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A National Program of Research for Bees and Other Pollinating Insects and Insects Affecting Man

U.S. Department of Agriculture
A National Program of Research for Bees and Other Pollinating Insects and Insects Affecting Man

Prepared by
A Joint Task Force of the U.S. Department of Agriculture and the State Universities and Land Grant Colleges
FOREWORD

The United States Department of Agriculture and State Agricultural Experiment Stations are continuing comprehensive planning of research. This report is a part of this joint research planning and was prepared under recommendation 2 (page 204, paragraph 3) of the National Program of Research for Agriculture.

The task force which developed the report was requested to express their collective judgment as individual scientists and research administrators in regard to the research questions that need to be answered, the evaluation of present research efforts, and changes in research programs to meet present and future needs. The task force was asked to use the National Program of Research for Agriculture as a basis for their recommendation. However, in recognition of changing research needs it was anticipated that the task force recommendations might deviate from the specific plans of the National Program. These deviations are identified in the report along with appropriate reasons for change.

The report represents a valuable contribution to research plans for agriculture. It will be utilized by the Department and the State Agricultural Experiment Stations in developing their research programs. It could not be regarded as a request for the appropriation of funds or as a proposed rate at which funds will be requested to implement the research program.

This report has been prepared in limited numbers. Persons having a special interest in the development of public research and related programs may request copies from the Research Program Development and Evaluation Staff, Room 318-E Administration Bldg., USDA, Washington, D.C. 20250.

March 1969
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PREFACE

Authority: The Joint Task Force on insects Affecting Man and Bees and
Other Pollinating insects was appointed in memoranda of Dr. G. L. Mehren,
Assistant Secretary of the United States Department of Agriculture (USDA),
dated May 17, 1968, and Mr. A. G. Hazen, Chairman of the State Agricultural
Experiment Station (SAES) Committee on Organization and Policy, dated
May 17, 1968.

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H. A. Dunn, Assistant to the Administrator, Cooperative
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C. H. Hanson, Leader, Alfalfa Investigations, Forage and
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Agricultural Experiment Station, New Haven, Conn.

L. D. Newsom, Head, Department of Entomology, Louisiana
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Participating Staff Member: David J. Ward, Research Program Development
and Evaluation Staff, USDA.

Assignment:
The Task Force was instructed to indicate, within the general framework
of "A National Program of Research for Agriculture" a report of a study
sponsored jointly by the Association of State Universities and Land Grant
Colleges and the United States Department of Agriculture in 1966, areas of
research which need emphasis, and to determine the most efficient pro-
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Research on bees and other pollinating insects in Research Problem Area
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Since these two subject areas have so little in common, the Task Force
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Since these two subject areas have so little in common, the Task Force decided to treat the RPA's separately, each as a distinct entity.
GENERAL RECOMMENDATIONS

The Task Force recognizes the merit of close association between research workers of SAES, USDA, and other U.S. Agencies and recommends that this relationship be continued as the research program expands. It also feels that in these two subject areas considerable fragmentation of research effort exists, and that future expansion should strengthen efforts primarily at existing locations and minimize further dispersion.

Since the research plans being reviewed are essentially problem-oriented, the Task Force wishes to emphasize the need for fundamental entomological studies, particularly of genetics, physiology, taxonomy, ecology, and insect behavior. The "feedback" from such investigations to solutions of specific insect problems is much greater than is generally appreciated.

In evaluating research needs in the two subject areas assigned, this Task Force recognizes that programs in Research Problem Areas specifically assigned to other Task Forces will greatly affect bees, other pollinating insects, and insects affecting man. Insecticide programs to protect most flowering crops create hazards for bees and other pollinators, while many insects that affect man also affect farm animals, or wildlife. Therefore, this report will list other RPA's where related effort appears to be needed, but no specific recommendations as to the level of these efforts is made.

Recommendations Concerning RPA 314 (Bees and Other Pollinating Insects)

The Task Force believes that the existing research recommendations through 1977 will not provide adequate information concerning the use of bees and other pollinating insects. It recommends that the level of effort by 1977 be increased from the 1966 recommendation of 31 to 55 scientist man years (SMY), with principal emphasis on pollination. This is summarized in Table 1 below. To clarify the nature of the recommendations and to emphasize particular needs, RPA 314 has been subdivided into eight problem areas. In addition, the Task Force recognizes need for related research in RPA's 204, 207, 214, 304, 306, 307, 309, 506, 508, and 511.

Recommendations Concerning RPA 706 (Insects Affecting Man)

The Task Force believes that plans formulated in 1966 did not fully recognize the commitment of USDA to fulfilling both military and agriculture research needs in the area of insects affecting man. Although most of the military research findings have eventual urban or agricultural application, the urgency of the military need is frequently of a different nature or location and is often much greater than the civilian need. It is also becoming increasingly evident that major new types of insect problems are occurring, primarily as results of spreading urbanization and increasingly specialized agriculture. The Task Force recommends that the level of research effort by 1977 be increased to 107 SMY from the 1966 recommendation of 75. An inventory of the 1966 effort indicates approximately 64 SMY, compared with 50 in 1965. This is summarized in Table 1. To clarify the nature of the recommendations and to emphasize particular needs, RPA 706 has been subdivided into five problem areas. In addition, a need for related research is recognized in RPA's 210, 313, 404, 408, 412, 801, and 901.

It is the opinion of the Task Force that the title of RPA 706 should be changed in order to be more specific and descriptive; a possible alternative is: "Insects Affecting Man and His Belongings in His Home and Outdoor Environment."
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<td>SAES:USDA:TOTAL</td>
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<td>Control of Insect Pests of Man and His Belongings</td>
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Table 1.—Summary of Inventory and Recommendations of Scientist Man Years for Research Problem Areas 314 and 706.
Traditionally, apiculture has been regarded as the production of honey and beeswax. Because of the much greater potential or actual importance of bees for pollination, as compared to honey production, future research should be expanded and strongly oriented toward pollination. Research on pollination would not only involve the honey bee but also other pollinators, particularly wild bees native to this country or wild bees from other countries intended for pollination purposes.

Many beekeepers rent their colonies to farmers for the pollination of numerous fruit, vegetable, oilseed and legume seed crops. Colonies that are not rented also inadvertently contribute to the pollination of nearby crops. Nevertheless rental and use of bees strictly for pollination has been relegated to a secondary position in the minds of most beekeepers and researchers. Because of its importance to our national food supply honey bee pollination of our crops should merit major support. The use of bees for honey production should be secondary to their use for pollination.

Questions sometime arise as to the importance of the honey bee as a pollinator. To what extent is crop production increased when special measures are taken to increase pollination over that which ordinarily occurs from the usual combination of honey bees, wild bees and other pollinating insects? And to what degree can thoroughly planned systematic use of honey bees or other pollinating insects further increase production, and on which crops? To what extent will the use of new insecticides or male sterile plant varieties from hybrid breeding programs increase the need for specialized bees, particularly bees that will be effective on pollenizer or hybrid lines of crops? Are the limited resources devoted to honey bee research properly oriented? Is emphasis on honey production proper? Honey as a commercial product could disappear from the market if beekeeping ceases to be profitable. It could do so without undue hardship to the public. But would beekeeping for pollination continue to exist if honey production becomes unprofitable? Bees and other pollination insects may continue to suffer from urbanization, pesticides and other agricultural practices. Will this cause a shift in our farm programs away from insect-pollinated crops?

The answer to these questions can have a strong impact on our agricultural economy. But they can only be obtained through research - increased research, strongly oriented toward insect pollination and directed specifically to the value and proper use of bees and other pollinating insects on our agricultural crops.
The beekeeping industry in the United States is in a declining condition. The commercial beekeeper continues to think of honey production as his primary source of income. But today many operators are finding it an unprofitable enterprise and are going out of business. In fact, for the last 20 years the number of colonies in the United States has declined steadily at the rate of 1% per year. Many reasons are given for this trend but supporting data are lacking. One quite plausible explanation is that bee pasturage is decreasing with development of modern farming practices and urbanization. Pesticides also take a heavy toll. In fact, heaviest losses to beekeepers are caused by pesticides. Bee diseases continue to be a problem. Costs of operation have risen, whereas the price of honey has remained relatively constant and quite low.

Rental of bee colonies for crop pollination has not stopped the decline. Unfortunately there has been poor communication between the grower and beekeeper on the value of bees for pollination and in maintaining and supplying strong colonies. As a result most pollination fees are "starvation wages" for beekeepers, and some colonies supplied for pollination are of inferior quality.

Much of the work on honey bees has been directed toward a better honey producing colony. Most researchers think that a colony that will store a satisfactory crop of honey will also be a satisfactory pollinating colony, but data to substantiate this are meager. Research is needed on the pollinating value of honey bees independent of their value as honey producers.

Management of wild bees for pollination is becoming an industry within itself in a few areas of the country. Commercial beekeepers should be particularly adept and might consider taking on the management of such bees as an additional source of income. The possible introduction and use of wild bees from other parts of the world for pollination is an untapped resource that needs to be exploited.

Research on pollinating insects other than the honey bee has been directed almost entirely to 3 genera of bees: Bombus (bumblebees), Nomia (alkali bees), and Megachile (leafcutter bees). Research on alkali and leafcutter bees has shown that they offer considerable opportunity for increased production of legume seed. Little attention has been given to the pollinating value of other insects associated with flowers or their significance in pollination. The information available implies strongly that both honey bees and the various species of wild bees account for most of the insect pollination, because they tend to go from flower to flower seeking nectar and/or pollen to provision the nest, and without damage to the flower in the process.

The vicious African bee (Apis mellifera adansonii) that was introduced into Brazil but escaped and spread out of control now poses a threat to beekeeping and pollination in the United States. When this bee is disturbed it viciously stings any man or animal within several hundred feet of its domicile. Such viciousness certainly limits the use of these bees in commercial pollination programs. In 13 years in South America, it has spread over an area equal to continental United States. At its current rate of spread it will reach the United States within 10-20 years. No feasible control methods exist that will stop it. Should it become established in the United States its characteristics may make beekeeping for honey production even less pleasant or profitable, and use of such bees for pollination unacceptable to the grower.

Research on bees has been about equally divided between the USDA (16 SMY's at 6 locations) and SAEs (15 SMY's in 21 states).

The Proposal

"Provide more information on the total value and proper use of pollinating insects in crop production." This was the consensus of the Task Force Committee. They stressed the lack of adequate information on the extent to which our current crop varieties depend upon a benefit by insect pollination, and the extent to which production can be enhanced by manipulated insect pollination. Research workers should be challenged to determine these factors.

The honey bee is of great value to agriculture, and it is the only known pollinator that can be moved into an area in mass numbers when desired. In addition, honey bees consistently visit flowers from early spring to late fall, they visit a wide variety of plants and their biology is well known as a result of centuries of studies by amateur and professional apiculturists. Because of these highly valuable traits research should be intensified to determine the most efficient use of the honey bee as a pollinator.

Parallel to research on the honey bee as a pollinator should be research on other insects commonly associated with flowers, and their significance in the pollination of crops. What is the potential of other insects as pollinators? Are they as effective as or more effective than the honey bee as pollinators of specific crops? Are they reliable in different areas, at different seasons, or in different agricultural settings? If they are of value, can they be manipulated and their diseases and pests controlled? Which ones can be produced under artificial conditions, maintained or made available for release at optimum times and at an economical cost? Can they be conserved and augmented by periodic coloni zation, development of adapted strains, provision of artificial nesting sites, or modification of agricultural practices that are detrimental to such pollinators? Should a search be worthwhile for foreign pollinators and the promising ones evaluated for possible introduction into our country? These questions should be answered.
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The Task Force feels that too much of the SAES bee researcher's time is devoted to extension work. It recognizes, however, that because of the special nature of beekeeping and pollination of crops, most extension workers are inadequately trained and research information is often lacking to advise beekeepers or growers on the most efficient management and use. The task then automatically falls back on the local researcher. The Task Force recognizes the value of such aid. It also recognizes the high degree of isolation that exists in SAES bee research - isolation both in miles and subject matter. In some instances isolation might be eliminated by organizing group research centers strategically located throughout the United States, with increased emphasis on extension service at the local level. However, another approach could be the coordination of efforts at existing research installations, where crops, climate, or other factors enhance productive research.

The Task Force recommends that better coordination and direction of the research on pollination in progress at existing installations particularly on plants specific to that region be strongly encouraged, implemented and strengthened. It also recommends the establishment of a well-rounded pollination laboratory or center. This laboratory would be comprised of bee specialists, crop specialists, and agricultural engineers, whose work would be devoted to establishing the economic value, contribution and utilization of pollinating insects.

Consideration should also be given in the future to additional strategically located pollination research to obtain maximum information on crops grown in the area, e.g., subtropical and associated southern crops, semiarid midwest crops, Great Lakes fruit and vegetable crops or irrigated crops of the southwest and far west.

Although economic studies are not within the realm of RPA 314, the Task Force feels that the lack of information on the economics of honey production justifies an economics study of the industry, possibly under RPA 511, Improvement of Agricultural Statistics, to obtain accurate data on costs and income and factors that influence such costs.

It appears to members of this Task Force that the major emphasis of the research program contained under Goal III, Section 14, page 113 of "A National Program of Research for Agriculture," which was prepared jointly by the Association of State Universities and Land Grant Colleges and the USDA in October 1966, should be revised to place importance on use of bees for pollination instead of the emphasis being placed on honey production. The program should relate to the evaluation of bees and other potential pollinating insects as the important and, in fact, sometimes critical factors in the production of essential legume seed, fruit, oilseed, and vegetable crops. We strongly recommend the revising and increasing of emphasis on bee research from the present 31 to 55 SMY by 1977 along the lines of the eight categories of research summarized in Table 2 and discussed in detail in the remainder of this section of the report.

### Table 2. Summary of Inventory and Recommendations of Scientist Man Years for the Sub-Division of Research Problem Area 314.

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<td>Contribution of Insect Pollinators in Crop Production</td>
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<td>314-5</td>
<td>Improved beekeeping, and development of Artificial Beefood, crops, and Agricultural Engineering</td>
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<td>3:4:7</td>
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<td>314-6</td>
<td>Behavior, Genetic &amp; Breeding Studies on Bees to Improve Pollination</td>
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<td>3:5:6</td>
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<td>314-7</td>
<td>Toll-S-Salute</td>
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<td>314-8</td>
<td>Development of Honey and Other Bee Products</td>
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<td>15:16:31</td>
<td>24:15:24</td>
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</table>
Table 2.--Summary of Inventory and Recommendations of Scientist Man Years for the Sub-Division of Research Problem Area 314.

<table>
<thead>
<tr>
<th>Sub-Division</th>
<th>Title</th>
<th>SMY'S 1966</th>
<th>Increase by 1977</th>
<th>1977 Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>314-C</td>
<td>Environmental Management to Improve Bee Pollination</td>
<td>2 : 0 : 2</td>
<td>3 : 2 : 5</td>
<td>5 : 3 : 7</td>
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<tr>
<td>314-D</td>
<td>Nutritional Requirements of Bee Pollinators Including Development of Artificial Diets</td>
<td>2 : 1 : 3</td>
<td>0 : 0 : 0</td>
<td>2 : 1 : 3</td>
</tr>
<tr>
<td>314-F</td>
<td>Behavioral, Biological, and Ecological Studies of Pollinators</td>
<td>2 : 2 : 4</td>
<td>0 : 1 : 1</td>
<td>2 : 3 : 5</td>
</tr>
<tr>
<td>314-G</td>
<td>Taxonomic, Genetic &amp; Breeding Studies on Bees to Improve Pollination</td>
<td>2 : 3 : 5</td>
<td>1 : 2 : 3</td>
<td>3 : 4 : 8</td>
</tr>
<tr>
<td>314-H</td>
<td>Development of Practices for Improved Production of Honey and Other Bee Products</td>
<td>1 : 3 : 4</td>
<td>1 : 0 : 1</td>
<td>2 : 3 : 5</td>
</tr>
</tbody>
</table>
This research should be conducted in close cooperation with RPA 304, Improvement of Biological Efficiency of Fruit and Vegetable Crops, RPA 307, Improvement of Biological Efficiency of Field Crops, and RPA 508, Development of Domestic Markets for Farm Products. The Task Force emphasizes the importance of the multidiscipline approach to these research problems and of establishing close working relationships among the scientists involved. Entomologists, plant breeders, crop management specialists, engineers, and others can all contribute toward more efficient use of bees and other pollinating insects. This will increase the production of seeds, fruit and honey. The development of hybrid plant varieties especially require team effort to attain successful pollination on a commercial basis. Related RPA's to 314, where studies on bees and other pollinating insects should be considered, are mentioned below.

204 Control of Insect Pests of Fruit and Vegetable Crops
207 Control of Insect Pests of Field Crops
214 Protection of Plants and Animals from Harmful Effects of Air Pollution
306 Systems Analysis in Production of Fruits and Vegetables
309 Systems Analysis in Production of Field Crops
506 Supply, Demand and Price Analysis
511 Improvement of Agricultural Statistics

Title: Contribution of Insect Pollinators in Crop Production. RPA 314-A

Situation: About 90 crops grown in the United States, valued at over a billion dollars, are considered to be dependent upon insect pollination. In addition, other crops valued at about 4 billion dollars are benefited by insect pollination. For many of these crops the information on their pollination requirements is scant, or based on varieties no longer in production. Some of the new hybrid varieties are male-sterile and only set seed when insects carry pollen to them from male fertile plants. In general, the crops specialists have paid scant regard to exercising control over the pollinators of the crop, leaving this work to the bee specialist. The Committee feels that the two groups should work closer together in the future on pollination problems.

Objective: To determine, crop by crop, the exact need for pollinating insects, the value and effectiveness of different insect pollinators on each economic crop and variety, the need for supplemental insect pollination, methods of utilizing insect pollinators most efficiently for maximum crop production, and the evaluation of pollinators as a management practice.

Research Approaches: In cooperation between crop and insect specialists: 1. Determine the kind and number of pollinating insects needed per unit area of the field for different crops and varieties. 2. Determine the value of supplemental pollination under different field environments, and the need for special pollinators for special crop varieties. 3. Determine the cost factors involved for both grower and beekeeper in the use of honey bee colonies for maximum crop production in cooperation with RPA 306, 309.

Character of Potential Benefits: Increased crop yield, quality and efficiency of production.

Recommended Research Effort:

TF Recommendation SMY
Present (1966) 1977
6 14

Title: Bee Management Practices for Improved Pollination. RPA 314-B

Situation: Some insect pollination of most crops occurs without any growers' action in arranging for this service. In most instances honey bees located in the area by hobbyists or commercial honey producers do the pollination. Sometimes feral honey bees or various species of wild bees may be responsible. In the Pacific Northwest growers arrange for and utilize leafcutter and alkali bees on about 20,000 acres of alfalfa. However, nationwide a great number of growers actively take steps to utilize insect pollinators, by arranging for the use of about 1 million honey bee colonies. These are placed in or alongside the fields in groups of 5 to 20 when flowering starts, and removed when flowering ceases or the desired pollination is accomplished. There is believed to be a potential use in pollination for a many-fold increase in the number of colonies of honey bees and wild bees. Present grower usage of honey bee colonies for crop pollination varies from one colony per season for several acres to several colonies per acre.

Objective: Develop better and more efficient methods of bee management for improved pollination. This includes both honey bees and wild bees.

Research Approaches: Through cooperation between insect, crop, and engineering specialists determine: 1. The most efficient honey bee colony number, strength, and distribution system for field saturation-pollination to achieve maximum crop production by relating numbers of bee visits per flower or plant to both quantity and quality of the crop produced. 2. The most efficient colony size for maximum crop production. 3. The proper time and method for moving bees to and away from the field for most efficient production. 4. Effective and efficient methods of colony protection from inclement weather, water stress, pesticides and other environmental hazards during crop pollination. 5. The optimum wild
This research should be conducted in close cooperation with RPA 304, Improvement of Biological Efficiency of Fruit and Vegetable Crops, RPA 307, Improvement of Biological Efficiency of Field Crops, and RPA 508, Development of Domestic Markets for Farm Products. The Task Force emphasizes the importance of the multidiscipline approach to these research problems and of establishing close working relationships among the scientists involved. Entomologists, plant breeders, crop management specialists, engineers, and others can all contribute toward more efficient use of bees and other pollinating insects. This will increase the production of seeds, fruit and honey. The development of hybrid plant varieties especially require team effort to attain successful pollination on a commercial basis. Related RPA's to 314, where studies on bees and other pollinating insects should be considered, are mentioned below.

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Objective: To determine, crop by crop, the exact need for pollinating insects, the value and effectiveness of different insect pollinators on each economic crop and variety, the need for supplemental insect pollination, methods of utilizing insect pollinators, most efficiently for maximum crop production, and the evaluation of pollinators as a management practice.

Research Approaches: In cooperation between crop and insect specialists:
1. Determine the kind and number of pollinating insects needed per unit area of the field for different crops and varieties. 2. Determine the value of supplemental pollination under different field environments, and the need for special pollinators for special crop varieties. 3. Determine the cost factors involved for both grower and beekeeper in the use of honey bee colonies for maximum crop production in cooperation with RPA 306, 309.

Character of Potential Benefits: Increased crop yield, quality and efficiency of production.

Recommended Research Effort:

TF Recommendation SMY

Present (1966) 1977
6 14

Title: Bee Management Practices for Improved Pollination. RPA 314-B

Situation: Some insect pollination of most crops occurs without any growers' action in arranging for this service. In most instances honey bees located in the area by hobbyists or commercial honey producers do the pollination. Sometimes feral honey bees or various species of wild bees may be responsible. In the Pacific Northwest growers arrange for and utilize leafcutter and alkali bees on about 20,000 acres of alfalfa. However, nationwide a great number of growers actively take steps to utilize insect pollinators, by arranging for the use of about 1 million honey bee colonies. These are placed in or alongside the fields in groups of 5 to 20 when flowering starts, and removed when flowering ceases or the desired pollination is accomplished. There is believed to be a potential use in pollination for a many-fold increase in the number of colonies of honey bees and wild bees. Present grower usage of honey bee colonies for crop pollination varies from one colony for several acres to several colonies per acre.

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Research Approaches: Through cooperation between insect, crop, and engineering specialists determine: 1. The most efficient honey bee colony number, strength, and distribution system for field saturation-pollination to achieve maximum crop production by relating numbers of bee visits per flower or plant to both quantity and quality of the crop produced. 2. The most efficient colony size for maximum crop production. 3. The proper time and method for moving bees to and away from the field for most efficient production. 4. Effective and efficient methods of colony protection from inclement weather, water stress, pesticides and other environmental hazards during crop pollination. 5. The optimum wild
bee population desired to achieve maximum crop production, the most effective method of using and protecting wild bees while they are pollinating the crop, and finally methods of protecting wild bees during the remainder of the season when they are not utilized for pollination. 6. The cost factors involved for both grower and beekeeper in the use of bees for maximum crop production. 7. The feasibility of using pollinating insects other than bees. 8. The use of special pollinating strains of bees for specific crops.

Character of Potential Benefit: Reduced per unit cost and increased yield and quality of crops through more efficient insect pollination.

Recommended Research Effort:

Title: Management of Environment to Improve Bee Pollination. RPA 314-C

Situation: The effectiveness of insect pollination is strongly influenced by such environmental factors as pesticides, predators, variation in attractiveness of plants to pollinators, the sequence of crops attracting pollinating insects, and the competing plants that tend to lure bees away from the crop to be pollinated. For example, some insecticides are highly toxic to bees, others are relatively non-toxic. Pesticides alone destroy or damage half a million colonies of honey bees annually, and they are equally hazardous to wild bees. When alfalfa is grown for seed near safflower fields in the Southwest, the bees may be lured into the safflower fields and fail to pollinate the alfalfa. In plant breeding programs, with the exception of alfalfa, only limited attention is being given to making the crop more attractive to insect pollinators even when it is dependent on such agents. Destruction of weeds that supply pollen for bees can reduce colony strength, and in turn, its pollinating effectiveness.

Objectives: To manage the environment around fields where insect pollination is desired through entomological, agronomic and engineering technology so that maximum effectiveness of the pollinating insect in the field can be obtained and to protect the pollinators from unfavorable environmental factors. To cooperate with plant breeders in the development of varieties more attractive to insect pollinators by determining and utilizing the attractant factors in the plant.

Research Approaches: 1. Determine the time of year to bring a crop into flowering to obtain its most efficient pollination and maximum production.

2. Develop methods of reducing pesticide drift damage. Determine relative toxicity of pesticides to bees. 3. Urge action to aid and protect pollinators in the following research program areas:

Under RPA 304 and 307, develop support crops to maintain pollinators during off-season pollination periods; study the plant constituents that influence pollination and pollinator activity; determine plant's pollination requirements and production potential from the botanical, plant nutrition, and agronomic standpoint; and join with plant breeders in the development of crop varieties more attractive to insect pollinators.

Under RPA 204, 207, and 214, give attention to protection of bees and other pollinating insects.

Under RPA 506, make a thorough economic study of the beekeeping and pollination industry.

Character of Potential Benefits: Reduce cost of production and increase yield and quality.

Recommended Research Effort:

Title: Nutritional Requirements for Bee Pollinators Including Development of Artificial Diets. RPA 314-D

Situation: The diet of bees consists of nectar and pollen collected from plants. Adult bees can survive on artificial feeding of sugar syrup, but there is no substitute for pollen which is necessary in rearing more bees. The reluctance of bees to feed on other materials increases the difficulty of finding a substitute. Beekeepers frequently fail to obtain a honey crop because weather prevents the colonies from collecting sufficient pollen early in the season necessary to build up colony populations to maximum strength. Undernourished, weak colonies are ineffective in crop pollination. Under present conditions colonies must be scattered in groups of only a few dozen throughout the countryside so they can obtain sufficient pollen and nectar. If nutritionally adequate artificial diets could be developed that colonies would consume and thereby develop to maximum strength, their effectiveness as pollinators and/or honey producers would be increased far beyond present capabilities. An artificial diet would permit maintenance of thousands of colonies in a single location where they could be readily available for use when desired for pollination. When
bee population desired to achieve maximum crop production, the most
effective method of using and protecting wild bees while they are polli-
nating the crop, and finally methods of protecting wild bees during the
remainder of the season when they are not utilized for pollination. 6. The
cost factors involved for both grower and beekeeper in the use of bees for
maximum crop production. 7. The feasibility of using pollinating insects
other than bees. 8. The use of special pollinating strains of bees for
specific crops.

Character of Potential Benefit: Reduced per unit cost and increased yield
and quality of crops through more efficient insect pollination.

Recommended Research Effort:

| Title: Management of Environment to Improve Bee Pollination. RPA 314-C |
|-------------------------|-------------------------|
| TF Recommendation SMY |
| Present (1966) | 1977 |
| 3 | 7 |

Title: Nutritional Requirements for Bee Pollinators Including Development
of Artificial Diets. RPA 314-B

Situation: The diet of bees consists of nectar and pollen collected from
plants. Adult bees can survive on artificial feeding of sugar syrup, but
there is no substitute for pollen which is necessary in rearing more bees.
The reluctance of bees to feed on other materials increases the difficulty
of finding a substitute. Beekeepers frequently fail to obtain a honey
crop because weather prevents the colonies from collecting sufficient
pollen early in the season necessary to build up colony populations to
maximum strength. Under present conditions colonies must be scattered in groups
of only a few dozen throughout the countryside so they can obtain suffi-
cient pollen and nectar. If nutritionally adequate artificial diets could
be developed that colonies would consume and thereby develop to maximum
strength, their effectiveness as pollinators and/or honey producers would
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permit maintenance of thousands of colonies in a single location where
they could be readily available for use when desired for pollination. When

2. Develop methods of reducing pesticide drift damage. Determine rela-
tive toxicity of pesticides to bees. 3. Urge action to aid and protect
pollinators in the following research program areas:

Under RPA 304 and 307, develop support crops to maintain pollinators
during off-season pollination periods; study the plant constituents that
influence pollination and pollinator activity; determine plant's pollina-
tion requirements and production potential from the botanical, plant
nutrition, and agronomic standpoint; and join with plant breeders in the
development of crop varieties more attractive to insect pollinators.

Under RPA 204, 207, and 214, give attention to protection of bees
and other pollinating insects.

Under RPA 506, make a thorough economic study of the beekeeping and
pollination industry.

Character of Potential Benefits: Reduce cost of production and increase
yield and quality.

Recommended Research Effort:

| Title: Nutritional Requirements for Bee Pollinators Including Development
of Artificial Diets. RPA 314-B |
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<td>TF Recommendations SMY</td>
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not used for pollination the colonies could be kept in isolated areas relatively free from damage by pesticides. This concentration of colonies in a single location would greatly reduce overhead expense to the beekeeper.

**Objective:** To develop an artificial diet which will stimulate bees to attain their maximum strength at a desired time.

**Research Approaches:**
1. Determine the chemical composition of pollen and of materials that might be substituted for pollen in the diet of the bee.
2. Isolate the attractive factors in pollen that might be utilized to induce bees to consume artificial diets that they otherwise ignore.
3. Determine the nutritional requirement of the bee and nutritional factors present in different pollens that bees collect.
4. Determine the physiology of the bee in terms of its nutrient utilization.
5. Study diets and need for supplement feeding of other insect pollinators.
6. Utilize the simpler feeding habits of wild bees in determining the reaction to nutritional materials for honey bees.

**Character of Potential Benefits:** Increased pollinator effectiveness with better diets.

**Recommended Research Effort:**

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<th>TF Recommendation</th>
<th>SMY</th>
<th>Present (1966)</th>
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**Title:** Protection of Pollinators from Diseases, Insect Pests and Pesticides, RPA 314-E

**Situation:** Approximately 17,000 colonies of honey bees infected with American foulbrood, a virulent contagious disease of bees, are destroyed annually by apiary inspectors in 47 states. Bee scientists also estimate that an equal number of colonies with this disease are destroyed by the owners. European foulbrood, while not always fatal, severely weakens thousands of colonies annually. Nosema disease severely reduces the productivity capacity of colonies, causes the death or supersEDURE of queens and severely decreases the effectiveness of colonies. Sacbrood and other diseases also cause some colony damage. Thousands of man hours are spent annually in inspecting and treating colonies for these diseases, and much equipment is destroyed. The wax moth destroys an estimated half-million dollars worth of comb, honey and bee equipment.

Diseases and pests are not confined to honey bees. In the large-scale use and maintenance of wild bees, diseases and pests have also become a serious problem. Growers who use alkali bees are frequently forced to abandon nesting grounds after about 5 years because of disease build-up in the soil. Growers who use leafcutting bees are forced to use poison baits and traps for dermestid beetle control. Such problems will undoubtedly increase in these and other bees when their populations are concentrated to provide the maximum pollination desired by the crop or seed growers.

An estimated 500,000 colonies of honey bees were destroyed or damaged in 1967 by pesticides. The total damage to the honey bee industry by diseases and pests is estimated to be $7.5 million annually.

**Objective:** To develop methods of protecting pollinating insects from diseases, pests and pesticides.

**Research Approaches:**
1. Develop practical methods of eradicating American foulbrood, European foulbrood, nosema disease and the wax moth with fumigants.
2. Determine effectiveness of heat in control of nosema disease and the wax moth.
3. Develop new and more effective drugs for control of bee diseases.
4. Develop strains of bees resistant to the different diseases.
5. Develop methods of bee manipulation, including feeding of artificial diets, that will improve or counteract the effect of bee disease damage.
6. Determine the extent of diseases and pests of other pollinators and develop better control measures.
7. Isolate and determine the impact of the benign diseases on colony strength.
8. Develop methods of protecting pollinators from pesticides, predator birds, lizards, skunks, and bears.
9. Determine the sub-lethal effects of pesticides on bees.

**Character of Potential Benefits:** By reducing diseases, pests of bees, and losses due to pesticides, the pollination and honey productive capacity of honey bee colonies and pollination by wild bees would be increased.

**Recommended Research Effort:**

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<th>TF Recommendation</th>
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<th>Present (1966)</th>
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**Title:** Behavioral, Biological, and Ecological Studies of Bee Pollinators, RPA 314-F

**Situation:** Honey bees are social insects; the leafcutting and alkali bees are gregarious. All of them, therefore, may be influenced by the behavioral activity of other bees around them. Honey bees are known to have a language whereby they communicate the direction, distance and quality of
not used for pollination the colonies could be kept in isolated areas relatively free from damage by pesticides. This concentration of colonies in a single location would greatly reduce overhead expense to the beekeeper.

Objective: To develop an artificial diet which will stimulate bees to attain their maximum strength at a desired time.

Research Approaches: 1. Determine the nutritional requirements of bees and nutritional factors present in different pollens that bees collect. 4. Determine the physiology of the bee in terms of its nutrient utilization. 5. Study diets and need for supplemental feeding of other insect pollinators. 6. Utilize the simpler feeding habits of wild bees in determining the reaction to nutritional materials for honey bees.

Character of Potential Benefits: Increased pollinator effectiveness with better diets.

Recommended Research Effort:

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<tr>
<th>Year</th>
<th>TF Recommendation SMY</th>
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An estimated 500,000 colonies of honey bees were destroyed or damaged in 1967 by pesticides. The total damage to the honey bee industry by diseases and pests is estimated to be $7.5 million annually.

Objective: To develop methods of protecting pollinating insects from diseases, pests and pesticides.

Research Approaches: 1. Develop practical methods of eradicating American foulbrood, European foulbrood, nosema disease and the wax moth with fumigants. 2. Determine the degree of effectiveness of heat in control of nosema disease and the wax moth. 3. Develop new and more effective drugs for control of bee diseases. 4. Develop strains of bees resistant to the different diseases. 5. Develop methods of bee manipulation, including feeding of artificial diets, that will improve or counteract the effect of bee disease damage. 6. Determine the extent of diseases and pests of other pollinators and develop better control measures. 7. Isolate and determine the impact of the benign diseases on colony strength. 8. Develop methods of protecting pollinators from pesticides, predator birds, lizards, skunks, and bears. 9. Determine the sub-lethal effects of pesticides on bees.

Character of Potential Benefits: By reducing diseases, pests of bees, and losses due to pesticides, the pollination and honey productive capacity of honey bee colonies and pollination by wild bees would be increased.

Recommended Research Effort:

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Title: Behavioral, Biological, and Ecological Studies of Bee Pollinators, RPA 314-E

Situation: Honey bees are social insects; the leafcutting and alkali bees are gregarious. All of them, therefore, may be influenced by the behavioral activity of other bees around them. Honey bees are known to have a language whereby they communicate the direction, distance and quality of
food available and other information. Ecological studies of leafcutter bees have shown that temperature influences pupation and emergence of adults. Growers utilize this information so the bees emerge at the appropriate time to pollinate specific crops. Studies of the soil and nesting sites of alkali bees revealed the type of nesting areas the bees prefer. Growers now prepare such sites by mixing types of soil desired by these bees. Certain high frequency vibrations cause honey bees to "freeze" on the comb. This reaction might be utilized to prevent bees from leaving the hive when they are likely to be exposed to dangerous pesticides.

**Objective:** To determine the behavioral characteristics and the ecological factors that influence pollinating efficiency of both honey bees and wild bees, and to utilize this information to provide more efficient bee pollination.

**Research Approaches:** Through cooperation of biological and physical scientists: 1. Determine the effects of high frequency sound upon bees. 2. Analyze the sounds produced by bees under different situations. 3. Attempt to decipher bee sounds and learn more of the language of bees. 4. Study the life histories and habits of wild bees. 5. Determine the effect of different temperatures and humidities upon wild bees. 6. Determine the foraging ranges of bees and factors that influence foraging range. 7. Determine ecological and behavioral factors that influence pollen collection in both honey bees and wild bees.

**Character of Potential Benefits:** Increase knowledge of bee behavior and other characteristics leading to more efficient utilization of bees for crop pollination and honey production.

**Recommended Research Efforts:**

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**Title:** Taxonomic, Genetic, and Breeding Studies of Bees to Improve Pollination. RPA 314-G

**Situation:** The recent development of an alfalfa-pollen collecting strain of honey bees demonstrates the value of genetic and breeding studies of bees. Preliminary evidence indicates that a strain of honey bees showing strong preference for cranberry pollen and another showing strong preference for cotton flower visitation may be developed. Strains specific for nectar collection would also be desirable for the best pollination of some plant varieties. Artificial insemination of queen honey bees is now a dependable and necessary tool in bee breeding. Stocks, strains, mutants and other types of bee germ plasm are being collected for use in the breeding programs. The genetics of foraging inheritance necessary in such programs is being determined.

**Objectives:** To develop and improve strains of honey bees for the pollination of specific crops, to obtain basic information on the genetics of these bees vital to a breeding program, to determine inheritance of characteristics associated with nectar and pollen collection and pollination. To work out the taxonomy of wild bees and other pollinating insects. To conduct research leading to the prevention of the African bee, in its present vicious form, from entering the U.S.

**Research Approaches:** 1. Collect and evaluate honey bee races, strains and selections for usefulness in crop pollination. 2. Transfer desirable characteristics, when found, into improved honey bee strains. 3. Determine the inheritance of the physiological and morphological nature of pollen and nectar collection and preference in honey bees. 4. Develop special pollinating strains for specific crops. 5. Develop and maintain a representative collection of pollinating insects for use in immediate field identification of material under study. 6. Work out the genetics of the African bee in Brazil which might lead to its control or prevention from entering the U.S. 7. Determine the feasibility of developing strains of bees that work at lower temperatures, or that are resistant to common pesticides.

**Character of Potential Benefits:** Reduce cost of crop production and increase yield and quality through more adequate pollination of various crops.

**Recommended Research Efforts:**

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**Title:** Development of Practices for Improved Production of Honey and Other Bee Products. RPA 314-H

**Situation:** Most of the problems that plague honey-producing beekeepers are the same ones that concern keepers of bees for crop pollination. The high cost of operation is one of the biggest problems. (An average beekeeper with 2,000 colonies has a capital investment of $100,000 or more.) Other problems are diseases and pests, pesticides, nutrition and the need for a suitable bee diet, bee behavior, ecological difficulties, and a multitude of management problems. Management problems include aided the colonies in spring buildup, swarm prevention, manipulating and providing sufficient room in the colony for honey storage, transporting colonies to the best nectar sources, in addition to harvesting, handling, and marketing
The recent development of an alfalfa-pollen collecting strain of honey bees demonstrates the value of genetic and breeding studies of bees. Preliminary evidence indicates that a strain of honey bees showing strong preference for cranberry pollen and another showing strong preference for cotton flower visitation may be developed. Strains specific for nectar collection would also be desirable for the best pollination of some plant varieties. Artificial insemination of queen honey bees is now a dependable and necessary tool in bee breeding. Stocks, strains, mutants and other types of bee germ plasm are being collected for use in the breeding programs. The genetics of foraging inheritance necessary in such programs is being determined.

Objectives: To develop and improve strains of honey bees for the pollination of specific crops, to obtain basic information on the genetics of these bees vital to a breeding program, to determine inheritance of characteristics associated with nectar and pollen collection and pollination. To work out the taxonomy of wild bees and other pollinating insects. To conduct research leading to the prevention of the African bee, in its present vicious form, from entering the U.S.

Research Approaches: 1. Collect and evaluate honey bee races, strains and selections for usefulness in crop pollination. 2. Transfer desirable characteristics, when found, into improved honey bee strains. 3. Determine the inheritance of the physiological and morphological nature of pollen and nectar collection and preference in honey bees. 4. Develop special pollinating strains for specific crops. 5. Develop and maintain a representative collection of pollinating insects for use in immediate field identification of material under study. 6. Work out the genetics of the African bee in Brazil which might lead to its control or prevention from entering the U.S. 7. Determine the feasibility of developing strains of bees that work at lower temperatures, or that are resistant to common pesticides.

Character of Potential Benefit: Reduce cost of crop production and increase yield and quality through more adequate pollination of various crops.

Recommended Research Efforts:

Title: Development of Practices for Improved Production of Honey and Other Bee Products. RPA 314-H
Situation: Most of the problems that plague honey-producing beekeepers are the same ones that concern keepers of bees for crop pollination. The high cost of operation is one of the biggest problems. (An average beekeeper with 2,000 colonies has a capital investment of $100,000 or more.) Other problems are diseases and pests, pesticides, nutrition and the need for a suitable bee diet, bee behavior, ecological difficulties, and a multitude of management problems. Management problems include aiding the colonies in spring buildup, swarm prevention, manipulating and providing sufficient room in the colony for honey storage, transporting colonies to the best nectar sources, in addition to harvesting, handling, and marketing.
of the honey crop. There is no USDA or SAES research on honey itself, on its promotion or utilization in the United States. It is imperative for agriculture that honey become a stronger competitor with other food commodities. Currently the honey and wax obtained from approximately 5 million colonies of honey bees in the United States owned by about 200,000 beekeepers amounts to less than $40 million. Only about 1,200 beekeepers are full-time commercial operators with 400 or more colonies. However, they produce about one-third of the honey crop and provide most of the colonies used in commercial pollination. About 12,000 part-time beekeepers own 25 to 400 colonies and produce another third of the honey. The remaining 187,000 are hobbyists with fewer than 25 colonies who produce the rest of the honey.

Objectives: To increase honey production per colony; to facilitate manipulation of the colony and equipment, honey processing and honey handling, and otherwise increase efficiency of operation; to prevent losses of bees from diseases, pests, and insecticides; to develop more efficient honey-producing strains of bees; and promote the utilization of honey. All of these will in turn stimulate beekeeping for its value in crop pollination.

Research Approaches: Many of these approaches will be the same as those presented under RPA 314 A-G and will require scientists of several disciplines. 1. Develop improved disease and pest control methods. 2. Develop genetic strains and varieties with increased resistance to diseases and pesticides. 3. Develop strains with higher honey production capacity but with gentleness, non-swarming tendencies, and other desirable characteristics. 4. Determine behavioral and ecological factors that influence the honey bee and methods of utilizing this knowledge for increased production of honey and other bee products. 5. Develop better and more efficient methods of handling colonies, honey, and equipment. 6. Develop better methods of protecting colonies from pesticides, such as sound, shade, confinement, and repellents. 7. Investigate the potential production of other bee colonies for products such as pollen, venom, royal jelly and propolis, and the utilization of such materials in other trades as a new source of revenue for beekeepers. 8. Develop a diet that will stimulate colonies to greatest productiveness. 9. Conduct research on the nutritive value and utilization of honey for human and non-human purposes.

Character of Potential Benefit: Increase production of honey through better bee management, control of diseases and pests, protection from pesticides, and more efficient manipulation of honey, hives and equipment. Develop new source of income from the production of bee products other than honey.

Recommended Research Effort:

**TF Recommendation SMY**

**Present (1966)** 1977

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INSECTS AFFECTING MAN AND HIS BELONGINGS IN HIS HOME AND OUTDOOR ENVIRONMENT

Introduction

Even though with the use of DDT and other organochlorine insecticides great strides have been made in controlling insect pests of man in the last twenty-five years, man is still beset by a host of insect problems. Many of these insect problems are the direct consequence of man's actions, such as those related to urbanization, population growth, changes in agricultural practices and to the ever-increasing use and expansion of recreational areas. Mosquitoes, house flies, ticks, and fleas exact a toll in human health, decreased efficiency and in time lost from work. Screens in homes and business establishments, interference with the cultivation or harvesting of crops, and the loss of business at resorts and recreational areas all cost the citizenry money.

Solving these problems through increased research effort will result in many benefits to man, such as better health and greater comfort both indoors and outdoors, the reduction in losses to possessions, and in the reduced cost of control against a host of insect pests and disease vectors. At present there are no adequate control procedures or means to protect man from certain species of biting flies, wasps, and yellow jackets. The risk of insecticide resistance is an increasing problem; not only are more species of insects becoming resistant to insecticides, but some species have developed cross resistance to several insecticides. It is becoming increasingly more difficult to keep even one step ahead of some of our insect pests.

It is very difficult to place dollar values where the well being of man is concerned. How does one evaluate, for example, keeping a farmer free of mosquitoes while he is working in his field, or a summer vacationer free from mosquitoes, black flies, ticks, chiggers, and yellow jackets, or a resort area free of an invasion by hordes of crickets? In many instances man will not tolerate the intrusion by pestiferous insects and it is absolutely necessary to develop techniques for economical control through a concentrated research effort. These techniques must be non-hazardous to man and his animals and must minimize contamination of the environment.

Historically, the Federal effort c.f. RPA 706 has been primarily oriented to serving the needs of the Armed Forces. A little background information is pertinent.

The critical impact of insect-borne diseases on the success or failure of military campaigns is well documented throughout history and is also
of the honey crop. There is no USDA or SAES research on honey itself, on its promotion or utilization in the United States. It is imperative for agriculture that honey become a stronger competitor with other food commodities. Currently the honey and wax obtained from approximately 5 million colonies of honey bees in the United States owned by about 200,000 beekeepers amounts to less than $40 million. Only about 1,200 beekeepers are full-time commercial operators with 400 or more colonies. However, they produce about one-third of the honey crop and provide most of the colonies used in commercial pollination. About 12,000 part-time beekeepers own 25 to 400 colonies and produce another third of the honey. The remaining 187,000 are hobbyists with fewer than 25 colonies who produce the rest of the honey.

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Present (1966) 1977

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At the beginning of World War II the Army requested the USDA to establish a laboratory at Orlando, Florida for research in military entomology. This laboratory was supported first by the Office of Scientific Research and Development, and later by the Army.

The funding of this program was transferred in Fiscal Year 1956 by direction of the Bureau of the Budget from the Department of the Army to the Department of Agriculture appropriation. The Administrator of The Agricultural Research Service (ARS) stated at the time of change in funding procedure that it was the intention of the USDA to meet military needs essentially as had been done in the past. At that time, ARS also requested that the Army Committee for Insect and Rodent Control (later included in the organization of the Armed Forces Pest Control Board) continue to review and evaluate the requirements of the Department of Defense for research by the USDA on the control of insects of military importance. In July 1961, a Memorandum of Understanding between the Department of Defense and the U.S. Department of Agriculture for Research on the Control of Arthropods of Military Importance was negotiated and is still in effect.

For over twenty years, research personnel at USDA laboratories have made outstanding contributions towards the control of insects attacking man, such as the development of the aerosol bomb, the use of DDT for vector control, the treatment of clothing with repellents, and many other special procedures of particular value to the Armed Forces but also for overall national welfare.

While many of the insect problems encountered by the military are similar to those of the civilian economy, there are many problems peculiar to the Armed Forces, and their solution requires the development of measures with special characteristics to meet military requirements in various parts of the world where our military personnel are stationed. Only specialized personnel of the military departments, who are in daily contact with such requirements, are in a position to appreciate the inadequacies of current control methods and the scope of future needs and hence to assess priorities for research and development.

Current research efforts by State and Federal agencies (1966 Inventory) in RPA 706 is 64 SYM's. Of these 45% are SAES and 51% are Federal. They are widely dispersed. SAES effort exists in twenty-seven States. One State has 9.8 SYM, four have over 2.0 SYM, and four have 1 to 2 SYM. The majority of States have less than 0.6 SYM. ARS effort is located in 14 States, one State with 20.3 SYM, another with 3 SYM, and 2 with 1 to 1.2 SYM.

The Proposal

The Task Force believes that the major emphasis of the research problem under Goal VII, Section 6, pg. 154 of "A National Program of Research for Agriculture," prepared jointly by the Association of State Universities and Land Grant Colleges and the USDA in October 1966 should be revised insofar as the definition of the problem areas is concerned. Many of the research needs are the same with variations depending on the peculiarities of particular problems. The five problem areas listed below are not mutually exclusive, but the research approach will be different for it should be tailor-made to the particular situation.

The Task Force decided to sub-divide RPA 706 into five distinct categories of research as follows:

706-A Insect Pests of Man in and Around his Buildings
706-B Insect Pest Problems in Recreational Areas
706-C Problems Associated with Farm and Other Outdoor Labor
706-D Problems Associated with Urbanization
706-E Problems Resulting from Modification of the Environment by Man

The breakdown by SYM's in five categories of research in RPA 706 is summarized in Table 3. The research needs for both SAES and USDA and the projected totals are based on the best information available to the Task Force. The five categories are discussed in detail in the last part of the report.
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<tr>
<th>Sub-Division</th>
<th>Title</th>
<th>1966 Base</th>
<th>Increase by 1977</th>
<th>1977 Total</th>
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<td>706-B</td>
<td>Insect Pest Problems in Recreational Areas</td>
<td>3:1:4</td>
<td>12:7:9</td>
<td>15:8:23</td>
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<tr>
<td>706-C</td>
<td>Problems Associated with Farm and Other Outdoor Labor</td>
<td>8:9:17</td>
<td>3:3:6</td>
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<tr>
<td>706-D</td>
<td>Problems Associated with Urbanization</td>
<td>5:4:9</td>
<td>3:3:6</td>
<td>8:7:15</td>
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<tr>
<td>706-E</td>
<td>Problems Resulting from Modification of the Environment by Man</td>
<td>2:1:3</td>
<td>5:2:7</td>
<td>7:3:10</td>
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<td>TOTAL</td>
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<td>31:33:64</td>
<td>27:17:44</td>
<td>58:50:108</td>
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</table>

* Includes 5.5 SMY for termite work.
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It should be noted that under RPA 706-A, the termite work has been included in the 1966 base. As of 1968, however, this important work has not been reflected as any increase in SMY for termite control.
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Since many of the research problem areas are subdivided arbitrarily there is bound to be some overlap. Therefore, the Task Force recognized that there existed a need for related research in the following areas, but did not feel that it should assign a definite number of SMY's to them.

RPA 210 Control of Insect Pests of Livestock and Poultry.—The main relationship between RPA 210 and RPA 706 is in the encroachment of agricultural lands by urbanization with the resulting proximity of cattle and poultry operations to large concentrations of human populations. Large fly populations are at times a great problem and more effective control means must be devised.

RPA 404 Quality Maintenance in Marketing Fruits and Vegetables.—Additional related research is required for effective and non-toxic methods to protect fruits and vegetables from insect damage in storage after produce has left the farm.

RPA 408 Quality Maintenance in Marketing Field Crops.—The main area of interest here is to prevent the deterioration of packaged goods; wheat, rice, flour, beans, etc., by insect pests during shipment and storage. This is of tremendous importance to the Armed Forces as well as the civilian market. It makes little sense to grow bountiful insect-free crops, only to have serious loss before the foodstuffs reach the ultimate consumer. More effort is needed in packaging and fumigating procedures.

RPA 412 Quality Maintenance in Marketing Animal Products.—Insect pests, including mites, continue to cause serious damage to stored meats, especially hams. This problem is of interest to both the Armed Forces and the meat packing industry. Additional related research on this problem is urgent.

Stored-products insects cause a great deal of damage to woolen goods. Research should be expanded to develop safer, more effective mothproofing treatments that can be applied in the home and during the manufacture of woolens. Once again, this is also of concern to the Armed Forces.

Title: Insect Pests of Man in and Around His Buildings. RPA 706-A

Situation: At least 10,000 species of pests eat or attack almost everything that man uses or owns—including man himself. Flies, mosquitoes, fleas, lice, mites, and roaches may affect the health of man directly or indirectly with disease. Other insects may sting and suck blood from us. Still other pests may cause no particular damage but become a nuisance by
their mere presence in homes and buildings--house spiders, clover mites, drain flies, cutworm moths (millers), centipedes and ants. Many spend their entire lives inside homes or other buildings--bed bugs, some wasps, ants, brown dog ticks, roaches and silverfish. A number of insects, not usually household pests, under favorable conditions may occasionally invade yards and buildings in fantastic numbers--midges, crickets and flies. These pests cost the U.S. public over $218 million for pest control services in 1963, exclusive of termite and rodent control. When the $110 million spent in 1963 by private citizens for household insecticides and repellent formulations is added, this represents a total cost in excess of $329 million. (This figure does not include the cost of insect proofing such as screening). This cost is increasing at the rate of over 10% a year and would represent an estimated cost of over $530 million for 1968. These figures of course do not reflect the losses both direct (damage to property and supplies) and indirect (lost productivity due to disease, allergies, etc.) caused by the pests. As our population increases and the number of homes become ever greater the household insect problems become more prevalent and more acute. Heavy concentrations of populations create conditions favorable for easy development and spread of many of these insects because of an abundance of food for the pests and numerous suitable places to live and multiply. This trend is certainly reflected in the figure mentioned above. According to a 1965 survey by the National Pest Control Association the German cockroach is the single most important pest species encountered. The problem of insecticide resistance in this and many of our other important pest species is becoming more and more important.

Objective: To develop cheaper, more effective control methods, both insecticidal and non-insecticidal that are not hazardous to man and his animals for the control of insects in buildings and surroundings.

Research Approaches: 1. Evaluate potential insecticides, repellents, attractants, and other agents such as pheromones and hormones. 2. Study biology and ecology to improve existing control measures. 3. Determine insecticide resistance in important pest species and find alternate materials for control. 4. Develop biological control techniques including sexual sterilization, parasites, and pathogens. 5. Conduct research on physical or mechanical control with light, temperature, sound, electrical or other attractive or repelling devices, both with and without trap units.

Character of Potential Benefits: Provide more effective, less costly insect control to the public, increase the productivity and well being of man by cutting down on time lost due to illness and allergies caused by insects and related arthropods, and provide information on source reduction or elimination which would decrease the amount of insecticides currently needed for control.

Recommended Research Effort:

<table>
<thead>
<tr>
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Situation: At the present time, only limited research attention is being specifically directed to the protection of people from insect pests in recreational areas and facilities. Much of the information being used for control purposes has been borrowed from that developed for military and public health purposes.

Pests vary greatly from area to area and State to State. Many insects and related arthropod pests are involved: Mosquitoes, house flies, gnats, biting flies, wasps and hornets, ants, ticks, scorpions and chigger mites. Enjoyment of recreational facilities in our public and private parks and forests will depend, in many instances, upon freedom from annoying pests. Even a moderate incidence of mosquitoes or biting flies will cause any site to be untenable as a recreation area. The presence of chiggers and ticks in a field or wooded area will discourage its use for either recreation or sports. Endemic populations of the tent caterpillar in the Northern woods of Minnesota have rendered resort areas useless because of their crawling into or voiding their droppings onto food. Wasps and yellow jackets attracted to the odors of meat, jellies, pickles and other picnic delicacies often have caused many an outdoor family get-together to be disbanded prematurely. The control of these insects will often require new approaches since extensive effort must be made not to contaminate the natural environment with pesticides.

A major drawback to full development of recreational areas in the Ozarks is an abundance of chiggers and ticks. Ticks have been reported to cause considerable consternation among tourists in the upper peninsula of Michigan. A well known example of the relationship of insect pests and development of rural areas for recreation was the mosquito problem in New Jersey. Coast line tourist resorts and facilities in the State could never have been successful without control of the salt marsh mosquito.

Pressures on public and private outdoor recreation facilities are already exceeding previous expectations by wide margins. As shown in Table 4, the demand for facilities by the year 2000 will undoubtedly exceed our most imaginative predictions.

We are entering an era where "leisure" time will approximate "work" time. This is a new experience for many, particularly in the middle and older age
their mere presence in homes and buildings—house spiders, clover mites, drain flies, cutworm moths (millers), centipedes and ants. Many spend their entire lives inside homes or other buildings—bed bugs, some wasps, ants, brown dog ticks, roaches and silverfish. A number of insects, not usually household pests, under favorable conditions may occasionally invade yards and buildings in fantastic numbers—midges, crickets and flies. These pests cost the U.S. public over $218 million for pest control services in 1963, exclusive of termite and rodent control. When the $110 million spent in 1963 by private citizens for household insecticides and repellent formulations is added, this represents a total cost in excess of $329 million. (This figure does not include the cost of insect proofing such as screening). This cost is increasing at the rate of over 10% a year and would represent an estimated cost of over $530 million for 1968. These figures of course do not reflect the losses both direct (damage to property and supplies) and indirect (lost productivity due to disease, allergies, etc.) caused by the pests. As our population increases and the number of homes become ever greater the household insect problems become more prevalent and more acute. Heavy concentrations of populations create conditions favorable for easy development and spread of many of these insects because of an abundance of food for the pests and numerous suitable places to live and multiply. This trend is certainly reflected in the figure mentioned above. According to a 1965 survey by the National Pest Control Association the German cockroach is the single most important pest species encountered. The problem of insecticide resistance in this and many of our other important pest species is becoming more and more important.

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</table>

Title: Insect Pest Problems in Recreational Areas. RPA 706-B

Situation: At the present time, only limited research attention is being specifically directed to the protection of people from insect pests in recreational areas and facilities. Much of the information being used for control purposes has been borrowed from that developed for military and public health purposes.

Pests vary greatly from area to area and State to State. Many insects and related arthropod pests are involved: Mosquitoes, house flies, gnats, biting flies, wasps and hornets, ants, ticks, scorpions and chigger mites. Enjoyment of recreational facilities in our public and private parks and forests will depend, in many instances, upon freedom from annoying pests. Even a moderate incidence of mosquitoes or biting flies will cause any site to be untenable as a recreation area. The presence of chiggers and ticks in a field or wooded area will discourage its use for either recreation or sports. Endemic populations of the tent caterpillar in the Northern woods of Minnesota have rendered resort areas useless because of their crawling into or voiding their droppings onto food. Wasps and yellow jackets attracted to the odors of meat, jellies, pickles and other picnic delicacies often have caused many an outdoor family get-together to be disbanded prematurely. The control of these insects will often require new approaches since extensive effort must be made not to contaminate the natural environment with pesticides.

A major drawback to full development of recreational areas in the Ozarks is an abundance of chiggers and ticks. Ticks have been reported to cause considerable consternation among tourists in the upper peninsula of Michigan. A well known example of the relationship of insect pests and development of rural areas for recreation was the mosquito problem in New Jersey. Coast line tourist resorts and facilities in the State could never have been successful without control of the salt marsh mosquito.

Pressures on public and private outdoor recreation facilities are already exceeding previous expectations by wide margins. As shown in Table 4, the demand for facilities by the year 2000 will undoubtedly exceed our most imaginative predictions.

We are entering an era where "leisure" time will approximate "work" time. This is a new experience for many, particularly in the middle and older age
groups. People will want to use this "free" time in an enjoyable and productive way. Much of this time will be used in places we define as recreation areas.

Federal, State, and local governments have expanded and will continue to expand public facilities. The commercial potential resulting from man's changing recreational habits is tremendous.

Cypress Gardens in Florida and Calloway Gardens in Georgia were early recreation investments. Story Book Land in New York State and Frontier Land in North Carolina are but two more examples of a new type recreation attraction springing up over the country to interest tourists and others with free time on their hands and money to spend.

Many of these recreation sites will be in areas used for multiple purposes. Insect and pest problems arising in these areas may require other than conventional methods of control. Many areas of multiple use may require specific research to appraise problems and develop controls that will not diminish any of the intended uses.

Table 4. Examples of Anticipated Participation in Recreation Activities by Individuals in 1980 and 2000.

<table>
<thead>
<tr>
<th>Recreation Activity</th>
<th>Percent Increase over 1965</th>
</tr>
</thead>
<tbody>
<tr>
<td>Walking</td>
<td>49</td>
</tr>
<tr>
<td>Playing Outdoor Games</td>
<td>72</td>
</tr>
<tr>
<td>Picnicking</td>
<td>48</td>
</tr>
<tr>
<td>Attending Outdoor Concerts</td>
<td>70</td>
</tr>
<tr>
<td>Camping</td>
<td>78</td>
</tr>
<tr>
<td>Sightseeing</td>
<td>54</td>
</tr>
<tr>
<td>Nature Walks</td>
<td>46</td>
</tr>
</tbody>
</table>

It is estimated that 340 million participations in the above recreation activities will be made in 1980. Imagine what it will be by the Year 2000.

Objective: To develop management systems in recreation areas that will minimize the pest effects of insects and related arthropods and eliminate annoyance and health hazards due to insects.

Research Approaches: 1. Determine acceptable levels of pest insect populations. 2. Determine ecological conditions and factors that are conducive to the production of pest population levels considered pestiferous.

3. Evaluate insecticides that can be utilized with management systems but leave no harmful chemical residues to humans and wildlife and minimize changes in ecological balances. 4. Explore effectiveness of area controls other than conventional chemicals. 5. Study engineering aspects of minimizing pest populations. 6. Study effect of prevailing wind conditions, humidity and temperature of arthropods as factors to consider in selecting recreation sites. 7. Evaluate repellents for use against specific pests in areas where control may be impossible or uneconomical. 8. Conduct research on the control of pest invaders of buildings, cabins, lean-to, etc., constructed in recreation areas.

Character of Potential Benefits: The effectiveness of pest control in any recreation area will be directly related to the success or failure of that area.

Recommended Research Effort:

Title: Pest Problems Associated with Farm and Other Outdoor Labor.

RPA 706-C

Situation: Farm laborers and other workers in outdoor environments are sometimes exposed to such severe insect attack that they may be driven from the field or their efficiency is seriously curtailed. In some areas, unexpected abundance of insect pests may cause labor shortages at critical periods (e.g., harvest time for a perishable commodity). The pests involved vary greatly from area to area. The nature of work on the farm, in the forest, and other outdoor places makes labor vulnerable to the attack of a variety of pests. Wasps and yellow jackets frequently nest in orchards and vineyards. When fruit pickers attempt to harvest the fruit, they may be driven from the field by savage wasp attack. Farm workers, school children, and others out-of-doors are continually annoyed by the attack of eye gnats in southern California, southeast Alabama, southwest Georgia, the ridge section of Florida, and farm and truck growing areas of Mississippi, Louisiana and Texas. Farm laborers frequently refuse to work in the field in the Sacramento valley of California when populations of the valley black gnat are high. The black widow spider and related spiders are recognized hazards in the fruit drying industry where open air drying of fruit is accomplished on stacked picking flats. Spiders are commonly located under stacks and precautions must be taken to avoid bites when handling them. In irrigated pastures, mosquitoes and tabanid flies attack man severely and interfere with normal farm operations. In the forest, attacks of mosquitoes,
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3. Evaluate insecticides that can be utilized with management systems but leave no harmful chemical residues to humans and wildlife and minimize changes in ecological balances. 4. Explore effectiveness of area controls other than conventional chemicals. 5. Study engineering aspects of minimizing pest populations. 6. Study effect of prevailing wind conditions, humidity and temperature on arthropods as factors to consider in selecting recreation sites. 7. Evaluate repellents for use against specific pests in areas where control may be impossible or uneconomical. 8. Conduct research on the control of pest invaders of buildings, cabins, lean-to, etc., constructed in recreation areas.

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Recommended Research Effort:

Title: Pest Problems Associated with Farm and Other Outdoor Labor.

Situation: Farm laborers and other workers in outdoor environments are sometimes exposed to such severe insect attack that they may be driven from the field or their efficiency is seriously curtailed. In some areas, unexpected abundance of insect pests may cause labor shortages at critical periods (e.g., harvest time for a perishable commodity). The pests involved vary greatly from area to area. The nature of work on the farm, in the forest, and other outdoor places makes labor vulnerable to the attack of a variety of pests. Wasps and yellow jackets frequently nest in orchards and vineyards. When fruit pickers attempt to harvest the fruit, they may be driven from the field by savage wasp attack. Farm workers, school children, and others out-of-doors are continually annoyed by the attack of eye gnats in southern California, southeast Alabama, southwest Georgia, the ridge section of Florida, and farm and truck growing areas of Mississippi, Louisiana and Texas. Farm laborers frequently refuse to work in the field in the Sacramento valley of California when populations of the valley black gnat are high. The black widow spider and related spiders are recognized hazards in the fruit drying industry where open air drying of fruit is accomplished on stacked picking flats. Spiders are commonly located under stacks and precautions must be taken to avoid bites when handling them. In irrigated pastures, mosquitoes and tabanid flies attack man severely and interfere with normal farm operations. In the forest, attacks of mosquitoes,
black flies, and rhabdionid flies may be so severe that loggers and others in the area must retreat indoors. On poultry farms, workers sometimes complain of the bites and the crawling infestation of the northern fowl mite. Control is difficult in the large open spaces where most of these attacks occur. New, imaginative approaches will have to be developed to find solutions.

Objective: To determine the specific breeding sites of the pests in these outdoor situations and to develop management practices which reduce or eliminate their potential as a harassment to laborers working out-of-doors.

Research Approaches: 1. Study the sources of the pest populations and eliminate or modify these sources so they do not produce serious pest populations during the critical times of the year. 2. Evaluate pesticides as a potential means of eliminating the pest populations, at least temporarily. In such studies, appropriate consideration should be given to the potential hazard of such chemicals to laborers in the field, and of possible undesirable contamination of the environment. 3. Seek acceptable repellent compounds that will give the workers protection from the attack of the pest insects. 4. Develop background information on the population dynamics of the insects to assist in the management of the pest populations.

Character of Potential Benefits: Lessen insect attack and annoyance to farm laborers and other outdoor workers thus increasing labor efficiency.

Recommended Research Effort:

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<thead>
<tr>
<th>TF Recommendations</th>
<th>SHY</th>
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</thead>
<tbody>
<tr>
<td>Present (1966)</td>
<td>1977</td>
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<tr>
<td>17</td>
<td>23</td>
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</table>

Title: Problems Associated with Urbanization. RPA 706-D

Situation: Urban populations surrounding metropolitan areas are growing at an accelerated rate. New cities are being developed in areas which only "yesterday" were wilderness. The intrusion by large numbers of people into the urban-rural fringe often leads to insect problems of considerable magnitude. The problems are varied: Ticks, mites, mosquitoes, midges, flies and crickets—too mention but a few—often seem to occupy the same space that man has selected for his own. As man becomes more affluent he demands to live in a more insect-free environment than did his predecessors. Some insect problems are more serious than just nuisances. Disease problems, such as encephalitis and plague, associated with mosquitoes, fleas and other biting insects, ticks and chiggers, often pose grave health hazards to large segments of the civilian and military populations.

Suburbanites in many areas of the United States are plagued annually in and about their homes by a complex of mosquitoes belonging to the genus Aedes and some species of Psorophora which breed in woodland pools and many temporary accumulations of water in fields, along roadsides, railroads and around new home and industrial development areas. Present methods of management of these mosquito populations are often inadequate and rely on local application of adulticides. Chemicals are applied primarily via ground equipment though aerial applications are often utilized. Larviciding is of questionable value in some locations and water management practices are minimal because of the numerous and widely dispersed "pockets" of water harboring juvenile mosquitoes.

Throughout much of California and in the Southern States fly control on poultry ranches is a serious problem. The accelerated growth of the poultry industry coupled with the rapid increase of the human population has created fly problems in the urban-rural fringe of major metropolitan areas. The three most common pests are the house fly, the little house fly, and the false stable fly. Presently, an integrated approach to the management of these flies is being partially utilized. Prudent use of residual insecticides along with the release of predators and parasites, and the removal of manure deposits are helping suppress fly populations. The problem, however, is not wholly solved.

As the human population extends the suburbs, insects capable of transmitting vertebrate disease agents also pose problems. One example is the complex of flies capable of transmitting Pasteurella pestis, the causative agent of sylvatic plague, a feral form of subonic plague, in the western part of the United States. Presently used measures suppress the disease rapidly but do not destroy the disease organism or all of the flea vectors. Death of the fleas' rodent hosts can increase the spread of plague, since the fleas leave a dead host to seek new ones, including man. Preliminary research has shown that systemic insecticides can kill the fleas on a rodent before the rodent dies, either from the disease or from rodenticides.

Methods have not been developed for dealing effectively with many of the insect pest and disease problems associated with the human population shift to the suburbs. Solutions to some insect problems are complex and often sufficient information is lacking. As some problems are solved new ones arise. Current techniques for control usually rely upon the application of insecticides.

Objective: To reduce pest insects to non-annoyance levels without danger to beneficial insects, fish, and wildlife, and to improve control measures for arthropod-borne disease vectors especially in suburbia.

Research Approaches: 1. Study the ecology of the major pest and disease transmitting insects and utilize this information for the development of control methods. 2. Collect, identify and culture pathogens and predators of the major pest and disease transmitting insects. Determine the relationships that exist between each parasite or predator and its host. Develop
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methods of mass production and dissemination for organisms that offer promise as control agents. 3. Conduct tests to determine if major pest and disease transmitting insects can be sterilized. Determine what techniques of sterilization can be used for area-wide control. 4. Evaluate new insecticides in the laboratory and in the field for the development of safer and more effective compounds. Develop new and more efficient methods of insecticidal application. 5. Evaluate new repellents in the laboratory and in the field for ticks, chiggers, and biting insects. 6. Evaluate cultural methods of insect control such as the design of new types of poultry houses and the development of new methods of stockpiling or removal of manure to reduce fly oviposition and breeding areas.

It is suggested that the above proposed research be coordinated with that of RPA's 313, 210 and 901, when applicable.

Character of Potential Benefits: Improve outdoor living in suburbia. Nuisance insects will be reduced in number and the health hazard posed by arthropod borne diseases will be lessened.

Recommended Research Effort:

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<th>SMY</th>
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<tbody>
<tr>
<td>Title:</td>
<td>Proportion of the Environment by Man. RPA 706-E</td>
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<td></td>
</tr>
<tr>
<td>Situation:</td>
<td>The face of the earth is being transformed by man's activities. The rate of transformation is accelerating so that drastic changes are occurring in many areas in very short periods of time. More extensive and more rapid modification of the environment may be expected in the future in response to the needs of burgeoning human populations. Permanently flooded swamps and estuarine areas will be drained for agricultural and industrial uses. Conversely, streams and rivers will be dammed to form large lakes for sources of hydroelectric power and to satisfy the needs for recreational areas. Deserts will be irrigated, forests cleared, grasslands planted to row crops and vice versa.</td>
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<tr>
<td>Species impoverishment usually follows modification of the environment. Simplification of the ecosystem is often accompanied by drastic fluctuations in populations of the remaining species. Any change in an ecosystem may result in the displacement of one species by another. Such a phenomenon may be beneficial or harmful to man depending upon the species involved. If, for example, the vector of a disease organism is displaced by a non-vector, man benefits; if the reverse occurs, he is harmed.</td>
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<tr>
<td>Species:</td>
<td>Problems Resulting from Modification of the Environment by Man. RPA 706-E</td>
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<td>Drainage of permanently flooded estuarine areas may eliminate problems with 3 species of salt marsh mosquitoes but the drainage operation may create serious problems with three other species all of which are vicious biters. Where large areas subject to periodical flooding are permanently flooded, the reverse may occur. Irrigation of pastures and other crops often creates conditions favorable for development of large populations of Culex tarsalis, an important vector of encephalitis. The growing practice of disposing of livestock wastes by means of waste disposal lagoons makes available quantities of polluted water suitable for production of large populations of another mosquito vector of encephalitis.</td>
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<td>Clear cutting large areas of forests and either re-seeding or allowing natural regeneration to occur is a growing practice in forestry. This type of forest management creates a favorable environment for ticks and chiggers. In addition the use of such areas as national and state parks for recreational purposes brings people into increasing contact with these pests. In some areas of the southern and southwestern United States maintaining deer herds in park areas has contributed to the development of conditions favorable for large populations of ticks that human use of these recreational areas has been greatly reduced. This presents the interesting situation in which the presence of wildlife that makes a recreational area so attractive to many people also contributes to the development of pest populations which detract from its value.</td>
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<td>Problems with nuisance pests are becoming increasingly common as a result of environmental modification. The eutrophication of lakes and ponds produces aquatic environments favorable for the development of midges whose numbers may become so great that they are extremely annoying. Several kinds of eye gnats are becoming increasingly important pests, especially in suburban areas. The march fly, Plocia marctica, which breeds in areas retired from row crop agriculture in the Gulf States often becomes so numerous along highways that windshields of automobiles become smeared, visibility is reduced and driving is hazardous. This same practice of crop-land retirement in northern areas creates ideal conditions for production of several annoying species of Aedes mosquitoes, making outdoor activities unbearable.</td>
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<td>Research on such problems is relatively difficult and there are comparatively few entomologists who possess the necessary training, interests, and special abilities for working effectively in this area. Results are not so easily translated into terms of dollars and cents as with more conventional entomological problems. Consequently, too little attention has been devoted to problems that arise from modification of the environment. Techniques for control have been based largely upon the use of conventional insecticides with consequent problems of adverse effects on non-target organisms, residues, resistance to insecticides, and resurgence of treated populations.</td>
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Objective: Develop methods for dealing effectively with many insect problems that are brought about as a result of modifying the environment. Determine what questions should be considered by policy making groups before projects are undertaken that will result in extensive environmental modifications.

Research Approaches: 1. Biological and ecological studies to accumulate data suitable for allowing accurate predictions of population trends of pest species following various types of environmental modification. 2. Evaluation of the potential long-range benefits and disadvantages of environmental modification from the standpoint of effects on pest populations. 3. Development of chemical control techniques that do not affect adversely non-target organisms or leave persistent, toxic residues in the environment. 4. Development of techniques of pest management which do not require use of conventional insecticides.

Character of Potential Benefit: Provide data required by planning groups to make intelligent decisions on projects that will involve modification of the environment.

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