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Scope and Method of Study: This report has been undertaken as a comprehensive survey of scientific literature since 1945 that has dealt with the effects of insecticides on bird populations. Particular attention was given to the effects of large scale programs, including (1) the Dutch elm programs in the East and Middle West, (2) the Japanese beetle program in the Middle West, and (3) the fire ant program in the South.

Findings and Conclusions: Dutch elm disease programs in the Middle West were found to decrease songbird populations 30 to 90 percent in the urban communities studied. Some study areas treated for the fire ant in the South sustained bird losses in excess of 80 percent. Japanese beetle control programs in the Middle West led to an 80 percent decrease in songbird populations in several localities. The author finds some circumstantial evidence that insecticides may be lowering the fertility of Woodcock, Bald Eagles, and possibly songbirds. The author is critical of the lack of field testing before the Japanese beetle and fire ant programs were implemented and further suggests that advance publicity preceding such programs has been lacking or inaccurate. It is suggested that values other than those immediate and economic deserve more consideration than they have received in the past. Alternatives to and modifications of some present spraying practices are suggested which will be less harmful to bird populations.

ADVISER'S APPROVAL F. M. Baumgartner

THE EFFECT OF INSECTICIDES ON BIRD POPULATIONS

By

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PREFACE

The purpose of this paper was to survey the literature published since 1945 on the effects of insecticides on bird populations. This study deals primarily with insecticides used in Dutch elm, Japanese beetle, and fire ant programs.

I wish to thank Dr. Fred M. Baumgartner for his suggestions and for reading this paper and Drs. H. L. Bruneau and James H. Zant for their encouragement and suggestions.

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CHAPTER I

INTRODUCTION

> We know now what was unknown to all the preceding caravan of generations: that men are only fellow-voyagers with other creatures in the odyssey of evolution. This new knowledge should have given us, by this time, a sense of kinship with fellow-creatures; a wish to live and let live; a sense of wonder over the magnitude and duration of the biotic enterprise.[1]

Insects have plagued man since before the dawn of recorded history. Though man has combated insects with chemicals for several hundred years, it has been only recently that this method of control has increased greatly in importance. In his zest to control the biotic enterprise man has recently demonstrated a pronounced lack of the sense of kinship which Leopold so eloquently described. In the opinion of the author, one of the great challenges of this generation is to apply technology so that man's effect on the environment will be as harmonious as possible. This study will deal primarily with instances of inharmonious application of technology.

The post war period has witnessed a phenomenal growth in agricultural and industrial technology and a corresponding

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[1]Aldo Leopold, A Sand County Almanac (New York, 1949), p. 109.

increase in leisure time leading to increased concern for the esthetic values of wildlife. The conflict in values which has resulted has not been as intense as the disagreements over how they are to be resolved.

CHAPTER II

HISTORY OF INSECTICIDES

As Decker (1960) states, the first thoroughly effective use of agricultural insecticides originated with the use of Paris green to control the Colorado potato beetle in 1867. During the following 75 years, arsenical compounds played an ever-increasing role in insect control.

Beginning in the 1930's there was considerable experimentation with organic compounds. Ethylene dichloride and phenolthiazine were developed during this time. Though DDT (dichloro diphenyl trichloro ethane) was synthesized as early as 1874, it was not released for civilian use in the United States until 1945. Following came BHC (benzene hexachloride), chlordane, toxaphene, aldrin, dieldrin, heptachlor, and endrin -- all with a high content of combined chlorine. More recently organic phosphates have been added: TEPP (tetraethyl pyrophosphate), parathion and malathion. By 1953 consumption of the 14 major insecticides was 186 million pounds and less than 20 percent was for materials known prior to the advent of DDT (Shepard, 1954). Due to decreased costs it is now considered practical to use pesticides to protect general farm and even forest crops.

With the amount and effectiveness of chemicals now in use it appears that the potential exists for more than incidental effects on bird populations. Research has not yet fully traced the effects of chemical pesticides on wildlife, plant life, or the soil. Knowledge of the long-term effects of chemicals on the environment is still fragmentary and research has failed to develop satisfactory techniques for measuring the ecological effects of chemicals already in use. In the opinions of some, insecticides are becoming "An unobtrusive, insidiously dangerous hazard to man and his resources . . ." (Cottam, 1963:21).

The best way to evaluate the potential bird threat offered by insecticides is to consider the extensive studies which have been carried out since the chlorinated hydrocarbons reached the market in 1945. Due to the extensive use of and research with DDT, it will receive the most extensive treatment in this report. Many other insecticides are described on a comparative basis with DDT (George, 1957).

TABLE I

CHEMICAL TOXICITY

More Toxic Than DDT	Same Toxicity as DDT	Less Toxic Than DDT
Heptachlor	Lindane	Methoxychlor
Aldrin	Toxaphene	TDE
Endrin	Chlordane	BHC
Dieldrin		Chlorthion
Diazinon		Malathion
EPN		
Parathion		
TEPP		

In spite of the extensive use of insecticides, crop losses to insects are staggering -- estimated at two billion dollars in 1954 by the Department of Agriculture (National Academy of Sciences, 1962). This loss resulted with the use of insecticides so it is obvious that a considerable need exists for effective chemical insecticides unless and until other effective control measures are found.

CHAPTER III

EARLY USE OF DDT

One of the first major investigations of DDT on breeding bird populations was undertaken in June, 1945, on a 117 acre tract of bottomland forest on the Patuxent Research Refuge (Robbins et al., 1951). A single aerial application of DDT in oil at the rate of 2 pounds per acre was made for the express purpose of learning effects on wildlife. Frequent censuses before and after spraying were made in a 31 acre plot in the center of the experimental area as well as in two check areas. It was found that a single application of 2 pounds of DDT per acre had no apparent effect on breeding birds of that mature forest habitat, except possibly the American Redstart (Setophaga ruticilla).

In order to determine whether continued yearly sprayings would have a detrimental effect on nesting birds, the area was treated once each year for the following four years -- the last application being made in June, 1949.

Detrimental effects which were obscure at the end of the first year were much more apparent in 1949. The three commonest species, Red-eyed Vireo (Vireo olivaceous), Parula Warbler (Parula americana), and American Redstart, all showed decreases of 26 pairs per hundred acres in the sprayed area, but showed no corresponding decrease in the check area. Significantly these were the only species which decreased perceptably. All three of the species with declining populations are largely treetop feeders which are entirely insectivorous.

The results of other studies have, in many cases, differed. Fishingbauer et al. (1957) found more American Redstarts in a sprayed section of a Minnesota hardwood forest than in the check plot. His study of a single application of 1 pound of DDT per acre led him to conclude that it caused no detectable loss of bird life. The study area was a small 40 acre plot so the insect diet of the resident birds could have been a mixture of uncontaminated along with contaminated insects. It should also be noted that Stewart and Aldrich (1951) stated that bird mortality within an experimental plot may be difficult to detect because of influx from outlying areas.

Several forest studies failed to indicate bird loss due to spraying. George and Mitchell (1947) found that the application of 1 pound of DDT per acre to spruce-balsam forests in the Adirondacks for the control of spruce budworm did not lead to bird mortality. They found that insects were not exterminated in the area and suggested that the mixed diet of nontoxic and toxic insects kept the amount of DDT at a sublethal level. They further postulated that if DDT were applied at much higher levels, it would be possible that the young would succumb from toxicity or perhaps starvation.

Hale (1957) investigated a spray program which covered 40,575 acres in a Wisconsin jack pine forest. The spray was applied at the rate of 1 pound of DDT per acre to control an outbreak of the jack pine budworm. The only physical evidence of bird loss found or reported was 5 dead Mallard ducklings (*Anas platyrhynchos*) on a Bayfield County pothole. Other types of DDT spray programs have not proved so harmless. George (1957) states that bird mortality is not uncommon even when applications of DDT average 1 pound per acre. This is because of uneven coverage: a difficulty in any aerial spray program. Tests run in 1945 indicated that local concentration ran as high as 15 pounds per acre in spite of the light average coverage.

CHAPTER IV

DUTCH ELM SPRAY PROGRAMS

The Disease

Dutch elm disease is caused by a fungus, *Ceratostomella ulmi*, which is spread from tree to tree by certain bark beetles of the family Scolytidae. It was first discovered in the United States near Cleveland, Ohio, in 1930. The disease spread rapidly over the eastern states.

Control of the bark beetle vectors was envisioned as a method of controlling the disease, Sanitation or the removal of dead trees and wood was one of the first methods used. With the advent of DDT it was decided to apply the insecticide to the bark of healthy trees in order to kill the beetles before they could introduce the deadly fungus beneath the bark. Since adult beetles emerge and fly to new trees during several spring and summer months, two applications are frequently made to provide residual amounts during this period.

The Princeton Program

One of the first spray programs for the control of DED (Dutch elm disease) was begun in August, 1947, in Princeton, New Jersey. In the first year an application of 1 percent

DDT emulsion was applied to the village elms. In 1948 the program continued with spring dosages averaging 3 pounds per tree and approximately another 1.5 pounds per tree was applied in August.

Bird mortality was first noted following the prefoliar spray of 1948 -- an event that could have been predicted from the work of Hotchkiss and Pough (1946). About a dozen birds were reported killed, but there was no proof that DDT was responsible. Some landowners grew apprehensive, however, and withdrew from the spraying program. More reports were received of bird mortality after the 1948 summer spray. In 1949, prior to the spring spray, arrangements were made by the Bureau of Entomology and Plant Quarantine personnel to receive dead birds. A total of 15 birds were recovered.

By 1949 there was sufficient concern to study bird mortality quite intensively. Censuses were made on a study area and on a similar unsprayed area, both before and after spraying. Of 26 songbirds recovered, the vast majority were juveniles. All 15 analyzed contained DDT. Considering only the species common to both sprayed and unsprayed areas, a population decline of 22 percent was noted on the sprayed area while the check area showed a 6 percent increase during the same two-week period.

Nestling mortality was considerably greater on the study area. Among 18 young found on the study area only 8 (44%) survived. On the check area 15 of 21 (71%) survived.

The Princeton story has been repeated many times all across the East and Middle West. Investigators who conducted studies in the Middle West found much greater bird losses but were unable to explain why this should be (Hickey and Hunt, 1960; Wallace et al., 1961).

Concentration of DDT by Earthworms

The University of Illinois campus at Urbana began a DED spray program in 1949 on the 430 acre main campus. During the period of the study, application rates were between 1.0 and 1.5 pounds of DDT per tree. A total of 1,400 elms were sprayed. It was not until the spring spray of 1950 that large numbers of dying Robins (<u>Turdus migratorius</u>) were reported. The reports of dying Robins were most frequently reported after rains. DDT poisoning was suspected but water analyses from puddles indicated only trace quantities of DDT. The problem of how the Robins became poisoned remained unsolved. Then, Barker (1958) made earthworm collections and analyses and found that fewer than 100 earthworms can accumulate 3 mg of DDT -- the approximate median concentration found in dying Robins in the study.

Beginning in 1950, G. C. Decker, a professor on campus, observed a conspicuous decline in earthworm populations and a corresponding decline in bird mortality. The last dead birds were reported in 1954. Hickey and Hunt (1960) report that direct contamination of the soil appears to be just as lethal.

Bird Mortality in Elmhurst

Spraying effects in Elmhurst, Illinois, were apparently more devastating than they had been in Urbana. The Elmhurst program was initiated in April, 1956. The effects on the birds were everywhere apparent by mid-May. Among the species on the casualty list were Robins, Cardinals (Richmondena cardinalis), Downy Woodpeckers (Dendrocopus pubescens), Red-headed Woodpeckers (Melanerpes erythrocephalus), Ruby-crowned Kinglets (Regulus calendula), English Sparrows (Passer domesticus), Starlings (Sturnus vulgaris), Blue Jays (Cyanocitta cristata), Baltimore Orioles (Icterus galbula), and Grackles (Quiscalus quiscula) (Montgomery, 1956). In mid-July it was reported that only one Robin was seen in central Elmhurst. Since dead earthworms appeared on many lawns, it is possible that at least some of the mortality was the result of eating the earthworms.

A Michigan Study

Dutch elm disease was first discovered in Michigan in the Detroit area during the summer of 1950. By 1959 the disease was known in 77 cities and townships in the Detroit area. Full scale spray programs were underway as early as 1953.

An extensive investigation of bird mortality was begun in 1956 on the Cranbrook campus. From 1956 to 1959 approximately 1,000 specimens were received for DDT analysis -- several hundred of these were chemically analyzed. Wallace et al. (1961) received specimens which they divided into five categories based on feeding habits: (1) terrestrial feeders -- especially Robins, but including thrushes, Catbirds (Dumetella carolinensis), Brown Thrashers (Toxostoma rufum), Cardinals (seed eaters), and flickers (ant feeders); (2) foliage gleaners, such as orioles and warblers; (3) bud feeders including Cedar Waxwings (Bombycilla cedrorum), Rose-breasted Grosbeaks (Hedymeles ludovicianus), Indigo Buntings (Passerina cyanea), Pine Siskins (Spinus pinus), and American Goldfinches (Spinus tristis); (4) bark foragers, such as Black-capped Chickadees (Parus atricapillus), White-breasted Nuthatches (Sitta carolinensis), Brown Creepers (Certhia familiaris), and several species of woodpeckers; (5) surprisingly, also included were 12 hawks, 5 Screech Owls (Otus asio), and several Crows (Corvus brachyrhynchos).

In 1959 and 1960 complete breeding bird censuses were conducted on the campus. Both censuses indicated there were less than 15 pairs compared to 250 pairs (estimated) in former years before spraying was begun. No successful nests of Robins were found in the last two years of the study. A comparable census on the University of Wisconsin campus in Madison indicated a reduction of 86 to 88 percent in Robin numbers (Hickey and Hunt, 1960).

Investigations by the same investigators (Wallace et al., 1961) on the East Lansing campus led to similar findings. Of 12 Robin nests observed on the 185 acre study area, 10 were known to be unsuccessful while the remaining 2 were presumed to be unsuccessful.

Laboratory Analyses of Bird Specimens

The Michigan study was followed up with some thorough laboratory investigations (Bernard, 1963). A total of 62 dead Robins which were submitted from the East Lansing study and from Wisconsin were chemically analyzed for DDT. All the specimens which were recovered in a state of tremors had levels greater than 50 ug of DDT/g in the brain. Bernard (1963) concluded from his investigations that the amount of DDT in the brain is the best single indicator of lethal effects of DDT. He further established that of the Robins found dead or dying in areas sprayed with DDT that 90.7 percent had sufficient quantities of DDT to cause death. The same investigator captured English Sparrows and fed measured amounts of DDT with their regular feed. Of 71 English Sparrows found dead or dying during the experiment, 54 had levels greater than 65 ug of DDT/g of brain tissue.

DDT Effects on City Bird Populations

The studies mentioned previously dealt primarily with numbers of DDT fatalities. Perhaps a more valid method of evaluating DDT effects is to consider population changes within cities where spraying is done. Hunt (1960) made a one-year comparison of breeding bird populations in three sprayed and three unsprayed communities in southeastern Wisconsin. Eleven quadrats, averaging 25.8 acres each, were chosen. The sprayed plots had received spray during each of three consecutive years prior to the study. The check plots and experimental plots were chosen with similar habitat. Robin populations in the sprayed communities were 69, 70, and 98 percent below the average unsprayed community. Densities of 13 other species varied from normal to moderately lower on the sprayed plots (See Table II). An evaluation of the Dutch elm programs lead the investigator to conclude that breeding birds, particularly Robins, can be reduced significantly in localities of high elm density where spraying programs are conducted annually.

TABLE II

SONGBIRD CENSUS RESULTS EXPRESSED IN BREEDING PAIRS PER 100 ACRES[2]

	UNSPRAYED COMMUNITIES			SPRAYED COMMUNITIES		
Community	Madison	Portage	Stoughton	Janesville	Wauwatosa	Shorewood
Effective Lb. DDT/Acre	None	None	None	3.6	3.2	9.6
Robin	180	179	159	54	54	3
Common Grackle	47	49	35	43	24	5
House Wren	48	21	43	46	10	4
Mourning Dove	25	40	39	28	13	4
Starling	20	16	73	47	8	10
Blue Jay	38	16	31	21	9	10
Catbird	37	11	22	5	4	0
Chipping Sparrow	1	30	0	0	4	0
Baltimore Oriole	4	20	6	10	1	1
Yellow-shafted Flicker	4	6	6	10	0	2
Cardinal	7	6	0	8	0	0
Rose-breasted Grosbeak	1	0	0	7	0	0
White-breasted Nuthatch	1	2	2	0	0	0
Scarlet Tanager	1	0	0	0	0	0
Total pairs	414	396	416	279	127	39
Total species	14	15	14	12	10	10

[2] L. Barrie Hunt, "Songbird Breeding Populations in DDT Sprayed Dutch Elm Disease Communities," *Journal of Wildlife Management*, April, 1960, p. 143.

CHAPTER V

INSECTICIDES AND JAPANESE BEETLES

The Japanese beetle (*Popilla japonica*) became established in eastern United States several decades ago. After much experimentation with control measures, milky spore disease (caused by *Bacillum popillae*) was successfully established as an effective parasite. Thereafter the seriousness of the pest was reduced, and its nuisance properties were more typical of some native insect pests. The insects moved steadily westward, however, and suppressive measures were undertaken by several states in the Middle West.

In the spring of 1954 the Plant Pest Control Branch of the United States Department of Agriculture and the division of Plant Industry of the Illinois Department of Agriculture cooperated in a control program. Both aldrin and dieldrin were used in the program at rates of 2 to 3 pounds per acre. According to Rudd and Genelly (1956), dieldrin is about five times as toxic as DDT and twice as toxic as aldrin. The extent of bird mortality bears out the high toxicity of the two insecticides.

A research team from the Illinois State Natural History Survey Division (Scott et al., 1959) assessed the wildlife losses with field counts and mailed questionnaires. Ground feeding birds which include insects in their diet seemed especially vulnerable. Robins, Ring-necked Pheasants (Phasianus colchicus), Brown Thrashers, Meadowlarks (Sturnella magna), Grackles, and Starlings were virtually exterminated in the treated area. Bird losses at the 375 residences in Sheldon were estimated (on the basis of questionnaires) at 1,840. In Blue Island, Illinois, a similar program resulted in songbird mortality estimated at greater than 80 percent (Bartel, 1960). Mourning Doves (Zenaidura macroura), principally seed eaters, came through with little apparent loss.

Bird populations remained depressed throughout the spring and early summer. It was thought that, to some extent, the depressed numbers were due to a markedly reduced insect population. Wildlife appeared well on the way to recovery by the following year. Though the investigating team labeled the wildlife losses as "severe," Hickey (1961) reports that one of the Illinois control officials was asserting in 1960 that the survey had not found any serious damage done to wildlife.

CHAPTER VI

THE FIRE ANT PROGRAM

Early History

The fire ant program in the South is probably the most massive spray effort in history. Hickey (1961) classifies it as "a classic example of how an insect problem can be mishandled at the administrative level." The fire ant (*Solenopsis saevissima richteri* Forel) was first noted in the United States near Mobile, Alabama, about 1920. It spread across the Southeastern States until some 26 million acres were affected by 1957. Apparently, the unpleasant bites the ants can administer and the machinery-impeding mounds that they build caused many farmers to demand eradication. The first effective insecticides discovered were chlordane and heptachlor or dieldrin. Some experimental work indicated that chlordane at 4 pounds and heptachlor or dieldrin at 2 pounds per acre, in granular formulation, would control the ants for periods up to five years.

Field Effects of Heptachlor and Dieldrin

Early in 1957 the United States Department of Agriculture in cooperation with several states began an "eradication" program. An experimental treatment area was established in Wilcox County, Alabama, to learn the immediate effects, if any, of the treatment on the Bobwhite (Colinus virginianus) population. The dieldrin test plot contained 1200 acres, and the heptachlor plot contained 2400 acres. A Bobwhite census was made before and after treatment. The percentage loss of birds was 87 percent (15 coveys completely wiped out) for both plots; whereas, a 3 percent decrease was noted on the control plot. The only surviving coveys (two) were at the edge of the experimental plots. Chemical analysis confirmed the presence of insecticides in Bobwhite tissue. The investigators concluded that this application of heptachlor and dieldrin resulted in the death of all or nearly all resident Bobwhite (Clawson and Baker, 1959). With no further treatment the Bobwhite population, however, returned to normal during the second year after treatment (DeWitt et al., 1960).

A study of bird mortality from a Texas fire ant program included all resident bird species (Lay, 1958). An aerial treatment of 2 pounds per acre of heptachlor was used on May 3, 1958. On the 1400 acre study area, dead birds found included Meadowlarks, Bobwhites, Mourning Doves, and 16 additional species. Almost all species present, including shrikes and Sparrow Hawks (Falco sparverius), were included. Strangely, vultures remained active and were evidently unaffected. The two resident Bobwhite coveys were exterminated. Though the June insect population appeared normal, the bird population was reduced 85 percent or more, and nesting success was reduced 89 percent.

Though the Texas investigator was concerned about the high immediate mortality, he was even more worried about possible long-term effects such as reduction in egg fertility or sterility of offspring.

Laboratory Studies on Insecticides

DeWitt (1956) found that sub-lethal doses of DDT, aldrin, or dieldrin led to reduced hatchability and high juvenile death rates in both Ring-necked Pheasants and Bobwhite. There were indications that the offspring from poisoned birds may be persistently weak even though they receive no toxin. Genelly and Rudd (1956) got similar results when they fed DDT, toxaphene, and dieldrin to penned Ring-necked Pheasants. Reproductive success ranged from 70 percent in the control group to 38 percent for the dieldrin group. In the opinion of the investigators, wild birds in many areas may be exposed to greater contamination hazard than the laboratory birds. In field situations birds may be contaminated by three rates of entry: oral, dermal, and respiratory. The penned birds received oral contamination only. Wright (1960), doing field work on Woodcock (Philohela minor), found production of young birds definitely reduced. Birds analyzed revealed that 322 out of 469 specimens had residues of DDT and heptachlor (Udall, 1963). As pointed out by Hickey (1961), the migratory habits of Woodcock expose them to DDT in New Brunswick (for spruce-budworm control) and dieldrin and heptachlor in the South where the fire ant program is in progress.

CHAPTER VII

THE EAGLE PUZZLE

Our national bird, the Bald Eagle (*Haliaeetus leucocephalus*), has recently been the subject of intensive studies by Audubon societies across the nation. Though this is a recent study, previous records give some evidence that reproductive success has been on the decline since 1947.

Sprunt (1963) contrasts some recent findings with those of the late Charles L. Broley. Mr. Broley, working on the Atlantic Coast, kept records of nesting success and banded hundreds of eaglets both before and after World War II. His death in 1957 terminated the important work. In 1946 a four county area in Florida had 73 active nests, of which 56 produced 103 young. This represents a success rate of 77 percent and 1.83 young birds per successful nest. By 1957 the number of nests had dropped to 43. Seven nests produced eight young. Nesting success was 16.2 percent and the young birds per successful nest only 1.14. With the resumption of Bald Eagle studies in the area in 1962, not all the nests were checked. Of those checked, 56 percent were successful, and the number of young per successful nest climbed to 1.43.

In January, 1962, a Bald Eagle census was made in the

Chesapeake Bay area (Abbott, 1963). A total of 200 Bald Eagles was found. Periodic checks were made of the nests during the nesting season. Of the 200 Bald Eagles in the area, only 106 attempted to nest. They produced 2, or possibly 3, eaglets. Four of the active Bald Eagle nests were known to have infertile eggs, and there may have been others. Whatever the cause, the poor reproductive success is reason for concern.

Admittedly, the study has only begun, and the data available are scanty. However, it does appear that present reproduction will not maintain the present Bald Eagle population. Predation upon the eggs by raccoons or other predators has been suggested as a possible factor in low fecundity. Others have blamed the encroachment of man into the Bald Eagles' breeding areas. In the opinion of the author, insecticides may play some role in the riddle.

DDT has been recovered in 31 of 32 field specimens collected from many parts of the continent (Udall, 1963). In their study of DDT effects, Wallace et al. (1961) found predatory birds along with songbirds. Lay (1958) found shrikes and Sparrow Hawks as casualties in the fire ant program. On Tule Lake, California, DeWitt et al. (1960) found high concentrations of insecticides in fish-eating birds. Both laboratory and field investigations have confirmed that insecticides can lower reproduction in some birds (DeWitt, 1956; Genelly and Rudd, 1956; and Wright, 1960).

Even though Bald Eagles are birds of prey, carrion is also an important part of the diet. As with practically all birds or mammals of prey, sick, crippled, and dying animals are easiest to capture. Bald Eagles' diets in particular consist of fish and other animals that are washed up on ocean, lake, or stream banks. It would appear then that Bald Eagles would be extremely likely to be exposed when insecticides were used within their feeding territories. Dr. Baumgartner (pers. comm.) relates how he has seen Sparrow Hawks attracted to a city area by incapacitated blackbirds that had received poison. In a matter of minutes one hawk had killed more than half a dozen of the hapless victims. In the author's opinion, it may be possible for eagles to receive sub-lethal doses of insecticides due to their food-capturing habits and their niche near the top of the food chain pyramid.

It is not the intent of the author to blame insecticides for the majority of bird mortality. Insecticides are still used on a relatively small percent of the total United States land mass. It is the author's opinion, however, that improper use can lead to considerable immediate, localized bird mortality and, more important, that longterm effects may be much more significant than they are presently thought to be.

CHAPTER VIII

CONCLUSIONS AND RECOMMENDATIONS

Conclusions

> Nature is leisurely and man must learn from her, lest his impatience cut him off from the very sources of his life.[3]

Studies of the Dutch elm disease spray programs, the fire ant programs, and the Japanese beetle programs have all furnished evidence of considerable localized bird mortality. The author finds some basis for the statement in Silent Spring (Carson, 1962) that chemicals have been used "with little or no advance investigation of their effect on soil, water, wildlife, and man himself." In Michigan 18 residential communities sustained breeding bird mortalities of approximately 90 percent (Wallace et al., 1961). In Wisconsin DED programs led to 30 to 90 percent reductions in breeding bird populations (Hunt, 1960). Hickey (1961) estimates the urban loss of birdlife from DED programs in the Middle West to be 3/4 to 1 million songbirds. Fire ant programs in the South led to almost complete extermination of Bobwhite (Clawson and Baker, 1959). Recent attempts at

[3]Roland C. Clement, "How Far Can We Go in Controlling Nature?" Audubon Magazine, LXIV (1962), p. 186.

Japanese beetle eradication in Illinois led to songbird mortality estimated at 80 percent (Bartel, 1960).

Though some of the immediate, localized bird losses are significant, many investigators are more concerned about possible long term effects. Wright (1960) found circumstantial evidence of DDT and/or heptachlor lowering Woodcock reproduction. The author points out the possibility that the present low rate of reproduction in Bald Eagles may be caused or the result of widespread use of DDT and other insecticides.

Controversies and misunderstanding concerning insecticides have been compounded by insufficient preparatory field research (as with the fire ant program) and inaccurate and insufficient advance publicity with both the fire ant and Japanese beetle programs (Hickey, 1961). On the other hand, some zealous protectors of wildlife have issued exaggerated claims of bird losses (Dietrich, 1960). Cooperation between government agencies has sometimes been lacking. Klimstra (1961) sent questionnaires and found that almost 90 percent of the state departments of agriculture said they cooperated with both the United States government and their own conservation departments; however, more than 50 percent of the state departments of conservation reported lack of cooperation from state and federal agricultural departments.

Economic Values Have Prevailed

In the author's opinion the accelerated technology of the past two decades has led to unlimited faith on the part of the citizenry that we are now capable of completely managing the environment. The generalizations arrived at have been those of the physical sciences (Clement, 1962). The influence from "biologists" has been too heavily weighted by the entomologists and agriculturists and too little by the ecologists. The result is stated succinctly by Klimstra (1961).

> Too frequently the use of pesticides is rationalized only on the basis of economics, food production, or unfounded evidences of human welfare. It appears to be heresy to consider esthetic, economic, and human values that are not directly associated with food production or disease.

The same author poses two questions pertinent to this discussion: 1) How many of our programs include an evaluation of effects on non-target species or habitat changes and food chains? 2) Why not recognize that the responsibilities for the safety and pleasantness of man's biological world reflect the interests of every walk of life, and warrant the integrity and cooperation of every profession related to the problem before us?

Biologists Must Communicate Wildlife Values

If, as Hickey (1961) states, our national policy in regard to songbirds and other wildlife is only now evolving, it behooves biologists in particular to play a significant role in deciding which policies are adopted. Biologists apparently haven't been as effective in getting their views across to the public as have some of the physical scientists. Glass (1957) states,

> . . . there are so few biologists who have gained anything like the required experience by entering in such public affairs as face citizens every day and everywhere. There are so few biologists who make their biology count for anything outside the laboratory and classroom.

If, as Glass says, the biologist is to be a biologist first and a specialist afterward, the biologist must do his part in submitting his qualified observations and opinions to the "public marketplace of ideas."

Let the biologist begin by teaching, speaking, and writing in such a way that he communicates a sense of the joy and consolation of sharing the universe with other living things (Krutch, 1962). Or, to paraphrase Carson (1962), let the biologist tell the world that there is something of intrinsic and indescribable value in the world which is graced by the curving wing of a bird in flight.

In the final analysis it will be the American public which will judge and determine which values receive priority. The methods of protecting food and fiber and looking after man's welfare in general will be no better than the ideas proposed and the theories researched by today's scientists. Certainly much has been learned from the past and some specific recommendations can be made. There is little doubt that <u>Silent Spring</u> (Carson, 1962) has focused new attention on the whole pesticide problem. Two recent Federal bills (H. R. 4487 and S. 1251) reflect the concern shown by government. These bills would authorize the construction and operation of necessary facilities, pesticide evaluation programs, and the wide distribution of information discovered as the result of the research program.

General Recommendations

Virtually all individuals and agencies working on the pesticide problem agree that factual information is lacking. Increased research is of prime importance in both industry and government. There are at least six critical research areas which are particularly important: 1) effects of long-term feeding of sub-lethal doses of insecticides, 2) effects of insecticidal treatments on whole ecological systems, 3) selectively toxic chemicals, 4) non-persistent chemicals, 5) selective methods of application, 6) non-chemical control methods. There have been few successful experiments using introduced biological controls, but in some instances (as with screw worm control) they have been spectacularly effective. Research in this field deserves more attention than it has received in the past.

The President's Science Advisory Committee (1963) recently reviewed the government's role in the pesticide problem and recommended: 1) review of present and proposed Federal control and eradication programs, 2) development of a monitoring system to provide constant data on pesticide residues in the environment, 3) coordination of Federal research programs on pesticides, 4) initiation of a broad educational program delineating the hazards of both recommended use and of the misuse of pesticides, 5) review of pesticide uses and, after hazard evaluation, restriction or disapproval for use on a basis of "reasonable doubt" of safety, 6) a forum for appeal by interested parties.

Specific Recommendations

DED has been controlled in cities in the East with sanitation programs alone. The feasibility of this method should be investigated by some communities in the Middle West. Experimental work in which methoxychlor was used instead of DDT indicated it was much less hazardous to wildlife. If methoxychlor and sanitation prove successful in the Wisconsin and Illinois communities where now in use, this program should be adopted by the communities which now use DDT. Regardless of the insecticide used, it should be applied before the main bird migrations begin to lessen toxic effects.

A complete reappraisal of the fire ant program is needed both as to necessity for the program and the manner in which it is to be carried out. Applying the granular poisons only to the ant mounds would certainly be safer for wildlife and much less expensive. The limited results achieved thus far should have convinced the agencies involved that the present insecticides can at best be expected to control the ants -- not eradicate them as was originally planned.

Chemical eradication programs were attempted on the

Japanese beetle in the East but failed. The eradication attempts recently made in the Middle West suggest that the pest will not be eradicated there either. It would seem that it would be more practical to establish milky spore disease at the earliest possible date so the insects can be kept at least under reasonable control.

This paper has pointed out some of the mistakes made in insecticide uses. Insecticides will of necessity continue in use, but values other than the immediate and economic must be considered. It is hoped that the investigations and discussions presented in this paper will contribute to prudent and proper use of insecticides so that wildlife resources may be enjoyed by future generations.

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