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Michigan State University

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Department of Zoology
Michigan State University
East Lansing, Michigan

DR. JACKSON: Over the past years as I have been attending and participating in conferences with the PCO's and associated groups, the name of Rachel Carson has frequently been raised, not entirely with reverence. The whole problem of the relationships of toxicants to the long-range impact on the environment, the whole problem of bird control to Audubon Society and bird lovers--this whole range of things--I'm not sure all of us have been entirely willing to look at all sides of the question. In the past two bird control conferences, we've taken whacks at this dilemma, but have not really come to grips with the rounded portion of this question. So, I am very pleased at this time that we can begin to tackle this, perhaps in a more definitive way. I am pleased that Dr. George Wallace has consented to walk into the lion's den, so to speak, and to take up this whole matter, particularly with some of his background with work in the area of residues and in terms of some of his experiences this past summer with international conferences. So, George, we'll let you take over.

DR. WALLACE: Thank you, Bill, for breaking the ice for me. I always have a few misgivings, being the last speaker on a day's program. Not only because people are getting tired toward the end, I mean toward the end of the program, but also because often, there isn't any time left. So I want to commend the chairman and the previous speaker for leaving me as much time as I had scheduled for my presentation. At another meeting I attended the speaker was not so fortunate. He was on a panel in the morning which dragged out. He had a long and carefully prepared manuscript and he realized as the noon hour approached that he wasn't going to be able to present this material, so he went over his manuscript and started deleting paragraph after paragraph, and at three minutes after twelve when the next to the last speaker sat down he had only a part of the first sentence left of his speech. Incidentally, his topic was Problems About Sex in Middle Age, and he got up and said: "Ladies and Gentlemen, it is a great pleasure," and he sat down. I can assure you of two things: one is I'm not going to talk about sex, the other is I'm

not going to sit down right away, because I have quite a lot of material I want to get off my chest and will take a crack at it.

As you can see from the general tenor of the printed program for this seminar, I am in the unenviable position of trying to discourage you from certain types of chemical control; but my assigned topic "Side Effects of Persistent Toxicants," implies that mission. However, my remarks may be somewhat anticlimax at this time, because it is now generally conceded that we need to reevaluate certain chemicals in control work and to restrict or severely curtail use of those that persist for long periods in the environment. So let me detail my reasons for a somewhat negative attitude toward the use of the persistent hydrocarbons from my experience with the effects of these materials on birds.

But first a few words of caution about control work in general, which so often disrupts natural processes and leads to new and unforseen difficulties. As an example, I think of the irruption of mice in the Klamath valley in northern California and southern Oregon in the late '50's. Intensive predator control, particularly of coyotes, but also of hawks and owls, was followed by a severe outbreak of mice in the spring of 1958. To combat the plague of mice, poisoned bait (1080 and zinc phosphide) was widely distributed in an area used by 500,000 waterfowl each spring. More than 3,000 geese were poisoned, so driving parties were organized to keep the geese off the treated fields. Here it seems conceivable that the whole chain of costly events--cost of the original and probably unnecessary predator control, economic loss to crops from the mouse outbreak, another poisoning campaign to combat the mice, loss of valuable waterfowl resources, and man-hours involved in flushing geese from the fields--might have been averted by a policy of not interfering with the original predator-prey relationship.

This points to a dilemma we always face. (We create deplorable situations by clumsy interference with natural processes, then seek artificial cures to correct our mistakes.) For example, we spend millions of dollars in seeking cures for cancer, but do little or nothing about restricting the use of known or suspected carcinogens such as nicotine and DDT.

Now a few remarks about problems created by our attempts to control Dutch elm disease. Spraying of an elm tree, or a rose bush or apple tree, creates three quite different problems: (1) drift of toxic materials away from the target, (2) persistent poisonous residues on the bark and twigs, and (3) accumulations in the soil which introduce other, often baffling, complications. Let us examine each of these problems.

The question of drift can be disposed of briefly. It is now known that most spraying operations create considerable drift, that small particles are carried in the atmosphere to distant regions, explaining the presence of DDT in the air over Pittsburg, on vegetation in the

Arctic, in the flesh of fresh water fishes on islands out at sea, and possibly in penguins in the Antarctic, although the latter might be from aquatic rather than atmospheric sources. Contamination from drift is very small, often measured in parts per billion (you may have 100 times as much DDT in you as that found in penguins), so perhaps it is nothing to worry about. But all of us are a little disturbed, I think, to learn that we have used DDT so freely in the past two decades that almost every living thing on our planet is contaminated with it.

Of more immediate concern, to ornithologists at least, is the persistent residue left on the bark, twigs, and foliage of sprayed trees. This affects all forms of animal life associated with the trees, from insects to squirrels. Spreading sheets under sprayed elms on the campus at the University of Illinois, showed that representatives of 14 insect families, including 4 families of presumably useful predators and parasites on aphids, were felled by the sprays. Incidentally, no bark beetles and no cicadellids (the vectors of phloem necrosis) were found among the insect victims.

Among birds habitually feeding in sprayed elm trees in southern Michigan, we have found several different food-habit types represented among the victims: bark-foragers, twig-gleaners, foliage-gleaners, and budders. We have analyzed samples from all of these categories and have found what we consider lethal levels of DDT (the lethal levels determined by feeding experiments with birds) in most of the specimens. Results of these analyses have been published elsewhere and need not be detailed here. [Audubon magazine 65(4): 198-203. Ed.]

The bark-foragers, of course, include such useful birds as woodpeckers, nuthatches and chickadees; the twig-gleaners include the gnatcatcher, kinglets, and early arriving warblers; the foliage-gleaners include the later warblers, vireos, and orioles; and the budders include a wide assortment of fringillids, such as grosbeaks, buntings, finches, and sparrows. Since all of these food-habit types, except the budders, are almost exclusively insectivorous, it raises a provocative question. How much damage has been done by the destruction of these insectivorous birds, which in southern Michigan include about 40 species that feed in the elm trees at about the time bark beetles are supposed to emerge and fly to other trees? I contend that the spread of Dutch elm disease has been hastened rather than halted by spraying, because spraying destroys the natural agencies which would slow down, though not entirely prevent, the spread of the disease.

A more serious, long-lasting, and complicated situation is created, as I am sure you all know by now, by accumulations of toxic materials in the soil. Residues under elms are derived from three sources: (1) settling from the atmosphere, (2) run-off or wash-off from bark, twigs and foliage (if foliar sprays are used), and (3) exfoliation, that is, the sloughing off of bark, twigs, and the falling of leaves. All of these sources contribute to a build-up of residues in soils over a

period of time, so that, in some cases at least, accumulations may be greater several months or a year after spraying than at the time of spraying.

However, our analyses of campus soils indicates a fairly rapid decline of DDT, we believe not from breakdown or decomposition, but by transfer to soil organisms such as earthworms. Analysis of soil samples soon after spraying shows that soils are carrying higher residues than the earthworms, but in a year or two after spraying the earthworms are carrying higher residues than the soils. We predict, on the basis of preliminary findings, that soil residues will continue to decline at a faster rate than the residues in soil organisms, so that in time, without additional spraying, worms will be carrying 10 or more times the concentration found in the soils in which they live. Hence, contaminated earthworms pose a threat to nearly everything that feeds on them--fish, frogs, salamanders, snakes, moles, shrews, and a great variety of ground-feeding birds. In a sense, then, earthworms and the sacrificed animals that feed on them are great purifiers of the soil, but they are also great redistributors through the various food chains indicated below.

The most publicized victim in the terrestrial phase of the DDT cycle is the robin. I estimate--conservatively as I am sure I could show if time permitted--that millions of robins have died of DDT poisoning in elm-treated areas. We analyzed about 160 specimens and all but one of them from DDT-treated areas were carrying DDT, so we know that robins, as well as the 50 or so other species of birds that we have examined, are great redistributors of DDT. At the time of death a robin has accumulated about 11,000 micrograms of DDT which is then transferred to another location--the rubbish heap, laboratory refrigerator, house cat, hawk or owl.

Perhaps the most serious aspect of terrestrial food chains is the effect on predators taking contaminated prey. Since the possibility of secondary poisoning with DDT has been questioned from time to time, or even denied in some cases, we carried out some experiments feeding DDT-treated sparrows and mice to a variety of hawks and owls. As few as six contaminated mice or sparrows proved to be a lethal dose for sparrow hawks. In nature, of course, a predator would usually be taking a greater variety of prey, some of it perhaps less contaminated than our sparrows and mice, but bear in mind that living prey may be carrying a greater total body burden of DDT than animals that have died of poisoning. This is because a bird in tremors ceases to feed, utilizes its DDT-saturated fat, and excretes some of the poison from the fat before it dies, but usually not at a fast enough rate to survive lethal accumulations in the brain. Thus a living bird, before it has depleted its fat reserves, may be a greater hazard for a predator than a dead bird. It would also be a prime target during its period of impaired mobility; one of the important functions of predation is to

dispose of incapacitated prey animals.

In discussing pesticides in aquatic cycles I would appear to be getting away from Dutch elm disease, but this is not necessarily so. Sprayed elms are often situated along streams which results in contamination from settling, drift, and falling vegetative parts. Aquatic environments seem to be even more susceptible to persistent contamination than the terrestrial ones. DDT, for instance, is relatively insoluble in water, but is quickly incorporated into aquatic organisms and passed on through varied food chains, from phyto- and zooplankton into herbivorous and carnivorous fishes, and eventually into a great variety of fish-eating birds--loons, grebes, pelicans, herons, egrets, gulls, terns, eagles, ospreys and kingfishers. Pesticide contamination in the Great Lakes is now a threat to all aquatic life, owing to run-off from orchards, as well as from elm spraying and mosquito control along contributing streams.

Problems of the side effects of persistent toxicants are now worldwide. At the meeting of the International Council for Bird Preservation held in Cambridge, England, this summer, delegates from about 20 participating countries discussed their widely varying problems due to pesticides. The decline of the golden eagle in Scotland was attributed to the eagles feeding on sheep carrying dieldrin from sheep dips in their wool. In Sweden, as well as in other western European countries, the near extermination of many predatory birds was blamed on secondary poisoning from feeding on the victims of mercury-treated seeds. In Israel, thallium sulphate was so heavily used in rodent control that nearly all predatory birds and mammals disappeared and many people were poisoned. Use of thallium sulphate has now been banned in Israel, but rodent plagues continue, surely in part due to the almost total loss of predators in that country. Parts of South America and parts of Africa, according to reports, have been severely devastated by overuse and misuse of pesticides. Several delegates to the convention raised the question of the ethics involved in the United States still shipping to foreign countries large quantities of pesticides whose use is no longer considered safe at home, or, in some cases, is illegal.

In conclusion, you may well ask, and I do too: what are we going to do about the dilemmas we face concerning the side effects of persistent toxicants? The amazing, and to me shocking, thing about the whole situation is that we are doing so little, or doing it so slowly. More than three years ago the President's Science Advisory Committee recommended progressive reduction, and eventually total elimination, in the use of the persistent hydrocarbons. I have been preaching pretty much the same gospel for ten years. But neither I nor the President's Science Advisory Committee have made much progress. All of us--whether pro or con--ask for more research, more information, more answers to unanswered questions. To accomplish this we plan to spend millions of dollars in further research, in part to verify what we

already know, and, unintentionally of course, creating new problems while trying to solve others.

Perhaps a good example of well intentioned tampering with nature is the costly research devoted to controlling weather cycles. What a boon to agriculture it would be if we could regulate rainfall. But some alarmists--who I predict are in for a bad time--have pointed out that plant and animal cycles have evolved and become adjusted over millions of years to variations in rainfall and other weather conditions. Disrupting these cycles would eliminate many useful plants and animals which might be replaced by weed species of plants and nuisance animals.

Unfortunately, I can offer no practical solution to these dilemmas we face. Obviously I favor as little interference with natural processes as possible, but obviously also, such a rule of thumb is not always practical in modern society. But like the man who gave up trying to control dandelions in his lawn and learned to live with them, we need to learn to live with nature, to cooperate with her rather than trying to beat her into submission.

DISCUSSION

DR. WALLACE: I used up all of my time so no one would ask me any questions.

DR. JACKSON: I think that you have raised a number of interesting theses. I suspect there are going to be some comments.

J. STECKEL: I think that one of the questions that will probably always come up is that it is awfully hard to take something away unless you have something to replace it. I think if we could maybe use your first illustration here where you are spraying elm trees with DDT; now they are starting to do work with systemics, to inject the tree where you don't get the hazards that there have been, the hazard of residues on surfaces and so forth. You can begin to see that this is taking effect. Now, is this a movement that you agree with or is there any dissent?

DR. WALLACE: Yes, I had great hopes for Bidrin. I guess they spent hundreds of thousands of dollars and newspapers came out with a glowing report, the final answer to our Dutch elm problem--injecting the trees with Bidrin. Some of our entomologists tried it and killed the trees. Dr. Norris, who worked on this, was never as optimistic about it as the newspaper reports, but he had a great deal of faith or at least optimism about it. But I understand that they've largely given up the idea now of trying to control the disease with Bidrin. There was another miracle chemical that was going to do the job but it didn't and

the company stopped the manufacture of the thing; so it's not available --it didn't work either. So I think that Bidrin is still a possibility but it takes a lot of training to get exactly the right amount into a tree. If you don't get enough it doesn't do the job, and if you get too much it kills the tree. But it doesn't have this, as far as we know, residue problem of contaminating the whole environment. . . . It also doesn't last very long.

J. STECKEL: Well, I wouldn't know the facts in particular, but I was just wondering, are there hazards to systemics? Do you have concerns here about the aphid dying and falling off on the ground and . . . ?

DR. WALLACE: I wonder, it presumably sterilizes the tree, like your airports; maybe that's the answer--complete sterilization of something you want to save whether it's an elm tree or keeping wildlife off an airport. But some of us shudder at the possible consequences of complete sterilization of any part of the environment, and the loss of all the animal life associated with that particular thing, whether it is an elm tree or something else. But, of course, if you can produce some good, demonstrate some good, anybody that's cynical about it runs into trouble. I think of this--(I can use this illustration because I don't know anything about it)--we're going to spend millions and millions of dollars, as you know, trying to control the weather. Now wouldn't that be a wonderful thing--a boon to agriculture--if we could simply control the rainfall--get it when we want it? You could have Sunday school picnics when you want them and just control the weather. But, imagine the problems you run into. The farmer wants it to rain a certain afternoon and somebody--a baseball fan--doesn't want it to rain that afternoon and who's going to win out? The farmer is more important, but the sheer superiority of numbers of baseball fans may win out.

But I'm thinking of something more serious, some ecologists whom I predict are in for a bad time in the future, have pointed out that controlling the weather might eliminate vast numbers of useful plants and animals which over the millions of years of the past have become geared or adjusted to variations in weather cycles. You know, of course, the desert is the most glaring example; things exist at all in the desert by being able to take advantage of rainfall when it comes. Now if we could sprinkle the deserts whenever we wanted to, move out there and grow grass, we're eliminating a lot of things that have evolved over the millions of years to adapt to that particular environment.

Some of the ecologists point out that these lost plants and animals would be replaced by weak species of plants, (there's an opportunity to use more herbicides) and also pest animals, (an opportunity to use more insecticides and rodenticides). I don't know whether they are just theorizing but it is a logical conclusion. A lot of our control operations

result in the simplification of your environment, a reduction in the variety of plant and animal life. Of course, sometimes that's what we want, in a garden or around your rosebushes and so forth. But, when you try to apply this to larger and larger areas in your environment, you're going to run into a lot of trouble.

L. STEVENS: Don't you develop that same thesis, though, and say, well, we shouldn't build any more roads or any more buildings? We shouldn't manufacture and pollute the air and the streams and so forth? End all human development; preserve our present habitat?

DR. WALLACE: Well, we think we're going to reach a point where we're going to have to stop building roads, stop raising more food and stop a lot of these things. I mean, what are you going to run into, there are too many people, too many roads, too many buildings. The planet won't support the number of people that they predict we'll have in 50 to 100 years. I don't know; I really doubt that we'll reach that level of standing room only. I saw an interesting film in England on colonial birds and the speaker, Roger Tory Peterson, said that's what's going to happen to people pretty soon. These birds had standing room only on the cliff. That's what they have for colonial birds for nesting purposes. Here were some birds without any standing room and they came down and lit on the backs of the birds that were nearest the edge of the cliff and pushed them off. He said that's what's going to happen to people when we have standing room only. That's really not a very good answer to your question. It's a good question but there is a limit.

L. STEVENS: Then you reach the point where you have to control people so you are again upsetting the habitat so you're right back where you started.

DR. JACKSON: I'd like to go on at this point and ask another question --we're commenting that we all have a certain amount of DDT in us, so many parts per million, particularly in the fat tissues. My question is, so what? Public Health Service records show that over the last decade this has stabilized, there's been no real increase in man. At these levels I don't think anybody has been able to demonstrate it's an important carcinogen. So what, it's stabilized. Isn't this something we're learning to live with and it's the price we pay for civilization?

DR. WALLACE: Actually, we could stand quite a lot more than we have. The question that many medical men have raised is, what does it do? Does it increase the rate of cancer and some of the blood diseases and a lot of other things? I've read a lot of the literature from the human medical aspect, but I don't know anything about it and don't have any particular convictions. But, the attitude of the medical profession

indicates that they're getting more cautious. Say that we breathe a stabilized level of this stuff, we excrete it about as fast as we take it in. You're taking in some DDT daily, but you're also excreting it. The thing that isn't known, is it producing an effect on the liver and the kidneys and so forth? It might be and we don't know and medical men don't know.

DR. JACKSON: So the way things look now, the answer is "No."

H. COLEMAN: Well, hasn't the equipment, the ability to detect DDT improved over what it was in the years past?

DR. WALLACE: We can now detect parts per billion, I guess even parts per trillion. Whereas, formerly, like on our original analyses on robins, we weren't concerned with levels below 10 parts per million. Well, this has no effect upon the robin. You get up to 30 and then you can begin to wonder what this is doing to the bird and in the robin 50 parts per million on the brain becomes lethal. Presumably we can keep it out of our brain by routing it to other parts of the anatomy. I think that one of the reasons that birds appear to be more susceptible than mammals is that mammals have a greater capacity to excrete the material than birds do, because as you probably know, the excretory system in birds doesn't produce any urine. In mammals, they can convert DDT into DDA and metabolize and excrete it, at least part of it, in the urine, but birds don't have any urine to speak of and water is recycled through the system. I just theorize that the bird has a much harder time getting rid of the material than a mammal would. It's just recycled and goes round and round.

DR. CORNWELL: You know, Dr. Wallace has brought us to a very high plain of philosophy here and rather than revert back to the technical, I'm wondering if we aren't dealing with a very basic thing here which is human behavior. And, at a family state where I'm watching very young children playing, unsupervised by adults, it seems to me that a great part of their total capacity goes into altering their environment and they devote a great deal of ingenuity to it. As we stood up here and represented ourselves as to our profession, the majority of us adults in this room devote our working time to altering our environments, by playing games. This seems to be a very basic life force in us and so perhaps our concern in seeking social answers would be to find ways that we can play our environmental games without altering the systems that are concerned.

DR. WALLACE: Of course, there really is a lot we can do to increase our food production, which we've got to do, but how much can you borrow from other interests and other needs. I give you the illustration,

I'm told that the Bird Protection Committee of the AOU that they're clearing the tropical rain forest at a terrific rate to get cultivatable land to produce corn and food to feed the masses in the tropical countries. Well, what is this going to do to the environment? I think first of the water resources, the rainfall and so forth. It's going to cause erosion and flooding and then lack of water. A lot of possible repercussions from large scale manipulation of the environment.

DR. JACKSON: We keep coming back to this man problem. Well, thank you very much, George.