

organizations other than the educational institutions, and the enforcement officer is now more often known as the State nursery inspector, and may be connected with the horticultural board, plant board, department of agriculture, department of conservation, or crop pest commissioner of a State. While the regulatory officer is primarily concerned with the inspection and certification of nursery stock, in most States he also handles greenhouse and other propagation stock and apiaries, as well as handling the enforcement of intrastate quarantines.

In the early years of State nursery inspection, each State enacted regulations without much consideration for the regulations of other States. There was little uniformity of laws. Eventually this resulted in the formation of a joint committee from the American Nurserymen's Association and the American Association of Economic Entomologists, which formulated a so-called model law. This, in turn, brought changes in State laws, until most State regulations now are uniform and reciprocal one with another.

Another major development was the formation of the National Plant Board and regional plant boards, a direct result of a conference of State and Federal nursery inspection officials in Washington, D. C., in April 1924. The purpose was to promote uniformity and efficiency in horticultural and quarantine regulations and State inspection services. The National Plant Board prepared a statement, "Principles of Quarantines," which has had an important part in the history of regulatory organizations.

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Surveys of Insect Pests

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Surveys are an intelligence service that provides the entomologist, plant quarantine official, farmer, county agent, and the insecticide industry with essential information regarding the insect enemy. The surveys tell where the enemy occurs, how abundant he is, and what damage he is causing or threatens to do. They are a basis for determining the need and type of action required to combat him.

The many kinds of insect surveys vary according to the objective and the circumstances of the particular problem. Some provide information about a species about which little is known, such as a pest new to an area or the country. Some concern the kinds of insects that attack a given crop, like cotton, or a group of crops, like vegetables or fruits, and are for the purpose of aiding farmers to protect such crops from loss due to insects. Others aid in planning organized control campaigns against specific pests, like grasshoppers, which periodically occur in outbreaks over large areas and require cooperative action by several agencies and organized groups. Some surveys are conducted primarily to obtain data as a basis for determining the need for and as a guide to the enactment of State or Federal quarantine or regulatory measures. Still other surveys are made primarily to provide a record of the occurrence, abundance, and host-plant relationships of all insect species within a given area, such as an entire State. In wartime, surveys are carried on as a defense measure in the event that deliberate attempts should be made to introduce injurious pests from abroad or to spread those of economic importance to new areas.

SURVEYS for a recently introduced or little-known pest are conducted primarily to determine its distribution and behavior, to determine the nature and extent of damage it causes, the manner and rate by which it spreads and to ascertain its potential destructiveness and the need for developing control measures before it can become widely distributed.

An example is the work by the Bureau of Entomology and Plant Quarantine and State agencies in the South to obtain information on the distribution and status of the imported fire ant. This little South American pest, first reported near Mobile, Ala., about 1918, has spread and increased to the extent that citizens in infested areas demanded action to control it. The surveys, started in 1949, have shown the pest to be widely distributed in Alabama and Mississippi and less abundant in Florida, Georgia, Arkansas, Tennessee, and Louisiana. The observations also suggest that shipments of nursery stock may be a common means by which the ant is spread.

SURVEYS OF THE INSECTS attacking a given crop or group of crops have been carried on extensively. During the Second World War supplies of the insecticides for the insect pests of essential crops were scarce, and nearly all the basic materials needed to make insecticides were placed under allocation control. Supplies therefore had to be conserved and the available stocks used only for the most pressing needs on crops having the highest priorities. As a part of the effort to make the best use of insecticides and equipment, the Department of Agriculture in cooperation with other Federal and State agencies and industry instituted special surveys of the insect pests of cotton, truck crops, and fruit and their control requirements.

Whenever possible, a special effort was made to anticipate the development of infestations. Information obtained from the surveys was circulated weekly or oftener to all persons and

agencies that needed to plan programs and advise farmers about protecting the crops. It indicated the localities where dangerous numbers of insects were attacking or likely to attack specific crops, the local or regional availability of the necessary insecticides, and the availability of equipment. Extension workers advised farmers promptly as to the situation in local areas by announcements over the radio, in newspapers, and through correspondence. Information from the survey was used by Federal officials to aid industry in obtaining supplies of the basic materials needed to produce additional quantities of insecticides or equipment and guided industry in the distribution of the limited supplies to meet emergency situations.

The emergency situation with respect to availability of insecticides and equipment remained an important problem to the producers of cotton, vegetables, fruits, and other essential agricultural crops, and it has been necessary to continue surveys of this type. For instance, entomologists in New York knew that the Mexican bean beetle entered hibernation in the fall of 1949 in larger numbers than ever. They also knew that because of the mild winter an unusually high percentage of the beetles would probably survive to infest the State's dry bean crop, worth 13 million dollars, in 1950. State workers made surveys in June 1950 to determine whether beetles were present on beans in numbers sufficient to threaten the crop. Counts of the beetles made in 15 counties showed that the insects had survived the winter in such numbers as to necessitate the application of control measures to prevent extensive losses. An intensive control campaign was developed immediately. An evaluation of the results of the control measures instituted because of the survey findings indicated that the growers of dry beans of New York profited by \$3,014,094 from an expenditure of \$785,162 for insecticides and the labor to apply them.

Several States now conduct surveys

of the insect pests of vegetables, fruits, the cereal and forage crops, and cotton and make the results available promptly in periodic reports. County agents, other agricultural advisors, and farmers thus are informed as to the status of insect conditions in their areas. The Bureau of Entomology and Plant Quarantine, through its field offices, assembles the survey data from the various States and summarizes and distributes it in weekly reports that show insect conditions throughout the country with regard to those crops.

The surveys of cotton insects have resulted in a great expansion in the use of control methods. The number of growers applying controls throughout the Cotton Belt has increased more than 100 percent since 1945 as a result of the advisory program made possible because of the survey. The survey of cotton insects has developed into an advisory service for farmers, others associated with cotton production, and the manufacturers of the insecticidal chemicals.

An advisory type of survey, much like those we have mentioned, provides advice to farmers on the timing of insecticide applications. An example is the surveys of the European corn borer, first conducted in 1948 by the State agricultural experiment stations of Illinois, Iowa, Minnesota, and Wisconsin and the Department of Agriculture and later expanded to include 10 other States. Research has shown that the losses caused by the insect can be reduced by the proper use of insecticides, but accurate knowledge of the development of the corn borer eggs and larvae is essential because the period for effective control is short and the timing of insecticide applications is critically exacting. Farmers cannot now determine this development accurately. On the basis of field information obtained by trained personnel, advice is given to farmers every week or oftener by State extension workers over the radio and in newspapers to guide them in carrying out control measures in areas where corn is threat-

ened. A cooperative survey of this type, carried on in 12 States in 1949, helped save some 10 million bushels of corn from loss by the borer. It also helps farmers to avoid unwise use of insecticides and the cost of unnecessary applications by advising them that the degree of infestation in their locality does not warrant treatment or that the time for effective control has passed.

SURVEYS OF PESTS that occur in periodic outbreaks form the basis for planning regional or national cooperative or volunteer control programs. Grasshoppers and Mormon crickets, chinch bugs, hessian flies, and screw-worms are such pests. The surveys vary according to the particular problem, but all are conducted cooperatively by Federal and State agencies. The annual grasshopper survey, for example, is carried on to provide in advance a general picture of the infestation to be expected as a basis for planning control needs for the following season. The knowledge obtained by surveying the population of grasshopper adults and later the eggs is mapped during the winter and enables control agencies to plan their needs for the coming year. The actual grasshopper population is then determined by surveys in the spring after natural enemies and weather have exerted their influence. Further scouting, following the application of control measures, provides information concerning the thoroughness of control coverage, effectiveness of results, and the need for changes in insecticide dosages, application methods, or other procedures.

SURVEYS CARRIED ON in relation to regulatory measures are among the most common types. They furnish a basis for the enactment of State or Federal quarantines against specific pests. Most such surveys are designed to delimit the areas of infestation and may involve inspection of plants, plant products, soil, or other commodities to determine ways by which the particular pest is spread. Examples are the

surveys of gypsy and brown-tail moths, the Japanese beetle, white-fringed beetles, the sweetpotato weevil, and the potato tuberworm. Such surveys are usually conducted by the Federal and State units. Special methods and equipment such as traps and lures are often used in the surveys. For instance, traps baited with a material that attracts adult Japanese beetles are placed each summer near airports and other strategic points outside the regulated area to detect new infestations that may get a start from the escape of hitchhiking beetles. For the survey to determine distribution and spread of the pink bollworm, gin-trash machines have been developed; they separate any pink bollworms that may be present in the trash that is regularly removed from seed cotton during the ginning process. Examination of samples thus collected provides a relatively simple and reliable means of detecting the presence of the insect.

A SPECIAL SURVEY for insect pests and plant diseases in the general vicinity of ports of entry was carried on by the Bureau of Entomology and Plant Quarantine in 1943-45. The project, a national defense measure, was undertaken because of the belief that the greatly increased traffic from overseas during the Second World War might have resulted in the entry and establishment of new foreign agricultural pests in the port areas. It entailed intensive inspection of cultivated plants, field crops, orchards, home gardens, ornamentals, and native plants. Special attention was paid wild plants belonging to families closely related to important cultivated crops. The search was concentrated in States along the eastern and west coasts, Gulf coast, and Mexican border. The major effort was in southern California, the Rio Grande Valley, and in States bordering the Gulf of Mexico, where survey crews worked the year around.

Cooperative working relationships were established and maintained with officials of plant boards and depart-

ments of agriculture in all States in which the survey was conducted. Upon arrival at a port city, the survey crew first got in touch with local port authorities and county agents. Inspections began near ports and airports, then included gardens in residential areas adjacent to such facilities, and were extended gradually to surrounding agricultural areas until, in general, the entire coast line and the shores of navigable rivers or lakes were covered. All parts of plants were examined for insects, although greatest attention was usually given to foliage and fruits. Nearly 32,000 lots of insect specimens were submitted to specialists for identification. From these, about 3,500 different species of plant-feeding insects and mites were determined. Many others were identified as to family or genus. The survey brought to light at least 41 insects that had never before been recorded in the United States but, fortunately, only a few foreign pests of agricultural importance. Only seven introduced species of insects were found that are recognized as pests of economic importance in their countries of probable origin and which thus might be considered of immediate potential importance to the agricultural economy of the United States. They were all found in Florida and Texas and are known as pests in the West Indies and in countries south of the Mexican border. Among the many specimens collected, the taxonomists also found some 46 species that were new, that is, not known to science, and 82 species which they considered as probably new. Furthermore, the data resulting from this survey established new State distribution records for at least 33 species of insects previously known to occur elsewhere in this country and innumerable new locality records for many others.

A review of the results of this project, which took only 2 years and was carried on in a relatively limited area, demonstrates that we know too little about how many insect pests occur in the United States and that our present

knowledge concerning the distribution of most insect pests is still far from complete. Systematic, intensive searches of this type are the only satisfactory means of filling these important gaps in our knowledge of the insects that quietly work away in our gardens, fields, and orchards.

A COMPILATION of the insects known to occur in a given State or locality has value when information is needed promptly about the distribution, seasonal occurrence, host-plant relationships, and economic importance of a species. Such lists can be prepared only from reliable records, maintained through the years, of authentically identified specimens and supplemented by summarizing similar records in the entomological literature. Valuable lists of this type have been published by New Jersey, New York, Connecticut, North Carolina, and Kansas.

A FEDERAL SURVEY of insect pests has been carried on since 1921. The service was established to provide a medium through which all entomologists could keep more closely in touch with current insect conditions throughout the country and to serve as a repository for miscellaneous field observations previously available to only a few persons. Collaborators, chiefly State entomologists and entomologists in the agricultural experiment stations, State universities and agricultural colleges, and Federal entomological workers are encouraged to submit notes or reports on observations regarding the occurrence, abundance, distribution, destructiveness, and host-plant relationships of insect pests throughout the country. Upon receipt in the Insect Pest Survey office, Bureau of Entomology and Plant Quarantine, Washington 25, D. C., the data are analyzed and abstracted, and the information believed to have permanent value is filed so that it remains readily available. A cross-reference index to all of the insects known to affect any given species of plant is maintained. From

May 1921 to May 1942, a publication known as the Insect Pest Survey Bulletin was compiled and issued monthly, and an annual summary of insect conditions was published at the end of each year to furnish entomological workers information on the distribution, abundance, and destructiveness of insect pests in the country. More detailed information on the ecology, distribution, and destructiveness of specific pests of major economic importance, such as the European corn borer, Japanese beetle, and others, is published from time to time in the form of special supplements. The activities were curtailed in 1942 because of lack of funds, and publication of the Insect Pest Survey Bulletin was discontinued. Brief monthly and annual statements summarizing available information on the status of a few of the more important economic pests replaced the Bulletin.

In 1951 the agricultural agencies in each State were invited to participate in a plan to make this service more useful to all agricultural workers throughout the country. As a result, since July 1951 information on the status of insects of economic importance is made available every 2 weeks in a statement known as the Cooperative Economic Insect Report and issued by the Bureau.

An adjunct of the service has been the accumulation through the years of an index file of data on the occurrence, distribution, ecology, and host-plant relationships of more than 23,000 species of insects known to occur in this country. Additional data are added to it each year. The records are cataloged so one can furnish promptly information on the occurrence of any specific pest in a given State or county, or its national distribution, in response to the numerous requests received from Federal and State workers. An index file of the host plants from which each insect species has been recorded and of the insects recorded as attacking certain plants of economic importance has also been developed and is kept current.

A good start also was made in recording pertinent data concerning the records of insect pests in foreign countries. There are on file notes on more than 30,000 such species, obtained as the result of reviewing and abstracting the literature published in the Review of Applied Entomology through 1941. The data provide a source of ready reference when needed in connection with foreign plant quarantine activities and are a source of information whenever infestations of new foreign pests are found in the United States. The work was discontinued in 1942 because of the curtailment of funds.

THE COOPERATION of all interested agencies is important to the success of any insect survey, as the pooling of information obtained through individual effort avoids considerable duplication and permits greater and more thorough survey coverage of an area with less expenditure of manpower and funds. Thus, the more effective insect surveys in this country are carried on cooperatively by State and Federal entomological agencies. At times the aid of agricultural officials in foreign countries is sought. The more reliable surveys are made by well-trained workers or by teams of field scouts operating under close supervision of such personnel. Adequately trained workers are thoroughly familiar with the insect or insects concerned and know the essential facts about their life history, food plants, and habits. They know how to search for a pest new to an area, how to measure insect abundance in relation to damage or crop values, and how to determine the degree of destruction likely to result from an infestation of a given intensity. They also know just where to look and what to look for. They know that transportation centers, especially those associated with foreign commerce or the movement of agricultural commodities, are most likely to reveal a new infestation. An effective insect survey requires careful advance planning, with provision to insure the adequate recording of essen-

tial data and weeding out of the unessentials that merely serve to clutter up the files.

Surveys are the basis of intelligent insect control programs—whether in one row of bush beans in the home garden or a grasshopper control program in several States. In order to know what action is required and when it should be applied, we must first look the situation over to be sure what pest needs to be combatted and whether it is present in numbers sufficient to warrant treatment. Surveys are the only sure means of providing such information. Regardless of the kind, expense, or trouble, the surveys are essential if we are to keep the upper hand in the constant battle against the insect enemies.

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Potato tuberworm.