The Ecologists' Role in Problems of Pesticide Pollution

All of us have long been deeply concerned with pollution problems and have long felt that these problems are indeed serious largely because it is rare that either our state or national governments, or our people generally, have thought or acted ecologically. Our monstrous control or eradication programs of government have largely ignored ecological relationships — if they knew anything about them. Consequently, their results have usually left much to be desired.

Need of ecological understanding

The application of ecological principles in the management of our renewable natural resources is one of America's major needs. Indeed, our nation's security, progress, and future greatness, in large measure, will be determined by the degree of wisdom and foresight used in the management of these resources. The abundance, diversity, and availability of these resources represent the physical basis of America's wealth, greatness, and stability. The importance of wise, sustained management that will insure use without abuse of all our resources, where all interests are appropriately considered, should need no defense.

Soil, water, air, and sunlight are the four basic ingredients that make life on Mother Earth possible. Accordingly, life is curtailed or handicapped to the extent that any of these basic necessities are made unusable or unavailable.

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Pollution abatement and an abundance of clean, usable water, therefore, have far more than academic significance for us and for those of succeeding generations.

The role of ecologists as organized leaders in resource management in America has borne little relationship to the needs or to the role they should have taken, or to the role that should yet be taken. Despite this, many individuals with an ecological and conservation conscience and an understanding of natural relationships have done considerable, and much of this has been effective.[10, 14, 15, 16, 17, 18, 21, 44, 51] Dr. Rachel Carson [9, 10] is a foremost recent example, as her earlier writing has been basically ecological. Dr. Ira N. Gabrielson, and earlier Jay D. (Ding) Darling, Hugh H. Bennett,[3] and Gifford Pinchot have effectively led movements toward better land use practices. Earlier leaders who have contributed greatly to ecological thinking certainly would include Aldo Leopold,[37] Homer L. Schantz,[47] Charles S. Elton,[26, 27] and G. P. Marsh.[39] Many eminent contemporaries are broadening the horizon of ecological thinking and a few of them are striving for action programs. Among these, the names of Frank E. Egler,[25] Frank Fraser Darling,[19, 20] A. Starker Leopold,[38] Ray Fosberg,[28] and LaMont C. Cole [12] should be listed.

Only rarely have ecologists, as an organized group, shown leadership in attempting to guide or influence resource management. Neither, it seems, have we had the courage to oppose even the more flagrant cases of environmental pollution or the destructive exploitation of our basic resources. It is time we, as an informed, articulate group, speak out, for the hour is growing late. We have a golden opportunity and a moral obligation to point the way. If we show leadership and courage, we will command respect and support.

The time is ripe for such leadership because our people are concerned and worried about the widespread pollution that is occurring. This is true despite the alarming fact that there appears to be little comprehension, even among the most educated, of ecological relationships throughout nature. On matters of resource management that alter or regulate population size and composition of biotic communities, there appears to be little public understanding of the factors involved. Worst of all, our policymakers, on nearly all national and state levels, are seeking and obtaining advice on such matters from groups of scientists who seem to be unaware of the existence of ecology. Many examples could be given.

The alarming human population explosion needs to be viewed from its probable ecological consequences.[13] We are polluting our environment at an unprecedented rate and with levels of radioisotopes and biocides to which this earth's biota have never before had to adapt. Poisonous, broad-spectrum, stable pesticides of many kinds * in almost unlimited amounts are placed in the hands of a public which knows little of how to use them nor of the possible or probable consequences of their use. Under national leadership and advice, extensive control or eradication programs have been inaugurated with dangerous, stable, broad-spectrum insecticides before even the leadership knew the safe levels of application or minimum dosages required. They knew but little of the immediate and almost nothing of the indirect, delayed side effects of such programs. The uncomplimentary history of the attempted fire ant eradication is but one case in point. Do we need better proof that an ecological understanding of nature is sorely needed? A few more recent examples showing the need of an ecological approach may be helpful.

Mississippi fish kill

Rough estimates of fish kill loss [5, 11] on the Lower Mississippi and its bypass, the Atchafalaya in southern Louisiana, in 1960, were listed at 3½ million, something slightly under one million each in 1961 and again in 1962, and from 5-10 million in 1963. Many species were killed, including catfish of several kinds, menhaden, mullet, sea trout, drum, shad, and buffalo. An intensive search for the cause by teams of researchers from agencies of government and the Monsanto Research Laboratories has given convincing evidence that the highly toxic insecticide endrin is at least the major cause.[5, 6, 40, 49] Extracts of mud from the areas where fish were dying killed healthy fish, as did tissue extracts of dying fish. Endrin, or its epoxide, was a common factor in all extracts studied. Dieldrin, DDT, or its metabolites, and other chlorinated hydrocarbons were also commonly found both in the mud and water. It is well to record [6, 11] that endrin or its epoxide has been found at all river levels south of Cape Gerardeau, Missouri, and dieldrin, or its analogue aldrin, was found at all stations between Dubuque, Iowa and New Orleans.

Through the development of highly sensitive methods of testing,[11, 45] endrin was found in the blood and kidney tissues of dying fish and waterfowl. A comparison of endrin concentrations in river water and in the bloodstreams of apparently healthy river fish revealed that the fish possessed a considerably higher endrin concentration. Dying river fish of a given species, and fish dying after exposure to experimental endrin solutions, had bloodstream endrin levels that were very similar. Dying river catfish contained 0.40 to 0.56 micrograms of endrin per gram of blood, or 0.40 to 0.56 ppm. Others were later found with as little as 0.26 ppm in the blood. In laboratory tests conducted by the Public Health Service, endrin concentrations in water ranged from 1.6 to 40.0 ppb and produced blood levels of 0.39 to 1.4 ppm, and death in 2-4 hours to 13 days. Other species of fish, including buffalo and shad, died with as little as 0.12 to 0.16 ppm of endrin in their blood. Obviously, the fish are able to and do concentrate the endrin in their bodies.

Loss of employment and income resulting from the destruction of fisheries resources is indeed serious.

Endrin, in 1960 and in 1963, was commonly used as an insecticide in the Lower Mississippi Valley on cotton and sugar cane. Little or none was used there in 1961 and 1962, which undoubtedly accounts for the lessened mortality of fish in those years. In 1963, some 1,661,000 pounds of endrin were applied to agricultural control operations in Louisiana, Mississippi, Arkansas, and Oklahoma. Ten-million pounds of aldrin were used in the Corn Belt States in 1963, and 160,000 pounds in Louisiana rice fields.

From information obtained, it appears that these pesticide pollutants got into the river from two major sources: (1) waste from a manufacturing plant producing endrin at Memphis, Tennessee, and (2) run-off from agricultural lands following crop dusting and spraying. As might be expected, all of the details by which pesticides enter river systems have not been fully worked out. Despite denials and protests of one company manufacturing endrin, the

* Approximately 500 different compounds are involved in some 56,000 pesticide formulations registered in the United States.

evidence is indeed convincing that this exceedingly toxic chemical is getting into our river courses [31, 36] and has already caused much loss of fish and probably other wildlife resources.

Clear Lake — a case of concentration build-up and delayed poisoning

Clear Lake,[34, 35, 46] comprising some 46,000 acres, about 100 miles north of San Francisco, California, is an attractive recreation and tourist center. Unfortunately, it occasionally produces a crop of pestiferous gnats. To control these with a relatively "mild and harmless" pesticide, DDD was used at the rate of about 0.02 ppm late in the summer of 1949 and again in 1954. Fully 99% of the gnats were eliminated at each application. The area was again sprayed in 1957, but not nearly so successfully. The gnats had developed a degree of resistance. Nearly 150 species of insects and related pests have now developed a degree of immunity against pesticides.

From time immemorial Clear Lake had been a favored nesting ground for western grebes, a species of diving birds common in the West that feeds on small fish and other aquatic animal life in the water. Until 1950, about 1000 pairs of these birds nested at Clear Lake. No young of these birds were produced from 1950 until 1962, when a single baby grebe hatched. And three hatched in 1963! From 1958 until 1963, about 15 to 20 nests were found, but no young were hatched until the single baby was produced in 1962. A serious die-off of grebes occurred in late winter and early spring of 1954 and again in 1957, 1959, 1961, and 1962, and probably also in other years. Some other fish-eating wading birds also are known to have died of DDD poisoning.

It is noted that a die-off of grebes occurred of DDD poisoning 5 years after the last application of DDD and long after a time when this pesticide could be detected in the water or mud of the lake. Still, it is interesting and highly significant to note that DDD or a metabolite was found concentrated to an amazing degree in the food-chain organisms, as follows: In plankton, DDD was found as high as 5.3 ppm, a 265-fold increase over the maximum applied; from the visceral fat of frogs and carp, from 5 to 40 ppm, representing a 2000-fold increase of the toxicant; in bluegills (fish), 125 to 250 ppm, up to a 12,500-fold increase; in bullhead fish, from 342 to 2700, up to a 135,000-fold increase; in grebes, up to 1600 ppm, an 80,000-fold increase; in largemouth bass, from 1550 to 1700 ppm, up to a 85,000-fold increase; in whitefish, from 80 to 2375 ppm, up to a 118,750-fold increase.

The flesh of the more edible fish contained DDD as follows: bluegills from 5 to 10 ppm, up to a 500-fold increase; bullheads, 12 to 80 ppm, up to a 4000-fold increase; largemouth bass, 4 to 138 ppm, and white catfish from 1 to 196 ppm, or from a 50 to 9800-fold increase.

It is to be noted that the pesticide DDD was not detected in the water after 2 weeks following an application. Still, the food-chain organisms were able to concentrate amazing quantities of the poison. The simple plankton and the fish that fed directly on this, along with the herbivorous fish, contained relatively small amounts. The carnivorous fish and birds contained much larger concentrations and the larger and older fish contained astronomical concentrations of the pesticide.

Richdale-Colusa study

The Richdale-Colusa study of pheasants illustrates a build-up of the chlorinated hydrocarbon content in the fatty parts of a terrestrial bird, the ring-necked pheasant.

Two areas in the Sacramento Valley were studied by the California Department of Fish and Game.[35, 46] One of these, near Richdale, was listed as the study area, and the other, a control or check area near Colusa, is a state wildlife refuge-management area. At the study area, agriculture, with its pesticidal controls, was carried on normally. No pesticides were used directly on the control area although some drift deposits reached the area from adjacent agriculturally treated farm lands.

Twenty-one female pheasants and their nests were located on the study area and 29 on the control refuge. These wild females were sacrificed and the eggs from the nests were collected, studied, or incubated, and the young held until they were 6 weeks of age. DDT and its metabolite, DDE, were found in all samples of eggs and in all pheasants from both areas. Other chlorinated hydrocarbons were also found in most samples. DDT, in one female bird from the study area, measured 2930 ppm in the visceral fat. The average of the 21 birds from this group measured 741.05 ppm DDT or metabolites as against an average of 2.14 ppm from the 29 control birds taken on the Colusa refuge. Dieldrin, in the study group of birds, measured from 0 to 25 ppm. Four egg yolks from the study area contained up to 9.6 ppm of dieldrin and from 0.8 to 1020 ppm DDT and averaged 510.7, as against 1.87 ppm in the control group. Fat extract from yolks ranged from 4.4 to 227.2 ppm DDT, while dieldrin ranged from 0 to 8.26 ppm.

A study of reproduction showed no significant difference in the clutch size, fertility, or hatching, yet a very noticeable difference in survival rate up to 6 weeks of age. It is interesting to note that DeWitt and associates [21, 22, 23] noted a marked difference in clutch size, fertility, hatchability, as well as survival, between pheasants fed small sublethal doses of chlorinated hydrocarbons in contrast with similar birds fed on a pesticide-free diet. Mortality of the California study-area-hatched-pheasants was 46.6%, and crippling was 25%, or a total of 71.6% mortality and crippling. In the control hatch, there was by contrast a 27% mortality and a 12.9% crippling, or a total of 39.9% of the hatch. The loss in the study area was, therefore, approximately 179.5% that of the loss in the control area.

It is apparent that chlorinated hydrocarbons had affected both areas, yet it was much more serious in the study area where heavy but normal applications of pesticides had been used.

Klamath Basin poisoning

Klamath Basin is a large, natural sump, shaped somewhat like a giant saucer. It is a federal waterfowl refuge on the border of Oregon and California, northeast of Mt. Shasta, California. It is an area of superior agricultural land and one of the greatest waterfowl concentration areas in the United States. Congress recognized these great values as early as 1908, when it passed a law designed to protect and support its great wildlife and agricultural values. Through recent legislation it has again been recognized for its great wildlife value. Because it is a natural sump, it receives the run-off drainage and irrigation water from adjacent agricultural lands.

In May, 1960, the federal refuge

manager found 307 large fisheating birds — pelicans, coromorants, grebes, herons, and egrets — dead or dying. The loss continued. Detailed studies were promptly made and it was soon evident that these birds were not dying of disease but from poisoning — from an accumulation of minute, sublethal doses of stable, broad-spectrum pesticides of several kinds. One American or Common Egret that died was found to contain 207 ppm of chlorinated hydrocarbons consisting of toxaphene, DDT, and DDD. A western grebe contained 689 ppm of toxaphene and DDT in its visceral fat. It is of interest to note that DDT had been used as a common pesticide on agricultural lands on the adjacent watershed for some 19 years! The other insecticide had been used for a much shorter period of time. The run-off from the land appears to be the only source of pesticides found in the water.

The meaning of these examples

It is most important to realize that these birds were killed because they were at the end of a food-chain line that had become contaminated. A study of the food chain revealed again that these highly toxic, stable, broad-spectrum toxicants had been accumulated and greatly concentrated from a multiplicity of sublethal doses until the point of lethality in their bodies had been reached. Data are rapidly accumulating showing this same story with a great variety of local variations because of local and peculiar conditions. Basically, this story is being repeated over and over again throughout America, at Bear Lake, California; Lake George, New York; Lake Sebago, Maine; and Coastal Louisiana, to cite a few examples, and we may be sure that many others will come to light in increasing numbers.

As biologists, we know that those processes by which wildlife and human beings acquire contaminants are similar. We also must know that the chlorinated hydrocarbons are increasing in our own bodies because we live in a contaminated environment that is rapidly becoming increasingly more contaminated.

Late last winter and early last spring, as already recorded, there was a terrific die-off of commercially valuable fish in the lower reaches of the Mississippi River. There was also a loss of a "considerable" number of waterfowl (ducks) in the same area. We yet have little information as to the extent of the loss of the food-chain organisms and the other aquatic resources near the mouth of the River, such as oysters, shrimp, and crabs. Research has demonstrated that DDT at a concentration of 0.007 ppm, for 96 hours, will reduce growth of oysters to one-half that of untreated controls. Endrin at 0.006 ppm will cause death or paralysis of 50% of the shrimp exposed for 24 hours.[51] A year ago the predictions were high that we would harvest a bumper crop of shrimp in the Gulf of Mexico, near the mouth of the Mississippi. At least near the mouth of the river the catches have been disappointing. Reports of catches out in the Gulf have not yet been received. Let us remember that several million human beings take their water from the Mississippi and much of their food. Certainly it would represent maturity of judgment to realize that some subsequent die-off could or might involve more than fish, ducks, and shrimp! A high administrative official directing control work of the U.S. Department of Agriculture shouted at me in indignation at a meeting in New York several years ago, "Why get excited over the use of pesticides, none of us has died yet?" Perhaps your descendants or mine or his may yet live to see that day — when it will be too late to get concerned or excited!

Some terrestrial examples of pollution

Not only are the toxic contaminants so polluting the aquatic environment that segments of these resources are being damaged and destroyed, but we are seeing more and more evidence that the terrestrial environments too frequently are showing some of these same depressing symptoms.[4, 8, 14, 15, 16, 17, 18, 22, 32, 33, 50, 52, 53] Perhaps a few examples will illustrate this point.

Elm trees, robins, and earthworms are teaching those whose minds have not completely closed through selfish, personal, or other reasons that there are, in fact, throughout nature subtle interrelationships and intricate webs of life. This interrelationship and interdependency in nature is rarely, if ever, in equilibrium or in steady balance, but there is a considerable degree of stability in composition and functioning of biotic communities. Certainly there is indisputable evidence that man is fully capable of disrupting this stability.

We applaud the objective to control our disease-carrying pestiferous insects. We all want them controlled. We want to do all we can to save America's majestic elms. They are a part of our cherished heritage. While we applaud the objective to save them, we question the single-track, shortsighted, chemical approach to the problem, where only one small facet of this situation is considered. Such an approach is ecologically unsound. Any program which destroys 80 or more species of birds, and almost completely eliminates a number of these from extensive local areas, along with an unknown number of beneficial predatory and parasitic insects, needs a more objective study.[53] We believe proof is lacking to show that this approach has been even reasonably effective and successful.

To control the beetle that carries the elm fungus about 2 pounds or more of DDT is sprayed on each mature elm tree. Soil on the surface of the ground shows about 1-3 pounds per acre of DDT or its metabolite. The 2 top inches of soil within a few weeks show about 14.9 ppm DDT, and leaves, about 293 ppm. Later these leaves on the ground contain about 32 ppm. Earthworms feed on the decaying leaves and robins on the earthworms. Earthworms, after spraying, contain about 233 ppm DDT, and late in the winter about 119 ppm. By spring the worms have increased the DDD in their bodies by a factor of 10. The robins are then eliminated from the area. A careful study of an Illinois city following elm disease control showed more than 85% decrease in bird populations.[32, 33] Eight years after the DDT spraying at Michigan State University there are now almost no birds.

The woodcock story is somewhat different and quite significant. This choice and interesting game bird is a common nester in New Brunswick. Two comparable areas in a spruce forest were studied by Wright.[55] One area was sprayed with DDT at 1 pound per acre to control the spruce budworm. The other was considered a check area and was not sprayed. Both areas were hunted normally in the fall for woodcock. From 1953 to 1958, before DDT was applied, the ratio of young to adult birds in the hunters' bags averaged about 50 to 50. In 1958, one area was sprayed. In 1959, no spraying occurred. It was a year of unusual production. On the unit of the forest sprayed in 1958, the ratio of woodcock taken during the fall hunting season was 49 young to 51 adult; in the check, nonsprayed area it was 60 young to 40 adults. In 1960-61 (fall and early spring), the treated area was again partially sprayed. The fall hunting season of 1961 gave a ratio of 19 young to 81 adult, and with better than 50-50 young-adult ratio in the check area. This seems a clear reflection of the effect of the pesticide on reproduction.

Our eagles and hawks

DeWitt et al.,[22, 23] Peterson,[42] Rudd,[44] Buchheister,[7] Buckley,[8] and many others have shown the serious delayed effects of America's pesticide programs. Unless the present trends are soon reversed, another decade is likely to see the last of our American emblem, the Bald Eagle, as a nesting species on nearly all of our Atlantic seaboard. It is at the end of a food chain that is being poisoned. During the past 10 years the ratio of adult to young bald eagles has decreased from 40 young and 60 adult to 15 young and 85 adult. For the past 2 years, there has been an almost complete failure of nesting pairs from North Carolina to Maine, and a marked decrease over much of this continent.

Of 27 carcasses of eagles tested in 1961-62, all but one, and that a juvenile taken in northern Alaska, showed appreciable levels of DDT and related pesticides in their bodies.[22] Eggs that failed to hatch showed a high level of poison. The osprey shows a similar trend and it, too, is declining alarmingly. Other raptorial birds in England [1] and America also find themselves in trouble because they are at the end of a food chain that is contaminated.

Delayed poisoning

These pesticide examples might end with a report of a very brief but highly significant study at Michigan State University. Richard Bernard [4] fed two groups of captive English sparrows on the same diet with the exception that a small sublethal dose of DDT was added to one group. Both groups of birds fared well and got fat. After several months both groups were starved for 16 hours, and by that time all of the sparrows that had accumulated much DDT in their fat had died. None of the sparrows in the other group was affected. Both groups seemed to be equally well and active before the start of the 16-hour fast.

When birds, fish, mammals, or humans have significant concentrations of chlorinated hydrocarbons in their fat and become ill, suffer a degree of starvation, or otherwise rapidly lose weight, it seems not improbable that the fat with the poison in solution would be absorbed into the blood stream, to supply the energy deficiency. There are indications that the released stored pesticide may then cause serious trouble.

Heavy losses of fish were observed [30] 4 months after spraying a large forest tract of the Yellowstone River Watershed. Scarcely any loss was recorded immediately following treatment. Later, when the spawning season came on and the fish were under stress and the food supply was diminished, some 600 dead and dying whitefish, brown trout, and suckers, all fall spawners, were counted in less than 300 yards of stream. Losses were noted 90 miles downstream from the treated area.

Perhaps one of the greatest delayed dangers of the excessive widespread use of pesticides is the likelihood of these poisons getting into and contaminating our underground natural aquifers. Many of our lakes and streams already are so dangerously contaminated that the U.S. Public Health Service annually summarizes the reported extent of fish losses from the various states [2] as a possible or probable danger and index to public health. These pollution losses include those from agricultural operations in the use of chemicals and industrial, municipal, and transportation operations and from a miscellany of other causes. The fish loss is serious and increasing.

With the widespread use of nearly a billion pounds of pesticides [48] in the United States per year, it seems inevitable that some of these materials ultimately will penetrate into our underground water reservoirs. Indeed, a number of startling examples already are on record [16, 24] and more seem inevitable unless there is an immediate reversal of present trends. The Montebello, California, case will illustrate this problem.

In June, 1945, a small plant in Alhambra, California, began manufacturing 2,4-D. A batch of the raw material failed to react properly and the chemicals were dumped inadvertently into a sewer. Thence, this waste entered the Alhambra pumping station, passed through the Tri-Cities activated sludge sewage treatment plant, and was discharged into a mile-long ditch. From here, the contaminant traveled some 3 to 5 miles above ground, then seeped into the underground strata from which Montebello, a city of about 25,000 population, obtained its water supply. Within 17 days after the manufacture of the weed killer began, taste and odor of a chemical used in the manufacture of 2,4-D, dichlorophenol, was noticed in the 11 wells supplying the city. The operation of the plant was stopped within 30 days, yet the taste and odor of dichlorophenol persisted for 4 to 5 years. This case is interesting because it shows the possible long-time effects from wastes even though they were unwisely discharged over a relatively short period.

Air contamination

Perhaps to many of our people, pesticide problems may be much less serious than air contamination of fog [29] and nuclear fallout. The production of nuclear energy for wartime or peacetime uses has introduced a host of new pollution problems. We are informed [41] that about 10% of the total explosion energy of an atomic blast comes in the form of residual nuclear radiation which is emitted over a period of time from fallout. The residual radiation is due almost entirely to the radioactivity of the fission products present in the weapon residues of the explosion. Of the radioactive debris produced by fission, 80% is deposited as local fallout, 15% as stratospheric fallout, and 5% as lower atmosphere or tropospheric fallout. The stratospheric fallout may take 6 months or more to settle to the lower atmosphere.

It is clear that the only practical way to assure protection against excessive human exposure to radioactive wastes is to treat and control them at their source before they are discharged into the environment. It is well to remember that some of the effects of radiation are cumulative during the life of the individual. For late effects, such as cancer, the total dose determines the radiation hazard. Consequently, for one who has used up his allowable quota, any further exposure to radiation is indeed hazardous. A further serious problem is the fact that certain important radioisotopes are concentrated by aquatic organisms and by sediments to levels hundreds and thousands of times the concentration in the surrounding water.

Fallout already is serious in arctic regions [43] because of atmospheric nuclear explosions and the resulting atmospheric contamination by the radionuclides, Strontium-90 and Cesium 137. The lichens of the far North receive their nutrients directly from the atmosphere. They are very slow-growing and accumulate much fallout. The caribou's principal food is lichens; therefore, it already is contaminated. The U.S. Radiation Council has set a "safe limit" for humans of 0.17 rems or units per year. This would give about 17 Strontium units in the skeleton. Caribou bones tested are now (1962) in the order of 100 to 200 Strontium units. People who eat caribou or reindeer in Alaska now have more than the safe quota of Strontium-90 in their bones. Obviously this is another food-chain problem.

Lest some uncritical readers be misled by the fact that most of the examples used above concern wild animals — birds, fish, and mammals — and, therefore, to the uninformed they may be of little concern. Let us remember that people also are animals. It is well to remember that human physiology, digestion, and assimilation, in most respects, are similar to other animals. Most experimentation and testing, and much medical research, are done on these "lower" animals and the results are extrapolated to give us our knowledge of human physiology, etc. The disastrous effects of pollutants upon carnivores, because of their terminal positions in these food chains, should be studied and pondered in the light of the fact that man is to a considerable extent a carnivore himself, and in his consumption of meat, fish, and fats of animal origin he places himself in the same terminal position as described above. The visceral fats of humans are just as capable of accumulating, concentrating, and storing pesticide residues as those of the rat, ring-necked pheasant, western grebe, English sparrow, or bass. Many of us, through sickness or at the direction of our doctors, or because of our own vanity, lose weight. Even those who have only a casual interest in wild creatures usually have a strong instinct for self-preservation and, to them, case histories given herein may be regarded as the analogues of medical research on white rats.

The above examples are but a few of the current ecological issues and land-use abuses that could be cited. It is to be hoped they leave all of us with a firm realization that America is dangerously polluting its environment, including the food we eat, the water we drink, and the air we breathe. Unless we correct some of these present trends and follow a wiser course, nature's stern hand of retribution is sure to strike. We live in a world of law and order and cause and effect. We will ultimately have to pay the price for our constant violation of nature's inexorable laws unless we soon correct our mistakes and follow a wiser course. The recommendations and findings of the President's Science Advisory Committee need careful study and support.[54] Even though this committee contained no prominent ecologist, it was composed of men of stature and vision and they submitted a good report. The report already is having a profound effect in improving policies and operations in government and in effecting much better coordination and cooperation between responsible government agencies.

We need to think, plan, and act ecologically. If this can be done, operating agencies should be able to anticipate most of the ramifications and consequences following given land-use practices. In the field of controls, we should recognize more than a single approach. We doubt that the chemical approach ever can or should be eliminated. The chemicals used should be much more specific and less toxic to nontarget species, and they should be less stable. Biological controls should be used wherever possible. Repellents, sex attractants, chemosterilants, desiccants, along with cultural methods and the application of genetics in developing resistant crops, should be given greater consideration in the control programs. It is imperative that control workers learn to think of the web of interactions that occur between components of ecological systems and of how ecosystems might be modified so as to need less control. Perhaps Fosberg's proposal [28] for a community ecologist to aid in planning and coordination will yet be a partial solution.

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