooperation with the WRIS program and included Phases 1 and 2 of the Forest Pest Evaluation System, which are:

1.) The Tree Mortality Survey
2.) The Pest Conditions Survey

Our photo interpreters detected 395 mortality groups over a 10,000 acre area. We ground checked 60 of these groups and made stand-site evaluation on 40 of them. Total cost for the surveys was 80¢ per acre. We estimated the total tree mortality for this compartment to be 1,363 trees $\pm$ 277 trees, or about 0.14 trees per acre. This level of tree mortality was not considered to be serious for this area.

Analysis of the data collected from these surveys supports the idea that much of the pest-caused mortality for an area is the result of a comparative few pest complexes operating in combination with particular types of stand and site conditions.

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* This cost can be greatly reduced. We found that with a multi-stage sampling design we could cover larger areas at a reduced cost.

Although many pests and pest complexes were associated with white fir mortality, only a few of these were associated with most of this mortality.

In the areas sampled, Fomes annosus/Scolytus ventralis(i.e., Fa/Sv) appears to be the principal complex associated with tree death in young white fir stands.

In mature and overmature white fir stands we found two primary pest complexes associated with most of the tree mortality. These are Fa/Dwm/Sv/ and Fa/DWm/Pho/Sv. Only a few of the dead trees in these stands were associated with Fa/Sv alone. Thus, it appears that dwarf mistletow and true mistle may play an important role in predisposing trees to killing by other pests.

Fomes annosus complexes in the dense pole-sized stands of white fir which we evaluated had the following characteristics:

1.) Basal area/acre ranged from 200-240
2.) They occurred on north-east facing slopes on or near ridge tops.
3.) They occurred predominantly on sandy loamus soil.
4.) Tree age ranged from 50-80 years of age.
5.) No cultural practices such as logging, thinning, or road building were associated with any of these mortality groups.

This came as a surprise to some of us because we anticipated that the primary source of infection for Fomes annosus was through disturbances caused by thinning or logging. Of the twelve mortality groups we studied in white fir stands, which were associated with Fomes annosus, only three were associated with logging or thinning. All of these groups occurred in the mixed-conifer type which had a ponderosa pine overstory.

The dwarf mistletoe-bark beetle complexes were highly correlated with ponderosa and Jeffrey pine mortality. Most of these trees tended to have a very heavy infestation of dwarf mistletoe and a patchy infestation of bark beetles. Most of the Jeffrey pine mortality occurred in understocked stands growing on ridge tops on shallow, sandy soil. We think that these trees were also under severe stress from drought.

The Douglas-fir tussock moth infestation is primarily confined to one soil type* in association with ridge tops. The smaller tree size classes (15-50 Feet), seem to be most severely affected, and the feeding damage was most severe in pure white fir stands, and less serious in stands associated with red fir.

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*The Linton Soil Series. For more information refer to Jim Delap or Bill Scheuner, Division of Timber Management, Stanislaus National Forest, Sonora, California 95370.

Information like this will be collected, organized and analysed in such a way that pest effects will be evaluated for each stand and timber type. From these data, stand life tables and hazard ratings will be constructed for local areas. It will require the accumulation of information over several years before these ratings can be developed, but already, trends are emerging which indicate that this is possible.

We realize that our information is limited and that firm conclusions cannot be based on this evaluation, but we feel that our method is good. This was only a small feasibility study where we took a few plots over a small area to help us develop the sampling and analytical procedures necessary for a State-wide pest evaluation system.

Western spruce budworm impact in Region 1 and studies underway: J. E. Dewey

The primary impacts of the western spruce budworm, *Choristoneura occidentalis* Free, in Region 1 are:

1. Growth reduction
2. Tree mortality
3. Insufficient regeneration establishment
4. Possible contribution to heart rot introductions

Probably the most striking but the least important of the above impacts is tree mortality. With the exception of some rocky, dry, poor sites in eastern Montana, outright budworm induced tree mortality has not been too extensive in the Region. There are areas on the Nezperce National Forest, Idaho, where a relatively high percent of the subalpine fir in some stands has been killed but usually subalpine fir is not the primary species in these stands.

Growth loss is suspected to be our greatest impact of the budworm. For the past 5 years over 4 million acres have been sufficiently defoliated as to be detectable from the air in the Region. Many hundred thousands of acres have been severely defoliated for 3 or more consecutive years. As a result, top kill and branch dieback are extensive. For example, a recent aerial survey of the Nezperce National Forest revealed 138,000 acres showing conspicuous permanent injury (top kill and/or mortality). Though to date we do not know precisely what the reduction in growth is in these stands, we are confident it is tremendous.

Associated with top kill and branch dieback is the possibility of a heart rot problem. In a study in eastern Canada, Stillwell (1956)[1] found "dead tops provide an excellent means of entry for wood-destroying fungi." He observed that "all trees that contained buried leaders 5 years old or more and 0.5 inch or larger in diameter were found to possess some measure of decay, which apparently had entered through or around the bases of the killed leaders." Currently, over 50 percent of the volume of old growth grand fir is being culled due to heart rots on some of the Idaho Forests. These same stands are presently heavily infested with budworm. It is possible, if not likely, that much of the rot present today gained entry through budworm killed tops when these stands were pole sized. If, in fact, a budworm killed top predisposes the tree to heart rots the impact, from a timber standpoint, is greater than had the tree been killed outright because it will continue to occupy space and utilize nutrients for years merely to be culled.

More recently the impact of budworm on regeneration has been brought to our attention. We have known for sometime that budworms are the major destroyers of Douglas-fir cones and seeds in the Region. Recently we have been approached by foresters from two National Forests indicating that their regneration programs are in a critical situation due to budworm. Since the current infestation began on these Forests (about 6 years ago) they have been unable to collect any Douglas-fir seed from infested areas. Regional guidelines prevent their obtaining seed from distant locations. These Forests have now utilized their entire Douglas-fir seed inventory and have nothing left for their artificial stocking program. When they asked the Division of Timber Management for advice they were given two choices:

1. Plant unaffected species (pines and larch).
2. Cease timber harvesting by regeneration cuts in affected areas.

Unfortunately, there are few Douglas-fir sites in the Region that are suitable for planting pines or larch. With the increasing demand for timber, you can imagine how it hurts to have to cease harvesting in areas that are to be artificially regenerated.

Budworm effects regeneration both directly and indirectly. We found that nearly all Douglas-fir cones are destroyed in areas where budworm are plentiful enough to cause aerially visable defoliation. Even in areas where no defoliation is apparent, as many as 70 percent of the cones, during a heavy cone crop year, have been budworm infested. Indirectly, regeneration is affected by the defoliated trees being too weak to produce cone crops. We have areas that were harvested with seed trees left to naturally regenerate, but have had to be artificially planted because seeds were never produced. The problem has been attributed to budworm.

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[1] Stillwell, M. A., 1956. Pathological aspects of severe spruce budworm attack. Science, Vol. 2, No. 3, pp. 174-80.

We have recognized the need for quantitative data to determine the impact of the budworm and have initieated two surveys to collect it. In 1971, a study was started on the Clearwater National Forest with its objective to measure the amount of budworm induced top kill, mortality, and growth loss. Permanent plots have been established in four recently infested areas. These will be remeasured periodically throughout the course of the infestation to update the condition of the 709 sample trees on 162 plots. Sample trees were selected with a variable plot cruise establishing plots every 5 chains along lines 10 chains apart. The following data were collected from each sample tree:

1. species
2. diameter breast height
3. height
4. tree condition
   a. nondefoliated
   b. light defoliation (0-25 percent)
   c. moderate defoliation (25-50 percent)
   d. heavy defoliation (50-75 percent)
   e. extreme defoliation (75-100 percent)
   f. top killed
   g. tree killed

Increment cores were taken randomly throughout the survey and radial growth rates measured. By using the Region's Stage II computer program, the expected radial growth can be projected by measuring the ring widths for the preceding 10 years. The difference between the expected ring widths and the actual ring widths since the outbreak began was attributed to the budworm. Some nonhost trees were measured to check for growth patterns that may be attributed to climatic conditions. The Stage II program gives a board foot value based on tree height and diameter and makes it possible to convert radial growth losses into board foot losses. Our most recent increment cores show an average radial growth reduction to host trees of over 25 percent since the outbreak began. The outbreak is only 3-5 years old in these stands, so we expect the impact on growth to intensify as the infestation intensifies and persists.

The second budworm impact survey underway in the Region is on the Nezperce National Forest. This survey is a multistage probability selection survey. It consists of:

1. Stratifying the infestation into damage classes.
2. Complete coverage, high level (1:15,840) color infrared photography to select flight lines.
3. Low level (1:2,000) true color photography of selected flight lines to select sample plots.

4. One hundred percent ground cruise of selected plots.

From this survey we expect to determine:

1. The number of trees and volume per acre by each damage class.
2. Board foot growth impact for the past 5 years.

To date we have stratified the area into damage classes. The aerial photography and ground examination is scheduled for completion during the summer and fall of 1973.

PANEL: INTERNATIONAL BIOLOGICAL PROGRAM

Moderator: D. L. Wood

Panelists: A. A. Berryman, R. N. Coulson

Objectives

On May 1, 1972, a national program of research entitled "The Principles, Strategies and Tactics of Pest Population Regulation and Control in Major Crop Ecosystems" was initiated at 19 universities under the auspices of the U. S. International Biological Program (IBP). The general goal of this program is: to develop pest management systems which will achieve economic (owner-centered) regulation of pest populations at levels compatible with tolerable socio-economic threshold values, using methods which operate in concert with the working of the ecosystem. Special objectives are:

1. Explore all principles, tactics and strategies of insect population regulation to find practical alternatives to the extensive use of broad-spectrum toxic chemicals.

2. Utilize these principles, tactics and strategies in a multi-disciplinary, integrated systems approach to decision-making.

3. Control pest populations at non-economic densities by means that will optimize cost-benefit relations and minimize environmental degradation.

4. Emphasize field-oriented (ecosystem) research, with attention to total pest and host plant populations and their interactions, and to the broad economic and environmental consequences of management actions.

5. Develop better methods of collection, management and interpretation of relevant biological, economic, and sociological data.

Although this program is field-oriented, the discovery and utilization of certain principles may require frequent and effective interplay between field and laboratory studies and close communication among the institution participants. Separate, but supporting, basic research in systematics, physiology, pathology, biochemistry, genetics, and mathematics is also needed.

Crop Selection

The following criteria were utilized in selecting the crop ecosystems to be studied:

1. The importance of the crop, geographically, economically, and socially.

2. The problems encountered with current action programs, and the pesticide load added to the environment.

3. The probability of quickly developing a suitable alternative program reducing economic problems and the pesticide load.

4. Each crop should represent a different agro-ecological type i.e., annual-perennial, temperate-subtropical, vegetable-forage-fruit-fiber, etc.

The crops selected and the key criteria used in the selection were:

1. Cotton: Nearly half the pesticides used for insect and related pest control on crops in this country are used on cotton.

2. Soybean: Although relatively little insecticide is used at present, increased acreages in the last decade exposes this increasingly valuable crop to losses by a complex of pest insects. An intensive campaign by industry to develop insecticide-based treatment programs is now underway and promises to follow the same disasterous path that has developed for cotton.

3. Pines (bark beetles): Although wholesale use of chemicals is not a problem, the multiple use aspects of pine forests and the fact that pines constitute the major wood fiber crop in the Nation, make this subproject important. Moreover, there is a substantial body of data and experience from which to proceed: a) the biology and ecology of pine bark beetles, b) the nature and extent of losses they can cause, c) the role of stand age-class composition and tree species diversity, d) the role of certain predisposing conditions, e.g., disease, fire, windthrow, e) the role of natural enemies, and f) the results of chemical treatments and various silviculture and management practices.

4. Citrus: There is a real need to decrease the use of broad-spectrum chemicals for citrus insect control. Unlike cotton, an extensive knowledge already exists concerning the basic potentials for greater use of non-chemical measures, notably parasites, predators, and pathogenic microbes.

5. Pome and Stone Fruits: The extensive use of broad-spectrum, persistent insecticides has complicated pest control by producing new complexes of pests and creating resistant species requiring additional treatments. Management of pests using ecologically sound practices needs to be demonstrated and encouraged in this crop system.

6. Alfalfa: Alfalfa is not only a major crop in its own right, but natural enemies and pests found here are very significant in other crops. Thus, an ideal opportunity is presented to better understand inter-crop movements of faunal elements and reciprocal benefits of management strategies.

The population dynamics of principal pests and their interactions with control measures have not been quantified for any of the above crop ecosystems. The methods of appraising conditions upon which decisions must be based are only partly scientific; they are mostly intuitive, based on past experience.

Funding

Funding for an anticipated five-year program is shared principally by N.S.F. and E.P.A. The U.S.D.A. provided funds for the cotton subproject and specific items of other subprograms during the first grant year which ran from May 1, 1972 to February 28, 1973. Funds provided for the first two years and the project directors are:

	1972-73	1973-74
1. Management Component:	$175,000 after sharing:	$173,641
C. B. Huffaker, Project Director, University of California R. F. Smith, Associate Project Director, University of California		
2. Cotton:	$200,000	$486,502
P. L. Adkisson, Subprogram Director, Texas A&M University		
3. Soybean:	$215,300	$540,449
L. D. Newsom, Subprogram Director, Louisiana State University		
4. Pines (Bark Beetles):	$155,300	$323,808
R. W. Stark, Subprogram Director, University of Idaho		
5. Citrus:	$146,400	$263,676
P. DeBach, Subprogram Director, University of California, Riverside		
6. Pome and Stone Fruits:	$100,200	$310,819
S. C. Hoyt, Subprogram Director, Washington State University, Wenatchee		
7. Alfalfa:	$274,100	$501,105
E. H. Armbrust, Subprogram Director, University of Illinois		

Management Organization

C. B. Huffaker
Director
R. F. Smith
Associate Director

Ad Hoc Panel of Experts

C. B. Craig
B. C. Ewing*
J. C. Headley
C. M. Ignoffo
R. B. Norgaard
W. E. Robbins
R. I. Sailer
W. J. Turnock*

Executive Committee

C. B. Huffaker, Chmn.
Ray F. Smith
P. L. Adkisson
Gordon Guyer
S. D. Beck

Steering Committee

C. B. Huffaker, Chmn.
P. L. Adkisson
E. J. Armbrust
S. D. Beck
P. DeBach
G. E. Guyer
S. C. Hoyt
L. D. Newsom
R. L. Rabb
R. F. Smith
R. W. Stark*
Non-voting:
E. F. Knipling
M. E. Martignoni*
R. C. Riley
W. E. Waters*
J. J. Cartier

Sub-project Technical Advice & Guidance Committees

Sub-program Directors

P. L. Adkisson (Cotton)
E. J. Armbrust (Alfalfa)
P. DeBach (Citrus)
S. C. Hoyt (Pome and Stone Fruits)
L. D. Newsom (Soybean)
R. W. Stark (Pines - Bark Beetles)

Management Component

C. B. Huffaker, Director
R. F. Smith, Assoc. Direct.
Biological control coord.
Systems analysis coord.
Secretarial & technical

Sub-program Institutional Coordinators

Institutional Participants

Institutional Guidance Committees

*Represents Forest Entomology Input

PINES (Bark Beetles) Subprogram

Pine forests of various types constitute one of the major timber resources of the world and bark beetles are the most important insect pests in these forests. They have accounted for as much as 12% of all losses to sawtimber which is comprised principally of coniferous species. Annual mortality has been estimated to have reached 5 billion board feet. This subprogram will treat three of the most destructive species: *Dendroctonus brevicomis* in ponderosa pine, *D. frontalis* in loblolly and shortleaf pine and *D. ponderosae* in lodgepole pine.

Specific Objectives

1. To develop analytical procedures for evaluation of the impacts of these bark beetles throughout their host ranges, considering all values of the resources involved.

2. To develop analytical and predictive models which will permit determination of local and regional trends in beetle activity.

3. To develop pest management systems, which can define the problem for any set of socio-economic values of the pine resource and beetle population levels and suggest an integrated ecologically harmonious treatment strategy.

4. To develop strategy analysis systems which will indicate the management options available in different situations and will provide bases for action and no-action decisions to the resource manager.

Organization of Subprogram and 1973-74 Funding

Subprogram Coordinator - R. W. Stark, University of Idaho
Component Coordinators -
Western Pine Beetle ($90,000) D. L. Wood, University of California
Southern Pine Beetle ($114,000) R. N. Coulson, Texas A & M University
Mountain Pine Beetle (119,808) A. A. Berryman, Washington State University

Western Pine Beetle Subprogram

From the earliest planning phases to the present, Forest Insect Research (FIR) of the U. S. Forest Service both at the Washington Office (WO) and at the Pacific Southwest Forest and Range Experiment Station (PSW) have participated in developing this program. During the past six months direct participation by the Branch of Forest Pest Control, Region 5 (R-5), U.S.F.S. has contributed importantly to the subprogram activities. A series of meeting were held in January in which representatives of the U. S. Forest Service, R-5 and PSW and the University of California met with W. E. Water, FIR-WO, in an attempt to better coordinate our many activities that relate to management of the western pine beetle. We agreed to establish the following working groups:

Stand Dynamics of Ponderosa Pine

Chairperson -	C. J. DeMars	-PSW
	G. T. Ferrell	-PSW
	R. H. Smith	-PSW
	J. W. Byler	-R-5
	D. R. Hart	-R-5
	F. W. Cobb, Jr.	-U.C., Dept. of Plant Pathology
	J. R. McBride	-U.C., School of Forestry & Conservation
	J. R. Parmeter, Jr.	-U.C., Dept. of Plant Pathology
	P. A. Rauch	-U.C., Dept. of Entomological Sciences

Western Pine Beetle Population Dynamics

Chairperson -	D. L. Dahlsten	-U.C., Dept. of Entomological Sciences
	B. Ewing	-U.C., Dept. of Entomological Sciences
	C. J. DeMars	-PSW
	P. A. Rauch	-U.C., Dept. of Entomological Sciences

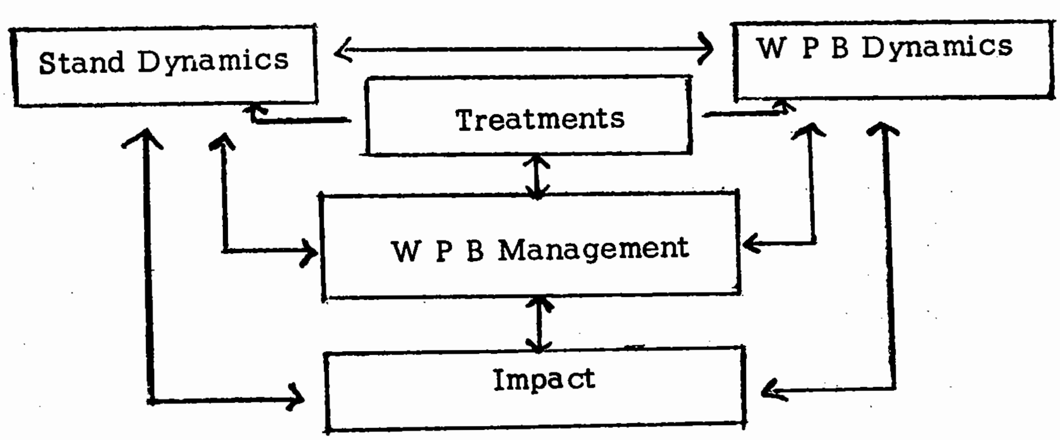
Treatments

Chairperson -	W. D. Bedard	-PSW
	L. E. Browne	-U.C., Dept. of Entomological Sciences
	B. H. Roettgering	-R-5
	D. L. Wood	-U.C., Dept. of Entomological Sciences

Impact

Chairperson -	W. E. Waters	-PSW
	W. C. O'Regan	-PSW

Western Pine Beetle Management System and Interrelationships Among Working Groups



The first priority efforts by the Stand Dynamics and WPB Population Dynamics Groups is to focus attention on the extensive data available from the studies performed at Blodgett Forest between 1967-1971. Their task is twofold: (1) to extend prior analysis of these data and obtain additional needed information, and (2) to develop stand and population dynamics models. Because WPB exploits trees infected with the root disease, *Verticicladiella wagenerii*, pest management strategies must account for this predisposing agent. Therefore, the cooperative R-5 and U. C. Disease Impact Survey in progress at Blodgett Forest is a crucial input to stand dynamics which in turn influences WPB population dynamics.

The Treatments Working Group will consider all possible manipulations of the WPB either directly or through the host. At this time, however, the Bass Lake and McCloud Flats pheromone tests represent the first priority of this group.

The Impact Working Group remains to be established. Contingent on his transfer to PSW in August 1973, W. E. Waters will organize this Group and initiate plans for its functions. This Group will have strong interactions with the other Groups, the Stand Dynamics Group in particular.

Southern Pine Beetle Subprogram

Two of the four subprogram objectives have been given highest priority and are now under investigation: 1) population dynamics-population modeling and 2) impact modeling.

Population Modeling

Principal investigators:	R. N. Coulson	- Texas A & M University
	Fred Hain	- Texas A & M University
Cooperators:	T. L. Payne	- Texas A & M University
	University of California, Berkeley	
	PSW - Berkeley and Southern Forest Experiment Station of the U.S. Forest Service	

Objectives: To develop adequate sampling procedures for within-tree population of the southern pine beetle and later to construct life tables. This research is especially challenging because the beetle is active throughout most of the year and produces up to eight generations each year. Also there is great variation in population density both seasonally and geographically.

Procedures: Sampling and data processing methods developed for the western pine beetle should allow rapid progress in defining an adequate measure of southern pine beetle populations.

Immediate Results Expected:

1. Sampling procedure: no. of samples per tree needed to characterize within-tree populations including attacking

adults, eggs - early instar larvae, late instar larvae, and emerging adults.

2. Intensity and distribution of the beetle and its parasites and predators along the infested bole.

3. Population variation through time and in different locations.

4. Relationship between stand characteristics and the occurrence of southern pine beetle.

Impact Modeling

Principal investigators: D. O. Yandal, R. A. Chapman and R. F. Anderson - all Duke University

Cooperators: U. S. Forest Service
- Division of Forest Pest Management
  - K. H. Knauer
  - A. E. Landgraf
  - D. A. Pierce
- Southern Forest Experiment Station
  - S. J. Barras
  - P. L. Lorio
  - J. E. Lotan
  - J. C. Moser

State Forestry Agencies from all 13 southern and southeastern states.

Objectives:

1. To develop the necessary data base for impact estimation and modeling

   a. by:
      1) access to state forestry agency records - usually historical in nature and variable in quality, quantity and format.
      2) timber resource data (forest survey)
      3) weather and soils data (SCS)
      4) economic data: government reporting agencies, trade associations, and industry.

2. To develop the systems for data processing and analysis which involves:

   a. development of procedures and computer programs for data capture, editing, pre-processing, and storage for primary data.

   b. acquire, adopt or develop programs and systems for statistical analysis.

c. acquire, adopt, or develop a general computer simulator to be used for model testing and prediction.

d. Provide for the efficient combination of impact data with population data for use in strategy analysis.

3. The information gained from the objectives 1 and 2 will be used for:

   a. making loss estimates on a state-by-state southwide basis.
   b. determining the "epidemic pattern" of southern pine beetle on a southwide basis, in relation to biological and weather variables and land use patterns.

(Note: Since the date of this presentation the Duke University project has been withdrawn. A new group to undertake this research is being sought.)

Mountain Pine Beetle Subprogram

This subproject has been organized as follows:

Participants

Associate Project Leaders
W. E. Cole - U.S.F.S. Intermountain Forest and Range Experiment Station ((NT)
M. C. Galbraith - U.S.F.S. Intermountain Region (R-4), Division of Timber Management

Population Systems Coordinator
D. G. Burnell - Washington State University

Economic Systems Coordinator
L. Anderson - University of Idaho

Data Management Coordinator
A. R. Stage - INT

Population Modeling

Chairperson - G. D. Amman - INT
M. D. Cole - INT
W. E. Cole - INT
W. H. Klein - INT - R-4, Forest Insect and Disease Prevention and Control
A. R. State - INT
D. G. Burnell - WSU
A. A. Berryman - WSU
A. L. Rigas - UI

Economic Modeling

Chairperson -	D. A. Hamilton	- INT
	L. Anderson	- UI
	E. B. Godfrey	- UI
	E. L. Michaelson	- UI
	C. D. Ditwiler	- WSU
	R. L. Shew	- WSU

Strategy Analysis

Chairperson -	D. E. Olson	- UI
	D. Adams	- UI
	J. A. Schenk	- UI
	R. F. Schmitz	- INT

Objectives

1. Develop a predictive model which will allow time for decisions and implementation of control procedures.

2. Develop a simulation model which will enable managers to experiment with the model system as an alternative to costly and hazardous field experiments.

3. Develop a monitoring device which enables determination of socio-economic impact of mountain pine beetle on timber, wildlife, recreation, aesthetics, range and watershed resources. A combination of these two models can be used to make decisions based on sound economic criteria.

4. Develop control procedures and analyses of combinations of these to determine optimum strategy for particular pest situations. The simulation and economic models can be used to test the effectiveness of various strategy alternatives on population and socio-economic values.

Current Status

1. Cole and Stage have developed a preliminary low resolution empirical population model based on beetle emergence as a function of tree diameter (phloem thickness). This gives a fairly good representation of conditions during epidemics.

2. Berryman and Burnell are working on a high resolution simulation model based on the conceptual framework of Berryman's Scolytus population model.

3. Anderson has been visiting U. S. Forest Service stations at Ogden and at the Targhee National Forest obtaining data on impact of mountain pine beetle on timber, recreation, aesthetics,

wildlife, water and range resources. This data base will be used in modeling and deciding priorities for further data collection

Plans - 1973

1. The largest holes in the data base are:

   a. population dynamics at endemic levels
   b. factors involved in triggering outbreaks

   Experiments have been set up to gather data on endemic populations and to test tree resistance characteristics in endemic, pre-epidemic, epidemic and post-epidemic conditions using the Canadian fungus innoculation technique.

2. The present emphasis in economics is to determine the effects of the mountain pine beetle on:

   a. Yield and timber sales
   b. Local income and jobs
   c. Changes in recreation use patterns
   d. Recreational value of resource
   e. Wildlife carrying capacity and values
   f. Changes in range uses and values

3. No plans for strategy analysis have been made due to limited funding. Analysis may be preformed on simulation model to provide information on which strategies could be profitably tested in the field.

PANEL: FOREST LEPIDOPTERA PHEROMONES

Moderator: Al Cameron

Participants: Dan Jennings, Chris Sanders, Iain Weatherston, Al Cameron

Notes: 1. Panel organized by Gary Daterman, USFS, Corvallis, Oregon. He deserves the credit.

2. Some problems or comments which recurred:

a) Inadequate knowledge of details of adult behavior, especially as it relates to mating, or response to or modification by pheromones.
b) All chemical components of pheromone systems may not be identified.
c) Difficulty in establishing standards, ex. - what is a 'female equivalent'? Is this a behavioral measure? a chemical measure? etc.
d) What are natural release rates of pheromones from insects? Are diel periodicities tied down adequately?
e) How stable are pheromones through storage?

Pheromone Studies on the Southwestern Pine Tip Moth, *Rhyacionia neomexicana* (Dyar) (Lepidoptera: Olethreutidae): Daniel T. Jennings

Males of the southwestern pine tip moth, *Rhyacionia neomexicana* (Dyar), are lured to traps baited with virgin females by an unidentified sex pheromone. Attraction begins ca. 2000 hr (MST) at Chevelon, Arizona and 70-80% of the males trapped per night are caught by 2330 hr. Sticky-board traps on stakes located in openings away from trees caught more moths than board traps on trees, cylinder traps on trees, or cylinder traps on the ground.

In collaboration with Martin Jacobson, Biologically Active Natural Products Laboratory, ARS, 15 synthetic acetates were field tested in 1971 for their attractiveness to males. Four of these compounds lured *R. neomexicana* males but only two, acetates of *cis*-7-dodocen-1-ol and *trans*-7-dodocen-1-ol, showed definite attractiveness. These two acetates were retested in 1972 along with five natural fractions obtained by column chromotography from hexane extracts of virgin females. Comparisons were also made with traps containing live virgin females. None of the natural fractions attracted males. *Cis*- and *trans*-7 again attracted males but more moths were caught in traps baited with live virgin females than those baited with *cis*-7. However, no significant differences were found in the attractiveness of *trans*-7 and virgin females for the 10-day trapping period. Thus *trans*-7 dodocen-1-ol is considered useful for detection surveys of *R. neomexicana*. It has potential use in trapping programs designed to reduce damage in isolated, low-level infestations of this insect.

Investigations of the Sex Attractant of the Spruce Budworm: C. J. Sanders

What was known as "the spruce budworm" 20 years ago, is now divided into six species. Two of these occur in the east, *Choristoneura fumiferana*, the eastern spruce budworm, and the sympatric *C. pinus*, the jack pine budworm. The other four are western species. Two of them, *C. occidentalis*, the western one year-cycle budworm and *C. viridis* are partially sympatric. The other two, *C. biennis*, the two year-cycle budworm, and *C. orae* are restricted in range but both may be contiguous with *C. occidentalis*.

The mono-unsaturated aldehyde, *trans*-11-tetradecenal (Soolure) has been identified as the major, if not sole, component of the sex pheromone communication system of *C. fumiferana*. It has been shown to be attractive to male *C. occidentalis* and *C. biennis*, as well as male *C. fumiferana*, implying that it is also a sex pheromone of these two species. *C. viridis* is attracted by the chemically related *trans*-11-tetradecenyl acetate. This chemical, and the alcohol, *trans*-11-tetradecenol, both inhibit the response of *C. fumiferana* to Soolure. Since the presence of a calling *C. pinus* female also inhibits the response of male *C. fumiferana*, it is probable that *C. pinus* uses the alcohol or acetate in its pheromone system. However, it has not yet been possible to attract male *C. pinus* with either chemical, alone or singly. The probable explanation is that *C pinus* uses a combination of chemicals. If this is so then the question remains of whether the other species such as *C. fumiferana* and *C occidentalis*, utilize more than one chemical, and if so, would the combination be more attractive than Soolure alone?

In 1972 traps baited with Soolure were evaluated as survey tools for *C. fumiferana* in eastern Canada and for *C. occidentalis* in B. C, and Oregon (by G. E. Daterman). Catches of males showed fair correlation with conventional larval beating samples in all three areas. However, the results were disappointing. In the east, catches were too low to be of much value in monitoring population fluctuations in low density populations. In the west, catches were higher, but still lower than anticipated. All these traps had been baited with Soolure from the same manufacturer, traps baited with Soolure from other manufacturers were more effective. Careful examination of the chemical and physical properties of the baits used has failed to explain this discrepancy and extensive use of Soolure as a survey tool must wait until this problem is resolved.

Attempts were also made to demonstrate that Soolure and the alcohol and acetate inhibitors can disrupt the mating behavior of *C. fumiferana*, both in lab experiments and in field experiments, conducted in New Brunswick and Ontario in 1972. All experiments gave positive results. The maximum reduction in mating success was around 40%, not a high figure, but in view of the very artificial conditions brought about by creating dense populations in the cages, any positive result is encouraging. Further evaluation of this technique must await formulations suitable for field application and several possibilities are being looked at.

Pheromones of the tussock moths: Iain Weatherston

In this preliminary report the problems involved in the isolation and characterization of tussock moth pheromones are considered.

Inter-species attractancy between the white marked tussock moth (*Orgyia leucostigma*) and the Douglas fir tussock moth (*O. pseudotsugata*) was demonstrated more than two years ago. Presently it is thought that the pheromones of both species are very similar. Most of the work has been carried out using white marked tussock moths.

Female *leucostigma* are wingless, emerge gravid from the pupal case and soon after eclosion adopt the "calling" position with the last few abdominal segments slightly raised and then begin a rhythmic protraction and retraction of the eighth, ninth and tenth abdominal segments. Females of less than two days old have been observed to call continuously for several hours. Bioassays using flight along a four foot glass tube, against an air current, has shown that the females are most attractive on the day following eclosion while the males are most receptive when two and three days old.

Various solvents, hexane, hexane/ether, ether and dichloromethane have been tested for extracting abdominal tips and all exhibited activity. Dichloromethane is currently used as the extraction solvent. Besides extracts, "ether washes" of jars which had contained virgin females are also being processed. These "washes" are a good source of starting material for the chemical investigations.

Acetylation or hydrolysis have no effect on the active components of the extract or wash; hydrogenation apparently has a partial effect, activity is not completely destroyed but the hydrogenated sample is not so active as controls.

Column chromatography, the first step in purification, was not successful due to inconsistent and contradictory bioassay results of the chromatographic fractions over three columns.

The initial purification was carried out by "Kugelrohr" distillation, the active material distilling at 110-114°C (0.7-0.9 mm. Hg.). Utilizing this technique it is hoped to acquire large amounts of starting material for a classical analysis of the pheromones.

Sex and the Single Gypsy Moth: E. Alan Cameron

Disparlure, *cis*-7,8-epoxy-2-methyloctadecane, the synthetic sex attractant for the gypsy moth, *Porthetria dispar* (L.) (Lepidoptera: Lymantriidae), isolated, identified and synthesized by U.S.D.A. chemists, is currently being used very effectively in baited traps for survey and detection purposes. It is potentially useful for gypsy moth population manipulation or control. It may be possible either to attract adult males to designated spots where they are 'treated' (as by physical capture), or to so disrupt the behavior of male moths that they are unable to locate and mate with females in infested areas. If populations can be manipulated adequately, ultimately the lure may be used for eradication of isolated infestations, establishment of a barrier zone to prevent further geographic spread of the insect, or in conjunction with other controls, to eliminate populations in generally infested areas. I do not foresee the eradication of the gypsy moth for North America, however, under any circumstances.

Working under a Cooperative Agreement with the USDA-ARS, we have been testing disparlure in the field in Pennsylvania. During 1972, cylindrical cardboard traps, 7.5 cm long x 2.5 cm dia, coated with Tack Trap containing 500 μg disparlure, were dropped by aircraft over test areas at rates of 1160 or 4640/km^2, and pupae were distributed within each 100 ha test plot to simulate different sorts of infestations. Where pupae were placed relatively closely together in aggregates, as many as 81.3% of the female adults in untreated check areas were fertile; fertility in areas with traps was reduced, but reductions were only occasionally statistically significant. In some test plots where pupae were placed in a modified random pattern, mating success was higher in the treated plots than in untreated check plots; in others slight reductions were noted.

With the traps and methods tested, we were unable to demonstrate suppression of mating adequate to reduce gypsy moth populations in the subsequent generation, even though trap to female ratios exceeded 75:1 in some tests. Indeed, mating success was increased in some plots, perhaps as the result of many lure emitters (traps) stimulating males to search longer and more widely for females and thus increasing the probability subsequent cues involved in host detection and location would come into play.

In tests in which we attempted to disrupt chemical communication, lure was applied to 6-12 mesh cork and applied by air at ca 570 g cork containing 7.5 or 25 g disparlure/ha. Mating success of female moths was significantly reduced in treated plots. Unfortunately, however, statistically significant reductions did not necessarily indicate reductions which were <u>biologically</u> significant in the sense that the population trend in the following year would be tipped downward; none of our reductions appeared biologically significant.

In one final late season test, in which a microencapsulated formulation of lure was applied at a rate of only 5 g lure/ha, we succeeded in completely disrupting mating; no females in the treated plots were mated, and no fertile eggs were laid. But the insects used in this test were ones which, although collected as eggs in the field last winter, had been reared to the pupal stage on diet in a laboratory. All tests conducted thus far in which disparlure has looked especially promising have utilized such lab-reared males. However, this breakthrough in application technique will be re-tested in 1973 against wild insects; we are optimistic that we are on the right track.

Basic studies of adult behavior, mainly by Jim Richerson, a post-doctoral appointee, have been undertaken more fully to understand the insect we are trying to manipulate. The two most important results thus far are that i) a 'wild' and a 'lab' adult gypsy moth are, behaviorally and in some respects physiologically, two very different insects. Wild insects are more aggressive, produce more lure or are more responsive to lure, and in general are a better insect than lab ones. ii) Cues, certainly visual and likely involving u-v reflectance, operate in addition to the chemical disparlure in getting male and female moths together. We must know more about these before we are likely effectively to use disparlure successfully for population manipulation.

In summary, we are learning much more about the adult behavior of the gypsy moth - the behavior we are trying to alter - and have had some limited successes in disrupting mating under field conditions. But we are not ready in 1973 to hold the line on the advance of the gypsy moth in the northeast. If key experiments are successful this summer, the story may be different in another year.

WORKSHOPS

METHODS OF MEASURING IMPACT

Moderator: Cliff Myers

Impacts of insects on a forest can be regarded as either positive or negative, depending on the interests of the persons involved in the interpretation. An impact study must, therefore, start with a statement of purpose that is formulated with potential users of the information in mind. Enough information must be obtained to provide for the examination of alternatives in the evaluation of the impact and the nature of controls. After the measurements have been obtained, analysis of the data and the way of presenting the results must be oriented to the purpose of the study.

Particular problems arise in the case of insects that produce periodic declines in tree vigor and volume growth. Methods of measurement and analysis that are being used in such cases include:

1. Borings of all trees at breast height. Radial growths are then plotted over time. A curve through the peaks is assumed to represent the growth that would have been obtained without attack. Performance below this line is considered to be a result of attack. Any effect of the infestation on height growth must also be considered. It is also necessary to consider other causes of change in growth, such as weather conditions and production of large seed crops.

2. Single trees uninfected for long periods have been used to determine the potential of similar but attacked trees. Similarity in site quality and stand density are necessary for adequate comparisons. Also, individual trees of similar size and appearance produce varying annual growths.

3. Stem analysis of infected and uninfected trees can show the effect of the attack on the entire tree, not just at one level. An interpretation problem is introduced, however, when stand density is reduced during the period of study. Disturbance of a formerly closed stand will cause the remaining trees to exhibit an adjustment of form to the increased wind load on the crowns. This will cause the formation of wide rings in the lower bole that do not represent true potential when used directly in volume computations.

Complications disturb the analysis of already complex problems. An example is the heart rot that occurs within the crown level of budwormed trees. This loss of volume is expected to increase with time.

A basic impact measurement is provided by aerial photographs--the area of infestation.

URBAN FOREST INSECT PROBLEMS

Moderator: J. Wayne Brewer

Recorder: Bruce Hostetler

Forest entomologists at all levels increasingly are becoming involved with urban forest insect problems. As native forest-type areas are invaded by housing and recreation developments, such problems intensify and the public demand for solutions becomes greater. At the same time, substantial pressure is exerted by other, or the same, groups to insure that such control causes little or no disruption of the environment. The problems created by this situation will certainly continue and some type of solution to the dilemma must be found.

The workshop opened with a discussion of the similarities and differences between typical forest insect problems and those found in urban situations. It was suggested that many of the insect pests were the same as those found attacking native plants because many landscape plants in the western states are transplants from the wild. However, the extent of the problems created by these new "urban" dwellers, and their solutions, may be considerably different from those in native forest situations. For example, the environment of the plant has been altered dramatically, frequently making it more susceptible to insect attack. This seems especially true when xeric plants are given an abundance of water and nutrients by the conscientious home owner. In addition, the level of acceptable damage varies considerably in the two situations. Many home owners want, and will pay for, control of unsightly insect problems even though the damage would not normally warrant control measures. Consequently, considerably more time and money can be spent on control of urban insect pests than could be justified in the typical forest situation.

Some of the specific insect problems included in the discussion were the Douglas-fir tussock moth, the elm bark beetle and Dutch elm disease, the elm leaf beetle, pinyon needle galls, pine tip moths, and mountain pine beetles.

Dr. Tom Koerber discussed a number of urban insect problems created by environmental changes resulting from the rapid development of the Lake Tahoe resort area. He pointed out that many of the "insect" problems were created by causing conditions unfavorable for tree growth. Some of these conditions included the removal of young vigorously growing trees or "brush" in favor of tall over-mature ones, unwise construction of swimming pools and parking lots adjacent to magnificant trees, and the general damage done by building "cities" in forest areas. He suggested that the only solution to the problem was to approach construction industry and convince them to make use of existing information to reduce tree damage and thus, the insect problem.

Another area of discussion was the problem concerning the registration of pesticides for landscape plant use. It generally was concluded that increased restrictions on the use of pesticides in this situation had greatly complicated the control of many otherwise manageable pests. It was agreed that more specific label requirements regarding pesticide use was making it difficult to give legal recommendations for urban insect control. In addition, many companies are not expanding their existing labels to include urban forest insects because of the high cost of research data required by new regulations.

EFFECT OF THE HOST ON INSECT POPULATIONS

Moderator: A. A. Berryman

The effects of host plants on the dynamics of forest insect populations was discussed. Participants wishing to present the results of recent (unpublished) research were first provided the opportunity to tell their stories.

Bob Cous1on discussed the relationship between the southern pine beetle and stand conditions. Stand density was thought to be a factor in predisposing southern pines to this bark beetle.

Karel Stoszek presented data on the relationship between moisture stress in Douglas-fir and successful and unsuccessful attack by *Dendroctonus pseudotsugae*, *Scolytus unispinosus*, *Pseudohylesinus nebulosus* and *Melanophila drummondi*. Stress measurements, made with a Scholander pressure bomb, were highly correlated with successful attacks by these insects. Karel also discussed the attractiveness of ethyl alcohol to these insects and commented on problems evolved in evaluating attractants (eg. monoterpenes) when ETOH is used as a solvent.

Rod Carrow presented data showing the effect of various fertilizers on reproduction and survival of the balsam woolly aphid. In general populations were lowest on trees fertilized with Ammonium nitrate.

Alan Berryman presented a hypothesis for population fluctuations of the fir engraver endemic populations being supported by root-rot infected trees, and epidemics triggered by factors predisposing large numbers of hosts (eg. Douglas-fir tussock moth outbreaks). Intraspecific competition was postulated as the mechanism by which populations are stabilized at limits set by the availability of susceptible hosts.

Subsequent discussion centered around the above presentations.

TECHNICIAN'S ROLE IN FOREST ENTOMOLOGY

Moderator: A. D. Tagestad

Attending were personnel from U. S. Forest Service Research and Pest Control including technicians, supervisors and a personnel officer. Also represented were University technicians and a private consulting firm.

General consensus was that technicians could contribute greatly to the success or failure of research and other programs. Bill Wilford stated that he remembered several program failures because of the lack of technicians. Mel McKnight stated in these days of budget restrictions it is important to recognize that technicians extend by several times the efficiency of each scientist. A great amount of formal training and education was not judged to be an absolute necessity but is helpful to understand why things are done the way they are. Harold Osborne stated that one of the most important requirements for a technician was common sense but that some degree of formal training was necessary. It was brought out that in the U. S. Forest Service in technician series the position and job description is graded unlike the scientist series in which the man is graded. Advancement for a technician is dependent on upgrading the job description. To establish a high level technician position, (GS-9 or higher) there must be a need and financial support for such a position. In some cases advancement is dependent on someone to fill the less advanced job the technician would vacate in advancing.

PROS AND CONS OF THE TREND TOWARD LARGE PEST MANAGEMENT RESEARCH AND DEVELOPMENT PROGRAMS

Moderator: Boyd Wickman

To set the stage for discussion, a brief outline of four additional Research and Development Programs not previously covered during the work conference were presented.

Chris Sanders, chairman of the Canadian Spruce Budworm Working Committee. Chris discussed the Canadian organization and goals. There are 5 different laboratories with 21 scientists and survey entomologists working on spruce budworm. The major objective in spruce budworm management is protection of foliage, consequently much of the research effort is directed toward control of the pest.

Bill Bedard, leader for a Forest Service program on biochemical determinants of insect behavior. This program works within the framework of the IBP pest management program on pine bark beetles described in the previous panel by Dave Wood and others. The goal is to make the use of bark beetle attractants operational for the western pine beetle, mountain pine beetle and southern pine beetle.

Dick Washburn, coordinator for a proposed Forest Service R&D program on the larch casebearer. The proposal is patterned after the gypsy moth program. Teams of 3 to 4 people prepared various parts of the planning document to use for funding proposals. The objective is to formulate control strategies for the casebearer. Present participants include INT, PNW, and PSW Experiment Stations; Regions 1 and 6; States of Washington, Oregon, Idaho, and Montana; and universities of Idaho and Washington State University. The document will be sent to the Forest Service, Washington Office shortly. If funding is obtained it is probable that much of the research will be contracted to universities.

Boyd Wickman, coordinator for the Forest Service Western Spruce Budworm Research and Development Program. A letter of understanding between western Experiment Stations and Regions agrees to coordinated effort on this pest. There is presently some R&D effort directed toward the problem; however, a larger broader-based program is needed. A proposal, patterned after the gypsy moth program, has been prepared by a team of Forest Service entomologists and submitted to the Washington Office for funding consideration. The objective of the program is the development of integrated control strategies through computer simulation and experimentation. If funded, much of the work will be contracted to universities.

With this background on proposed and ongoing projects plus an earlier panel on IBP programs and a paper by Jim Bean, leader of the gypsy moth program; workshop participants were asked to comment. There was lively discussion and a list of pros and cons follows:

<u>Some Pros</u>:

1. Such programs focus on important pest problems, putting major emphasis on having operational management techniques within a time framework.

2. It directs assorted researchers toward a common goal rather than each doing his own thing.

3. Once a model management system has been devised for one pest it should be applicable to other pest problems with little extra effort.

4. This approach will create new educational opportunities. Contracts to universities will provide opportunities to educate people toward broader outlooks and train them for participation in other programs.

5. There are simply not enough resources around to work on all pest problems so it is better to concentrate efforts on a few highly priority problems.

6. The fire-fighting approach of the past has not worked. A "NASA", R&D approach has time limits to meet to set objectives.

7. With a systems approach, as used by most programs, there is a similar commitment to a common goal so there is a logical and useful information flow.

8. There has been no other way to obtain the large amount of money necessary to mount a meaningful attack on major pest problems.

Some Cons:

1. The large programs do not solve day-to-day problems, especially for lesser known pests.

2. After decades of work, we still do not have acceptable control techniques for most pests. How are large programs going to do any better?

3. There are problems in handling and analyzing the masses of data accumulated in such programs. Perhaps computer and systems analysis technology are not ready for this approach for biological problems.

4. We should be looking at associations of insects in ecosystems rather than just one pest problem.

5. Large programs are difficult to fund, they are politically oriented and influenced by lobbyists so when funded we do not always make best use of the money.

6. The nature and solution of entomological problems do not follow 5-year patterns.

7. We may overemphasize educating people toward systems and teams to the detriment of developing specialists.

8. Large programs are formed at the expense of many smaller research programs. There should be some overview so that smaller projects are not swallowed-up during reprograming.

9. Large programs create problems at the individual, working level. Team efforts change how we look at the individual's productivity and motivation. It may take a long time to reorient individual workers into accepting this approach.

There were some other comments which related to operating problems in the large programs and ways of improving programs and proposals.

1. There must be flexibility in both funding and manpower. When one segment of work is finished the leader must have the flexibility to shift people to new work.

2. It is not practical to complete some of these programs in 5 years so we should avoid promising too much. There is also a lag time between funding proposal, approval, and actual initiation of work. The 5 years may be up just when you start achieving results.

3. There is competition for R&D funds among many forest management proposals now and pest proposals may have low priority. Therefore, we should coordinate our requests because there just won't be enough to go around. There should be better ways for lobbying groups to help obtain funding perhaps by pushing for programs that meet broader needs e.g. insect, diseases, and silviculture, in other words, total forest management problems.

4. We must tie the forest management objectives with our objectives through our systems approach or we'll fall flat on our face.

5. Why can't we still fund small parts or individuals (Star system), but keep the parts integrated toward a larger objective? This would ultimately lead to "star teams" competing for money in place of the "stars" and there would still be no overall commitment to goals or discipline to work as a team.

CACODYLIC ACID

Moderator: C. K. Lister

Cacodylic acid (dimethylarsinic acid) is currently registered for bark beetle control in the States of Oregon, Idaho, Wyoming, South Dakota, Utah, Colorado, New Mexico, Arizona, Virginia, Georgia, Louisiana, and Texas. It can be applied for control of spruce beetle (*Dendroctonus rufipennis*), mountain pine beetle (*D. ponderosae*), Douglas-fir beetle (*D. pseudotsugae*), round-headed pine beetle (*D. adjunctus*), southern pine beetle (*D. frontalis*), Arizona five-spined beetle (*Ips leconte*), pine engraver beetle (*I. pini*), and California five-spined beetle (*I. confuses*).

Two techniques for using cacodylic acid are pre- and post-flight treatments. Variation of tree and beetle species limits the effectiveness of any single technique. Timing of application is very important and may vary for each insect or host species. The pre-flight treatment looks promising where green conifers are to be cut and never removed or removal is not timely to prevent bark beetle buildup and flight, such as in trail construction, powerline construction, and road right-of-way clearing. Post-flight treatment appears best for the more remote areas. The greatest drawback is the short time available to do effective treatment.

Insect suppression can be obtained by pre- and post-flight treatment techniques. However, frilling of the tree and timing of treatment are very important. Axe-made frills are superior to frills made by chainsaws. Axe-made frills which are too perpendicular are inferior to those with high angle. Proper timing is very important in order to obtain satisfactory control. For example, in post-flight treatment of mountain pine beetle in ponderosa pine, effective mortality can be obtained if applied within 2 weeks after attack. Timing of treatment is also important in pre-flight treatment of spruce for lethal trap trees. The chemical must be introduced before sap movement is inhibited in the fall. In Colorado, indications are that a rapid decline of sap movement should be expected sometime in September.

In 1972, personnel of Regions 2 and 3 and the Rocky Mountain Forest and Range Experiment Station initiated studies using cacodylic acid against spruce beetle using the pre- and post-flight techniques. The post-flight treatment area is in southern Wyoming. Four dosages are being tested. The pre-flight treatment area is in southern Colorado, where four dosages and three treatment times are being tested.

The mode of action of cacodylic acid in the tree and on the insect was discussed at some length. Little factual data is available. In studies of cacodylic acid-treated trap trees, arsenic analysis of phloem shows that beetle mortality is related to the levels of arsenic.

PROBLEMS IN INSECT IDENTIFICATION

Moderator: Mel McKnight

Ten participants attended the workshop: Brewer, Tagestad, Iselin, Jennings, Chavez, Acciavatti, Finlayson, Bodenham, Cibrian, and Ives.

The following areas were suggested for discussion: problems encountered; "outside specialists"; "Hopkins system" and other retrieval systems; needs.

The salient problem seemed to be getting specialists to name and describe new species after recognition that the entity is new. Considerable delay in obtaining a name makes publication of other information on the species very difficult. The fact that taxonomy is underfunded seems to be the basis of the problem. Taxonomy needs greater financial support so that service work and description (research) work can be separated. It was recognized that sooner or later we can expect to pay for identification services received. The U. S. Forest Service does not contribute funds to ARS for identification services. It was reported that APHIS does contribute financially and also has an entomologist assigned to do routine identifications.

Sometimes we encounter the problem of "no specialist available" for particular groups when we submit material to the usual sources of identification services (ARS, Smithsonian Institution, Entomology Research Institute). To partially overcome this deficiency, and to also provide alternative sources of assistance who may give more rapid service, a list of "outside specialists" was prepared for inclusion in the Proceedings. The specialists listed are those who are known by the indicated "source" to be willing to identify material for forest entomologists. It is imperative that these specialists be contacted before material is submitted. For some groups contact should be made with the specialist before the material is collected and preserved.

The versatility of the Hopkins system, used within the U. S. Forest Service, was discussed. The mechanics of using the Hopkins system probably vary at each field location but it provides a means of associating data on biology with specific specimens. Specialists in the Hymenoptera and Tachinidae apparently utilize the Hopkins data which is submitted to the National Museum with specimens for identification of Hopkins system records with other information retrieval systems in use by ARS or APHIS, for example.

The Canadian system which utilizes a sampling form was discussed. In this system the collector records various details of the habitat on the form which accompanies the collection thereafter. This data is eventually stored on magnetic tape where it can be retrieved.

Specialists available to forest entomologists for identification service

Always contact these specialists <u>before</u> sending material

Group	Specialist	Address	Source
Aphids	A. G. Robinson	Univ. Manitoba, Winnepeg	Wong
Aphids	G. R. Bradely	CFS, Ottawa	Wong
Homoptera-Aphididae; Thysanoptera; Acarina	Tokuwo Kono	Calif Dept. Agr., 1220 N Street Sacramento, CA. 95814	Buxton (CDA)
Homoptera except Aphididae; Psocoptera; Collembola	Raymond Gill	Calif Dept. Agr., 1220 N Street Sacramento, CA. 95814	Buxton (CDA)
Thysanoptera	B. Herning	Univ. Alberta, Edmonton	Wong
Heteroptera	G. G. E. Scudder	Univ. British Columbia, Vancouver	Wong
Lepidoptera: Geometridae	Frederick Rindge	Amer. Mus. Nat. History; Central Park West at 79th Street New York, N. Y. 10024	Wygodzinsky
Orthoptera	D. K. McE. Kevan	MacDonald College, P. Q	Wong
Sawflies	H. R. Wong	CFS, Edmonton	Wong
Hymenoptera-Pompilidae, Tiphiidae; Diptera - Tephritidae	Marius S. Wasbauer	Calif. Dept. Agr., 1220 N Street Sacramento, CA 95814	Buxton (CDA)
Carabidae	G. E. Ball	Univ. Alberta, Edmonton	Wong
Cerambycidae	L. M. Gardiner	CFS, Sault Ste Marie	Wong
Bark Beetles	G. R. Hopping	CFS, Victoria	Wong
Scolytidae	J. B. Thomas	CFS, Sault Ste Marie	Wong

Group	Specialist	Address	Source
Scolytidae	Stephen L. Wood	Dept. Zoology, Brigham Young Univ. Provo, Utah 84601	McKnight
Buprestidae	Stanley G. Wellso	USDA-ARS, East Lansing, Mich. 48823	McKnight
Cerambycidae	W. H. Tyson	Apt D., 593 W. San Jose Ave., Fresno, Calif. 93704	Stein
Chrysomelidae	Edward U. Balsbaugh Jr.	Ent.-Zoo Dept., S. D. State Univ. Brookings, S. D. 57006	McKnight
Eriophyid mites	H. H. Keifer	1112 Swanston Drive, Sacramento, CA. 95818	McKnight
Spiders	R. Leech	CWS, Ottawa	Wong
Spiders in forest environments	D. T. Jennings	Rocky Mtn. For. & Range Exp. Stn. Albuquerque, N M 87101	Jennings
Diptera: Dolichopodidae, ?Culicidae	Fred C. Harmston	Communicable Diseases Laboratory Colorado State Univ. Fort Collins, 80521	Schmid
Diptera: Asilidae	Robert J. Lavigne	Box 3354, Univ. Sta., Laramie, Wyo. 82070	Schmid
Scolytidae: Ips	Gerald N. Lanier	State Univ. College of Environ. Sci. and Forestry, Syracuse, N. Y.	
Ichneumonidae	John M. Schmid	Rocky Mtn. Sta. 240 W. Prospect, Fort Collins, Colo. 80521	Schmid
Olethreutidae	Wm. E. Miller	North Central Exp. Sta., Folwell Ave., St. Paul, Minn. 55101	McKnight

Group	Specialist	Address	Source
Scolytidae	D. E. Bright	Coleoptera Section, Research Branch Entomology Research Institute Ottawa, Ontario KIA OC6	Stevens
Curculionidae	C. W. O'Brien	Laboratory of Aquatic Entomology Univ. P. O. Box 111 Florida A & M University Tallahassee, Fla. 32307	Stevens
Scales	R. F. Wilkey	Arthropod Slidemounts 118 W. Cherry Street P. O. Box 185 Bluffton, Indiana 46714	Stevens
Olethreutidae (esp. Rhyacionia and related genera)	J. A. Powell	Department Entomology University of California Berkeley, California 94720	Stevens
Buprestids, cerambycids, clerids	Robert H. Perry	2734 Ohio Street Michigan City, Indiana 46360	Stein
Spider family Oxyopidae	Alan R. Brady	Biology Dept. Hope College Holland, Michigan 49423	Stein
Spider family Salticidae	Bruce Cutler	2441 W. Larpenteur Ave. St. Paul, Minn. 55113	Stein
Order Opiliones (Harvestmen or Daddy Longlegs)	Alan L. Edgar	Dept. of Biology, Alma College Alma, Michigan 48801	Stein
Spiders, especially the family Anaphaenidae	Norman Platnich	Museum of Comparative Zoology Harvard University, Cambridge, Mass. 02138	Stein
Spider family Thomisidae	Richard J. Sauer	Dept. of Entomology Michigan State University East Lansing, Michigan 48823	Stein

Group	Specialist	Address	Source
Spider family Gnaphosidae	Karl J. Stone	Minot Business College Minot, No. Dak. 58701	Stein
Spider family Lycosidae	H. K. Wallace	Dept. of Zoology University of Florida Gainesville, Florida 32601	Stein
Spider family Clubionidae	Jonathan Reiskind	Dept. of Zoology University of Florida Gainesville, Florida 32601	Stein

Attention was called to two recent studies and reports concerning support for systematics "Systematics in Support of Biological Research" was published by the National Council, Washington, D. C. 1970.

Both reports urge the separation of service work from descriptive research, and financial support in return for services rendered.

A discussion of wet storage of insects followed. Neoprene stoppers were considered best for vials stored in plastic or wood trays or racks. For permanent museum storage cotton plugs in vials inverted in jars of alcohol were suggested.

USES AND APPLICATION OF INFRARED PHOTOGRAPHY

Moderator: Peter A. Murtha

The panel moderator began by presenting a brief report on a photo interpretation study of tree mortality alongside the International Boundary zone, Waterton Lakes National Park, Alberta. Because of Tordon 101 (a herbicide) spraying in 1968 of the International Boundary zone, trees outside the zone and located either in Waterton Lakes National Park or Glacier National Park had been killed. The extent of the tree mortality was interpreted from color infrared air photograph, scale 1:6,000. Strips of dead trees were noted to adjoin 45 percent of the forested boundary on the Canadian side and 52.3 percent on the U.S. side. On the Canadian side 1,490 dead trees were counted whereas 1,236 dead trees were counted on the U.S. side of the boundary.

Mr. Bill Ives, Canadian Forestry Service, Northern Forest Research Centre, Edmonton, Alberta, followed with a brief description of photo interpretation study of "red-belt" damage near Hinton, Alberta. The problem of obtaining air photos at the correct time of the year was discussed, and when the red belt photos were taken, it was too late in the season; a year's growth having obscurred some of the damage. The relationship between the air photo interpretation study and its value as an ERTS (Earth Resources Technology Satellite) test site was discussed. Since the syndrome of damage is similar to that caused by other agents the requirement for ground verification was emphasis.

Mr. John Wear, U. S. For. Serv., Pacific Southwest Forest and Range Experiment Station, followed with a brief discussion of enhanced satellite imagery. An example of a test site in Oregon was displayed. Mr. Wear emphasized that interpretation of items on satellite imagery was still based solely on a priori knowledge.

Mr. Doug Ross, C.F.S., Pacific Forest Research Centre, Victoria showed an ultra-small-scale (1:140,000) normal-color photo with a spruce budworm infestation outlined on it. Again, the infestation was only recognizable because of a priori knowledge. The same infestation was also outlined on a Canada Centre for Remote Sensing color composite ERTS satellite image.

Mr. John Laut, pathologist, Colorado Forest Service, Fort Collins, brought the discussion back to earth with a description of the "Denver incident". An example of "over-kill" by untrained, but enthusiastic army personnel to delineate all the Dutch elm diseased trees in Denver. Multi-scale, multi-date, multi-film combinations were used to find the affected trees. Ground checking by forestry people revealed that the interpreted infected elms were white ash under some sort of stress. Total project cost $80,000 and provided no true results.

Mr. Jules Caylor, U.S.F.S., P.S.W. Forest & Range Exp. Station, San Francisco, described efforts in applying photo interpretation knowledge to practical field problems of assessing tree mortality due to insects or disease over large acreages (30,000). To complete the study some equipment had to be "invented" or modified to permit photo interpretation in the field. It was estimated that 95 percent of all single and multiple tree spots of mortality were detected on each sequential flight.

The major consensus of opinion was the need for more practical application of remote sensing knowledge and photo interpretation techniques at the field management working level. The knowledge and techniques are available and have been successfully used in many cases, however, a communication gap exists between the people with the knowledge, and those at the every day management level who should know how to apply the knowledge.

FOREST INSECT PHEROMONES

Moderator: J. H. Borden

Approximately 45 persons attended the workshop. The basic theme was to consider pheromones in applied measures. The workshop was divided into 3 subgroups with leaders and reporters as below:

	Leader	Reporter
A. Survey and Detection	D. Jennings	B. Wickman
B. Disruption	A. Cameron	C. Sanders
C. Mass Trapping	M. Atkins	G. Lanier

Each group was given instructions as follows:

1. Identify all past and/or continuing work which has tested or utilized forest insect pheromones in the applied measure in question.

2. Identify the types of additional basic information necessary to improve the applied measure for the species listed above, or to implement the measure with other species. Suggest all possible modifications and improvements which would make the method more effective.

3. On the basis of known economic importance and particular biological characteristics, identify a selected group of forest insect pests which would be good candidates for future application of the method in question. Justify your choices.

CONCLUSIONS

The individual group reports to the reassembled workshop contributed to three major conclusions drawn by the workshop moderator.

A. There has been very little practical application of forest insect pheromones in North America, either on an experimental, or tested and recommended basis.

B. There is much need for basic biological and economic data so that pheromones may be used optimally and evaluated accurately. Principal fields in which data are needed are:

   1) Behavior with regard to pheromones
   2) Population dynamics; including predictive models
   3) Economic impact and thresholds.

C. Candidate species for application of pheromones in any particular applied measure can be effectively chosen only on the basis of accurate and comprehensive behavioral, ecological and economic data.

INDIVIDUAL GROUP REPORTS

A. Survey and Detection

1. Past and/or Continuing Work

There was a general feeling that this applied measure is too broad and should have been subdivided. "Detection" refers simply to detecting the presence or absence of an insect, whereas, "survey" implies some means of monitoring the population density, distribution and other factors. Nevertheless, several insects were identified which had been the subject of applied work using pheromones in survey and detection, as follows:

a.* European pine shoot moth, *Rhyacionia buoliana*
b. Southwestern pine tip moth, *Rhyacionia neomexicana*
c.* Gypsy moth, *Porthetria dispar*
d. Nantucket pine tip moth, *Rhyacionia frustrana*
e.* Spruce budworm, *Choristoneura fumiferana*
f.* Western pine beetle, *Dendroctonus brevicomis*
g.* Mountain pine beetle, *Dendroctonus ponderosae*
h.* Douglas-fir beetle, *Dendroctonus pseudotsugae*
i.* Southern pine beetle, *Dendroctonus frontalis*
j. Spruce beetle, *Dendroctonus rufipennis*
k. *Ips* spp.

* Pheromones used for monitoring to provide an index of population.

2. Modifications, Improvements, and Additional Information

Information in several fields was considered essential to the future development and effective use of pheromones in survey and detection work.

a. Trap Design. Several types of improvements should be worked on to improve: air passage, ease of handling, size of trapping surface and ease of servicing. It was suggested that a standardized and tested trap design would be useful in providing reliable, comparative data between species, and between and during seasons or areas for a single species.

b. Trap Placement. More information is needed on the effect of trap efficiency as affected by both vertical and horizontal trap distribution.

c. Biological Information. More data are needed on the basic biology, behavior and physiology of many species in order to interpret trapping data effectively.

d. Population Dynamics. Improved methods of within tree sampling, sampling natural enemies, monitoring population changes through time, and area sampling would provide the background data necessary to use pheromone survey and detection systems as effective prediction methods.

e. Economic Data. More precise information on the relationship between population level and damage caused will also enhance the use of pheromone survey and detection systems in predicting impact of various pests.

f. Release Systems. Information on effective pheromone concentration, doses and timing, and on trap distribution will make pheromone survey and detection systems more effective.

3. Candidate Species for the Use of Pheromones in Survey and Detection

Several pest species were identified for future application. Justification for the choice was not possible for all species due to insufficient time.

a. Douglas-fir tussock moth, *Hemerocampa pseudotsugata*. Justification: Cycle pest, present beating plots are expensive, very difficult to detect at endemic levels, does most of damage in one year, female is flightless.

b. Pine tip moths. Justification: economically important, low levels can cause considerable damage.

c. Hemlock Loopers

d. Black-headed budworm, *Acleris variana*

e. Cankerworms

f. Carpenterworms

g. Spruce beetle, *Dendroctonus rufipennis*

B. Disruption

1. Past and/or Continuing Work

Disruption of mating behavior has been attempted with only one forest insect, the gypsy moth, *Porthetria dispar*. In addition the technique has been successfully demonstrated in 2 agricultural insects, the cabbage looper, *Trichoplusia ni*, and the pink bollworm, *Pectinophora gossypiella*. Trials were also conducted on several agricultural pests in 1972 by Roeloffs, but the results have not yet been reported. Considerable discussion focused on the principles and definitions of disruption.

Principles

a. Individuals of the candidate species in nature must depend predominantly on pheromone to orient successfully.

b. Sufficient chemical must be disseminated in the environment to disrupt orientation of one sex to the other, i.e. the released chemical(s) must mask the effect of naturally occurring females.

c. Adaptation (inhibition of sensory neurons due to repeated stimuli) and/or habituation (lack of response to repeated stimuli) should not occur so that orienting individuals are inhibited from switching to alternative orientation stimuli.

Definitions

Disruption may take three forms:

a. Displacement. The searching individual becomes fatigued from an exhaustive search due to stimulation from released pheromone and is eliminated from the effective population.

b. Confusion. In a pheromone-saturated enviroment orienting individuals "don't know which way to turn".

c. Inhibition. A pheromone analogue or masking compound could compete for receptor sites on olfactory sensilla, thus inhibiting perception of pheromone.

2. Modifications, Improvements and Additional Information

Essential information needed proved to be principally biological in nature.

a. Odor Reception. In order to understand and use disruption techniques most effectively it is essential to understand the perception capabilities and variability of the responding insects.

b. Odor Meteorology. Very little is now known on what happens to chemicals released into a natural atmosphere. It is essential to know dispersion rates and distribution of chemicals so as to plan effective and persistent disruption.

c. Dependence in Nature on Pheromone. If the calling individuals in nature rely solely on pheromone to attract mates, then disruption would be practical and effective. If responding individuals can perceive and respond to other stimuli such as sound or reflected ultraviolet light, disruption attempts with released pheromones might be ineffective.

d. Calling Behavior and Release of Pheromone. Knowledge of timing of calling and pheromone production and/or release will indicate when and in what amounts to release disruption pheromones.

e. Population Dynamics. Essential information includes data on population density (disruption may have a better chance to succeed at low population levels), and on the spatial distribution of populations, i.e. whether individuals are aggregated or evenly dispersed.

f. Computer-Based Simulation Techniques. These techniques may allow more effective estimation of target populations, and in addition, may permit evaluation of disruption techniques (i.e. the impact of a particular technique may be predicted).

3. Candidate Species for the Use of Pheromones in Disruption

No species were identified, partly due to time constraints. However, it was emphasized that selection of candidate species would depend particularly on the extent to which the essential information detailed in the above section was available. For example, if the females in a given species depended entirely on a sex pheromone to attract males, if there were adequate data on population characteristics, and techniques of predicting population changes were well developed, the species would be considered a good target for pheromone disruption techniques. The group on Mass Trapping suggested that anti-attractants could be used in species in which they are known.

C. Mass Trapping

1. Past and/or Continuing Work

Two species of agriculturally important lepidoptera were included as examples because of the successes reported in mass trapping programs. In addition, 4 species of scolytids have been the subject of "trap out" programs with varying degrees of success. The species and results are as follows:

a. Red banded leaf roller, *Argyrotaenia velutinana*, (Roelofs, et al.). Pheromone traps have maintained populations at low levels and reduced damage in New York apple orchards,

b. Cabbage looper, *Trichoplusia ni*, (Shorey et al.). Population reduction reported

c. Western pine beetle, *Dendroctonus brevicomis*, (Wood et al.). Bass Lake Study of 1969-1970 was highly successful. Mortality reduced from 247 to 7 trees after trapping. McCloud Flat study killed millions of beetles but has not been successful in reducing damage.

d. Douglas-fir beetle, *Dendroctonus pseudotsugae*, (Atkins, Pitman). Baited trap log technique resulted in 90% reduction of population. However, there was no way to separate the impact of trapping from other influences because there was no adequate check area. Pitman reported success in containing a spot infestation by pheromone baiting of standing trees. Using this technique almost all of the infested trees in the area could be identified and the spot clearcut at the convenience of the logger. "Seudenol" enhanced the attraction of frontalin + alpha pinene 8-fold. Next year a trap-out using the new pheromone on sticky boards is planned.

e. Mountain pine beetle, *Dendroctonus ponderosae*, (Pitman). Trapping on sticky boards during the past 2 years reduced the damage by 58% and 56% respectively. (This means that overall damage was reduced by 75% after 2nd year.). A cost-benefit analysis showed that this program made money for Potlatch Timber Co.

f. Southern pine beetle, *Dendroctonus frontalis*. Baiting cacodylic acid-treated trees with frontanlin + alpha pinene was of limited usefulness. The short generation time minimized beetle mortality and reduction in intra-specific competition resulted in healthier beetles.

2. Modifications, Improvements and Additional Information

Four fields in which additional information and technology are desirable were identified.

a. Assessment of impact of trapping programs. Damage index is useful, but in bark beetles the variable attack density confounded evaluation of the impact on the beetle population. Lincoln index approach may be applicable for gypsy moth. Males could be marked by injecting naturally occuring pupae with dye.

b. Measurement of release rate of pheromone is generally not well known.

c. Identify optimum bouquet if pheromones occur in mixtures.

d. Develop the concept of using pheromone sources to disseminate disease organisms or chemosterilants.

3. Candidate Species for the Use of Pheromones in Mass Trapping

   Two principles were identified, one involving cost and the other population dynamics, as follows:

   a. Trap-out programs are expensive and can be justified only for important pests.

   b. Trap-out may be practicable in low to moderate population levels or in high populations in a restricted area. However, there seems to be no hope of controlling widely spread outbreaks of forest insects.

   Two examples of insect groups which would be good targets for mass trapping were advanced, one for economic and the other for biological reasons.

   a. Pests with a low economic threshold such as *Pissodes strobi* are good candidates for trap-out success.

   b. Bark beetles in general seem more susceptible to trap-out than Lepidoptera because both sexes are attracted, and reducing the population could result in a further mortality due to reducing attack density to a level too low to overcome host resistance.

CONE AND SEED INSECTS

Moderator: J. E. Dewey

The workshop opened with each participant briefly stating their interests relative to cone and seed insects. Participants represented graduate students, University system, USDA Forest Service Research, USDA Forest Service Pest Control, USDI National Park Service, and private industry.

A report was given by Dave Kulhavy on his graduate research at the University of Idaho. He showed a slide series on the insect complex he has found associated with grand fir cones.

Stan Meso distributed copies of the Cone and Seed Insect Newsletter and reported briefly on some work being done by people not in attendance. He indicated he was looking for someone to assemble the Newsletter for next year.

Dewey told of the situation on some of the Forests in Montana and Idaho where seed shortages exist primarily due to spruce budworm. The budworm affects cones both directly and indirectly by (1) feeding on the cones, and (2) by weakening the tree, as a defoliator, to the extent that no cones are produced. As a result of budworm infestations, some Districts have been unable to collect any Douglas-fir cones for the past 5 or 6 years. They are currently without seed for their regeneration programs and are having to modify their cutting schedules in these areas.

Meso indicated that he thought it may be desirable in some areas to have high levels of such cone insects as cone worms during light and moderate cone crop years for they destroy the cones and help keep midge populations down. This results in better quality cones the years of heavy crops.

There was considerable discussion on where we stand in terms of chemical control of cone and seed insects. John Schenk reported on his work with injecting systemic insecticides into Douglas-fir for cone and seed protection. Tom Koerber indicated that phytotoxicity can be a problem when Dimethoate is injected. In a recent paper Al Hedlins (Can. Ent., Jan. 1973) reported good control of cone and seed insects of spruce by applying the systemic insecticides, Dimethoate and Formathion, as a spray in mid-June. Subsequent tests showed the insecticides had no harmful effect on germination.

VALUE OF VISUAL AERIAL DETECTION SURVEYS

Moderator: G. L. Downing

The beginning of aerial detection flying was reviewed. The earliest records available indicate that Swaine and Craighead surveyed for spruce budworm in Canada in 1920. This was soon followed by aerial observers delineating spruce budworm defoliation and also preparing accurate sketch maps of these areas. In 1931, Keen and Cowan mapped a hemlock looper epidemic in Pacific County of Washington State. Records of aerial detection during the 1920's and 1930's are sketchy and for the most part are lacking. Annual aerial surveys were started in Oregon and Washington in 1947 and about 1950 in California. Similar surveys were begun in many parts of the western United States and Canada during the early 1950's and continue at varying levels of intensity in all areas to this date.

Research to improve aerial survey methods began about 1950. Techniques for sketch mapping were developed and improved by such innovations as strip count sampling, map rolling devices, oblique strip viewers, use of tinted lenses, and the operations recorder.

Aircraft requirements changed over the years with small, low horsepower, single-engine airplanes used in the earliest days. As aircraft design and performance improved, aerial detection flying gradually shifted to larger planes with greater horsepower. Some Regions now do almost all of their flying with twin engine aircraft. This is particularly true of flying over rugged terrain and at higher elevations where high performance aircraft are essential to the maintenance of safety standards.

Most State and Federal agencies in the western U.S. and Canada now have strict standards for both aircraft and pilots that apply to aerial detection flying as well as other types of flying.

Aerial detection serves many potential purposes, including: (1) locating dead and dying trees for salvage, (2) locating windthrow both for salvage and for possible sources of insect buildup. (3) locating areas of incipient insect activity so that these areas can be ground-checked, (4) providing a rapid overall review of insect pest activity over a broad area on a yearly or periodic basis, and (5) providing an historical record to show long-term trends and importance of individual insect species.

Intensity of flying varies considerably from one area to another. Some areas are being flown to detect only the major insect activity, while others are flown to detect all insect damage that can be identified on all forested lands. Again, some Regions are attempting to fly most of their lands each year whereas others are flying the chronic problem areas only. Others are placing some areas on an intermittent aerial detection schedule, with flights planned every second or third year.

Detection flying in most regions of Canada and the U.S. is being done from a central office. One Region reported the delegation of this flying to field units scattered over their Region. Both methods have advantages and disadvantages. Where flying is centralized there is less turnover in personnel but field units are less involved and greater efforts are required to assure that detection data are supplied to the field units. Use of microfilm was mentioned as a means of making aerial survey maps available to field units. This method is limited at present because of the availability of microfilm readers at many field units.

Where field units do the flying, turnover in personnel requires continual training. Consistency of aerial sketch mapping is more difficult where many persons are involved, but knowledge of pest conditions by field personnel may be improved by this firsthand involvement.

While flying intensity, scheduling, and methods do vary considerably from one area to another, all areas are carrying out an aerial detection program. The total number of flying hours by regional areas varies between 100 and approximately 400 hours per year.

Representatives of all but one area of the western U. S. and Canada participated in the workshop. These representatives gave a rundown on the aerial detection program for their respective areas. This resulted in a general exchange of information, but within the time alloted for the workshop it left no time for an in-depth discussion of the many differences in programs between regional areas.

PREVENTIVE SPRAYS FOR INDIVIDUAL TREE PROTECTION

Moderator: Galen Trostle

The people present at the time the workshop was begun, were requested to indicate who, within the group, might have inputs into the discussion regarding work presently underway other than those who have been asked to participate. No one indicated that they had any additional information on current work.

A brief sketch was given covering the 1972 preventive spray work:

1. It has been quite well documented that lindane applications will reduce or eliminate attacks by bark beetles. Dick Smith has demonstrated that he can obtain significant reduction in brood production 6 and 7 years after treating with 2% lindane.

2. Because of the general opposition to lindane in the forest environment, it was thought desirable to test other pesticides which might be substituted for lindane as preventive sprays to be used on selected trees of particular value. There is no intention that any widespread application of these materials will be made to reduce beetle populations.

3. In consultation with Bob Lyon, from the Insecticide Evaluation Project, in Berkeley, it was concluded that Dursban and Sevin (carbaryl) had some promise, but residual action over time had not been tested.

4. Further communication with others working on bark beetle sprays revealed that they would be interested in coordinating a test of these three pesticides in different localities and under different conditions in order to provide a broader base of information.

   As a result tests were set up in the following States using three chemicals on the tree and insect species indicated:

5.

State	Insect	Dursban	Lindane	Sevin
Nevada	RPB	PP	PP	PP
Colorado	MPB	PP	PP	PP
Idaho	MPB	LPP	LPP	LPP

   In addition, Zectran and a systemic were tested in Colorado. The test in Idaho and Nevada involved an additional study to determine the effect of the three chemicals over time.

6. Colorado report of results: Below are the preliminary data on insecticides applied to green ponderosa pine for the protection of such trees from attacks by the mountain pine beetle. On each

tree a female beetle infested bolt confined in a screen hung to attract beetles. One 6" x 12" sticky board was nailed to each tree near the attractant bolt to indicate if the beetles did come to the tree. It appears that mountain pine beetles failed to come to 3 trees in Site 1 and 1 tree in Site 2. One of the 3 trees in Site 1 attracted one clerid (Lindane in H_2O to 20'); another attracted 3 ostomids.

Table 1. Number of successful mountain pine beetle attracts per tree per 2 6" x 12" bark samples at each height. All sprays were 2% strength applied at 1 gal./50 sq. ft. of bark to a height of 20' (except as noted).

Insecticide	4.5'	Site #1 beetles captured 1/	22'	4.5	Site #2 beetles captured 1/	22'	4.5	Site #3 beetles captured 1/	22'
Dursban in oil	0	1	4	0	28	3	0	14	11
Dursban in water	0	4	3	1	25	7	insufficient material to test		
Lindane in oil	0	1	0	0	6	0 3/	0	19	5
Lindane in water	0	0	0 2/	0	5	0 4/	0	20	5
Lindane in oil to 10'	0	3	8	0	0	0 2/	0	5	6
Lindane in water to 10'	0	1	0	0	1	0	0	22	7
Sevin in oil	0	0	0 2/	0	0	4	1	0	3 3/
Sevin in water	0	10	0 4/	0	13	6	0	5	8
Zectran in oil	0	0	0 2/	0	10	2	0	8	0
Check	9	3	6	5	1	6	7	1	5

1/ Captured on 6" x 12" sticky board placed at 6'
2/ Field notes show no evidence tree was attacked
3/ Heavy beetle attacks above 22'
4/ Some attacks within sprayed area

Beetles were able to penetrate the Dursban in water (Site #2) and the Sevin in oil (Site #3). One might suspect these attacks occurred in small missed areas and that is possible. However, the crew (Steve Mata and summer assistant Larry Yarger) was very careful and very aware to avoid missed areas of bark. All of the remaining materials (viz. Dursban in oil, Lindane in oil, Lindane in water (see below for a different story), Sevin in water, and Zectran in oil) appear to have prevented attack where they were applied. We won't know until next summer if the successful attacks above 22' will kill the trees. Many attacks between 20' and 22' were aborted with beetles dead in attack holes that just reached the phloem.

7. Idaho test:

A short term test was designed to measure the relative effectiveness of three chemicals, as a water and an oil formulation against the 1972 beetle flight.

Methods: Six 2% formulations were prepared, a water and an oil spray of each of the 3 pesticides, Lindane, Dursban and Sevin. These six sprays were applied to the bole of larger lodgepole pine to a height of 15 feet. Each formulation was applied within a separate group of trees. Each tree group contained a check tree. Two trees were sprayed around their full circumference and 2 trees were sprayed on half their circumference. Spray was applied to the point of runoff with a 3 gallon pressure sprayer equipped with an extension wand to reach to a height of 15 feet.

Infested bolts, obtained from early attacks at low elevation were hund on all test trees, one bolt per tree, to provide a source of attractant to flying beetles.

A long term test was designed to determine the relative effectiveness of the 6 formulations over time.

Methods: The same six formulations used in the short term test were each applied to 4 different trees between 8 and 12" d.b.h. Spray was applied to a height of 10 feet. At 3, 6, 12 and 24 months after spray application, one tree from each treatment is to be cut and subjected to attack by freshly emerged beetles. After a period of time, the log will be peeled to determine the success of attacks.

Results:

A short term test: Mountain pine beetle attacks were not as numerous in some areas as in others. However, there was evidence that some trees with each treatment were exposed to beetle attack. No successful attacks occurred on any of the sprayed areas.

Long Term:

3 Months Treatment	Tree No.	Results	6 Months Tree No.	Results
Lindane and oil	1	2 attacks less than 1/8"	2	No attacks
Lindane and H_2O	5	No attacks	6	No attacks
Sevin and H_2O	9	No attacks	10	1 attack to cambium
Sevin and oil	13	No attacks	14	1 flathead alive
Dursban and H_2O	17	1 attack not through bark	18	No attacks
Dursban and oil	21	4 attacks less than 0.25" total	23	5 attacks 9/16" total
Unsprayed	25	16 attacks 40" gallery	Check	25 attacks 119" galleries

Conclusion: Thus far there appears to be no difference in the relative effectiveness of any of the sprays. Although trees treated with Dursban in oil have been attacked with a greater frequency than any other treatment, the beetles died before they began galleries.

8. A test similar to the Idaho long term test was conducted in Lee Canyon on Mountain Charlston in Nevada, on ponderosa pine using roundheaded pine beetle and at Placerville, California, using western and mountain pine beetles.

Table 1. Effectiveness of 2% sprays of the noted insecticides 2 to 3 months1/ after their application to ponderosa pine; tests run by cutting treated and untreated trees into bolts, caging them with beetles2/, and examining 100% of each bolt 2-6 weeks3/ later. (This is a preliminary summary) (Dosage approximately 1 gal./40-50 sq. ft. of bark)

		Round-headed pine beetle (rhpb)		Mountain pine beetle (mpb)		Western pine beetle (wpb)	
		Inches of gallery	Percent reduction in galleries	Inches of gallery	Percent reduction in galleries	Inches of gallery	Percent reduction in galleries
Lindane	emul	0	100	0	100	0	100
	oil	0	100	0	100	0	100
Dursban	emul	0	100	0	100	0	100
	oil	0	100	0	100	0	100
Sevin	water4/	0	100	0	100	18	93
	oil	0	100	0	100	0	100
Check	--	335/	--	65	--	240	--

1/ (rhpb) at 3 months, (mpb) and (wpb) at 2-1/2 months
2/ (rhpb) used brood bark from which adults about to emerge
(mpb) and (wpb) used freshly emerged adults
3/ (rhpb) at 6 weeks
(mpb) and (wpb) at 2 weeks
4/ Inadvertently applied at 4% conc.
5/ 22 attacks

9. Future plans include the development of an application system which would limit the environmental contamination and yet permit application to sufficient height to protect mature ponderosa pines.

10. It was the general concensus that protective sprays would be beneficial. Their use would be determined by the ease of application, the cost, and the length of protection obtained.

EASTERN AND WESTERN SPRUCE BUDWORM SUPPRESSION

Moderator: Dick Washburn

Twenty people attended and participated in the workshop. Approximately 50% of the participants were from eastern Canada or eastern United States. The workshop provided the first real opportunity for specialists from the eastern and western portions of the North American continent to discuss and compare suppression efforts against the spruce budworms. The lively discussion for the most part concentrated on objectives, techniques, strategies, and results.

As a group the various species of coniferous feeding budworms have annually infested more forested area than any other group of forest insects. In the last 25 years huge sums of money have been expended annually to suppress the spruce budworms.

In eastern Canada the usual objective of spray programs is to save foliage and to keep the trees alive until they can be harvested. The objective in recent years in eastern United States has been to treat infestation to prevent or minimize tree mortality. Objectives of pest control programs in western United States have been basically the same as for eastern United States. Today however, in much of western United States the feeling is that the objective should be to reduce budworm population to low levels and thus provide opportunity for the stand to resume normal expected growth. Considerable concern is being expressed in Montana and Idaho over the loss of cone and seed crops caused by persistant budworm infestations. The budworm destroys the seed and cones by direct feeding and through defoliation reduces cone production. It is possible that in the future, control programs may be proposed with the objective of reducing cone and seed losses and increasing cone production by protecting the trees from continuous defoliation.

Aerial applications of Zectran have consistently produced greater budworm mortalities in eastern Canada and eastern United States than have occurred in western United States. In eastern United States the use of Zectran is considered fully operational, with predictable results. Results of Zectran tests in the west have not been consistant and in many cases mortalities were less than expected. It was the consensus, of those most knowledgeable of the western tests, that Zectran is toxic against the budworm and should produce desired predictable mortalities of budworm when applied in the field. Most felt the problem lies in application techniques and the great number of environmental variables common to aerial application over rough steep mountainous terrain.

Fenitrothion has proven effective against the budworm in eastern Canada. It has been used operationally for the last six years.

Aerial application of insecticides have generally been tied to budworm larval development. In the west nearly all of the spraying has been directed against 4th and 5th instars. Whereas in eastern Canada most of the spray application has been timed to reach the 2nd and 3rd instar larvae. The first application is often followed by a second application 4-10 days later.

In eastern Canada many areas have been sprayed for up to 10 successive years. In western United States a given area has rarely been sprayed more than once.

A large spray program was directed against the budworm last year in Maine. Another program to treat .5 million acres is scheduled for 1973. Massive spray programs have become an annual event in eastern Canada. Spraying on a large scale will continue through 1973. In eastern Canada the move has been to use larger aircraft, with higher carrying capacities. In western United States there has not been a large scale spray program for the last several years. No operational spray programs are scheduled for 1973.

Tests run in eastern Canada show that some insecticides effectively kill adult budworms. Additional field experiments will be conducted this year. Reduction of adult populations may prove to be an effective adjunct that could be used in conjunction with applications directed against the larval population. The reduction of young larvae would save foliage and the combined effects of larval and adult mortalities could reduce the mating population to a level that could cause a significant reduction in the subsequent population.

MINUTES OF FINAL BUSINESS MEETING
March 8, 1973

The meeting was called to order by Chairman Bob Stevens at 3:25 pm. in the Williamsburg Room, Hilton Inn, Tucson, Arizona.

The minutes of the initial business meeting were read and accepted.

The Secretary-Treasurer reported that 94 members had registered at this Work Conference, 77 full members and 17 student members. All of the bills had not been paid but it appeared that registration fees would cover the expenses.

Bill Wilford reported for the Common Names Committee. The new chairman is Bill Ives. Thelma Finlayson will replace Don Dahlsten on the committee. The Committee considered the common name "leader weevil" proposed for *Pissodes strobi* by Les McMullen but decided against it preferring the common name "white pine weevil" for the complex.

John Borden reported for the Nominating Committee for a councillor to replace Walt Cole on the Executive Committee. Borden moved that Royce Cox be nominated. Tom Koerber seconded. Galen Trostle moved that unanimous ballot be cast. Seconded. Passed.

Dick Washburn reported for the Ethical Practices Committee. Hec Richmond reviewed the origin of the Committee from his personal knowledge. Washburn presented the award to Bob Dolph for his outstanding performance.

Bob Frye made the awards for the Golf Tournament. First prize went to Bob Dolph, second to Tom Payne, third to Harold Flake.

Discussion was opened on the subject of payment of travel expenses for keynote speakers. Galen Trostle moved that the Work Conference go on record as approving the payment of travel expenses, within the limits of resources available, for notable keynote speakers. Motion seconded by Ives. In the discussion that followed Alan Berryman suggested that there be no registration fees for students, and that the Work Conference might set up a grant to enable students to attend the Work Conference. John Borden also spoke against the motion. Borden suggested that the next Executive Committee meeting consider the use of the Work Conference treasury to assist student attendance. The motion was defeated.

Bob Wickman moved that the Work Conference express its appreciation to Jim Bean for attending and for presenting the keynote address. Seconded. Passed.

Jack Coster announced that the Southern Forest Insect Work Conference would meet August 14-16, 1973 at Jackson, Mississippi. Jim Bean announced the Northeastern Forest Insect Work Conference for April 4-5, 1973. Alan Cameron suggested that announcements of forthcoming Work Conferences be included in the Proceedings.

Bruce Baker suggested that preliminary notices of this Work Conference not include announcement of extracurricular activities (skiing, golf tournaments, etc) before or after the Work Conference. It was suggested from the floor that the Secretary submit announcements of WFIWC meetings to the ESA and ESC Bulletins. Discussion against this suggestion followed.

Discussion was opened on the meeting site for 1975. Tom Koerber moved that the WFIWC hold a joint meeting with the Western International Forest Disease Work Conference in the San Francisco Bay Area in the spring of 1975. Seconded by Wickman. Motion passed.

Chairman Bob Stevens, on behalf of the Work Conference, expressed appreciation to Bob Frye and his committee for the fine program and arrangements at Tucson.

REPORT OF THE COMMON NAMES COMMITTEE

WESTERN FOREST INSECT WORK CONFERENCE

Tucson, Arizona
March 6-8, 1973

Attending: John Borden, Bill Ives, Bob Stevens, Harold Flake, and Bill Wilford.

Items: *Pissodes strobi* (Peck) is the now accepted scientific name for the three leader weevils formerly listed as *Pissodes strobi* (Peck), *P. sitchensis* Hopk., and *P. engelmanni* Hopk. Their common names were white pine weevil, Sitka spruce weevil, and Engelmann spruce weevil, respectively.

A proposal, dated January 25, 1973, submitted by Les McMullen, recommends the adoption of the common name Leader Weevil.

The committee after discussing and considering this proposal, with its supporting arguments, decided against the name Leader Weevil, preferring the common name White Pine Weevil for the complex.

No common names for other insects were submitted for discussion, consideration, and vote of acceptance.

Bill Ives was elected to the post of chairman of the Common Names Committee of the Western Forest Insect Work Conference.

Thelma Finlayson of Simon Fraser University, Vancouver British Columbia was appointed to membership of the Common Names Committee. Professor Finlayson will replace Don Dahlsten whose membership terminates at this meeting.

Respectfully submitted,
Bill H. Wilford
Acting Chairman

Committee Membership as of 1973 Conference:

R. E. Stevenson, past chairman, Calgar, Alberta (1970)
D. D. Dahlsten, Berkeley, California (1972)
H. W. Flake, Albuquerque, New Mexico (1973)
D. McComb, chairman, Portland, Oregon (1973)
W. F. Ives, Edmonton, Alberta (1974)
R. E. Stevens, Fort Collins, Colorado (1974)
B. H. Wilford, Fort Collins, Colorado (1975)

FUTURE WORK CONFERENCES

Southern Forest Insect Work Conference
Jackson, Mississippi
August 14-16, 1973
For more information contact: Dr. Jake E. Coster, School of Forestry, Box 6109, Stephen F. Austin, State University, Nacogdoches, Texas 75961

Central International Forest Insect and Disease Work Conference
Holiday Inn, International Falls, Minnesota
October 2-4, 1973
For more information contact: Dr. Harvey Toko, NA-S&PF, Room 627, Federal Bldg., 316 Roberts St., St. Paul, Minn. 55101

Northeastern Forest Insect Work Conference
The Pennsylvania State University, University Park
March 18-20, 1974
For more information contact: Dr. E. Alan Cameron, Department of Entomology, 106 Patterson Building, The Pennsylvania State University, University Park, Pennsylvania 16802

Western Forest Insect Work Conference
Royal Executive Hotel, Salt Lake City, Utah
March 5-7, 1974
For more information contact: Dr. M. E. McKnight, USDA - Forest Service, Shelterbelt Laboratory, Bottineau, North Dakota 58318

TREASURER'S REPORT

Balance on hand March 6, 1973		$ 949.51
Received from Registration, 1973	$1,122.00	2,071.51
Expenses for 1973 meeting	836.48	1,235.03
Received for membership fees	70.00	1,305.03
Interest earned on bank account	21.45	1,326.48
Balance on hand July 23, 1973		1,326.48

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