A SYMPOSIUM ON

Pest Control and Wildlife Relationships

Committee on
Pest Control
and
Wildlife Relationships

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Pest Control and Wildlife Relationships

A Symposium by

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of the Committee on
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FOREWORD

As a contribution to the program of the Annual Meeting of the National Research Council on March 10, 1961, the Committee on Pest Control and Wildlife Relationships was invited to present a symposium on the present status of the pest control and wildlife situation.

The information here presented represents the views of the individual members of the symposium who are recognized as outstanding authorities in their respective fields. At the close of the symposium the National Research Council unanimously recommended that the papers presented be published by the Academy—Research Council.

CONTENTS

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PEST CONTROL AND WILDLIFE RELATIONSHIPS

INTRODUCTION

W. H. Larrimer
National Academy of Sciences—National Research Council

Since as far back as biblical times man has been plagued by pests of one kind or another—insects, diseases, weeds and other plants and animals that take their toll of the products of farm, forest and range and threaten the health and welfare of man himself. Over the years man has fought back, winning here and losing there.

During World War II a tremendous advantage was gained in the development and use of the insecticide, DDT, for the control of pests and disease vectors of concern to the armed forces and civilians alike. By the widespread use of this one insecticide literally millions of lives have been spared and hundreds of millions of people have escaped diseases without one known case of serious toxic effects. [1]

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[1] Knipling, E. F. in Nature and Fate of Chemicals Applied to Soils, Plants, and Animals, Agricultural Research Services, U. S. Department of Agriculture, Sept. 1960, p. 28: "... Yet this insecticide has been applied as a 10% dust inside the clothes of hundreds of millions of men, women, and children by military and public health officials, and has been applied as residual sprays in as many homes without one known case of serious toxic effects to individuals exposed to such intimate insect control practices. As a result literally millions of lives have been spared and hundreds of millions of people have escaped diseases."

The impetus created by this remarkable success carried over into the post-war development of a vast array of the newer pesticides—the chlorinated hydrocarbons and the organic phosphates. Unfortunately, some of these newer pesticides were put into use before they had anything like the careful testing given to DDT and that now is considered essential. It is little wonder that some mistakes have been made in the development and use of these new pesticides and that wide differences of opinion exist as to their effectiveness and safety. Here we have inevitably a conflict of interest.

Because of the highly controversial nature of this situation the National Academy of Sciences—National Research Council was urged to establish a committee on Pest Control and Wildlife Relationships. Such a committee was appointed in May 1960. At its first meeting, June 14, 1960, the following statement of objectives was developed:

1. To provide technical advice and guidance to government agencies, industries, and other public and private organizations and individuals on problems involved in the maximum control of pests with a minimum of damage to other forms of plant and animal life.

2. To provide critical evaluation of information concerning the effects (direct and indirect) of various pest control operations on plants and animals, particularly fish and wildlife.

3. To stimulate and encourage research and investigations to obtain factual information as a basis for sound guiding principles and policy determinations.

4. To foster cooperation among various agencies, organizations, industries, and individuals concerned with pest control operations and the effects on plant and animal life.

5. To provide a forum for the discussion of problems of pest control and wildlife relationships.

The main committee and three subcommittees are now in the midst of the evaluation of available information and the preparation of reports on the various phases of the problem. These studies have not yet reached the stage in which sound conclusions and recommendations can be made available. However, this symposium has been organized as one of the ways to provide a forum for the discussion of the problems of pest control and wildlife relationships.

PEST CONTROL IN AGRICULTURE

George C. Decker
Illinois Natural History Survey

Nature recognizes no such categories as pests or wildlife and these man-conceived terms have vastly different meanings to many people. It makes little difference whether we regard wildlife as embracing all non-domesticated plant and animal life or accept a more limited definition. In either case, pests are living organisms distinguished from many other forms of wildlife only by the fact they have acquired the great displeasure of one of their chief competitors, man.

In nature, from time immemorial every living organism has been engaged in relentless competition with every other organism upon which its interests impinge. Man is a part of that environment. By virtue of a unique attribute called intellect which enabled him to develop powerful tools capable of changing physical and ecological environments to suit his needs and whims, he has risen to a position of dominance. In his ascent man selected, protected, propagated, and husbanded certain plants and animals most desired by him. Other species detrimental to man or to the organisms he has chosen to husband he regards as pests to be suppressed or, if possible, exterminated.

Man's success is evidenced by the fact the human population of this country has risen from less than one million to over 170 million in some fifteen to twenty generations. To clothe and feed this vastly increased population, a high level of agricultural production must be maintained. While America is presently blessed, or, as some say, plagued, by overproduction, with populations increasing and the area of farm land decreasing, it is only a matter of a few years until agricultural scientists and farmers will have to make ever-increasing use of agricultural technology, including even greater efficiency in pest control, to meet the nation's food and fiber requirements.

Cultivated crops grown in North America are attacked by over 3,000 economically important species of insects, as many plant disease agents, and unestimated numbers of nematodes, rodents, weeds, and other competitors. In 1954, the United States Department of Agriculture estimated that to offset the pest losses in agricultural production, an extra 88 million acres must be cultivated, and that losses subsequent to harvest equal the production of an additional 32 million acres. Estimates of the destruction caused by agricultural pests made independently by several other agencies range somewhere between 8 and 15 billion dollars annually—a quarter of our annual production—and this despite the widespread use of the best control practices now available.

One must recall also Section 402 of the Food, Drug and Cosmetic Act clearly indicates that food contaminants may be either biological or chemical in nature. Thus, each year the Food and Drug Administration seizes as unfit for human consumption literally thousands of tons of food. Roughly three-fourths of all these seizures are attributable to filth or decomposition, which of course includes the presence of insects, insect fragments, molds, fungi, bacteria, and other undesirable organisms.

In the light of these facts the Food Protection Committee has repeatedly said:

> "Plant and animal pests rank among the foremost causes of food destruction, food deterioration, and food contamination. Hence, the absolute necessity of protecting growing crops and products from serious attack by insects, plant diseases, and other pests is recognized as essential from the standpoint of both quantity and quality of the food produced."

There seems to be general agreement that pest control is essential. The area of disagreement seems to involve the procedures to be followed. Since nature does such an excellent job of establishing and maintaining balances between species and establishing limitations on species, it would seem logical that man, to be most successful in influencing plant or animal populations, should thoroughly study and then attempt to emulate nature.

Our highly successful agriculture of today reflects and is a tribute to man's success in modifying the forces of nature to provide a suitable environment for the production of his crops and livestock. Likewise biologists are attaining considerable success by making rather minor changes in an established environment to provide additional food and cover favoring the reproduction and survival of selected species such as pheasant, quail, and game fish. Conversely entomologists and plant pathologists have through manipulation of the environment, attained considerable success in controlling a number of agricultural pests.

Pursuing this concept, pest control should be largely biological and ecological in nature. But some home philosopher has said, "You can't have your cake and eat it too." By modifying the environment in his own favor, man provided an abundant food supply and other environmental conditions highly favorable to many species of insects and other pests; thus he inadvertently created many of his most important pest problems. To reverse the procedure might well nullify some essential production gains. Actually, in years gone by, biologists generally did devote most of their research time to biological and ecological studies, and for many years ecological, cultural, and mechanical control measures dominated all pest control activities. It was only after such methods alone proved to be inadequate and the needs for better pest control became imperative that the farmers themselves turned to the use of chemicals which showed promise. Scientists more or less reluctantly followed their lead, and thus we entered an age of chemical pest control.

The rise in pesticide usage has been closely associated with and has run parallel to the advances in farm mechanization. Thus, in these days of automation and labor-saving devices, pesticides are regarded as chemical tools which are just as indispensable as mechanical tools in the production of agricultural crops. It would be economically impossible for farmers to abandon the use of pesticides. Capital investments in farms today are such that occasional complete or even partial crop failures cannot be tolerated.

If the use of chemical pesticides were to be prohibited or abandoned, it is safe to say most fruits and vegetables would totally disappear from the market or the price of the meager quantities produced would be prohibitive. We know from valid studies conducted over the years that apples produced without pesticides will be 40 to 80 per cent damaged by codling moth and 60 to 80 per cent damaged by apple scab, plus an equal or even greater degree of damage caused by other insects or diseases. To this we must add the destruction that would be wrought by wood borers, scale insects, and other pests of the trees themselves.

Without the benefit of pesticides, the yield of staple fiber, cereal, and forage crops could be expected to drop by from 10 to as much as 25 per cent. Careful studies have shown that the omission of insecticide treatments resulted in reduction of cotton yields 25 to 40 per cent.

Agronomists have demonstrated quite conclusively that a given acre of land is able to produce just so much dry matter in any given season. With weeds partially uncontrolled, crop yields would be proportionately reduced, and with weeds completely uncontrolled, yields would be practically nothing.

With the advent of DDT for agricultural use in 1945 and the large array of cholorinated hydrocarbon and organophosphate insecticides that followed in quick succession, a number of individuals, including some distinguished scientists expressed concern lest the widespread use of these materials might create a public health problem. This aspect of the problem was reviewed by several scientific bodies, notably the World Health Organization, the U. S. Public Health Service, and the Food Protection Committee of the National Research Council. The general conclusions drawn in each instance were: (a) The large scale usage of pesticides in the manner recommended by manufacturers or competent authorities and consistent with the rules and regulations promulgated under existing laws would not be inconsistent with sound public health programs, and (b) although the careless or unauthorized use of pesticidal chemicals might pose potential hazards requiring further consideration and study, there was no cause for alarm.

However, the very fact insecticides may and no doubt will be misused still remains a matter of some concern to a considerable segment of the American public. This is true particularly of conservationists and wildlife enthusiasts who quite correctly insist that many forms of wildlife are subjected to certain potential hazards not shared by man and his domestic animals.

Many pesticides are admittedly highly toxic to a wide variety of plants and animals. Unquestionably under certain conditions of use they could and do cause some damage to certain species of wildlife. However, a survey of the literature quickly reveals that practically all of the unfortunate incidents recorded to date have involved non-agricultural uses of pesticides such as outright experimentation, eradication programs, excessive rates of treatment in non-agricultural habitats, etc. While there have been numerous minor incidents involving carelessness, misuse, and accidents, the number of such incidents in agriculture have been amazingly few and far between.

In general, agricultural lands present simplified ecosystems with minimal wildlife populations. Pesticide dosage rates are relatively low, and residue dissipation is often so rapid as to necessitate frequent retreatment in order to hold even highly susceptible pests in check. Thus, despite the use of billions of pounds of pesticides on millions of acres of cropland, damage to wildlife attributable to these treatments has been relatively insignificant and in the vast majority of cases undetectable. To quote from the most comprehensive and complete study of the problem, "Considered in its broadest scope, at the present time pesticides seem to be only minor influents in nature compared to other factors in land and water development and use."

Not infrequently pesticides are accused of upsetting the balance of nature, when insofar as agriculture is concerned it would be more accurate to say they were used to suppress an organism already out of balance. Actually, man himself has been the primary factor in upsetting the so-called natural balance. When he cleared the forest, plowed the prairies, drained a marsh, or dammed a stream, he altered an entire environmental complex and set up an entirely new set of opposing forces which if left uninhibited would establish an entirely new biotic equilibrium.

When those who oppose the use of pesticides propose the substitution of unevaluated, untested non-chemical procedures, they might do well to recall that any change in the environment produces almost endless chain reactions and a realignment of all the forces operating in an ecosystem. Thus, it is possible such measures might have even greater repercussions.

Fortunately, most exaggerated differences of opinion emanate from individuals of limited experience or interest who are apparently unable or unwilling to visualize the problem in its full perspective. Now, as never before, scientists in the various disciplines are working together in a common effort to evaluate and solve a mutual problem.

FOREST PEST CONTROL

Tom Gill
Charles Lathrop Pack Forestry Foundation

It may be well at the outset to mention some of the basic differences between pest control in the forest and in agriculture, especially as they affect wildlife and wildlife habitats.

One essential difference has to do with the size of the average operation, which in forest control work covers much larger areas than in agriculture. There is very little analogy between the control activities of the individual farmer and the small forest owner. The small forest owner does not greatly concern himself with pest control. Much forest pest control is on a cooperative basis, between Federal, State and industrial agencies. Operations of this type can be carefully planned, with definitely established responsibilities, and made to follow definite procedures, to safeguard not only wildlife but other forest values.

Another fundamental difference lies in the comparatively small amounts of pesticides used in forest pest control. Out of the several hundred million pounds of pesticides consumed annually in the United States, less than one and three-quarters million are employed in Forest Service control operations. Of this, fully one and a half million pounds are used in bark beetle control, and directly applied to individual trees. So what remains as a potential hazard to wildlife is the application of about 180,000 pounds of DDT sprayed from the air—not very much, surely, compared with the over 70,000,000 pounds used annually in the United States.

You may wonder why bark beetle work so completely overshadows the control of defoliators. It is simply a choice as to where the dollar will accomplish the greatest protective good. With definate limitations on the money that can be spent, forest managers recognize the more immediate emergency in bark beetle infestations. As between bark beetle and defoliators, the beetle requires instant action. The defoliators, if necessary, can wait. But the point, I think, to make here, is that from the wildlife standpoint the direct application of pesticides to beetle infested trees has no known effect on the environment or on wildlife mortality. Certainly no harm has come to the forester's ally, the woodpecker.

As a matter of fact, the woodpecker and the control men seem to have entered into an informal compact. The control men spray the lower 20 or 30 feet of the infested tree, and above that the woodpecker takes over, and so far as I know without any deleterious effects.

But I should not want to leave you with the impression that the relatively small amounts of insecticides used in forest pest control are any measure of the need for control itself, nor of the damage caused. Insect damage in the forest is staggering enough. It has been estimated at an annual loss of five and a half billion board feet of merchantable timber, plus an additional three and a half billion lost in the death of immature trees, in slowing down growth, and in other unfavorable factors. Someone more pictorially inclined has estimated this loss at about 600,000 five-room houses a year, plus about one-fourth of the amount of pulp wood which goes into the nation's newsprint.

Nor does the small amount of forest spraying indicate that we need not concern ourselves about hazards to wildlife, or with detriment to the environment. It must be remembered that every forest acre that is sprayed is potentially wildlife habitat. Further, the small amount of spraying done this year might be vastly increased next year because of an emergency, or because of more available money. Meanwhile the use of silvicides is likely to increase with the coming years. So it is of primary importance that when chemicals are sprayed over forest land their use be confined to situations in which no other form of control is effective, and under conditions which safeguard the application.

I would like to tell you briefly just what some of these safeguards are. Today, most insect control in our forests is based essentially on the Forest Pest Control Act of 1947. Prior to that time there was no Federal authorization for cooperation with the States, or with private owners in pest control, but this Act authorized Federal cooperation with State and private land owners in a united attack upon insects and diseases on forest lands of all ownerships. Under it the Federal Government has set up very detailed and precise procedures. Here in a much oversimplified way is about how it works. A request for aid to combat some insect infestation originates with the land manager. On Federal lands this might be the local supervisor. On private or State lands requests would ordinarily come through the State Forestry Department or some similar organization. After due processing, the request ordinarily goes to the Forest Experiment Station of that area.

Here a biological evaluation is made to determine the damage being done, probable trends of the outbreak, whether any feasible control exists, and the foreseeable results. The station staff checks on the abundance and probable trends of parasites and predators. These evaluations are not confined to the economic value of the timber lands. They are the result of studies made by entomologists, wildlife specialists, foresters, and others. They estimate control costs, and the multiple forest values threatened. They consider possible dangers to fish and other wildlife. For projects of any size, there are written work plans, progress reports, and inspections. If control is indicated, there are further examinations into whether the measures should be cultural, biological, chemical or a combination.

It would probably be hard to conceive of a more integrated operation, or a more promising instance of team work in bringing together the viewpoints not limited to timber as an industrial product, but giving due consideration to the values represented by recreation, hunting, and wildlife.

The decision to use chemicals is never made lightly. Chemicals are called into play only when other methods cannot do the job, and the forest manager has little choice. Either he sprays, or he loses his forest.

The Forest Pest Control Act has worked well. Probably no other field of control has such definite legislation. Perhaps its one weakness lies in the fact that it is predicated largely on cooperation with States, and State laws are variable. Some are good, some are weak, and some States have no laws governing pest control.

Now a word about other forms of control. Dr. Decker has mentioned biological and cultural measures available in agriculture. We have them too in forestry, where they are playing an increasingly important role. Cultural controls—particularly those effected by forest management—offer an immense field of hopefulness, especially in preventing epidemic infestations. Some foresters will tell you that the potentialities of cultural control are far greater than those of chemicals.

There is no lack of instances illustrating how dangers of infestations can be diminished by cultural means—how, for example, a light overstory of an immune species will protect a vulnerable species beneath. Prof. Samuel Graham has instanced the protective value of mixed versus pure stands. In the North, where you have the familiar mixture of beech, birch, maple, hemlock and pine, you seldom find damage done to the hemlock. But where the species exists in pure stands it may be destroyed in a single season by the hemlock looper. Similarly, maple is attacked by a number of defoliators when it occurs pure, but in association with other species, outbreaks are virtually unknown.

This is a field in which it pays the forest manager to be everlastingly alert. In the past, we have actually set the stage for insect attack in some of our reforestation work. In the Lake States, the Civilian Conservation Corps planted mile after mile of pure red pine, and today we are paying a heavy price for that ecological blunder.

There are many preventive steps the forester can take besides simply avoiding pure stands. There is much to be gained by fitting the right species to the right site, by taking out high-risk trees, by thinning too dense stands. And there is this to be said about cultural control: When it does work, it is much more satisfactory than chemical control, and more lasting. That is why the forest manager looks forward hopefully to the day when we will know enough to apply cultural control on a wider scale.

That phrase, "when we know enough," brings out a major need in forest pest control—the need for more research, especially ecological research. We simply don't know enough. In pest control we are today just about where we were 25 years ago in forest fire control. What do we know about the bark beetle, an enemy that accounts for over 90 per cent of forest insect damage? Well, we know a great deal about some species, but in comparison to our fund of ignorance, our knowledge is a scant drop in the bucket. As Noel D. Wygant has pointed out, we have not even been able to develop a synthetic food to enable us to rear these beetles in the laboratory and learn their nutritional requirements. We know these requirements are critical, but we don't know whether they are due to toxic substances, or nutritional deficiencies. We don't know why certain trees are resistant, and others are apparently a toothsome morsel. We don't know by what organism the beetle senses the tree chosen for attack, or how he is guided to it. The life histories and habits of their parasites and predators are largely a closed book.

One could go on and on in cataloging our lack of knowledge regarding other insect species, but it would all add up to saying that for effective pest control we need a vastly accelerated program of research.

Public awareness of the extent of insect damage to forest values can do much toward hastening effective control, and the forest manager is becoming increasingly alert to the need for bringing the public into the pest control picture. This does not mean selling the public a bill of goods, but giving them better advance information, keeping them informed of the damage and dangers of infestations, and especially making it possible to secure the viewpoints of all affected groups. The public wants to know and has a right to know the need for pest control, the price that may have to be paid, the possible adverse effects on wildlife, and if mortality is likely they should know how much to expect.

One forward step in securing public cooperation has been through the so-called Forest Pest Action Councils. Originally organized on the West Coast, they have spread to the East and into British Columbia. These Councils are not control agencies, but informal organizations made up of groups and individuals likely to be affected by control programs, and include Federal, State and private forest and land owners. The Councils act as coordinating bodies, consolidating the plans for control programs before they are put into actual operation. They scrutinize the needs for control and the ultimate effects on all forest values. They insure that both the problems and the plans for control are fully understood by all affected groups, with the result that a project must have undoubted merit to survive this scrutiny. Although the Councils' decisions are advisory, they have the force of public opinion.

Mr. Chairman, in the one minute left, I should like to try to make a little clearer what I believe is the viewpoint of the forest manager toward the use of chemical pesticides. One can, I think, say this: The forest manager in his never-ending battle against insects has come to look on chemicals as an emergency weapon that is both necessary and effective. He may look on chemical control as a last resort, but at certain times and under certain conditions it is the only resort. He knows that chemical pesticides often demand a price and he is continually working to reduce that price by smaller dosage, better materials, and safer methods of application. Meanwhile, he looks forward to the day when biological, cultural, systemic and other controls may drastically curtail the need for chemical pesticides. But as a forest manager—whether Federal, State or private—he can never forget that in his keeping lie enormous resource values, and that his clear responsibility is to protect these values by the best techniques available. And often that means chemical pesticides.

PEST CONTROL IN PUBLIC HEALTH

Samuel W. Simmons
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During the 20th century, remarkable progress has been made in eliminating vector-borne diseases from the United States. Such scourges as yellow fever, urban plague, dengue fever, and malaria are no longer with us. Although the reasons for the disappearance of these diseases are not fully known, it is felt that a combination of many factors was responsible, among which are: general improvement in individual health and chemotherapeutic control, concentrated efforts to control vector species in strategic areas with more efficient methods, general public education on hazards associated with the diseases, and improved sanitation in urban areas. It is of interest to note that the elimination of these diseases was not contingent upon eradication of the arthropod vector, because the yellow fever mosquito, the common malaria mosquito, and the oriental rat flea are still well established in this country.

Increasing Importance of Vector Problems

In view of the foregoing information, it may seem paradoxical to note that vector control activities throughout the United States have increased considerably during recent years, both in the extent of area covered and the types of problems included in control programs. Today's vector control activities are directed principally against vectors of mosquito-borne viral encephalitis and innumerable "pests" that interfere with man's physical and mental comfort as well as producing secondary infections and allergic manifestations. In addition to mosquitoes, other pestiferous arthropods include sandflies, dog flies, blind mosquitoes or non-biting midges, blackflies, ticks, fleas, and chiggers.

The public health importance of vector problems is being intensified due to such factors as: (1) the rapid increase in population, (2) the development of suburban areas in close proximity to breeding sources, (3) the expansion of man-made aquatic habitats created by the construction of new water resources projects, (4) the increasing exposure of man to insects of public health importance due to expanded public use of water-related recreational areas, (5) the development of insecticide resistance, and (6) the public demand for a more healthful environment.

In many cases, control programs directed against pests injurious to public health are confined to urban and suburban areas and thus generally have minimal adverse effects upon wildlife resources. Vector control programs that present the greatest potential hazard from the wildlife standpoint are those directed at extensive mosquito sources in rural areas, particularly fresh-water and salt marshes. For the purposes of this discussion, emphasis will be given to mosquito control.

It is common knowledge that conflicts sometimes arise between fish and wildlife conservation and mosquito control interests. They are usually related to drainage, filling, and the use of insecticides. Experience on TVA impoundments has demonstrated that fish and wildlife conservation and mosquito control interests are not always antagonistic and that a cooperative approach to problems often results in the development of mutual interests. In order that these conflicts will be kept to a minimum, the following principles should always be followed: (1) the instigation of mosquito abatement programs should be based upon a demonstrated need established by field investigations; (2) in choosing the method of control, adequate consideration should be given to fish and wildlife resources, i.e., recognition of the wildlife values associated with the mosquito-breeding habitats; (3) public ownership of wet lands should carry with it responsibility for mosquito control. Mosquito control and wildlife management programs should be undertaken only when in the public interest.

One of the most fundamental items in the development of a sound mosquito control program is an adequate survey to determine the source and extent of the problem. The practice of beginning major control operations with inadequate information is highly wasteful, and may result in complete loss of public confidence in a worthwhile project.

Methods of Control

The choice of control method may be exceedingly complex. Various factors to be considered, some of which are intangible, include: habits and biology of the species, the physical environment, urgency of control - especially vectors of disease such as encephalitis - and permanence of control measures.

The three principal methods of mosquito abatement are source elimination (reduction), naturalistic control, and chemical control.

Source elimination.

Where at all feasible, efforts should be made to eliminate breeding places permanently by filling, drainage, impoundment, sanitation, or other means. These are widely known as permanent or primary control methods. These methods are particularly well adapted for all areas of high economic development. Such areas include those within and close to cities or resorts where a high degree of control is sought. In the long run, permanent control measures generally are the most effective, economical, and enduring of all control measures. Limitations in the use of permanent control methods may arise where the costs are excessive for the size of the area to be protected, or where valuable wildlife resources need to be preserved.

Naturalistic control.

This may be defined as the willful manipulation by man of one or more natural factors - physical, chemical, or biological - so as to prevent or discourage mosquito breeding. Examples include water-level management of impoundments, salinification of a body of water, and the use of biological control techniques. The best known of the biological agents are the larva-eating fishes, particularly the top-water minnow (Gambusia). Some observers think that the success of tidal ditches is substantially due to making mosquito larvae accessible to native predaceous fishes.

Naturalistic control is largely an unexplored field. A recently developed method that appears very promising is the creation of impoundments on salt marshes where the water level can be manipulated and controlled. This method not only suppresses production of Aedes mosquitoes but it actually enhances wildlife values. It would be highly desirable for conservation and wildlife agencies to foster and promote research on naturalistic control methods.

Chemical control.

Pesticides may be used for destroying both the immature and adult forms of mosquitoes. Chemical control includes temporary larviciding, residual larviciding, residual adulticiding, and space spraying. Control at the source, if at all possible, is the procedure of choice. Prior to the advent of DDT, adulticiding was a "premium" type of control; today it is common. The large-scale global campaign against malaria vectors is based on the application of residual toxic coatings of chemicals to surfaces where mosquitoes rest.

The use of chemicals is frequently termed a supplemental or secondary control method. Limitations of this method include the temporary effectiveness of the treatments, the high cost of repeated applications, the toxic hazards involved, and the development of insecticide-resistant strains of insects. One of the chief advantages of chemical control is the immediate and often spectacular relief from annoyance. It is for this reason that chemical control measures play such an important role in suppressing epidemics of mosquito-borne diseases. Chemical applications are also used where the more permanent methods for mosquito control are not feasible. Since chemical control methods may adversely affect fish and wildlife, they should be planned and executed with full consideration given to the protection of fish and wildlife values.

The best procedure in vector abatement programs is to utilize a combination of source elimination, naturalistic, and chemical control methods.

Protection of Wildlife Values

Insofar as the public health use of mosquito larvicides and adulticides is concerned, the associated dangers to wildlife are largely potential rather than real. Mosquito control has a good record for over 50 years. It should be emphasized that the amount of aerial spraying for mosquito control comprises only about two per cent of the total acreage (100 million acres) sprayed annually in the United States. Furthermore, the dosages needed for mosquito control are generally lower than for most other insect control operations.

Every feasible effort should be made to minimize possible detrimental effects of chemicals to wildlife. The following rules or precautions should be observed in the use of insecticides in mosquito control:

1. Use insecticides that are not unduly harmful to wildlife.

2. Apply the minimum dosage consistent with effective control.

3. Apply larvicides to known or verified potential production sites only.

4. Choose dosages, formulations, manner, and frequency of application that comply strictly with Federal and State recommendations.

5. Execute programs under competent supervision.

6. Time the applications in order to accomplish the greatest good and least harm.

In conclusion, the best procedure for solving conflicts of interest between mosquito control and wildlife conservation is for a cooperative approach by all. In the future, emphasis must be on a positive approach - the promotion of mutual interests based on a proper understanding of each other's problems.

WILDLIFE - PESTICIDES RESEARCH NEEDS

Ira N. Gabrielson
Wildlife Management Institute

With the increase of industrialization and urbanization in recent years, wildlife managers have been faced with a familiar problem stemming from an unfamiliar cause. The wildlife conservation program has its beginnings in attempts to check the wholesale slaughter of beneficial birds and mammals by market hunters. The market gunner was outlawed and brought under control many years ago, but the wholesale destruction of wildlife by more modern agents still continues. The spectacular kills of birds and mammals, which are reported from time to time in the newspapers and more often in technical journals, are often accidental, but the end result to the animals involved is the same and such events occur frequently enough to cause serious concern among those who are interested in perpetuating the fauna of North America.

Some of these wholesale kills involve the collision of migrating birds with aircraft navigation beacons; others involve the entrapment of sea birds in oil discharge by ships at sea; and still others are the result of poisoning from ingesting chemical pollutants in watercourses. All of these are important, but one of the most serious problems, and one which is growing rapidly in importance, is the effect on birds, mammals and fish of widespread pesticide programs.

The effects of chemical insecticides upon wildlife are very complicated. Frequently there is no immediate effect that can be noticed by observers. In the case of birds trapped in an oil slick, the cause and effect are both apparent. In the case of woodland area sprayed with a mist of heptachlor or DDT, birds may still be seen in the area and an extensive search may turn up few or no dead specimens. To all outward appearances, the area may be as attractive to wildlife as it was before the treatment and the lethal effects insignificant.

In analyzing the direct lethal effects of any product in the field, the observer is handicapped greatly by the normal behavior of a stricken animal. Many years ago one of my jobs was to conduct and evaluate rodent and predator control programs. Even though we almost saturated some areas with toxicants in an effort to kill a rodent population, we rarely found many dead animals. As soon as the animals began to sicken from the effects of the poison, they crawled into holes or other hiding places, and only occasionally were numbers of dead animals found in the open. Evaluating the direct lethal effect of a specific treatment, therefore, is very difficult, even when the object of the treatment is to kill the animals. When the object of the treatment is to control an unrelated insect species, the problem of evaluation is even more acute.

Significant though the direct kills of desirable wildlife may be, however, they are of far less concern to the biologists than the indirect effects of the newer pesticides. In the first place, they are much more difficult to evaluate than the direct effects, and their importance may far transcend that of direct kills. Some of the newer chemicals remain toxic long after they are applied, and their lethal effect may be delayed for many months after the specimen is exposed. In certain areas where elms have been treated with DDT in efforts to eliminate Dutch elm disease, earthworms in the contaminated soils have been found to have concentrated lethal doses of the chemical within their bodies. In some instances sufficient amounts of the chemical have been found stored in the bodies of earthworms to kill any bird that ate them, a full year after the spraying of the area.

Another indirect effect that is just coming to focus involves the woodcock, an important migratory game bird that winters in the southern part of the United States, where they have been using heptachlor extensively in insect control. Heptachlor has been found in the tissues of woodcock killed in New Brunswick and Nova Scotia, the center of their breeding grounds, six months after they had left the South. Moreover, there is some evidence that young birds, which have never been known to be exposed to heptachlor, sometimes have the substance in their tissues.

Much of the research on this problem is being conducted and coordinated at the Patuxent Wildlife Research Center of the U. S. Fish and Wildlife Service in Laurel, Maryland, although the amount of money that has been available to date has been limited. There have been, however, some carefully controlled laboratory experiments that indicate that many of the chlorinated hydrocarbons, in particular, decrease the reproductive capacity of birds and mammals. When very minute quantities of these chemicals are included in the diet of captive birds and mammals, their fertility is decreased. In the case of birds, the hatchability of eggs is substantially decreased and the vitality of the chicks that are produced, and their ability to survive, also decrease.

The parent birds, in spite of a steady diet which includes small quantities of chlorinated hydrocarbons, usually, show no obvious effects. They seem just as active as the control birds and sometimes lay normal sized clutches of eggs. It is often difficult to distinguish by the appearance of the birds the control pen from the pens in which the experimental birds were held. It was only in the reproductive capacity of the treated birds and the vitality of the second generation that the effects become apparent.

A legitimate criticism of the use of many of the pesticidal chemicals is the fact that they are being applied without adequate knowledge of what they may do. Only one of the chlorinated hydrocarbons, for example, has ever been given a reasonably thorough testing before it was put into public use, and that was DDT. An entire series of tests were made of it by a cooperative team of wildlife specialists, entomologists, and chemists. Where recommendations for the use of DDT are followed, there are no immediate effects upon wildlife.

Much of the present trouble with DDT and later members of the chlorinated hydrocarbon family of pesticides comes from their application by people who are incompetent to handle such lethal substances. Many feel that if the recommendations call for a pound of the substance to give effective insect control over an acre, five pounds should be five times as effective. I have personally seen and have had reported to me by competent biologists amazing examples of carelessness and of complete violation of the instructions for the use of toxic pesticides. Most involved overapplication for the task at hand.

There was relatively little conflict between agricultural pest control and wildlife conservation until the development of the chlorinated hydrocarbons. The arsenical insecticides, which were the most prevalent type used before 1945, will kill birds and mammals if they ingest enough of them, but most species have a relatively high resistance to arsenic and consume much less than is needed to kill them when sprays are used in accordance with the recommendations of the entomologists. The organic phosphates are as deadly as the chlorinated hydrocarbons, but in most cases they lack their residual effects and stability after application. The pesticides of greatest concern to biologists are the newer chlorinated hydrocarbons, which are relatively stable and retain their toxicity much longer than any family of chemicals previously used for this purpose. The secondary effects of these are of greater concern to the biologist than the occasional spectacular kills of local wildlife populations that are reported in newspaper items.

A serious handicap in studying the chlorinated hydrocarbons is the enormous variation in the toxicity of the materials to very similar species of wildlife. Only general statements can be made as to their effects. Fish and crustaceans are usually more susceptible than birds and mammals, and it takes much smaller concentrations to affect them adversely. But among the fishes, even those that are closely related, there is wide variation in the concentration of many chemicals that they can tolerate. No one knows why. All we know is that such a wide variation exists among the various species.

The complications that this injects when safeguards are being evolved for the application of these substances are obvious. How do you recommend the spraying of a marsh area where there are four or five important species of fish, one of which may be 500 times as susceptible to the poison used as are the others? Studies are being conducted at the present time to find the answer, but they are in their early stages and they are not as many as are needed.

At the outset it was felt that if we could get adequate toxicity tests started for the various species, we would have a beginning. Now it appears that we shall have to run toxicity threshold tests on all species before we can be certain what is going to happen to a given area of marsh or stream when it is treated with a specific concentration of a given pesticide.

On agricultural lands the problem is not as acute as it is on watered areas of forested lands. Most cultivated land is of necessity reduced to a simple ecological system, since one plant is favored over all others, a practice that incidentally favors pests but which produces generally unfavorable conditions for desirable wildlife. The same is true, although in a lesser degree, of open pastureland.

On all cultivated areas, therefore, the number of wildlife forms are much fewer than those which regularly use the "wild lands"—those which are neither intensively cultivated nor planted for pasture and hay. Such areas represent a complex ecological system and provide a habitat used by a wider variety of wildlife species. The most spectacular kills of wildlife through the application or misapplication of pesticides usually occur on such areas.

In New Brunswick where a standard application of DDT was applied for spruce budworm control on the headwaters of the Miramichi River, a team of Canadian fishery biologists working in the area was able to observe and evaluate the effects upon the salmon. Since this team had been working there for several years, its members were entirely familiar with the existing and past age-classes of the fish population, and they were able to measure accurately the effects of the spraying operation. It killed from 80 to 90 per cent of all one- and two-year-old salmon in various sections of the stream. It also nearly obliterated the organisms on which the young salmon depended. It will be a year or possibly two before we have a complete evaluation of the over-all effect. This is only the most spectacular of many fish kills that have been traced to the application of pesticides.

One of the approaches desired by all wildlife workers is a reduction in the number of the broad-spectrum poisons that are being used and the development of specific poisons that will be toxic to individual pests without endangering other species. One of the most interesting examples of what can be done is found in the development of a chemical that is being used to control the sea lamprey in the Great Lakes. The poison, which is being applied in the tributary streams where the larvae lampreys live in the mud, kills only the lamprey without apparent adverse effect upon any other species. Yet it is being applied in an ecological environment where the use of non-selective poisons would be exceedingly dangerous to valuable fish resources and possibly to man. From the standpoint of the biologist, that type of control represents the ideal, and much more research should be geared to the development of pesticides that are specific in their effect on individual pest species. This is a tool that can be used with the precision of a rifle in eliminating a single pest from an ecological area. Under present shotgun techniques, beneficial forms of life are usually destroyed along with the prime target of the control program.

A second ideal method, in which spectacular success already has been achieved, is through the use of biological and cultural controls. The screw worm, a particularly unsavory parasite on cattle and deer in the Southeast, has been virtually eliminated through the saturation release of male screw flies sterilized by the use of radiation.

Only a few weeks ago I inspected mosquito-control projects in Florida where successful control of salt-marsh mosquitoes has been effected through the use of water-level manipulation. Thousands of acres of impoundments have been constructed by authorities along the coast of Florida as the cheapest and most effective way of coping with the problem. Not only have the mosquitoes been controlled but the environment in many instances has been improved substantially for wildlife. The impoundments vary from 100 to several thousand acres, but each has one or more flood gates which permits control of the water level of the marsh. In each of these projects there has been close cooperation between the mosquito control authorities and the Florida Game and Fish Commission so that the opportunities to enhance wildlife habitat are recognized and followed up. The use of chemicals has been largely eliminated.

The one drawback to this system has been that it has not proved entirely successful in controlling fresh-water mosquitoes which breed under different conditions than the salt-marsh species. It has proved successful against some varieties of the fresh-water species but not all of them. Additional research may find the answer to this problem.

The Florida salt-water marsh mosquito control program is highly significant to biologists since the estuarine waters affected are the breeding grounds of our most valuable food and game fishes. Either the adult fishes seek out bays, inlets and the mouths of streams to spawn, or the fringes of the marshes serve as vast nurseries for the larvae and fry of these fishes. In all of the impoundments provision is made to pass fish over or through the dikes in order that their cycle of life may not be interrupted.

These instances, however, are only the fringes of the potential that exists for improving present control programs. A vast amount of additional research is needed before the theoretical ideal of the biologist can be approached on a general scale; a tremendous improvement in present techniques of distribution and application of pesticides is required before the biologist can rest easily. We need desperately a wider public understanding of the secondary effects of chemical pesticides and the dangers that are inherent in the overuse and misuse of pesticides.

No responsible wildlife biologist would advocate the abrupt prohibition of chemical pesticides, even if such a prohibition were within the realm of possibility. Properly used by responsible individuals, they serve an important purpose. All that the biologists ask is that a greater degree of caution and responsibility be demonstrated all the way from the manufacturer down to the spray-tank operator and an awareness on the part of all concerned of the potential dangers of overapplication. We also ask that more attention be given by federal and state authorities concerned with pest control in developing methods that will be less hazardous to beneficial forms of life. When the chemists produce a product that is specific for individual pest species, as they have already done with the sea lamprey, they will find the wildlife biologists leading the applause.

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