PEST CONTROL RESEARCH

HEARINGS

BEFORE THE

SUBCOMMITTEE ON AGRICULTURAL RESEARCH AND GENERAL LEGISLATION

OF THE

COMMITTEE ON AGRICULTURE AND FORESTRY UNITED STATES SENATE

NINETY-SECOND CONGRESS

FIRST SESSION

ON

S. 1794

A BILL TO AUTHORIZE PILOT FIELD-RESEARCH PROGRAMS FOR THE CONTROL OF AGRICULTURAL AND FOREST PESTS BY INTEGRATED BIOLOGICAL-CULTURAL METHODS

SEPTEMBER 30 AND OCTOBER 1, 1971

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PEST CONTROL RESEARCH

THURSDAY, SEPTEMBER 30, 1971

U.S. SENATE,
SUBCOMMITTEE ON AGRICULTURAL RESEARCH
AND GENERAL LEGISLATION OF THE
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 10:05 a.m., in room 324, Old Senate Office Building, Hon. James B. Allen (chairman of the subcommittee) presiding.

Present: Senators Allen (presiding), Chiles, and Curtis.

Senator ALLEN. The subcommittee will please come to order. There is a quorum of the subcommittee present, so we will proceed with the hearings.

The subcommittee is holding hearings today on S. 1794.

This bill directs the Secretary of Agriculture to carry out pilor field-research programs to develop and test integrated biological-cultural methods of controlling agricultural and forest pests, and to determine the environmental effects of such methods. At the time of introducing this bill, Senator Nelson described these methods as being carried out primarily by utilizing beneficial insects that are predators and parasites of harmful insects.

The Secretary under the bill would be authorized to reimburse farmers and ranchers for losses sustained by them as a result of research conducted under the bill on their lands, crops or livestock.

An appropriation of $2 million for fiscal 1972, and appropriations of such sums as may be necessary for each of the succeeding 5 fiscal years, are authorized to carry out such research.

Appropriations in like sums are authorized for expansion by the National Science Foundation of its fundamental research on integrated biological-cultural principles and techniques.

A copy of the bill and the departmental report will be inserted in the record at this point.

(The bill and report are as follows:)

[S. 1794, 92d Cong., first sess.]

A BILL To authorize pilot field-research programs for the control of agricultural and forest pests by integrated biological-cultural methods

Be it enacted by the Senate and House of Representatives of the United States of America in Congress assembled, That (a) the Secretary of Agriculture is authorized and directed to carry out, through the Agricultural Research Service of the Department of Agriculture, pilot field-research programs for the purpose of (1) developing and testing the control of agricultural and forest pests by the employment of integrated biological-cultural methods, (2) determining the economic and environmental consequences of predicting and modifying agricultural and forest pest populations through utilization of multidisciplinary and integrated biological-cultural methods, and (3) developing methods of collecting, handling, and inter-interpreting data obtained from such field research.

(b) The Secretary of Agriculture is authorized to reimburse farmers and ranchers for any losses sustained by them as a result of any research authorized under this Act being conducted on their lands, crops, or livestock.

(c) There are hereby authorized to be appropriated to the Secretary of Agriculture to carry out the provisions of this section during the fiscal year ending June 30, 1972, the sum of $2,000,000, and such sum as may be necessary for each of the five succeeding fiscal years.

SEC. 2. There are hereby authorized to be appropriated to the National Science Foundation for the fiscal year ending June 30, 1972, the sum of $2,000,000, and such sum as may be necessary for each of the five succeeding fiscal years for the purpose of expanding its fundamental research on integrated biological-cultural principles and techniques to control agricultural and forest pests.

DEPARTMENT OF AGRICULTURE,
OFFICE OF THE SECRETARY,
Washington, D.C., September 30, 1971.

Hon. HERMAN E. TALMADGE,
Chairman, Committee on Agriculture and Forestry,
U.S. Senate.

DEAR MR. CHAIRMAN: This is in reply to your request for a report on S. 1794. The bill is entitled "To authorize pilot-field research programs for the control of agricultural and forest pests by integrated biological-cultural methods."

The first section of the bill would authorize and direct this Department to carry out, through the Agricultural Research Service, pilot field-research programs for the purpose of (a) developing and testing the control of agricultural and forest pests by the employment of integrated biological-cultural methods; (b) determining the economic and environmental consequences of predicting and modifying agricultural and forest pest populations through utilization of multidisciplinary and integrated biological-cultural methods; and (c) developing methods of collecting, handling, and interpreting data obtained from such field research. The bill would authorize payments to farmers and ranchers as reimbursement for any losses sustained as a result of any research authorized under the bill bieng conducted on their lands, crops or livestock. To carry out the provisions of Section 1 of the bill, the sum of $2 million would be authorized to be appropriated during fiscal year 1972 and such sum as may be necessary for each of the five succeeding fiscal years.

Section 2 of the bill would authorize the appropriation of $2 million in fiscal year 1972 and such sum as may be necessary for each of the five succeeding fiscal years to the National Science Foundation to expand its fundamental research on integrated biological-cultural principles and techniques to control agricultural and forest pests.

Under the authorities of the Research and Marketing Act of 1946 (7 U.S.C. 427) and the Organic Act of 1862 (7 U.S.C. 2201), this Department is actively engaged in the type of research which would be authorized under Section 1 of the bill. Therefore, enactment of that section of the bill is unnecessary. We defer to the recommendation of the National Science Foundation regarding the enactment of Section 2 of the bill. The enclosed statement provides a more detailed explanation of this position.

The Agriculture-Environmental and Consumer Protection and Interior and Related Agencies Appropriations Acts for fiscal year 1972 provide $82.8 million for pesticide research activities of USDA. More than one-half of this amount is directed toward biological, cultural and other alternative methods of pest control. Based on budget recommendations submitted by the President, the fiscal year 1972 appropriations for USDA provided additional funds to expand pesticide research, including $800,000 for undertaking of pilot field-research projects to evaluate integrated biological-cultural techniques for the control of the tobacco budworm (on cotton), corn earworm (on cotton), green peach aphid, lesser peach tree borer, codling moth, greenbug (on sorghum), and the range caterpillar.

This Department is totally committed to the integrated biological-cultural approach to the control of pests. We intend to direct every effort to this goal as available resources will permit.

The Office of Management and Budget advises that there is no objection to the presentation of this report from the standpoint of the Administration's program.

Sincerely,

J. PHIL CAMPBELL, *Under Secretary.*

U.S. Department of Agriculture, Agricultural Research Service

EXPLANATION OF USDA POSITION ON S. 1794

The Department of Agriculture conducts extensive pesticides research activities, particularly research on biological and cultural methods of pest control. This includes insect sterilization, sex attractrants, insect pathogens, parasites and predators of insects, varieties of crops resistant to insects and diseases, crop morphology, disposal of crop litter, and others.

Pesticide research activities also include developing safer and more effective pesticide use patterns, formulations, and methods of application, studies on the toxicity, pathology, and metabolism of pesticides; investigations on the levels, effect, and fate of pesticide residues in plants, animals and other products and other parts of the environment; and others.

We have begun a large-scale field testing program to determine whether or not insecticides, attractants, sterilized males, and cultural techniques, employed in an integrated program, can be used to eliminate the boll weevil. The program is underway on about 30,000 acres of cotton in southern Mississippi and adjacent areas in Alabama and Louisiana. If this integrated biological-cultural program proves successful, it could save cotton farmers from millions of dollars in crop losses annually and drastically reduce the use of insecticides in cotton production, which presently accounts for about one-third of all insecticides used for agricultural purposes in the United States. The program is sponsored and financed jointly by this Department, the States of Alabama, Louisiana, and Mississippi and the National Cotton Council and Cotton Incorporated, representing the industry.

Because we are already engaged in the type of research that would be authorized under Section 1 of the bill, enactment of that section of the bill is unnecessary. Instead, a determination by the Congress for undertaking any additional research projects directed toward the purposes of S. 1794 should be made as a part of the appropriations process. If any further consideration is to be given to legislation along the lines of Section 1, we would suggest deleting the words ", through the Agricultural Research Service of the Department of Agriculture," on p. 1, lines 3 and 4.

This Department supports fully the research activities of the National Science Foundation. In March 1971, a Memorandum of Agreement was conpleted which clearly establishes the basis for cooperation between the National Science Foundation and this Department in research on alternative methods of control of insect pests. With regard to the enactment of Section 2 of S. 1794, we defer to the recommendation of the National Science Foundation. We understand, however, that the Foundation shares our support for the purposes of S. 1794, and agrees with us that its enactment is unnecessary in view of the ample research authorities in his field which both this Department and the Foundation already possess.

Senator Allen. We are delighted to have Senator Gaylord Nelson, of Wisconsin, the author of S. 1794, appearing as the initial witness in behalf of the bill.

We welcome your testimony, Senator Nelson. You may proceed at this time, if you will.

STATEMENT OF HON. GAYLORD NELSON, A U.S. SENATOR FROM THE STATE OF WISCONSIN

Mr. Chairman, I want to thank you for the opportunity to appear before your committee as leadoff witness at this hearing to consider S. 1794, a bill that I introduced on May 6 of this year. This legislation would provide for the establishment of demonstration projects and expanded basic research in the principles of integrated pest control. A companion to this bill, H.R. 8159, has been introduced in the House by Congressman David Obey, of Wisconsin, and others.

It is particularly pleasing to me that you, Mr. Chairman, and two distinguished members of your committee, Senator Eastland, of Mississippi, and Senator Chiles, of Florida, have joined with 24 other Senators in cosponsoring this bill. Few pieces of legislation receive such strong, bipartisan support in advance of committee hearings.

Mr. Chairman, at this point in the record, I would like to put in the list of the names of the sponsors of the bill.

Senator ALLEN. Without objection, so ordered.

(The list follows:)

COSPONSORS OF S. 1794

Sen. James B. Allen of Alabama
Sen. Quentin N. Burdick of North Dakota
Sen. Clifford P. Case of New Jersey
Sen. Lawton Chiles of Florida
Sen. Frank Church of Idaho
Sen. Alan Cranston of California
Sen. Peter H. Dominick of Colorado
Sen. James O. Eastland of Mississippi
Sen. Sam J. Ervin, Jr. of North Carolina
Sen. David H. Gambrell of Georgia
Sen. Edward J. Gurney of Florida
Sen. Clifford P. Hansen of Wyoming
Sen. Philip A. Hart of Michigan
Sen. Hubert H. Humphrey of Minnesota
Sen. Charles McC. Mathias, Jr., of Maryland
Sen. George S. McGovern of South Dakota
Sen. Walter F. Mondale of Minnesota
Sen. Joseph M. Montoya of New Mexico
Sen. James B. Pearson of Kansas
Sen. Claiborne Pell of Rhode Island
Sen. Charles H. Percy of Illinois
Sen. William Proxmire of Wisconsin
Sen. Jennings Randolph of West Virginia
Sen. John Sparkman of Alabama
Sen. Adlai E. Stevenson III of Illinois
Sen. John V. Tunney of California

Senator NELSON. I think that the excellent list of witnesses that has been assembled for this hearing is further evidence of the strong support for the concept of providing a sound alternative to this Nation's addiction to the widespread use of broad-spectrum chemicals to control agricultural and forest pests. I cannot recall another instance when leaders of agriculture and leaders of the environmental movement in this country have demonstrated in unison the support that has been demonstrated in this case for getting on with the job of providing food and fiber for a growing society without depending on broad-spectrum, persistent chemicals to control insect pests. The bill being considered here provides the thrust that is needed to accomplish this highly desirable goal.

I think these hearings will give recognition to the thesis that with the single strategy of chemical pest control we have not only saturated the environment with deadly poisons that endanger a wide spectrum of living organisms, including man himself, but that we have begun to seriously disrupt the economic stability of the farming community. Entomologists, ecologists, and biologists, along with a good many others, have been warning us for some time of the folly of single-strategy chemical pest control. But we seemed to be so mesmerized by the apparent magic and efficacy of the chemical approach that we refused to listen.

The environmental damage and human health hazards posed by persistent pesticides contamination is quite clear. Ample documentation of this is provided in the hearing record on the Federal Environmental Pesticide Control Act that was compiled before this same committee last March

The peregrine falcon is extinct as a breeding species east of the Rocky Mountains and is so suppressed west of the Rockies that it borders on extinction. The bald eagle, osprey, brown pelican, and numerous other species of carnivorous birds have shown substantial reproductive failure as a result of contamination by chlorinated hydrocarbons. The increasing concentration of persistent pesticides in the environment threatens the survival of fresh water and ocean fisheries.

The hazard of genetic toxicity due to pesticide residues clearly is implied by findings in experimental animals. Even the human species carries an average of 10 parts per million of the residues, substantially more than the level allowed for most foods in interstate commerce.

Today some of the persistent chemicals are being phased out of use, partly due to recognition of the documented environmental dangers which have resulted in more stringent regulations. The chemical companies have responded only by marketing chemicals with less persistence but with much higher toxicity.

Last year, Mr. Chairman, it was reported by the Poison Control Center in the Food and Drug Administration, that 200 persons died from pesticide poisoning. In 1969, the last year for which nonlethal accident figures are available, the center reported 5,747 cases of accidental ingestion or poisoning due to pesticides. The center estimated that this probably represents only 10 to 15 percent of the cases which actually occur.

We can only expect that these figures will be increased if the trend toward the use of high potency pesticides continues.

Too, there have been serious economic disruptions due to pesticides use.

Among the numerous examples are the seizure of Coho salmon from Lake Michigan processors and, more recently, the removal from the market of Lake Michigan fish chubs due to the high level of DDT residues in the fish. Millions of dollars have been paid by the Federal Government to cranberry growers and dairymen whose products were removed from the market because of pesticide contamination. Honeybee operators have been driven out of business when entire apiaries were severely damaged, if not destroyed, by pesticides.

The problem with honey bee damage has become so acute that a special pesticide indemnification program was authorized by Congress in the Agricultural Act of 1970. That indemnification, by the way, may assure the economic stability of the apiarists, but it does nothing to guard against the loss of the important pollination work carried out by the bees.

And the evidence is accumulating rapidly that chemical pesticides have failed in controlling agricultural and forest pests. This is dramatically evident in the high plains of Texas and surrounding States where producers of cotton, grain sorghum, and other crops have become alarmed over the invasion of pests—in this case a new strain of the greenbug—despite massive chemical treatments. In California, many cotton farmers have seen their cost of chemical control double in the last 20 years. In northeastern Mexico, many farmers have abandoned their fields because production no longer was profitable in the face of massive tobacco budworm infestations—a direct result of a massive chemical pest control program. In regions where citrus, soybean, alfalfa, stonefruit, and forest crops are produced, pests are increasing in number and pesticides decreasing in effectiveness.

The fact of the matter is that the single strategy of chemical pest control has been an agricultural, economic, and environmental failure. The use of broad-spectrum chemicals was doomed from the start because this practice ignored the phenomenon of genetric diversity—that remarkable ability of insects to continually evolve and develop resistant strains capable of withstanding even heavy dosages of toxic chemicals.

Insect resistance to chemicals is the primary reason why farmers are seeing their cost of chemical control rise to the point where, in the case of some, the break-even threshold is perilously close.

Still, some would have us believe that either we use pesticides or starve. The evidence, however, suggests the contrary: if we continue to rely on broad-spectrum chemicals, we may very well imperil our abilities to continue to produce an adequate supply of food and fiber.

On August 4 of this year, the Medical News in New York published an item based on a report by the World Health Organization. The WHO report said that more than 200 species of insects, including 105 disease vectors, have developed resistance to one or other of the insecticides used against them. The list included: 30 species of malaria mosquitoes, 19 species of the mosquitoes carrying a disease (filariasis) that can lead to elephantiassis, the yellow fever mosquito, the rat flea which carries bubonic plague, and blackflies, houseflies, lice and cone-nosed bugs, all of which carry disease.

On August 8 of this year, the New York Times published a dispatch from Palo Alto, Calif., which reported that two species of mosquitoes native to California have acquired complete immunity to all manmade pesticides. One of the immune mosquitoes, the Times said, has a special capacity to transmit certain deadly encephalitis viruses among humans and animals. Further, the article said, the insects acquired their immunity after 20 years or more of adaptation to increasingly potent chemical poisons used in pest control programs.

That same New York Times article also reported that some carriers of the equine encephalitis, responsible for the deaths of more than 1,000 horses in the Southwest earlier this year and the illness of scores of humans in the same area, also have become immune to insecticide controls.

One of the scientists quoted in the Times story is Dr. Robert van den Bosch of the University of California at Berkeley. I understand that Dr. van den Bosch, who is very knowledgeable in the pest immunity situation, will testify at this hearing later today.

The point in this discussion is this: whatever value that chemicals may have in preventing widespread disease in a plague situation, then that value is severely minimized—if not eliminated—when these same chemicals are continually applied in a control program.

There is a compelling and urgent need to reconsider our approach to pest control by recognizing a very basic ecological principle. That is, each integral part of the natural system survives in balance with—not at the expense of—the other parts.

I believe that integrated control offers the alternative that recognizes this principle.

Integrated control involves the use of the best-suited combination of alternate pest control methods to suppress pest insects in a given crop situation below the economically disruptive threshold.

There is a wide variety of alternative pest control methods that have been developed over the years. I'm sure that Dr. Edward F. Knipling, and entomologist who is considered one of the most prominent pioneers of alternative pest control methods, in this country, can better describe some of these approaches when he testifies later in this hearing.

Some of the approaches outlined by Dr. Knipling and others include the use of predators and parasites of pest species to control the pests, cultural controls involving the alteration of farming practices to create a better environment for beneficial insects, the development of plants resistant to pests, the development of synthetic hormones to interrupt the physical cycle of selected insect species, and the development of insect diseases to control pest populations. One approach that has a rather remarkable degree of success is the controlled release of sterile male insects to suppress pest populations.

Under the integrated control approach, the field is surveyed by scientists, entomologists, or others, to determine the insect populations and other characteristics so that the best combination of control methods can be integrated into an effective pest management program. The key here is the word "integrated." We are not talking about a unilateral, one-method approach that we have become accustomed to in the application of broad-spectrum chemicals. And we aren't ruling out the use of chemicals in an integrated control program, because some situations may call for selective chemical applications during a particular phase of the overall program. But the use of chemicals—particularly broad-spectrum chemicals—necessarily is very limited in integrated pest control so as not to interfere with other aspects of the program, most notably the use of beneficial insects.

This, essentially, is what integrated control is. I'm sure that many of the details of this approach will be discussed by the several excellent scientific witnesses that are scheduled to be heard at this hearing.

At this point, Mr. Chairman, I want to emphasize that the continued development of nonchemical methods of pest control is an important program to improve the arsenal of weapons that can be utilized by scientists in an integrated control program.

In the last session of Congress, I sponsored an amendment to increase funding of nonchemical pest control in the agricultural appropriations bill when it was before the Senate. The amendment had broad support in both House and the Senate, and eventually it was agreed in conference to add $1 million to the bill specifically for expanded nonchemical pest control research.

However, after this bill was signed into law the administration impounded the $1 million for fiscal year 1971. Only recently part of the money, $775,000, was added to the budget for fiscal year 1972. The effect of all this is that money specifically appropriated by the Congress was not spent during the fiscal year for which it was appropriated, and now, 1 year later, we may get $225,000 less than the Congress wanted.

Now, we have heard much rhetoric from the administration about environmental enhancement generally and about the need to reduce our reliance on the use of pesticides. However, it is difficult to reconcile this rhetoric with the action by the administration in imposing this freeze of the nonchemical pest control research money.

I certainly hope that this ill-advised action by the administration is not an indication of the fate of the bill being considered at these hearings. If so, it will do little good for Members of Congress to earmark $4 million for development of an integrated control demonstration and research program and direct the Secretary of Agriculture to carry out this program if the Office of Management and Budget is going to turn around and impound the money.

On another point, I recognize that this bill is granting authority to the Secretary of Agriculture to do something that already can be accomplished under existing authority.

There have been several instances when legislation being considered by the Congress was deemed unnecessary by the Federal department or agency that would be affected because it was claimed that authority to carry out the intent of the legislation already was in effect.

When the Environmental Education Act of 1970 was being considered, the Department of Health, Education, and Welfare said the legislation was unnecessary because HEW already had authority to establish an environmental education program. However, it wasn't until the Congress enacted the bill that the Department got on with the job of establishing a meaningful environmental education program.

The Clean Air Act of 1970 established a deadline for the automobile industry to meet strict emission standards several years ahead of the schedule that was being contemplated by the National Air Pollution Control Administration. The administration could have moved the deadline up on its own, but it took Congress to enact a law to make this improvement in the air quality program.

It took an amendment to the water quality bill of 1970 to provoke the administration into establishing the Environmental Protection Agency. It took another act of Congress to establish the President's Council on Environmental Quality.

In the case of integrated pest control, it is generally known that several persons with the Agriculture Research Service have been attempting for several years to get the Department of Agriculture not only to expand nonchemical pest control research but to embark on a meaningful demonstration program in integrated control. But obviously the Department's budget managers have not been convinced that this program is worth the commitment of the level of funding that is needed.

It is a credit to the ARS that some work in integrated control has been started very recently. However, from all indications this program will not move ahead nearly as rapidly as it could because the Department still isn't convinced of its high worth.

The legislation being considered here, S. 1794, would direct the Secretary of Agriculture to establish a meaningful demonstration program in integrated control, and just to make sure that the commitment is followed by positive action, the bill specifically earmarks $2 million to begin work on these demonstration projects. No longer could the Department hold back on the implementation of this extremely important program.

The bill provides that both the demonstration projects by the Agricultural Research Service and the basic research through the National Science Foundation would continue to be funded through at least a 5-year period. I consider it extremely important that a program as critical as developing sound integrated control concepts be funded for at least 5 years so that a solid foundation can be laid for substantially reducing our reliance on chemicals to control agricultural and forest pests.

The legislation consists of two sections. The first insures that those farmers participating in the demonstration program will be indemnified for any economic losses that they may suffer as a result of the testing program. The chances are not great, according to the scientists I have discussed it with, that any losses will be suffered by anyone. Several farms in the country already are engaged in integrated pest control programs, and many report improved crop quality and greatly improved profit margins.

Also under the first section of S. 1794, the Agriculture Research Service would receive $2 million specifically for the demonstration program. The ARS is well equipped to handle such a demonstration program. It has a nationwide network of offices to coordinate and direct this effort, and it has the laboratory facilities and highly qualified scientific personnel necessary for success in a complex technical program such as integrated pest control.

The second section of the bill would authorize the appropriation of another $2 million to the National Science Foundation which, through its grant program, would enlist scientific researchers in universities throughout the country in an expanded effort to provide the basic studies to assist in the development of successful integrated programs on a wide variety of crops and in varied climates.

We are very fortunate here that the Agricultural Research Service and the National Science Foundation last spring initiated a joint agreement in the area of alternatives to chemical pest control. Already these two governmental agencies have joined hands in this effort.

It is my understanding that some 18 universities, in the United States, together with the Agriculture Research Service, the U.S. Forest Service and elements of private industry have done some extensive planning in how to implement a demonstration program in integrated pest control. This, of course, is a major effort, one that will depend on strong financial support if success is to be attained. I believe that the Congress, with S. 1794, has the opportunity to lend a great assist to this program by committing the necessary funds. In succeeding years, the commitment of Federal funds may well have to be increased over the $4 million in this bill for the first-year effort.

Mr. Chairman, I think it is important even though the Agriculture Department has the authority, if they wish to do it, to establish these programs now. The idea of a pilot program has been under discussion for several years and it has not happened. I think the real import and the real importance of this matter is that it directs the establishment of a pilot project which would involve various crops in the South, Southwest, Midwest, East, and Far West, so that we can have a genuine, scientific demonstration program to discover what successes we can have and to educate farmers and the country on the effectiveness of a rational use of a scientific integrated program.

Thank you.

Senator ALLEN. Thank you very much, Senator Nelson.

Senator Curtis.

Senator CURTIS. What you propose here at this time is in the nature of a pilot and demonstration program; is that right?

Senator NELSON. Yes.

Senator CURTIS. What work has already been done on this in the scientific world, either in universities or private laboratories, or ARS, or any place else?

Senator NELSON. First, let me say, Senator Curtis, I would waste the committee's time by relating to you what I know about it. You are going to have as witnesses Dr. Van den Bosch and some other experts testifying. But the short answer is that there has been considerable scientific work carried on in universities by the Agricultural Research Service, and practical application of this scientific knowledge in a number of areas in the country which Dr. Van den Bosch will discuss with you.

Senator CURTIS. Which do you regard as the most immediate need, methods of applying the information they already have now or the need for basic research?

Senator NELSON. I think both. Our knowledge about controlling insects by, shall we say, natural methods, is fairly limited. But in those areas where studies have been made and there has been application of the techniques, such as the California project, they have been very successful.

I think we need both. We need expanded research and new and better techniques for control of insects and we need also an educational program.

As you well know, when we created the land-grant colleges, one of their most important functions for over 100 years has been the educational program for the farmers to teach them better methods of production and agricultural management. So I think we not only need the research, but we need to be out in the field so that farmers can see what can be done by this kind of a technique, so that we can also develop better techniques of doing it.

Senator CURTIS. What has caused the increase in pests?

Senator NELSON. Again, you will have some very fine scientists more qualified than I. However, two obvious things have happened. In the use of broad spectrum pesticides and insecticides—when I say "broad spectrum" I mean insecticides that adversely affect all insects, or all or most insects—where they are used we have wiped out predator insects that prey on the pest insect.

The other thing that has happened is the insect, since it breeds very rapidly, develops a genetic immunity to the pesticides that are being used. There are now two mosquitoes in California which are not affected at all by any pesticide used on them. This has happened over the period of the last 20 years.

So we do know that we have disturbed the balance of nature and we have developed pesticide-resistant pests and it will get worse and worse as time goes by.

Senator CURTIS. It has been my understanding that removing crops from their natural habitat, where they have developed a capacity to survive, and starting to raise them in far-removed places, has been one of the contributing factors to the increase of pests. Is that right?

Senator NELSON. I do not think there is any question that when you take a plant and introduce it into an environment it has never existed in before, that you will discover very frequently, as we are discovering, that it has pest enemies of one kind or another to which it is not resistant because it has never survived in that environment before.

That is one of the problems we are seeing now in developing high production strains of various crops and introducing them in various other parts of the world, where that particular strain has never existed before, and has never developed a resistance to the various kinds of predators, or rust of various kinds that occur there.

So that obviously is a problem, and I have grave reservations about the long-term success of the so-called green revolution.

Senator CURTIS. I do not know what that is, but that's all.

Senator ALLEN. Senator Chiles.

Senator CHILES. No question.

Senator ALLEN. Senator Nelson, we appreciate your coming before the committee and giving us the benefit of your views and explaining the bill. We certainly commend you for your leadership in the field of the protection of our environment.

This bill, I believe, is an outgrowth of hearings held before this subcommittee earlier on the matter of pesticide regulation and control, the fact being that by providing an integrated method of eradication and control of pests, there would have to be less reliance on the use of chemicals that might be harmful to the environment.

Senator NELSON. That is correct. There will be some witnesses that you have that will give you some very compelling testimony concerning pilot projects, demonstration projects, or, in fact, operating projects in California right now.

Senator ALLEN. Yes. There are actually uses of an integrated system by private producers?

Senator NELSON. Correct.

Senator ALLEN. But so far as you know, no pilot program of any sort similar to this has been carried on by the Department of Agriculture or any of its divisions?

Senator NELSON. They have various experimental programs on various methods involving control of pests by predators, sterilization, and so forth, but I am not aware of any program of a pilot project nature involving private farmers in integrated pest control projects.

The objective here would be to select—and the National Academy of Sciences and Agricultural Research Service have been discussing this over a period of time—would be to select some areas in four or five parts of the country on various crops in the Midwest, citrus fruits in the West, cotton, tobacco, that sort of thing in the South, and Southeast, and develop and demonstrate what can be done in an integrated program without excessive use of chemicals to control pests.

Senator ALLEN. Yes. Now, the system would be then, under the first phase, the work by the Department, the Agricultural Research Service, would that be contracts made with individual farmers for applying this method of control, the integrated method, to certain of their fields with certain of their acreage?

Senator NELSON. Correct.

Senator ALLEN. And if any loss was sustained by them through the use of this method, then they would be reimbursed under the bill?

Senator NELSON. That is correct. And again, some of the scientists can speak more knowledgeably than I, some of them I have talked to do not feel there will be any loss at all, but if there were for the first year or two a production drop in the conversion stage, we would reimburse that farmer for the difference between what was produced on his land and what was produced on adjoining lands in the area. Although I think they will tell you that they do not anticipate that there will be much loss

But since it is not a compulsory program, and we are asking farmers to join in a demonstration project with us, it seemed to me that we ought to be able to assure them that whatever losses they may sustain in the demonstration project we would make up the difference.

Senator ALLEN. In effect, then, it would be a type of crop insurance; would it not?

Senator NELSON. Yes.

Senator ALLEN. I believe that is all. Thank you. We certainly hope you will be able to stay through some of this.

Senator NELSON. I can stay for a little while. Thank you very much.

Senator ALLEN. I would also like to invite you to stay here at the table with the committee. And if you would care to bring out any testimony from any of the witnesses, feel free to join in the questioning.

Mr. T. W. Edminster, please, and Dr. Knipling.

STATEMENT OF TALCOTT W. EDMINSTER, ADMINISTRATOR, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Senator ALLEN. You may proceed.

Mr. EDMINSTER. Mr. Chairman and members of the committee, I appreciate the opportunity to appear before your committee to discuss S. 1794. I am accompanied by one of my science advisers, Dr. Edward F. Knipling, about whom several spoke earlier.

The purpose of the bill is to authorize pilot-field-research programs for the control of agricultural and forest pests by integrated biological control methods.

The Department of Agriculture is totally committed to the integrated biological control approach to the suppression of pests and diseases of importance to producing the quantity and high quality of food, feed, and fiber in our Nation, as well as for the protection of our environment.

The American farmer has been active in developing and applying many programs that will protect our environment. For an outstanding example, we have only to look to the soil and water conservation programs. Programs that are supported and led by farmer-oriented associations in concert with the technical agencies of the State and Federal Government. These successful programs came out of the early research findings that provided an array of integrated conservation practices. Our research programs for pest control are geared to provide a similar array of integrated pest control practices. The agricultural sector with the tools at hand can then take similar leadership in applying biological and cultural methods of controlling pests and diseases.

For a number of years, the Agricultural Research Service, in cooperation with the State agricultural experiment stations, has conducted research to develop biological and related alternative pest control methods including the use of insect predators, parasites, pathogens, insect sterilization, attractants, hormones, varieties of crops resistant to insects and diseases, crop morphology, and various combinations of such techniques for integrated control of pests.

In fiscal year 1972, $61.4 million was appropriated to the Agricultural Research Service to conduct research on ecological, cultural, physical, and biological methods for the control of insects, diseases, nematodes, and weeds. An additional $21.3 million was appropriated for pesticide research activities by the Forest Service. Economic Research Service, and the Cooperative State Research Service. Also, about $950,000 was provided for pesticide educational programs in the Extension Service.

The extensive research program being conducted by the Agricultural Research Service toward biological and cultural methods for controlling insect pests and diseases is authorized under the Research and Marketing Act of 1946 (7 U.S.C. 427) and the Organic Act of 1862 (7 U.S.C. 2201). These acts provide the Department with very broad authority to conduct research in every facet from the original producer through to the ultimate consumer. Therefore, we consider the enactment of section 1 of S. 1794 to be unnecessary.

With regard to section 2 of the bill, we defer to the recommendations of the National Science Foundation. In this connection, I offer for the record an agreement between USDA and the National Science Foundation which forms a basis for cooperation in research on alternative methods of insect pest control.

Senator ALLEN. Without objection, it will be inserted in the record at the conclusion of your remarks.

Mr. EDMINSTER. This joint activity provides an excellent mechanism for effective program coordination.

Mr. Chairman, this concludes my statement. With your permission, Dr. Knipling will discuss details of our pest control research programs, particularly in the area of pilot field-research projects. I might add that Dr. Knipling is a pioneer in developing the concepts of integrated systems for the control of agricultural pests. At the conclusion of Dr. Knipling's statement, he and I will be happy to respond to any questions you or members of the committee may have.

(The agreement follows:)

BASIS OF NSF-AGRICULTURE COOPERATION IN RESEARCH ON ALTERNATIVE METHODS OF CONTROL OF INSECT PESTS

Preliminary discussions at the meeting of 28 September 1970 identified substantial areas of mutual interest as well as unfilled gaps in the ability of either agency to independently push forward as rapidly as required by the accelerating problems of environmental pollution. The National Science Foundation has provided substantial support to scientists in universities and colleges for the study of biological processes and mechanisms which provide the basis for biological control and other methods of controlling unwanted populations of plants and animals. The Department of Agriculture recognizes the need to support such research in increasing amounts, and to do so as a part of its broad approach to the problem, but recognizes that it will continue to be limited by other demands on the Agriculture budget. Therefore, it endorses the NSF effort to expand support of basic research in this area, particularly in universities and colleges.

A second step in the development of effective programs to improve environmental quality by alleviating pollution involves exploring the application of promising methods to control pests of particular economic importance. Such research is usually considered applied research, although it involves aspects of basic research. While the Department of Agriculture is actively engaged in this area, many of the problems may be appropriately explored in colleges and universities and associated experiment stations. The National Science Foundation has gener-

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ally not been substantially involved in such work in the past, feeling that its resources for support of basic research were already inadequate, and that to do so would encroach upon the province of Agriculture. The Foundation now believes, as does Agriculture, that an additional effort is needed to keep following leads in all areas of concern. Consequently, the Foundation will consider support of this more applied type of research as resources become available. In general, such research awards can be made to universities, using the normal NSF granting procedure, but some mechanism should be established to assure proper coordination with work supported by Agriculture.

The third critical effort involves developmental research, research that might be called the pilot plant level. When a truly promising method reaches the point where field tests of effectiveness as a practical control are required, evaluation of some methods must be done on a very large scale and under such conditions that the test area cannot be repopulated from surrounding areas. The problem is quite different from that of testing chemical pesticides, for example, where a persistent poison will continue to kill organisms almost immediately after they move in from surrounding areas. Furthermore, there is no incentive to industry to support such tests at the moment because there is no clear indication that any industry will profit by the introduction of these methods. Agriculture is now at the point of evaluating a large area pilot boll weevel eradication experiment, involving an integration of several methods of control, but believes that funds for completion of the experiment are marginal. It is possible that studies of a more basic nature, which could not otherwise be incorporated into the pilot field study, could be carried out in connection with this project by a performer who would qualify for NSF support. By this kind of cooperative effort it might be possible to enhance the value of the USDA profect.

In order to provide an overview of the full range of the research effort in this field, it is proposed that a joint committee between USDA and NSF be established to identify gaps and particularly important leads worthy of support and to provide coordination of the efforts of the two agencies in this respect. This committee should be empowered to call on the services of *ad hoc* committees, drawing upon the expertise of the general scientific community as well as the agencies when required.

Finally, if the plan for a pilot study of boll weevil eradication can be effected, the above committee could aid the National Science Foundation by encouraging and coordinating a technological assessment study centered on the pilot study. The approach to integrated control of pests cannot be taken on a grower-by-grower basis, or generally on a limited regional basis. In addition to the present lack of incentives for industrial support, an integrated control method for the boll weevil would destroy about a third of the remaining DDT market in the USA. These factors all contribute to creating legal, marketing, and economic problems of some complexity, and raise problems not unlike those associated with compulsory immunization or fluoridation of water supplies. Although various parts of USDA are already concerned with some aspects of the problem, it should be most useful to have as thorough an analysis as possible of the problem, including possible alternatives for financing a national program as well as costs and benefits. The screw worm control program would serve to provide further insight into the questions which should be studied.

(Signed) JOHN W. MEBEL,
(for Harve J. Car on,)
Division Director Biological and Medical Sciences.

(Approved) EDWARD C. CREUTZ,
Assistant Director for Research.

(Approved) WILLIAM D. MCELROY,
Director National Science Foundation.

(Concurred) NED D. BAYLEY,
(for the Secretary of Agriculture).

Senator ALLEN. Very well. We will be delighted to hear from Dr. Knipling at this time, and then the committee will feel free to ask questions of each of you separately or jointly.

Go ahead, Dr. Knipling.

STATEMENT OF DR. E. F. KNIPLING, SCIENCE ADVISOR, AGRICULTURAL RESEARCH SERVICE, U.S. DEPARTMENT OF AGRICULTURE

Dr. KNIPLING. Mr. Chairman and members of the committee, for more than 15 years the Entomology Research Division of the Agricultural Research Service has been orienting its fundamental and applied research efforts to the development of alternative ways to control insects, with particular emphasis on those insects that are responsible for the most extensive use of insecticides. We recognize the great contributions to agriculture, forestry, and health that modern chemical pesticides have made. The need for many of the pesticides will continue for years to come if we are to cope with the thousands of pests that attack crops, forests, livestock, and which affect man's comfort and health. Yet, we also recognize that our goal for the future must be to achieve the same or even a higher degree of efficiency in pest control but by methods that will not adversely affect the quality of our environment.

In the intensified efforts that have been underway for some years to develop ecologically acceptable methods for insect control, some progress has already been made. The screw-worm, a major pest for livestock, was eliminated by a unique method which utilizes the insect itself as a biological agent for its own destruction. The same technique is now employed to operate a barrier zone to keep screw-worms in Mexico from reinfesting this country. Each week from 100 million to 150 million screw-worm flies are being reared and sterilized by exposure to atomic radiation and then released in a broad band about 200 miles wide along the U.S.-Mexico border region from the Gulf of Mexico to the Pacific Ocean.

The success of the sterile male method stimulated research efforts to develop the technique for use against other insect pests. As a result, the technique is now used along the California-Mexico border area to control the Mexican fruit fly. Each week several million sterilized Mexican fruit flies are released to prevent the establishment of this dangerous pest of fruits and vegetables. These sterile insect releases have replaced the use of insecticides which were formerly used to prevent the establishment of this pest in southern California fruit and vegetable growing areas. Last year the USDA and the California Department of Agriculture jointly financed a program to rear, sterilize, and release more than 100 million pink bollworm moths in the San Joaquin Valley of California in an effort to prevent the spread of this dangerous and costly pest of cotton into this important cotton-growing region. When the pink bollworm spread from Texas to cotton-growing areas in Arizona, New Mexico, and the Imperial Valley in California, it immediately posed a serious problem to growers, because chemical insecticides now provide the only effective way to control the pest under conditions that cotton is now grown in these areas. It is the hope that the sterile pink bollworm release technique will continue to keep the pest from getting a foothold in the San Joaquin Valley and thus obviate the need for an intensive use of insecticides in this large cotton-growing area in California.

We recognize that the use of sterile or genetically altered males for their own destruction will not solve all or even most of our major insect pest problems. Yet, our research has advanced to the stage that we see excellent possibilities of developing the techniques to help solve or alleviate a number of other major insect problems. Research on the insect sterilization method has advanced to the point that this technique shows promise when integrated with other methods for the control of low populations of such major pest species as the boll weevil, codling moth, Mediterranean fruit fly, oriental fruit fly, melon fly, Caribbean fruit fly, corn earworm, tobacco budworm, tobacco hornworm, gypsy moth, horn fly of cattle, and other pest species. However, we will not know if or how the technique can be employed effectively against these and other species until suitable pilot field tests are conducted against ioslated populations.

There is a big jump from laboratory and small pilot type of research to practical operational scale field testing. As an example of the type of pilot testing research that needs to be undertaken to develop some of the new techniques for insect suppression, I would like to cite a test program on the boll weevil now under way, which is jointly sponsored and financed by the Agricultural Research Service, the Cooperative State Research Service, the States of Mississippi, Alabama, and Louisiana, and the cotton industry. A pilot test is now underway to determine if insecticides, attractants, and sterile males employed in an integrated program can be used to eliminate isolated populations of the cotton boll weevil, one of the Nation's most damaging pests. The large-scale field test will cost $2 million each year for 2 years. However, if the procedures used prove successful, we may have the means of eliminating a pest that alone costs cotton farmers about $75 million per year on the average to control the boll weevil with chemical insecticides.

The genetic approach to insect control is just one of several approaches that offer more acceptable solutions to insect pest problems. Insects have many natural enemies. One of the most important goals of Federal and State scientists is to use insecticides more judiciously so as to obtain maximum help from the biological agents that already occur naturally in our agricultural and our forested areas. We know through many years of experience and long before insecticides were used intensively, that these natural agents, as valuable as they are, do not provide adequate control for many pests. Therefore, USDA is investigating a number of parasites and predators with a view to rearing certain species by the hundreds of millions, or even billions, so that enough of them can be released on a programed basis into crop environments to assure effective control of some of our major pests. One of our scientists located at Texas A. & M. University has shown that the release of large numbers of eggs or larvae of a predator called chrysopids on cotton will effectively control cotton bollworms.

To explore fully this biological method, we need to develop low-cost methods of rearing the predator in large numbers and determine its usefulness in well-planned pilot field tests. A tiny natural biological agent called *Trichogramma* is known to be an effective parasite for suppressing a wide variety of crop pests. However, like many natural enemies, this parasite seldom produces a high degree of control until the pest has already exceeded the economic damage level. We are taking a new look at this parasite and there is good reason to believe that the release of from 50,000 to 100,000 of these tiny parasites per acre each week on crops attacked by such insects as the bollworm, tobacco budworm, sugarcane borer, cabbage looper, and imported cabbage worm can lead to the control of pests. Again, however, we will not know how effective and how practical this biological agent can be as alternatives to chemicals without conducting suitable pilot field tests on a community size scale. Similar exploratory studies are underway on parasites of such important crop pests as the greenbug on sorghum, the pea aphid on peas, and the green peach aphid on potatoes. Parasites that attack aphids often control aphid populations but too late to prevent damage to the crops. This is typical of many parasites, thus our goal is to develop ways to rear potentially useful parasites on a large scale and conduct pilot field tests on a sufficient size scale to determine their value as a biological control procedure to replace chemical pesticides.

Insects are also affected by a number of insect diseases. Thus, we have another type of biological agent to exploit. Insect viruses are known that seriously affect such pests as the cabbage looper, cotton bollworm, tobacco budworm, and the gypsy moth. Several strains of the bacterium *Bacillus thuringiensis* are under investigation, which are more virulent than the strain now sold for the control of certain vegetable pests. Fortunately, most insect diseases are highly selective against a given pest or a closely related pest complex; therefore, the use of insect pathogens offers a way to control some of our important pests without adversely affecting other natural biological agents or fish and wildlife. We believe that such pathogens can eventually provide effective ways to control a number of important pests; but again, pilot tests are needed to determine how effective some of the insect viruses and the different strains of *Bacillus thuringiensis* are for the control of such pests as bollworms on cotton, the cabbage looper, gypsy moth, and other species.

Another approach to insect control involves the use of attractants. There is a special interest in the use of insect sex attractants for insect detection and control. In a strict sense the use of sex attractants would not involve a biological method because the attractants are chemicals. But they are chemicals of natural origin and are highly selective in action, generally only against the insects that produce them naturally. Chemists with Federal and State research institutions have made remarkable progress in recent years in the isolation, identification, and synthesis of these highly active chemicals. Sex attractants have been synthesized for such important pests as the gypsy moth, cabbage looper, boll weevil, codling moth, redbanded leafroller, European corn borer, and pink bollworm. Other major insects are known to produce powerful sex attractants and chemists are now trying to isolate, identify, and synthesize the compounds. They include such pests as the peach tree borer, Japanese beetle, tobacco hornworm, tobacco budworm, and sugarcane borer. We are hopeful that insect sex attractants will eventually offer a way to control a number of important pests without causing any harm to other organisms in the environment. However, we are finding it to be difficult and costly to conduct the type of tests that are needed to determine how effective insect attractants can be for insect control. Most of the insects are strong fliers and it is not possible to demonstrate effective control by the use of attractants unless the test area is sufficiently large to minimize the influence of previously mated insects immigrating into the experimental area.

One of the most desirable ways to control insects is to develop crop varieties that tolerate or resist insect attacks. This approach to insect control is by no means new, but there has been a renewed interest in developing this method for more insect problems. Good control is now obtained by growing wheat resistant to the Hessian fly; growing alfalfa that is resistant to the spotted alfalfa aphid and the pea aphid, and corn that is resistant to the European corn borer. Research has been expanded on this approach in recent years. Promising lines of cotton are known that possess a high degree of resistance to the boll weevil, the cotton bollworm, tobacco budworm, and the flea hopper. It requires long and painstaking research by plant breeders and entomolgists to expect to find and develop crop varieties that are resistant or tolerant to insect attack. But even after promising germ plasm is found, it becomes necessary to grow resistant lines in special field tests and on a sufficient size scale to fully evaluate their agronomic qualities and to measure their effectiveness against the pest. One of the special problems is to be sure that such varieties, while resistant to one pest, will not be more susceptible to some other pest or diseases. Small scale tests do not always provide the information needed to fully evaluate the performance of new varieties. Mr. Chairman, I would just like to add the eventual goal is to determine how we can integrate these alternative methods to achieve the highest highest degree of control possible that will be sound from an ecological standpoint.

Mr. Chairman, I have given you only the highlights of the determined efforts now underway within USDA to develop effective but at the same time more acceptable ways to control insects. We believe that we have made good progress with the available resources, on a most difficult undertaking. Much remains to be done to follow through on the promising leads we now have and on other new leads we hope will emerge as research progresses. In some cases we still need to perfect mass rearing methods for insects that might be used as biological agents. In other cases, we already know how to rear the insects in large numbers but suitable size field tests are needed to be determine how useful they are in practical control.

Mr. Chairman, that concludes my statement. I will be happy to respond to any questions you may have.

Senator ALLEN. Senator Curtis.

Senator CURTIS. Mr. Edminster, as I understand your statement, you feel that this legislation, so far as the Department of Agriculture is concerned, is not necessary?

Mr. EDMINSTER. From the standpoint of the authorities that are to be granted, we do not feel it is necessary, because those authorities already exist; yes, sir.

Senator CURTIS. You cited two acts, the Organic Act of a very early date, and then the act of 1946?

Mr. EDMINSTER. The Organic Act of 1862 and the Research and marketing Act of 1946.

Senator CURTIS. Do either of those acts have a dollar limitation in their authorization, or are the open end?

Mr. EDMINSTER. They are open end.

Senator CURTIS. Does the bill before us in any way broaden the scope of the authorization beyond what the existing law is?

Mr. Edminster. We feel the recognition of the potential cooperation with NSF is one form of broadening. Although we are already working in that direction, as indicated in our cooperative agreement with them.

Senator Curtis. I understand that, but from the standpoint of an authorization being necessary in order to have an appropriation, you feel that you are already fully authorized to seek an appropriation to do any of the things that this proposal would call upon you to do; is that right?

Mr. Edminster. Yes sir. As Dr. Knipling has pointed out, we have a number of programs of this sort under way with the resources that we now have at hand, such as the boll weevil work and several others that were mentioned.

Senator Curtis. About how much money is now being spent by the Federal Government on various kinds of pest control, including the research and cooperative work and other ways?

Mr. Edminster. As indicated in my statement, if we look at the broad spectrum of research, not only in the Agricultural Research Service, but in the Cooperative State Research Service, the Forest Service, the Economic Research Service, and the Extension programs, it would come to about $82.8 million.

Senator Curtis. That is the current year?

Mr. Edminster. In fiscal year 1972, yes sir.

Senator Curtis. Do you have any idea how many individuals are engaged in this work, professionals and nonprofessionals?

Mr. Edminster. I would not want to guess on that point. Many of these workers are in the State agricultural experiment stations under Federal funds provided through CSRS and many are in other USDA agencies. We can look into this and supply it for the record.

Senator Curtis. If you can supply something for the record, I think it would be well that we assess what is going on now.

(The information follows:)

U.S. DEPARTMENT OF AGRICULTURE PESTICIDES RESEARCH ACTIVITIES

[Dollars in millions]

	Fiscal year 1972		
	Total funds available	Professional man-years	Nonprofessional man-years
Agricultural Research Service	$61.5	1,186	1,400
Cooperative State Research Service	12.3	330	320
Economic Research Service	.4	6	6
Forest Service	8.6	288	290
Total	82.8	1,810	2,016

Senator Curtis. By my questions, I am not intending to imply that there is no need for emphasis and renewed emphasis in this field, but I did want to get the record straight as to the situation with regard to the need for authorization language so far as further appropriations are concerned. That is all, Mr. Chairman.

Senator Allen. Senator Chiles.

Senator Chiles. No questions.

Senator Allen. Senator Nelson.

Senator NELSON. If I may be permitted to make a brief statement——

Senator ALLEN. Yes sir.

Senator NELSON. I am well aware of what the authority is and know about the agreements and the activities between the National Science Foundation and the USDA, as well as their activities in the field. I would only point out that Congress repeatedly passes legislation specifically mandating an activity which the department or agency already has the authority to do. My most personal experience with that was when I introduced the National Teacher Corps and HEW came to the committee to say, "We already have the authority." But they never did create the National Teacher Corps and the Congress decided they ought to do it, so we mandated that it be done.

I think it is important we mandate a program and fund it. That is why the bill is here.

Privately, many people in the USDA and the National Science Foundation are saying, "We wish you would mandate this program. We have the authority but it will not be done unless Congress funds and mandates it."

They will tell you that privately at the National Science Foundation and over at the Agricultural Research Service.

Senator ALLEN. Mr. Edminster, Dr. Knipling, do either of you care to comment on Senator Nelson's comments?

Mr. EDMINSTER. I do not believe I have any comments.

Senator ALLEN. Dr. Knipling, I believe you state your Research Division, Entomology Research Division, Agricultural Research Service, has been working in this general field for some 15 years and providing alternate methods for eradication of insects and pests?

Dr. KNIPLING. I would say we had a renewed emphasis in this direction in the last 15 years.

Senator ALLEN. Yes. Up to now your efforts have been largely in the area of research and field tests; is that correct?

Dr. KNIPLING. That is right. The work has been done in the laboratory and on small-scale field tests.

Senator ALLEN. Nothing really in the area contemplated by the bill, which would be going to farmers, going to foresters, and working out a project whereby they use the integrated method of control in actual field production rather than the experiments that the Department has been using?

Dr. KNIPLING. This is somewhat a different program. This is one part of the total effort. The type of programs I have been talking about involve taking promising leads from basic and exploratory laboratory research and trying them out on a somewhat operational size scale to see whether they actually will work, so as to perfect the systems that might be involved.

Senator ALLEN. Would that be at an experiment station, or where?

Dr. KNIPLING. It could be almost anywhere. We have carried out a few programs like this in the past, and we have others underway. For example, in developing the screw worm eradication program using the sterile insects, we could not go just from the laboratory recommending that an eradication program be undertaken, based only on laboratory findings. We had to prove to ourselves and to others that the sterile male technique would work.

Because of the strong flying ability of the screw worm, the only way we could do it was to go to an area with an isolated insect population.

We went to the Island of Caracao in the Netherlands Antilles in order to try out the sterilization method and to demonstrate that it would work. The reason we went there was our resources permitted us to conduct a test only on a small scale.

We did the same thing with the Oriental fruit fly and the melon fly in the Pacific Islands. We ran a pilot test experiment on the Island of Rota to see whether we could use an attractant to eradicate the Oriental fruit fly. We tried sterile males on the same island to see if we could eradicate the melon fly.

We have some tests underway on the Island of St. Croix to see whether we can use light traps on a large scale as a means of controlling the tobacco horn worm.

These are examples of the types of pilot tests we have carried out in the past. But there are probably 20 or 25 different types of pilot tests, using one method or another, that remain to be carried out.

Senator ALLEN. What about contracting with a cotton farmer in Alabama, or a grain farmer in the Midwest for use of an integrated control system on a 40-acre tract of land? Have you done that?

Dr. KNIPLING. Well, the type of tests we have in mind, the farmers would hardly be qualified to do it——

Senator ALLEN. I did not say for them to do it, but could be allowed to be done under your supervision and control.

Dr. KNIPLING. We have a program underway now which is a test program on the boll weevil in Mississippi.

Senator ALLEN. How is that being carried on?

Dr. KNIPLING. The Agricultural Research Service, the States, and the cotton industry have each contributed funds which total $2 million a year. We have selected an area in Mississippi, near Prentiss, Miss., in which about 30,000 acres of cotton will be treated with an integrated effort. First, the use of chemicals in the fall, then the use of sex attractant traps that have been developed, and then finally to release sterilized male boll weevils. The object of this test—and it is to be carried out on a large scale—is to see whether these methods that have been under investigation for some years have reached the point that we can demonstrate the boll weevil can be eliminated from a prescribed area.

The growers are cooperating to the extent that they can. Some of them have gone ahead and used an insecticide up until we started the program this fall.

So, where it seems feasible and appropriate, we are using the farmers' area. I can mention other projects underway now. The coddling moth in the State of Washington in which we are conducting a pilot test to see whether sterile coddling moths can control the codling moth rather than continue to use insecticides.

Senator ALLEN. Now, would that be used in addition to the farmer's accepted method of pest eradication?

Dr. KNIPLING. Well, we hope to see whether we have the technology to substitute other pest control techniques instead of chemicals.

Senator ALLEN. Do they refrain from using the chemicals in your test?

Dr. KNIPLING. In the first year, the groers have not refrained from using chemicals. We wanted them to continue because this method depends on getting the insect population down to the lowest level possible. If we can show that the release of these sterilized moths will keep the coddling moth population from pairing up to large numbers, then we can withdraw the use of chemicals and have this biological method to take over.

Senator ALLEN. But pending that time, they are going ahead with the old accepted method that we are trying to eliminate?

Dr. KNIPLING. That is right. Until we can prove that there is an alternative method that is suitable, then we will have to continue using pesticides.

Senator ALLEN. That is merely demonstrating the efficacy of one certain method, is it not?

Dr. KNIPLING. That is right. We are testing to see whether we have methods that can substitute for the use of chemicals or supplement the use of chemicals.

Senator ALLEN. In the meantime, the farmer goes his merry way of using his old methods, whether that be by chemicals or parasites or predators, or how.

Dr. KNIPLING. I would like to add, Mr. Chairman, that there are demonstration programs that are—I think Senator Nelson mentioned—that are underway by the Department to see whether or not the more or less integrated pest management approach can be effective in meeting the insect problem with less use of chemicals. This is one of the goals, to make maximum use of the matched biological agents, and there will be experts here who can speak to this subject very effectively. This is getting a little bit closer to working with the farmer, you see, but what I have been talking about largely is research to determine whether or not we had the means of substituting alternative methods for the methods that are now being used by the growers.

Senator ALLEN. Now, under existing law, could you contract with the farmer for the use of the integrated method and pay him for any loss that he might sustain by reason of that method not being effective?

Dr. KNIPLING. Perhaps Mr. Edminster would want to comment on this, but my impression would be that this would not be——

Senator ALLEN. In other words, this bill then does give additional authority to the Department?

Mr. EDMINSTER. Mr. Chairman, from the standpoint of pure research relations with a farmer or a group of farmers, we have for many years used a memorandum of understanding or a cooperative agreement with them whenever we go on to a farm to do research work.

In general, there is a clause in this cooperative agreement that provides for mutual agreement on compensation to the farmer if there is a change in his production level as a result of research practices that he has permitted us to put on his land, or on his crop, or on his livestock.

It is a permissive thing in which we agree that the level of compensation will be jointly determined between the two parties. It is based on the extent of the acreage and the type of research. The agreement provides that compensation would not exceed some level. This takes into consideration market conditions and the general level of production that he has normally carried on. We have been doing this for a number of years.

Senator ALLEN. At present, you do not have any program underway whereby contracts are made with farmers for the use of the integrated pest control method, and compensation to the farmer for losses sustained in the use of that integrated control method? No such program is being caıried on at this time?

Dr. KNIPLING. As I mentioned, we are cooperating with the farmer. They are cooperating with us.

Senator ALLEN. That is something additional, though, rather than a substitute, an alternate method?

Dr. KNIPLING. We have no particular program in which there are agreements with the farmer, for example, to use an integrated or alternative method and no other?

Senator ALLEN. Yes.

Dr. KNIPLING. No; we have no such agreements. There are demonstration programs working with the farmer and giving him advice and suggesting that he use this method or that method, but no contract. The farmer does the work or makes the decision.

Mr. EDMINSTER. Mr. Chairman, I think the point Dr. Knipling has brought out is very significant; that is, working in "cooperation" with the farmer. I would illustrate this by some of the work in New Jersey in recent years. The U.S. Department of Agriculture has been working through State agencies and other cooperators in the introduction of parasites for the alfalfa weevil. Prior to the cooperative program in which the farmers became very much interested, they were having to spray about 90 percent of the alfalfa area with chemicals to controls the alfalfa weevil. After the introduction of the parasites and with sufficient time for them to take effect, the level of spraying required in a rather broad area last year has been less than 10 percent.

This has been as a result of the cooperation by farmers working together with the technical agencies, both State and Federal.

Dr. KNIPLING. I would cite another example which I think comes closer to what you are describing. This is the work of the State extension services which work with and organize groups of farmers in the community on pest control matters. The boll weevil program, for example, is organized into what is called a diapause control program for boll weevil control in the fall of the year. The farmers were organized, and they are paying the cost of insecticide treatments to suppress the boll weevil in the fall after the cotton is harvested. This is done so as to have a minimum adverse effect on the natural biological agents. The farmers do not have to go in so early the next spring or the next summer and disrupt the ecology and cause problems.

Senator ALLEN. That is more or less telling them when to apply the insecticide?

Dr. KNIPLING. Yes, and organizing them. Getting unified action by the growers in the community to use this method in lieu of the individual method later on next year.

Senator ALLEN. Yes; but that is more a general areawide timing of application of an insecticide, rather than having integrated methods, any change in their present method of control. That is still the one method, insecticide method, and merely a timing on that.

I notice, Dr. Knipling, that this program you have, the pilot test regarding the boll weevil, which I think is very fine, I am delighted that this test is being carried on; this large-scale field test will cost $2 million each year for 2 years.

Now, that, as you have suggested, is an additional method that is added on to whatever the farmer is already doing and an effort to see if this additional method would be helpful. That is costing $2 million a year, which is all that is asked under this bill for the reimbursement to farmers and ranchers for losses they sustain on account of this research work under the integrated method basis.

Dr. KNIPLING. Well, this is just an example of how costly some of these field tests will be. However, I think the pilot boll weevil test is by far the most costly one I can envision right now. The other pilot tests that we envision, or should be carried out in the next few years, might range all of the way from $50,000 for a year or two up to $500,000 a year or 2 for 3 years.

If a pilot test is carried out at a cost of $100,000 a year for 2 years, and if it is successful, then we think the research phase is completed. If it is not successful, we may have to go back to the drawing board, so to speak, and perfect it. But in the meantime, there would be some other method or some other insect for which we should use the $200,000 or $100,000 a year and test some other method on some other insect.

So it would continue year after year.

Senator ALLEN. Well, now, aside from whether this present program is now authorized or whether there is a bill pending that would authorize it, do you feel that the efforts contemplated by this legislation are constructive, and can they be possibly helpful in solving the problem, or eradication of pests?

Dr. KNIPLING. I think that the principles provided for here, or called for here, support the efforts that we are trying to make and many are trying to make, to find alternative solutions that are more acceptable.

Senator ALLEN. You stated, however, that the Department had never gone so far as to undertake the method envisioned by this legislation.

Dr. KNIPLING. There have not always been the resources available to carry out the programs of this nature on the scale that is envisioned.

Senator ALLEN. Yes. Well, now, that being true, and the legislation offers some of those resources to the extent of $2 million a year for each of two phases of the program, what, then, would be the objection of the Department to accepting these funds?

Dr. KNIPLING. I do not know how to answer that, Mr. Chairman. I do not believe the Department really objects to the matter. I think it is a matter of budget restraints and so on that are involved.

Senator ALLEN. How much money is handled by the Agriculture Department per year? How many billion?

Mr. EDMINSTER. I cannot quote——

Senator ALLEN. $6, $7, $8 billion? Two million dollars would be an infinitesimal amount to have there; would it not?

Dr. KNIPLING. A small percentage; yes.

Senator ALLEN. Now, gentlemen, with all due respect to the Department, which I think is doing a fine job, I will address my question with respect to any bureau or agency of the Government where it has general oversight and general authority in an area of activity, the Department has some objection and does not necessarily look with favor on the Congress requiring it to do something specific that is covered within the general phase of the work of that Federal bureau; is that correct?

Mr. Edminster. I do not know if I quite agree entirely with that interpretation. I would simply say we do have the authority; and that it is not required to add to this. As I indicated we are fully committed to moving in this direction within the constraints of the resources that we have available for this. These resources, of course, would come through the appropriations process rather than through special legislation.

Senator Allen. Yes, of course, you both realize that the mere authorization of the appropriation would be only the start, and that they would have to be included in the appropriation bill.

Mr. Edminister. Yes, sir.

Senator Allen. Gentlemen, I appreciate your coming before the subcommittee.

Senator Chiles. Mr. Chairman.

Senator Allen. Excuse me. And I certainly want to commend you on this work that you are carrying on in this field. I feel great good is being accomplished in finding methods at the research level of eliminating these pests. We certainly are delighted that you expect to carry on, know that you anticipate having many breakthroughs in the next few years. We do hope, knowing that if this legislation is passed, you would go right ahead and implement.

Excuse me, Senator Chiles.

Senator Chiles. Mr. Chairman, I just want to ask him a couple of questions which either or both can respond to.

Starting from the proposition that we now have, the American farmer who has had to increase his production every year in order to stand still because he gets the same amount basically for his product that he was getting 10 and 15 and 20 years ago, and yet his costs are going up, his cost of borrowing money, his cost to labor, his cost to mechanization, and the fact that he has to continue to try to increase that production all of the time, plus the cost of pesticides. Now, you add to that the factor that Government has now gotten into control of pesticides and we have decided, in the Government's wisdom, to try to protect the environment, try to protect many species of life, that it is necessary for us to impose governmental controls on pesticides and what he can use. So on the one hand, Government is now telling hım "you are not going to be able to use the pesticides you have been using." That is one way he has again gotten this increased production.

Do you feel Government has a responsibility then, to at a time we say to the farmer, you cannot use DDT or you cannot use one of these pesticides that you have used, that Government owes the responsibility to him to try to give him an alternate method of trying to control the pests, if Government is going to take away his right, restrict his right?

Mr. Edminster. Very definitely. This really is the objective of the research program, to find new alternatives, either alternative systems or combinations in the integrated approach.

There is another important area which is the educational and the assistance area. Assuming that we find an alternative combination in terms of biological control, it becomes a question of how can we bring this to the farmer so that he can make the best use of it in the shortest possible time. It has been indicated in the previous testimony here, the farmer is in the habit of using a certain system. It is hard to convert.

In 1971, we have, through our Educational and Extension Service and through our regulatory programs, initiated a preliminary program on pesticide-use management. We are trying to proceed through a cooperative program of research, regulatory, and educational groups working together with the States, the industry to do three things, basically. One is an assessment of the pest populations that are involved in an area and selecting beneficial treatments in order that pesticides would be only used when necessary. In other words, giving the farmer specific, on the ground guidance, to reduce the amount of pesticides used. He does not just go out once a week and spray, but goes out when the economic threshhold has been reached and the spray should be applied.

This has been carried out by having teams trained to go out and make the surveys, bring the data back, and then have professional guidance given to providing the recommendations to him.

A second phase of the program is in the collection of the data on a very systematic basis, so we can use this as a historical background in the future.

Then a third is a sampling of all of the components of the environment to find out what effects this system has on the environment and get a clue from that.

This is a program separate and apart from the research that Dr. Knipling has been discussing, but still has the integrated approach to control development. These two programs would work hand in hand.

So this is a part of providing the service to the farmer.

Senator CHILES. Yes, sir. All right. Now, recognizing then that you do accept that thesis, and I am delighted the Department does accept the thesis, the Government does have a responsibility at a time we are taking away the right of the farmer and restricting his right in the use of pesticides, we have a corresponding responsibility to give him a substitute and educate him in other methods. Now, do you think we are keeping up with what Government is doing on the one hand, and the EPA and the other agencies of Government that are restricting his rights; are we keeping up with providing him now the services, the information, the knowledge, so that he will have that substitute at the same time that he is restricted on the other?

Mr. EDMINSTER. That is a question that would be very difficult to anwer.

Senator CHILES. I just want a yes or no.

Mr. EDMINSTER. I think we are making every effort in that direction. Whether we can mount a sufficient number of programs and enough integration to keep up with the other——

Senator CHILES. But you know today we are not.

Mr. EDMINSTER. That is right. It is very difficult.

Senator CHILES. And Congress, sitting as a public policymaker, has got to determine whether we want to keep up with it or not. And if we want to keep up with it, we have to direct the Agricultural Department to keep up with it or get something so we can keep up with it.

Mr. EDMINISTER. Move at a faster pace.

Senator ALLEN. Thank you, gentlemen. We certainly appreciate your cooperation.

Mr. Harry S. Bell and J. Ritchie Smith, please.

STATEMENT OF HARRY S. BELL, NATIONAL COTTON COUNCIL OF AMERICA, WARD, S.C.; AND J. RITCHIE SMITH, DIRECTOR, TECHNICAL RESEARCH SERVICE, NATIONAL COTTON COUNCIL OF AMERICA, MEMPHIS, TENN.

Senator ALLEN. Mr. Bell, please proceed.

Mr. BELL. Mr. Chairman, my name is Harry S. Bell, and I am a cotton farmer and ginner from Ward, S.C. I am also a delegate member of the National Cotton Council, and I appear here today on behalf of the council. I have with me today Mr. J. Ritchie Smith, who is director of the council's Technical Research Service.

The council is the central organization of the raw cotton industry, representing cotton producers, ginners, merchants, warehousemen, cotton cooperatives, cottonseed crushers, and cotton spinners.

I am also president of the South Carolina Farm Bureau and a member of the Cotton Board which was established by the Cotton Research and Promotion Act of 1966. The board administers the cotton research and promotion order and contracts with Cotton Inc., formerly Cotton Producers Institute, to carry out cotton research and promotion programs. Cotton Inc., is the producer research and promotion organization, and I will refer to some of its programs during the course of my testimony.

The council supports the purposes of S. 1794, and we wish to congratulate Senator Nelson on his foresight in drafting a bill which will authorize increased research on problems which farmers share with the general public. We will suggest one small but important change in the bill as drafted, and explain why we feel it is desirable.

At the outset, I would like to say a few words on my own behalf, as a farmer. I think we farmers have a special interest in the environment and in ecological problems. We live in the country, not only because we make our living there, but because we like the country. We enjoy the birds and the animals. Hunting and fishing are recreation for many farmers. We value the clear country air.

But in addition to living in the country, we live from the country, as do all Americans. But we are closer to it than most, and the country is our basic resource. Therefore, our objective is to be able to produce and at the same time preserve the environment, which is our main resource.

We believe this view is shared not only by cotton farmers and the rest of the cotton industry, but by all engaged in agricultural production. The farmer has long been in a cost-price squeeze and must lower his production costs if he intends to stay in business. The cotton grower competes with the synthetic fibers and foreign-grown cottons. Producers of other commodities have similar incentives to produce quality products for consumers and to keep the costs of these products reasonable.

We cannot do these things without controlling pests—insects, weeds, plant diseases, nematodes, and other agents and influences which would otherwise destroy our crops or substantially reduce our yields, raise our costs, and result in lower grade products for the public. At the present time, we have to rely mainly on chemicals to control these various pests.

The cotton industry has for years recognized that there should be better alternatives to wide-scale poisoning with broad-spectrum insecticides. We are concerned not only with the effect on the environment which can result from misuse of these materials, but also with the complications occurring when insecticides destroy beneficial insects that normally help check pest buildups. In addition, the cost of what I might call total chemical control, in which broad-spectrum insecticides are used on a scheduled basis, is excessive. We would be much better off to combine judicious use of chemicals with the benefits to be obtained from cultural and biological control methods.

I feel certain that these views are supported by most of the progressive chemical pesticide manufacturers.

For more than a dozen years, cotton producers have supported research on biological methods for controlling pests, on cultural methods, and particularly on integrated biological-cultural-chemical approaches. Let me give you a few examples of the types of research producers have supported and, in many cases, are still supporting.

Cotton Inc. supports research on the development of new strains of Trichogramma. The Trichogramma is a tiny wasp-like insect which parasitizes the eggs and young larvae of bollworms and pink bollworms. This research is being carried out in California. Both the bollworm and pink bollworm are difficult insects to control by chemicals; and, if successful, the use of beneficial insects like the Trichogramma might eventually give us better ways to control various types of bollworms.

In a somewhat related program in Texas, Cotton Inc. has supported research in which a special diet has been developed for the mass rearing of the insect Chrysopa, an important predator of bollworm eggs and largae. The diet is encapsulated in tiny globules which simulate bollworm eggs, and several successive generations of Chrysopa—otherwise known as the green lacewing—have been reared on it. It appears that sufficient quantities can be reared at low enough cost to utilize them in field releases to cut down heavily on bollworm infestations. But large-scale field testing is necessary to evaluate and demonstrate the effectiveness of this highly promising nonchemical control method.

Producers have supported research on microbial pesticides, including the nuclear polyhedrosis virus. This virus occurs naturally and attacks both bollworms and budworms, but apparently is harmless to other insects and man. It was granted a temporary exemption from tolerance on cottonseed for this year by the Food and Drug Administration. Further work on formulations and usage under varied field conditions should make this new tool an effective part of integrated control techniques.

We have financed research on chemical feed stimulants to cause insect pests to feed on trap crops which themselves can be treated, or to feed on lethal bait. We have supported research on sex attractants which may lure certain pests to traps where they can be caught or otherwise destroyed.

One of the more successful Cotton Inc. projects was a method of strip cutting alfalfa so that certain cotton insects, such as lyqus bugs, would remain in the alfalfa, which they prefer, rather than flying to cotton, had the entire alfalfa acreage been cut. This, in turn, has led to interplanting cotton with strip sof alfalfa. In some cases, this has completely eliminated the need for chemicals to control weevils.

Cotton, Inc., is supporting research on narrow-row, high-population cotton, which can also be called short-season cotton culture.

Cotton produced in this manner can be planted later and harvested earlier than normal crops. Through this shorter season, it escapes the buildup of pest populations. This buildup is one of the most troublesome aspects of insect control. This system of production also provides a shorter period required for crop protection from pests, especially insects, and should reduce the overall use of cotton pesticides.

The development of increased plant resistance to specific insects and diseases has been successful in many cases and represents an ideal method of biological control. Cotton, Inc., is supporting several projects which appear to be highly promising in this area.

A large project with USDA and the States involved integrated practices to eradicate the cotton boll weevil—the No. 1 cotton pest and the one requiring the heaviest usage of insecticides.

I won't attempt to outline all of the programs of this type which cotton supports. I think those we have mentioned are ample evidence that we agree with the concepts of S. 1794. We are already working on various methods for integrated biological-cultural-chemical control. We think a great deal more research in this area is needed on cotton, and we believe the authorizations in the bill can be enormously helpful.

Laboratories and small-scale field tests can only go so far in developing practical integrated control procedures. Large-scale pilot field research programs are essential to success in terms of program ingredients and in speeding widespread adoption. Basic research to develop new methods and techniques should be expanded at the same time. In the need for the closest kind of cooperation between the U.S. Department of Agriculture and the National Science Foundation, as well as others involved.

In our opinion, the development and use of practical integrated control techniques would reduce our production costs, cut environmental contamination, lessen pesticide residues in cottonseed, avoid or delay the onset of pest resistance to chemicals, and reduce toxicity hazards to people and other animal life.

We do suggest that the word "chemical" be added to the words "cultural" and "biological" in the bill. In other words, the bill should call for increased research on integrated cultural-biological-chemical methods for controlling pests. Our experience indicates that chemicals are required even when other methods can be used successfully as supplements. And certainly in some cases we shall be heavily dependent on chemicals for years to come. But these chemicals need not cause environmental problems. This is the case with many of the chemicals which are used to make cultural and biological approaches effective. These chemicals include juvenile hormones, narrow-spectrum chemicals, chemosterilants, chemical attractants and repellents, sex lures, feeding stimulants and antifeeding materials, antimetabolites, and systemic chemicals which work through the plant itself.

Cotton production in this country uses about 13 percent of all pesticides used in the United States, and around 20 percent of all the insecticides. I mention these figures for two reasons: first, to highlight the fact that pesticides are extremely important in cotton production; and, second, to clear up some inaccurate statements that have been made about pesticide use on cotton. It is not true that about 50 percent

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of all pesticides go into cotton production. However, it is true that about 50 percent of all insecticides used on U.S. crops is applied to cotton.

I would like to point out that in addition to our efforts on methods of integrated cultural-biological-chemical control, we are deeply concerned with the proper use of both those chemicals employed in this manner and the conventional chemicals on which we are now almost fully dependent. Our industry is moving, therefore, to develop educational programs of the safe, judicious use of pesticides. We intend to make the cotton industry a model segment of agriculture in its use of chemical tools. These programs are being developed by the council and the Cotton Foundation. I might add that the Cotton Foundation is receiving support from chemical manufacturers themselves and a hearty endorsement of these educational programs from those firms.

We are convinced that with more research, with education, and with Government-industry cooperation, we can produce for the needs of the American people and still preserve the kind of environment we all want.

Senator ALLEN. Thank you, Mr. Bell.

Mr. Smith, did you have separate testimony?

Mr. SMITH. No, sir. I am just here in case you might have some questions to direct to us.

Senator ALLEN. As I understand, you gentlemen individually and also representing the National Cotton Council of America, recommend the purposes of the bill and its objectives?

Mr. SMITH. That is correct.

Senator ALLEN. Now, I notice the suggestion you made of adding the word "chemical." I believe that phrase appears at three places in the bill. I will, however, see it is mentioned to Senator Nelson. I am sure he would have no objection. I feel that it was his intention, of course, to include that word.

Mr. SMITH. I believe he indicated in some of his earlier remarks, sir.

Senator ALLEN. Yes.

Gentlemen, I do not believe I will ask any further questions. I appreciate your coming before the committee and giving us the benefits of your views.

Mr. BELL. Thank you very much.

Senator ALLEN. We will see that your statement is presented to the members of the subcommittee and of the full committee.

Mr. BELL. Thank you, sir.

Senator ALLEN. Mr. B. F. Smith, please.

STATEMENT OF B. F. SMITH, EXECUTIVE VICE PRESIDENT, DELTA COUNCIL, STONEVILLE, MISS.

Mr. SMITH. Mr. Chairman and gentlemen, my name is B. F. Smith and I am executive vice president of Delta Council, an organization that represents the 18 delta and part-delta counties of Mississippi. This area is recognized as one of the foremost agricultural sections of our Nation and income from agriculture is of major importance to all of the people who live or do business in this area. Cotton is our principal crop; however, we also produce soybeans, rice, oats, wheat, feed grains, and beef cattle. Effective and economical pesticide measures are, therefore, of vital concern.

We wish to express appreciation for the opportunity to present this statement in support of S. 1794 and to commend the Senators who are cosponsoring this important measure.

Insects as competitors of man for food and fiber are well known. Also, the role insects play in transmitting several deadly diseases of man, animals, and plants has been well documented. However, great advances have been made in insect control and these advances have contributed to improvements in agriculture with increased yields and better quality products. These advances have helped to make it possible for less than 5 percent of our population to produce the food, fiber, and agricultural raw material needs for the entire Nation with enough left over to supply export markets and assistance for underdeveloped nations.

Present day control methods have evolved as farming methods and livestock management procedures have changed. The practice of growing large acreages of one crop has contributed to problems in insect population management but effective control measures have usually been provided. However, due to pesticide resistance in insects and other problems, such as the possiblilty of environmental pollution and biological balance upsets of beneficial insects, continued effective and economical control with chemicals alone appears to be unlikely.

Farmers obtained phenomenal results with the synthetic organic insecticides in the middle and late 1940's and developed a dependence on these chemicals. Although insecticides, no doubt, will continue to play an important role in agriculture for many years to come, there are difficult problems associated with their use. Repeated and extensive use of insecticides has resulted in many insects building up resistance.

Also, unwanted residues may occur in animals and crops, and certain residues may adversely affect beneficial insects, including pollinators, parasites and predators, wildlife and fish. Thus, the effect of the use of chemicals on the quality of the environment has become of concern, not only in the United States but in other countries of the world. While I do not wish to minimize the environmental problem, I do wish to point out that effective and economical alternative control methods must be developed and tested before conventional methods are phased out.

There has been a gradual shift from the persistent chlorinated hydrocarbons, such as DDT, to the less persistent organophosphorous compounds. Restrictions on the use of DDT and several other chlorinated hydrocarbons are now of considerable concern to the grower and also raise serious questions pertaining to public health. DDT cannot be used on tobacco, forest insects, shade trees, and pest mosquitoes or for control of many insect pests of vegetables and fruits. Alternative insecticides of a less persistent nature can be used in many cases but there is a question as to whether they will give the desired degree of control and at economical costs. Certain of the less persistent insecticides such as parathion are highly toxic to mammals and must be used with special precautions.

Dr. C. H. Hoffmann of the Division of Entomology, USDA, in an article in the Journal of Dairy Sciences, volume 54, No. 5, May 1971, "Alternatives to the Use of Organochlorine Compounds for Insect Control", has pointed out that a reorientation of the Department's research program on the control of insects of agriculture began in 1955. There has been a shift from the search for conventional insecticides to the study of more selective chemicals and nonchemical methods of controlling major insects, particularly those pests requiring heavy annual application of insecticides.

Dr. Hoffmann points out that whereas about two-thirds of the Division's resources were expended on the search for conventional insecticides in 1955, presently, as a result of reorientation of research, 16 percent of the Division's effort is devoted to chemical insecticides, 51 percent to biological and selective chemical control methods, and 33 percent to biological and selective chemical control methods, and 33 percent to basic and fundamental research. It should be pointed out that the trend in entomological research at State institutions also emphasizes basic research, nonchemical control methods, and development of integrated control and management systems.

Rather than try to continue control with chemicals alone, present-day efforts are being directed at integrated control, that is, controls involving all available practical and effective methods being brought to bear on the population of a destructive pest. This may require the use of limited amounts of insecticides at certain points in the control program.

Several examples of successful biological-cultural control methods can be cited to illustrate the possibilities. Probably the most outstanding example is the eradication of the screw worm in the southeastern United States. The technique often referred to as the "sterile male release technique" not only involves releasing sterile flies but the releases must be timed to take advantage of a low-level population that usually results during winter. Also, every effort must be made to prevent and treat cases of screw worm to reduce development of adult population.

The operation against the screw worm has been moved to the Southwest United States and Mexico where great progress is being made toward reducing and eliminating the population through the sterile insect release program. More than 100 million flies per week are being produced at Mission, Tex., for this operation.

Other examples employing the sterile insect release technique to a certain extent have been successful. The Mexican fruit fly has been prevented from becoming established in southern California by sustained releases of sterile flies used in lieu of spray programs to spray all backyard fruit trees and orchards with insecticides. Experimentally, melon flies and the oriental fruit fly have been eradicated from certain islands in the Pacific. A program to prevent the establishment of the pink bollworm in the San Joaquin Valley in California by releases of sterile pink bollworm has been underway since about 1968. Millions of sterile males have been released. To date, the pink bollworm has not become established in the valley.

In addition to the above cases, the potential for using the sterile release techniques for suppression of a number of destructive pests such as the boll weevil, cabbage looper, tobacco hornworm, corn earworm, the mosquito, the hornfly and others, shows great promise and should be field tested. At this time, a large scale pilot testing program for suppression of the boll weevil is underway in southern Mississippi. This is an integrated program employing every known method of population suppression including a fall reproductive-dispause program, use of sex pheromone, sterile male releases, resistant varieties, and other controls.

Other approaches to insect control that have received attention and show great promise for success in an integrated program against several of the insects cited above and others include supplemental release of parasites and predators, plant resistance, production and use of insect diseases, use of attractants, hormones, cultural practices, and other approaches.

All these promising methods for suppressing or managing insect populations have been developed at the laboratory level through small plot or field size experiments. Additional pilot testing on a large scale will be necessary before it is known whether we can rely upon them for control.

If effective control can be obtained at reasonable cost by a combination of methods without or with only a limited use of insecticides, then other benefits are likely to occur. These benefits are; (1) reduced amounts of insecticides to pollute the environment, (2) reduced likelihood of insects developing resistance to chemicals (3) establishment of a better biological balance between insects on different crops so that those of minor importance do not become serious pests, and (4) hopefully, more economical control methods.

Even though the prospects for developing effective control with a minimum use of chemicals appear promising, additional high-caliber research involving highly trained personnel and development of facilities and equipment must be done before widespread suppression or eradication programs can become a reality.

This involves additional detailed knowledge of the life history, host plant relationship, flight habits, population dynamics, relationships with natural enemies, numbers of insects per acre, nutritional requirements, mass rearing techniques, vigor and competitiveness of reared insects, packaging, transporting and releasing sterilized insects or reared parasites and predators.

Experience has shown, for example, that rearing a few insects in the laboratory may be relatively easy, but when the rearing is expanded to produce millions or billions of insects, whether for the sterile male release technique or for production of parasites, predators, or diseases, many serious problems develop that were not even anticipated. It has been shown that consistent production of healthy, vigorous, competitive insects requires development of clean room techniques as well as adequate diets and correct conditions for mating and oviposition. After facilities have been provided and techniques developed for mass production of an insect or parasite, the evaluation of the method against the insect in the field must be done. Then, the final step is to translate the results obtained in the field to a large-scale area control program.

It should be stressed that while many promising methods of control are indicated, extensive time-consuming research involving development of rearing and other techniques and adequate facilities for production of insections must be developed and the results field-tested on a large scale before it can be determined that the methods will be effective, economical, or practical for the producer to use.

There is little doubt but that many of these methods will prove to be as practical as the male sterile release techniques for the screwworm. It is also evident that these integrated methods must be developed, and rapidly, if safe, economical, and effective practices for control are to replace chemicals and minimize or reduce residue problems, environmental pollution, and resistance to chemicals. All this is time consuming and expensive, but experience has shown that it is worth the investment.

Mr. Chairman, we wish to strongly endorse S. 1794 which authorizes pilot field-research programs for the control of agricultural and forest pests for integrated biological and cultural methods. The authorized support level, however, is inadequate and we recommend that it be increased to at least $10 million.

Mr. Chairman, it has been brought out here, this pilot program in Mississippi is costing $2 million a year. That does not include the $550,000 appropriated by the State of Mississippi to build this rearing facility.

Here is an article on this. It shows the area, including part of Alabama. I thought you would be interested in that.

We wish to respectfully point out that the USDA has been "knocking at this door" for many years but has been handicapped by a lack of funds to initiate and carry on the necessary work. It will not be enough to simply authorize funds and direct the Secretary to carry out such programs. The office of Budget Management must somehow be convinced of the importance of this work so that needed funds will be included in USDA budget recommendations. And then, as has been already brought out, next, funds must be appropriated by the Senate and House of Representatives.

Also, pilot field-research programs of this kind, while highly necessary, must not dilute or supplant the basic research effort that is so fundamentally important. The basic research program must be stepped up and intensified if we are to solve the problems.

We want to again express appreciation for the opportunity to appear here and to strongly support this bill. Although they do have authorizations in this line, we think the refocusing of attention will be very helpful and we want to help in every way possible.

Thank you.

Senator Allen. Thank you, Mr. Smith. We appreciate your coming before the committee and giving us the benefit of your views on this legislation.

Without objection, the article on pages 20 and 21 of "The Furrow," September and October 1971, will be inserted in the record and made a part of the record.

(The article is as follows:)

[From the Furrow, September and October, 1971]

TARGET: BOLL WEEVIL

(By Len Lindstrom, Regional Editor)

In a 150-mile patch of the deep mid-South, the boll weevil is on the spot. All available weapons are trained on this billion-dollar beetle; the goal is not control, but eradication.

If workers can wipe out the weevil in this first large-area test, beltwide eradication will be proposed.

The current test runs from July 1, 1971, to July 1, 1973. By the end of that 2-year period, researchers should have a clear picture of whether eradication is feasible, and about what it would cost to shove the weevil out of U.S. cotton. Right now they believe the total cost might be about $275 million, equal to what the infamous insect costs farmers in yield loss and control cost in one average year.

Key insect. Nobody is holding his breath waiting for city congressmen to approve that amount for agricultural expense. Even the test run was almost put off this year because of a budget squeeze. But it could be aruged that everyone benefits from reduced use of insecticides. At least one-third of all insecticide use is on cotton insects, according to USDA. In Mississippi, the figure is about 85 percent, according to Dr. David Young, extension entomologist. And the boll weevil is a key in use of cotton insecticides. Midseason spraying of the boll weevil upsets biological control of the bollworm and tobacco budworm, and puts the cotton producer on a treadmill of increased spraying for these pests.

It's true that diapause treatment of weevils in the fall with organic phosphates reduces overwintering populations as much as 99 percent, and greatly reduces the spray needed the following season. But who knows when the boll weevil will develop strong resistance to phosphates, as the budworm has in some areas? This element makes the trial a race against time, and the stakes are high.

Location. The trial area includes an eradication core zone centered on Columbia, Miss., containing about 3,600 acres of cotton.

Three buffer zones of progressively less intense treatment extend beyond that, spilling over slightly into Alabama and Louisiana.

The zones are irregular in shape, to allow workable enforcement of quarantine regulations, but in general they put at least 50 miles distance between the core zone and the nearest untreated cotton, to prevent weevils from migrating in. The boll weevil usually flies only 10 miles or so during its migration period, but has been known to ride a stiff tailwind for 40 miles or more.

The test area is a boll weevil's paradise, with many small fields of cotton scattered in timber; in the past, many of these fields were harvested late or not at all, and few efforts were made to control weevils. Last winter killed only 35 percent of the weevils, leaving 1,500 to 2,000 per acre, enough to take the entire cotton crop.

No delay. It seemed last February that the big test was doomed, because the necessary $3 million was just not available. But by March it became apparent that cotton acreage in the test area was down sharply because of transfer of allotments. Young, who felt that the situation couldn't stand delay, mobilized county agents for a survey. They found that cotton acreage had declined from about 55,000 down to 25,000 in the whole area, and from 10,000 down to less than 4,000 in the core zone. In April, the project got the green light again; the lower cost of treating fewer acres had brought expense within the budget limitations.

Treatment will involve at least six operations, put together in one large-area package for the first time. These include in-season spray as needed; a series of reproduction-diapause sprays in the fall to prevent overwintering; defoliation; stalk shredding; pheromone traps to attract and capture weevils emerging in the spring; release of sterile males to prevent reproduction by surviving females.

In addition, continued experiments with Frego-bract weevil-resistant cotton and Temik systemic insecticide will be part of the research associated with the program.

The workhorse weapon will be diapause control, a series of up to seven fall sprays applied mainly by five helicopters in the core zone and the first buffer zone. Properly timed, this can kill up to 99 percent of weevils entering hibernation. Chemicals used will be ultra-low-volume Guthion or malathion, depending on the hazard involved in various areas.

The Fish and Wildlife Department of Mississippi State University will monitor effects on bees and wildlife.

Next spring, adhesive-coated traps baited with grandlure will be placed on fencelines. According to results of previous tests, traps should catch about 80 percent of emerging weevils.

A single application of insecticide before squares are one-third grown should kill about half of the surviving weevils, without permanently suppressing beneficial insect populations.

Sterile males. If survivors then number less than 10 weevils per acre, sterile-male release has a chance for success. In fact, it may be the only way to mop up stragglers. Sterility, the long-sought key to eradication, is achieved by feeding adult males for six days with busulfan, the new and currently most practical chemosterilant for boll weevils.

The neutered males will then be released at 50 to 200 per acre for several generations, and theoretically should reduce the native population by 98 percent with each generation.

The big test is a cooperative effort of USDA, Cotton Incorporated, and the states involved. The Plant Protection Division of USDA is in charge of operations. By next July they expect to know the odds on weevil eradication.

Senator ALLEN. Are you familiar with this program there?

Mr. SMITH. Yes, sir. We have worked with it since the very beginning. In fact, we were largely responsible for getting the State appropriation for the rearing center.

Let me say this, it was the easiest appropriation we ever got from the Mississippi Legislature. There was no dissenting vote at all.

Senator ALLEN. Certainly, it was a step in the right direction.

Mr. SMITH. Very much so.

Senator ALLEN. We certainly hope it will solve the boll weevil problem.

Mr. SMITH. And if it does, it will help on the boll worm problem, too.

Senator ALLEN. You feel a larger authorization should be made than the $4 million?

Mr. SMITH. Yes, sir; I do. I think the $4 million, while that is a forward step, is inadequate to do the type of job that needs to be done even in the beginning stages. We have a very vocal and, I think, in some ways, irresponsible segment of our population that is demanding an immediate halt to the use of all of these chemical controls.

Now, we think this would be a great mistake, but we can see the possibility of phaseout of some of these materials before we have alternatives. And if this happens, the public, the consumer, will suffer greatly. It is not going to be just the farmer, it is going to be the consumer, because the farm segment cannot produce the food and fiber unless we have some effective control for insects.

Senator ALLEN. Well, now, there are great dividends to the farmers and to the Nation, if it could be found that the intergated method of control of pests can be made to work.

Mr. SMITH. I will say, in fact, one of the things we have greatest hope for is that through these measures we can actually reduce the cost of insect control.

Senator ALLEN. Yes.

Mr. SMITH. We have already used in our area the diapause method, which is a part of this program. This has cut down on the necessity for a lot of poision applications the next year. This type of effort can be economically significant, greatly so.

Senator ALLEN. Well, farmers certainly are willing to give up the use of insecticides and pesticides if acceptable and effective methods can be discovered or developed to combat the pests and insects.

Mr. SMITH. Certainly. They would welcome the opportunity because of the fact, not only are these materials expensive, but they represent a significant factor in the cost of production. Even when we are using all of the knowledge that we have and the chemicals that we have, we are still getting losses from these insects.

Senator ALLEN. Thank you very much, Mr. Smith. I appreciate your testimony. I appreciate your going to the trouble of coming and meeting with us.

Dr. Boger, please.

STATEMENT OF DR. LAWRENCE L. BOGER, DEAN, COLLEGE OF AGRICULTURE AND NATURAL RESOURCES; AND DR. GORDON E. GUYER, CHAIRMAN, DEPARTMENT OF ENTOMOLOGY AND DIRECTOR, PESTICIDE RESEARCH CENTER, MICHIGAN STATE UNIVERSITY, EAST LANSING, MICH.

Dr. BOGER. I will make an introductory comment and Dr. Guyer will talk.

Mr. Chairman, my name is L. L. Boger. I am dean of the College of Agriculture and Natural Resources at Michigan State University.

My colleague, Dr. Gordon Guyer, and myself are pleased to present testimony in support of research on biological and cultural control of pests that infest our forests, crops, and livestock, affects the quality of our recreational enterprises and create problems for our people.

This approach has great significance for the environment of our State, and our State is not atypical of many other States.

For example, new pests such as the cereal leaf beetle threaten large segments of our agricultural community, and insect vectored diseases such as encephalitis are rapidly becoming important considerations for the future of our Midwest recreational development. At the same time, we see increased pressure for the realinement of control techniques.

Few people realize that such alterations in control philosophy such as integrated control must be established on a firm research foundation.

The funding for the research that will be necessary to provide this foundation must come from new sources. For 25 years, the chemical industry provided the incentive and support for most of the research involved with pesticides. But it will now be necessary to establish new and extensive sources of research support.

The philosophy and support that has been incorporated in S.1794 represents an important step to an integrated control system. We are very anxious to support this legislation.

I should like now to turn to my distinguished colleague, Dr. Gordon E. Guyer, chairman of our university's department of entomology, director of our pesticide research center, to continue the testimony. He is a technical expert with an international reputation in his field. He is an able administrator who leads a pioneering program in pest control and is a distinguished faculty member.

With your permission, Dr. Guyer.

Senator ALLEN. Dr. Guyer.

Dr. GUYER. Increased demands for food and fiber have emphasized the importance of crop and animal protection from an expanding array of pest problems including insects, diseases, weeds and rodents. The use of synthetic organic pesticides has provided enormous beneficial accruements and at the same time has resulted in certain undesirable side effects which have often not been fully assessed. Whereas, chemicals have allowed for the greatest agricultural production in history and made major contributions to world health programs, they have also contaminated our environment.

It is generally agreed that the use of pesticides should be reduced and only used when and where necessary. However, few effective alternatives have been developed which compare with insecticides as being quick acting, consistently effective, economically feasible, technologically adaptable to grower implementations and applicable to a broad range of crops under diverse environmental conditions.

One alternative approach to the unilateral use of pesticides is integrated pest control, which envisions the maximum use of nonchemical—biological, cultural, genetic, et cetera—control methods and the minimization of chemical control tactics. This philosophy is advanced by entomologists as the most practical and realistic alternative for reorienting plant and animal protection practices away from the excessive use of chemicals.

At present, Michigan State University is conducting research to develop integrated control programs for three major classes of crops. These include cereals, tree fruits, and alfalfa.

Alfalfa Weevil and Cereal Leaf Beetle

The alfalfa weevil was first found in Michigan in 1966. By 1968 economic damage was found and an integrated control research program was initiated with the introduction of alfalfa weevil parasites from Pennsylvania and New Jersey where they had been established in the early sixties. In 1971, alfalfa acreage in Michigan totaled 1,250,000 acres, of which approximately 500,000 acres were sprayed at an average monetary cost of about $8 per acre, or $4 million.

Based on data obtained since 1968 in Michigan and research carried out in other parts of the United States, we believe we will be able to implement an integrated program of biological (parasites) and cultural control (timing of cutting)—in Michigan that will result in noneconomic populations of the alfalfa weevil and very limited spraying in most years.

We believe we have arrived at a satisfactory integrated program for alfalfa weevil management in Michigan in less than 5 years, but it must be pointed out that we have benefited from more than 50 years of research that has been carried out on the alfalfa weevil and its management in other parts of the country. If we had to go to Europe to find, collect, ship, and establish alfalfa weevil parasites into the United States, it would be many years before we could reach this stage.

We also believe we can improve on our present integrated program by continuing our research—especially on the parasites—so as to be be better able to manage all the components in a complementary way. This will save the farmer a very significant spray bill, and also prevent the treatment of large acreages with insecticides, avoiding the potentially undesirable side effects of such treatment.

The cereal leaf bettle was first identified in the United States in 1962 from specimens collected in southwestern Michigan. It attacks all cereals but is most damaging to spring-seeded grains. Its current distribution extends from western Illinois to the east coast and from northern Michigan to Kentucky. As yet it has not invaded the large grain-producing areas of the Great Plains and Western United States and Canada. It is predicted that if the insect spreads into these areas it will result in very serious crop damage with significant economic losses.

Intensive research on many aspects of the cereal leaf beetle was begun in 1963, including basic biology, population dynamics, insecticide trials, host plant resistance, cultural manipulations, and biological control. In contrast to the alfalfa weevil, we were starting from a knowledge base of practically zero since the cereal leaf beetle was a recent introduction and very little was known about this insect in Europe where it is generally not a serious pest problem.

To date the most promising results have been in the integrated control area utilizing host plant resistance and biological control. Excellent resistance has been found in winter wheat and this resistance should be valuable in the wheat areas of the southern Great Plains when it is incorporated into acceptable commercial varieties. No significant resistance has been found in oats—a spring grain—and this is the cereal crop that is most severely damaged in the Midwest. In 1971, in Michigan approximately 370,000 acres of oats were sprayed one or more times to prevent complete destruction from this pest.

The biological control program has resulted in the establishment of one egg and two larval parasites to date and appear to have the potential of becoming very effective if the biological requirements of the parasites can be integrated with acceptable farming practices. At the Michigan State University Kellogg Biological Station one of the larval parasites has increased at a rate of better than 35-fold per year under the optimum cultural practices we have employed experimentally.

This year we began a program in cooperation with county extension agents to get this larval parasite subcolonized throughout the lower peninsula. We are confident that we have the biological tools to manipulate this very destructive insect at a noneconomic level. To realize the total impact of this integrated control technology, it will be necessary to evaluate the interactions of the many factors that regulate the populations of this insect over large geographical areas. We are confident of the future success of this approach if it can be supported at a reasonable level.

INTEGRATED CONTROL ON FRUIT IN MICHIGAN

The value of fruit produced in the United States approaches $1 billion annually and in 1966 over 15 million pounds of insecticides and acaricides alone were used on these crops at a cost of over $100 million. Michigan is consistently among the top three States in the Nation's fruit production exceeding a value of $75 million annually. Because of a large complex of plant-feeding insects, mites and plant pathogens, very large amounts of pesticides are applied to protect this crop.

Statistics indicate that around 48 percent of the total growing cost for apples in Michigan is spent for pest control.

In 1966, the national average use of insecticides per acre on fruits and nuts was 7 pounds. For Michigan in 1971, we estimate an average of around 20 pounds per acre on 58,000 acres of apples alone, for a total use of over 1 million pounds sprayed annually. Current spray practices require an average of 10 fungicidal, 6 to 8 insecticidal and 2 to 3 acaricidal applications of materials to ensure a marketable crop of apples. The environmental implications of these practices are obvious.

In 1970, the Michigan State legislature appropriated limited funds to specifically create a research position to develop integrated control programs for tree fruits. Moneys for research were provided on the basis of annual appropriations and were largely controlled by grower interests in the State. Pressures from this group justifiably dictated that the initial programs in integrated control would be directed to immediate grower problems to provide short-term solutions.

If we are to have an enduring system to control our fruit pests, more substantial and extended support must be provided. Passage of S. 1794 and the appropriate allocation of support would provide for an enlargement and much-needed stimulus to the development of a successful pest management program for our fruit pests.

Preliminary research programs conducted during 1970–71 have provided several statistics which indicate the potential pesticide and cost reductions that might be accomplished through implementation of integrated programs on fruit.

Preliminary trials in six apple orchards indicate that insecticides can be reduced by as much as 50 percent. Grower reactions to these successes were enthusiastic. During the past year and presently we are organizing an extension, farm advisor, commercial interest and grower corps of cooperators to implement these programs as they are developed.

The Importance of S. 1794 to Michigan Programs

We propose to continue and expand our research toward developing integrated programs for the north central regions fruit pests. Before these methods can be implemented on a large scale, additional information is needed to make integrated programs consistently effective, and workable by growers. This will necessitate much additional research, the establishment of insect monitoring services and a large educational program to educate growers to the program.

In each of the above examples, the implementation of integrated methods accomplished the following results:

1. They reduced the amount of chemical previously applied.
2. They reduced the cost for controlling the pest as well as increasing crop production.
3. They establish a more balanced system of control based on a broad ecological overview which considered the total environment rather than the myopic view of simply controlling a single target pest.

The future development and implementation of integrated programs in Michigan will develop at a rate commensurate with available support. Large inputs from State or regional sources are unlikely. The general philosophy and support that is proposed in S. 1794 is absolutely essential to the future of integrated control programs in the United States. We commend you in your foresight in developing this proposed legislation and strongly support its passage.

Senator Allen. Thank you, Dr. Boger and Dr. Guyer. I appreciate your coming before this subcommittee and giving us the benefits of your views.

You certainly have an active research center in the College of Agriculture and Natural Resources there at Michigan State. I certainly commend the fine work you are doing and the truly amazing results you have accomplished. I think this is very interesting, and it shows what can be done in this field.

I am sure you work very closely with the Entomology Research Division of the Agricultural Research Service of the Department of Agriculture, do you not?

Dr. GUYER. Yes. I was surprised Dr. Knipling did not refer to our cooperation on the cereal leaf beetle. I believe this is a picture book story of what can be done. The only think that has hampered this program is sufficient support. It is ready to go to the grower. This is a cooperative program. The parasites were brought into this country and the research involving their successful introduction was a cooperative adventure.

I think the important issue here is the comment the dean made, in that the kind of research for control of agricultural pests has been in a large degree supported by the chemical industry. We must find ways to support a new type of research and philosophy. We do have the cooperation, but the kind of support that is going to be necessary to move these programs quickly and successfully is not available.

Dr. BOGER. The value of these programs has been demonstrated and the institutional organization is available to move these out to the farmers. And the story that Dr. Guyer told on the cereal leaf beetle—a program we had this summer has established colonies all over the State.

Dr. GUYER. I think, Senator, if I might just speak to this, it might be interesting to you.

We had a crash program where we invited every county in southern Michigan. We got complete cooperation, and the growers in each of the counties prepared certain biological control areas where they agreed to preserve parasites in certain ways. This in a matter of 2 weeks' time. So the question that you asked earlier was an excellent one, which indicates people are ready to accept this kind of program.

Senator ALLEN. Now, the parasite, the predators brought in, that was not without some danger, was it? Isn't there some danger accompanied with that? Have you had experiences where they bring them and not do the job, and then they in turn would be pests that needed to be eradicated?

Dr. GUYER. I think you should ask Dr. van den Bosch, later today, this question. It is not in my area. But to my knowledge there have been very few problems. But certainly the potential is there.

Dr. BOGER. When the host goes, the predator goes. That is an important point.

Senator ALLEN. That has not always been the case, has it? Haven't there been some remarkable failures, widespread failures?

Dr. BOGER. That is likely true. It is my point the genius of a program like this is to get specific parasites, host specific parasites, and in the cereal leaf beetle this is true.

Senator ALLEN. Yes. It is the nature of these pests, then, that they attack one particular plant; is that right? In other words, an insect that would attack, say, alfalfa, would not attack a fruit tree, say? Is that correct? Or will it move from one to another?

Dr. GUYER. You are thinking now of a predator parasite situation?

Senator ALLEN. No.

Dr. GUYER. The host itself?

Senator ALLEN. The original insect or pest.

Dr. GUYER. It depends on the pest. The potato beetle has developed an appetite for a number of different hosts. And in the cereal leaf beetle, we are restricted to cereals and a small group of cereals. There are two answers to the question. Some are specific and some have wide hosts.

Senator ALLEN. Now, you gentlemen feel there are some excellent possibilities in the program that is envisioned by this proposed legislation?

Dr. BOGER. We definitely do, Senator. I would like to underscore Mr. Smith's statement that we think this is just the beginning. The direction is right. Research is necessary. There should be a research base behind all of these efforts, and then, through a process of screening and selection, move them into the pilot and finally application stages.

But my point in the introduction was that few people realize the necessity of having a good research base behind these efforts. So without getting into ARS versus NSF, and this sort of business, let us just say the objectives are sound from this standpoint as we view them.

Senator ALLEN. Now, the use of this legislation by the Department would enable it to break out into a new field, would it not, carry its work one step farther?

Dr. GUYER. I feel this is the case. I feel there is a select number of outstanding possibilities today, and the only thing that is holding these up is the appropriate support. I would hope the existing channel of the experiment station and the educational arm of the Extension Service would not be superimposed or superseded. I think this is what is needed to get these programs underway.

Senator ALLEN. Isn't great progress being made in research, both by the Department, by your university, by other agricultural schools throughout the country; great progress is being made in finding methods of eliminating pests, various methods?

Dr. GUYER. Definitely.

Dr. BOGER. We think tremendous progress.

Senator ALLEN. The sterilization, the predator, the resistant host, any number of methods. And this would allow the use of alternate methods and varying the use of these alternate methods, out in a natural crop. That would be the best test.

That is something that you cannot handle at the laboratory stage, is it not? I mean, to prove its worth, it has got to be proved out in the field, does it not?

Dr. BOGER. True. And these two other points, all of this in a manner that enhances the quality of our environment, hopefully, and then the other one reduces the cost of production to producers.

Senator ALLEN. Yes.

Dr. BOGER. This is something, as was pointed out earlier, that is a mighty important component of the whole effort.

Senator ALLEN. Yes. Much good could come from this legislation, in your judgment?

Dr. BOGER. True.

Dr. GUYER. Particularly on the economics; it is impossible to get a clear picture of the economics of the program from the test tube or laboratory. Pilot projects are the only way you are going to find what the direct responses are in relation to the economics of the producers.

Senator ALLEN. Thank you very much.

Dr. van den Bosch, please.

STATEMENT OF DR. ROBERT VAN DEN BOSCH, CHAIRMAN, DIVISION OF BIOLOGICAL CONTROL, DEPARTMENT OF ENTOMOLOGY AND NEMATOLOGY, UNIVERSITY OF CALIFORNIA, BERKELEY, CALIF.

Dr. VAN DEN BOSCH. Mr. Chairman, it certainly is a privilege to appear again before this committee and speak particularly on this piece of legislation, which I at the start will say I heartily endorse.

I will dispense with my pedigree here. It is in the prepared text.

Senator ALLEN. We will admit your qualifications, as they say in court.

Dr. VAN DEN BOSCH. There are a lot of hungry colleagues waiting to devour me if I do not shut up in short order.

I would like to emphasize, though, that I am appearing as a private citizen on my own leave time, not as an official representative of the University of California. I do that in order to save deans and directors gray hairs and ulcers and things like that.

Several people this morning have alluded to the problems associated with the traditional pattern of pesticide utilization, and they have described why this usage has resulted in these problems.

The symptoms are clear; today they are more insect, species of pest status than ever before, many of the most serious pests have become resistant to insecticides. I think it's about 250 species now worldwide. Pest control costs have soared. In some of our industries in California, for example, cotton, there has been unfortunately a doubling in costs over the past decade. I know that similar increases have occurred in Texas. One can look at the national statistics on the use of insecticides and see the volume going up year after year.

For example, there was a 150-percent increase in insecticide usage during the decade 1957 to 1967. Associated with this, there has been an increasing amount of environmental pollution from the insecticides.

Now, we all deplore insecticide pollution, but what of the other costs of the treadmill? I will give some examples.

You heard about the situation in northeastern Mexico, where a previously innocuous pest, the tobacco budworm, unleashed from its natural enemies by insecticides and resistant to the materials destroyed, in one case, a $50 million cotton industry in just 10 years. The Mexicans then moved their cotton production about 200 miles south and the budworm destroyed the industry there in about 4 years. This was an industry worth about $33 million.

Now the budworm is causing severe damage in the lower Rio Grande Valley of Texas and threatens the cotton industry there. I think Dr. Adkisson will allude to that later.

In California, the encephalitis vector mosquito, *Culex tarsalis*, has become resistant to virtually all insecticides. As a result, the human population is threatened with an aggravated mosquito nuisance problem, and there is the possibility of an encephalitis epidemic.

Nationwide, insecticides have extensively disrupted the biological control of spider mites, turning this formerly minor group of pests into the most serious one affecting agriculture. For example, in California, the citrus red mite, once a relatively minor pest, now costs the citrus industry more than $10 million a year, or about half of all its losses to arthropods.

Finally, honey bees, particularly in the Southwest, crucial pollenators of multimillion-dollar crops, have suffered devasting blows from insecticides. In California alone, tens of thousands of colonies have been destroyed, which not only affects pollenization, but the apiary business itself.

I would like to further allude to the mosquito problem in California. It is very disturbing and relates in a number of ways to matters under consideration today. In other words, it has a message which is particularly relevant.

This insecticide resistance in the California mosquitoes is a chilling development. For this we have no one to blame but ourselves. Our culpability lies in our blind and obstinate adherence to a bankrupt mosquito abatement policy; namely, our over-reliance on a single tactic, chemical control. It was inevitable under this program that the mosquitoes would defeat the chemicals—and so they did. This in itself is bad, but what makes matters even worse is that the commitment of the bulk of our resources, that is research funds and energies, to chemical control has left us without alternatives to throw into the breach now that the chemicals have failed.

Agricultural insecticides have been a part of the scene, too, because our profligate use of these materials has affected the resistance in the mosquito. There is a double tragedy here because the development of resistance was largely unnecessary. With a balanced allocation of finances and research efforts, integrated control programs could have been developed and put into practice. Ironically, these programs would have assured the full and sustained efficacy of those insecticides that are failures today.

In other words, if we had had an integrated control program, those same materials that now no longer control the mosquitoes would probably still be useful. Instead, our use of the materials played to the advantage of the mosquitoes.

Their mastery of the materials was rapid. DDT, first used against mosquitoes in California in 1947, had already begun to fail by 1949. In other words, in 2 years failure began to appear and the material was essentially useless in all areas in the State by 1951. Just in 4 years.

Senator Allen. They worked up resistance to it?

Dr. van den Bosch. That is right. Genetic resistance. Since that time, mosquitoes have quickly mastered substitute organochlorines and virtually all of the organophosphorous and carbamates employed against them.

The modern insecticides were insidious because they lured us into believing that they would provide effective mosquito control indefinitely. In the near future we may pay a terrible price for this mistake, for we stand naked before the potential ravages of an encephalitis epidemic, and there is virtually nothing that we can do to control the mosquito that transmits the viruses.

There are two important viruses in California now.

We could have had the control technology in hand, but we lost the opportunity to develop it when we abandoned multifactoril research in favor of chemical control a quarter of a century ago.

I am not an epidemiologist and I do not predict an encephalitis epidemic. There are many factors involved besides the vector mosquito. But the viruses occur in California and there is literally nothing we can do about the animal which transmits them. If all of the pieces fall together, there will be an epidemic, because we have lost our ability to suppress the one variable over which we might have had control. That is the mosquito itself.

I want to stress the point that I am not predicting an epidemic. This would be irresponsible. But everything is there to set one up in case pieces fall together.

I will try to hustle through this as quickly as possible. I have dealt quite harshly with chemical control and its shortcomings. Today, many persons seem to find chemical control a favorite whipping boy. I have done this in order to hammer home the point that even the most promising of control tactics will ultimately fail if applied unilaterally against our incredibly diverse and adaptable rivals, the insects.

There simply is no measure, method, or material which in itself will prove to be a panacea. And any proponent of a unilateral measure, be it autosterilization, natural enemy manipulation, selection of resistant plant or animal strains, use of third-generation insecticides, pheromones, cultural manipulations, microbial controls, et cetera, is simply deluding himself and the public if he thinks he has found the all-encompassing answer to insect control.

We cannot continue to indulge a system of pest control research that dilutes our resources and energies in fragmented programs which seek unilateral solutions.

I am afraid in the past there has always been someone with a new miracle in hand who has come along and said, "I've got it, give me the wherewithal and I am going to handle the insect problem." It just has not happened. We cannot afford that kind of mistake again.

If we persist in this folly the insects will retain their advantage and in fact exact an increasing toll. We must instead recognize insects as versatile competitors for the common bounty and develop a more imaginative way to minimize their inroads on our resources.

We have talked a lot about integrated control this morning and I would like to give you my definition of it just to make clear what it is that I am discussing.

Integrated control is a system which attains pest population management by meshing all available information, and all suitable management techniques—chemical, biological, cultural, genetic, et cetera—with the natural regulating and limiting elements in the environment. It is the emphasis on the fullest practical utilization of the existing regulating and limiting factors in the ecosystem which gives integrated control its uniqueness. Perhaps the greatest attribute of integrated control is that in maximizing the role of naturally occurring mortality and regulating factors it automatically assures a high level of environmental quality, since such maximization can only be attained where there is minimum disruption of the environment. A second major advantage of integrated control is economy, which again derives from its heavy reliance or natural controls and minimal dependence on costly artificial measures.

There have been some questions raised this morning, or discussion about where we stand on the implementation of the integrated control programs. I am going to eliminate a lot of this because time is running short, but I do want to speak to this point.

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As a person who has been intimately associated with the development of major programs over the last 20 years in alfalfa, cotton, and walnuts in California, and indirectly with the program in grapes and some of our other crops, it is highly disturbing that it has been so difficult to get these programs across to the growers. And to me, one of the points of genius in this particular piece of legislation is that it will attempt to promulgate information and to demonstrate these systems to the men who need them most, and that is the growers. The inability to do this is one of the great flaws in integrated control today. Another disturbing point is that we still have a lot of situations where we are doing individual things, or unilateral things, and are not putting them together in demonstrations that are leading to effective application.

For the edification of those who want to know how one of the systems works, I have cited, in my prepared statement, the alfalfa program in California. It is a lot more complex than I have indicated, but you can see from what I have pointed out, how much money alone was saved. And I might point out that not only was money saved, but the use of the very dangerous material, parathion, which was widely and heavily applied against the aphid, was greatly reduced as a result of this program. So we had a resultant ecological benefit as well as an economical one.

We are developing other programs in California. The one in cotton is now in effect on about 50,000 acres, and among other things has reduced costs in by about 50 percent. We have an excellent program in grapes, which is a very sensitive crop, because of the farm labor situation, and again we have reduced the cost of control and the amount of pesticides used in that crop.

Other countries, and I list a number of them in my statement, are involved in the development or use of integrated control programs. The Food and Agricultural Organization of the United Nations has even established a section on integrated control and is actively promoting these kinds of programs worldwide.

In summary, I can state flatly that, the integrated control concept is gaining momentum and programs are already bringing tangible benefits. Unfortunately, a major problem is that they are not being adopted as quickly and widely as desirable. However, the provisions of Senate bill 1794 can give a powerful boost to this new way of insect control and, indeed, could be essential catalyst in its rapid fruition. And it is for this reason that I strongly support as an individual the intent of S. 1794.

Thank you.

(The prepared statement of Dr. van den Bosch is as follows:)

Dr. van den Bosch. My name is Robert van den Bosch. I am professor of entomology in the Department of Entomology and Parasitology, University of California, Berkeley, and chairman of that department's division of biological control.

My career as a professional entomologist extends back to 1949 when I was appointed to the Hawaii Agricultural Experiment Station. After spending 2 years in Honolulu, I joined the staff of the Citrus Experiment Station, University of California, Riverside, where I remained until 1963 when I moved to the Berkeley campus.

During the course of my professional career I have worked on a wide variety of insect pests including fruit flies, and pests of citrus, deciduous fruits, vegetables, cotton, alfalfa, walnuts, ornamental plants, and other crops. Over the past 22 years I have published more than 100 technical and semitechnical papers relating to my research findings.

I have been a member of research teams that have pioneered integrated control programs in the massive alfalta, cotton, and walnut industries of California. I have also traveled extensively in connection with my work on biological control and this has given me the opportunity to observe pest problems worldwide and consult with entomologists in many foreign countries.

Today I appear here as a private citizen on my own leave time to speak in favor of S. 1794.

Of all the animals which compete with man, only the insects have held their own. Indeed, today insects are doing better than ever, and it is now abundantly clear that our overwhelming reliance on chemical control has worked to their competitive advantage.

There is nothing wrong with the concept of chemical control. Insecticides used in ecologically tenable ways can and should be powerful tools in pest control systems. Unfortunately the materials have not been so used. Instead they have been literally dumped into the environment in programs essentially designed to batter insects into submission. And since most available insecticides are virtual zooicides, their indiscriminate use has had shattering effects on the treated ecosystems. The delicately balanced insect communities have been especially hard hit, and this has led to a disturbing pattern of target pest resurgence, secondary pest outbreak and pesticide resistance. As a result, we now have on our hands a pesticide treadmill of global proportions, characterized by economic and ecological chaos.

The symptons are clear; (1) today there are more insect species of pest status than ever before, (2) many of our most serious pests have become resistant to insecticides (e.g., over half the major pest insect species in U.S. cotton), (3) pest control costs have spiraled upwards, and (4) there has been increasing environmental pollution from insecticides.

We all deplore insecticide pollution, but what of the other costs of the treadmill? The following examples give some idea of the price we have paid.

A. In northeastern Mexico, a previously innocuous insect, the tobacco budworm, unleashed from its natural enemies by insecticides and resistant to the materials, destroyed a $50 million cotton industry in just 10 years and then wrecked the industry when it was moved to a new area. Now the budworm is causing severe damage in the lower Rio Grande Valley of Texas and threatens the cotton industry there.

B. In California, the larvae of two of the most important mosquito species (one of them the dreaded encephalitis vector, *Culex tarsalis*) have become resistant to virtually all insecticides. As a result the human population is now threatened with an aggravated mosquito nuisance probem and a possible encephalitis epidemic.

C. Nationwide, insecticides have extensively disrupted the biological control of spider mites, turning this formerly minor group of pests into the most serious one affecting agriculture. (For example, in California the citrus red mite, once a relatively minor pest, now costs the citrus industry more than $10 million a year, or about half of all its losses to arthropods.)

D. In several States, honey bees, crucial pollinators of multimillion-dollar crops, have suffered devasting losses to insecticides. In California alone, tens of thousands of colonies have been destroyed and the apiary business is threatened with economic ruin.

The problems just cited represent but a fraction of those plaguing imsecticides, but they provide sufficient evidence that today, a quarter century after the DDT miracle, chemical control is something less than a panacea and unmixed blessing.

I have dealt quite harshly and in considerable detail with chemical control and its shortcomings. This has been done deliberately in order to hammer home the point that even the most promising of control tactics will utlimately fail if applied unilaterally against our incredibly diverse and adaptable rivals, the insects. There simply is no measure, method or material which in itself will prove to be a panacea. And any proponent of a unilateral measure, be it autosterilization, natural enemy manipulation, selection of resistant plant or animal strains, use of third generation insecticides, pheromones, cultural manipulations, microbial controls, etc. is simply deluding himself and the public if he thinks he has found the all encompassing answer to insect control.

To put it bluntly, we cannot continue to indulge a system of pest control research that dilutes our resources and energies in fragmented programs which seek unilateral solutions. If we persist in this folly the insects will retain their advantage and in fact exact an increasing toll. We must instead recognize insects as versatile competitors for the common bounty and develop a more imaginative way to minimize their inroads on our resources. I am convinced that this can best be done through integrated control which attains pest population management by meshing all available information, and all suitable management techniques (chemical, biological, cultural, genetic, etc.) with the natural regulating and limiting elements in the environment. It is the emphasis on the fullest practical utilization of the existing regulating and limiting factors in the ecosystem which gives integrated control its uniqueness. Perhaps the greatest attribute of integrated control is that in maximizing the role of naturally occurring mortality and regulating factors it automatically assures a high level of environmental quality, since such maximization can only be attained where there is minimum disruption of the environment. A second major advantage is economy, which again derives from its heavy reliance or natural controls and minimal dependence on costly artificial measures.

What I have just described may be somewhat confusing to those hearing of integrated control for the first time, and so I would like to use an actual case to help illustrate the mechanics and benefits of this approach. The program I have in mind is the one developed for control of the spotted alfalfa aphid in California.

The spotted alfalfa aphid is an exotic species which invaded the U.S. southwest (New Mexico) in early 1950's, reaching California in 1954. It developed explosively in California and in 1955 caused losses estimated at nearly $13 million. This staggering blow to the alfalfa industry turned into a major crisis when the aphid developed widescale resistance to organo-phosphate insecticides and could no longer be controlled by chemicals.

This left no alternative but to develop an integrated control program if the California alfalfa industry were to survive. To meet this challenge, the various University of California researchers (entomologists, agronomists, plant breeders, extension specialists) abandoned their traditional isolationism and pooled their talents and resources in a synchronized effort to piece together an integrated control system. The immediate goal was to gain an understanding of the alfalfa ecosystem and the role of the alfalfa aphid in it. In this way it was hoped that the aphid's weaknesses could be determined and ecologically tenable methods developed to exploit these weaknesses. The research program involved a determination of the seasonal activity patterns of the aphid, evaluation of the impact of its native natural enemies, importation of exotic parasites, establishment of a valid economic threshold, selection of aphid resistant alfalfa varieties, development of cultural practices to hinder the aphid and favor its natural enemies, and perfection of a selective chemical control for the aphid.

The researchers worked with total dedication and cooperation. They met as a group at frequent intervals and in these meetings presented new data, exchanged information, and set research priorities. Progress was rapid: by the end of 1957 an effective integrated control program had been developed and during the winter of 1957–58 the mechanics of this program were communicated to the growers. The program was fully implemented in 1958, with spectacular effect. Losses to the aphid plummeted from about $10 million to less than $2 million, and remained more or less at that level for the next several years. Thereafter, losses dropped even lower as aphid resistant varieties came into widescale use. The alfalfa industry was saved and today the minor pest status of the spotted aphid in California is a lasting testimonial to the efficacy of integrated control.

The successful program against the spotted alfalfa aphid set the stage for an expansion of integrated control investigations in California. Today significant programs have been developed in cotton and grape as well as in alfalfa. Furthermore, substantial progress has been made on programs in citrus, apple, walnut, peach, and woody ornamentals.

Outside California effective programs have been developed for spider mites in apple in the Pacific Northwest and Pennsylvania, while encouraging progress is reported in the development of programs in cabbage in Missouri, tobacco in North Carolina, and cotton and grain sorghum in Texas.

Outside the United States, programs have been or are being developed in a variety of crops in Canada, Peru, Nicaragua, England, the Netherlands, Switzerland, Greece, Egypt, Israel, Indonesia, Taiwan, Korea, Japan, and Malaysia.

Significantly the Food and Agricultural Organization (FAO) of the United Nations has recognized the importance of the integrated control concept and has strongly encouraged this approach in a variety of ways in many parts of the world. For example, an integrated control program in Nicaragua initiated by an FAO expert on loan from an American university, helped that country attain its best yields and first profits from cotton in 5 years.

Clearly, the integrated control concept is gaining momentum and programs are already bringing tangible benefits. The provisions of S. 1794 can give a powerful boost to this new wave in insect control, and indeed could be the essential catalyst in its rapid fruition.

It is for this reason that I strongly support the intent of S. 1794.

Senator ALLEN. Thank you very much. Your testimony will be real helpful to the committee. I feel like you covered the ground real well and I do not have any additional questions to ask you.

We do appreciate your coming before the committee.

Thank you, sir.

The next witness is Dr. P. L. Adkisson.

STATEMENT OF DR. PERRY L. ADKISSON, HEAD, DEPARTMENT OF ENTOMOLOGY, TEXAS A. & M. UNIVERSITY, COLLEGE STATION, TEX.

Mr. ADKISSON. I wish to speak in favor of S. 1794.

My name is Perry L. Adkisson. I am head of the Department of Entomology, Texas A. & M. University, Chairman of the Governor of Texas Scientific Advisory Panel on Agricultural Chemicals, a consultant to the Hazardous Materials Advisory Committee of the Environmental Protection Agency, a member of U.S. Department of Agriculture Technical Advisory Committee on Eradication of the Boll Weevil and a member of the Panel of Experts on Integrated Control of the U.N./Food and Agricultural Organization. I have been active in entomological research for 15 years and have authored more than 100 scientific papers concerning insect control. I wish to speak in favor of S. 1794.

Man has fought an eternal battle with his insect enemies and the problems of today are just as serious as those faced by the first men to practice agriculture. In Biblical days, famine and pestilence were common to the lives of all men; however, modern societies, such as ours, have developed chemical pesticides that have greatly alleviated these problems. Today, the average U.S. citizen enjoys an abundance of wholesome food and freedom from insect-borne diseases far beyond anything experienced before in the history of man.

However, the human society has not yet conquered the problems of famine and pestilence and more people in the world are hungry than well fed. Even in the most advanced nations, insects are threatening to render obsolete much of the agricultural technology that underlies their greatness.

Insecticidal chemicals have played a major role in the development of the present agricultural technology and their use has accomplished a tremendous amount of good. It is becoming increasingly obvious, however, that the use of these chemicals has not been without problems and that society is now asking that the benefits of each use be weighed against possible adverse side effects on environmental quality.

There is another problem of considerable magnitude associated with the use of insecticides that has not yet caused great concern among the general public. This is the continued development of resistance to insecticides by many species of insect pests of agricultural and medical importance. There presently are more than 200 species of insects that have developed resistance to one or more insecticides. Over the long term, this problem could more severely affect man by endangering his food supply or health than does the adverse side effects of certain pesticides or nontarget organisms. Certain of these resistant insects already are inflicting great losses to crop yields and some species may not be controlled by presently available methods. The continued development of insecticide-resistant strains of insects threatens to render obsolete much of present pest control technology. If new methods of pest control are not developed, then entire agricultural industries may severely decline, or even disappear.

The present situation in Texas in our two major cash crops, cotton and grain sorghum, present excellent examples of the threat presented by insects to our agricultural production. Cotton and grain sorghum contribute more than $1 billion per year to the Texas economy and any great loss in these crops is felt by both producers and related agribusiness concerns such as processors, feedlot operators, agricultural suppliers, bankers, et cetera. Also, since these commodities are major items for export, great losses could compound our current difficulties in maintaining a favorable balance of trade.

Senator ALLEN. What insects would you list as attacking cotton, other than the boll weevil and budworm?

Dr. ADKISSON. In our situation, we have the boll weevil. That is one of our most important pests, but the tobacco budworm is the one beyond chemical control.

Senator ALLEN. On cotton?

Dr. ADKISSON. On cotton. I might add, Alabama has had a taste of this pest and it is beyond control over there.

Senator ALLEN. What is the length of a generation in this insect?

Dr. ADKISSON. It is about 30 days, of which the active feeding stage of the larvae is about 2 to 3 weeks. The remainder is spent in the pupa and moth stages.

Senator ALLEN. That would mean, then, that nature would change the metabolism of oncoming generations of the insect in such a way that the insect would resist the pesticide, or the insecticide; is that correct?

Dr. ADKISSON. That is correct.

Senator ALLEN. Obviously, a living strain could not develop an immunity to it during that short lifetime; it would have to be succeeding generations of the insect, with nature accomplishing that.

Dr. ADKISSON. This is true. I would like to emphasize what Dr. van den Bosch has said. The cotton industry in south Texas currently is being threatened by destruction by the tobacco budworm, an insect that has developed resistance to all presently available insecticides. This pest has destroyed the cotton industry of northeastern Mexico, an area which in the 1960's produced more than 700,000 acres, or almost 1 million bales, of cotton per year. This area of Mexico is no longer producing cotton, and the impact on the economy has been severe.

The south Texas cotton producer still is in business, but his existence is dependent on the fragilities of nature. We have developed noninsecticidal methods for partially controlling two key insects in the area, the boll weevil and pink bollworms. Then we recommend he do nothing that might adversely affect beneficial insects, thus releasing the tobacco budworm.

This program, even though it has kept our producers in business, is far from perfect. In 1969 and 1971, excellent yields were produced in the area, but in 1970 the yields were the lowest in 25 years. Thus, we are currently in a boom or bust cycle. If tobacco budworm outbreaks do not occur, yields are good; however, if they do occur, then yield losses are severe. For example, in 1970 many producers saw their crop entirely destroyed, even though they applied 15 to 20, or more, applications of insecticide.

Grain sorghum in Texas has been relatively free of insect pests that required insecticidal control, until 1968. In this year, a new pest of grain sorghum, the greenbug, attacked the crop. Expenditures for chemical insecticides in the plains of Texas, our major production area, increased from approximately $100,000 to $14 million. The greenbug is easily controlled, but pesticidal treatments have, through destruction of beneficial insects, released a secondary pest, the Banks grass mite, that has developed resistance to all known insecticides. This pest now is a greater threat to grain sorghum than the greenbug. This year the grass mite caused severe losses to the feed grain industry of the El Paso-Trans Pecos area. If methods are not soon found that will control this pest, then the entire feed grain industry of west Texas is threatened, as is the allied industries of cattle feedlots et cetera.

As insect pests become resistant to pesticides, the common reaction is to apply more toxic pesticides in greater doasges at shorter invervals The result is increased production costs, increased hazards to applicators and farm laborers, and increased contamination of the environment. Many of these hazards may be averted by a system of pest management known as integrated control. This system, which brings all known suppression measures to bear; that is, insecticides, resistant varieties, beneficial insects, insect pathogens, cultural measures, et cetera; offers the greatest promise for keeping our agricultural production viable and environmental contamination by agricultural chemicals at a minimum.

I wish to provide two recent examples from two major crops, which shows that under certain conditions the amount of insecticide used on these may be drastically reduced. In the Pecos Valley of Texas, 10 to 12 applications of insecticides are applied to cotton each year. However, entomologists, working at the Texas Agricultural Experiment Station at Pecos, have produced a crop for each of the past 4 years with almost no insecticide. They have been able to accomplish this mainly because cotton in the area is not infested with a key pest such as the boll weevil. Insect outbreaks in the Pecos crop generally are induced by the unwise use of insectcides which kill beneficial insects; thus, allowing secondary pests, mainly the bollworm, to develop to damaging numbers.

Approximately 40 percent of the total amount of insecticide applied to cropland in the United States is used on cotton. The results produced at Pecos provides ample reason to believe that supervised control of insect pests by trained specialists could drasitcally reduce the amount of insecticides used on cotton without the development of new technology. It is my opinion that insecticide usage on cotton in most areas of the United States might be reduced by perhaps 50 percent without reduction of yields. In fact, from our experiences in the valley, we found yields may be even increased.

A second example is provided by recent research in Texas that shows the amounts of insecticides used for controlling the greenbug on grain sorghum may be reduced twofold to fivefold or more. This can be accomplished by reducing the dosage applied per acre in each treatment. For example, producers currently are applying certain insecticides at a rate of 0.50 pound per acre when 0.10 pound is sufficient. During 1971, approximately 3.5 million acres of grain sorghum were treated one or more times with pesticides. If producers will treat with the minimum dosage, rather than the maximum, then the amounts of pesticides released into the environment may be greatly reduced.

Senator ALLEN. Excuse me. At this point, this is not true, the use of an integrated system; it is just reduction in the amount of pesticides used; is that correct?

Dr. ADKISSON. That is right. They presently are operating under the opinion that if a little is good, a whole lot would be better. Also, they practice what is called cosmetics crop protection. The farmers want their crops to look good, insect free, and they can do this by applying higher rates.

Senator ALLEN. And the results might even be better if, in addition to reduction in the use of pesticides, other phases of an integrated program had also been used?

Dr. ADKISSON. This is true.

Senator ALLEN. Thank you.

Dr. ADKISSON. The problems involved in developing and implementing pest management programs that will both save agricultural production and preserve environmental quality are great. Multidisciplinary and multiuniversity teams of researchers must be formed to mount this effort. The funds provided by Senate bill 1794 will for the first time allow us to begin implementing the programs needed.

A massive coordinated Federal-State effort is needed for this important problem, and the funds requested seem small in comparison to the stakes involved. It is my belief that this legislation is the essential first step needed for the continuation of a viable agricultural technology in this country, for the production of the food needed by our citizens and a hungry world, for the maintenance of our agricultural exports and a favorable balance of trade, and for the preservation and improvement of the environment.

Senator ALLEN. Thank you, Dr. Adkisson. We appreciate your coming before the committee and giving us this information. We feel that this will make an important contribution to the record.

We are grateful to you. Thank you very much.

We stand in recess, then, until two.

(Whereupon, at 12:50 p.m., the subcommittee recessed, to reconvene at 2 p.m., this same day.)

AFTERNOON SESSION

Senator ALLEN. Dr. J. Lawrence Apple and Dr. R. L. Rabb.

STATEMENT OF DR. J. LAWRENCE APPLE, DIRECTOR, INSTITUTE OF BIOLOGICAL SCIENCES; AND DR. R. L. RABB, DEPARTMENT OF ENTOMOLOGY, NORTH CAROLINA STATE UNIVERSITY, RALEIGH, N.C.

Senator ALLEN. Dr. Rabb will not be here?

Dr. APPLE. That is right. We have a combined statement.

Senator ALLEN. Would you proceed, please?

Dr. APPLE. Thank you very much, Senator.

Agriculture has never witnessed a period of dynamic change in production technology comparable to the present. And these changes have significant implications in the management of the myriad of pests that threaten the food and fiber crops of the Nation. We would like to review briefly some of the changes that characterize "modern" agriculture and the manner in which they influence pest management problems.

1. INTENSIFIED PRODUCTION PRACTICES

The pressures for enhanced production efficiency have prompted the development of monocultures, multiple cropping, and shortening of rotations, all of which contribute to a more simplified agroecosystem that is more readily exploited by pests and comparatively less stable than more complex ecosystems.

(I would like to insert, parenthetically, that when we talk about "pests" in this statement, we refer not only to insect pests but to all pests that afflict a growing crop under field conditions. We will have more to say about that in a moment.)

2. DEVELOPMENT OF IMPROVED VARIETIES

Great demands have been pressed upon the plant breeders to develop crop varieties that are: (a) high yielding, (b) adaptable to mechanical harvesting (which demands uniform plant type and uniform maturity), (c) resistant to major endemic pests, and (d) acceptable to the product market. Plant breeders have been very successful in responding to this challenge but in the process they have enhanced the genetic vulnerability of major crops in the United States to attack by pests. This was demonstrated convincingly in 1970 with the outbreak of southern corn leaf blight (caused by the fungus *Helminthosporium maydis*) which reduced the Nation's crop production by an estimated 400 million bushels. This was attributed directly to a single source of male-sterile cytoplasm which was present in about 90 percent of the corn planted in the United States in 1970. It is a good example of a relatively minor pest assuming major pest proportions on a national scale.

This situation has promoted a study of the genetic vulnerability of the Nation's major food and fiber crops to pests under the auspices of the National Academy of Sciences. This is a much needed study which will probably point to potential genetic weaknesses in basic crops other than corn. The national and world trend toward planting a few varieties, all of which may be genetically related, on millions of contiguous acres has far-reaching and awesome implications for pest management programs.

3. CHANGED CULTURAL PRACTICES

Many cultural practices such as increased levels of fertilization (especially nitrogenous fertilizers), higher plant populations per acre, irrigation, and others result in a much changed microenvironment which favors the development of many pests and exerts additional pressures on the pest management system.

4. BRINGING NEW LANDS INTO CULTIVATION

There are situations of new lands being brought into cultivation under conditions which are more favorable for pests than more adapted production areas.

5. SPREADING OF PESTS INTO NEW AREAS

The intensification of pest problems in certain areas and the high mobility of man within and between continents has resulted in the invasion of previously uninfested areas by major pests. A very recent and most important example was the discovery of the coffee rust fungus in Brazil in 1970. The full impact of this event will be felt by the Brazilian economy within a few years since coffee exports constitute its major source of foreign exchange.

These and other factors characteristic of modern agriculture have simplified agro-ecosystems. Plant pests have exploited this more simplified system with resultant direct losses to the producers and higher priced products to the consumer. The situation has promoted rapid increases in the use of pesticides with concomitant environmental impacts that give cause for grave concern. Many now share the view that the situation has reached crisis proportions that the problem demands the implementation of new strategies.

In the long run the pressures to increase crop productivity efficiency will intensify pest problems. The intensive agricultural production systems that must be developed to feed burgeoning populations will require sophisticated and precise pest management programs.

Personnel in the School of Agriculture and Life Science at North Carolina State University are actively interested in developing ecologically sound pest management systems for agricultural pests. Evidence of this interest can be found in the research and extention programs in entomology, weed science, and plant pathology departments. In addition, personnel in the entomology department were instrumental in organizing an international conference on pest management in March 1970, in Raleigh. As a result of this experience, some rather clearcut concepts of the requirements of developing and implementing pest management systems have emerged. We would like to speak briefly of these requirements.

A prerequisite in developing a management program for insect pests on a predictive and continuing basis is an adequate description of the pest population. If various control actions are to be integrated in lowering the mean population level below the economic injury level, the pest management specialists must have an accurate and representative picture of the spatial variations and temporal changes in the populations to be managed. Due to the high mobility of most insect pests, the populations to be managed will of necessity be a large area population. Thus, the population dynamics data must be based on a wide area and must depict seasonal and annual changes. Without such data, many possible management practices cannot even be visualized, and unless base data are kept current, management practices cannot be evaluated objectively.

A mere census of pest numbers will not result in an adequate population picture. The pest numbers must be placed in a meaningful relationship with the various environmental factors influencing pest density. Key factors such as host plant conditions and acreage, natural enemies, and cultural practices that may influence pest density must be monitored in addition to pest numbers. Guidelines for developing a population description are available, but unfortunately have not been used effectively. One of the chief reasons for our present lack of adequate population data is that the investigation of the population dynamics of a wide area field population is a big undertaking logistically which requires a relatively large multidiscliplinary, technical staff. Such projects usually require more personnel and funds than typically are available to a single university or agricultural experiment station. Individual scientists have recognized the need for such projects for many years but have been unable to command the requisite resources.

Another requisite for long-term, ecologically sound pest management programs are large-scale field trials through which basic population data can be utilized and basic management concepts tested. A pilot program of this nature was carried out in North Carolina in 1971 as a cooperative project of the Plant Protection Division, Agricultural Research Service of the USDA, North Carolina State University and the North Carolina Department of Agriculture. This pilot project collected data in selected tobacco production areas on insect pests and beneficial arthropod populations which was used by the farmers in making decisions concerning their pest management programs. Data were also collected to enable economic and ecological evaluation of the pest management effort. About 12,000 acres of tobacco were involved in the project. Preliminary evidence indicates that it was very successful. Collaboration of producers in the project was excellent.

Another important aspect is that pest management projects must be structured and funded on a regional or national basis because pest problems are not limited by political boundaries and cannot be managed effectively if the purview of the scientists is restricted. Consequently, the planning must be national (and in some cases international) and the funding source must be national with supplementation from local or State sources.

A multidisciplinary research and extension team is another important requirement of a successful pest management program. The complexities of the problems and their interrelationships with other disciplines require a team effort comprising specialists in population ecology, genetics, toxicology, agronomy, insect taxonomy and pathology, plant pathology, weed science and others. The team must consist of both research and extension personnel because the object of the extension specialist's attention, the grower's crop, is also the laboratory of the researcher.

It should also be stressed that the highly scientific, pest management approach is justified only with major pest problems on major or basic food crops. There are many minor pests on major crops and some major pests on minor crops for which this approach cannot be justified economically.

We are in favor of S. 1794, a bill "To provide a Viable Alternative to the Nation's Reliance on Pesticides," but we feel it is too restrictive in its present form. As written, it addresses specifically the problems of controlling insect pests through integrated control measures. We can no longer afford to look at pest control or pest management in piecemeal fashion. We must not only integrate methods for the management of a given pest (insect or disease) on a given crop, but we must integrate management methods for all important pests in the agro-ecosystem involved. There must be developed an integrated systems control strategy for each of the major crops. Such strategies would have to be adjusted to reflect regional pest or environmental differences but there could be many common elements in a national program.

The undergirding research activity for the integrated systems control program must be pest oriented without regard to hosts, either cultivated or wild. This represents a departure from the single-crop orientation of most agricultural experiment station projects. Population management systems cannot be restricted to a single host crop (unless it is the only susceptible host crop in the agro-ecosystem) but must reflect the general population that is supported by all potential hosts in the area.

We are sure some question the advisability or practicality of a comprehensive pest management approach that embraces all forms of pests that impinge upon a given crop; however, to us it is illogical to devise a management system for insect pests of a crop without also integrating with the systems required to manage disease and weed pests. Insects are also vectors of some disease agents, and cultural practices that suppress the populations of some pests may favor the buildup of others; consequently, the need for an integrated program. The farmer must have developed a systems approach for a given crop which is logical, ecologically sound and economical for him to follow. And in devising that system, the approach should not be from the standpoint of insects pests alone but a comprehensive approach that includes diseases, nematodes and weed pests. It must be put together in a logical fashion for the farmer. Management efficiency and environmental quality considerations dictate this comprehensive systems approach which includes all forms of pests that threaten the productivity of a crop.

Not only would we like to see the scope of S. 1794 broadened to include all pests that affect basic food fiber crops of the Nation, but the funding authorization should be increased substantially. Others have alluded to the fact that this level of funding authorization is quite inadequate to meet the complex problems before us. We would also like to point out that the agricultural experiment station and cooperative extension service personnel of the land-grant institutions comprise the major resource of this Nation that can be applied to this important problem area and the only available resource for implementing integrated systems management programs on a local and regional basis.

Now, this is not saying that the USDA does not have a role, through ARS and other action agencies. Definitely, they do have a role and, as Dr. Knipling pointed out this morning, many of the things which they are doing can have a very important effect in reducing insect populations over a wide area such as the sterilization technique. But in the final analysis, someone must work directly with the grower to assess regularly the pest level in his field or in his community or in his region. This information would formulate the basis for a recommended action program that is meaningful. We have to gear up at all levels to do the job. We have extension personnel in the field and we have research personnel in the agricultural experiment stations. This is the system that must be geared into a national pest management program. Consequently, we recommend that major funding in support of this work be provided to the States through the Cooperative State Research Service of the U.S. Department of Agriculture under the granting authority of Public Law 89–106.

I do think this bill provides the opportunity of attacking one of the great problems that environmentalists recognize, conservationalists recognize, and, surely, we, as people interested in agriculture, recognize. I hope that it can be favorably endorsed by this subcommittee and enacted by Congress.

Senator ALLEN. Thank you, Dr. Apple. We appreciate your testimony and appreciate your coming before the committee.

You do not feel that under the present language of the bill that it would permit a broadened program that you speak of?

Dr. APPLE. I think the broadened program should be addressed in the bill. Although one might interpret certain facets of it in broader fashion, the basic thrust of this bill is in the area of entomological pests. We really need to look at this problem area in the broader spectrum.

Senator ALLEN. I am sure the committee would be delighted to hear from you on specific language that you might recommend to accomplish the goal that you suggest.

Dr. APPLE. In North Carolina this year, we have had a cooperative scouting program on tobacco with the U.S. Department of Agriculture which covered about 12,000 acres. It was centered in three different regions of the State and specifically at reducing the pesticide burden in the environment. Apparently, this was very successful, although our data analysis is not complete.

We also collected information on predators and insect pathogens that were present in these areas. So, it is this kind of information that we need, as others have mentioned. We have available at the present time a lot of information that can be used in structuring pilot-type programs over the country for major crops and major pests on those crops.

I am concerned about some comments made in these hearings relative to the use of chemicals. We look upon a pest management system as one that will involve the use of all of the tools at our command in controlling pests. Undoubtedly, this shall continue to involve—and in some cases very heavily—the use of chemicals. We want to minimize the chemical load to the extent possible for several reasons. But for many of the major crops, we cannot foresee the day when we will no longer need chemicals.

Senator ALLEN. I am sure that that is true. Dr. Adkisson suggested that areas in Texas where the use of insecticides had been drastically reduced, that the results were about the same.

Dr. APPLE. That is right.

Senator ALLEN. There was a tendency on the part of the farmer to overuse pesticides.

Dr. APPLE. Well, I think we can understand the action of farmers in many of these cases, in that they do not really have the guidance that is necessary to make a rational decision as to when to use and when not to use pesticides. That is the type of information we need to supply to the farmer. But we can only provide it through these intensive pest management programs.

I think we can well understand the situation of a farmer. His whole livelihood perhaps is at stake out in that field, and he does not want to gamble with it. As it has been stated, if he needs perhaps 2 pounds of pesticide to the acre, he might use 3 so he can sleep better at night.

Senator ALLEN. You feel that the thrust of the legislation is sound and constructive——

Dr. APPLE. Very definitely.

Senator ALLEN. That it has a good chance of accomplishing a worldwide purpose?

Dr. APPLE. Very definitely. North Carolina State also has two projects on pest management, which are now funded through the National Science Foundation, and these are directed at the tobacco budworm, corn earworm—the problem Dr. Adkisson from Texas was talking about this morning. We have it on cotton, soybeans, tobacco, and corn in our State. These pests are worldwide and need to be understood from that purview.

Senator ALLEN. To what extent do the research programs carried on in land-grant colleges overlap the research work being carried on by the Department?

Dr. APPLE. We work, generally, in concert with the Department.

Senator ALLEN. They keep you advised of the developments?

Dr. APPLE. Yes. And, of course, through professional contacts, our people know what is going on in the Department and vice versa. We also have some Department personnel working in our experiment stations on assignment in North Carolina. These are cooperative projects. All of these things tie together.

Senator ALLEN. Great progress is being made in providing alternate methods of combating pests?

Dr. APPLE. Right.

Senator ALLEN. And as this information is developed, as the results of the research become known, that information is disseminated out through the country and circulated through the colleges?

Dr. APPLE. Yes. This bill, if properly funded, can help tie all of this information together. There is much information available dealing with this very complex problem reflecting different factors of environment, cultural practices, varieties, temperature, humidity, and the multitude of pests to be controlled. We are talking about a very complex system that can be coped with only through computer analysis. It will require a computer program written to give us the best judgment answers as to what to do under certain circumstances. But before such computer programs can be written, we must have good basic data on the behavior of important pests under a range of conditions.

Most of these pest-management programs will have an element of risk involved. Now, whether we should go so far as to consider a type of crop insurance to cover judgments, as recommended in the paper of Dr. Van den Bosch is another consideration. This approach will have to be considered very seriously, because it has long-term implications in terms of costs.

Senator ALLEN. Well, now, this bill does contemplate reimbursing the farmers and the ranchers.

Dr. APPLE. Right, for the pilot study; and I think this is proper.

Senator ALLEN. That would, in a sense, be a form of crop insurance.

Dr. APPLE. It would protect farmers during the experimental stage or testing phase. They should be protected.

Senator ALLEN. If this problem can be solved, will it not go a long way toward helping the ever-increasing difficult task of providing the food and the fiber for a hungry world?

Dr. APPLE. No question. And I think we are going to need improved pest management programs. The years ahead will demand the kind of program referred to in this bill because, with a burgeoning world population we will have to intensify production practices even more than we have today. We will also have less and less land on which to grow agricultural products. Consequently, we are going to have to grow more per unit area, and, as we do that, we will continue to compound and complicate pest control.

The investment level is going to be such in agriculture at that time that that protection of the investment will be absolutely essential. A catastrophic occurrence like helminthosporium blight on corn in 1970 could not be tolerated by the farmer. He would be forced out of business.

Senator ALLEN. It seems to me that the bill, far from showing any lack of confidence in the Agricultural Research Service, shows our great confidence in the Research Service because it requires them to implement the program that is envisioned by the bill.

Dr. APPLE. Right; this seems to me to be proper, but I would like to see the bill also give some consideration to the funding needs of the States, because the States must participate in the overall program. We have a structure there that definitely should be utilized in the overall strategy. We need the Federal superstructure which has the broad purview and which develops such programs as the male sterlization approach which has regional application. One State could not do that. Consequently, the ARS input here is absolutely essential.

But under that umbrella, there must be action people on the ground in every county. This should be the extension and research personnel of the land-grant universities.

Senator ALLEN. Well, now, the local people are ready, willing, and anxious to cooperate in this type of endeavor, are they not?

Dr. APPLE. In our pilot in tobacco in North Carolina in 1971, collaboration and cooperation on the part of growers was truly outstanding. As already mentioned, our farmers do not want to put more pesticides on their crops than required for economic control of pests. They really lack the necessary information and assistance to guide them in the judicious use of pesticides. That is one thing this bill could provide.

Senator ALLEN. You feel that it will be helpful to you and in your work, the information that could be obtained from this?

Dr. APPLE. Very definitely.

Senator ALLEN. Do you think it desirable to hit upon alternate mentods and combined or integrated methods of controlling or eliminating pests?

Dr. APPLE. It is the only way we should do it, because we have a number of tools available, and we must make use of all of these in an integrated package program. It is sheer folly to rely completely on one method.

Senator ALLEN. Will it be desirable to seek to have methods that will allow less and less emphasis to be put on the use of insecticides and pesticides?

Dr. APPLE. That is absolutely essential, also.

We have already mentioned that there is much overapplication now, just because they do not have adequate information. A scouting program that would provide population data as a basis for determining when to apply pesticides would reduce the pesticide burden in the environment very significantly and also reduce the cost to the farmer.

Senator ALLEN. With the low price at the marketplace of most most agricultural products, isn't the farmer pretty well breaking himself investing so much money in pesticides?

Dr. APPLE. In some cases, this is true. The background information printed with this bill in the Congressional Record states that many farmers could afford to pay for a pest management advisory service. I do not find that the farmers in our part of the country are sufficiently affluent to afford such a service. I think this is going to have to be a program sustained by Government funds through our existing agricultural organizations.

Senator ALLEN. One of the main defects in the legislation I gather is the lack of sufficient funding or authorization for funding——

Dr. APPLE. This is true.

Senator ALLEN (continuing). To really get it off the ground?

Dr. APPLE. I think that is right. The $4 million figure is quite small as compared to the magnitude of the problem.

Senator ALLEN. Thank you very much. I appreciate that. Dr. Stark, please.

STATEMENT OF DR. RONALD W. STARK, COORDINATOR OF RESEARCH, AND GRADUATE DEAN, UNIVERSITY OF IDAHO, MOSCOW, IDAHO

Dr. STARK. My name is Ronald W. Stark. I am presently the coordinator of research and graduate dean at the University of Idaho, but prior to assuming this position in 1970, I spent 22 years in forest insect research, 11 years in Canada, and 11 years at the University of California at Berkeley. My general philosophy and opinions regarding the potential of integrated control is fully expressed in the reprint of the article which I wrote last year, and I do not believe there is any point in rehashing that at this hearing. I hope this will be entered in the record.

In the interest of brevity, I just would like to address myself to one or two comments.

First, I want to emphasize the remarks of Dr. van den Bosch that alternative methods of control, if conducted unilaterally, are not a substitute for present practice. They carry no guarantee of success. An integrated approach using all feasible methods and taking full advantage of all the natural regulating mechanisms is the only possible means by which we may guarantee success on insect control.

I would also like to disagree with an earlier witness regarding the implementation of integrated control, at least as far as forest structures are concerned. It is my understanding there are a few experimental programs in integrated control in agriculture in California in process now, but in forestry there is nothing comparable at this time. We do not have any projects in integrated control in forestry. We have been following the lead of agriculture and adopting a unilateral approach to our problems. These vary all the way from aerial spraying of DDT (which is being phased out) and other insecticides, to single-tree cutting and treating for such pests as bark beetles at very high cost, and there is very little evidence that these methods are working.

Forestry differs from agriculture in several ways: first, of the 770 million-plus acres of forest land, about 450 million acres are considered commercial and these can be compared in some fashion with agricultural lands. The remaining 320 million-plus acres, however, are either in public trust, as national parks, wilderness, primitive areas, or classified as noncommercial. However, these lands have many uses including watershed, recreation, general land cover, and others.

The problem of control of pests of these and commercial forests is, therefore, usually more complex than control on agricultural lands where the product's use is more clearly defined. The ecological aspects of the problems which will be added by this bill have been well covered by previous speakers, with particular reference to agriculture. I would like to emphasize that the general ecological diversity of forest lands lends itself eminently well to the integrated control approach. In fact, because of the ecological diversity of forest lands the integrated control approach is essential.

The one area which I do not think has received sufficient attention is the other principle of integrated control, and that is what is termed the economic threshold.

In forestry, in the name of "pest control," we have expended considerable sums of money when this is not necessarily essential. For example, does it make sense to spend great sums of money in controlling bark beetles in a wilderness area, or is it proper to expend great sums of money in control of forest insects in a national park?

Back in the early 1900's, and, then, again, the late 40's, there was a tremendous outbreak of an insect in the Yosemite National Park which killed thousands of acres of trees. At that time, funds were not available for control, but since that time funds have become available and have been expended on control, with limited success, I might add.

The point I am trying to make here is that in this national park where these forests were killed, these dead forests are now a tourist attraction. The trees themselves are noncommercial; it is an area which is not used for commercial purposes, but in the long run the actual phenomenon became a tourist attraction which, in itself, is economically productive in a sense.

So, I believe with the adoption of integrated control as our control philosophy, we need to spend a great deal of effort in defining what is the economic threshold or the threshold at which we must take action with each real or potential insect pest. In forestry, this is particularly complex because of this diversity of ownership.

These comments and my remarks in the published paper on integrated control are all I would like to say at this time, Senator Allen. I would be happy to respond to any questions.

Senator ALLEN. Thank you very much, Dr. Stark. We will insert the booklet in the record.

(The booklet follows:)

(USDA Forest Service Research Paper NE-194, Northeastern Forest Experiment Station, Upper Darby, Pa., 1971.)

INTEGRATED CONTROL, PEST MANAGEMENT, OR PROTECTIVE POPULATION MANAGEMENT?

by R. W. STARK, University of California, Berkeley, California (now at University of Idaho, Moscow, Idaho).

THE PREOCCUPATION of foresters and forest entomologists in suppressing populations of phytophagous insects competing for the forest resource has led to the establishment of several "territories":

Mechanical control.—Mechanical methods such as burning or felling, and peeling and burning the bark of trees infested by bark beetles.

Chemical control.—Applying insecticides.

Biological control.—Utilizing predators, parasites, and diseases. Classical biological control emphasized the use of introduced parasites, predators, and diseases for exotic insects.

Silvicultural control.—Utilizing silvicultural and management practices.

Ecological control.—Includes not only biological and silvicultural methods but also selection of genetically resistant trees.

To this list should be added the new definition of biological control. Biological control now encompasses all methods of control that can be considered biological in nature—excluding chemical and mechanical.

Two more definitions of control came into being more or less simultaneously: harmonious (*Voute 1964*) and integrated (*Smith and Allen 1954*; *Stern et al. 1959*). Both were a consortium of territories.

Harmonious control.—A synthesis of ecological, chemical, and eventually mechanical. It includes integrated control. It is the most many-sided idea of control of insect pests possible. The application of pesticides is not abandoned, but is intended for use in addition to other methods since it is explicitly stated that chemicals should not interfere with natural population regulators.

Two definitions of integrated control are necessary, first to establish proper priority, and second to define its current status.

Integrated control.—The earliest definition of integrated control (*Smith and Allen 1954*) recognized the necessity for consideration of the ecosystem; but social, political, and economic pressures necessitated an immediate reconciliation between chemical and biological control. The definition arrived at by Stern *et al.* (*1959*) was more palatable at the time to growers and industry. This was: "applied pest control which combines and integrates biological and chemical control." As techniques improved, the benefits of minimizing pesticide use became more apparent, and the hazards of intensive use of chemicals more obvious; and the broader concept of integrated control evolved.

Smith (*1969a, b*) said: "Integrated control is a pest population management system that, in the context of the associated environment and the population dynamics of the pest species, utilizes all suitable techniques and methods in as compatible a manner as possible and maintains the pest populations at levels below those causing economic injury."
and, further:

"Integrated control is an ecological approach to the control of harmful pests. It derives its uniqueness from emphasis on the fullest practical utilization of existing mortality and suppressive factors in the environment. Its strategy is one of 'management and containment' rather than 'seek and destroy.' The goal of the integrated control system is to provide a stable and economically sound procedure for crop protection."

There are two principles common to both these definitions, but particularly the later one, without which the definitions are incomplete. These are: (1) consider the ecosystem, particularly avoiding disruptive actions, and (2) utilize critical injury levels.

By agreement, at various international symposia, integrated control is used in appropriate literature rather than harmonious control. I think it is obvious at this stage that there is a drawing together of ideas concerning pest regulation.

The concept of utilizing natural enemies and forest cultural methods to minimize damage by forest insects is deeply rooted in European forestry (*Voute 1964*). Those chemicals used were natural compounds, and biologists were more or less forced to study natural causes and treat accordingly. When broad-spectrum insecticides appeared they were utilized but with far more respect for the environment than in North America. The store of fundamental knowledge built up over the centuries in the care of their forests was not neglected as it has been in North America. Verbal formulation of the concept of harmonious control began about 1958.

In North America, faced with a superabundance of forest resources, early foresters were little concerned with the relatively minor losses inflicted by forest insects or diseases. It was not until late in the 19th or early in the 20th century, when large capital investments in physical plants were made, that losses in the vicinity of those industries became of concern. Then the myth of superabundance was replaced by the myth of super-technology, encouraged by the apparent success of lethal insecticides in agriculture. Initial apparent successes in "pest control" led to what Graham (*1964*) refers to as "preoccupation with procedural aspects". A type procedure was adopted for each situation as it arose, and the underlying manipulations were largely ignored.

Meanwhile, the agriculturists were learning that the use of a single kind of control procedure was not solving the problem. Indeed, new and more serious problems were evolving, and integrated control in its narrow sense evolved (*DeBach 1951*); *Griffiths 1951; Pepper 1955; Pickett et al. 1958; Ripper 1944, 1951; Smith and Hagen 1959; Stern et al. 1959*). Although most ecologists and entomologists had long embraced the ecological approach to pest regulation, it was not until evidence accumulated on the harmful side effects of pesticides and public reaction and opposition to their use increased, that the broader and more inclusive concept began to be promulgated and accepted

(*Chant 1966a; FAO 1966, 1968; Geier and Clark 1960; Smith 1963, 1968a, 1969a; Smith and Reynolds 1965*).

The concept of integrated (harmonious) control grew out of forestry practices in Europe and agriculture in North America. There have been to date only token efforts to apply the system in forestry. Early forest entomologists and biologists preached the lessons learned from European foresters, but their sermons fell largely on deaf ears. If one goes to texts of S. A. Graham, Hawley and Stickel, and others he will find the seeds of the "integrated control" concept planted there. They are only now beginning to show signs of germinating. Smith (*1963*) and Franz (*1965*) are among the most recent to propose that we fertilize them.

However, the situation is still in a state of flux. Several recent authors have proposed another way of looking at this whole problem of protecting our forest resource from its enemies. Since the forestry profession, as I see it, is on the brink of embracing something along this line, I think it behooves us to examine this concept. We may not have to tread in every footstep the agriculturists have placed before us—perhaps we can skip a few. I refer, of course, to the concept of "pest management", or "protective population management".

Geier and Clark (*1960*) coined the term "protective population management". They argued that a continuous sequence of ad hoc programs of destruction of noxious insects has occupied available personnel so that they have ignored fundamentals of ecology, including socio-economics—which is really ecology. In practice, there is no real difference between their definition of pest population management and integrated control. Geier (*1966*) shortened the name to "pest management" and stated:

> [it] was coined to emphasize the comprehensive nature of the approach and to underline its preoccupation with ecological realities. It is intended to convey the idea of intelligent manipulation of nature for man's lasting benefit. The greatest single quality which the new strategy should possess is selectiveness in its action on a specific population. This selective action must remain at all times commensurate with population's potential injuriousness. To achieve that, the new approach must aim, above all, at making control operations fit well with the biology of the noxious species.

It should be noted that in a truly ecological sense no manipulation of the environment is truly selective. Beirne (*1967*) broadened the concept of pest management:

> Pest management is one of a number of more or less analogous terms that refer to management of aspects of the environment in ways that will benefit our interests . . . [It] refers to actions at a different level, actions that are primarily aimed at harming living organisms that are harmful to us or to resources that we use. . . It consists of the intelligent management of pests and of their surroundings and the management of the people who devise or do that managing. The management of pests is commonly what is meant by the term pest control.

Authors have in recent years begun to use the terms pest management and integrated control interchangeably. For example, the index of recent publication of the National Academy of Sciences "Insect Pest Management and Control" (*1969*) has the curious section heading "Successful Unilateral Pest-Management Systems".

Chant (*1966b*) suggested that pest management and integrated control are synonymous. Smith (*1968b*) used the term pest management almost exclusively when discussing the ecological approach to pest regulation and mentioned the social and political ramifications. However, although the rationale of both are practically identical and the guidelines for integrated control (*FAO 1968*) can be incorporated as a part of the guidelines for pest managers, I feel we should consider pest management and integrated control as two distinct entities. Pest management should be considered as a component of resource management (*Watt 1968*). Integrated control is the approach by which regulation of pest populations is achieved, whereas pest management is the decision-making process where all aspects such as societal values, impact on other resources, and the like are considered prior to making the decision whether population regulation is to be undertaken.

Management of Pests

One of the fundamental principles of integrated control can be transposed intact to pest management: "utilize critical injury levels" (*Smith 1969a*). This has been variously named economic threshold (*Stern et al. 1959*), action threshold (*Chant 1966a*), and economic injury level. The intent is clear, but the application in practice is not simple and requires examination in the forest environment.

The concept of economic threshold as developed for agricultural entomology is not adequate for most decisions in management of forest pests. It was developed along strict profit-loss relationships and does not include sufficient recognition of forest ownership and mixed values.

There are approximately 773,400,000 acres of forested land in the United States, 461,044,000 of which are classed as commercial. If an insect problem occurs on the noncommercial forested land, how do the economic considerations of marketplace values on which most of our evaluations are based apply? Of the commercial forested land, approximately 106,071,000 acres are under public guardianship, either federal, state, or other. Portions of this land are designated as national forests, national parks, wilderness areas, and other types of reserves, administered by a variety of agencies. Again, how do you apply *economic* thresholds compatible with the multitude of uses involved? Of the remaining commercial land, about 350 million acres, an estimated 59 percent, is in scattered nonindustrial private holdings that are either not managed at all or only slightly so. How can you apply *economic* thresholds to land that is not managed for its crop? The economic threshold is defined as the density (of the pest population) at which control measures should be determined to prevent an increasing pest population from reaching the economic injury level. The economic injury level is the lowest population density that will cause economic damage (*Stern et al. 1959*). Use of this concept is, at best, feasible only for that 150 million acres under management for forest crops.

Johnson (*1963, 1966*) and others have addressed themselves to the problem of determining economic thresholds under various commercial forest situations and have pointed out that even where a single ownership is involved and the kind of crop is fixed, the task of determining the benefits derived may be far from simple. A forest crop such as a nursery or a Christmas tree plantation approaches the agricultural situation, and the techniques of establishing economic thresholds can be applied with justification. But if the crop depends on a harvest 80 years from the time of planting, how can you apply today's marketplace values and control costs to a product (for example, lumber) that not only fluctuates markedly in value for top-grade products but just as widely depending on the quality?

In most commercial situations in forestry the "economic thresholds," where they are set at all, are set arbitrarily and are dictated largely by emotional responses—fear of what might occur rather than any justified economic base. The many absurd "control projects" committed in the name of protection are possible only through government subsidy. Outbreaks that truly jeopardize commercial managed forests are rare even in apparently susceptible uniform forest types: where they occur they rarely proceed unchecked to eliminate entire forests. The chief malefactors, bark beetles, although they may cause cessation of growth (death) of significant portions of the stand, do not destroy the crop. It remains there, amenable to harvest, should the management plan be flexible enough to utilize it (*Johnson 1940*). Also, much of our forest economy is geared to a single product. Where the product is only lumber, a dead tree, blue-stained and invaded by secondary insects, may be a total loss; but in a multiple-use industry, most of the tree may be recoverable.

The emotional response to insect kill and damage is often unrealistic, as is the attitude that we must give away, in the name of control, perfectly valuable ponderosa pine, Douglas-fir, sugarpine, etc., killed by bark beetles. Occasionally, as in catastrophic storms with the incipient insect consequences, this may be justified; but the annual sales of bug-killed trees and adjacent green (infested or not) timber at prices far below going prices and additional tax benefits seems to me questionable.

It is not unlike the situation existing in the cotton industry. Annually the Government spends millions of dollars for landowners *not* to grow cotton. At the same time, research agencies, growers, and the Government spend millions to protect what cotton is grown! It would seem to me that if a national policy were developed that would permit rotation of crops over the total range of cotton land, a balance might be achieved with cotton plants, insects, and national production goals. If restricted to cotton lands, subsidiary industries would not suffer unduly as it is unlikely that in any particular area no crops could be grown. For those growers who could demonstrate a financial loss from changing to another crop, an indemnity replacing the no-grow subsidy would suffice.

Another example of abuse of the economic threshold concept is the spruce budworm problem in eastern Canada. The vast acreages over which control has been attempted often have little relation to the economic interests involved. The areas covered by such control, and this applies to budworm control in Montana and Washington as well, if on commercial land at all, usually exceed any that might conceivably be utilized in a lifetime. There would be ample time for a replacement crop to mature—assuming the budworm did its worst. Protection of a national resource is then invoked. A type procedure—chemical spraying—is adopted, and a private corporation is formed to carry out this procedure. This would seem to be the acme of "Graham's Law" (*1964*), to the end that once a type procedure is adopted for a type situation it is pursued inflexibly without thought of what it is actually contributing. The dissolution of a public corporation or a government bureau because of obsolescence is a difficult feat to accomplish!

Many authors have stated that we do not have realistic estimates of the impact of insects in forests upon which to base treatment decisions. There is confusion between injury and damage (*Smith 1968c; Strickland and Bardner 1969*). Injury consists of the actual acts of insects, which cause damage to the plant. This damage varies according to insect numbers and behavior. Plant damage is the effect on the plant of the insect injury and may or may not result in crop loss (e.g., beneficial thinning by bark beetles may actually increase yield). Damage may take several forms, such as loss of growth, direct mortality, reduction in quality, and destruction or deterioration of finished products. This determination of realistic estimates of damage is the most urgent item in forest pest management today. I suspect that we will find that we have little justification for most of the past and existing control programs—at least in the manner in which they are executed.

In an industrial situation it is apparent that the benefits from specific pest-control actions should exceed by an adequate profit margin the total costs of such actions. This cost-benefit ratio should include long-range costs such as costs of treating secondary pest outbreaks, costs of sorting or handling the final product, and supervisory charges. Agriculture, in general, ignores long-range costs—but foresters cannot. The long-range costs or even reasonable estimates of them are usually not available at the time the decision must be made. Unfortunately also, the decision-maker, even if aware of them, may feel that the long-range costs need not be accounted for by him, but will be paid for by the succeeding generations or a remote government or society. Hence, unfortunately, most control decisions at the individual producer level are made on a very short-term basis and at current market values. Since in forestry situations insect control is heavily subsidized by the Federal and state governments and decisions usually rest with them, it would seem that this would be amenable to change.

I repeat that the necessity for taking a hard look at our justifications for control is our most urgent task, and it has always been a matter of wonder to me (and lately slightly of suspicion) why forest economists have, in general, ignored this problem. I think the techniques for developing economic criteria for at least industrial forest lands are available. I believe the use of the life-table approach adapted by Waters (*1969*) married to the systems-analysis techniques of Amidon (*1966*), Hill and Amidon (*1968*) and Davis (*1968*) with existing data will provide realistic figures in industry-oriented forests for those forest insects currently considered pests. What is required is that a pest manager and a forest manager integrate their respective resources and talents to that end.

To this point I have limited this discussion of "economic threshold" to industrial forest land, essentially "cost-benefit" relationships. The greatest bulk of forested land is not in "production" in the strict sense, and although I do not have figures, I would hazard a guess that as many control efforts are on this public land as are on private. The criteria for control decisions on public land dedicated to various uses is infinitely more complex than on industrial land.

The most comprehensive example of the problems involved is given by Vaux (*1954*), who discussed the economic implications of a vast control project involving the outbreak of Engelmann spruce beetle in Colorado. The justifications invoked (and which are commonly invoked by forest entomologists) were protection of watershed values, recreation values, and timber utilization. Assigning economic values to the first two is an exercise in frustration. It may never be possible.

Rather than attempt to commercialize what are essentially sociopolitical problems, why can we not assign "critical injury limits" based on a risk-benefit ratio (*Starr 1969*) where the risk to that particular enterprise is evaluated not in dollars but in relation to its continued efficiency in that particular function? For example, the most efficient watershed is probably paved so there is no loss by transpiration and interception. The water is conveyed immediately to covered storage ponds in the valleys, and runoff is regulated by valves. Although not well documented (which means I could not find any references), the belief exists and is growing that heavy forest (tree) cover is not particularly efficient in terms of water production. Perhaps insect kill or heavy defoliation may actually be beneficial in terms of water supply. Additional risks to be considered, however, would be increased fire hazard, increasing protection costs, and perhaps less efficient flood control.

Some economic values can be assigned to recreation—for example, fishing and hunting permits, increased number of tourists, average dollars spent, etc.—but these so overlap and depend upon so many intangible values that to assign the value to the forest or lack of it alone would be misleading if not false. Does the presence of extensive budworm defoliation or beetle kill really affect recreation possibilities? Does it really discourage people from visiting forested areas? My experience in Canadian and Californian national parks indicates that if such damage has any effect, it is negligible. In fact, in Yosemite National Park, the Ghost Forests of Tioga created by a needle miner outbreak is an attraction!

The spruce bark beetle outbreak was mentioned above. According to Vaux (*1954*), a separate economic analysis of the area indicated that the timber area affected constituted a poor investment risk. The appearance of the area affected, including untreated areas that have undergone extensive beetle outbreaks in Canada and California lead me to state that apparently such outbreaks created no material effect on watershed or recreation. What is required in pest management is an extremely broad perspective in assessing risk from outbreaks on noncommercial lands. The pest manager must look at the area from at least a regional view, if not national. Consideration of land allocation must be included. For example, the Rocky Mountain States are the least productive part of the United States for timber production (*Wagar 1969*). Northern Idaho and western Montana already have more industrial plant capacity than can be kept supplied with current levels of timber management. Old-growth stands once permitted (without management) a profitable industry, but this is not true today. This has created a pressure to permit use of old-growth stands locked up in national forests. Whether this comes to pass or not, it merely prolongs the situation. On the other hand, these same areas are extremely rich in watershed and potential power sources for the Northwest and Central States and in recreation potential. My point is that the pest manager, in concert with the forest manager, should examine land use in this context.

One last example of the necessity for broadening the scope of pest management to be included in the resource-management level is closer to home. The research forest of the University of California is located in a highly productive mixed conifer forest. A recent study (*Teegarden and Werner 1968*) presented a case history of integrating forest-oriented recreation with timber growing. They pointed out that under certain conditions conversion of timberland to vacation homesites was a profitable venture. Lacking in their analysis was consideration of costs for protection from bark beetles. Since bark beetles are a chronic problem in the area studied, and since protection costs in vacation home areas far exceed those in commercial forests, consideration of this may well affect such decisions. On the other hand, an area identified as a focus of bark beetle populations was determined to be unproductive from an economic point of view. The ends of pest management and land use would both be met if such areas were removed from timber production, which is under constant threat from insect damage, and converted to other uses such as vacation homes, grazing meadows, or recreational areas if suitably located.

The second basic principle of integrated control—"consider the ecosystem"—is of particular importance in the forest environment. The forest ecosystem as implied above is much more diverse than most agricultural ecosystems. Public ownership of and public concern for the forests far exceeds that of any agroecosystem. Our values are many and diverse, and the pest manager must be cognizant of these and include them in his recommendations.

The conventional approach to methods of control is oriented toward procedures or classes of procedure (chemical control, biological control, etc.) and to date, never set forth in an integrated system. None of the classifications of forest insect control differentiate clearly between the ramifications of a course of action and the underlying ecological theory to be served. We are sadly deficient in our understanding of the forest ecosystem, but this lack is being rectified. It seems to me that the tremendous economic growth of forestry in the past has blinded us to the fact that prior to our exploitation of the forests, forest pest problems were much less. In many of those areas that are still relatively undisturbed, problems are usually minimal. Why? It is apparent that the great majority of phytophagous insects never reach outbreak levels, and their numbers fluctuate far below the capacity of food plants to support them. Whatever theory of population regulation you ascribe to, the fact remains that the majority of our pests are man-made. It seems to me that the forests, because of their inherent species diversity (both floral and faunal) and the relatively long time over which they develop, lend themselves to the ecological approach to pest regulation and, conversely, are more susceptible to upset by a strictly unilateral approach. We should have learned earlier from the agricultural entomologists that rarely, if ever, will single factor treatment, such as the use of parasites, predators, diseases, or an insecticide, achieve true regulation of insect populations.

Forest entomologists have, to a considerable degree, been guilty of parochialism in their approach to the problem. They have sought explanation of the eruption in entomological terms rather than ecological. On the other hand, forest entomologists have been responsible for major advances in ecological theory. However, now more than ever, it is essential that we approach each problem insect from a truly ecological viewpoint. The evidence is accumulating that outbreaks of forest insects are symptomatic of ecological disturbances in the forest ecosystems. We now have examples of insect problems occurring as a result of air pollution (*Sinclair 1969*), root diseases (*Stark and Cobb 1969*), possibly excess organic debris, site effects (*Fauss and Pierie 1969*; *Bess et al. 1949*), and probably infection by nematodes (*Ruehle 1969*) as well as the many well-documented causes (*Graham 1963; Graham and Knight, 1965*).

Yet these problems, many known for a long time, have been much less the object of study than the application of insecticides. To effect forest pest management we must investigate the true cause of insect population fluctuations and determine ways of rectifying the underlying problem. This may not be completely feasible, and regulation may be necessary. Regulation may also be necessary while attempting to determine the cause and rectify it, and the ecological approach to population regulation—integrated control—should be our goal. The pest manager should be dedicated to consider all potential techniques relevant to the particular problem, while remaining obedient to practical realities. We are obsessed when faced with an apparent abundance of insects that we *must do* something. Perhaps doing nothing might be the right decision.

We should be aware that many of our problems have their parallel in forest pathology, and the pest manager should not restrict himself. To illustrate this I have selected a few statements from books and papers in forest pathology and forest entomology. I will not identify them or elaborate on them. The message should be obvious.

X	Y
Trees growing on good sites . . . are more vigorous than those on poor sites.	Vigorous trees survived when growing on favorable sites whereas less vigorous trees in same localities did not.
Trees growing under optimum stocking conditions according to age and size are more vigorous than those that are overmature.	The destruction may be reduced by regulation of forest density.
Trees from sapling age to physiological maturity are more vigorous than those that are overmature.	The importance of loss and the irreversible effects of damage increase with the age of the problem.
Uninjured trees are more vigorous than those that have had to withstand injurious influence.	Scarring of trees during logging increases incidence of the problem.

I have tried to convey the concept that, in our task of preventing damage to the forest ecosystem (whatever our value system), we should avoid the trap of merely adopting a new procedural philosophy, i.e., integrated control as a set of techniques. Rather, either individually or in cooperation with others of our persuasion and the resource manager, we look at the entire ecosystem from the viewpoint of resource management in the broadest sense.

Conclusions

Pest management, implied in the use of the human-oriented word pest, deals with the real world. Many of us have a tendency to turn away from a real and immediate problem and approach it from so fundamental a level that we never get back to the problem in time to join in the solution of it.

On the other hand, we tend to think of population oscillation as being made to happen, and we seek that factor that caused it. We ignore the possibility that events happen because some antecedent event, by not happening, failed to prevent that particular oscillation. This may require extremely fundamental work.

This pest manager is an individual who has the ability to consider all variables simultaneously, is sensitive to feedback from tentative calculations, application results, and environmental or social reaction, whatever the source, is capable of assessing strategies for the deployment of time and resources, and is able to perceive the relevance of one fact to another or of hypothesis to fact (*Caws 1969*).

Also, the pest manager should bring together all elements of protection and should be subject to dictates of the forest resource involved. The forest manager should bring together all the potential uses and benefits of the area in question. Man is an animal with ingrained territorial instincts, so we tend to view the forest from our particular territory; for example, lumber producing, fishing area, a place for privacy, etc. Many forests are capable of being almost all things to all people and should be so viewed. The final set of values decided upon for any particular forest or region has a profound influence on pest management decisions.

Forest pest management can be viewed in three stages (*Geier and Clark 1960*).

1. Treatments should no longer be applied blindly according to type procedures inherited from the past or other disciplines, but should be made to conform objectively with the forest ecosystem, local circumstances, and the future.
2. A working knowledge of the natural numerical regulation of noxious species and particularly the identification of existing limiting density factors must be acquired. Regulation of an insect population should be viewed as an exercise in population dynamics.

3. Suppression of intolerable population levels (whatever the criterion) is the ultimate consequence of comprehensive husbandry based on sound ecological fact and theory. The integrated control concept is the embodiment of this philosophy.

Although great creative effort will be necessary, stage 3 should prove to be less costly, invoke less social and ecological repercussions, and be of more lasting benefit than the continued use of present-day methods, which ignore the ecological realities of pest regulation.

Last, I would like to quote the Society of American Foresters policy statement concerning forest protection. Although more honored in the breach than in observance, the philosophy of pest management is contained there:

> Protection commensurate with the values protected is essential to the management of all forest land resources. The Society advocates coordinated, intensive efforts to reduce and prevent forest losses from fire, insects, diseases, animals and other causes. Cooperation among all protection organizations and forest landowners will best achieve the objectives. Prevention is the ideal form of protection and is furthered through strong information and education programs. Public and private forest owners and the general public share the responsibility and benefits of adequate forest protection. The Society endorses programs of integrated protection involving judicious uses of ecological, biological, chemical and mechanical control."

Let us take heed!

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Senator ALLEN. I notice, I believe possibly the first time the word has been used in the testimony, "harmonious control" seems to embrace "integrated control," according to the booklet. Just how does that work?

Dr. STARK. That is in a historical sense. In Europe, in forestry in particular, they have practiced a form of integrated control from the 1600's. And in Europe, in general, they have practically no major forest pest problems as we know them; they do have some small problems but they are not near as destructive as ours. They call their practice of control 'harmonious control."

Then, more or less independently, the concept of integrated control grew in this country, and then by international agreement they decided to drop the term "harmonious control." I think it was at an FAO meeting they adopted the term "integrated control" for all cooperating countries; the two terms are synonymous.

Senator ALLEN. I see. Do you feel that the legislation under consideration would be constructive and that it would serve a useful purpose?

Dr. STARK. Undoubtedly. Not only that, but I believe it is absolutely essential, because, without casting any stones at anbyody, I believe that the way we are structured in our various agencies there just does not seem to be any vehicle at the present time for implementing the type of programs we are talking about.

I was delighted when I heard about this bill and being invited to testify, thinking that there would be, hopefully, a clear mandate to proceed in this direction.

I understand the objectives of the various agencies involved would be in this direction, but I think this would implement and speed up the process. I think this is absolutely essential.

Senator ALLEN. It has to be a completely limited program, actually, with the funding that is authorized.

Dr. STARK. Right. But I do believe it is possible in specific instances. I think, with a relatively limited amount of funds, that certain control mechanisms are available now, due to prior research funding. For example, for 11 years I was with the University of California at Berkeley. We received considerable financing from the National Science Foundation for a population dynamics study of the western pine beetle, which is one of our major destructive agents in ponderosa-pine forests of the Pacific Northwest. These studies gave us the foundation which was needed for a good integrated control program. These include analytical assessment of insect populations, the basis upon which we can evaluate.

This is where I think we have been the weakest in all of our control programs in agriculture and forestry but we are now able to evaluate the success or failure of a western pine beetle control program. These methods include the use of aerial photography and infested tree sampling; from these we are able to determine what the insect population is as of this date.

Then, after we have carried throughout a control program, we can then determine whether we had decreased the population or we had not affected the population.

I do not view this appropriation as something totally new, totally independent of previous events, but as a logical culmination of a sequence of events which had been funded by various agencies, such as the U.S. Forest Service and the National Science Foundation, in basic research leading to the development of techniques whereby we can put into practice the philosophy of integrated control.

Senator ALLEN. Just taking one step further toward implementing this program and having a desirable end result in the field?

Dr. STARK. Yes.

Senator ALLEN. When you develop a resistant host plant, the pest that has been feeding on such plant, it has to adapt to another type of plant or else go out of business; does it not?

Dr. STARK. Right.

Senator ALLEN. So that could well be one of the elements of integrated control?

Dr. STARK. Very definitely so. In forestry I think this is particularly true. I mentioned earlier the ecological diversity of forests. It has been a matter of some wonder to us forest entomologists that insects have done as well as they have, given the natural defense mechanism of forests. The majority of us in forest entomology have come to the conclusion that the reason we have so many forest insect problems is as the result of man's mismanagement of the forests in general.

Again, to stick to an example—because, of course, there are many generalities and many exceptions, but sticking with bark beetles as an example—the pine tree has a beautiful built-in resistance mechanism. These mechanisms include repellent chemicals, a resin system which, when the beetle bores into it, actually drowns the insect in the flow of pitch, and various others. These mechanisms are less effective when trees are grown in too-close competition or when the water table is reduced by unwise location of roads, or by various means. These are controllable by managerial and cultural methods.

The trend toward monocultures, again an imitation of agriculture, a trend towards growing, for managerial purposes, pure stands in very large blocks is a natural situation for an insect to move into. We know, for example, that mixed stands, a stand composed of several species of trees, is more resistant to insects than is a pure stand. We know that in certain densities, trees are more resistant to insects than they are if they are more closely crowded together. We have many such guidelines learned from observing the natural situation.

However, these guidelines—which have been known, as I said, in Europe since the 1600's—have been largely ignored. Along with cultural and managerial methods, we have various biological control methods such as augmentation of bird populations which are important predators of bark beetles; the translocation of important parasites and predators or the actual introduction of parasites and predators; possibly the use of disease; possibly the use of the new chemicals called sex pheromones which have been developed for the western pine beetle and others. These are pheromones which one of the sexes, depending upon species, emits to attract the other sex, and these can be used in various ways to reduce the population.

With the intelligent use of those techniques cited and others, added to the natural difficulty that an insect has of finding its host in a very large forest, we think we can do the job of integrated control.

Senator ALLEN. That is very interesting. I sure appreciate the testimony that you have given us. We appreciate your putting into the record the previous report that you made.

Mr. Lawson, please.

STATEMENT OF F. R. LAWSON, GAINESVILLE, FLA.

Mr. LAWSON. I am very happy to be asked to testify here.

Perhaps, I should clarify my status.

I was formerly director of the Biological Control of Insects Research Laboratory. I retired 6 months ago.

I was very much interested in Dr. Knipling's and Mr. Edminister's statement this morning concerning the Department of Agriculture's position.

I was also amazed to hear them say—they did not actually say they did not need the money, but on the other hand they did not say they needed it.

I feel this official attitude of the Department of Agriculture perhaps does not reflect the feelings of the men in the field, of whom I have until very recently been one. I am quite sure if you ask the directors of laboratories or the men at the bench, they will tell you that they desperately need the money.

One other comment I would like to make in addition to the prepared statement which I would like to put it on the record, although I will not say much about it.

Senator ALLEN. Yes.

(The prepared statement of Mr. Lawson is as follows:)

Mr. LAWSON. In his remarks of May 13 (Congressional Record, vol. 117, No. 70, pp. 1–4), Senator Nelson has pointed out that total reliance on chemical insecticides has resulted in the destruction of beneficial parasites and predators of insect pests and led to the development of insecticide resistance in the pests themselves to the point where serious crop losses have resulted from our inability to control them. I would like to add to the Senator's statement in order to emphasize the potential danger to the world's food supply and health posed by these phenomena and to suggest some ways in which this bill might improve the situation.

The highly successful short-term results of heavy insecticide usage and the long-term failure of this method of control have taught us much about the structure and function of crop ecosystems. Any field of cotton, corn, cabbage or an orchard is not just a piece of land with a certain number of plants per acre, plus a few weeds and some bugs bent on destroying the crop. In reality, it is a teeming ecological universe that supports hundreds or thousands of different species of insects and micro-organisms. Dozens of the insects (nobody knows just how many) feed on the plant and would be pests if they were numerous enough, which a few of them are. Several hundred additional species are parasites and predators that eat the plant feeders and each other. Many of the potential pests are kept at very low population levels by these enemies and even the worst pests suffer heavy losses, commonly in excess of 90 percent.

When one of the potent modern insecticides is applied to these swarming populations, the immediate result is a drastic reduction in the numbers of nearly all insects, both the harmful and the beneficial ones, with a high degree of crop protection. However, if the destruction of the living system associated with the crop is long continued, a pattern of events is set in motion which, if allowed to proceed to the end, may eliminate production of the crop in the area affected. We are now beginning to call this pattern the "insecticide syndrome."

One of the earliest symptoms of the syndrome is the appearance of new pests from the ranks of previously scarce species. This occurs because among so many plant feeders there is almost certain to be at least one that is not much affected by the insecticide. If its enemies are eliminated there is then nothing to keep it in check. The appearance of serious mite damage when DDT was first used on apples was an early and typical example of this. Another early symptom of the syndrome is an increase in the number and severity of outbreaks of the target pests, because the absence of enemies permits a high rate of survival of those that escape treatment or enter the field from outside.

These symptoms of ecological damage can generally be suppressed for some time by the addition of new insecticides and more applications to the spray program, but this does still more damage to the natural control system. In the end most farmers adopt a schedule of "preventive" applications at regular and frequent intervals. By this time all natural enemies have been practically eliminated and their place taken by chemicals. The pressures of natural selection that are always acting on organisms are now channeled mostly in the direction of adjustment to the dominant force in the environment which is now chemicals. Sooner or later some of the pests develop the ability to cope with these materials by changing their own chemistry to become resistant.

Farmers generally counter this development by increasing the dosage and/or the number of applications, but this is at best only a temporary expedient and sooner or later it is necessary to find and use an insecticide of an entirely different chemical family. This may solve the problem for several years, but infortunately the number of chemical families available for use as insecticides is very limited. Excluding the older arsenicals and botanicals, there are now only three classes of insecticides that are generallly useful. Furthermore, the cost of developing and testing new compounds has become so great and possible sales so reduced by factors such as resistance and the public outcry against pollution that the major chemical companies have greatly reduced their research effort at the very time when a number of pests have become highly resistant to all of the available insecticides and we have, in effect, lost the ability to control their populations. This has become a fairly common occurrence and to a farmer trying to cope with bugs he cannot kill, Rachel Carson's dire vision seems all too accurate. The worst case is probably cotton, perhaps because it occupies a large acreage and more insecticides have been used for a longer time than on other crops. In the United States half the insecticide sold is applied to cotton. The first well documented crop failure from overuse of insecticides occurred in the Canete Valley in Peru in 1956, but the problem spread to other countries. According to Dr. Ray Smith, University of California, who has worked in the area, cotton in Central America was attacked by two major and three occasional pests about 10 years ago. There are now eight major pests and many lesser ones in spite of up to 30 applications of insecticide. Information furnished me in 1970 by an official of the national bank of Nicaragua shows a steady increase in yield from 26.2 quintals per manzana (1.7 acres) in 1961 to 41.0 in 1965. After that, the yield declined due to insect damage to only 26.3 quintals. The cost of insecticides was said to be $70 per manzana plus $3–5 for application. The economy of the whole country is seriously affected.

Senator Nelson's statement mentions that cotton production in the Rio Bravo-Reynosa area of northern Mexico dropped from more than 710,000 acres in 1960 to barely over 1000 in 1970 because of resistance in the tobacco budworm. This insect was a very minor pest of cotton prior to the heavy use of organic insecticides. The production lost here was moved to the region between Valles and Tampico. This move entailed digging wells for irrigation, clearing the land and erecting gins and other necessary facilities. The acreage increased from about 4,000 in 1960 to half a million in 1967. The same resistant budworms again appeared and in 1970 only 100,000 acres were planned of which 80,000 were plowed out before harvest because of insect damage. The budworm also caused severe losses in Texas in 1970. Furthermore, this is not the only pest that has escaped from control in this country. The true cotton bollworm, which is also a major pest of corn, tomatoes, soybeans and other crops, cannot be controlled on cotton in the Bradley River bottoms of southwest Arkansas with any of the available insecticides. The same species was studied by Dr. F. D. Parker on commercial sweet corn in Missouri in 1970. One grower had three fields which he sprayed daily with carbaryl or every 2 to 3 days with diiazinon. Dates of harvest and the percent of wormy ears were as follows: July 9 to 16, 41 percent; July 23 to August 5, 64 percent; August 4 to 7, 100 percent.

The Banded Wing Whitefly on cotton in the corner of Texas, Louisiana, and Arkansas, and certain spider mites in Texas are highly resistant to all of the available insecticides. The most serious problem of all may be mosquitoes. Transmission of malaria by resistant species has caused a serious rise in the incidence of that disease in Senegal and Tanzania. The news media in the United States have recently carried reports that some mosquitoes in California have become resistant to all insecticides.

Although in the United States the losses from insects that could not be controlled have not been extensive, except on cotton in Texas in 1970, there is clearly a potential for a much greater problem unless different methods of control are adopted. For example, on tobacco in the Southeastern States, the major pests are the tobacco budworm and the tobacco hornworm. Both were controlled by chlorinated hydrocarbons until countries in Europe set very low tolerances on imported leaf. This has forced tobacco growers to use phosphates and carbamates, both of which are notoriously destructive to natural enemies. There are indications that some populations of the budworm on tobacco are already partially resistant and highly resistant strains are known to be moving east from Texas. It is difficult to predict anything but disaster for tobacco production if the present practices are continued.

It seems quite clear that the unrestricted use of insecticides must soon end. This applies not only to the very persistant compounds such as DDT, which are major pollutants in the environment, but also to those with a short half life and whose major effects are quite local. The effects of these compounds on the natural control system is even worse than that of the persistant materials. It makes very little sense to continue increasing the number of pests that attack our crops, the incidence and severity of their outbreaks and the level of resistance to insecticides if there is any other alternative. After all, insecticides are highly useful materials. Furthermore, the chemical companies' contention that we could not sustain the present level of food production without insecticides is probably true at present. However, I must point out that this statement by itself is also quite misleading because we really need less than half of the amounts of insecticides now used and the rest is wasted.

In the past 10 years, primarily as a result of the increased funds provided by Congress, entomologists in the U.S. Department of Agriculture and the State experiment stations have developed a whole arsenal of new weapons that have little, if any, effect on the natural control system and hence are not self defeating. Examples are the use of radiation sterilized males to eradicate the screwworm from Florida; highly potent attractants to lure pests to their own destruction as in the eradication of the oriental fruit fly from Rota; the development of cheap supplementary food for predators that hold them in the field, thus substantially reducting aphid populations; mass rearing and release of parasites to control the imported cabbageworm; and of predators to reduce bollworms on cotton. One of the most important of these new developments is the production and use of the diseases of insects as living insecticides. Many very promising pathogens have been isolated and tested and two of them are now offered for sale commercially. There have also been improvements in botanical insecticides that do not pollute the environment and there are new cultural control methods, for example the use of strips of alfalfa in cotton to provide a source of predators and trap Lygus bugs moving into the cotton. We also have new varieties resistant to certain pests.

However, many of the new weapons have only been tested on a small scale and will require several years of work before they can be used to reduce the insecticide load. Others, such as the pathogens, are held back by the reluctance of the Food and Drug Administration to pass on their safety. Most of the new methods are highly specific and will control only one pest. Other pests on the same crop must still be treated with insecticides. Because of these limitations, very few entomologists believe that insecticides can be replaced in the near future. We can perhaps look forward to this on the major crops and in forests within 20 years but that is not soon enough to save the bald eagles and the brown pelicans or to prevent the practical elimination of cotton, soybeans, sweet corn, tomatoes, snap beans and various fruits from large areas where they are now grown profitably.

I believe, and I think most entomologists who have studied the situation will agree, that the only way to change our present course in time to prevent serious losses is to adopt a rational system of pest management and integrated control on a very wide scale. This means that instead of highly toxic chemicals applied in any quantity, anywhere, by any persons with money enough to buy them, we must somehow persuade farmers, foresters, and public health officials to use these highly useful but very dangerous materials more wisely and limit applications to places and times where and when they are necessary to prevent real loss or control disease. Many investigators have worked out and tested on a small scale integrated control programs that do this. Indeed, there are probably very few crops where the amount of insecticide now used could not be reduced by at least half with a proportional reduction in cost and pollution. As part of a study conducted by the Scientists Institute for Public Information, I had occasion last year to ask specialists in insect control on several crops to discuss the question of what might be done now, within the limits of present technology, to reduce the current level of insecticide use without drastic reductions in yield. These papers, which will be published in the task force report, show that the production of tobacco in North Carolina would probably be more profitable if growers stopped using insecticides altogether except perhaps for an occasional treatment against a severe outbreak. On cotton in the San Joaquin Valley of California, figures given by Dr. Robert van den Bosch indicate that overuse of insecticides is costing the growers about 5 percent of the total value of the crop over and above the losses that would occur with no control at all. An integrated control program with some insecticides used wisely would save them about 8 percent. The pests of cabbage in Missouri (and probably elsewhere) can be controlled entirely with pathogens with very considerable savings over the present use of insecticides.

On apples in Indiana, it has been demonstrated that a simple monitoring procedure for the codling moth would reduce the number of applications by half. On bananas in Honduras, the establishment of realistic economic thresholds and proper timing of treatments increased the effectiveness of natural enemies and reduced the insecticide load and costs. On citrus in Tulare County, California, the actual cost of insecticide has been reduced from $80 per acre to $15 (plus $25 for supervision) and, near Riverside, the reduction has apparently been greater than that. This has been achieved by expert supervision of control procedures. On soybeans, the problem seems to be less one of reducing present levels of use, although there is a need for that in some areas, than it is of preventing the development of a pattern of overuse. The principal pests of corn in the Middle West are two rootworms. Both can be controlled quite well by crop rotation and are really serious problems only in continuous culture. However, due in part to Government supports, corn is the most profitable crop in the corn belt and growers can make more money by growing it on their best land, hence in many areas continuous culture is the most profitable method of production. The real value of this practice to the farmer and the public, when all hidden costs are considered, has not been determined.

It is clear from these studies that although much research still needs to be done, much of the technical information necessary to drastically reduce insecticide usage is already available but it is not being applied. The gap between technical feasibility and practical application may well be the most refractory problem we have to solve to overcome our present difficulties in insect control. The bill now before this committee sets up pilot field projects where advanced technology can be demonstrated to the people who must use it. This may well be their most important function but they would also contribute substantially to the development and testing of principles of pest management that cannot be evaluated with existing facilities. For instance, we know that many control methods, including insecticides, would be much more effective if they were applied by everybody at the correct time and simultaneously, but these cannot be tested without risking some crop loss on quite a large acreage. S. 1794 provides for compensation to farmers in such cases.

I believe that this is an excellent bill that will contribute substantially to the advancement of research and the adoption of better methods of insect control.

You have heard this morning, Senator, a long list of accomplishments of the Department of Agriculture and the State experiment stations. These are very important accomplishments. Every word you heard about then was quite true.

(End of prepared statement.)

Mr. LAWSON. You have heard this morning Senator, a long list of accomplishments of the Department of Agriculture and the State experiment stations. These are very important accomplishments. Every word you heard about then was quite true. I had a little something to do with this myself.

I would like to point out, however, that in spite of at least a half a dozen major developments that we can now use in the place of insecticides, the situation in the last 10 years has gone from bad to almost desperate.

Senator ALLEN. That is, throughout the country?

Mr. LAWSON. In the control of insects in this country.

Senator ALLEN. Yes.

Mr. LAWSON. Now, this legislation is a paradox. We have spent very large sums; we have major accomplishments, and yet we are in a worse condition now than we have ever been. We have more pests; their outbreaks are coming closer together, and they are more severe.

I have been in entomology 42 years, and I have never heard, in the last 30 years at least, any such statements as Dr. Adkisson made this morning, for example, about the losses in Texas; the people in Mexico who had been wiped out absolutely, gins, wells, crops gone down the drain. This is a discrepancy which bears some examination.

I think that one thing is clear: either the new methods do not work or they are not being applied, and there is no doubt that the latter is the situation.

I had occasion about a year ago in connection with a booklet Dr. van den Bosch and I and others are preparing, to ask a number of people, specialists on certain crops: What could you do now, not tomorrow, now, within the limits of present technology to reduce the pesticide load on your crop?

The answers were these: On apples in Indiana, a simple monitoring system which we know how to set up and has been tested on a small scale will reduce the pesticide load by half.

On flue cured tobacco, the answer I got was: If the farmers would quite using insecticides altogether they would be better off than they are now. If they would use insecticides judiciously, they would be still better off.

Dr. van den Bosch gave me data showing that on cotton in the San Joaquin Valley, the use of insecticides as they are used now is costing growers 5 percent of the value of the crop. If they were used properly, there would be a gain of 8 percent.

On bananas in Honduras, the insecticide rate can be cut by at least half and the cost by the same amount with the same results.

A couple of the men whom I had the pleasure of supervising have worked out a biological control system for cabbage in Missouri, so that instead of insecticides once a week, if the growers will use a pathogen, a bacterium which is now on the market, once or twice in a growing season, they would get the same identical results.

It seems to me that, badly as we need new research, and we must have new methods; they are absolutely essential; it is even more important to begin to use them. That is why I urge you, as strongly as I can, to pass this bill.

Thank you, sir.

Senator ALLEN. Do you think that this legislation is constructive and that it will accomplish a worthwhile result?

Mr. LAWSON. Yes, sir, I definitely do. There is a big gap between research to fill a need and putting it into practice. This is not easy, Senator; it is very difficult.

Senator ALLEN. In other words, this takes all of the research, all of the pilot experiment work of the Department and goes one step further and puts it into use on the farm, under farm conditions?

Mr. LAWSON. Under a workable system. There is a big difference between what I as an experimentor may come up with and what a farmer can apply on a practical basis. This ought to bridge the gap.

Senator ALLEN. Yes. That is a good statement; a good point.

Now, apparently, the Department has not seen fit to take this additional step up to now. Do you feel that this legislation is necessary to get the Department to move in that direction?

Mr. LAWSON. Sir, may I make a small correction. The Department has worked with integrated control systems——

Senator ALLEN. Yes.

Mr. LAWSON (continuing). But we have only been able to work them out on a small scale.

Now, at the present, money is so tight in the Department and there are so many laboratories which need money for good purposes that I think my former superiors in the Department—not Dr. Knipling but higher up yet—feel that other projects are more important. They may be right.

But to answer your second question: I feel that if you are going to get this done, you must mandate it.

Senator ALLEN. That is something the legislation would do.

Mr. LAWSON. Good.

Senator ALLEN. Thank you very much, Doctor. We appreciate your coming before the committee. Your testimony was excellent.

Mr. LAWSON. Thank you.

Senator ALLEN. This completes the hearing for today. Two of our witnesses did not show up, Dr. Newsom and Dr. Anderson. We have other testimony to be adduced tomorrow, and, if they should come in, we will hear from them. We invite those of you who are here today to come back and be with us tomorrow for further testimony.

We will recess now until 9 o'clock in the morning.

(Whereupon, at 2:55 p.m., a recess was taken until 9 a.m., Friday, October 1, 1971.)

PEST CONTROL RESEARCH

FRIDAY, OCTOBER 1, 1971

U.S. SENATE,
SUBCOMMITTEE ON AGRICULTURAL RESEARCH
AND GENERAL LEGISLATION OF THE
COMMITTEE ON AGRICULTURE AND FORESTRY,
Washington, D.C.

The subcommittee met, pursuant to notice, at 9:05 a.m. in room 324, Old Senate Office Building, Hon. James B. Allen (chairman) presiding.

Present: Senators Allen and Chiles.

Senator ALLEN. The committee will please come to order.

There is a quorum of the subcommittee present, so we will proceed with the hearing.

Dr. Barton, please.

STATEMENT OF DR. WELDON V. BARTON, ASSISTANT DIRECTOR, LEGISLATIVE SERVICES, NATIONAL FARMERS UNION

Dr. BARTON. Mr. Chairman and members of the committee, I am Weldon V. Barton, assistant director of legislative services of the National Farmers Union. I am pleased to have the opportunity to testify before the subcommittee this morning in support of S. 1794.

The delegates to National Farmers Union's 1971 convention, held here in Washington, February 24 to 27, 1971, adopted the following statement of policy on the use of agricultural pesticides and other chemicals:

> Farmers Union urges effective regulation—in combination with governmental research and educational programs—aimed at proper use of pesticides, herbicides, fertilizer, and other chemicals if they constitute a source of pollution.
>
> Any new legislation relating to pesticides and herbicides should include recognition of the benefits as well as the risks to man and the environment, and the decisionmaking agency of Government should be required to weigh the recommendations of the U.S. Department of Agriculture, land-grant colleges, and experiment stations to the end that the Nation be assured dependable production of a reasonably priced food supply of highest quality and that the future of the family farm not be jeopardized.
>
> We favor efforts to establish priorities for immediately controlling nonbiodegradable pollution that is hazardous to mankind. Nuisance pollution such as noise and harmless odors should have a lower priority.

S. 1794 is consistent with this policy statement of our membership, and we favor its enactment. We must strengthen our basic and applied research and development programs on the integrated, biological-cultural methods for the control of agricultural insect pests.

The development and usage of integrated methods, whereby we attempt to eliminate agricultural pests by working primarily with biological means from within their cultures rather than by applying chemical insecticides "from the outside," is increasingly being recognized as essential. It is essential for at least two reasons: (1) Because the continuous usage of chemical insecticides and pesticides pollutes our water, land, and other natural resources: and (2) because from a strictly economic standpoint, farmers can be the real losers from the continued reliance on nonintegrated chemical applications.

This second reason—that farmers can be hurt unless we develop biological pest controls—is not to be taken lightly. There is mounting evidence that pests build up resistance as a result of increased chemical applications, which in turn increases the immunity so that larger applications are required. For the benefit of farmers as well as the protection of our natural environment, we must develop integrated pest control methods that can help us to move away from this spiral of chemical pesticide usage.

A substantial effort is now underway on biological pest controls. The Entomology Research Division of the Agricultural Research Service (ARS) of the Department of Agriculture is now spending about $10 to $11 million a year on biological methods; and other divisions of ARS, including the Plant Science Division, also have research and testing underway. In addition, the National Science Foundation is expanding its programs on the problem.

There is real promise that integrated methods can be successful in controlling agriculural pests, especially pests that are not native to the United States. For instance, ARS is currently carrying out an integrated 2-year cotton boll weevil eradication program in Mississippi, using a combination of an initial chemical insecticide application followed by use of sex traps and the release of sterile boll weevils. The fire ant, similar to the boll weevil, is an imported pest, and therefore should be susceptible to a biological eradication program. Certainly the promise of eradication of these two pests alone warrants a stepped-up program of integrated biological-cultural methods.

Farmers Union therefore supports enactment of S. 1794 which, we understand, would place a solid statutory commitment behind more extensive research (including basic research) and development programs for biological controls. Our understanding is that S. 1794 will in no way restrict programs that are now underway in the NSF and USDA, but instead will allow greater latitude in the kind and scope of research and experimental programs that can be carried out.

We have one recommendation for change: the $2 million authorized for the USDA is probably too low to allow very much additional experimental activity. The same probably applies to the $2 million authorized for the NSF. These figures should be increased substantially: perhaps to $10 million for the USDA and $5 million for the NSF.

We recite the fact that when S. 1794 was drafted, the boll weevil project in Mississippi was calculated at a certain cost, and now the actual cost of the project is going to be at least four times the original estimate. The $2 million was derived basically from the original estimates, and since the cost has gone up fourfold, we think the authorization ought to go up at least comparably. This is where we get the $10 million.

This concludes my prepared statement, Mr. Chairman. I would be pleased to respond to any questions you might have.

Senator ALLEN. Dr. Barton, thank you very much for appearing before the committee and giving your personal views and the views of the National Farmers Union. We are always glad to hear from you and from the National Farmers Union.

Dr. BARTON. Thank you, Mr. Chairman.

Senator ALLEN. Even though there seems to be some doubt in the minds of the representatives of the Department as to whether it has the authority to implement this program or like program under their general powers, there could be no objection to specifically authorizing them to carry on this work, if it is a good program.

Dr. BARTON. I do not see how there could be, Mr. Chairman. It is so important that special emphasis be placed upon these kinds of research and upon more larger-scale experimentation in the field than they have going on now, that we feel very strongly the need for a separate statutory authorization. I do not see why the Department would have any objection to getting a stronger legal basis for this kind of research.

Senator ALLEN. The members of the Department on yesterday testified that they felt this was a good program. The only objection they made was the expense involved, the appropriation involved. But you feel the $2 million authorization for the coming fixcal year would be too small?

Dr. BARTON. That is right, Mr. Chairman. You know, research and testing of this kind is really very expensive and it is becoming more and more expensive. In order to really put some teeth into this and get a workable, larger program underway, we think there ought to be several million dollars more put into the program during the first year.

Senator ALLEN. The bill merely authorizes the 2 and 2 for this fiscal year and thereafter for the ensuing 5 years, it would be open end, whatever amount the Appropriations Committee recommends.

Dr. BARTON. This would be certainly good. It could be expanded in future years; however, I still say this is not a new thing that the Agriculture Department and the National Science Foundation are getting into, so they would have to start out with a very small amount. This is an area in which there are on-going programs in both NSF and USDA, and consequently we feel they could use the extra money to good advantage in this fiscal year in broadening those programs and getting more similar programs and experiments underway.

Senator ALLEN. I recall the testimony given before the committee on the proposed pesticide legislation. There was a position of the National Farmers Union in considering the overall pesticide problem, that we not only consider the dangers in the unrestricted use of pesticides, but we also consider the benefits that the use of pesticides confers on agriculture and the ability of our farmers to furnish sufficient food and fiber to supply the needs of the free world.

Dr. BARTON. Yes, Mr. Chairman.

Senator ALLEN. There is a double aspect to the program, is there not?

Dr. BARTON. That is certainly correct, and perhaps in this sense I should refer to our policy statement. What you have said is virtually a direct quotation of the policy statement that was adopted by our delegates. We feel very strongly we should not curb the use of

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insecticides too fast before we have other ways of controlling the pests, which could prevent farmers from producing enough food for the American people. And certainly, we see this as a way of getting ahead of the problem and trying to find substitutes to replace, as we can and consistent with the needs of farmers, the use of chemical insecticides.

Senator ALLEN. It is desirable to move in the direction of reducing and, wherever possible, eliminating the use of pesticides; is that not correct?

Dr. BARTON. Yes.

Senator ALLEN. And if alternate methods can be devised to use in combination with the pesticides, or in time possibly eliminating the use of pesticides, if it is proved that can work, we should move in that direction; is that not correct?

Dr. BARTON. Yes, we certainly agree with that, and we point out that the Mississippi project on the cotton boll weevil, for example, is a combination of first application of insecticides, followed by biological control methods. I think this is what we mean by the idea of an integrated approach, that you work from within. Even though you may use chemical insecticides as a first application, this is followed by biological controls that are intended to make sure that continued application of chemicals will be unnecessary.

Senator ALLEN. I believe it was pointed out in the Mississippi project, the farmers there are using all of their present methods and this is added on top of all of the other methods that they use. Actually, it is not a true integrated system, it is in addition to the present method.

Dr. BARTON. I think it could be described in that way. Mr. Chairman. There is, as you say, the customary use of insecticides during the harvesting season and the biological approaches follow during the the winter with the intention of eliminating the remaining boll weevil reproduction organisms. The intention is that the weevils will not come back the next year so that insecticides will have to be used at the same level as the previous year.

Senator ALLEN. Are not alternate methods of controlling pests and insects being developed all the time by the Department of Agriculture and by the colleges and the scientific community through the country?

Dr. BARTON. Yes, Mr. Chairman. As I understand it, there is research going on all of the time, and testing in the field, so that new methods are being developed.

Senator ALLEN. This legislation would provide the machinery whereby these various methods could be applied under actual farming conditions out on the farm, or in the forest, both included, and the ranches?

Dr. BARTON. That is certainly the way we understand it. We like the provision in the legislation, also, that farmers can be compensated for any loss that they incur to their crops if you have this kind of experimentation on their farms. If the alternate methods that are used in the experiment are not as effective in the short run, there is provision in the legislation for the Government to bail the farmer out, so to speak, and help them to overcome any losses that might occur.

Senator ALLEN. It would be in the nature of a crop insurance, this is what it amounts to. If their yield did not come up to the yield of their neighbors or some similar system could be worked out, could it not?

Dr. BARTON. Yes; if this is tied in to losses that result from the experiments.

Senator ALLEN. Yes; but you would recommend a somewhat larger authorization even for the first year?

Dr. BARTON. This is correct, Mr. Chairman. This is our basic recommendation for change in the bill; that the Department of Agriculture could use to good advantage $10 million from this legislation during the current fiscal year. Since the Department of Agriculture has a larger program in this area, we do not recommend the same size of increase for NSF; we are recommending an increase from $2 to $5 million to the National Science Foundation. We feel they are geared up so they could use to good advantage the $5 million during this fiscal year.

Senator ALLEN. The testimony of some of the witnesses yesterday was to the effect that the insects and the pests are constantly gaining on the human beings and on the methods we have for eliminating and controlling pests and insects.

Dr. BARTON. Yes. We feel that this is certainly the argument for working from within the insect cultures and developing to the maximum extent these biological controls, so we do not just keep pouring on from the outside these insecticides that build up immunity and in turn lead to the need for larger applications of insecticides, and so on.

Biological controls have their best promise of success in the case of imported pests, that is, pests such as the boll weevil that came in from Mexico, and the fire ant that came in from South America. They are not native to our environment, to the United States, and consequently we ought to be able to eliminate them with these biological-cultural methods.

Senator ALLEN. Where you put all of your eggs in one basket, so to speak, and have merely one approach, one method of the control or elimination of pests and insects, that is a much hazardous approach than at least experimenting with an integrated approach.

Dr. BARTON. We certainly think it would be. We think a number of approaches ought to be tried, so that we get the most effective methods of control that have the least cost to the farmer himself, and to the environment in the case of pollution.

Senator ALLEN. Of least cost and of most effect.

Dr. BARTON. Yes.

Senator ALLEN. Thank you very much. We appreciate your testimony.

Dr. BARTON. Thank you very much, Mr. Chairman.

Senator ALLEN. Senator Tunney, I apologize for going ahead with the witness. I was not advised as to just when you were to arrive, although I understood you were on the way. We appreciate your coming before the subcommittee, particularly since you are one of the sponsors of the bill.

STATEMENT OF HON. JOHN V. TUNNEY, A U.S. SENATOR FROM THE STATE OF CALIFORNIA

Senator TUNNEY. Thank you very much, Mr. Chairman.

Senator ALLEN. We look forward to your testimony on this bill, and later on we look forward to your testimony on some other legislation which you are sponsoring, in fact, that you are the principal sponsor of. We are looking forward to having you up here at that time. But we also welcome you before the committee today.

Senator TUNNEY. Thank you very much, Mr. Chairman.

It is a great pleasure to appear before your committee and before you personally, because I know of your great knowledge of the problems that relate to agriculture.

I wanted this morning to introduce a gentleman who is going to be testifying before you later on this afternoon, a person who I think has a great background in the area covered by S. 1794. I am referring to Dr. Harold T. Reynolds, chairman of the department of entomology at the University of California, Riverside.

Senator ALLEN. Yes, sir. Dr. Reynolds, won't you join us?

Senator TUNNEY. Dr. Harold T. Reynolds is an international authority on the chemical control of insects on cotton, a distinguished entomologist and professor at the University of California, Riverside, which is my hometown. He was one of the first scientists to realize that an integrated control program of cotton and other field crop insects was necessary for control methods that would not disturb agricultural ecosystems. He is also interested in the development and use of systemic insecticides.

Born in Manteca, Calif., in 1918, Dr. Reynolds received his bachelor of science degree in entomology at the University of California, Berkeley, in 1941, and his doctoral degree at Berkeley in 1949.

From 1942 to 1946 he served in the U.S. Air Force, with the rank of captain.

He joined the Riverside faculty in 1949 following 2 years as a research assistant at the Berkeley campus. Dr. Reynolds was named professor and entomologist in 1962, and in 1969, he was named chairman of the department.

He is the author of more than 100 technical papers in the fields of entomology, integrated control of insects, and in the development and uses of systemic pesticides.

Dr. Reynolds is a member of the governing board of the Entomology Society of America, and is also a member of Sigma XI, Gamma Alpha, and Alpha Zeta. He is a member of the Party of Experts on Resistance of Pests to Pesticides of the Food and Agriculture Organization of the United Nations; the FAO Panel on Integrated Control, and the Cotton Pest Control Advisory Board of the California State Department of Agriculture.

I think it is very clear from the background that Dr. Reynolds has, he will be able to give to this committee valuable insights which I feel will be very important to the committee in the consideration of S. 1794.

I feel S. 1794 is very valuable legislation. It is going to authorize pilot field research programs for the control of agricultural and forest pests by integrated biological-cultural methods. The purpose of these pilot field research programs is:

1. To develop and test the control of agricultural and forest pests by the employment of integrated biological-cultural methods;

2. To determine the economic and environmental consequences of predicting and modifying agricultural and forest pest population through utilization of multidisciplinary and integrated biological-cultural methods;

3. To develop methods of collecting, handling, and interpreting data obtained from such field research.

This portion of the program would be administered by the Secretary of Agriculture through the Agricultural Research Service. The Secretary is authorized to reimburse farmers and ranchers for any losses sustained as a result of research authorized under this act which is conducted on their lands, crops, or livestock. The bill authorizes $2 million in fiscal year 1972.

Section 2 of the bill authorizes $2 million for the National Science Foundation for fiscal year 1972. These moneys are to be used for expanding their programs of fundamental research on integrated biological-cultural principles and techniques to control agricultural and forests pests.

Biological-cultural control methods are among the most promising alternatives to the current practices of chemical control of pests. With the environmental damage caused by these chemical methods, it is essential that any and all alternative control methods be aggressively sought and implemented wherever possible. Developing resistance to chemical pesticides demands that new methods of control be constantly sought.

The alternatives to chemical pest control are many and complex. This topic was the subject of a 2-day symposium recently held by the National Academy of Sciences. It was agreed that while alternatives are promising, the present state of the art does not permit abandoning established chemical controls. The Academy recommended that a management program be based on utilizing existing methods more efficiently applying insecticides more sparingly and only when absolutely necessary, and using a combination of practices including various alternatives as they may be appropriate.

Alternative methods of pest control identified are the augmented use of nonpersistant chemicals, development of pest-resistant plants, promoting the success of natural enemies of insects, development of increased populations of predators and parasites of harmful insects, development of insect pathogenic bacteria and viruses, use of chemicals which attract or repel insects, or which upset their orderly growth and development through disruption of hormonal systems, and the massive introduction of sterile males so that reproductive success of the insect population is lessened. The latter method has been tried in California to control the pink bollworm. However, more funds for experimentation are needed.

Most of these biological controls are effective in reducing large populations but do not have much success against small ones. Pesticides on the other hand, rarely completely control large populations, but can eliminate small ones. Combination of one or more of these techniques will probably be more successful than the massive administration of any one control method. Another consideration is that elimination of all pests is not necessary for protection of food and fiber, or public health. Simple reductions in populations usually will provide the desired amount of increased yield or protection without overloading natural ecosystems, with toxic materials. Heavy doses of insecticides can kill off necessary predators which would otherwise help to control the harmful insect population. Heavy repeated doses of expensive chemicals are not in the interest of the farmer or are destructive to the environment. Government incentives such as provided by S. 1794 are going to be necessary if we expect our environment to remain a suitable place for us to live and work, without great danger to our health.

Man has always been plagued by pests; pests that endanger his health, pests that disturb his comfort, and pests that spoil and destroy his food. The first human being that gave up his nomadic existence for a cave carried pests into it on his body and in his belongings. Undoubtedly, he also found other pest species left behind by the previous animal occupants after their eviction. As man learned to better survive the winters by storing food, pests of stored food became a major problem. When man began growing crops, he embarked upon a new struggle against pests for survival. Vivid accounts of insect attacks against crops—often accompanied by famines—may be found in the ancient literature of the Hebrew, Egyptian, Chinese, and Greek civilizations.

Over 50 years ago, a famous entomologist, S. A. Forbes, wrote:

> The struggle between man and insects began long before the dawn of civilization, has continued without cessation to the present time, and will continue, no doubt, as long as the human race endures.

Modern technological man tends to assume that all problems have technological solution. There is no foreseeable solution to the battle between man and pests, however, nor is there ever likely to be one. Man may temporarily win a skirmish in that battle, but new pests will continually arise as problems and old pests will find ways to circumvent his control methods. Dr. Forbes' statement thus remains as accurate today as when he wrote it.

Methods of pest control can be said to differ only in their degree of sophistication; they all have a common objective of eliminating pests or reducing them to manageable levels. Man's earliest method of pest control was probably removing lice from his body by hand. Early hunting and gathering societies developed more advanced means of pest control for their protection. The Cahuilia Indians near Palm Springs, Calif., for example, learned to store food in granaries mounted off the ground. They also set fire to the palm trees every few years to destroy the insect pests that competed with them for the fruit of these trees. For thousands of years, however, efforts to cope with insect problems were feeble at best, and man was forced to share his habitat and much of his food supply with insects. It wasn't until the late 19th century that our accumulation of knowledge about the habits of pests—their life history and ecology—plus a steadily advancing technology provided us with reasonably effective means of protection.

Most of us today live in relatively synthetic environments and are reminded of the existence of pests only when an annoyingly obtrusive fly causes it to reach for the flyswatter. Few people understand the nature and extent of past damage. Even fewer people understand how complex problems with insects can be or why we can't simply solve these problems once and for all.

About 75 percent of all known kinds of animals on earth are insects. We can only guess about how many distinct species are already known, but estimates range from 750,000 to 1 million kinds. Many entomologists believe that there may be from 2 to 10 times this many insects if all species were known. The truth is nobody knows. It has taken literally millions of years for so many species to develop and there are fossil records of insects with fully developed wings dating back to the upper carboniferous period about 250 million years ago. In the immense period of time since then, insects have evolved to occupy nearly every conceivable environment possible to sustain live. Thus, when a farmer plants a seed in the ground, there is a complex of many different species which may attack it in all the various growth stages after emergence of the plant. Furthermore, whatever the marketable commodity may be, another group of insects are available to attack it in storage also.

Nobody can accurately guess the total damage caused each year by different kinds of pests. We may be able to arrive at some economic estimates for losses to various crops, but how can a price tag be placed on the annoyance created by a mosquito buzzing about one's ear or by ants in the kitchen or picnic basket? Nor can be put a dollar value upon the misery and productivity lost over a lifetime by the debilitating effects of a nonfatal case of malaria or some other disease.

Perhaps the most complicated way in which insects cause injury to man and animals is as carriers of disease organisms. With our high standard of living in the United States, we tend to forget the scourge of such insect-borne diseases, which sometimes reach epidemic proportions, as bubonic plague, black death, malaria, typhus, yellow fever, sleeping sickness, encephalitis, filariasis, and about 25 more. Only a few years ago, about 200 to 250 million clinical cases of malaria, a protozoan disease carried by certain kinds of mosquitoes, occured each year in the world, and about 2.5 million people died from it. Many areas of West Africa even today are lightly populated because fo the tsetse fly which transmits African sleeping sickness. One epidemic alone in Asia Minor several centuries ago of the bubonic plague is estimated to have killed 100 million people. A major typhus epidemic is believed to have been averted in Europe at the end of World War II, only because heavy treatment of DDT were applied to bodies and clothing of refugees and people living in crowded, substandard housing. Animals both domesticated and wild are similarly subject to insect-carried diseases. And while we may find means to control or reduce to manageable proportions many diseases, there is always the threat of invasion of new diseases, such as the equine virus that has recently moved up from South America into Texas where it threatens both horses and man. California is currently facing difficulty in controlling the mosquito population. Thus, even in our highly sanitized society in the United States, it is only through the constant vigil and efforts of organizations such as the public health agencies that serious and occasional epidemics are averted or controlled. Many countries in the world do not have such effective organizations, and the toll of diseases transmitted by insects continues to be incalculable.

A similar situation exists in agriculture and in household backyard gardens and ornamental plantings. Estimates of losses caused by pests are notoriously inaccurate, but in the case of insects, are widely believed to result in a 10 to 20 percent loss of the gross agricultural production of the United States every year. Agricultural losses may range from very little to almost all of a crop. Small losses from insect pests may be scarcely noticed by individual farmers. Multiplied over thousands of acres, however, they amount to millions of dollars. It has been estimated that the total loss each year to agriculture in the United States from insect pests is at least $7 billion. These losses occur despite our use of our most advanced control methods and modern technology.

For thousands of years, man has searched for remedies to protect himself and those things he values, from insect attack. Among methods man developed to reduce pests in crops were those that rendered the environment unfavorable to pests, such as draining or flooding land or pruning vegetation to reduce foliage density. Other cultural practices against pests have included eliminating diseased or infected plants from fields, rotating crops, removing plant debris harboring pests, and planting crop varieties known to be resistant to certain pests. In the late 19th century, the accidental discovery of the Bordeaux mixture in France touch off what has been called the squirt-gun period of crop protection. In the United States, one of the most spectacular demonstrations of biological control in agricultural history came about in 1889, when the ladybird beetle was imported from Australia as a weapon against cottony-cushion scale in citrus groves. The early 20th century was a period of intensive experimentation, as scientists found more and more chemicals that could be used in the war against pests.

Then about 25 years ago, the newly developed synthetic organic insecticides, beginning with DDT and benzene hexachloride, opened a new era in man's ability to kill pest species. The results of their application were frequently so spectacular that they were soon widely and repeatedly used in many areas of the world for public health and crop protection. Entomologists were able to successfully prevent quality and quantity losses of food and fiber of many species for the first time in human history. The use of these new compounds from the laboratories of industry usually resulted in dramatic improvements in existing control measures. The means were finally available for controlling and possibly eradicating diseases such as malaria in some parts of the world. The World Health Organization estimated the new insecticides, particularly DDT, saved tens of millions of lives, and that the socioeconomic consequences of ridding areas of the debilitating effects of such diseases was equally, or more, important than the saving of lives. In the field of crop protection, results were equally miraculous. Apple crops, even with the best applications of lead arsenic, had still remained up to 12-percent worm ridden. Even with fewer applications, DDT reduced that damage to as little as 1 percent or less. Alfalfa seed production was increased by 10 to 15 times that possible before DDT. Hundreds of such examples might be listed. It is little wonder that farmers, public health officials, foresters, and many others eagerly accepted and added the new weapons to their insect control arsenal.

Unfortunately, the new insecticides were viewed by many people as a panacea for all of our best problems. They were applied heavily and often indiscriminately, and it was only gradually that the limitations and problems involved in their use became increasingly apparent. Literally hundreds of new compounds were developed and evaluated on a wide variety of pest species attacking man's crops and infesting his environment. Many entomologists devoted the major portion of their time to evaluate the new chemicals, often at great sacrifice to research concerned with the more basic aspects of plant problems. Perhaps the situation can be said to be somewhat analogous to a man who purchases a complex new tool to use on weekends and in his spare time. Only as he works with the tool and develops some skills does he gradually discover the limitations of its use and the potential problems which follow misuse.

Scientists have learned a great deal in the past decade about the use of chemicals for protection against pests, and it is now apparent that the use of chemicals as an almost unilateral approach to pest problems is not the total answer. Controlling pests must be an exercise in applied ecology. Insects and related species live in complex ecological systems, and even in the agricultural field they represent part of a dynamic and remarkably adaptable complex.

It is not desirable to consider a single pest species without analysis of its role in this complex ecological system and the potential impact of population reductions and the means of obtaining such a reduction upon the entire system. Pesticides are most valuable tools when used properly and in the context of the entire ecological system of an environment, but they are not ultimate solutions to pest control. Their widespread use has brought a number of pressing problems, including pollution caused by toxic chemical residues and the development of insect resistance to such chemicals.

Our knowledge of pest management techniques has entered a critical period. Without marked improvements in agricultural production and in controlling pest species, it will not be possible to catch up with increasing demands of a rapidly expanding population in a world where millions of people go to bed hungry every night. Pest control is only one avenue to maximum crop production, but without it, the spectacular advances made in recent years by the geneticist, the agronomist, and other protection and production personnel in agriculture cannot be realized.

What is the answer to this complex and aggravating problem of pest control? Scientists at the University of California and elsewhere are convinced we must learn to manage our insect and other pest populations through a variety of integrated techniques. They define integrated pest control as:

> A pest population management system that utilizes all suitable techniques in a compatible manner to reduce pest populations and maintain them at levels below those causing economic injury. Integrated control achieves this idea by harmonizing techniques in an organized way, by making the control practices compatible, and by blending them into a multifaceted flexible evolving system.

The integration of biological control methods with chemical controls has been stressed to date in several successful integrated control programs. This emphasis on using both biological and chemical methods in an integrated manner is necessary because these two means are our main resources in the struggle against insect and mite pests. But we must go further than that. We must develop methods that integrate not only chemical and biological control techniques but all other control procedures and agricultural production practices that man has developed through the ages into single systems approaches aimed at profitable production of high-quality products in a manner not inimical to our environment.

The entomological society of America in a recent statement declared that our "goal should be to limit control efforts to those necessary to accomplish these objectives in the most economical and scientifically justifiable manner rather than merely to attempt the reduction of insect populations to the lowest achievable levels." These objectives must be accomplished with a minimum of undesirable side effects. When chemicals are necessary, they should be selected carefully and applied in a manner least disruptive to nontarget organisms and the total environment.

Both the U.S. Department of Agriculture and in the many land grant universities across the Nation there is at present increasing research upon methods of insect control that do not rely upon the use of insecticides at all or at least not in the classical sense. The potential value of such alternative control methods (for example, the sterilization and release of males of a pest species to reduce insect populations in the field) has been demonstrated to be effective even if their full potential sometimes is not realized for many years.

Many research centers in the United States and throughout the world are deeply involved in an attempt to utilize recent exciting breakthroughs in insect phusiology, biochemistry, and other areas, including efforts to develop practical pest protection programs through the potential use of pheromones, hormones, and other so-called alternative methods for management of pests. In the department of entomology at the University of California, nearly one-third of the total research effort is now devoted to biological control methods, and a large portion of other staff members are devoting their efforts to development of pest management programs for many of the important agricultural commodities produced in the State of California. In general, however, technology has not advanced to the point where such programs can be put to a high degree of practical utilization. Our knowledge is still highly theoretical and funding for the most part is insufficient to enter upon the developmental and operational pilot programs necessary to perfect successful integrated pest control systems.

There have, however, been a number of successes. In California, for example, the grape leafhopper in recent years developed resistance to the organophosphates regulaıly used for control. It was noted that the wasp actively attacks the leafhoppeı, but only during the latter part of the growing season, which leaves the young grape leaves open to leafhopper attack early in the season. When wasps were absent from grape vineyards, they normally were attacking another leafhopper on blackberry bushes some distance away. Blackberry bushes were once grown in the vineyards, but they were looked upon as weeds and in recent years have been killed with herbicides. The result was a decision to reintroduce blackberries in vineyards. This gave the wasp an alternate prey which kept the wasp population around the vineyards high enough throughout the season to effectively control the grape leafhopper.

Another successful type of integrated control has recently been discovered in California in alfalfa, where the spotted alfalfa aphid becomes a problem when large tracts of alfalfa are cut. Instead of disrupting the environment with a broad spectrum insecticide that also kills beneficial insects, many farmers are now harvesting their fields in strips, thus leaving refuges in the unmown strips for the natural enemies of the aphid.

A third recent example of use of integrated control methods is in the Canete Valley in Peru, where modern organic-synthetic biocides were first introduced between 1949 and 1956 to control seven major pests of the chief crop, cotton. At first cotton yields increased dramatically from 406 to 649 pounds per acre. Then in the mid-1960's, the yield began dropping drastically as several of the insect pests developed resistance to chemicals. The solution was to adopt a variety of control measures and to rely only partially on chemical controls. By varying the control methods, cotton production was once again increased.

One hears a great deal about biological control methods these days and many young people who are interested in ecology and solving our problems of the environment have a fanciful idea that we could solve our pest problems tomorrow if we would rely totally on biological control methods. Most entomologists are aware, however, that the situation is much more complex and that our main resources in the never-ending struggle against pests will continue to be beneficial insects, insect diseases, cultural controls, and the use of insecticides. In other words, integrated control methods.

Why not complete dependence upon biological control? Well, for one reason, the effectiveness of biological agents vary widely under different situations. All but the most sterile agricultural environments have biological agents which influence pest populations. Their effectiveness varies from area to area, from season to season, and is greatly influenced by the length of crop cycle and the active growing season. It should be recognized that many potential pests of crops are normally kept below damaging population levels and that many primary pests are successfully regulated by these biological control agents much of the time. The ever higher quality and quantity of agricultural produce and the competitiveness of crop production by the farmer and demands by the consumer, however, continually impose greater pressures upon such biological control agents. Such demands simply cannot be met all of the time or rapidly enough much of the time, nor do conventional biological control agents in the crop environment succeed in solving all pest problems that may arise. In many situations, when beneficial insects fail to sufficiently repress pest populations, it should still be remembered that without such biological control agencies in the environment it is doubtful if farmers could long supply marketable produce even with the aid of pesticides. The high level of quality and quantity of agricultural production demanded by society has become impossible without some use of pesticides. At the same time, however, the failure of natural enemies or beneficial insects to keep a given pest population under economic levels should not lead to the use of control practices that disrupt these natural enemies or other beneficial species in the environment. Thus, we must continue to recognize that there will continue to be a role for pesticides in agriculture, but we must also develop integrated pest control techniques that make use of chemicals as only one of a number of tools without disruption of the ecological systems in our agricultural production areas.

The concept of integrated control systems for pest management still is relatively new, difficult for some scientists to think about, and even more difficult for many farmers to consider. Many farmers think in terms of an immediate solution—because they are primarily concerned with this year's crop—and thereby an easy mark for the promises held out by their friendly neighborhood chemical salesman. When an insect pest develops resistance to a chemical, he is most likely to turn to another chemical, perhaps creating a new array of pest problems a few years down the road: the familiar problems that the unilateral chemical approach has encountered: problems with resistant strains of pest insects, rapid resurgence of pest populations, and secondary pest outbreaks and toxic residues.

At present, the farmer must make a decision on how to protect his crops. The decision to employ a pesticide may be the only solution available to him—or there may be a better solution of which he has no knowledge. During the past decade, there has been extensive support of studies of ecosystems and of basic research in fields supporting pest control. We have already acquired much of the knowledge we need for biological inputs for a broad ecological approach to pest control. What is needed, however, is more multidisciplinary research among the various scientific disciplines upon the development of control strategies and support of pilot studies on integrated control approaches to pest management that are based on systems analysis of specific agricultural ecosystems.

This means that we need to know much more about the economics of crop production relative to pests and pest control and economic injury levels relative to individual pest species so that we can define the required intensity of population regulation. We need to know more about the dynamics of pest populations relative to mortality factors already operating in crop ecosystems so that we can predict future population trends and determine the most effective methods to be employed in modifying or manipulating environments. Finally, we need to evaluate methods of control available for use in specific ecosystems to determine which are most useful and to harmonize these into existing pest management systems.

The ideal pest management systems of the future will be dynamic and have great flexibility. This means that we will need to develop monitoring systems that make it possible to dispense with one control technique when its usefulness has passed and add new techniques to the system as they become necessary. The development of such integrated pest management systems will require a new sophistication on the part of farmers and others in agro-business. Yet without such sophistication and without marked improvements in agricultural methods and production it is doubtful that civilization can survive. We are entering a period in the history of civilization in which, according to Dr. B. R. Sen, director-general of the Food and Agricultural Organization, total food supplies of the developing countries will have to be increased fourfold to give the world's vastly increased population an an adequate diet. Critical to the success of that effort will be the development of integrated pest control programs that rely on basic ecological principles.

Therefore, I would reiterate my support for early enactment of S. 1794. I feel that the Congress must commit sufficient funds—quickly—to develop effective and environmentally compatible methods of pest control.

I would just like to say one additional thing that is a matter of personal experience. I am not anywhere near an expert in the field, I would not say that I am even a well informed layman; but I do have some degree of understanding of the problem through personal experience in representing, as a Member of Congress and now as a Senator, a great agricultural region in the country. As a congressman, I represented Riverside County and Imperial County.

I recall a few years ago when the pink bollworm first came to Imperial Valley, the farmers of that area were anxious to have the Government help them with a pesticide program. I appeared before the House Appropriations Committee, before Congressman Jamie Whitten, in order to get some additional funds, supplemental funds, which could be used. We were able to increase the budget by $750,000 and all of those funds were used in the Imperial Valley, to the best of my knowledge. They had planes flying over the cottonfields and, as I recall, they had about 12 applications. Subsequent to the applications of that pesticide for the pink bollworm, we had havoc in the Imperial Valley in all other crops as a result of the natural predators, insect predators, being killed off as well as the pink bollworm.

When you upset an ecosystem such as we did at the time of the application of these heavy doses of pesticides, it does produce these very detrimental effects in the ecosystem.

I, for the first time, became aware of it, because the farmers then came to me and asked me for help in other areas, in how could we control these other pests that suddenly appeared which had not been a problem before.

So I can only speak from personal experience and not as an expert, but somebody who is very deeply concerned about the environment, that we do something to promote a cultural controlled program. I think this legislation does it.

I want to thank you very much for giving me the opportunity to appear before you.

Senator ALLEN. Thank you very much, Senator Tunney. We appreciate your appearance and appreciate this fine testimony you have given. Since the statement has covered the field extremely well, I do not believe I will ask any further questions. You do feel that this is a step in the right direction, looking toward the control and elimination of pests and insects, devising effective methods and the least expensive methods. That is the purpose of the legislation, is it not?

Senator TUNNEY. Yes; it is. My understanding is that that is the purpose, and I think it does need this kind of identification by separate authorization.

Senator ALLEN. There is one point you make especially on the need for integrated systems, you point out that the biological control might be effective mainly against large populations of pests and insects, whereas the pesticide or the insecticide would be more effective against small populations. So rather than having an overkill with insecticides and pesticides, under this system, you could use a small amount of the chemical and integrate that with the biological control and in that way get at the problem better than resort to only one method.

Senator TUNNEY. That is my understanding, and I think that such an integrated system is needed. In my conversations with experts in the field, they have, with a degree of unanimity that is rare, indicated to me that this was important, an integrated system.

Senator ALLEN. The Department witnesses on yesterday stated that they felt it was a good program. But I asked the question of the Department witnesses, if possibly their reluctance to having specific legislation might be traced to the fact that any Federal agency or bureau, which is assigned general supervision or control of a subject or an area of activity, does not like to have Congress come along and mandate something within their field, apparently feeling that that would point up a lack of proper handling or their area of activity. They were a little bit hard put to give a contrary answer to that.

I rather believe that is the only reason that they could object to this, if they are charged with this duty already and they have not gone this far in their approach.

Senator TUNNEY. That is interesting.

Senator ALLEN. This mandate set this activity and this program upon their Department. So there could be no harm in specifically mandating this activity on the part of the Department.

Senator TUNNEY. I think it also, perhaps, gives the Congress a better opportunity for oversight.

Senator ALLEN. Yes; I think that is quite true. That would be a very constructive effect of it, it would seem to me.

So, in your judgment, this is a constructive approach to the problem, looking toward a lessening of the use of pesticides and better protection of the ecology?

Senator TUNNEY. Precisely. Yes, Mr. Chairman.

Senator ALLEN. Thank you very much.

Senator TUNNEY. Thank you very much, I really appreciate it.

Senator ALLEN. We would be glad to hear from you at this time, if you wish, Dr. Reynolds.

Dr. REYNOLDS. My testimony is just now being typed in Senator Tunney's office. It might be ready this afternoon.

Senator ALLEN. Mr. Stalbaum, please.

STATEMENT OF LYNN STALBAUM, ASSOCIATED DAIRYMEN

Mr. STALBAUM. My name is Lynn Stalbaum, appearing today as the spokesman for Associated Dairymen, Inc., with offices in Washington, D.C.

Associated Dairymen is composed of two large Midwest dairy cooperatives. They are Associated Milk Producers, Inc., whose main office is in San Antonio, Tex., with over 43,000 dairy farmer members, and Mid-American Dairymen, Inc., of Springfield, Mo. with over 20,000 dairy farmers. Producing nearly 20 percent of the Nation's milk, the two groups have members in about half of the 50 States, mostly throughout central United States.

We support bill S. 1794. While we support it for many of the broad reasons expounded by others, permit me today to give the specific reasons why those who produce milk are vitally interested in this legislation and this type of research.

To my knowledge, milk is the only agricultural commodity for which the production location is subject to Government inspection. This inspection takes full cognizance of adequate pest control but it also prohibits contamination of milk by the pesticides.

In the U.S. Public Health Service, 1965, "Recommendations for a Grade A Pasteurized Milk Ordinance" it is stated:

> Effective measures shall be taken to prevent the contamination of milk, containers, equipment, and utensils by insects and rodents, and by chemicals used to control such vermin. Milkrooms shall be free of insects and rodents. Surroundings shall be kept neat, clean, and free of conditions which might harbor or be conducive to the breeding of insects and rodents.

Note that we are obliged not only to prevent the contamination of our product by the pest but also by the pesticide.

Language virtually identical to that which is quoted above is found in every grade A milk ordinance in the United States.

Senator ALLEN. Those are not unreasonable requirements, are they?

Mr. STALBAUM. No; they are not. We have no quarrel with these. They are checked, and certainly our farmers long ago accepted them and produce under them.

Compliance with that portion of the law regarding pests is not too difficult to observe. When a milk inspector visits a dairy farm—and I might add they visit them at least twice a year—he can readily note visually whether or not adequate efforts are made to keep flies and other insects under control. If he notes inadequate efforts, the farmer has his grade A milk permit suspended until the farm is in compliance on this point.

That portion of the grade A milk ordinances dealing with pesticide contamination, except in the most flagrant cases, is more difficult to detect.

For, in many instances, the chemical-type pesticides are absorbed and stored by the dairy cow in the fatty tissues of her body whence they are slowly transferred to the milk which she gives. As a result this type of contamination cannot be detected until the milk is checked, often after it has left the farm and started to move into commercial channels.

Indicative of the recognition of this problem is the fact that since 1965, dairy farmers can obtain indemnity for loss of their product due to pesticides when the contamination is not the fault of the farmer. In 1970, this was extended to dairy plants, and currently there is legislation pending to extend the indemnity program to dairy cattle (H.R. 10630).

Payments under this program have been as follows: 1965, $260,937; 1966, $149,705; 1967, $274,818; 1968, $193,641; 1969, $111,385; 1970, $179,800.

Illustrative of this type of problem is a situation which developed in Texas early this year where dairy feed was packaged in bags which had previously been used for rice. For this instance, the filled bags were dipped in a pesticide solution when they contained the rice seed. The bags, because of their size, were found ideal for bulky dairy feeds but milk contamination resulted.

Attached is a copy of the memo draft sent out to the feed industry in Texas by Texas A. & M. University. It is appended. Mr. Chairman, at the end of my statement. One sentence in it sums up the problem we have:

> The residues, of course, in turn contaminate the feed thus, rendering it potentially injurious to the animals and converts to the milk, which in the case of dairy animals, provides the opportunity for harmful effects to people who drink the milk.

While the indemnity program serves a useful purpose in compensating farmers for their loss it is far from the most satisfactory way of meeting this problem. It, in effect, is locking the door after the horse is out. Or perhaps we should say that it is locking the milkhouse door after the milk is out. No farmer wants to go through the loss of his market, the inconvenience of getting cleaned up, and the possible necessity of disposing of part of his milking herd. Like most indemnity programs, this one cannot possibly cover every contingent loss which a farmer has.

Mr. Herring, your next witness, a Texas dairy farmer, will give you a good first-hand report on the problems one encounters with pesticides.

Digressing from my printed statement, Mr. Chairman, I visited with Mr. Herring this morning and found in their instance, they had never used the pesticides and have had tremendous dairy losses because of contamination from other sources, which, as he will explain it, have been most difficult to trace.

During the past 2 days, I was at another meeting, and heard a State Senator from Mississippi tell of a friend of his in the broiler business, who had found his broilers contaminated with diolefin (?) and as he so succinctly stated, the farmer said, "I didn't put this on the plate for the broilers to eat, it comes from other sources." And he again is having the problem, not of his own doing, but someone else's. Nonetheless, the broilers are contaminated.

Last year the dairy industry was given a bit of an alert by a Federal appellate court here in Washington, on DDT tolerances in milk. Though the FDA requirements for permitted DDT in milk are extremely restrictive, the court required FDA to hold hearings on why this tolerance for DDT in milk should not be set at zero. Most of us feel that the persistence of this chemical and the physical nature of the cow make a tolerance of zero at this time a virtual impossibility. For the foreseeable future, we can expect tests to show minute traces of this chemical in virtually all milk.

I mention this, because to me it affirms the fact that our best efforts should be directed toward not using these types of chemicals and toward finding alternate methods of getting the same job done.

For where will the continued use of chemical pesticides in the production of milk lead us? If we have reached the stage where we may have to accept a trace of DDT in milk, what other chemicals might soon join in it being persistently present? It is here that our path joins up with that of the environmentalists and others who say "There must be a better way" to accomplish the control of pests than to use chemicals.

To us that is what bill S. 1794 is all about. It is an effort to focus direct attention on this problem—not just for dairying but for all of agriculture. It recognizes the need for field research as evidenced by its first paragraph which reimburses farmers for losses incurred in research under it, in addition to supporting laboratory research.

A few weeks ago it was my pleasure to visit the dairy research center at Beltsville. At that time I was shown some of the work which they are doing on alternatives to chemical pesticides. Since then, in conjunction with these hearings, and at my request, they have sent me considerable material on their research activities in this area, including an excellent summary article by Dr. Hoffmann.

But I believe the problem is so great—and the time is so short—that this research should be greatly expanded. As is true of most research what has already been done at Beltsville and elsewhere can serve as a base for a more comprehensive program, including going out into the filed, to concentrate on this pesticide problem.

In summary, gentlemen, the dairy industry has a unique problem in the use of pesticides. By public health regulations we must keep both the pests and the pesticide under control. The cow, however, refuses to cooperate. Once these chemicals have entered her system, she insists on transferring them to her milk. To overcome these problems which the dairy industry and dairy producers must constantly face, we wholeheartedly support research to find new ways of controlling pests other than with the use of chemicals.

(The attachment follows:)

Texas A. & M. University,
College of Agriculture,
Texas Feed and Fertilizer Control Service,
College Station, Tex.

Feed Industry Memorandum No.—, Reuse of Bags Contaminated With Pesticide Residues

On the basis of experience and information from reliable sources there is evidence to indicate that certain commercial feeds, and particularly those which are packaged in bags or containers that have previously been used in the transportation of products such as planting seeds, are contaminated with pesticide residues. This appears to be more prevelent in bags that have contained treated rice and grass seed. Contamination also extends to other bags which are warehoused or stored in close proximity with the contaminated bags. The residues, of course, in turn contaminate the feed thus, rendering it potentially injurious to the animal and converts to the milk, which in the case of dairy animals, provides the opportunity for harmful effects to people who drink the milk.

This practice violates Section 8 and other provisions of the Texas Commercial Feed Control Act of 1957.

The purpose of this letter is to request the immediate, voluntary discontinuance of this practice. The members of the inspection staff of this department will commence investigations in this area and will, after providing an opportunity for compliance, apply detainers to any products where there is reason to believe that the opportunity for contamination exists. Detained products will be released only after an analyses of a sample indicates the absence of pesticide residues We hope this procedure will not be necessary.

The usual fine cooperation of the industry is earnestly solicited.

Senator Allen. Thank you, Mr. Stalbaum. I appreciate your testimony, appreciate your coming for the committee.

Now, pests that would attack a dairy farmer's field would vary according to sections of the country, would they not?

Mr. Stalbaum. Yes; there are certainly different pests in the southern climate than you would have in the northern climate, and so forth.

Senator Allen. How are the pesticides applied to a field; to a field of grass?

Mr. Stalbaum. Mostly sprayed in the area that I come from, in large sprayers. And, of course, as I attempted to point out here, I think the dairy farmers in many instances are aware of the hazards, potential hazards they have, but they are sometimes at the mercy of neighbors and other factors they cannot even recognize in these sprays getting into their milk.

Senator Allen. Well, now, once a pasture is sprayed, would that field or pasture be closed up for a time?

Mr. Stalbaum. Yes, sir; it would. However, if they are spraying crops, they do not do it at a time when it is going to move into the milk. If they spray a feed crop, certainly, it is long before the harvest and can be washed, naturally. The same with pastures. They keep the cattle away from it.

Senator Allen. It looks like there is an added hazard then on the use of pesticides and insecticides in pastures as distinguished from just growing crops because the grass is taken directly into the cow.

Mr. Stalbaum. This would be true. I would believe that many of the dairy farmers would avoid spraying their pastures because of this problem, but where they do, they certainly would fence this off and keep the cattle out. So I guess we can say the dairy farmer has three areas of concern: (1) the pest control around the environment of the area where the milk is produced, the milking barn, and so forth,

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(2) the crops which are grazed by this animal, and (3) the same problem the others have of the sprays on the other harvested crops. He takes it from three different angles.

Senator ALLEN. Yes, sir.

So you feel that the pending legislation would be a step in the right direction toward reducing the amount of chemicals that might be used in growing crops or in growing grass in pastures?

Mr. STALBAUM. Not only that, but also in areas around the milk-houses, barns, and so forth. As I mentioned, I had visited Beltsville—I did not detail my visit—they had a number of experiments in this area. I think this is excellent.

This can be the start for further research. This would permit them to get in the field, as you and Dr. Barton discussed earlier this morning, where a farmer would cooperate in the research.

As I was talking with Dr. Barton, since he appeared, here I said the farmer has a calculated risk. There is a provision here to indemnify him for his risk. Because if you are going into research, there is no assurance you may not have some bad side effects. We may kill all of the pests and kill all of his crop.

But we want to move out of that area and permit what has been done in Beltsville, and greatly expand this program and speed it up. I feel here my testimony is not different in that than any other, and certainly therefore the dairy farmers support is as they do.

Senator ALLEN. I notice the payments under the indemnity program for dairy farmers has not been too large. Are these nationwide?

Mr. STALBAUM. These are the national totals as given to me by USDA. Of course, they vary from year to year.

Bear in mind, none of these covered milk plant indemnities because that was only started in 1970. So that would undoubtedly increase the total for 1971.

Senator ALLEN. I notice in 1969, $111,000; 1970, $179,000. Then that figure is considerably less than the first year, 1965, $260,000.

Mr. STALBAUM. You notice the figures are quite erratic. Mr. Herring, the next witness, has received some of the indemnity payments, as he will indicate in his testimony.

I think what you are running into there in part is the fact we are getting larger diary farms, and when the farm is off the market, they are indemnified for all of their milk.

If it is a larger farm, certainly the payments will be larger in proportion to the others. I think it is sort of a where-does-it-hit type of of thing, as to the size of payments that have been made.

Senator ALLEN. Is there a reluctance on the part of the dairy farmers to apply for this indemnity——

Mr. STALBAUM. Not that I know of.

Senator ALLEN (continuing). As possibly being bad advertising, that the milk from their herds is contaminated?

Mr. STALBAUM. Not that I know of. Usually this ability to get money offsets many adverse factors.

Senator ALLEN. And they probably do not advertise when a claim is being made?

Mr. STALBAUM. I think that is true. Nonetheless, it still shows, even though the payments are not extremely large, that we still do have the problems. And bear in mind, they can only apply if these contaminations are through fault other than their own. If they are spraying around the milkhouse with a pesticide and this is a contamination, I think they would have a hard job proving it was someone else's fault, even though they have been very careful.

Senator ALLEN. I have no further questions. I sure appreciate your coming before the committee and giving us this testimony. It is very helpful to us.

Mr. Herring, please.

STATEMENT OF HENRY HERRING, PRESIDENT AND MANAGER, H. & D. DAIRY, CLINT, TEX., REPRESENTING THE ASSOCIATED MILK PRODUCERS

Mr. HERRING. My name is Henry Herring. My address is Post Office Box 156, Clint, El Paso County, Tex. 79836. I own 49 percent of the stock of H. & D. Dairy, Inc., of Clint, Tex., and am president and manager. The other major stockholder is also 49 percent stockholder in Trans-Pecos Dairy, Pecos, Reeves County, Tex. The two dairies, though 185 miles apart, are similar operations. Each milk approximately 500 cows.

I am appearing today as a concerned dairy farmer and on behalf of Associated Milk Producers, Inc., which headquarters in San Antonio, Tex., and which markets approximately 12 billion pounds of milk annually, for 43,000 dairy farmer members located in 22 States. It is our Nation's largest dairy cooperative.

We support S. 1794 and vitally need the research that would be provided by its passage. To more clearly point this out I am submitting to this committee my actual experiences with pesticides in my dairying operation.

During early 1967 we, along with other dairies in my immediate area, were required to dump our milk into the nearby desert sandhills because of excessive pesticides. Fortunately for us there was an indemnity program in operation to cover this loss. The total amount of milk dumped by the two above-mentioned dairies—H. & D. and Trans-Pecos—was worth approximately $225,000. The pesticide was DDT.

During the years 1967 through 1969 the two dairies spent over $5,000 on laboratory tests alone in a effort to ascertain contamination sources.

1. We tested all food stuffs on hand at the time we were first notified our milk had exceeded tolerance prescribed for DDT.

2. We called in all experts we could find to determine what levels of DDT in feed we could depend on to prevent an overage in milk, once the level lowered to the point acceptable.

3. Since the original notification that our milk exceeded the allowable DDT level, I have tested all feeds and plan to continue doing so.

4. We needed to ascertain our position as rapidly as possible. If time and tests proved we were in an area that did not permit milk production, we needed to know as soon as possible so we could relocate our facilities or cease production.

5. At the time DDT had not been used as a cotton poison in approximately 10 years, except for very minor instances.

6. DDT and its degradations were found in all feeds we tested, regardless of their source.

7. Though all feeds showed levels of DDT, we found no large amounts in any of the feeds.

8. We tested the soil in our areas and found DDT in all of the soil tested.

9. We did not know whether the DDT in the soil was translocated to alfalfa hay grown on it. Since then I believe the fact has been established that such translocation takes place in all feed crops.

10. Though the DDT levels found in the soil were quite small, it compounded our problem. The DDT level was already too high. How best could we lower this level in our animals? Where could we get feed low enough in DDT to do this within a reasonable time and continue to get such feed in the future?

11. We were aware that dairies in other sections of the United States had dumped milk because of excessive pesticide contamination, but in all cases the cause was ascertained and determined to be misuse of pesticide. Once the misuse was discontinued, the level in the animals declined.

12. Our problem was different because no DDT had been used, in around, or over our dairy premises. Both dairy operations are "dry lot"—that is, the animals are born and raised in corrals and are at no time pastured nor exposed to any pesticide outside of the dairy premises.

13. We checked what seemed a similar problem in Arizona but the data from there was of little help.

14. Our first fear was that locally grown hay might be the chief cause of contamination. Over a 3-year period, I very carefully checked samples from many areas, including one which was 200 miles from us.

15. We did extensive testing of grain—milo maize in this case—to see what variations there might be.

16. I wrote to several feed manufacturers asking if they could guarantee a level that would not exceed what we had been advised to be a safe level. All replied, and all regretted to say that they could not and would not. Thereafter we continued to manufacture and mix our own feed, taking every feasible precaution to check each batch that went into dairy feed. We even set up a special holding area where only the lowest level grain was stored.

17. I worked with a local feed manufacturer in checking his purchased milo to locate the cleanest possible area. These tests did not prove meaningful so we continued mixing our dairy feed as carefully as we possibly could.

18. To further complicate matters, we found that split samples within the same laboratory, as well as split samples in two different laboratories, in both feed and milk, were often too inconsistent to be helpful.

19. I share the thought, expressed by others, that the animal is a more efficient extractor of pesticide than are presently accepted laboratory techniques. This in itself would still be acceptable if the percent of error was consistent, and we knew the test tolerance factor for each feed and each type of pesticide.

20. I believe the discontinued usage of DDT has brought about a lower count in the soil and in feeds. However, from my own tests,

there is no indication that the general level is lower, although the levels are more consistent due to less use of DDT and/or more uniform lab techniques.

21. I believe the discontinued use of DDT will solve one problem for us—that of the transfer of excessive DDT from feedstuffs to milk.

22. Personally I have strong and mixed emotions regarding DDT. I remember, among other instances, that during World War II in the Pacific Islands, DDT eliminated scrub typhus that we feared more than we did the Japanese. It has been with us a long time and has accomplished much, even though it almost ripped the bottom from the basket I keep all my eggs in.

23. I live in an open, spacious area and do not presume to recognize the problems nationwide in using pesticides.

24. It has been suggested that our dairying be moved to an area that is less contaminated. But if so, where? And even then, are we assured that the feed we get will not be contaminated?

25. We, as dairymen, are quite aware that our products have a lower permitted level of DDT than any other food. And we know why they do.

26. If we as dairymen are expected to produce milk with the present extremely low levels permissible, then I see no way to continue at present cost levels, should DDT usage continue.

27. My dairy is located approximately 1½ miles from the Rio Grande River, separating Texas from Mexico. In an effort to overlook nothing, I visited the Mexican side of the river suspecting that the farmers in Mexico might be using DDT with less caution than we were. This test was run in the spring of 1970 in an effort to determine if DDT from Mexico was windborne.

28. I do not believe a soil sample can be taken anywhere in the United States—or possibly in the world—that will not show some presence of DDT. The gas chromatograph is capable, I am told, of picking up seven parts in a trillion. Dairy products are permitted 1.25 parts per million. At this level we have the right to expect accurate analyses of our samples. From a practical standpoint, the results are not that accurate.

29. When DDT is applied, time causes a breakdown into DDT, DDD, DDE. In our product we are charged with the total of all of these degradations. The final berakdown (DDE) is the most frequent and persistent.

30. I am told that DDT in the soil lies in approximately the top 3 inches. Practically the only way it can be moved is mechanically.

31. Methods are being developed for causing the dairy cow to dissipate DDT at a faster rate than normal. This may save the herd, whereas having DDT dissipated through milk by normal milking, may be too slow and costly, thus forcing the dairymen to dispose of these animals or cease production.

32. Prior to the use of the gas chromatograph, the methods of analysis were not nearly so sophisticated and the term "zero tolerance" applied to milk. The new methods were able to detect more minute amounts. Thus, the loss of "zero tolerance" did not necessarily mean that there is now more DDT in milk. The gas chromatograph is a wonderful tool, but I do not believe we understand all we need to know about it.

CONCLUSION

In this report I have attempted to show the many problems attendant on chemical pesticide contamination. These include the variety and the uncertainty of the source of such contamination, the retention of the chemical by the cow, and its slow dissipation into the milk, and the uncertainties of the testing procedures in determining the extremely small amounts which are permitted in milk, as well as the persistence of chemicals such as DDT in the environment. And again—all of my problems were the results of things beyond my dairying activities, as I was not using DDT in my operation.

A segment of our population is demanding the discontinued use of chloronated hydrocarbons, including DDT. They are convinced that present pesticides attributes are more than offset by harmful effects.

The view by others is that DDT has contributed much to the whole world. They contend that complete withdrawals of such material would leave a definite void if made prior to the development of an effective substitute.

In either case, research to find means to control insects and pests by other than chemical means should be encouraged. If others are to have the types of problems I have encountered, there is an urgency to this research and to finding these alternatives. Bill S. 1794, is intended to do that. The urgency I mention is as applicable for the benefit of the consumers as it is for the agricultural industry.

We therefore support bill S. 1794.

Senator ALLEN. Senator Chiles?

Senator CHILES. Mr. Chairman, Mr. Herring, I think what you just said so graphically is what some of the members of this committee have been concerned about, and that is why I think his testimony for S. 1794 is as valid and strong as anything we could possibly receive.

I think Mr. Herring is now telling so graphically why, if we are going to discontinue the use of DDT, perhaps we need to because of the harmful effects of it, what in the world are we getting as a substitute? I am now concerned that $4 million is an awfully small sum that we are putting in this bill for crop testing, and we know this is just one way of going into the research.

I just wanted Mr. Herring to know some of us are concerned about the problems he is facing, and we are going to try to see if we can alert some other people. We perhaps have been moving on the control of these pesticides faster than we were trying—the Government, that is—than we were trying to get some viable substitutes that we could use in control of pests.

Senator ALLEN. Thank you, Sentor Chiles.

I thank you very much, Mr. Herring, for this fine testimony and the benefit of the personal experiences you have had in the problem of DDT.

I must say you take a most objective view of the problem; even have a good word or two to say about DDT in your statement.

I am a little bit at a loss to understand just what your present situation is. Did you find out who the culprit was? I noticed you changed your method of obtaining feed, you processed your own feed. You do not use DDT in your own operation, but you do buy grain or do buy feed, unprocessed feed, from neighboring farmers; do you not?

Mr. HERRING. Yes, sir; as a matter of fact, I do not raise any of my own feed. It is all purchased. And it comes from a rather wide area.

Senator ALLEN. Yes. Have you checked the various sources of your supply as to their use of DDT?

Mr. HERRING. All of it; yes.

Senator ALLEN. What do you find there?

Mr. HERRING. I find the level to be lowering because its, DDT in my area, the use has been—well, it has been discontinued virtually, but certainly lowered. And every time it is lowered, I run these tests annually. I even pick the same spot, the same alfalfa field in the neighbors I buy from yearly, to try to ascertain from year to year whether there is a lowering of the level, and there is.

Senator ALLEN. You think it is in the ground, though, from prior years' use; is that right?

Mr. HERRING. Definitely yes. And even though the amount is very low, the section here pertaining to the dairy cow being a more efficient extractor of pesticide than laboratory techniques, this is not just my view. I agree. The cow will show approximately four times in the milk what the laboratory shows to be in the feed. This has been confusing to us.

Senator ALLEN. In other words, the cow's system then apparently magnifies the amount of DDT that they take in?

Mr. HERRING. Yes; very efficiently. Too efficiently, I guess.

Senator ALLEN. In other words, there is less DDT in the feed than there is in the body of the cow and in the milk from the cow; is that correct?

Mr. HERRING. That is right. It is very confusing.

Senator ALLEN. The cow, then, is pretty well a manufacturer of DDT, according to your view.

Mr. HERRING. I guess she has a nasty habit of storing it and dissipating enough to keep us in trouble. Actually, she does. She does store it in fat. It can be eliminated. This method of elimination is phenobarbital and charcoal in animals. It is supposed to cause them to dissipate at a rate faster than normal in order to keep from losing the herd. Otherwise you cannot keep the animals.

Senator ALLEN. Yes; the cow naturally will take in more feed in volume than it would give off in milk, so that might be the answer.

Mr. HERRING. Oh, yes, definitely. Of course, it is all measured in parts per million in the butter fat.

I might add, if I may, we were also fearful, in that not only are we charged with DDT and its analogs, we are also charged with any other hydrocarbons that may show up. So you add all of these together, and the tolerance being 1.25 parts per million, any addition to DDT and its analogs could easily exceed the tolerance.

Senator ALLEN. Yes. These feed suppliers, they were not able to assure you that their feed would have an acceptable DDT tolerance?

Mr. HERRING. This is true. Yes, sir. Actually, they face somewhat the same problem we do. I do have control over the alfalfa I buy, but I do not have control over any grains, nor did they. We asked, in this case, for grain not to exceed one-tenth part per million total ration and they said they would not be responsible.

Senator ALLEN. Your standard, then, was considerably lower than the accepted standard. You want to have a little margin there then; is that correct?

Mr. HERRING. Yes, sir. I have to.

Senator ALLEN. So we would not gather from what you said then, these particular feed dealers are sending out feed over the country that is infected with unacceptable tolerances of DDT?

Mr. HERRING. Not knowingly. From a practical standpoint, so many of them have so little control of the amount of grain they handle, they test in batches and, of course, I do. But what we all fear is what we call hot batches and we have to be constantly on the alert. That is why I test all of my own.

Senator ALLEN. Do you have your operation down now to such an extent that all of your milk is of acceptable DDT tolerance?

Mr. HERRING. Yes, sir.

Senator ALLEN. When is the last time you had to dispose of milk on account of DDT?

Mr. HERRING. About the middle of 1967. It made such an impression, I cannot get over it.

Senator ALLEN. Do you feel that your experience is an unusual experience for a diary farmer, or is it an experience that is shared by many other dairy farmers throughout the country?

Mr. HERRING. Well, sir, I think I am more alert to the fact it could happen to anybody. A lot of this is involved in interstate versus intrastate milk, and mine was involved in interstate. And even though the level I do not think anywhere is too high, we are getting it in minute quantities, and should you be checked and found over, then certainly you are subject to having to dump your milk. It is just a constant thing.

Senator ALLEN. You are checked only twice a year?

Mr. HERRING. No, this is under the Food and Drug Administration and they come in any time.

Senator ALLEN. How often do they come in, as a general rule?

Mr. HERRING. I really do not know. I have no idea. Of course, they are checking for interstate. They can do it any time. They can pull a carton off the shelf and check it and check the carton back to its source. I do not process milk. Mine is whole milk and sold in bulk to the various plants. I am not only subject to being checked myself, but also the finished product, which they bring back to its original source.

Senator ALLEN. During what years did you apply for the dairy farmers indemnity because of contaminated milk?

Mr. HERRING. It was in 1967.

Senator ALLEN. That is the only time?

Mr. HERRING. Yes.

Senator ALLEN. What was the amount of your indemnity?

Mr. HERRING. My own dairy was approximately $44,000. The one at Pacos was about $197,000. We did receive the money.

Senator ALLEN. How much?

Mr. HERRING. I believe his figures were $197,000 in round figures. Mine was $44,000.

Senator ALLEN. What year was that?

Mr. HERRING. 1967.

Senator ALLEN. You had $241,000 total?

Mr. HERRING. Yes. I think I gave you 225, which was a bit conservative.

Senator ALLEN. That was in 1967?

Mr. HERRING. Yes.

Senator ALLEN. According to Mr. Stalbaum's testimony, the whole nationwide indemnity payment for 1967 was only $274,000. So you all got about 90 percent of the nationwide indemnity.

Mr. HERRING. That is true. It was a very high percentage.

Senator ALLEN. That is rather unusual, is it not?

Mr. HERRING. Yes, sir.

Senator ALLEN. You do not think the other dairy farmers knew about this program?

Mr. HERRING. Oh, yes, sir. I was embarrassed myself. People do not want to associate with you. They are going to treat you like a leper, maybe it will go away. But as Mr. Stalbaum pointed out, you can overcome some of these things when that much money is involved.

Senator ALLEN. But you did not suffer any losses in 1968, 1969, 1970, or thus far in 1971?

Mr. HERRING. No, sir. We do have continuous sampling on our own. We are not waiting for the Food and Drug to tell us. We are going to know. If we find in time that we cannot live under the rules, the thing to do is relocate or get out.

Senator ALLEN. You would certainly like to see efficient, integrated methods of control devised that would cause a lessening of reliance on pesticides and insecticides, would you not?

Mr. HERRING. Absolutely. Yes; sir.

Senator ALLEN. And you feel that the legislation under consideration would be a step in the right direction toward that end?

Mr. HERRING. Definitely. Yes; sir.

Senator ALLEN. Thank you very much.

Senator Chiles.

STATEMENT OF HON. LAWTON CHILES, A U.S. SENATOR FROM THE STATE OF FLORIDA

Senator CHILES. Mr. Chairman, members of the committee. S. 1794 before us this morning would authorize the appropriation of $4 million to establish pilot field projects for research on a variety of crops for the control of agricultural and forest pests by integrated biological-cultural methods. The $4 million would provide the outline for a change in our present method of attack of agricultural insects—a change in strategy—a change directed toward helping the farmer, who is bearing the burden of increasing costs of pesticides and yet what he receives for his product seems to be the same; a change aimed at reestablishing the natural ecological balance now being damaged on an appalling scale and rate; a change that would provide the much needed funds and leadership to substantially reduce our single prolonged reliance on pesticides.

It is about time we face the fact that pest control practices have been fraught with many grave problems. From the introduction of DDT after World War II down to the more than 10,000 formulations of various pesticides, our method has not only been destructive of nontarget organisms, not only obsolete, but also a danger to our own environment and an added problem for our farmers.

As you know, our American farmers are the world's most productive and efficient food producers. But they've been caught in a squeeze between rising operating costs and a declining share of increased retail food prices. The increasing use of pesticidies for control and management of agricultural insects makes up a segment of that rising cost. Where farmers are using heavy pesticide treatments, natural parasites and predators have no opportunity to recover and continue the balance and self-regulation that is desirable. The farmer gets snagged into continuous use of the pesticides in ever-increasing amounts with ever-decreasing effectiveness. The pests develop resistance to the chemical used over time. The nontarget beneficial organisms are destroyed in the saturation pesticide process. And the farmer is then forced to continue in this circle of more and more potent pesticides, forever digging into his pocket to pay for a good crop. The farmer is caught again—already forced to produce more and more to keep his profits stable, he now is forced to use harmful chemicals to protect his crops and thus becomes subject to considerable criticism from the ecologically concerned.

It cannot be emphasized enough that within this vicious cycle the farmer is caught by the need to constantly strive to increase his productivity merely to keep even with this increase in consumer prices. He receives little or no increase in benefits for this increased productivity. It is the middleman, who processes and packages these commodities, who drives the price to the consumer ever upward. For Congress to say to the farmer to unilaterally stop using pesticides, without making a sincere effort to help the farmer find alternate means of pest control, is grossly unfair. I feel we owe a responsibility to the farmer by giving him an acceptable viable alternative to the use of pesticides.

Farmers and entomologists throughout the Nation are turning toward biological controls as well as the Agricultural Research Service in the Department of Agriculture. But many endeavors have been thwarted for lack of leadership and funds. Surely all our talk of preserving the ecological balance and preserving our land and animal life is only that—talk—unless steps such as those suggested in this proposal are taken quickly.

Senator Nelson referred to our single-strategy pest control, and its first impressions on all of us as a "magical" destruction of target pests. But like any magic it is a trick. It has a catch. And that catch is decreasing effectiveness, wholesale destruction of natural balance and a confusing burden on the already beleaguered farmer.

Integrated biological control has been successful in a wide array of diverse situations. It has worked well in both temperate and tropical climates, in forests and in agricultural plantings. It has succeeded in suppressing target pests of a great diversity. It has been effective everywhere man has persevered in its endeavor.

Ecological disaster can and must be prevented. The farmer can and must be helped to produce a reasonably pest-free crop efficiently and ecologically. This legislation offers the framework and incentive to prevent that disaster, and offers assistance in an expending of energies and funds in a positive direction: research for ways and means of controlling our agricultural pests, using natural predators and parasites of harmful insects in a correct balance.

We must seek practical, economically and eologically feasible alternatives to pesticides. This bill would aid that search.

Mr. Chairman and members of the committee, I am pleased this morning to introduce two distinguished entomologists from the University of Florida department of entomology and nematology, Drs. Eden and Whitcomb. I am confident their testimony this morning will cover a more specific and technologically detailed reasoning for support of the proposal. Both professors have worked extensively in the area of integrated control, particularly with pests dangerous to citrus.

The first to testify before us this morning is Dr. Eden. He was born in Alabama, bachelor of science in agriculture from Auburn, M.S. in entomology from Auburn, Ph. D. in entomology from the University of Illinois. He worked in the extension service at Auburn, came to the University of Florida in 1965 as chairman of the department of entomology and nematology. Dr. Eden is serving this year as the president-elect of the Entomology Society of America, an organization of some 6,000 scientists from all over the world. He has served on the National Research Council as a representative of the Entomological Society.

Also, to testify from Florida today, the University of Florida, is Dr. Willard H. Whitcomb, with his B.S. in biology from Bates, M.S. from Texas A. & M. in entomology. Did 1 year of graduate study at the University of Rostak in Germany, and received his Ph. D. from Cornell in entomology. Dr. Whitcomb served as an entomologist for the Ministry of Agriculture in Venezuela, and for Shell Oil, also in Venezuela. He, too, is a member of the Entomological Society of America, as well as the Florida Entomological Society. Both men have authored some 100 articles on entomology and biological control.

Senator ALLEN. Thank you, Senator Chiles.

Now, we like to have Dr. Eden and Dr. Whitcomb. But getting back to the regular order, Mr. Grefrath, the National Forest Products Association witness, was the next scheduled witness on our list. You gentlemen just have a seat, if you will, and we will hear from Mr. Grefrath, inasmuch as that is the order listed here.

Then Senator Chiles will take over as chairman, as I have other commitments I have made. And at such time as he adjourns the meeting, it will be adjourned until 2:15, and I will take back over at that time.

Thank you very much.

Senator CHILES (chairing). Mr. Grefarth.

STATEMENT OF BRUCE C. GREFRATH, NATIONAL FOREST PRODUCTS ASSOCIATION

Senator CHILES. Mr. Grefarth, we are delighted to have you testify before us today.

Mr. GREFRATH. Mr. Chairman and members of the committee: I am Bruce C. Grefrath, a forester with the National Forest Products Association, Washington, D.C. NFPA is a federation of 21 regional, species, and product associations representing the solid wood products industry throughout the Nation. It is my privilege to present the views of these groups on S. 1794 "to authorize pilot field research programs for the control of agricultural and forest pests by integrated biological-cultural methods."

The forest products industry has several compelling reasons for supporting increased funding of Forest Service research to find newly integrated methods of controlling forest insects and disease. In the past 10 years there has been increasing concern over the adverse effects that persistent pesticides may have on the environment. Several national study committees have recommended that hard pesticides be phased out of use and that increased emphasis be placed on finding new methods that will not rely on persistent chemicals.

The industry is not necessarily supporting any particular control method. It is always willing to use newer methods that are safer to the environment and humans, and more economical and effective. Thus, we support the principle of integrated control found in S. 1794. There is a need to find new control methods to fill the void created by the elimination of persistent pesticides.

Integrated control methods require coordinated use of pesticides chemicals, biological chemicals, viruses, bacteria, and other materials that must be registered by the Environmental Protection Agency before they can be used. Integrated methods, however, also make use of cultural practices such as timing of thinning and delayed planting, as well as parasited and predators which do not require registration with EPA. I might add here tha cultural control methods have long been used in forest management.

Development and registration of any insect and disease control method is a long and expensive process. A recent survey of the pesticide industry, sponsored by the National Agricultural Chemical Association and compiled by independent auditors, indicated that it takes from 5 to 9 years and from $1 to $12 million for industry to register any primary control method. Forest Service practice toward registration involves four basic steps: (1) laboratory research, (2) field experiments, (3) pilot control studies, and (4) registration of a method with the Environmental Protection Agency for use against a specific pest.

While the strategy for integrated control methods emphasizes biological and cultural techniques, it also must include both toxic chemicals and other nontoxic chemicals, such as sex attractants, that can be used to induce specific pests to destroy themselves. The current proposal makes no reference to safe, effective, and economical use of nonpersistent and natural pesticides such as Zectran, sex attractants, and Pyrethrines, an extract of chrysanthemums, which must play an important role in integrated control methods.

Forest Service laboratory research has identified several chemicals, viruses, and bacteria which show promise in controlling forest insects. The Forest Service program is currently aimed at gathering data on the contact toxicity of insecticides. Promising candidates indentified by this basic process may then be selected for further research and evaluation leading toward field experimentation and pilot tests.

I have brought with me today a copy of "Results of Primary Screening Against Forest Insect Pests" published by the U.S. Department of Agriculture, Forest Service, Pacific Southwest forest and range experiment station in March of 1971. I request that this document be inserted in the hearing record as a part of my statement.

Senator Chiles. Without objection, it will be inserted.

(The document follows:)

U.S. DEPARTMENT OF AGRICULTURE—FOREST SERVICE PACIFIC SOUTHWEST FOREST AND RANGE EXPERIMENT STATION INSECTICIDE EVALUATION PROJECT

INTRODUCTION

(Results of primary screening against forest insect pests, March 1, 1971)

The following tables summarize the primary screening of insecticides against forest insect pests completed to date by the Insecticide Evaluation Project, Berkeley, California. The screening program is aimed at gathering data on the contact toxicity of insecticides from which promising candidates may be selected for further research and evaluation, leading toward field experimentation and pilot tests.

Many of the data that follow have been computerized, using probit analysis. Some data are preliminary, and the tables may change somewhat as additional work is done. It is requested that permission be obtained before quoting this material in published reports.

Screening is done by topical application or by spray chamber. The tables that follow are separated according to which procedure was followed. For topical application, the insecticides are formulated in acetone in a series of concentrations and applied to the insect, with a microapplicator, at the rate of 1 -μ1./100 mg. body weight or, in some cases, 1 -μ1./insect.

Spray chamber tests are conducted by treating insects with a series of concentrations of insecticide solutions in tripropylene glycol monomethyl ether (TPM). Sometimes other solvents or solvent mixtures are used where TPM proves toxic to the insect.

In all screening tests, the insects are held after treatment in petri dishes or other containers with natural or synthetic food. Mortality observations are made, usually 3 and 7 days after treatment. Most of the data reported here are from 7-day, post-treatment examinations.

The insecticides are listed in descending order of toxicity at the LD_{0} (dosage lethal to 90 percent of the population sampled). A "toxicity index" is estimated by the ratio:

$$\frac{LD_{90}\ \text{DDT}}{LD_{90}\ \text{candidate}}$$

The larger the ratio, the more toxic the insecticide. For example, a toxicity index of 10 indicates the candidate insecticide is 10 times more toxic than DDT. A candidate with 100 times the toxicity of DDT would have a toxicity index of 100. These indices are not final or immutable. Bioassay data are variable, and the degree of that variability determines how much reliance can be placed on the toxicity index. Further testing may show changes in magnitude or order of toxicity.

Finally, these tables are not meant to be used at face value for selecting candidates for field use or experimentation. Properties other than acute toxicity to the target insect have an important bearing on which candidates should be considered for use in field experimentation—properties such as residual life; persistence in the environment; magnification in the food chain; toxicity to man, other animals, and beneficial insects; cost; and availability. Some compounds are included in the screening program in spite of having adverse properties. They may be highly toxic to the target insect but, because of risks that their use may entail, would not be the best candidates to take to the field.

DISCLAIMER

Use of trade names is for information purposes and does not imply endorsement by the U.S. Department of Agriculture.

TOPICAL APPLICATION

BOXELDER TUSSOCK MOTH, HEMEROCAMPA N. SP., FROM GILA NATIONAL FOREST. N.MEX. 5TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxity index at LD_{90}*
Pyrethrins	250	0.14	0.35	74
Zectran	300	3.5	8.5	3.0
DDT	290	7.9	26	1.0
Landrin	250	12	28	.93
Carbaryl	280	16	58	.45
Malathion	450	1,966	4,550	.0057

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

CALIFORNIA OAKWORM, PHRYGANIDIA CALIFORNICA, FROM CALIFORNIA, 3D- AND 4TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	539	1.3	11	2.5
Zectran	540	5.2	25	1.1
DDT	501	9.3	28	1.0
Malathion	518	59.0	343	.082
Carbaryl	519	18.0	1,208	.023

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

DOUGLAS-FIR TUSSOCK MOTH, HEMEROCAMPA PSEUDOTSUGATA, FROM CALIFORNIA, 4TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index† at LD_{90}
Pyrethrins	1,927	0.28	0.83	13
Dursban	179	1.2	2.4	4.6
Zectran	610	2.1	5.5	2.0
Dichlorvos	130	3.2	6.1	1.8
GC 6506	280	4.2	7.0	1.6
Aminocarb	250	4.2	9.3	1.2
Tetramethrin	159	4.4	9.4	1.2
Allethrin	150	2.4	9.8	1.1
DDT	151	4.1	11	1.0
Mobdm	129	6.8	13	.85
Landrin	240	11	21	.52
Naled	148	7.8	28	.39
Propoxur	131	7.2	30	.37
Trichlorfon	250	14	31	.35
Diazinon	192	14	42	.26
Sumithion	159	22	52	.21
Bromphos	340	22	56	.20
Dimethrin	290	32	82	.13
Carbaryl	310	18	84	.13
Carbanolate	240	17	107	.10
Carbophenothion	170	111	1,441	.0076
Malathion	364	971	2,534	.0043

*Partial list only; 55 compounds tested.
†Toxicity relative to DDT: LD_{90}DDT over LD_{90} candidate equals toxicity ndex.

FALL CANKERWORM, ALSOPHILA POMETRIA, FROM VIRGINIA, 4th-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	390	2.2	7.3	23
Zectran	490	6.3	17.0	9.7
Gardona	379	47.0	138.0	1.2
DDT	520	39.0	165.0	1.0
Malathion	550	258.0	552.0	.30
Carbaryl	700	66.0	677.0	.24

*Toxicity relative to DDT: LD_{90}DDT over LD_{90} candidate equals toxicity index.

FOREST TENT CATERPILLAR MALACOSOMA DISSTRIA, FROM MINNESOTA, 4TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	LD_{90}	Toxicity index* at LD_{90}
Pyrethrins	340	0.12	0.40	105
Methomyl	300	.24	.50	84
Dursban	260	.59	1.6	26
Landrin	280	1.0	1.8	23
Zectran†	620	1.1	1.8	23
Zectran	280	.88	2.3	18
Aminocarb	300	1.8	3.1	14
Tetramethrin	300	.70	3.3	13
Naled	420	2.2	3.7	11
Carbaryl	300	2.3	6.6	6.4
Sumithion	379	3.4	8.4	5.0
Bromophos	260	5.0	12	3.5
Trichlorfon	300	13	23	1.8
Dimethrin	300	8.5	30	1.4
Malathion	480	7.6	36	1.2
DDT	460	6.4	42	1.0
Fenthion	440	17	45	.93

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.
†Insects from Louisiana.

JACK-PINE BUDWORM, CHORISTONEURA PINUS PINUS, FROM WISCONSIN, 6TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	LD_{90}	Toxicity index at LD_{90}*
Zectran	121	0.90	3.1	177
Aminocarb	119	2.0	5.1	108
Sumithion	120	3.0	9.0	61
Pyrethrins	120	3.1	10.0	55
Trichlorfon	120	4.4	14.0	39
Imidan	119	10	50.0	11
DDT	120	16	550.0	1

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

ORANGE TORTRIX, ARGYROTAENIA CITRANA, FROM CALIFORNIA, 5TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}[1]
Pyrethrins	260	12	60	>167.0
Zectran	390	37	151	>66.0
Malathion	160	>2,000		
DDT	270	>10,000		1.0

[1] Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

PANDORA MOTH, COLORADIA PANDORA, FROM OREGON, 2d- AND 3d-STAGE LARVAE

[μg./g. body weight]

Insecticide*	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}†
Pyrethrins	178	0.34	0.68	288
Tetramethrin	180	1.9	6.9	28
Dursban	180	5.7	13	15
Allethrin	159	7.3	16	12
Aminocarb	120	11	16	12
Zectran	380	8.3	19	10
Dichlorvos	145	9.4	19	10
Naled	330	8.6	21	9.3
GS-13005	238	15	22	8.9
Trichlorfon	210	12	26	7.5
Phosphamidon	140	64	85	2.3
Imidan	138	28	107	1.8
Dimethoate	120	100	155	1.3
Dimethrin	130	73	163	1.2
Propoxur	130	86	176	1.1
DDT	220	63	196	1.0
Sumithion	312	35	332	.59
Diazinon	160	38	398	.49
Malathion	218	193	496	.40
Bromophos	310	127	726	.27
Carbaryl	70	(‡)	(‡)	
Gardona	80	(‡)	(‡)	

*Partial list only; 40 compounds tested.
†Toxicity relative to DDT: LD_{90} DDT÷LD_{90} candidate equals toxicity index.
‡Nontoxic.

PINE TUSSOCK MOTH, DASYCHIRA SP. NEAR/=GRISEFACTA, FROM EASTERN MONTANA, 4TH-STAGE LARVAE

[μg./g. body weight]

Insecticide*	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	210	1.4	4.6	18
Zectran	270	1.9	6.8	12
Malathion	280	9.4	36.0	2.3
DDT	290	15.0	84.0	1.0
Landrin	290	35.0	200.0	.42
Carbaryl	260	115.0	2,000.0	.042

*Toxicity relative to DDT: LD_{90} DDT÷LD_{90} candidate=toxicity index.

WESTERN SPRUCE BUDWORM, CHORISTONEURA OCCIDENTALIS, FROM MONTANA AND IDAHO, 6TH-STAGE LARVAE

[μg,/g, body weight]

Insecticide*	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}†
SBP 1382‡	459	0.26	0.90	73
Dowco 217	240	.66	1.5	44
Dowco 214	240	1.6	2.9	22
Mevinphos	90	1.5	3.1	21
Zectran	921	.94	3.3	20
Pyrethrins	370	1.0	3.7	18
Aminocarb	120	1.3	4.3	15
Chlorphoxim	259	2.0	4.4	15
Dursban	140	1.4	5.4	12
Phoxim	275	2.6	5.7	11
Sumithion	480	3.8	6.6	9.9
GC-6506	90	2.8	6.7	9.8
Parathion	90	3.2	8.6	7.6
Cyanox	180	3.9	8.8	7.4
N-acetyl Zectran	200	4.0	8.8	7.4
Methomyl§	280	1.7	9.2	7.1
Methomyl″	240	1.0	9.5	6.9
Dichlorvos	260	3.9	9.5	6.9
Naled	150	4.8	12	5.4
Surecide	90	5.2	26	2.5
Imidan	490	7.0	30	2.2
Monitor	379	11	33	2.0
C_{12}-trichlorfon¢	319	8.4	35	1.9
Acetyl-carbofuran	300	14	35	1.9
Landrin	330	17	40	1.6
Bromophos	90	16	44	1.5
Dimethoate	90	18	48	1.4
Tetramethrin	90	14	53	1.2
Methomyl	410	2.3	54	1.2
Carbofuran	300	3.0	60	1.1
Allethrin	150	18	60	1.1
DDT	360	24	66	1.0
Trichlorfon	319	20	67	.98
Fention	120	19	67	.98
Gardona	240	24	68	.96
Carbaryl	310	20	76	.86
Phosphamidon	90	18	79	.83
Malathion	360	29	88	.75
Bux	210	25	90	.73
Mobam	150	25	90	.73
Abate	90	------------	>100	<.50
Carbanolate	90	------------	>100	<.50
Carbophenothion	90	------------	>100	<.50
Dimethrin	90	------------	>100	<.50
Disulfoton	90	------------	>100	<.50
Propoxur	90	------------	>100	<.50

*Partial list only; 100-plus compounds tested.
†Toxicity relative to DDT: LD_{90}DDT ÷ LD_{90} candidate = toxicity index.
‡Based on D-trans isomer content (cis isomer not toxic).
§14-day mortality count; includes substantial latent pupal mortality.
″2-hour knockdown.
¢An analog of trichlorfon synthesized by Mel Look (IEP) with the vernacular name of dodecanoyl-trichlorfon.

SPRUCE BUDWORM, CHORISTONEURA FUMIFERANA, FROM MAINE, 6TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	120	0.91	3.4	102
Aminocarb	120	.54	3.5	99
Zectran	120	1.2	3.7	94
Dursban	120	1.9	5.3	65
Sumithion	110	3.8	10	35
Trichlorfon	120	5.2	19	18
DDT	119	56	347	1.0
Malathion	120	52	1,000	<1.0
Carbaryl	120	80	>1,000	<1.0
Imidan	120	115	>1,000	<1.0

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

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WESTERN HEMLOCK LOOPER, LAMBDINA FISCELLARIA LUGUBROSA, FROM COASTAL OREGON, 4TH- AND 5TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD50	LD90	Toxicity index at LD90*
Pyrethrins	240	0.16	0.83	8.0
Zectran	150	.51	2.3	2.9
Naled	160	.69	2.3	2.9
Dichlorvos	130	.86	4.0	1.7
DDT	150	1.7	6.7	1.0
Allethrin	150	2.2	11	.61
Malathion	90	2.4	16	.42
Trichlorfon	170	5.2	30	.22
Phosphamidon	60	4.1	40	.17
Ronnel	110	12	68	.098
Propoxur	90	87	368	.018
Carbaryl	90	60	>1,000	<.01
Thanite	60	(†)	(†)	

*Toxicity relative to DDT: LD90 DDT over LD90 candidate equals toxicity index.
†Nontoxic.

WESTERN HEMLOCK LOOPER, LAMBDINA FISCELLARIA LUGUBROSA, FROM MT. BAKER WASHINGTON, 5TH-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD50	LD90	Toxicity index at LD90*
Pyrethrins	318	0.38	1.7	772
Dowco 217	301	4.2	7.6	173
Phoxim	296	2.3	7.8	168
Zectran	320	2.8	10	131
Sumithion	317	8.5	28	47
DDT (4th stage)	480	42	356	3.7
DDT (5th stage)	439	95	1,313	1.0

*Toxicity relative to DDT: LD90 DDT over LD90 candidate equals toxicity index.

WESTERN TUSSOCK MOTH, HEMEROCAMPA VESTUSTA, FROM IDAHO, 4th-STAGE LARVAE

[μg./g. body weight]

Insecticide	Number of insects	Dosage needed for— LD50	LD90	Toxicity index at LD90*
SBP 1382	480	0.126	0.230	3,743
Pyrethrins	390	.145	.265	3,249
Allethrin	390	.562	1.06	812
Methomyl	440	.955	1.82	473
Phoxim	400	1.89	3.37	255
Zectran	508	4.63	11.5	75
Dursban	530	3.48	11.6	74
Naled	300	7.96	11.8	73
Dichlorvos	340	8.92	13.9	62
Aminocarb	338	8.18	14.5	59
Landrin	409	6.69	16.2	53
Trichlorfon	250	47.6	86.5	10
Carbaryl	468	34.7	126	6.8
Dowco 214	590	54.4	147	5.8
Sumithion	269	222	475	1.8
DDT	380	115	861	1.0
Malathion	140		>1,000	<1.0
Gardona	60		>1,000	<1.0

*Toxicity relative to DDT: LD90 DDT over LD90 candidate equals toxicity index.

APPLICATION BY LABORATORY SPRAY CHAMBER

BLACK-HEADED BUDWORM, ACLERIS GLOVERANA, FROM ALASKA, 3rd-, 4th-, AND 5th-STAGE LARVAE

[Oz./acre]

Insecticide	Number of insects	Dosage needed for— LD50	Dosage needed for— LD90	Toxicity index at LD90*
SBP 1382	205	0.078	0.34	159
Zectran	214	.12	.47	115
Pyrethrins	370	.16	1.9	28
Malathion	160	1.6	42.	1.3
DDT	180	5.9	54.	1.0

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

COTTONWOOD LEAF BEETLE, CHRYSOMELA SCRIPTA, FROM MISSISSIPPI, ADULT STAGE

[Oz /acre]

Insecticide	Number of insects	Dosage needed for— LD50	Dosage needed for— LD90	Toxicity index at LD90*
Dursban	569	0.13	0.33	280
SBP 1382	390	.15	.38	243
Phoxim	710	.20	.48	193
Diazinon	630	.31	.67	138
Zectran	667	.42	1.50	62
Aminocarb	688	.65	1.81	51
Dimethoate	659	.61	2.13	43
Sumithion	467	1.13	3.22	29
Dowco 217	499	.78	4.39	21
Trichlorfon	780	2.03	4.44	21
Landrin	492	1.26	4.52	20
Carbaryl	660	.98	5.17	18
C_{12}-trichlorfon†	440	3.03	5.16	18
Propoxur	569	.82	5.35	17
Methomyl	569	2.91	8.20	11
Pyrethrins	770	2.73	11.7	7.9
Carbofuran	790	.60	12.0	7.7
Gardona	489	1.48	17.4	5.3
Naled	680	1.88	19.4	4.8
Malathion	699	6.12	44.4	2.1
DDTpp'	668	12.4	92.5	1.0

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.
†An analogue of trichlorfon synthesized by Mel Look (IEP) with the vernacular name of dodacanoyl-trichlorfon.

COTTONWOOD LEAF BEETLE, CHRYSOMELA SCRIPTA, FROM MISSISSIPPI, 4TH-STAGE LARVAE

[Oz /acre]

Insecticide	Number of insects	Dosage needed for— LD50	Dosage needed for— LD90	Toxicity index at LD90*
Zectran	518	0.021	0.18	111
SBP 1382	430	.15	.32	62
Dursban	300	.16	.34	59
Phoxim	460	.23	.54	37
Propoxur	300	.56	1.65	12
Diazinon	300	1.25	11.2	1.8
DDT	250	5.14	20.0	1.0

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

HEMLOCK SAWFLY, NEODIPRION TSUGAE, FROM ALASKA, 4TH- AND 5TH-STAGE LARVAE

[Oz /acre]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Gardona	358	0.042	0.075	240
Sumithion	410	.079	.17	106
SBP 1382	571	.077	.20	90
Naled	451	.088	.21	86
Malathion	258	.14	.24	75
Zectran	541	.11	.37	49
Dimethoate	421	.22	.49	37
Pyrethrins	560	.18	.63	28
Propoxur†	339	.26	1.6	11
Carbaryl	307	.28	3.8	4.7
Methomyl	359	.30	4.7	3.8
Trichlorfon	397	2.8	5.2	3.5
DDT	364	6.9	18	1.0

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.
†4th-stage larvae only.

LARCH CASEBEARER, COLEOPHORA LARICELLA, FROM IDAHO, 2ND- AND 3RD-STAGE LARVAE †

[Oz./acre]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Sumithion	180	0.026	.048	1.3
Zectran	300	.033	.064	1.0
Pyrethrins	281	.047	.13	.49
Aminocarb	150	.053	.19	.34
Malathion	294	.063	.19	.34
Gardona	120	.22	.60	.11

†Larvae treated while in needle cases.
*Toxicity relative to Zectran: LD_{90} Zectran over LD_{90} candidate=toxicity index. Zectran used for standard in absence of DDT.

LODGEPOLE NEEDLE MINER, COLEOTECHNITES SP. NEAR MILLERI, FROM WINEMA NATIONAL FOREST, OREG. ADULT STAGE

[Oz./acre]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	265	0.010	0.018	6.7
Zectran	454	.033	.081	1.5
DDT	400	.039	.12	1.0
Malathion	524	.034	.13	.92
Naled	303	.041	.13	.92
Aminocarb	314	.062	.16	.75
Allethrin	174	.066	.20	.60
Methomyl	229	.10	.29	.41
Sumithion	274	.14	.44	.27

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.

LODGEPOLE NEEDLE MINER, COLEOTECHNITES SP. NEER MILLERI, FROM INYO NATIONAL FOREST, CALIF.; ADULT STAGE

[Oz./acre]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
Pyrethrins	236	0.0078	0.016	7.5
Malathion	288	.058	.10	1.2
Sumithion	122	.054	.11	1.1
Allethrin	58	.065	.11	1.1
Zectran	167	.062	.12	1.0
Aminocarb	130	.084	.17	.70
Naled	98	.088	.19	.63
Methomyl	101	.15	.25	.48
Trichlorfon	92	----------	>1.0	<.10

*Toxicity relative to Zectran: LD_{90} Zectran over LD_{80} candidate equals toxicity index. Zectran used or standard in absence of DDT.

PINE BUTTERFLY, NEOPHASIA MENAPIA, FROM MONTANA, 3RD- AND 4TH-STAGE LARVAE

[Oz./acre]

Insecticide	Number of insects	Dosage needed for— LD_{50}	Dosage needed for— LD_{90}	Toxicity index at LD_{90}*
SBP 1382	220	0.013	0.058	117
Pyrethrins	318	.037	.11	62
Dowco 214	199	.19	.31	22
Methomyl	160	.30	1.1	6.2
Dursban	140	.35	1.1	6.2
Gardona	140	.52	1.5	4.5
Sumithion	290	.62	1.8	3.8
Phoxim	177	.72	2.4	2.8
Zectran	357	.32	2.8	2.7
Aminocarb	259	.70	3.1	2.2
Malathion	160	1.8	4.1	1.6
Carbaryl	279	1.0	4.3	1.6
DDT	220	2.7	6.9	1.0
Trichlorfon	200	(†)	(†)	----------

*Toxicity relative to DDT: LD_{90} DDT over LD_{90} candidate equals toxicity index.
†Nontoxic.

Mr. GREFRATH. The report shows the toxicity of several chemicals that have yet to be registered for forest use on a scale compared to the toxicity of DDT. The screening research found that Pyrethrines are 13 times more toxic to Douglas-fir tussock moth than DDT. The study also found that there were seven additional compounds more toxic to that specific moth than DDT has proved to be.

Pyrethrines proved 3,249 times more toxic to Western tussock moth than DDT.

These two, and several other chemicals indentified by the Forest Service look promising, and can be considered candidates warranting field experiments. This is preliminary information and some of these chemicals may prove unfit for use. For example, before some of these chemicals can be field tested, the Forest Service must show that they have a low toxicity to nontarget organisms, including man. It must also be shown that these chemicals are nonpersistent. It is significant to note that research is being conducted at a slow pace due largely to insufficient funding available to the Forest Service.

Field experiments and pilot control studies are the most underfinanced steps in the Forest Service development process. Any increase in funding in this area would accelerate development of new forest insect and disease control methods. Forest Service budget for fiscal year 1971 was $9.45 million, including $7.65 million for laboratory research, $1.35 million for field experiments and $0.45 million for pilot control programs. The Forest Service budget for fiscal year 1972 is $9.9 million, including $7.8 million for laboratory research, $1.65 million for field experiments and $0.45 million for pilot control programs.

NFPA does not believe that the special project approach in S. 1794 is the best way to approach the problem of underfunding in Forest Service field and pilot control programs. Funding should be increased through normal appropriation channels, thus research would be a continuing rather than a terminal program. Despite this primary reservation, we consider that this bill, if enacted, would demonstrate the genuine and informed support of the Congress for special research efforts to develop practicable and effective integrated control programs for forest pests. With this in mind, we have the following comments on S. 1794:

This bill as drafted makes no references to the Forest Service, which already has authority and is conducting this kind of research on forest insects and disease. In our opinion, the Forest Service is a major single source of research on forest insects and disease in the United States. The Agriculture Research Service of the Department of Agriculture is conducting similar research on agriculture and forest insects and disease.

We have intended, in this statement, to make clear that the $2 million authorized by S. 1794 for the entire Department of Agriculture would not substantially increase efforts of the Forest Service in field research. The primary intent of the bill seems to provide funds for work on agricultural pests alone. If the Congress interpreted this proposed legislation in a manner that would limit annual pest research expenditures for the Department of Agriculture to $2 million, then the Forest Service would be forced to reduce an already inadequate program. Perhaps these problems could be eliminated by appropriate language in an introductory, policy or findings statement. We will be glad to work with the committee staff to develop language that would specifically accomplish these objectives if the committee decides to report this bill.

In summary, a comparison of available data indicates that: (1) the Forest Service must receive more funds if it is to develop better forest pest control methods, (2) $2 million is not adequate to do the job, (3) increased field experiment funding would probably produce the greatest immediate returns, (4) S. 1794 has several shortcomings that could be eliminated with appropriate amendments, and (5) probably the best method of increasing Forest Service funding would be through normal appropriation channels.

If you have any questions, I will be glad to try and answer them.

Senator CHILES. As I understand your testimony, it is generally you support the bill as being a statement from Congress that they are supporting and directing there be additional research; you do not want this in any way to be limited to the existing inadequate funding that is now going on.

Mr. GREFRATH. That is right.

Senator CHILES. In the Department, both Forestry and Agricultural products?

Mr. GREFRATH. Yes.

Also, I think we would like to see the Forest Service included in this bill.

Senator CHILES. I think that can be made clear, either in the record or in the bill itself, that this legislation in no way is intended to be limited, or to prevent any funds, nor does it even purport to be sufficient or adequate funds. But it is an attack in a direction to at least look at some biological control research, in which you try to have complete control, biological control. It would be a pilot for some pilot projects that you would hope to increase from there.

And it is your feeling, and the feeling of your association, that there is not sufficient moneys being expended today by the Government for biological research?

Mr. GREFRATH. Especially in the area of field experiments and pilot control research. As noted in my statement, there has been a great deal of promising methods developed in the laboratory, but the Forest Service has not been able to proceed because funding was not available.

Senator CHILES. Do you have any idea what level of funding would be necessary to have a sufficient amount?

Mr. GREFRATH. At this point, no. But we are working with the Forest Service, trying to find out what would be an adequate level for them. We will be glad to submit this material to the committee.

Senator CHILES. I think it might be very helpful, perhaps not on this bill, but when we are working on the next appropriations bill, that we hear from your association and other interested parties. Because it does not appear now that the level of funding is not adequate, either in agriculture or in forestry. I think the Congress might be willing to make that funding adequate.

I think the Congress is under some limitation because the Department itself, perhaps not because of their own desires, but because of desires or orders that they get from the Office of Management and Budget, they do not ask for sufficient moneys and are not spending sufficient amounts of the moneys that are budgeted to them. I think at the appropriations time would be when we need to hear from an association such as yours.

Mr. GREFRATH. We will testify Senator Chiles.

Senator CHILES. Thank you.

(Additional information submitted by Mr. Grefrath is as follows:)

WASHINGTON, D.C., *October 26, 1971.*

Hon. JAMES B. ALLEN,
Chairman, Subcommittee on Agriculture Research and General Legislation,
Committee on Agriculture and Forestry,
Senate Office Building, Washington, D.C.

DEAR SENATOR ALLEN: On October 1, in testimony before your Committee, I indicated NFPA's general support of S. 1794 in stating that if enacted this bill would demonstrate the genuine and informed support of the Congress for special research efforts to develop practical and effective integrated control programs for forest pests. I also suggested that several amendments should be incorporated into the bill to improve its effectiveness.

The Forest Service under existing authorization, is presently conducting research on biological and cultural methods of controlling forest insects and disease. It is probably the largest and best equipped single source of forest pest control research in the United States. For this reason, we suggest that the Forest Service be specifically referred to in the bill.

The bill would authorize moneys for both forest and agriculture pests. However, the bill does not indicate that "forest land owners" would be reimbursed for losses sustained as a result of research authorized under this proposal."Farmers and ranchers" are accorded this protection.

As noted in my testimony, integrated control methods emphasize biological and cultural techniques, and, sometimes adequate control is achieved solely through these means. However, there are two technical reasons why it is unrealistic to believe that adequate insect and disease control can be attained without the use of chemicals:

First, biological or natural materials or chemicals synthesized in nature are available only in very small amounts and at extraordinary high costs. Thus, these materials or chemicals must be synthesized synthetically before they can be used in practical control programs. This group of chemicals are probably not toxic to humans or the environment and include sex attractants, insect hormones and other similar materials.

Second, in some integrated control programs use of toxic chemicals similar to those presently available is not necessary, but for most insects, methods have yet to be perfected that would control them without the use of those chemicals. For the foreseeable future integrated control must also use some toxic chemicals and new non-persistant pesticides must be developed to replace persistant ones. These points were elucidated in March by Dr. E. F. Knipling, Science Advisor, Agriculture Research Service, U.S. Department of Agriculture before the House Agriculture Committee during hearings on the Federal Pesticide Control Act of 1971, (attached).

Persistent pesticides that were registered or approved for use by the Federal Government over the past 25 years or so are now being cancelled by the Environmental Protection Agency, an agency of the Federal Government. Many, if not all, of the reasons given for their elimination is the alleged harmful side effects these chemicals have on wildlife, man and the environment. Prior to their elimination or registration it is our opinion that it is the responsibility of the manufacturer in cooperation with other parts of the private sector and public institutions, such as land grant colleges, to show that the benefits of continued use of a particular pesticide outweigh the risks involved. However, once a chemical or control method is eliminated from use by the Federal Government it is our opinion that the Federal Government, who initially approved the use of the control method, is at least partially responsible for finding an immediate alternative means of controlling the pest, if, of course, a void has been created. For these reasons, NFPA suggests that this proposal be amended to include "integrated biological-cultural-chemical methods" of pest control.

If your Committee feels, as we do, that there is also a need for pure research into strictly non-chemical means of controlling forest and agriculture pests then perhaps Section 2 of S. 1794 could remain unchanged. This approach would provide two ways of solving a major problem in agriculture and forest pest control: one, through the National Science Foundation for fundamental research to meet primarily long range goals, and the other by the Agricultural Research Service and the Forest Service primarily on applied research designed to solve current short-term needs. NFPA suggests that a policy statement be included in this proposal outlining the above rational. We have attached to our statement language that we believe would accomplish these suggested changes.

Sincerely,

Bruce C. Grefrath,
Forester, National Forest Products Association.

(The amendment is as follows:)

Sec. 1. The purpose of this Act is to accelerate current research efforts in developing effective and workable integrated methods of controlling forest and agricultural pests that will be safe in the environment. To accomplish this objective the Congress finds that there is a need for applied research to meet immediate needs and fundamental research to meet long term goals.

Sec. 2. To meet short term needs: ~~That~~ (a) the Secretary of Agriculture is authorized and directed to carry out, through the Agricultural Research Service *and the Forest Service* of The Department of Agriculture, pilot field-research programs for the purpose of (1) developing employment of integrated biological-cultural *chemical* methods, (2) determining the economic and environmental consequences of predicting and modifying agricultural and forest pest populations through utilization of multidisciplinary and integrated biological-cultural-*chemical* methods, and (3) developing methods of collecting, handling and interpreting data obtained from such field research.

(b) The Secretary of Agriculture is authorized to reimburse farmers, ranchers, *and forest landowners* for any losses sustained by them as a result of any research authorized under this Act being conducted on their land, crops or livestock.

(c) There are hereby authorized to be appropriated to the Secretary of Agriculture to carry out the provisions of this section during the fiscal year ending June 30, 1972, the sum of 2,000,000, and such sum as may be necessary for each of the five succeeding fiscal years.

Sec. ~~2~~ *3. To meet long term goals* there are hereby authorized to be appropriated to the National Science Foundation for the fiscal year ending June 30, 1972, the sum of 2,000,000 and such sum as may be necessary for each of the five succeeding fiscal years for the purpose of expanding its fundamental research on integrated biological-cultural principles and techniques to control agricultural and forests pests.

Senator CHILES. Dr. Eden, we will be happy to hear from you next.

STATEMENT OF DR. W. G. EDEN, CHAIRMAN, DEPARTMENT OF ENTOMOLOGY AND NEMATOLOGY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLA.

Dr. EDEN. Thank you, Senator Chiles.

We appreciate the opportunity of speaking in behalf of this effort to take some pressure away from our reliance on the use of pesticides. I also appreciate the opportunity of having Dr. Whitcomb along with us to add to our testimony here.

I speak with some confidence of my knowledge and experience on the matter of pesticide usage, particularly of insecticides, miticides, and nematicides. I have been a professional in this area for over 30 years, involved in research, extension, and university teaching—and for the past several years the administrator of programs in entomology and hematology at the University of Florida. In my present capacity I have the responsibility for developing and promulgating insect and nematode control recommendations in the State of Florida, So, I feel qualified to discuss the implications and significance of the bill. I have also brought along Dr. W. H. Whitcomb of my Department to make a statement to you. Dr. Whitcomb is a recognized leader in biological control investigations.

In Florida we have long recognized the importance of pest control, particularly of insect pests. We have nearly a million acres of citrus; thousands of acres of avacado, mango, and other subtropical fruits; extensive plantings of pecans, peaches, and berries, nearly 400,000 acres of beans, cabbage, tomatoes, sweet corn, and other vegetable crops; extensive acreages of corn, cotton, tobacco, sugarcane and other agronomic crops; and well developed livestock and poultry industries. Because of our extreme southerly location and warm, humid weather every plant and animal in Florida is subject to attacks by insect. As a matter of fact we have many destructive species of insects in Florida, that most of the rest of the Nation never sees. In addition, because of our location we are continuously subjected to new destructive species from other parts of the world. So, in Florida we know about insects and the ravages they can impose on man and his property. It is with this first hand knowledge and background that I comment on S-1794.

Let me say here that I heartily endorse the basic principle and intent of this bill, which is to promote research by pilot field projects on the control of agricultural and forest pests by integrated biological control methods. Support for research on biological control of insect pests has been minimal and is long overdue.

Professional economic entomologists on society's payroll as I have been for over 30 years, have overriding responsibility to society. That is to develop, promulgate, and promote the use of insect control practices that result in the production, harvesting, processing and storing of products in the most efficient and economical manner that results in the least deterioration and pollution of the environment. Other responsibilities are also involved, or course, in the protection of man, his property, and his animals against vectors of disease, etc. Here, however, we are dealing purely with agricultural crops. I realize that many "protectors of the environment" in their zeal and naivete would have you believe otherwise, but I assure you this is so.

During the past 30 years, which have spanned my professional life as an entomologist, we have through demonstrated effectiveness become to depend largely on pesticidal chemicals for insect control. The use of these chemicals has been fundamental in making it possible for agriculture to provide the dining tables of this country, as well as some other parts of the world, with the most abundant, diversified, attractive, safe, and cheapest food supply ever known in the history of mankind. This use of pesticidal chemicals has led many misled enthusiasts to label the economic entomologist as "tools of the chemical industry." Nothing could be further from the truth. It would be just as logical to label all automobile dealers, car owners and mechanics as "tools of the automotive industry," shoe wearers of the shoe manufacturing industry, football lovers of the TV industry, or housewives of the detergent, clothing, or cosmetic industries. We have come to depend largely on pesticidal chemicals in agriculture because they have done the job; it's that simple.

Now we are in trouble. Historically, entomology has always been vastly undersupported. Small staffs of one or two or three entomologists at most land-grant universities spent their time "firefighting", grabbing quick solutions to insect control problems. The discovery of the insecticidal activities of certain synthetic molecules has helped us survive. But, the increasing awareness of an affluent society to the undesirable side effects of certain pesticides and the greatly increased sophistication of detecting infinitesimally small residues has us in trouble.

I was very interested in Mr. Herring's story this morning. I heard an analyst say in jest just recently, he believed with the right amount of time and equipment, he could find one molecule of DDT in a 1,000-pound bull. So we are quite sophisticated in being able to find very small residues.

As rapidly as possible, and still maintain our standard of living for American society, we must develop, promulgate and use non-chemical insect control techniques. These methods may take various approaches: insect sterilization, parasites, predators, diseases, plant and animal resistance, cultural practices, mechanical devices, and others. We have had some good successes in Florida as well as in other States. The screwworm was eradicated from Florida by the sterile male technique; the purple and red scales were brought under control in our citrus orchards with parasites. In certain parts of our Everglades muck soils we can manage wireworm populations by controlling flooding. We have developed corn hybrids that have good resistance to rice weevil. We avoid the use of certain insecticides in citrus because their use results in increased mite problems.

In Florida, as well as other States, we utilize a considerable amount of biological control now. We know more than we practice. However, the problems of insect control are so varied and complex, and there is so much we must learn that we do not know, that for the foreseeable future the proper and judicious use of pesticidal chemicals must continue—which brings me to the term "integrated control," as used in S. 1794.

Integrated control is essentially a relatively new term for what we who are responsible for insect control information to society have been doing all along: the utilization of all kinds of techniques for the most efficient insect control with the least harm to the environment. It usually involves the careful, proper, judicious use of pesticides. Minimum use consistent with proper pest management is always encouraged. As an example of this, I would like to quote from our Dean for Research at Florida, Dr. J. W. Sites, on the position of our Institute of Food and Agricultural Sciences on the use of pesticides:

> The position of the Institute of Food and Agricultural Sciences is that the public well-being must determine the use of pesticides; that banning of pesticides should not be resorted to; that efforts to eliminate their need be continued and increased so that ultimately a minimum pollution of the environment from these sources will exist.

This bill will aid in the development of pest control systems that utilize a minimum amount of pesticides. There are two specific points about S. 1794 to which I wish to call your particular attention:

1. The funds are appropriated to the Agricultural Research Service and the National Science Foundation. This concerns me in that the only provision for input from land-grant universities where much of the applicable talent lies—some of the greatest people of the Nation are in this room today from land-grant universities—the only provision for land-grant university participation funds would go through the National Science Foundation. For this program to have its fullest impact, land-grant universities must have a full share of the planning, execution, and utilization of these pilot plot programs. I submit that this can and should be done by making the cooperative State research service (CSRS) a "full partner" in the appropriation. I am sure you are aware that it is through the CSRS that Federal research funds are made available to the land-grant universities.

2. My second point deals with the scope of the bill. I hope that this committee will not feel that the Congress has "done its duty for biocontrol" by the passage of this legislation. I assure you, gentlemen, in the strongest terms that this appropriation is mere peanuts to the job that must be done. As a matter of fact, this bill will simply allow entomology to put together its present knowledge (which is woefully inadequate) on pest management in some pilot plots in several of the major agro-ecosystems, The limited funds involved do not and cannot provide for the massive research efforts that this country must make to ultimately have a gross effect on our dependence on insecticidal chemicals.

We did not acquire the basic knowledge that made possible the manufacture of the atomic bomb or putting a man on the moon with "peanut" appropriations. Neither will we make great strides in the problem at hand with token efforts. I urge not only your support of S. 1794, but of CSRS and ARS appropriation requests for next fiscal year that will permit important research on various approaches in biological control. I would remind the committee that CSRS funding to land-grant universities also results in additional inputs of State funds, thereby resulting in even greater amounts of resources going into research on biological control.

And this figure, incidentally, Senator, is about $4 or $5 to $1. Your State puts in $4 or $5 for each Federal dollar that goes into the programs.

Finally speaking, for entomologists all over the country, I say that the science of entomology stands ready to accept the challenge to move toward less dependence on pesticidal chemicals. It is up to the American public to provide the resources.

That is the end of my comments, Senator. I would be glad to answer any questions you may have.

Senator CHILES. All right, sir. I am again delighted, Dr. Eden, to have you testify before us and to have your statement that this is just touching the surface, but is a direction. I think from the testimony that we have elicited on this bill, this subcommittee is certainly better informed as to what the needs are.

I hope, again, that you will be back up here when it comes to the appropriations——

Dr. EDEN. Would be glad to.

Senator CHILES. For you CSRS budgets and the other budgets. Do you feel that the cooperative States research services should be made a part in this?

Dr. EDEN. Yes, sir. This makes it possible for the Nation to share in all of the wonderful talent that is in all of the land-grant universities of this country. Yes, sir, indeed.

Senator CHILES. All right, sir.

Dr. Whitcomb, we would be happy to hear from you now.

STATEMENT OF DR. W. H. WHITCOMB, DEPARTMENT OF ENTOMOLOGY AND NEMATOLOGY, UNIVERSITY OF FLORIDA, GAINESVILLE, FLA.

Dr. WHITCOMB. Gentlemen, before I begin to discuss detailed data in regards to the proposed bill, I wish to point out certain generalities in regards to biological control of pests.

A. In general, noninsecticidal controls are more sophisticated than insecticidal controls and requires far more intricate knowledge—knowledge which requires many man-hours to procure and, as of a matter of course, costs money. In my own work, I am often dealing with the interrelation of a thousand species of insects on a single crop. Men and computers must work hand in hand.

B. Entomologists have been working on ecological approaches for the control of insects since long before the publication of "Silent Spring." They worked on starvation budgets and with little recognition save from the farmers, I am convinced that had their research been properly supported and had their advice on using insecticides intelligently been heeded, we would not be in the mess we are today. However, all around me I see signs of the same exasperating stupidity of 2 decades ago. Great universities are reducing their numbers of graduate students in entomology because there are no jobs open. New developments in entomology will require more, not fewer entomologists.

C. Insecticides can be used together with most biological control techniques in so-called pest management programs. Materials must be specifically selected and must be used in such a way that each ounce is effective. Again, we need more research to know exactly what we are doing.

D. In my opinion, there are at least seven distinct methods of insect control which could keep pest populations within tolerable limits. Insecticidal control has lent itself uniquely to the American system of private enterprise, since it depends largely on private development and private use. The new methods are going to demand greater community participation, supervision, and support, with areawide crop inspection programs and intelligently guided planning backed by adequate research.

Although I began my career in biological control of insects working for the German Forest Service when an exchange student at the University of Rostock in 1938–39, most of my professional life, I have been a cotton entomologist. Much of what I have to say here will be concerned with this crop.

Recognition of the importance of beneficial insects in cotton came very early. By 1856, Glover published a 12-page report on the beneficial insects in cotton. Comstock, in 1879, studied the predators and parasites in the cottonfield with a thoroughness that would shame many modern workers. During the latter part of the 19th century, several researchers found beneficial insects important against a long list of cotton pests.

In 1892, the boll weevil appeared near Brownsville, Tex., and began its destructive sweep across the cotton belt, threatening this crop with disaster. If the cotton industry was to survive, economic control was needed quickly. An intensive search began for parasite and predators of this pest. By 1920, it became increasingly clear that, with the techniques known at that time, natural enemies were not able to handle the situation. To fight the boll weevil, early maturing varieties of cotton and insecticides appeared to be the only answer. Soon, this attitude prevailed for all cotton pests; a good insect was a dead insect.

Suddenly, in 1943, Ewing and Ivy showed definitely and clearly that use of insecticides could cause an increase in bollworm infestations, resulting from loss of predator efficiency. Their work, however, was overshadowed by the arrival of the highly efficient chlorinated hydrocarbons. DDT was in general use among cotton farms by 1946, BHC by 1947, and toxaphene by 1948. The automatic features of most of the control programs were destructive to any beneficial insects in the fields. I myself experimented on a large scale with the so-called early season treatment program in the Tocoron section of the Venezuelan Aragua Valley. Boll weevil control was very effective, it was followed by a heavy bollworm outbreak, which was in turn controlled with two applications of DDT. This resulted in a heavy outbreak of still another pest, the Colombian bollworm. Very little cotton was harvested in the area that season.

By the summer of 1947, several investigators suspected heavy predator kill from these compounds and began to worry about outbreaks of the bollworm. The experiments of Newsom and Smith in 1949 confirmed these fears. Entomologists, especially in Louisiana, Arkansas, and Alabama, began to insist that the materials be used only when infestations warranted it.

The discovery of boll weevil resistance to chlorinated hydrocarbons by Roussel and Clower in 1955, and its announcement by Newsom at the cotton conference of 1956 was a landmark. However, powerful new mixtures of chlorinated hydrocarbons continued to give control of the boll weevil. Resistance of the tobacco budworm and the bollworm to most chlorinated hydrocarbons came almost as an anticlimax in 1963 and 1964.

Integrated control with insecticides applied only when infestations warranted it became the order of the day in many areas. New and more exact information on predators and parasites began to appear. An integrated control program involving proper timing of insecticide applications depends upon knowing when infestations reach a dangerous level. Satisfactory field inspection programs began to develop.

Since the mid-1960's, cotton insect research and cotton insect controls have taken on new dimensions, but new information and more research is seriously needed. Florida and many other States are particularly concerned that the unfortunate experiences in cotton not be repeated in soybeans. Already, in some States, applications of toxicants are being made with no reference to insect pest populations in the field. We must have economic threshold information on all pests as fast as possible. New approaches to insect control will depend on financial support. A sensible integrated approach using all methods is the only answer, but if this is to be accomplished, new systems analyses and coordinated programs on a scale never before contemplated will be an absolute necessity.

Citrus is the most important agricultural crop in Florida. It is a crop which lends itself beautifully to biological and ecological controls. Programs like the introduction of *Aphytis* against citrus snow scale must be done on a small scale. The State of Florida on its own has financed the building of a modern quarantine facility so that parasites can be brought directly from abroad for investigation and eventual release. This effort will be in vain, however, if research in this direction cannot be properly financed in such a way that research talent can be used most effectively. The day of an individual gifted scientist working in a dingy laboratory, washing his own glassware and allowing his hunches and new ideas to go untested because of lack of equipment and assistants must be behind us.

As the accompanying lists show, Florida has contributed freely to the development of noninsecticidal and integrated control. It was here where the biggest victory of the century against a single pest, the Mediterranean fruit fly, was fought and won. The alertness of quarantine inspectors, sanitation methods, and an attractant in the baits were far more important than the insecticide used. It was in Florida that Knipling first tested screw-worm eradication with sterilized males on a large scale. Florida is ready and willing to become a leader in biological control, but it will take programs like the one in the proposed bill to make it possible.

In conclusion, I wish to make clear that the proposed bill contributes in two distinct ways to the future of entomology:

1. It makes possible the proper training of scientists with sufficient vision and comprehension to widen the scope of the professions.

2. It makes possible immediate research to fill wide gaps in our knowledge of new approaches to insect control.

(The attachments follow:)

SOME OF THE OUTSTANDING SUCCESSES OF NON-CHEMICAL CONTROL OF ARTHROPODS, NEMATODES, AND WEEDS IN FLORIDA

1. Control of cottony-cushion scale with the vedalia lady beetle as early as 1900.
2. Repellents of pests of man gave excellent success by 1948 (Mosquitoes, (etc.).
3. Control of Florida red scale in citrus by the parasite *Aphytis holaxanthus*.
4. Control of Rhodes-grass scale by *Anagyrus antoninae*, a parasite.
5. Partial control of *Diatraea saccharalis* with *Apanteles flaviles* and parasites.
6. Control of purple scale in citrus with the parasite *Aphytis lepidosaphes*.
7. Male sterilization of the screw-worm in 1960–1961—The most outstanding success of all.
8. Drywood termite control by use of "Wolmanized" lumber (non-toxic chemical).
9. Use of *Bacillus thuringiensis* for control of cabbage looper and "rindworm" in melons.
10. Two lined spittlebug control in pastures by proper management.
11. Resistant variables of Saint Augustine grass against chinch bug.
12. Control of wireworms by flooding.
13. Saline marsh manipulation for control of mosquitoes by Dr. Provost and others.
14. Use of chemosterilants for mosquito control in pilot operation.
15. Control of sugar cane mealy bugs with cultival techniques.
16. Control of red-headed pine sawfly with virus.
17. Control of Mediterranean fruit fly and hundreds of others through quarantine.
18. Control of nematodes through crop rotation, a standard practice in Florida.
19. Control of alligator weed with a flea beetle, *Agasicles* sp.

INTEGRATED CONTROL PROGRAMS WHICH HAVE BEEN SUCCESSFUL IN FLORIDA

1. Control of citrus pests.
2. Soil termite programs.
3. Stored product pests.
4. Sweet potato weevil
5. Papaya pest control.
6. Sugarcane pest control.

Senator CHILES. Dr. Whitcomb, we appreciate very much your testimony on this, too.

We thank you both very much for coming up here today and testifying before us.

Mr. Watson, glad to hear from you now, sir.

STATEMENT OF DR. THEO F. WATSON, DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF ARIZONA, TUCSON, ARIZ.

Dr. WATSON. Mr. Chairman, before I get into my statement, I would merely like to echo the expression that Dr. Eden made with regard to where these appropriations are directed. I did not include it in the official statement, but it did bother me somewhat that the funds to be appropriated seemed to be going toward ARS and National Science Foundation, with the exclusion of the State Agricultural Experiment Stations.

I do think these experiment stations should be considered in this type of an approach.

I am Theo F. Watson, professor of entomology, department of entomology, College of Agriculture, the University of Arizona.

This statement has been prepared in consultation with knowledgeable colleagues and bears the approval of the administration of the College of Agriculture. I wish to emphasize the current situation in pest control resulting primarily from the unfounded belief held by many that insecticides provide a panacea for insect control. This relatively simple, inexpensive, and effective approach to pest control has benefited mankind in many ways; nevertheless, it has also resulted in numerous problems for which we must now find solutions.

The first unanticipated problem was the selection of individuals within many arthropod species that were tolerant or resistant to insecticides. At the present time there are approximately 225 species of agricultural and medically important pests which have developed resistance to one or more classes of insecticides. The ecological consequences were manifold. Increasingly higher dosages and shorter application intervals were required to achieve the results to which the grower had become accustomed. New materials with different modes of action were introduced to replace those which had become ineffective and thus the chain reaction has continued. A prime example is the bollworm (*Heliothis zea* (Boddie)) problem in cotton. Initially, the bollworm was highly susceptible to DDT. After only a few years of continuous exposure to this insecticide, field populations developed resistance to the point that higher dosages were required and finally, where DDT became virtually ineffective. Subsequent control of the bollworm required the use of such short-residual, but acutely toxic, compounds as methyl parathion, which necessitated shorter application intervals. In some areas, the development of resistance to this insecticide has reached the point that unusually large dosage levels no longer provide adequate control.

A second problem resulting from the use of insecticides has been the rise to major pest status of insects and other arthropods which were originally of only minor importance. For example, prior to the need of multiple applications for control of the pink bollworm (*Pectinophora gossypiella* (Saunders)) over most of the cotton acreage of Arizona and the Imperial Valley of California, the cotton leaf perforator (*Bucculatrix thurberiella* Busck) was only an occasional pest. However, during the past 5 years it has become a major economic problem. The cause of this shift from an incidental or minor pest to one of major economic importance was apparently due largely to the destruction of natural enemies which had kept the cotton leaf perforator under control. The large number of pest species requiring control has resulted in the need for a greater variety of insecticides applied more frequently over a longer period of the growing season. Additionally, the adverse effects on beneficial insects such as the honeybee have been demonstrated when large quantities of these insecticides are applied to large areas on a fairly rigid schedule.

Other major problems arising from the widespread and often times indiscriminate use of insecticides have been the accumulation of harmful residues on food and feed crops, and direct health hazards to persons who may come into immediate contact with these insecticides, such as applicators, loaders, flaggers, and field workers.

Since the advent of effective insecticides, complete crop protection has been the usual practice. This practice may or may not influence the quantity and quality of the crop produced. Many agricultural and forest crops may harbor pest populations without adversely affecting yield of quality. The economic infestation level is dependent on many factors and varies with different crops, pests and economic conditions. There is a pest population level, however, at which obvious economic losses are sustained by the grower. Economic levels have been established through experimentation on a number of pests and crops, although adequate data are still lacking in many other cases. Accurate economic thresholds must be established on all crops for the ecological approach of pest management to be successful. Maintenance of sub-economic levels of pest species is necessary to provide the food supply of predators and parasites and thus establish some semblance of a balance in the agroecosystem.

In the process of integrating various methods of pest control into a more satisfactory, long-range management system the whole concept of pest control, which to most people implies direct kill by insecticides, must be altered to connote pest population management, that is living with sub-economic pest populations in equilibrium with their environment and their complex of parasites, predators, and pathogens.

Programs as envisioned in this legislation are essential to changing the present treadmill on which we find ourselves with regard to repeated applications of insecticides for effective insect control. This trend cannot be reversed in a short period of time. Ecological disruptions have taken place which may take several years to correct. The gradual changeover to a truly integrated control program will encompass continued use of insecticides in the conventional sense, but with greater care exercised in their selection and use. It will also require greater emphasis on augmentation and conservation of natural enemies and the use of biotic insecticides. Cultural practices which are beneficial to crop production and which adversely affect the pest complex will need to be incorporated in the overall integrated system.

I would list the following essentials for the establishment of an effective integrated control program as follows:

1. We need more basic research into the effects of diversified agriculture on the natural balance of crop pests and beneficial species, as well as the feasibility of gradually returning to this type of agriculture. Present large-scale monoculture in this country has created simple agroecosystems in which the limited number of crops are inherently unable to provide a suitable physical and biological environment to support resident populations of predators and parasites. Thus when pest species invade the crop area, the delay which accompanies the natural reinvasion and buildup of beneficial organisms is oftentimes too great to prevent serious economic losses to the crop. A system to diversify agriculture in a localized crop area would enhance the complexity of the agroecosystem and help to stabilize it by providing more internal checks and balances and thus reduce the violent fluctuations which normally occur in simple one-crop ecosystems. The problem remains of how to obtain grower acceptance of this approach which necessarily requires more time and consideration in management decisions but on the other hand ultimately improves production efficiency as well as environmental quality.

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2. We need well-trained professional pest management speciailsts, capable of analyzing agroecosystems for pest population levels and their potential for development, considering such factors as the physical environment, stage of crop maturity and natural enemy complex. These specialists must know or be able to quickly ascertain the influence of the physical and cultural environment on pests as individuals within the total pest population and the effects of interacting factors such as predators, parasites, and pathogens relative to the overall dynamics of pest populations. For example, an understanding of the epizootiology of the virus disease of the cabbage looper (*Trichoplusia ni* (Hübner)) on cotton can prevent costly and disruptive applications of insecticides.

3. We will have to cultivate acceptance of the concept of optimal pest management and crop yields rather than maximum pest kill and/or maximum yields. It is not feasible to have almost completely insect-free fields, as we have attempted to do in the past, and yet expect any significant help from beneficial insects. A balance must be established at a low enough pest level to prevent economic losses and yet maintain predators and parasites in numbers sufficient to insure their continuity. This might or might not result in some yield reduction but, more importantly, this type of management system would, in all likelihood, result in more net profits and permit an enduring agriculture.

4. It will be necessary to pursue educational efforts, directed toward both the consumer and the grower, for acceptance of esthetically imperfect products when neither the quantity or quality of the crops in question are affected. I cite, for example, citrus thrips that cause a scarring of the outer surface of orange peels but have no adverse affect on yield or quality of the fruit. This approach would certainly require changes in grading and marketability standards which, in many cases, are unnecessarily strict. These standards force the grower into what some designate as cosmetic control programs which ultimately result in accentuated pest problems because of environmental abuse with insecticides. It seems logical that the problems associated with some slight blemish on a product would be less serious than those resulting from the residues of insecticides required to produce an unnecessarily perfect product.

5. It will be necessary to revise drastically agricultural regulations (such as the Agricultural Act of 1970) adversely affecting the development of integrated control systems. An example is the regulation which ties future allotments or subsidy payments to current production in cotton. This encourages maximum production regardless of costs or consequences and largely negates the attempt to control the pink bollworm by cultural methods. If maximum yields were not the primary objective, early crop termination could be practiced. This approach would utilize a naturally-occurring phenomenon in the biology of this pest to control it, i.e., the cotton would be brought to maturity at an early enough date to preclude the development of large pink bollworm populations capable of overwintering.

The problems of pest management are presently far more complex than simply the selection of one or more chemicals to destroy destructive pests. In short, decisions in the field of agricultural pest control require nothing less than professional judgement, taking into account long range consequences as well as short range benefits. The basis for such jugment has to come from a well ordered aggregate of scientific observation and inference, including, most importantly, the natural ecology of untreated field crops. From here, the relative impact of pest and beneficial species can be assessed, and the value of various control measures, chemical, biological and cultural, can be determined with objectivity.

What is needed, essentially, is a new professional, armed not only with the knowledge available from modern entomology and industrial chemistry, but also thoroughly imbued with the broader insights of the population dynamics operating in a complex crop ecology. The reward of such professionalism will be an agriculture aimed not at maximum immediate profit, but rather at optimum sustained production, year after year, with minimum detriment or hazard to nearby food-or-feed-producing enterprises, to agricultural workers, to wildlife, and to the general consumer.

In conclusion, the principles embodied in this bill commend its enactment, particularly if the following situations are recognized and considered in the context of this legislation:

1. Integrated pest control will utilize all available tools, including the discriminate use of pesticides.

2. Crop diversification designed to insure greater permanence and stability in the agroecosystem will be an essential component of this integrated control program.

3. Certain economic incentives such as subsidy payments based on maximum yields must be changed.

4. Crop economics versus management practices must be evaluated over a composite 5- to 10-year period instead of on a year-to-year basis.

The proposed legislation is a tremendous step forward in the area of pest control, but I think a broader approach to include the points enumerated above is essential. With just consideration of these points, I wholeheartedly support this legislation.

Senator CHILES. Thank you, sir. I appreciate your testimony.

It appears you bring out very graphically what we have done in many instances. We had to use more and more pesticides in attempting to control the pests, and therefore to the farmer we tremendously raised the cost and the frequency with which he then had to apply the pesticides, and also increased greatly the resulting harm that happened to the environment because of the tremendous usage.

Now, then, you think this has got to be a coordinated effort of all of the methods.

Dr. WATSON. Yes, sir. I certainly do.

Senator CHILES. Thank you very much.

Dr. Lincoln.

STATEMENT OF DR. CHARLES LINCOLN, DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF ARKANSAS, FAYETTEVILLE, ARK.

Dr. LINCOLN. Adequate insect pest control programs are essential to maintain production of quality food, fiber, and forest products. Such programs must serve the national interest and be economically and socially acceptable.

Integrated programs of insect control are generally recommended and commonly used on Arkansas crops and forests. The components of such programs are: (1) Cultural practices, (2) utilizing weather advantages, (3) biological control, and (4) insecticidal control as needed.

In practice, we have taken advantage of what the Lord provided on the first three items, but have not manipulated them for purposes of insect control to any great extent. When insect infestation reaches threatening levels, broad specturm insecticides are applied. Insecticides are cheap and effective. Results are immediate, and they often give spectacular results.

Development of effective insect control programs based on insecticides, requires only a modest investment of funds for research from the public sector of the economy. Given an array of potentially effective insecticides, a competent entomologist can easily and cheaply determine which ones are effective against a given pest, and develop timing and application procedures.

I say this with confidence, because like Bill Eden and many others, I have been in this business, and I know how easy it is and cheap it is for the taxpayer.

Primary dependence on broad spectrum insecticides, which makes that cheap program possible, is no longer a tenable approach to insect control, however. Resistance of insect pests to insecticides, pollution, and disruption of populations of nontarget species have reached critical levels. We must, therefore, place much more emphasis on biological and cultural methods.

A great deal of research information is available on biological and cultural control of insects. To a large extent, it is piecemeal and fragmentary. To put such practices into application will call for changes, often drastic, in present farm practices.

Commercial farms are highly mechanized and specialized. Good farm labor is scarce, and farmers are caught in a cost-price squeeze. Farmers are in no position to gamble on a truly integrated program of insect control until such has been proven under farm conditions. Indeed, current commercial farm practices of land preparation and harvesting create an ecological catastrophe. Even with drastic reorientation of farm practices, there are serious doubts that the local environment can be modified to the extent that highly mobile pests can be controlled by biological methods. Speaking now of inundative, migratory type flights, that we are sometimes subjected to.

If integrated programs of insect control are to be developed and widely adopted, pilot field research programs must be conducted. In a pilot program, all available methods of cultural and biological control will be brought together to obtain acceptable yields of crops and forest products. Insecticides use will be kept at a minimum, with emphasis on use of safe, selective insecticides.

Such research will be expensive. For example, more than 600 species of predatory insects and spiders have been found in Arkansas cottonfields.

This figure, incidentally, comes from Dr. Whitcomb, and he raised the ante to a thousand in his previous testimony.

In a pilot test, it will be necessary to monitor populations of many of these species in relation to crops and other vegetation, pest insects, other prey insects, weather, et cetera. Predators move freely, and insecticide applications disrupt their populations far beyond the borders of the treated field. A pilot test must, therefore, include several hundred to a few thousand acres as a minimum, and require a great deal of manpower and instrumentation.

Of course, when the objective is near eradication, as in the boll weevil project, instead of a few thousand acres, it turns out to be a few thousand square miles.

Another reason that such research will be expensive is that each integrated system will be applicable to only one agroecosystem in a limited area. A large number of pilot tests will be necessary to cover the principal farming and forested regions of the United States.

Our research has reached the point that we must begin pilot tests in some agroecosystems: (1) To determine feasibility of fully integrated programs based on present knowledge; and (2) to get feedback to give direction to future single phase research.

To that end we plan to put one of our branch experiment station farms into a pest management program next year, but it will fall far short of adequacy even for a single test location. The area is too small and limitations will be imposed in meeting the needs of project leaders in other desciplines who are using the same branch station for part of their research. This is the best we can do with out funds.

In other agricultural and forestry ecosystems further basic and single phase research is needed before pilot tests of integrated control can be mounted with reasonable chances of success.

Research funding of the sort proposed in S. 1794 is the logical next step, indeed necessary step, to effectuate insect control programs needed to maintain an adequate and wholesome supply of food, fiber and forest products.

Now, Senator, I have attached here bibliography and a statement of current research at the University of Arkansas. These are to serve as an indication of our dedication to this approach.

Also, in light of what Dr. Eden said, it might serve as an example of some of the expertise that is available at the land grant universities.

This is attached, but I will let you decide whether to include it in the official record or not. It is a little bulky.

Senator CHILES. We would be happy to append this to the record, and will do so.

(The attachment follows:)

ANNOTATED BIBLIOGRAPHY OF RESEARCH IN ARKANSAS RELEVANT TO S. 1794

This bibliography sketches 50 years of research on cultural and biological control of insects by Arkansas entomologists. In the early years the agricultural and forestry communities were not yet ready to make much use of such information. In more recent years the spectacular successes with insecticides have limited farmer acceptance of cultural and biological control practices.

This accummulated research information must now be put to use. The most promising such vehicle is pilot field tests with broad evaluation of their effectiveness in pest control and their environmental impact.

Baerg, W. J. 1928. "Three shade tree insects." Ark. Agr. Exp. Sta. Bul. 224.

The rough silken bag protects bagworm larvae from birds and largely from insect predators. Several parasites successfully attack bagworms, often to a considerable degree. The egg parasite, *Telenomus ichthyurea,* almost completely controls the second generation of the walnut caterpillar. *Apanteles hyphantriae* and *Hyposoter pilosulus* parasitize the fall webworm and the latter is very effective.

Baerg, W. J. 1935. "Three shade tree insects, II, great elm leafbeetle, catalpa sphinx, and eastern tent caterpillar." Ark. Agr. Exp. Sta. Bul. 317

Owing to unfavorable conditions, presumably climatic, the great elm leaf-beetle disappeared in 1930 and has not since been seen in Arkansas. Parasites of the catalpa sphinx, one attacking the caterpillar and another the egg, function as a very effective natural control. Parasites and birds make heavy invasions on tent caterpillar families, but the result is rarely more than preventing marked increases.

Baerg, W. J. 1942. "Rough-headed corn stalk-beetle." Ark. Agr. Exp. Sta. Bul. 415.

Fall plowing and control of grass within fields before planting will prevent injury. Late planting escapes injury. Heavy seeding rates of corn followed by hand-chopping is an effective control measure.

Baerg, W. J. 1947. "The biology of the maple leaf scale." Ark. Agr. Exp. Sta. Bul. 470.

Chalcid parasites and hot dry weather are effective natural controls.

Boyer, W. P., L. O. Warren and Charles Lincoln. 1962. "Cotton insect scouting in Arkansas." Ark. Agr. Exp. Sta. Bul. 656.

Gives development of the scouting program in which each cotton field is systematically surveyed weekly for cotton insect pests. Reviews infestation records by pest, area and year.

Brazzel, James R., L. D. Newsom, John S. Roussel, Charles Lincoln, F. J. Williams and Gordon Barnes. 1953. "Bollworm and tobacco budworm as cotton pests in Louisiana and Arkansas." La. Tech. Bul. 482.

These two economic species and a similar non-economic species are differentiated and compared as to hosts, life and seasonal history, etc. Causes of outbreaks of each species were determined and explained within limits of current knowledge.

Dumas, B. A., W. P. Boyer and W. H. Whitcomb. 1964. "Effect of various factors on surveys of predaceous insects in soybeans." Jour. Kans. Ent. Soc. 37:192–201.

Populations of more than 20 species or groups of predaceous insects and spiders were estimated by two methods in relation to time of day, crop condition and weather.

Hunter, Robert C., Thomas F. Leigh, B. A. Waddle and Louis A. Bariola. 1965. "Evaluation of a selected cross-section of cottons for resistance to boll weevil."

Starting with 336 different seed lots representing the array of biotypes that will fruit at temperate latitudes, resistance through tolerance, non-preference and anti-biosis was sought from 1957 to 1962. Techniques for evaluation were developed. Promising sources of resistance of each type were found.

Isely, Dwight and A. J. Ackerman. 1923. "Life history of the codling moth in Arkansas with special reference to factors limiting abundance." Ark. Agr. Exp. Sta. Bul. 189.

Sundown temperatures control egg-laying in the spring, a temperature below 62° F. preventing egg-laying. Sundown temperatures vary from orchard to orchard.

Isely, Dwight and W. J. Baerg. 1924. "The boll weevil problem in Arkansas." Ark. Agr. Exp. Sta. Bul. 190.

Control measures must be made to fit conditions of the region or locality. Destruction of hibernation places and early production are recommended. Dust application of calcium arsenate should be made only where weevils actually occur.

Isley, Dwight. 1926. "Early summer dispersion of boll weevil with special reference to dusting." Ark. Agr. Exp. Sta. Bul. 204.

Early summer dispersion within fields was mapped. Spot dusting controlled boll weevil until migration began and only small areas were treated.

Isley, Dwight. 1928. "The relation of leaf color and leaf size to boll weevil infestation." Jour. Econ. Ent. 21:553–9.

Boll weevil has a marked preference for cotton plants with green foliage over those with red foliage. There was little choice between small leafed and large leafed varieties.

Isely, Dwight. 1929. "The southern corn rootworm." Ark. Agr. Exp. Sta. Bul. 232.

To avoid injury by the southern corn rootworm, the bottomlands to be planted in corn should be kept free from wild grasses at least a month before planting.

Isley, Dwight, 1932. "Abundance of the boll weevil in relation to summer weather and to food." Ark. Agr. Exp. Sta. Bul. 271.

Rearing was done in cabinets with controlled temperatures and humidities. Effects of temperature, relative humidity and food on development and

survival were worked out with much more precision than ever before because of the new techniques of temperature and humidity control.

Isley, Dwight and H. H. Schwardt. 1934. "The rice water weevil." Ark. Agr. Exp. Sta. Bul. 299.

The loss caused by this insect may be greatly reduced by drainage at the time the majority of the larvae have entered the third instar and before severe root pruning begins. Drainage should continue until the soil is thoroughly dried.

Isley, Dwight. 1934. "Relationship between early varieties of cotton and boll weevil injury." Jour. Econ. Ent. 27:762–6.

Under boll weevil conditions, early varieties outyielded late varieties. The latter, however, gave a greater response to dusting with calcium arsenate.

Isley, Dwight. 1935. "Relation of hosts to abundance of cotton bollworm." Ark. Agr. Exp. Sta. Bul. 320.

Bollworms were reared on several hosts at controlled temperatures. Better hosts gave shorter larval feeding periods, heavier pupae, and more eggs per female. Corn was the best host.

Isley, Dwight. 1939. "Timing seasonal occurrence and abundance of the codling moth. Ark. Agr. Exp. Sta. Bul. 382.

The variations from season to season in abundance of the codling moth and the variations in time of occurrence of the successive generations are response to differences in temperature. Temperature is of importance chiefly because of its effect on fecundity.

Isley, Dwight. 1942. "Insect problems resulting from changes in agriculture in Arkansas." Jour. Econ. Ent. 35:473–7.

Several examples are given and cause and effect relationships are suggested.

Isley, Dwight. 1943. "Early maturing varieties in codling moth control." Jour. Econ. Ent. 36:757–9.

Early fall varieties which ripen before a majority of worms of the third generation have left the fruit, if grown in blocks separate from later varieties, do not present as difficult problem of control as late fall varieties, but nevertheless, require adequate protection by spraying. Mixing blocks of early fall and late fall varieties makes the problem of control more difficult.

Isley, Dwight. 1946. "The cotton aphid. Ark. Agr. Exp. Sta. Bul. 462.

The cotton aphid causes serious losses to cotton only following dusting cotton with calcium arsenate for boll weevil control. Ordinarily, they are held in check by insect enemies. Dusting with calcium arsenate reduces the numbers of insect enemies and thus favors multiplication of aphids. The temperature most favorable for reproduction is 68° F. which is lower than that of the insect enemies of aphids. For this reason cotton aphids are often abundant in spring and fall, but are never important in midsummer unless cotton is dusted. Nutrient culture studies showed that nitrogen stimulated fecundity.

Isley, Dwight. 1947. "Relation of crib type to weevil injury to corn." Jour. Econ. Ent. 40:438.

Well-ventilated, isolated corn cribs are drier in summer and colder in winter, resulting in less injury. from rice weevil.

Leigh, Thomas F. and Charles Lincoln. 1964. "Feeding and development of the boll weevil, *Anthonomous grandis*, on several cotton types."

A cross section of available commercial material was examined for possible resistance to boll weevil using a varity of techniques.

Lincoln, Charles and Thomas F. Leigh. 1957. "Timing insecticide applications for cotton insect control." Ark. Agr. Exp. Sta. Bul. 588.

Several years of research work relating to timing of applications of insecticide were presented. The approach was to depend on scouting and to accept the maximum tolerable infestations before treatment. Four years of predator population studies on cotton and other crops were reported, including effects of insecticidal treatment.

Lincoln, Charles, Grover C. Dowell, W. P. Boyer and Robert C. Hunter. 1963. "The point sample method of scouting for boll weevil." Ark. Agr. Exp. Sta. Bul. 666.

A system of scouting for boll weevil was developed that yields quantitative information instead of percentages. It also yields valuable information on bollworms.

Lincoln, Charles, J. R. Phillips, W. H. Whitcomb, G. C. Dowell, W. P. Boyer, K. L. Bell, Jr., G. L. Dean, E. J. Matthews, J. B. Graves, L. D. Newsom, D. F. Clower, J. R. Bradley, Jr., and J. L. Bagent. 1967. "The bollworm-tobacco budworm problem in Arkansas and Louisiana." Ark. Agr. Exp. Sta. Bul. 720.

In crimson clover 1 to 3% of the eggs survived to produce adults with predation the principal cause of mortality. On cotton predators destroyed 32% of the eggs in 12 daylight hours. The important predators are discussed. Population studies were made in relation to host. Pupal dispause was characterized. Field behavior of moths was studied and their activity logged.

Lincoln, Charles. 1969. "The effect of agricultural practices on insect habitats in a typical delta community." Proc. Tall Timbers Conf. on Ecological Animal Control by Habitat Mgt.

The Jefferson community in Desha county, Ark., has undergone two revolutionary habitat changes in the past 20 years. The synthetic organic insecticides made possible great increases in cotton yields. By destruction of beneficial as well as pest insects they required additional insecticide inputs. An appreciation and knowledge of these beneficial insects led to an effective program of integrated control. Soybeans and mechanization then placed such stress on native bio-control agents that the integrated control program ceased to work consistently. Suggestions are made for habitat modification consistent with intensive, mechanized agriculture. A heavy investment in research will be required to develop and evaluate an ecological approach to habitat management in intensively farmed areas.

Lincoln, Charles, W. P. Boyer, Grover C. Dowell, Gordon Barnes and Gerald Dean. 1970. "Six years experience with point sample cotton insect scouting." Ark. Agr. Exp. Sta. Bul. 754.

Scouting records from 21 locations in Arkansas were evaluated. Boll weevil and bollworm were of approximately equal importance. Biological control of bollworm was not impressive. From 27 to 42% of the fields were first treated at lower than recommended infestation levels.

Miner, Floyd D. 1952. "Biology of the prairie white grub, *Phyllophaga crassissima*." Ark. Agr. Exp. Sta. Bul. 521.

First instar larvae fed principally on fungi growing on decaying organic matter in the soil. The heavier infestations in bottomland soils of Arkansas as compared to hill land are probably due not to direct effects of moisture on the grubs but to inability of the grubs to move about and feed in dry, hard clay soils.

Miner, Floyd D. 1966. "Biology and control of stink bugs on soybeans." Ark. Agr. Exp. Sta. Bul. 708.

The green stink bug depends on wild hosts, especially dogwood, for the first generation. Soybeans are attacked by the second generation and infestations are localized.

Rolston, L. H. and Phil Rouse. 1965. "The biology and ecology of the grape colaspis, *Colaspis flavida* Say, in relation to rice production in the Arkansas Grand Prairie." Ark. Agr. Exp. Sta. Bul. 694.

Stands of seedling rice following lespedeza are frequently destroyed. Omitting lespedeza from the rotation is one solution. Water seeding of rice is another. Both call for drastic changes in farm practices. Varietal resistance in lespedeza offered little promise. Insecticidal treatment of rice seed proved cheap and effective.

Tugwell, Noel P. and B. A. Waddle. 1964. "Yield and lint quality of cotton as affected by varying production practices." Ark. Agr. Exp. Sta. Bul. 682.

Two levels each of insecticides, irrigation, fertilizers, varieties and spacings were compared. One level was that recommended and the other level of insecticide, irrigation and fertilizer was higher. Yields were not increased above that to be expected when the currently recommended practices were followed.

Wall, Marvin L. and Willard H. Whitcomb. 1964. "The effect of bird predators on winter survival of the southwestern and European corn borers in Arkansas." Jour. Kan. Ent. Soc. 37:187–92.

Birds are valuable predators of both species. The flicker is most important on southwestern corn borer and the downy woodpecker on European corn borer.

Warren, Lloyd O. and J. F. Coyne. 1958. "The pine sawfly, *Neodiprion taedae* Ross, in Arkansas," Ark. Agr. Exp. Sta. Bul. 602.

Wet, cool, cloudy weather inhibits adult activity and egg-laying, prolongs the hatching period and lengthens the larval feeding period. 13 or more species of parasites and a polyhedral virus serve as natural control agents but often fail to check infestations until spectacular damage has been done.

Warren, L. O. and M. Tadic. 1970. "The fall webworm, *Hyphantria cunea* (Drury)." Ark. Agr. Exp. Sta. Bul. 759.

A complete study of the pest with emphasis on biological control and population dynamics in the United States, where it is native, and eastern Europe, where it has been accidentally introduced.

Whitcomb, H. W. and K. Bell. 1964. "Predaceous insects, spiders, and mites in Arkansas cotton fields." Ark. Agr. Exp. Sta. Bul. 690.

Approximately 600 species of predaceous arthropods were found associated with cotton. Observations were made on their abundance, favorite prey, favored habitats, etc. This is a monumental piece of work.

York, J. O. and W. H. Whitcomb. 1963. "Breeding for resistance to the southwestern corn borer." Ark. Farm Research XII.

A high degree of resistance to stalk invasion was incorporated into a synthetic corn variety designated as SWCB Syn.

Current Research on Cultural-Biological Insect Control at the University of Arkansas

The bollworm, *Heliothis zea*, is presently the No. 1 pest of both cotton and soybeans in the delta. Moths are strong fliers and infestations often appear to originate from flights from outside the state. Studies are being made on migration and possible races of this insect. Thresholds of damage are being studied in an effort to limit insecticide usage to the minimum necessary to avoid losses. An effort is being made to improve scouting and we hope to improve utilization of scouting information through computerization.

Biological control studies include augmentation of predator and parasite populations through strip and border plantings, minimum tillage, and artificial feeding. Basic studies of pathogens are being made as well as field tests to utilize a nuclear polyhedrosis virus.

Good progress is being made with a selective insecticide for bollworm that has minimal effects on parasites and predators.

Glabrous soybeans are being studies for possible resistance to bollworm, since ultra-smooth cottons are resistant.

Cultural control is being studied as part of a cost-reducing package for cotton. Fast-fruiting varieties planted in narrow rows shorten the fruiting season, thereby reducing the period of crop susceptibility and the time that pests can build up in cotton. Close row spacing may also reduce soybean susceptibility to bollworm.

The boll weevil shares honors with bollworm as the major pest of cotton. The Frego bract character confers a high degree of resistance and it is being incorporated into desirable commercial cottons.

Diapause control of boll weevil reduces overwintering populations by use of low dosages of non-persistent insecticides. There appears to be very little carryover effect on beneficial insect populations.

The common delta varieties of cotton are quite tolerant of plant bugs. Unfortunately, cottons with the Frego or the ultra-smooth character are extremely susceptible to plant bugs. Breeding efforts are underway to break this linkage. Other work on plant bugs includes wild hosts that serve as sources of infestation, survey methods, thresholds of damage, and selective insecticides. Indiscriminate strip and border plantings for predator augmentation might well furnish breeding areas for plant bugs.

Alfalfa weevil studies include biological control, damage thresholds, and aestivation-hibernation.

Sorghum studies relate to effect of time of planting on midge populations, trap crop effectiveness on bollworm, and predator population buildup.

Nuclear polyhedrosis viruses are showing great promise for cabbage looper, soybean looper and a pine sawfly. Studies are being made of ways to improve effectiveness of the commercially available *Bacillus thuringiensis*.

Ecological control of pine tip moth has been studied for several years. Good progress has been made but not to the extent of being able to prevent damage to new plantings of pine. Large-scale site preparation for new pine plantations has resulted in severe damage from tip moths and reproduction weevils for the past four years. The use of heavy machinery in clean harvesting favors the buildup of turpentine beetles.

Forestry production practices increasingly emphasize yield, short rotations, mechanization of planting and harvesting and even-aged stands of a single species. Effects of these practices on pest insect populations are being studied. Results are discouraging.

On a more cheerful note, *Ips* bark beetles are not tree-killers. Small plot and large-scale field studies show that a tree is irreversibly dying before it is attacked.

Senator CHILES. Thank you very much for your testimony.

Dr. LINCOLN. Did you have any questions?

Senator CHILES. I have no questions. Thank you very much.

I think we have to recess, to reconvene at 2:15. The Senate is about to vote.

(Whereupon at 11:20 a.m., the subcommittee recessed, to reconvene at 2:15 p.m.)

AFTERNOON SESSION

Senator ALLEN. Dr. Bay, if you will, please.

STATEMENT OF DR. ERNEST C. BAY, HEAD, DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF MARYLAND, COLLEGE PARK, MD.

Dr. BAY. My name is Dr. Ernest C. Bay. I am head of the department of entomology at the University of Maryland, College Park.

I speak now as a professional entomologist and educator with 24 years of training and experience gained on both the east and west coasts of the United States. My experience has been almost equally divided among chemical and biological approaches to insect control with the latter being most recent.

Before coming to the State of Maryland on September 1, as head of the department of entomology at College Park, I was head of the division of biological control at the University of California, Riverside.

Like most field entomologists, I have long been concerned with the fragility of traditional field experiments where the researcher must gamble months of work and thousands of dollars on the good faith that a cooperating grower will not panic and spray out his experiments at a critical time. When such does happen it is difficult to blame the grower for breach of promise when his crop is his livelihood, and he faces no compensation for its loss.

Where the risk of grower cooperators retreating from agreements has been of concern in the past, it poses a much greater threat in the area that we are now considering, that of integrated and biological control. One reason for this is the admittedly imperfect state of the art of biological and integrated control, and the likelihood that during the development of techniques for its improved implementation there will be a greater incidence of threatened crop yields. Also, there is the widely held but seldom spoken skepticism that the term "integrated control" is an ecological platitude, and that our only practical reliance can continue to be on strict chemical schedules.

Chemical pesticides, with their quick catastrophic biological effects are easy for the grower to understand, and the failure of an experimental compound is likewise easy for a grower to comprehend and to forgive. Biological and integrated control interactions, on the other hand, are comparatively slow to take effect, sometimes requiring several seasons for their maximum benefits to be realized, and are often so complex in their working that the investigator himself finds it difficult to explain exactly what is happening.

Withdrawing a crop from hard pesticide use is somewhat analagous to a drug-addicted person withdrawing from his chemical dependence.

Both are biological systems that have been disrupted. The crop, like the patient, often looks its worst before it is to revive. It takes a strong and faithful cooperator to live through this period with the investigator.

I would like to relate an incident that is applicable to the matter at hand. Recently, in California, while teaching a course in biological control, I had a local supervised pest control worker, a former employee of the Entomology Department of U.S. Riverside, take my class on a field trip of the ranches that he serviced.

After showing us several healthy supervised ranches on integrated pest control programs and explaining the "hand-holding" hours that he had to spend with owners seeing them through dark moments, he stopped by an obviously sick crop of oranges. He explained that this was not one of his groves, but a grove on strict chemical control where an ill-timed thrips spray had been applied.

The fruit was not only thrips scarred, but the spray material had affected the wax cuticle of the fruit, allowing stem rot to occur. The crop was a total loss. As he explained and I believe you will understand, had this been one of his groves in this condition he would have been crucified. As a grove under traditional chemical control, however, it would be easy for the pesticide salesmen to commiserate with the grower for the ill-timed application, and to advise additional, more closely timed sprays for the following year. The grower would understand. And I would add, probably comply.

If integrated and biological control is to be accepted widely as more than a platitude and if it is to realize its best potential, researchers must be guaranteed adequate acreage, sufficient time, and complete authority over crop management for these methods to be developed. In our system of free enterprise this cannot be done without a means of compensating the grower for losses incurred through our experiments.

As an agricultural official from Bulgaria understandingly commented after studying biological control at Riverside for several months, "It is odd but, here you are the leaders in biological control and you are not free to practice your science. Only in my country could you use your science."

As a concluding thought, I remind you that most agricultural research in the United States is in some way federally supported. However, the investment represented by this support is unprotected as regards grower cooperation. Looked upon in this way, Senate bill 1794 is actually an extremely modest insurance policy to protect, in a small way, the investment that the Government now has in the experiments of its land-grant colleges, experiment stations, NSF graduate fellows, EPA and NIH programs aimed at reducing pesticide use, and many others.

I urge you to consider this bill in this light, and to give it the support it deserves.

Senator ALLEN. Thank you very much, Dr. Bay. We appreciate your testimony. I believe it will be of great deal of value to the committee in its deliberation.

Now, you have a division of biological control at the University of California, Riverside?

Dr. BAY. Correct.

Senator ALLEN. You are constantly engaged in research and experiments to the extent that you are able to engage in them, depending upon grower cooperation; is that right?

Dr. BAY. This is true.

Senator ALLEN. But you do have pilot programs on a limited basis?

Dr. BAY. They are on a limited basis, yet we have to rely on grower cooperation to a large extent, especially as we get into integrated and biological control, insofar as we cannot rely wholly on agricultural field stations and university experiment stations because the conditions represented there are too limited and too—they are not sufficiently descriptive of the problem over its variety of situations.

Senator ALLEN. You really need something under actual farming conditions; do you not?

Dr. BAY. That is correct.

Senator ALLEN. Where the farmer is earning his livelihood in farming——

Dr. BAY. That is true.

Senator ALLEN (continuing). Rather than just have a limited field as an experiment station.

Dr. BAY. In order for it to be representative—this is the term I was looking for—it has to be the case, because conditions vary so much from one locale to another. As a matter of fact, at a recent pesticide conference at the University of Maryland, several people espoused this skepticism about the whole idea of pest management and integrated control, simply because of the fact there are entomologists in the East dealing primarily with small farmers who have vested interests in their ways and are not about to change.

So this is where this platitude comes in, they say it is all well to talk about integrated control, but we are not going to be able to convince these people, we are not going to be able to use it in 1 or 2 years, and we are not going to use it at all unless we have the wherewithal and the locations upon which we can experiment and develop these techniques. It is a long-term thing, as I am sure has been made clear by the other speakers here.

Senator ALLEN. Now, in your biological control research, have you had programs of locating predators and parasites, that phase of biological control?

Dr. BAY. Not so much the problem of locating them, because——

Senator ALLEN. Discovering them, identifying them——

Dr. BAY. Yes, of course.

Senator ALLEN (continuing). As being predators?

Dr. BAY. Of course, this is done mostly in foreign lands. Those that we have here we can bring into the laboratory and rear in the insectary in large quantities.

But then the problem develops in finding places where we can give these honest tests in the field, because everything being under such heavy insecticide control in so many areas, too often there is not a favorable environment to release these and manipulate them. And even where there is, oftentimes it does not last long enough for meaningful results because it is difficult to find a grower who will be willing to cooperate with you for the necessary years.

Some growers have cooperated for a number of years, on a very personal basis, working with an individual, such as the supervised control representative to whom I referred. I have spoken with these people and they are very happy with the results, but they admit it has been pretty hair raising at times, going in this direction.

Senator ALLEN. Now, has your department conducted research in the sterilization of male insects?

Dr. BAY. No. I should clarify. We are talking about two things right now. We are talking about my division that I recently left in Riverside but, I am now with the University of Maryland.

Senator ALLEN. I see.

Dr. BAY. But in Riverside, our concentration was primarily on what we consider the traditional aspects of biological control. But yet some of our younger staff were very appropriately beginning to integrate this in the integrated control concept, which has been discussed here.

But as far as the eradication, and so on, we have not been equipped, and that has not been our specialization.

Senator ALLEN. You feel that under the mechanism provided by this proposed bill, it would remove this element of the grower panicking, if provision is made for reimbursement of any loss he sustains by using the integrated method of control?

Dr. BAY. I do not think I would go so far as to say "eliminate" it, but I do think you would reduce the risk considerably. And any move we can make in this direction, I think is well warranted.

Senator ALLEN. Do you feel that the approach used by this bill is a sound and logical approach?

Dr. BAY. The only thing I would say there is, the bill itself is too abbreviated as to how the provisions might be implemented. I would reserve comment for the reason I am only basing my thoughts right now on the overall purpose of the bill. I think it is modest.

Senator ALLEN. Well, the bill, after providing a mandate to the Department, does leave the Department with authority to make the rules and the regulations and provide for actually implementing the legislation. It does not seem to be advisable to spell out every bit of detail of the program.

Dr. BAY. No, that I understand. So I would say, as I stated here, I would agree very much with it in principle and I would trust that the implementation would be sound.

Senator ALLEN. What do you think of the authorization for the first year of $4 million, total authorization? Would that be adequate?

Dr. BAY. Again, depending—My suspicion would be that it would be adequate if it were concentrated over a selective number of situations.

Senator ALLEN. Yes.

Dr. BAY. But if it is spread too thin, then I think it would lose its meaning.

Senator ALLEN. I gather from what you say, that where a farmer has familiarity with a method of pest control or pest eradication, he is more inclined to be lenient with the shortcomings of the failure of a known method than he would be of a method with which he was not familiar?

Dr. BAY. This is true. I find people are much more ready to forgive mistakes or disruptions in things that they can understand. It is usually true that people are rather impatient with not being able to get results from something they do not understand.

To clarify that, years ago when I was working with an insect problem on a large lake, people would come to me and sometimes be very irate, and want to know why such a seemingly simple thing had not been cleared up. I found that after I discussed with them some of the highlights, as to the complexities of the problem, their whole attitude changed. They turned around and were much more forgiving and understanding, and more ready to live with their problem.

I think we find this in all walks of life.

Senator ALLEN. Is it not possible that, using integrated control methods, one method might hit at some of the pests and insects, and another method used in conjunction with the other method, might hit at still another segment of the pest population?

Dr. BAY. This is absolutely true.

Senator ALLEN. And if you put your reliance in one chemical, if an immunity was built up by the insect or pest spraying, you might find yourself having no effect whatsoever on the insects or pest by continued use of the same pesticide?

Dr. BAY. But you use the same pesticides. And yet, pesticides have been something that have had a broad reliability. When someone comes up with something like DDT, maybe you can use this on farms A, B, C, and D, and expect the same results. Whereas, with an integrated program working with a given pest, maybe you would have approaches 1, 2, 3, and 4, and one might be applicable to one farm and another to another farm. The point being that it is a more variable type of thing, and the approaches have to be almost custom-made, or at least you have to have a variety of plans that you can use for different types of insect problems in any particular locale.

This is one difficulty—as I say—these approaches are slow to develop and it is a much more complicated area we are going into, and one reason so many people are distrustful of it. But again, it is the type of thing that has to be worked on, has to be studied in a rather sacrosanct way, really, for 4 or 5 years, before it can be reliably said as to whether this is a reliable and valid approach.

Senator ALLEN. Even an integrated system would not necessarily eliminate, certainly at the outset, chemical methods of control?

Dr. BAY. No. Your chemical methods are entwined with this. The chemical method is absolutely a part of it.

It is the same idea—I think one way I like to look at it oftentimes is getting back to a medical analogy. In the sense, many times you come down with colds and diseases that at given times your body will take care of, but there are periods in which you know it is not going to, and you have to rely on the doctor's prescription and actually take a chemical to do it. We are talking about the same thing here on a different scale.

Senator ALLEN. Is there a tendency on the part of the average farmer to overuse chemicals?

Dr. BAY. I would say it has been, and I would say that most of your authorities will agree it is still the case. Just recently, I was discussing with one of my staff the situation on apples in the nearby State of Maryland. He said that just in recent seasons the best farmers have already cut back on insecticides substantially, and that the poorer farmers who are less appreciative of the effects of their overuse are having the problems. So there are moves going in this direction.

Likewise, through these integrated control efforts, the alfalfa weevil is becoming much less a problem on the Maryland eastern shore. For several seasons eastern shore alfalfa farmers have used absolutely no sprays, where they used to have to spray quite regularly. I understand that the same situation is prevailing due to natural enemy releases up in Delaware and New Jersey, and that there are several areas where farmer reliance on chemicals is now declining because given the time, they have been able to discover parasites will work. But there are the periods where they do have to come out and use chemicals.

There is a situation in California, in the Fillmore Citrus Protective District, which has really been practicing integrated control for a number of years, where they use chemicals on red scale, to be sure, but just use the very, very least fraction of what is used in Riverside County and other areas, where growers remain totally reliant on chemicals. But again, integrated control has to be developed to where you have professionals well trained, who know what they are doing, who can look at the grove or crop and be able to instruct the farmer, "This infestation is not going to get out of hand, so just sit back and do this," or "We can implement it with this particular natural enemy," as opposed to the idea of a strict spray schedule, where someone says, "You are going to have to spray once a week or twice a week in order to be sure."

Senator ALLEN. In the continuing battle of those who produce food, fiber, and lumber, against insects and pests, who is gaining; are the insects gaining on the human race?

Dr. BAY. Have you seen the "Helstrom Chronicle"?

Senator ALLEN. No. I have read about it.

Dr. BAY. I strongly advise you see it. It will be the dessert after these hearings.

Senator ALLEN. That would be the answer, would it not?

Dr. BAY. That is what the whole movie is about, as to who is gaining, man or the insects. I would say it is a pretty close race right now. I would say if we could curtail our human population, we would be in good shape, but as long as we allow out human population to continue to grow, we are going to have to rely more heavily on chemicals. I do not see that we have any choice, even with integrated control. Because by our own practices, we too often disrupt the environment unwittingly in favor of the insects.

Senator ALLEN. You think with the gains the insects are making even under the integrated method of control, we are going to have to continue using pretty nearly the same amount of chemicals?

Dr. BAY. I would like to think not, but maybe we would be at least able to develop a system where we could hold our own. But without the use of integrated control, the use of chemicals will have to be increased with the population increase.

Senator ALLEN. That is very interesting. I enjoyed your testimony and enjoyed out little discussion. Thank you very much.

Dr. Reynolds.

STATEMENT OF DR. H. T. REYNOLDS, CHAIRMAN, DEPARTMENT OF ENTOMOLOGY, UNIVERSITY OF CALIFORIA, RIVERSIDE, CALIF.

Dr. Reynolds. My name is H. T. Reynolds. I am professor of entomology, and chairman of the department of entomology at the University of California, Riverside. This department is composed of three divisions: (1) Biological control, (2) economic entomology, and (3) toxicology and physiology. I am speaking for the University of California.

We wish to go on record as strongly supporting Senate bill 1794. In the University of California, for some years we have been actively engaged in developing the basic ecological, biological, cultural, chemical, and other information necessary in order to formulate strategies to manage pest populations.

As Dr. Bay indicated, on the Berkeley and Riverside campuses, approximately one-third of our effort is devoted to population dynamics and biological control, and a large number of the remaining staff are engaged in other efforts, such as cultural techniques, host crop management, et cetera, in development of programs leading to pest management.

Progress towards this goal is apparent in a number of instances, but in our opinion, research must be greatly accelerated and, simultaneously, made on a broader, multidisciplinary team front. Further, we believe time is critical.

The University of California is not alone in this effort, as many scientists in other universities and in the U.S. Department of Agriculture, likewise, are directing their efforts toward this goal. This is no small undertaking, however. Basic studies requiring years of continuing research are indicated, and the cost will be substantial.

It does not seem necessary to document in detail all the compelling rationale for the development of pest management programs. This background has been amply provided in statements previously submitted, and, indeed, much of it was included in Senator Tunney's excellent presentation earlier today.

It should be borne in mind, however, that a host of pest problems existed long before the development of the synthetic organic insecticides, and despite our best efforts, they will continue to exist. In modern farm technology, man has created environments which intensify some problems and create others. Agricultural monocultures, irrigation, fertilization, new crop varieties of a narrow genetic base designed for high yield, and other modern practices favor certain pests. To counter this, man has relied increasingly upon pesticides—unilaterally in many instances.

Entomologists now generally accept as fact that pest populations can and frequently do resurge to high and damaging levels following application of certain chemicals, particularly when they are broad spectrum in nature and applications are repeated. The resurgence may involve the target pest, certainly, but it has been repeatedly demonstrated that nontarget—often secondary—pests, normally under population regulation or below levels causing damage, may surge as well.

If I may digress just briefly from the statement, I can illustrate this. In the mid-1950's, when we got onto an integrated control program on cotton in the Imperial Valley in California, approximately seven or eight formerly serious species virtually disappeared from the environment.

Senator ALLEN. How did you attack in order to eliminate?

Dr. REYNOLDS. This was a very simple integrated control program. We did not completely understand the reasons for success at the time. It was based primarily on the recognition that we needed selective insecticides and that we needed more careful evaluation of pest population levels before treatment was made. Just these two things put us on a successful integrated control program, which reduced costs, necessitated far fewer insecticide applications, and consequently what I call the secondary pest problems disappeared.

Pest resurgences usually are caused by disruption of the beneficial insect fauna in the crop ecosystem. The end result, of course, is the requirement of more pesticide applications with serious implications in production costs, possible illegal crop residues, increased environmental contamination, et cetera.

Pest resistance to pesticides has developed also in over 200 important agricultural pest species worldwide. The serious nature of the resistance problem was precisely why I am ill prepared today for this hearing, as I returned just yesterday from a working party meeting on this subject at the Rome headquarters of the U.N. Food and Agriculture Organization. I know that much testimony given here in the last few days has spoken at some length upon the hazards of resistance.

The above sets the problem. We believe the solution lies in integrating all the methods of alleviating pest damage into a systems approach based upon ecological information in which no method is disruptive to another but each acts in a complementary fashion.

It is our feeling in the university that complete or unilateral dependence on any single measure, whether pesticides or whatever, is not going to be the total answer. It is foredoomed to failure, or at least failure at times.

Scientific pest control has always required a working knowledge of ecological principles, of the delicate biological relationships of each pest in the system, and of the natural factors tending to regulate its numbers. It is more essential, in our mind, than ever before to take a broad ecological overview of these problems and to consider all factors, both natural and applied, that can be used. We must no longer consider a single pest without an analysis of its role in the ecosystem and of the impact of reducing its population upon this entire ecosystem. A unified, balanced approach is obviously needed. Entomologists must recognize the limitations as well as the advantages of any new method before it is implemented. It would be disastrous, in my opinion, to discard currently available technology, including pesticides, and adopt possibly glamorous methods not thoroughly tested and evaluated.

It is obvious, I am sure, that earlier statements given by my colleagues, including that by Dr. van den Bosch yesterday, have made it abundantly clear that it is imperative to accelerate research in biological control, cultural methods including host crop management, ecological studies, and in the many other areas of immediate need. I would like to comment, finally, about needs in pesticide development as we anticipate that even in successful and sophisticated programs, pesticides will play an essential role.

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In the final analysis most methods discussed herein are preventative in nature. When a pest population reaches an economic threshold——

Senator ALLEN. Just what do you mean by that?

Dr. REYNOLDS. "Economic threshold"—it is an important part of pest management programs, and it represents an area of research that is very difficult to develop. Based on population sampling over a period of years, correlating the population levels with the yield and other factors, we can say that a certain pest population level is the time when it is important to initiate some kind of treatment. This is normally, of course, chemical. It must be very carefully defined. It must remain flexible, due to price fluctuations, changes in crop variety, and all of the other things that apply.

Senator ALLEN. You mean when it reaches an economic population threshold, until it gets up to that point, there is no need of doing anything about it?

Dr. REYNOLDS. That is right.

Senator ALLEN. If it goes over that point, it is a real danger, it must be either eliminated or controlled?

Dr. REYNOLDS. Yes. We think it is exceedingly important. Without such thresholds overtreatment often occurs and they also insure against economic losses.

When it does reach an economic population threshold, however, there is literally no recourse except to use a pesticide to reduce the problem to population levels no longer constituting a threat to crop production. In order not to cause ecological disruption, the need for pesticides which affect only, or virtually only, the target pest—sparing beneficial insect populations—is imperative if we are to maintain our system. By this, I include not only selective chemical pesticides but insect diseases as they, too, are selective.

There are several approaches to selectivity in use of chemicals which include applications in a selective manner—e.g., in bait form, precise placement, and dosage rates sufficiently low that mainly target species are affected. The development by the chemical industry of pesticides which are physiologically selective is probably the most important method, and by this I mean, they affect only certain species or types of species. Development of selective insecticides is extremely important but this presents an enigma to the industry.

In such cases, the potential market is limited and the increasingly high costs of development to the point of sales is discouraging. I know of several selective compounds which are not being developed at this time for this reason. Other discouraging aspects include the specter of resistance occurring before the enormous development costs are realized and the fact that the many years spent in development shortens the period of patent protection alarmingly.

A somewhat analagous situation exists in the case of utilization of insect diseases. Of the many types of insect diseases, viruses seem, today, to hold the most promise. Virus diseases are generally regarded by regulatory authorities as being in a similar category to pesticides and must, therefore, go through similar procedures for registration and ultimate sale.

Many insect viruses are known—I think there are something like two or three hundred—and they affect only a single insect species, or a closely related group of insects. Thus development costs are high for a single pest compared to that of a broad spectrum insecticide which is effective against many species. To date only the nuclear polyhedrosis virus of the corn earworm, which is also the same species as the cotton bollworm and tomato fruit worm, is available but its utility has been limited to date. There is reason for optimism about viruses as they have shown promise for control of many pests and they are selective.

As it is not possible, however, to patent a virus, there is little incentive for industry to expend the huge sums necessary for clearance. Research workers can do much of the preliminary work but, even though to date those investigated affect only insects, toxicological and pharmacological evaluations are necessary for reasons of safety but prohibitively expensive. International attention is being focused on this problem, but perhaps the existing expertise at the Pine Bluff Arsenal and at Fort Detrick can be brought to bear as these facilities seem to be our main hope at this date.

Finally, many exciting developments in integrated control are happening over the world. I will not attempt to itemize these. There is a new awareness of ecology in crop protection. You are already aware of the large program proposed for NSF funding in the area of pest management on six major crops in the United States.

This is a truly interdisciplinary team effort involving some 18 universities, segments of the Agricultural Research Service, the Forest Service, and elements of private industry. About 70 percent of the insecticides used in agriculture in this country are applied to these six crops. It is hoped to optimize cost-benefit relations on a long-term basis to the agricultural industry and to society. Results can be expected perhaps in from 5 to 10 years following full inception.

We believe that only through programs such as this can the use of pesticides be brought into better perspective and some of the current serious situations with pesticides and their concomitant environmental problems be alleviated.

Senator ALLEN. Thank you very much, Dr. Reynolds. I appreciate this mighty fine testimony and appreciate the fine work that you are doing there at the University of California at Riverside. We also appreciate the work that you are doing in the international field.

Dr. REYNOLDS. Thank you.

Senator ALLEN. What pest control methods are used in Europe, say?

Dr. REYNOLDS. Europe is in somewhat of a similar situation as we are, and in rather heavy dependence upon insecticides. I think, however, they have a backlog of more ecological information in some situations than we have.

But I must also point out, however, that in much of Europe many insect problems are less serious, although not all, of course, than in States like Alabama or Texas or southern California, where we have long seasons with multiple generations, one right after the other, which can build up to damaging pest populations.

As an example, I spent 2 days in Wageningen in eastern Holland, at a very fine research center. I spent part of 1 day in their integrated control research area on deciduous fruit and found they had only one generation of codling moth. They have a very good opportunity to develop integrated programs, because they do not have the multiple generations we have in most of California, for example.

They would run maybe 6 to 10 percent damaged apples, in case of the codling moth, whereas we will often go close to 100 percent in most of California.

Their programs to develop integrated control are similar. I have the impression many of their research centers have done less problem-oriented research than we, at least in the past. They have concentrated more on basic research and the large chemical companies have really done much of the advising of farmers.

Senator ALLEN. Are they ahead of the United States——

Dr. REYNOLDS. No, sir.

Senator ALLEN (continuing). In the use of the integrated method?

Dr. REYNOLDS. I think they are actually following the lead of this country. There are some cases, for example forest pests, where they may be ahead of us. But in the agricultural field, they are moving more in a parallel fashion, perhaps, to us. This is also happening in Australia and in portions of Malaysia where there are some very fine examples of integrated programs. We have several in California that we think are rather outstanding. Some of these were described yesterday by Dr. van den Bosch.

I would guess in cotton in the San Joaquin Valley, that we have obtained probably 50 to 70 percent of our objective, but it will prove difficult to sell our program to the farmers. In the Imperial Valley, as described in Dr. Watkins' testimony for Arizona, the pink bollworm which invaded the valley in 1965 has destroyed a successful program. Until we can manage this pest, we have no way of developing a truly integrated control program. We are working toward this, of course.

Senator ALLEN. Turning briefly from the pest control problem, what about the wearing out of the land in farming areas in Europe? We have so much, certainly in some areas of our country. They have been farming there for centuries.

Dr. REYNOLDS. Yes. I have no expertise, of course, but I have never seen any evidence in my travels, although they are somewhat limited, of good land that is being worn out. Much of Europe is very heavily populated and they have had to develop and cultivate some land which would be poor, I think, by any standards.

Senator ALLEN. Do they have better conservation pra·tices?

Dr. REYNOLDS. They have had such large populations for so long, that they have been much more conscious of these factors than we have in this country. Although we are becoming aware of it very rapidly, as you so well know.

Senator ALLEN. They farm plots over there that our farmers would not think of using?

Dr. REYNOLDS. I saw a grain field at Rothamsted, England, one of the experiment stations, which has been planted to grain for decades—well over 100 years if I recall correctly. Some without additions of any kind of fertilizer, some of which have been manured, and some using inorganic fertilizer. And where they use the fertilizers they look very good. The other is pretty weak.

Senator ALLEN. Dr. Bay was suggesting that as we were talking about the ever-running battle between insects and mankind, that as our population increased, it was going to accentuate our problem with the insects and pests.

Dr. REYNOLDS. Yes. I think that this could well be. Many people anticipate increasing use of not only just insecticides, but all kinds of chemicals—herbicides, fertilizers, et cetera. However, I do feel that integrated control programs, when fully developed, will produce just as much and perhaps better than the kind of programs which are currently in existence.

We anticipate or hope that with this NSF proposal, that we will be able to eventually reduce use of pesticides by at least 50 percent on those crops which currently rely heavily on insecticides, for example on cotton. This would be, I think, a minimum goal. I believe we can anticipate this in most of these crop areas.

Senator ALLEN. That is a real fine goal. Do you think that this legislation will help you in the direction, as you move in the direction of that goal?

Dr. REYNOLDS. Yes, sir. No question about it. Like Dr. Bay said, the amount is a little modest. There is a tremendous amount at stake and we do feel that time is of real essence in this overall program.

We think it is imperative that we take the team approach as the proposal makes clear. I do not mean only a team of entomologists, but incorporating agricultural economists, agricultural engineers, plant breeders, systems analysts, and so forth.

Of course, we would hope some day to be able to put this information in the computer and get answers out that way. This is far away—perhaps it will never come about—but we are attempting to computerize some of our programs.

Senator ALLEN. Is it absolutely necessary that we make progress in control of pests and insects if our producers are on less and less land, and with fewer and fewer people called upon to do the tremendous job that they have providing the food and fiber for a hungry world, that we are going to have to keep the pest problem under control and make progress in eliminating pests?

Dr. REYNOLDS. Yes, sir. There is no question about it. We do not expect to eradicate pests by these methods, but what we will attempt to do, of course, is learn how to manage the pest population, manage the beneficial insects, and perhaps intensify our foreign exploration for beneficial species which is particularly pertinent to California as we have very few native pests. And than, by putting all of this into one sophisticated program, perhaps we can learn to keep these pests below the economic threshold which we discussed a little bit ago.

Senator ALLEN. Now, does the integrated control method of controlling insects and pests offer the best method of not having to rely so much on pesticides and insecticides?

Dr. REYNOLDS. Yes. I think there is no question about it, that this is, at this time, the best way of which we are aware. Of course, there are exciting developments and breakthroughs in insect biochemistry, physiology, and so forth.

For example, the work with hormones and with sex pheromones is of interest. We are using sex pheromones in pest survey and detection now. You are probably aware of the work with boll weevil in your area, and with pink bollworm, codling moth, and other insects in California and elsewhere. Eventually, we hope to even manipulate populations, or manage them. We are working now on saturating the environment with a sex pheromone or attractant so that the male can never find a mate.

We have feasibility studies on this which show some promise. We made a very small effort in the field last summer, and it failed. However, this was premature and a shot in the dark. We were working in a small field in the middle of a vastly infested area, and we are confident,

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if not for other reasons, we were overflooded by migration of gravid females.

Most of our research on these so-called alternative methods, the sterile male, the hormones, the pheromones, and many others, we think should be concentrated on our key pests. Almost every agricultural ecosystem has one or more key pests. Boll weevil in the South and pink bollworm in southern California on cotton, are examples of key pests, and these are the ones on which we really need to concentrate our new alternative methods, and, hopefully, eventually we can fit these into integrated programs.

But this is precisely why I said, let us not use methods until they have been tested and throughly evaluated. These are vastly expensive to develop. However, I think they should be pursued until we can ultimately find out if there is utility in their use.

Senator ALLEN. This program proposed here will help you find those things out, will it not?

Dr. REYNOLDS. It would. It would help us greatly in these areas. A good part of the NSF proposal we discussed is basically an ecological approach, although it incorporates many other areas. We do not know enough about ecosystems. This knowledge is fundamental to integrated control programs.

Senator ALLEN. You obviously find your work very fascinating and exciting, do you not?

Dr. REYNOLDS. I tell my students, it is the most dynamic of all the sciences. In our Department, for example, we run the range from pure biologists, biological control specialists, organic chemists, behaviorists, and many other fields of expertise. We try to put all of these together, and we think it is dynamic and certainly fascinating.

Senator ALLEN. I find it very interesting myself. I have enjoyed our discussion.

Dr. REYNOLDS. Thank you.

Senator ALLEN. I appreciate it very much.

I apologize for saving the best to the last. And I just have to explain, if I had set this agenda, if you had wanted to be the first witness, you would have been the witness. But we have looked forward to hearing your testimony so, if you will, proceed, please.

Miss Billings.

STATEMENT OF LINDA M. BILLINGS, ASSISTANT TO THE WASHINGTON REPRESENTATIVE, SIERRA CLUB

Miss BILLINGS. I am Linda M. Billings, assistant to the Washington representative of the Sierra Club, a conservation organization with over 155,000 members. I am delighted to be afforded an opportunity to speak in support of S. 1794, a bill to authorize pilot field-research programs for the control of agricultural and forest pests by integrated biological-cultural methods.

Senator Nelson, who has long been a leader in bringing forth environmentally responsible legislation, is to be highly commended for sponsoring this bill. I would also like to commend you, Senator Allen, as chairman of this subcommittee, for holding these excellent hearings.

Since the list of witnesses which have preceded me has been long and distinguished, and they have already contributed a wealth of knowledge on the subject as a result of their own research, I will not attempt to bring forth further data in my testimony. Rather, my purpose here is to lend the support of conservationists to this legislation. Conservationists have long protested the exorbitant use of chemical pesticides. This committee has heard previous testimony of the hazardous effects at hearings held earlier this year on pesticide control legislation.

I would refer anyone, who is unfamiliar with documentation of the widespread adverse effects of chemical pesticides, to those hearing records and to the wealth of literature and research reports which now abound. Not only has the reckless use of chemical pesticides wrought ecological havoc and decreased biological diversity—a condition which is necessary to the quality of our environment—but, as testimony has shown, such overdependence and reckless use also threatens production of vital food and fiber crops, forest products, and endangers human health. Therefore, pest control methods which will alleviate these problems must be sought. We welcome the promise held out by successful development of integrated biological-cultural pest control methods.

I take great pleasure in being able to join with representatives of agriculture and forestry in supporting this legislation. I feel confident that other conservationists will also lend their support. For too long, conservationists, farmers, and foresters have appeared to be on opposite sides in controversies over pest control methods.

Development of integrated biological-cultural pest control methods is long overdue. In the modest amount of reading I have done on the subject, I was taken aback to note that as long ago as 1939, there have been warnings that overreliance on chemical means of pest control could have negative effects not only on the surrounding environment and ecological systems, but also on crop productivity. I suspect that further readings will reveal even earlier warnings.

The task of this legislation is especially urgent in view of the almost daily revelations of research indicating hazardous, long-term effects of many widely used pesticides. The wide-scale use of chemical pesticides has gone on in a largely unregulated manner for over 30 years. There is at present small hope that the long-needed controls over pesticides will be developed.

New legislation which offered adequate controls was introduced earlier this year by the administration and by Senator Nelson and Congressman Obey; however, these bills have been largely ignored by the House Agriculture Committee, and a thoroughly inadequate bill has been reported. In some respects, the new bill is a step backward from the current law, FIFRA.

I look forward to your committee, Senator Allen, to take the necessary leadership role in bringing about the needed reforms in pest control methods.

In closing, let me just make two suggestions. Previous testimony has indicated that considerably more than $4 million is needed to fund the necessary research.

I hope that this committee will give consideration to increasing the money called for. Finally, let me say that I hope the lessons of the past will not be ignored by those developing new pest control methods and that care will be taken to note and guard against adverse environmental effects.

Thank you.

Senator ALLEN. Thank you, Miss Billings. I appreciate your honoring us by coming before the committee and giving the benefit of your views and the views of the many members of the Sierra Club.

I just wonder, as a matter of curiosity, where the name "Sierra" came from, if it came from the Sierra Nevada Mountains, which is certainly a great beautiful spot of nature.

Miss BILLINGS. It is. Yes, it does come from the Sierra Nevada, because the club had its origins there. Originally, it was formed to protect and explore the Sierra Nevada. Since then we have expanded nationally and now internationally, recently.

Senator ALLEN. That is very interesting. Certainly, I feel that this fine club and its membership is doing a great job in assisting the molding of public opinion behind preserving the ecology and the natural environment of the beautiful areas in this country. The entire country, for that matter.

In Alabama, I know, the Sierra Club is a big booster of the wilderness bill that we have in this committee, that we are trying to get a report from the Department on, so we can go ahead. Actually, our whole delegation from Alabama in the House and the Senate is agreed on this bill and we want to get it approved, to preserve part of the Bankhead Forest there in its original state, as a wilderness area.

So we are glad that you do take an interest in preserving our country and protecting its environment, its ecology. I feel that is a fine movement with which you are associated and we are glad to get your views and your recommendations on this particular legislation.

Now, it has been pointed out that the machinery provided by this bill, the encouraging of the use of the integrated control method to control insects and pests, probably offers the best mechanism for a reduction in the use of pesticides and insecticides that could cause damage to our environment. I feel that this piece of legislation, as you point out here, is something that the farmers and the conservationists are agreed on.

We certainly welcome the getting together of these schools of thought because our interests are the same. Certainly, the farmer has to be a conservationist, because that is where he derives his livelihood, the environment, from the soil. So this bill is designed to protect our soil, protect our countryside, protect our farms. I am not surprised to find you on the side of the objective of the bill.

We have yet really to encounter any great opposition. The Department representatives said they thought it was a good program. Possibly some of the pesticide people might not be too strong for it, but the bill does not necessarily contemplate immediate withdrawal in the use of pesticides. It is just what it says, an integrated method. But I am sure the ultimate purpose of it is to provide for the gradual withdrawal of the use of pesticides.

I appreciate your help and your comments and appreciate your support of the bill.

Miss BILLINGS. Thank you very much. I appreciate the opportunity to testify.

Senator ALLEN. This concludes the hearings. The record will be held open through October 13, so that anyone desiring to submit a written statement can do so. We have had a large number of witnesses, some 25, and there was very little or any opposition to the bill. So all schools of thought were given every opportunity to appear, to testify for or against this bill. This is the policy of this subcommittee on any and all legislation.

There will be no further hearings so far as we know on the bill, and the record will be held open through October 13. At the end of that time, when the testimony has been transcribed and the subcommittee has an opportunity to study it, we hope to meet and take action with regard to the bill and then report that action, whatever it may be, to the full committee.

Sometime this month, the subcommittee should take action with respect to the bill.

The subcommittee stands adjourned.

(Whereupon, at 3:35 p.m., the subcommittee adjourned.)

(Additional statements filed for the record are as follows:)

WASHINGTON, D.C., *September 28, 1970.*

HON. JAMES B. ALLEN,
Subcommittee on Agricultural Research and General Legislation,
Committee on Agriculture and Forestry,
U.S. Senate, Washington, D.C.

DEAR CHAIRMAN ALLEN: The National Council of Farmer Cooperatives supports S. 1794, a bill to authorize pilot field research programs for the control of agricultural and forest pests by integrated biological cultural methods.

We believe a balanced system of controlling pests in agriculture eventually will be most desirable in enabling farmers and foresters to most effectively curb destructive pests.

We recognize that one of the problems in the use of pesticides is that no effective alternatives are available, but, at the same time, the termination of the use of pesticides would have a serious impact on the production of food and fiber in this country.

We would appreciate your making this letter part of the record on S. 1794.

Sincerely,

RICHARD T. O'CONNELL,
Secretary, National Council of Farmer Cooperatives.

STATEMENT OF CHARLES L. FRAZIER, DIRECTOR, WASHINGTON STAFF, NATIONAL FARMERS ORGANIZATION

In S. 1794 it is proposed to authorize $2 million each for the Secretary of Agriculture and the National Science Foundation in the fiscal year ending June 30, 1972, for research work in three broad catagories. The first would be the development and testing of a control of agricultural and forest pests by integrated biological-cultural methods. The second area of interest is the determination of economic and environmental consequences of protecting and modifying pest populations through a combination of methods. The third area would deal with collecting and interpretation of data in these fields of research.

The National Farmers Organization supports the proposal. Our agricultural technology has progressed to its present point of efficiency by expanding reliance on chemical means of controlling many very serious insects that hamper the production of livestock and farm crops in this country. The recent widespread expressions of concern for the undesirable influence of agricultural chemicals in the environment have raised many very complex questions as to where we go from here in dealing with these insects. The economic aspects alone relating to the decisions that must be made about the future use of many of our important agricultural chemicals are sufficiently significant to make this issue second only to the matter of fair and acceptable prices for our major farm commodities. In some instances this may be the primary issue bearing on the producers' ability to continue successfully in the production of vitally needed farm commodities.

In this brief statement we refrain from repeating detailed examples of the damage done by chemicals in some environmental circumstances in recent years. By the same token, we will not list the many benefits of chemicals that have become almost a necessity in modern day farming One example is offered, however, to demonstrate the need for new research and the development of some type of biological control to replace chemical methods that may have been proven successful but may no longer be acceptable to the public It could be presumed that widespread use of appropriate chemicals might have controlled the mosquitoes that carried the equine sleeping sickness north from Mexico into the southwestern part of the United States in 1971. It is noted, however, that certain strains of mosquitoes have become immune to all chemicals known to be effective at this time. So the issue is clearly presented—do we continue to press on with the research for new and stronger chemicals or do we devote a part of our effort to biological controls that may become wholly successful in their own right or at least quite successful if supported by occasional use of effective chemicals?

In summary, it would appear most important at this time that we not undertake to resolve the future of all chemicals in agricultural production by sweeping, widespread actions based on emotional reactions to a few instances that are truly sad or disappointing to all who are interested in a proper environment for the future—but rather it would be preferable to approach each of the major insect problems in some realistic and dispassionate manner that would move the control of insects of such economic importance to the nation from chemicals to biological means or to combinations of the methods that may be available. This may be accomplished only by a careful review of the research now under way and stronger support for the development of new biological means that may be possible.

Consequently, we commend Senator Nelson and each of the senators who have joined him in seeking to advance this very vital research effort. We urge your favorable action on this bill.

Statement of Dr. Paul DeBach, Division of Biological Control, University of California, Riverside, Calif., and Associate Director, International Center for Biological Control

The Ecological Society of America has concluded that "much basic information already known to science is not finding its way into the decision-making process (BioScience, 1970, 20(24): 1285). To a considerable extent this is where we stand today in pest management ecology. We already have a portion of the scientific information required for a successful solution. On the other hand, we still lack some essential knowledge of certain key pests, natural enemies or processes, and we thus far have not achieved industry or grower acceptance and application of what is already known to be practical for much improved pest management.

From extensive (but still insufficient) foreign exploration and study in the native home areas of many pests we know that many, if not most, are held under natural control by parasites or predators in one place or another. We know and have imported and established some of these natural enemies but many more await discovery, testing and use. Taxonomic experts estimate that only 10–25% of the parasitic Hymenoptera are known, even though this is the most important beneficial group used in biological control of insects pests. Nonetheless, we have considerable background knowledge regarding biological control of pests and in many cases we know the most likely areas to go abroad to discover new natural enemies and what types of new natural enemies are needed.

Most major pests are invaders, the majority come from the original countries of infestation. This means most agricultural pests should be highly suitable subjects for classical biological control through importation of new natural enemies. It is also well recognized that pest problems may differ between habitats within a state, between states and between countries, so that no single or simple solution is expected. This situation means that basic ecosystem studies in each major region are required. This is especially true where the crop has a large complex of pest species. The biology of many key agricultural pests is fairly well known but it is obvious that we still know far too little in most instances.

Many major pest problems have been solved by importation of exotic natural enemies. Complete biological control of *all* pests on certain crops has even been attained in a few instances. This represents the ultimate in ecological pest management—permanent regulation of potential pests at a subeconomic level without the necessity of continuing manipulation. In most crops, however, many problems remain to be solved before general extension of application of satisfactory pest management can be achieved and, currently, unilateral chemical pest control continues to be the vastly dominant method used, to the detriment of long-term interests of the growers, the consumers, and the environment.

A considerable number of successes in biological control of insect pests has now been achieved throughout the world. The United States leads in this respect but has only scratched the surface. These successes truly were the key to the present limited amount of pest management that exists. If all of these pests had continued at their formerly serious status, so much chemical treatment would be required that it is doubtful if any significant degree of real ecological pest management would be possible. Hopefully, with the future biological control of certain of our current major or key pests, or through the successful use of other non-chemical methods of control, true ecological pest management will be made relatively easy.

Many ecological studies in the United States and abroad have shown that biological control may be negated by the adverse influence of environmental factors on natural enemies. There is little question but that certain pesticides constitute the most adverse factor of all. Their responsibility for upsets of non-target organisms and above-normal resurgences of target pests has been well documented. The initial use of pesticides tends to accentuate and perpetuate their continued use—thus presenting the aspect of an "ecological narcotic."

The problem of how to back away from the use of chemicals and to develop good ecologically-based pest management is a major one. The chemical control method is very strongly entrenched both economically and traditionally. However, we know from field tests on several crops that various means of manipulation of established natural enemies as well as their conservation has proven practical or shows real promise in this regard. Mass-production and periodic colonization is one approach. The field trials make it clear, however, that very careful monitoring of the ecology of the entire faunal complex is essential for reliable pest management decisions and yet this has not been done. Further, this points up the necessity of having trained bio-ecologists, not insecticide salesmen, as the final decision makers. Such decisions, however, must be based on a complex of inputs, adequately structured and modeled, and embracing economic and systems analysis of the entire pest control and crop production system.

The support offered by S. 1794 is absolutely necessary if we are to achieve meaningful integrated biological-cultural pest management in the near future. We currently lack the scientific information or tools (such as natural enemies, etc.) to solve certain key problems; we lack sound economic data and adequate analysis of the results of alternative approaches; also, the research disciplines have been operating more or less independently and this precludes systems analysis. Also lacking and vitally needed is a unified multidisciplinary well organized team effort to integrate and properly apply the various ingredients; indeed, the urgent need for such a systems approach and the tools for its execution are only now beginning to be understood. To obtain this understanding we need substantially more funds as well as some on-the-job retraining of personnel.

Statement of Dr. Stanley C. Hoyt, Tree Fruit Research Center, Washington State University, Wenatchee, Wash.

Following World War II a wide variety of synthetic organic pesticides became available for control of pests on agricultural crops. The immediate effect of use of these pesticides was improved control of some major crop pests. Before long, however, it became obvious that there were deleterious side effects from the use of these chemicals. These included the resurgence of pest populations, selection of strains resistant to the pesticide, and elevation of minor pests to major pest status. The "solution" to these problems brought on by the side effects was to increase dosages of pesticides, use more frequent applications, substitute new chemicals for old, or combine two or more chemicals for control. This increasing load of pesticides added to the environment has recently been implicated in environmental degradation.

Coupled with the above has been the attitude that the mere presence of a pest was detrimental, and control procedures were frequently undertaken when the pest population was well below the mumbers which could produce economic loss.

If all of the effects of pesticides on target and non-target pests, beneficial species, and on the environment were known, there would be many instances where the detrimental effects of pesticide usage would outweigh the benefits gained. This is particularly true where broad spectrum pesticides are used as "insurance" sprays.

Over the past 25 years this unilateral approach to pest control (reliance on chemicals alone) has failed to provide permanent solutions to our most serious pest problems.

One approach to the problem which can result in reduction of the amount of pesticides used while still maintaining good control of pests is called integrated control. In these programs all compatible methods of reducing pest damage are integrated. Pests are recognized as part of a complex system rather than treated as isolated organisms. The presence of a pest is not considered a problem until population levels are reached where economic loss may occur. It is recognized that in some cases a subeconomic population of a pest may be desirable to maintain numbers of beneficial organisms. Pesticides are used only when necessary, and those pesticides which are used are selective in action and have the least undesirable side effects. In short, integrated control is a system of pest management utilizing biological, cultural, physical and chemical controls in a harmonious way to prevent economic loss by pests.

The development of integrated control programs is more costly and time consuming than development of a program based entirely on chemicals.

The type of information required in establishing integrated control programs includes the following: (1) the population dynamics of pest species and their interrelationships with other organisms in the ecosystem; (2) distribution, feeding behavior and effectiveness of beneficial species; (3) the effects of cultural practice on pests, predators and parasites; (4) selective chemicals, dosages, timing, and techniques of application of pesticides to minimize ecological upsets; and, (5) economic levels of infestation of major pest species. When this information is established for a crop, a more permanent program of pest management with minimum deleterious side effects should evolve. The results should also provide broad principles of pest management applicable to other crops.

Present funding is highly inadequate to support a broadly-based, multidisciplinary approach to pest control such as that outlined previously. Isolated attempts to achieve these goals will continue with present funding, but rapid progress and more meaningful results can only be obtained when major funding for a coordinated research effort is available.

RIVERSIDE CALIF., *September 28, 1970.*

HON. GAYLORD NELSON,
U.S. Senate,
Washington, D.C.

SIR: I have been invited to submit testimony for use of the Subcommittee on Agricultural Research and General Legislation concerning Senate Bill 1794.

I strongly support this bill and the method of pest control which it seeks to foster. Others testifying in behalf of this bill will, I am sure, give ample evidence of the difficulties in which insect pest control finds itself today (resurgence of pests, destruction of cornerstone natural enemies and consequent outbreaks of secondary pests, development of resistance making chemical control overly costly or unattainable, and severe side effects on wildlife, farm workers, consumers and the environment generally).

What is needed is the demonstration that we can have good pest control without engendering the above described consequences which spell dire economic problems for the grower and serious environmental pollution besides. Indeed, the long-term interests of the grower and of the environment are both served by a balanced biological and multidisciplinary approach to pest control which this bill seeks to foster.

I should emphasize that a vehicle for turning our national pest control wagon around and heading it in the right direction has already been set in motion by the National Science Foundation in their sponsoring the organization of a broad multi-institutional research effort to develop alternative methods to conventional use of broad-spectrum toxic chemicals for insect pest control. This organizing effort has reached the stage of submittal to NSF of a plan by 18 universities, in collaboration with the U.S.D.A. and sectors of private industry, to conduct the necessary research and develop the necessary field programs. The necessary expertise has been identified, facilities are in readiness, the management and research sectors are described in detail and the vital ingredient, an unprecendeted, enthusiastic team approach to the problem, is evident on every hand.

Support of this bill should enable the program to get underway.

I do not believe that pest control can take this solid road to correction of part ills under any program that lacks the essentials that this program presents. It is only through the pooling of the resources of the U.S.D.A. with those of strategically situated universities that research of the scope and depth required can be conducted. Crops are looked at as beltwide systems and the pest problems are viewed, not in isolation, but in relation to all the problems and costs of crop production, bringing in local socio-economic restraints.

The goal of this program is to place pest control on a more scientific basis, wherein the grower can manage his crop pests in a more reliable and predictable manner without need for the extensive use of broadly disturbing toxic chemicals that have been the hallmark of insect pest control for a quarter century. This should be possible through proper integration of natural control factors and a wise choice of selective applied measures.

Through Senate Bill S 1794 and the companion H.R. the program described here will obtain substantial support and for the reasons given above I am strongly in favor of this bill.

Very truly yours,

CARL B. HUFFAKER,
Director, International Center for Biological Control,
University of California.

STATEMENT OF WILLIAM A. BUTLER, WASHINGTON COUNSEL, ENVIRONMENTAL DEFENSE FUND

Mr. Chairman and members of the committee, on behalf of the Environmental Defense Fund, may I thank you for the invitation to testify before you today on this most important bill, S–1794. The Environmental Defense Fund (EDF), which I represent in Washington, is a national organization of about 22,000 whose membership is composed of scientists, lawyers, educators, and other citizens concerned about environmental problems and their scientifically sound solutions.

Perhaps more than any other national environmental group, EDF has been in the forefront of efforts to encourage through law and administrative action the control of agricultural and forest pests by integrated biological and cultural, as well as chemical, methods. Through our experience in administrative and court actions dealing with DDT, Dieldrin, Aldrin and Mirex—all highly persistent chlorinated hydrocarbon pesticides posing environmental hazards to non-target wildlife and even to man himself—we have become acutely aware of the intense need for more research on integrated biological-cultural methods of insect and pest control to complement, reduce, and in some instances entirely to supplant current overreliance upon chemical controls for pests.

Currently I am personally involved as an attorney representing not only EDF, but also the National Audubon Society, Sierra Club, and West Michigan Environmental Action Council, in the marathon DDT cancellation hearings taking place before the Environmental Protection Agency. I can testify from my personal experience that one fact upon which all parties to that proceeding are in agreement is the urgent need of more financial support for research programs on biological and cultural methods of pest control to supplement or complement present chemical methods.

Rather than discussing the place of integrated biological and cultural methods of pest control at length at this time, I will ask permission of the Chairman to submit for the record several scientific articles on the subject of integrated pest control which explain EDF's position in this matter. These articles, several by EDF trustees, trace problems of resistance, destruction of natural enemies of pests, and environmental harm to non-target species as the result of overreliance upon chemical pesticides. They also describe some notable successes in increasing yields through biological control of insect pests.

I will restrict my remarks now to specific comments upon the bill itself. First and foremost is that S–1794, despite the fact that it earmarks $4 million a year for demonstration projects and expanded basic research in integrated pest control, still greatly restricts its potential effectiveness by serious underfinancing. The $4 million support level is very inadequate, particularly when compared with the millions of dollars the pesticide industry pours into research and sales promotion. farmers must be sold the effectiveness of biological and cultural control methods, and much expensive basic and field research must be undertaken first before demonstrable evidence will overcome their natural skepticism. Entomological researchers work on starvation budgets; if their research had been properly supported in the past, the present resistance and environmental problems caused by overreliance on pesticides would not exist. We must now make up for lost time.

Other more minor suggestions for the bill's improvement include (1) greater specificity on what is meant by "pilot field-research programs" (e.g. does this term include basic laboratory research?) and (2) inclusion of the notion of implementation in U.S.D.A. recommendations to farmers of those experimental and biological control methods which are successfully developed as a result of this or other experimentation programs on integrated pest control.

With these comments, Mr. Chairman and members of the Committee, may I express the strong support of the Environmental Defense Fund for S–1794. Thank you.

(NOTE. The attachments to Mr. Butler's statement are on file with the Subcommittee.)

NEW YORK, N.Y., *September 23, 1971.*

HON. JAMES ALLEN,
Subcommittee on Agricultural Research and General Legislation,
Senate Office Building, Washington, D.C.

DEAR SENATOR ALLEN: The Garden Club of America, a national organization with member clubs from coast to coast and in Hawaii, herewith records its support for S. 1794, and requests that this letter be included in the hearings on this legislation.

Despite wholesale application of chemicals over the years there are today more insect pests than ever before and over 200 of these pests are resistant to some degree to chemical controls. In fact, Dr. Robert Van den Bosch, the distinguished entomologist at the University of California, has said, "The insects are beating us."

Passage of S. 1794 will provide funds to study methods of insect control with vastly reduced reliance on pesticides, and enable pilot field research programs for developing and testing the control of forest pests through the use of integrated biological cultural methods.

Environmental damage and the health hazards resulting from the use of many persistent pesticides has been proven beyond a shadow of doubt, and we feel that in their use modern technology is out of hand. In fact, our organization has long opposed the indiscriminate use of chemicals, particularly the chlorinated hydrocarbons, to control agricultural and forest pests. We are aware that every corner of the world has been contaminated by DDT, and that it was found in 584 of 590 samples of fish taken from 45 rivers and lakes across the United States.

We are alarmed by the fact that two or three times more residues of DDT and related pesticides have been found in the body tissues of persons with cancer of the liver, leukemia, and carcinoma at the time of death than in those of the persons who died accidental deaths.

Obviously, the members of The Garden Club of America are growers, and as we are a national organization our members come from all sections of the country. They know that the use of DDT and other residual pesticides have at times proved economically beneficial to some cotton and citrus growers, but they know also that they contaminate food stuffs, and that the dangers far outweigh the economic advantages. Today more than 300 pesticides are mixed in over 10,000 formulas, and as insects continue to develop resistance, many pesticides are destined to become obsolete, or economically unfeasible. Furthermore, while the object of many chemical controls has been to eradicate pests, they have in many cases actually succeeded in creating a more favorable environment for these pests by destroying their natural enemies.

We appreciate that the control of insect pests is a necessity for efficient and profitable agricultural production, and to meet the needs of growing populations. However, because of the increasing costs of chemical controls, their reduced effectiveness following long term use, and their tremendous contribution to environmental pollution, we feel that dependence on them is both undesirable and dangerous.

We agree with Dr. Van den Bosch that continued reliance on chemical pesticides is a one-way street to ecological disaster, and believe that the results of the research which S. 1794 will provide will substantially reduce the overall reliance on chemical pesticides.

Sincerely,

WILHELMINA K. WALLER
Mrs. Thomas M. Waller,
National Affairs Chairman,
Garden Club of America.

NATIONAL SCIENCE FOUNDATION,
Washington, D.C., October 20, 1971.

Hon. HERMAN E. TALMADGE,
Chairman, Committee on Agriculture and Forestry,
U.S. Senate, Washington, D.C.

DEAR MR. CHAIRMAN: This is in response to your letter of October 6, 1971, requesting the views of the National Science Foundation on S. 1794, "To authorize pilot field-research programs for the control of agricultural and forest pests by integrated biological-cultural methods."

The Foundation welcomes this opportunity to comment on S. 1794, for this is a field in which we have been active for several years. As you are aware, the Department of Agriculture and the National Science Foundation are operating under an interagency agreement which provides for close coordination between the two agencies and in general divides the effort between basic research to be supported primarily by the Foundation, and applied research, development and testing to be supported primarily by the Department of Agriculture. We feel that our efforts have been and are continuing to be productive. I am attaching a brief description of the National Science Foundation research support activities in biological-cultural pest control methods. Also attached are copies of two recent press releases which illustrate the training as well as the research interests of the Foundation in this important area.

In formulating our research programs, the National Science Foundation seeks to achieve a balance among many competing fields of research within the limits of appropriated funds. Reaching conclusions as to appropriate support to be given to any one field or interdisciplinary group is a very complicated process involving inputs from many sources.

However, while the Foundation strongly supports the general objectives of the legislation, in view of the well established authority of both the Agriculture Department and the National Science Foundation to do all of the things prescribed in this bill, we believe that enactment of S. 1794 is unnecessary.

The Office of Management and Budget has advised us that there is no objection to the submission of this report from the viewpoint of the Administration's program.

Sincerely yours,

RAYMOND L. BISPLINGHOFF,
Acting Director.

(The attachments are as follows:)

NATIONAL SCIENCE FOUNDATION RESEARCH SUPPORT ACTIVITIES RELATING TO BIOLOGICAL CONTROL OF PESTS

The utility of biological control methods has long been known, but the methods require precise knowledge of complex ecological and physiological processes which differ for each species. In addition to broadening the base of scientific knowledge, Foundation support of research in this area will contribute to the development of sound alternative strategies for the regulation and control of specific pests.

Research on biological pest control supported by the National Science Foundation can be classified into four general areas.

1. *Chemical Synthesis.*—The Foundation supports investigators involved in the synthesis of biological control substances including both the juvenile hormone and various pheromones. An analog of the juvenile hormone, if it can be produced cheaply and in quantity, promises to be an extremely effective method of controlling insects. The analog interdicts the development of an insect at the larval stage and prevents maturation, therefore preventing reproduction. It is selective at the larval state of the insect and essentially harmless to adult insects, birds, and mammals.

The pheromones are a remarkable group of substances which act amongst insects as a chemical communication system. The pheromones function as trail markers, as sex attractants, signal danger, and in many other ways we still do not understand. The sex attractant pheromones appear to be particularly advantageous for use in insect control as many are highly specific and are effective in extremely minute concentrations.

2. *Plant, Animal, and Insect Physiology.*—A large number of research projects concerned with insect, animal and plant physiology are supported by the National Science Foundation. Physiological investigations are undertaken to comprehend the complexity of control mechanisms, to understand the evolution of insect resistance to pesticides, and to anticipate possible future problems of control. Research in this area leads to a better understanding of insect pathology, the pharmacology, specificity, and site of action of toxic chemicals.

3. *Ecological Considerations.*—A multidisciplinary project at North Carolina State University is carrying out a broadly based study of the population ecology of *Heliothus,* one of the major pests of corn, cotton, tobacco, and soybeans in southeastern United States. This research is intended to develop a sufficient understanding of the ecology of this insect in relation to its total environment that an effective population management system can be devised.

Support is also provided for taxonomic and systematic studies on the classifications and relationships of pest species and their enemies which is necessary if more selective ecological pest control methods are to replace the widespread use of broad-spectrum insecticides.

4. *Biological Control.*—Insects because of their complex life history offer manifold opportunities for biological control procedures. The identification, isolation and production of insect hormones offers one of the more exciting approaches to insect control. Application of hormones or their analogs which alter the development and maturation of insects may prove the safest and most effective procedure for controlling insect populations in a specific manner.

In cooperation with scientists from many other nations, researchers associated with International Biological Program are planning a multi-institutional program which will ultimately involve as many as 100 investigators from twenty universities and federal and state laboratories. This program will encompass all aspects of pest population management, from control through predators and parasites to improved cultivation methods and selective use of the newly developed synthetic insect hormone and sex attractants. The rationale for its application involves the development of a strategy capitalizing on ecological knowledge of pests and utilizing all forms of control either singly or in combination. This national program will benefit appreciably from IBP research being conducted in other countries under their own funding.

Research and Training in Pest Management, Applied Ecology Supported by NSF

Two special programs for training scientists to help solve problems of the environment were funded today by National Science Foundation grants totaling $350,000.

The special programs, in Pest Management Control and Applied Ecology, call for faculty and students to rotate between the participating universities, studying and conducting research, taking advantage of the particular expertise available at each institution. In the pest management field, emphasis is placed on natural means for controlling pests which can be used without contaminating the environment.

Five cooperating universities are participating in the Pest Management Control Project under grants totaling $200,000. Grants were awarded to:

INSTITUTION, PROJECT DIRECTOR AND AMOUNT

Cornell University, Ithaca, N.Y. 14850: David Pimentel, $40,000.

North Carolina State University, Raleigh, N.C. 27607: David E. Davis, $40,000.

Oregon State University, Corvallis, Oregon 97331: Paul Oman, $40,000.

University of California, Berkeley, Calif. 94720: C. B. Huffaker: $40,000.

University of California, Riverside, Calif. 92502: Paul DeBach, $40,000.

In applied ecology, three grants totaling $150,000 were awarded. Awards were made to:

North Carolina State University, Raleigh, N.C. 27607: Robert Rabb, $70,000.

Pennsylvania State University, University Park, Pa. 16802: Edward Bellis, $40,000.

Rutgers—The State University, New Brunswick, N.J. 08903: Paul G. Pearson, $40,000.

PEST MANAGEMENT

In the Pest Management Control program, the areas of specialization for each institution are:

Cornell University—genetic resistance in host plants and animals.

North Carolina State University—vertebrate pests, mice, rats, and starlings.

Oregon State University—ecology of insect parasites and predators employed in biological control.

University of California, Berkeley—biological control of weeds and predator-prey population dynamics.

University of California, Riverside—biological control of scaly pests and the use of non-pest competitors to replace pests in the environment.

Methods of biological control of pest populations vary greatly depending on factors in the pest's life cycle and relationships with its environment. At Cornell scientists are seeking to breed an alfalfa more resistant to the alfalfa weevil. At Oregon State scientists are studying the dynamics of the life cycle of the Douglas Fir cone moth so as to be able to interject controls at some time in the life cycle. At the University of California, Riverside scientists are seeking to breed parasites that will attack the cotton boll worm that annually destroys millions of dollars worth of cotton crops.

A well-known example of biological control of an insect pest made possible by such detailed study of pest life cycles involved flooding an insect range with sterile males as was done in eliminating the screw-worm fly in the Southwest. In this case, the scientific plan of attack was based on the knowledge that the female screw-worm fly mated only once in her adult life. Elimination of the pest was then made possible with the development of methods of mass producing and distributing sterile male flies.

APPLIED ECOLOGY

In the Applied Ecology program, North Carolina State University plans to train graduates at the master's degree level to carry out the development of insect pest management programs and to work with existing agricultural extension personnel, rural and civic organizations.

Penn State will train scientists on how to combat acid mine drainage, particularly serious where the coal has a high sulphur content, from coal mines that pollutes many streams in Appalachia. A new experimental field laboratory has been established to study, develop, and train scientists in improved methods of treating such acid waters. A second area of research and training is the development and application of new techniques utilizing spray application of soils for treatment of domestic sewage effluent.

The training and research at Rutgers will emphasize the influence of air pollution on vegetation; the impact of pesticides and other pollutants on ecosystems; and methods and principals of radioecology—the effects and methods of disposal of waste products of nuclear power plants.

HORMONES AND VIRUSES FOR INSECT CONTROL TO BE TESTED FOR POSSIBLE HARMFUL SIDE EFFECTS UNDER NSF GRANTS

Two promising new methods of controlling insect pests, by deploying specialized hormones and viruses against them, will be tested for possible harmful side effects upon "nontarget creatures" under grants announced today by the National Science Foundation.

It is hoped that these methods can do their work upon the target pests without adverse side effects. The new projects would seek to make sure of this, and thus avoid belated discovery of such unwelcome consequences as those which DDT, for example, have been found to bring about.

Much research is being conducted, including some supported by the Foundation, on the use of insect hormones, insect viruses, and other "naturally-occuring materials" for purposes of insect control. Their prospective advantages apart from their effectiveness, lie in expectation that they will not be harmful to man or other animals, including those in the food chain and those desirable or useful for other reasons; will not accumulate; and will not spread through the world environment as an unwanted permanent fixture.

Under one grant, a group of scientists at Marquette University in Milwaukee, Wis., will spend a year studying the biological effects of hormones used for insect pest control. The investigators will include an insect physiologist, Alapati Krishnakumaran; an organic chemist, Norman E. Hoffman; and two embryologists, Brian R. Unsworth and Salley Hennen. The grant is $33,000.

The effects on insect viruses on animal cells will be studied under the second grant, to the Boyce Thompson Institute for Plant Research at Yonkers, N.Y. The investigators are Karl Maramorosch and Gert Streissle. The grant of $39,300 is for one year.

The use of hormones against insect pests, subject of the Marquette study, would exploit the fact that hormones control the growth and activity of tissues and organs, and in this way regulate the life cycles of the insects. It is believed specific insect hormones can, for example, be cunningly synthesized in a slightly modified structure which, upon being received by insects, would abort their process of maturing and reproducing.

Such substances, distributed upon green plants used as food for the insects, would be widely effective in infinitesimal amounts. Contrary to earlier views, however, there is some evidence that an insect can develop some, although not complete, resistance to hormonal agents.

Because insects over several hundred million years have developed a highly complex physiological system of their own, it is assumed that special hormones used to control the pests among them would be quite specific, that is, would affect only the target insect and would not adversely affect other animals. That is not known for sure, however.

While two private firms working on large-scale synthesis of special hormones as a means of insect control may test side effects, the desirability of an independent and completely objective trial was one of the considerations underlying the NSF grant for the Marquette study.

Since hormones are available and their use appears feasible for insect control, it is reasoned, there is little question they will be used commercially. Hormonal agents used against insects may be taken in by humans eating fruit or vegetables, and may be distributed by rainfall into streams and rivers. There is thus the need for researching for such effects as genetic change, or abnormalities, on non-target creatures.

The tests at Marquette will use mouse tissues, mouse, chick and amphibian embryos, and chromosomes in amphibian embryos.

Insect viruses of a highly specific sort aimed at specific insect pests are another likely replacement, to some extent, for kinds of insecticides widely used in recent years. They could be used by themselves or in combination with other substances biological in nature. For example, "attractants" of the kinds the insects themselves secret and use could be employed to lure them to traps where they could be treated with lethal viruses or bacteria, and then released to spread doom among the rest of their population. But there is no adequate information on whether such viruses have a bad effect on cells of different kinds of animals, including mammals.

The Boyce Thompson investigators propose to search for all possible effects of insect viruses on different types of animal cells, including the fostering of tumors or of cancer, and enhancement of latent virus infections.

WAUKEGAN, ILL., *October 27, 1971.*

Hon. JAMES B. ALLEN,
Senate Subcommittee on Agricultural Research and General Legislation,
Old Senate Office Building, Washington, D.C.

DEAR SENATOR ALLEN: We would like to take this opportunity to comment in favor of Senate Bill 1794. It is our opinion that it is extremely important for us to determine new ways of controlling pests of agriculture. It has been shown in the past that under many field conditions it is practical to utilize integrated control methods.

Orkin Exterminating Company, Inc., although not directly related at this time to agricultural production, is most interested in advancing our knowledge of pest control techniques for the added protection of agricultural crops, products in storage, and for the structures housing these products. We are also vitally concerned for the safety of the applicator, the consumer, and the contaminated product.

It is our desire to support the U.S. Department of Agriculture and the National Science Foundation as proposed in this bill. We look forward to their continued good work with the additional financial support indicated over the next five years. We will look forward to the results of their investigations.

Please enter our comments into the record in support of S. 1794.

Very truly yours,

MICHAEL P. SHINKLE, Ph. D.,
Administrative Assistant to the Regional Vice-President,
Orkin Exterminating Co.