
UNIVERSITY OF MISSOURI - COLUMBIA
COLLEGE OF AGRICULTURE
AGRICULTURAL EXPERIMENT STATION
ELMER R. KIEHL, *Director*

THE PESTICIDE PROBLEM AN ANNOTATED BIBLIOGRAPHY

J. CHARLES HEADLEY, ELIZABETH ERICKSON



(Publication Authorized October 16, 1969)

COLUMBIA, MISSOURI

J. Charles Headley is Associate Professor of Agricultural Economics at the University of Missouri - Columbia. Elizabeth Erickson was formerly graduate research assistant, Department of Agricultural Economics, University of Illinois (Urbana).

The research work for this contribution was financed by a grant from Resources for the Future, Inc. while the senior author was on the staff of the University of Illinois, and the University of Missouri.

Preface

The decade of the 1960's has been the decade of active concern, discussion and action directed at environmental pollution. While air and water pollution as such have received considerable attention, nothing has evoked so much emotional response as the issues around the environmental pollution associated with the widespread use of chemical pesticides.

Since much of the debate on the question has centered around the biological effects of the materials used with arguments by conservationists on one extreme and counter arguments by supporters of the technology on the other, an obvious void exists in terms of the means of making assessments of the problem for the purposes of public policy. The senior author of this bibliography has taken the view that the issues involved have significant economic content and, that in fact, any rational policy will involve a balancing of "trade-offs" between environmental pollution on the one hand and effective pest control on the other. In the process of preparing a book, now published, on this subject an intensive review of literature was made to bring all relevant information on the pesticide question.

This bibliography is not intended to be exhaustive. Anyone who has dealt with the problem appreciates how much literature there is on the subject. It is, however, intended to present literature from a wide variety of sources that may be pertinent to the problem. Some of the references could be classed as significant journalism. Others are research reports of renowned biological and physical scientists. Still other references present material from the social sciences that points to ways of analyzing information so that values can be considered.

This bibliography is divided into sections and contains annotations by the authors on most of the entries. The first section presents general references which are primarily books and reports dealing with arguments for and against, specific analyses of the broad policy problem and reports of government and world agencies. There is a section dealing with residues, which presents results of studies of the residual deposition of pesticides. A third section presents citations on alternative methods such as biological control, sterilization, etc. Another section provides references that present material on wildlife and pesticides followed by a series of legal references where the existing laws and format for new laws are displayed. Statistical data on pesticide use by agriculture forms another section showing sources of published use data. There is a section on pesticides in agriculture reviewing research work in control of agricultural pests with pesticides. The following section presents literature of the health aspects selected from reputable journals of health and reports of organizations such as WHO. This is followed by references to economic theory applicable to the pesticide problem. Much of this literature comes from the fields of water resource economics, the economics of conservation and welfare economics. Finally, the closing section deals with examples of public decision models and provides references that explain measuring benefits from government investments, measuring returns from technology, systems analysis for government efficiency, etc.

It is our hope that this compilation will provide a beginning for persons interested in the total issues present in the pesticide controversy and that biological and social scientists alike will be able to use it to broaden their perspective of the problem without any loss in the sharpness of their views.

J. Charles Headley
Elizabeth Erickson



Use Pesticides Safely
FOLLOW THE LABEL

U.S. DEPARTMENT OF AGRICULTURE

TABLE OF CONTENTS

General References Dealing With "The Pesticide Problem"	5
References Pertaining to Residues	9
Alternative Methods of Pesticide Control	16
Wildlife and Pesticides	21
Legal References	24
Pesticide Statistics Emphasizing Agriculture	27
Pesticides in Agriculture	32
Health Aspects of Pesticides	39
Economic Theory Applicable to the Pesticide Problem	44
Examples of Public Decision Models	48

Section 1

GENERAL REFERENCES

Carson, Rachel. *Silent Spring*. Boston: Houghton Mifflin Co., 1962. x, 368 pp.

This is the well-known and controversial book which brought the possibilities of hazards from pesticides to public notice. It is a piece of persuasive writing and should be read as such. The author does not try to set out a sober review of all the facts but to dramatize possible dangers. The results of all studies in various areas are not reviewed. Frequently single examples are quoted out of context. Few explicit references are made to the frequency of incidents. Implicit conclusions are made without explicit corroborating evidence. There is no discussion on possible benefits from pesticide use. Nevertheless, this overstatement of the case does not mean that many valid issues are not raised. The book should be read because it has raised issues which require further and more coordinated investigation; and because it calls for a reappraisal of what are the valid decision-making criteria in this area. Readers should, however, consult less readable but more balanced accounts of experimental findings in each area discussed.

"Committees Studying Pesticide Problem," *Farm Chemicals*, Vol. 128, Jan. 1965, pp. 13-18.

Lists the committees on pesticides set up in each state, and at the Federal level. Gives chairman, purpose, when due to report and appropriations. Useful review of such information.

Decker, George C., "Don't Let the Insects Rule," *Journal of Agricultural and Food Chemistry*, Vol. 6, No. 2, Feb. 1958, pp. 98-102.

This article is referred to in a number of review articles listed here, usually in relation to losses due to insects. Like "Silent Spring," it presents an argument for a point of view and should be read as such. It should, therefore, be supplemented by more neutral reviews of documentary evidence. The author believes there is a never ending struggle between man and insects. While ecological or biological control may be the ideal, use of pesticides is the only practical weapon now available, and one which has saved great losses. He quotes losses which would have occurred without pesticides but the sources of the figures are not set out. Some of the figures seem based on correlations which are not necessarily causal. Also, no mention is made of any hazards of pesticide use.

Headley, J. C. and Lewis, J. N. *The Pesticide Problem: An Economic Approach to Public Policy*, Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1967, xvii, 141 pp.

This is an important reference to the pesticide problem, and is essential reading to anyone involved in decision making in this area. It sets up an explicit framework for analyzing the various aspects of the problem—a framework which integrates the economic and technical dimensions into a meaningful conceptual decision model. The economic concepts involved are explained in order to be understood by non-experts without being over simplified; and actual methods of measurement are discussed in detail.

Factual material, on the basic nature of the pesticide problem, and its effect on agriculture, health, fish and wild life, are reviewed to determine the major issues and to determine what is known about the technical relationships between pesticides and environmental quality. The study does not carry out detailed analyses of these areas, but makes important suggestions on the technical and economic research required for meaningful decision making. There is a bibliography of relevant technical and economic literature.

McMillen, Wheeler, *Bugs or People*, New York: Appleton Century, 1965, 228 pp.

This book is one of those written in answer to "Silent Spring." It is for the general reader and has an easy journalistic style. The author's treatment is polemic, selective, and also rather uncoordinated.

Rudd, Robert L., *Pesticides and the Living Landscape*, Madison: University of Wisconsin Press, 1964, XIV, 320 pp.

This book could be considered a balanced analysis of pesticide hazards from the point of view of a conservationist. The purpose of the study is to document and evaluate the hazards of pesticide usage rather than contrast them with the benefits. Hence, a major part of the book is an exhaustive review of the technical data on deleterious effects of pesticides on wildlife, humans, soil and the problem of resistance. The author provides a balanced account of the data. However, in all these fields, there are situations where the evidence is such that value judgments need to be made, and these do not favor chemical control. Judgments made in this study can usefully be compared with U.S.D.A. analyses and other technical analyses.

The major part of the book covers the relation between pesticides

and various types of ecological chains. It is one of the best sources of material on this subject.

Mellanby, Kenneth, *Pesticides and Pollution*, London: Collins, 1967, 221 pp.

This book is one of the *New Naturalist* series published in Great Britain. Authored by an entomologist, it covers all of the pollution cases—air, water, radioactivity and pesticides. It provides an expert assessment of the hazards to fish, wildlife and people as seen by, what appears to be, an objective entomologist. Most of the chemical and biological processes involved in pollution are clearly explained for the lay reader. The book provides a comprehensive insight into the situation in Britain. It is complete with index and bibliography. An excellent reference for background on the problem.

There is also a useful review of information on control programs; concepts of chemical and biological control; and residue legislation.

The least satisfactory chapter covers losses and gains from pesticides. Although the author makes some useful technical criticisms of data on losses due to insects, he does not use an economic framework which would allow him to apply meaningful criteria. This book can be recommended as an excellent review of pesticide literature (there is a 17 page bibliography) from someone who stresses the hazards of pesticide usage.

U.S. President's Science Advisory Committee. *Use of Pesticides*. Washington, D.C.: The White House, 15 May 1963, 25 pp.

This report has been an important document in the current analysis of pesticides. It provides a clear and short introductory review of the benefits and hazards. The authors concentrate on reviewing information on hazards, and on the adequacy of the role of a government in controlling these hazards.

Discusses biological effects on man and wildlife and toxicity of specific compounds. Includes short section on major non-chemical methods, and mechanisms and adequacy of government control. Provides recommendations for information requirements, regulation and research in a number of areas. While these recommendations are controversial and make value judgments, they are valuable because they were made as a result of a review of experimental data and because the effect of pesticides on the total environment is considered. The report has two major limitations, first its brevity—no references are listed, and some aspects are not covered thoroughly. Secondly, the framework of the analysis is exclusively biological—

based on technical benefit and biological risk. Economic benefits and costs do not form a basis for its recommendations.

The committee's conclusions indicate clearly that the issue is not pest control as such. The Committee finds fault with certain types of pesticides and with the excessive use made of them, because they can produce resistance to toxicants in pest populations, hazards to human health and welfare and undesirable side effects on non-target animals and plants. The Committee enumerates some elementary qualities required to make control procedures safer and more specific and submits recommendations on administrative policies, *ad hoc* research and regulatory legislation. It lists a number of ways in which noxious species have been controlled without chemical pesticides, but provides no general principles to guide the development and wider application of those methods.

World Health Organization. *Toxic Hazards of Pesticides to Man*, Report of a Study Group, Geneva, 1956. Technical Report Series, No. 114, 1956, 51 pp.

Report and recommendations with short sections covering toxic properties of pesticides; incidence and nature of poisoning; measures for the protection of operators handling pesticides; contamination of food and water; effects on domestic animals and fish; and control of pesticide hazards by means of regulations. The report particularly applies to public health programs under WHO auspices. It provides a good simple introduction and some of the information and problems considered to be important at world wide levels.

Section 2

REFERENCES PERTAINING TO RESIDUES

Akesson, Norman B., and Yates, Wesley E. "Problems Relative to Application of Agricultural Chemicals and Resulting Drift Residues," *Annual Review of Entomology*, Vol. 9, 1964, pp. 285-318.

The first sections of this article are useful in any consideration of problems of drift. The authors discuss use of regulations to control drift problems of 2,4 D, and there is a very useful paragraph on criteria to be considered for application and drift. An important drift problem relates to hydrocarbon deposits on stock feed which lead to high milk and meat residues. Three factors that affect the drift of a given application are (a) distribution equipment and method of use, (b) the physical form (and formulation in case of sprays), and (c) the microclimatology controlling the materials dispersion. Work on these three aspects is reviewed. Some of it is likely to be too technical to be of interest to the general reader.

Bowery, T. G., Evans, W. R., Guthrie, F. E., et al. "Insecticide Residues on Tobacco," *Journal of Agricultural and Food Chemistry*, Vol. 7, No. 10, October, 1959, pp. 693-702.

Reports results of tests for TDE and Endrin residues on green and cured tobacco; on auction market tobacco and in cigarettes. There are indications that residue levels are still high on flue-cured tobacco delivered to auction. Suggests that growers must learn to apply insecticide in ways to minimize these residues. The authors also note that though appreciable dissipation and degradation of residues occurs during smoking, small but detectable amounts of TDE are still found in the main stream smoke of commercial cigarettes. Investigations are continuing to determine the fate of these chemicals.

Breidenbach, Andrew W., and Lichtenberg, James J., "DDT and Dieldrin in Rivers: A Report of the National Water Quality Network," *Science*, Vol. 141, No. 3584, Sept. 6, 1963, pp. 899-901.

As a part of the water quality surveillance activities of the National Water Quality Network at 101 sampling stations located on the main rivers and Great Lakes of the U.S., DDT or dieldrin was identified in 38 samples from 10 rivers during the period May through December 1962. Concentrations were approximately 1 to 2 micrograms per liter, which is well below values known to be toxic to fish or hazardous to man. (Neither chemical was found in drainage from Mississippi or Missouri, prob-

ably because chemicals are absorbed by the silt). Includes a map showing stations involved.

Breidenbach, Andrew W. "Pesticide Residues in Air and Water," *Archives of Environmental Health*, Vol. 10, June 1965, pp. 827-830.

This article describes the current work and methods of the Water Quality Section of the Division of Water Supply and Pollution Control of the Public Health Service. It contains quite a lot of technical detail but is of interest because it indicates the very sensitive methods of analysis, the large number of regular samples taken and the possibilities for co-ordinating data now that water quality records are processed and stored by electronic data processing equipment. Includes useful references to materials which consider pesticides as part of the water quality problem.

Chadwick, Donald R. and Straub, Conrad P. "Guidelines for Tolerance Levels of Radionuclides in Man," in *Proceedings of the North Central Experiment Station's Workshop on Radio-nuclides in Foods and Agricultural Products*, Cincinnati, Ohio, Feb. 19-21, 1963, (Ohio Agricultural Experiment Station Special Report Series No. 1), pp. 65-69.

Describes an alternate method to tolerance levels for determining basic protection standards. This method has the advantage of recognizing that risks and benefits are involved in any size dose and should be evaluated. This basis of protection standards replaced tolerance limits in 1961. The article briefly discusses factors which must be considered in order for decisions to be made. The same type of analysis should apply to the case of pesticide residues.

Courshee, R. J. "Some Aspects of the Application of Insecticides," *Annual Review of Entomology*, Vol. 5, 1960, pp. 327-352.

Reviews work on factors which affect the deposition, retention, runoff and persistence of pesticides applied in various ways. The subject is important because it is possible that equally efficient biological effects might be achieved with more efficient application using smaller amounts, at lower costs and decreases in hazards from residues, but does not, however, recommend particular methods, because different factors can affect decisions on particular cases. A good and reasonable non-technical review of available data.

Durham, William F., "Pesticide Residues on Foods in Relation to

Human Health", *Residue Reviews*, Vol. 4, 1963, pp. 33 81

Extensive reviews of available data on all aspects of residue hazards. Covers studies on DDT buildup, potentiation, neurotoxicity and carcinogenic effects as well as acute toxicity effects. Considers data from use-experience, poisoning cases and human volunteer studies used to determine dosages which produced poisoning. Also includes a section on residue levels found in food and water. This review includes material not found in earlier articles. It is well set out, and though detailed, fairly easy to follow. There is an eight page bibliography.

Concludes from data that real hazards exist for those who work with pesticides without appropriate precaution, but that hazards to human health from pesticide residues as they occur in diets in the U.S. are very slight, although there is no way to exclude the possibility that subtle dangers remain to be discovered. Recommends continued study of workers handling pesticides as any delayed effects would first appear there.

Fischbach, Henry. "Problems Stemming from the Refinement of Analytical Methods," in *New Developments and Problems in the Use of Pesticides*. Proceedings of a Symposium held on November 29, 1962 in connection with the 12th Annual Meeting of the Liaison Panel of the Food Protection Committee. National Academy of Sciences—National Research Council, Publication 1082, Washington, D.C., 1963, pp. 55-64.

A useful introductory explanation of what effects new analytical methods have on the concept of zero tolerance and its determination for pesticide registration, by a member of the Food and Drug Administration. Author also reports on a continuing study by this Department on levels of pesticides in total diet samples taken from five cities. These are analyzed with the most sensitive methods to determine trends in residues at minute levels. The author suggests such analyses should provide early identification of any possible harmful trends in residue levels.

Linsley, E. Gordon, (ed). "Evaluation of Certain Acaricides and Insecticides for Effectiveness, Residues and Influence on Crop Flavor," *Hilgardia*, Vol. 26, No. 1, April 1956, pp. 1-106.

A series of reports on results of pesticidal, flavor, and chemical or bio-assay residue studies of certain acaricides applied to pears, apples, peaches, and almonds and of insecticides (chlorinated hydrocarbons applied to soils in which several root crops were grown.) Results show that

several acaricides when used in accordance with described procedures give satisfactory control of tetranychid mites, without giving rise to serious residues or alterations. Results of experiments on insecticides for vegetables showed that a number of hydrocarbons (but not lindane or BHC) can control wireworm, without off flavour or residue problems as yet.

Mahoney, C. H. "Flavor and Quality Changes in Fruits and Vegetables in the United States Caused by Application of Pesticide Chemicals." *Residue Reviews*, Vol. 1, 1962, pp. 11-23.

Reviews examples of above changes. The effects of 61 pesticide chemicals are discussed. Concludes that a comparatively small number of pesticide chemicals cause definite off-flavors, especially in fruits and vegetables processed by heat. Other changes affect quality e.g. PH, acidity, and color. Suggests further research. Bibliography is included.

Martin, James P. "Influence of Pesticide Residues on Soil Microbiological and Chemical Properties," *Residue Reviews*, Vol. 4, 1963, pp. 96-129.

The article gives an excellent comprehensive review of the research in this field. It is somewhat technical but clear, not abstruse. Topics discussed—utilization of pesticides and herbicides as carbon and energy sources by soil microbes; quantitative and qualitative effects of pesticides, especially fungicides, on soil microbe populations, and the influence of pesticides on soil chemical properties. The possible problems are pointed out, although the author concludes that evidence indicates that the soils of the world should not be made permanently infertile by pesticide residues. He lists the conditions under which toxicity might occur. The article has an extensive bibliography.

National Academy of Sciences, National Research Council. *Report of the Pesticides Residues Committee*, Washington, D.C., June 1965, 13 pp.

Report on a committee study of the technical issues involved in the concepts of "no residue" and "zero tolerance" as they relate to the registration of pesticides, the setting of tolerances for pesticide residues, and the enforcement provisions of the Food, Drug and Cosmetic Act relating to residues in food. Gives a good clear description of the concept and problems in use of "no-residue" and "zero-tolerance." Recommends the replacement of these by "negligible residue" concepts, depending on

whether use results in the intake of a negligible or a permissible fraction of the maximum acceptable daily intake as determined by appropriate safety studies.

Discusses briefly and nontechnically the problems involved in the use of "no residue" and "zero tolerance" concepts, and the use of animal tests and tests in man to evaluate these. Includes comments on proposals by Federal Drug Administration for use of "Negative residues" or "permissible residues." Includes 11 recommendations for legislation and its enforcement.

National Academy of Sciences—National Research Council. *Safe Use of Pesticides in Food Production*. A Report of Food Protection Committee, Washington, D.C., National Academy of Sciences Publication 470, 1956. 16 pp.

Proposes a series of pre-marketing requirements for evaluation of hazards of new pesticides. The proposals include details of physical and chemical data, tests to provide biological or use data. It gives methods of obtaining toxicological data. The Report covers a wide field, but does not cover any topic in enough detail for anyone to be aware of alternatives or of problems. Does not question or justify, for example, zero tolerance levels. It does, however, provide a non-technical introduction to some of the types of analysis required.

Nicholson, H. Page. "Contamination of Water with Pesticides: Pesticide Pollution Studies in the Southeastern States," in *New Developments and Problems in the Use of Pesticides*. Proceedings of a Symposium Held on November 29, 1962, in connection with the 12th Annual Meeting of the Liaison Panel of the Food Protection Committee. National Academy of Sciences—National Research Council, Publication 1082, Washington, D.C., 1963, pp. 65-71.

Effect of parathion found. Concludes pollution occurs but more work is required on evaluation of effects of chronic exposures at low levels. Reports on a continuing project to investigate water pollution from pesticides in a 400 square mile river basin and cotton growing area in Alabama. Project commenced by Public Health Service in 1959 and valuable as one of few analyses on this scale. Survey of quantities of pesticides used, made each year. Water supply (from river) sampled; investigation of plankton, bottom organisms, and fish carried out. Separate study made on effects of parathion residues in pond water on flora and fauna. BHC and toxaphene present in river—no evidence as yet of effect on river fauna.

Novak, Arthur F. and Ramachandra Rao, M.R. "Food and Safety Program: Endrin Monitoring in the Mississippi River," *Science*, Vol. 150, 24 December 1965, pp. 1732-1733.

Report of an investigation (made in response to mass death of fish in 1963) into the levels of endrin in soil and water in the lower Mississippi area. Twelve successive monthly samplings and analyses of representative fish and shellfish and of mud and water were made in 1963. These showed neither a high concentration of endrin nor a time ordered change in concentration. The results indicated no significant contamination of the environment, though possibility of localized and sporadic occurrence of residues was not ruled out.

Stoner, H. B. "The Concept of Acceptable Daily Intakes of Pesticides for Man," *Food, Cosmetics and Toxicology*, Vol. 2, No. 4, Oct. 1964, pp. 457-466.

Discusses concept of "virtual safety" which is defined as an intake of 1 part per 100 million. To demonstrate "virtual safety" of an intake level would require 460 million animals free from any effect to assure 99 percent confidence. Therefore, extrapolation is necessary.

Toxicity of the applied chemical is relevant for the applicator or operator. Toxicity of the metabolites of the applied chemical is relevant for consumers and evaluation of consumer hazards.

U.S. Dept. of Agriculture, Agricultural Research Service, Pesticides Regulation Division. *Summary of Registered Agricultural Pesticide Chemical Uses*, 2nd Edition. Washington, D.C., U.S. Govt. Printing Office, 1964.

Lists chemicals, their uses, tolerance dosages and limitations. Set out in tabular form for easy reference. A useful reference to the presently accepted technical data.

Weaver, Leo, Gunnerson, Charles G., Breidenbach, Andrew W., et al. "Chlorinated Hydrocarbon Pesticides in Major U.S. River Basins," *Public Health Reports*, Vol. 80, No. 6, June 1965, pp. 481-493.

Reports a special synoptic survey of pesticide pollution of surface waters taken at 96 stations in the various U.S. river systems during Sept. 1964, by Public Health Service, as part of its surveillance activities. The survey used new and more sensitive analytical procedures. In order of frequency of occurrence, dieldrin, endrin, DDT and DDE were found in

all major river basins. The authors remark on the widespread occurrence of dieldrin, although it is used less than DDT. Heptachlor and aldrin were less abundant, and other hydrocarbons were very rare. These comparisons are summarized in a convenient diagram. Maps with sampling stations marked for presence, presumptive presence, or absence of each chemical also provide useful overall picture. Detailed tables of concentrations at each point are also included.

One comment of interest to those interested in trends over time—stored extracts, collected from pollution surveillance stations since 1958, are to be re-examined using more sensitive techniques to determine any trends over time.

Williams, S. "Pesticides Residues and Chlorinated Organic Pesticides Parathion and 2,4-D, etc., in Total Diet Samples," *Association of Official Agricultural Chemistry Journal*, Vol. 47, No. 5, Oct. 1964, pp. 815-821.

Diet samples were taken in a metropolitan area in August 1963, November, 1963, and February, 1964. The various components of the diet were analyzed to determine pesticides present and the composite diet was analyzed for composite concentration. All the organic chlorinated pesticides in the diets were present at less than .04 ppm. The preponderance of residues were at less than .01 ppm. A few samples showed parathion. All levels found were less than 1.0 ppm. No herbicides were found in any samples. They would have been found if they had been present at .01 ppm or higher.

Section 3

ALTERNATIVE METHODS OF PEST CONTROL

Beirne, Bryan P., "Trends in Applied Biological Control of Insects," *Annual Review of Entomology*, Vol. 7, 1962, pp. 387-400.

Reviews current investigations of biological control under headings: permanent biological control, temporary biological control and intensified biological control. Covers the needs and problems of each approach and suggests that the trend of practical importance is that of integrating biological and chemical procedures. (Points out that this last approach is more talked about than applied: Because of the amount and complexity of background information that is necessary on the insects involved, biological control procedures often must be integrated with existing chemical controls, rather than vice versa; the economic pressure to use the fast acting chemical insecticides; and the frequent neglect of the virtues and potentials of one control method by proponents of the other.

Beirne, B. P., "Ecology in Biological Control," *Memoirs of the Entomological Society of Canada*, Vol. 32, 1963, pp. 7-10.

Suggests that one reason for failures in biological control is that there was insufficient ecological information on the agents used. Presents a general discussion of the role of ecology in the introduction of natural enemies of pests, and in the manipulation of the environment to increase natural enemies already present. Cites and documents examples of work in this field (including Russian). Discusses integrated control methods and steps in implementation. Not too technical.

Bucher, G. E. "General Summary and Review of Utilization of Disease to Control Insects," in *Proceedings of the 10th International Congress of Entomology*, Montreal, 1956, pp. 695-701.

Discusses the future of using diseases to control insects, in terms of the various factors which limit use of the method. Not a historical review. A review of technical data which can be followed and is of general interest. Short bibliography.

Bushland, R. C. "Male Sterilization for the Control of Insects," *Advances in Pest Control Research*, Vol. III, 1960, pp. 1-26.

A short discussion of this general method followed by a detailed account (not too technical) of the screwfly example—the problem; experimentation, field tests, and plans for eradication (the program was not at

that date completed). Useful to get an idea of the time, resources and planning involved.

Clausen, C. P. "Biological Control of Insect Pests," *Annual Review of Entomology*, Vol. 3, 1958, pp. 291-310.

Reviews the utilization of insect parasites and predators in control of crop pests. Covers a great number of specific projects in numerous parts of the world and includes a section on current research relating to control. Useful guide to literature. 119 item bibliography.

DeOng, E. R. *Chemical and Natural Control of Pests*, New York: Reinhold Publishing Co., 1960. viii, 244 pp.

The stated purpose of this book is to assist manufacturers, research workers, instructors, and farmers in evaluating chemical and natural control methods. Stresses that excessive use of pesticides can be harmful and therefore gives an introduction to natural methods which can complement pesticide use. It is a good introductory text and reference on the subject. Covers each crop—its major pests; methods of chemical and natural control which have been successful (the experimental work is referred to); problems of beneficial insects, etc. Presents available materials, does not suggest integrated control programs.

Francke-Grosmann, H. "Some New Aspects in Forest Entomology," *Annual Review of Entomology*, Vol. 8, 1963, pp. 415-438.

This review provides interesting information on possible new methods of insect control in forests to replace some pesticide usage. The sections on attractants, genetic control and effects of forest management provide a semi-technical review of the literature. Some of the literature and discussion on fungal/insect symbiosis can probably be skipped by the general reader. 201 item bibliography.

Geier, P. D. "Management of Insect Pests," *Annual Review of Entomology*, Vol. 11, 1966, pp. 471-490.

Suggests that problems of pesticide resistance and effects on non-target species requires a new concept of pest control. Defines and develops the idea of "pest management" (a systematic attempt to create a new or modified ecology in which pest populations can be stabilized at tolerable levels of abundance). Reviews ways and means of such management (lures, sex attractants, biological control, etc.) and evaluates present types

of pest control within "pest management" framework. Concludes that at present the specific type of chemical method will be required to contain pesticide populations, but that developments of this method will require management of the whole ecosystem. A clear review of new pest control methods related to principles of population ecology. Recommended as a clear review of new methods of pest control which also tries to look at the principles of population ecology involved.

Huffaker, C. G. "Biological Control of Weeds with Insects," *Annual Review of Entomology*, Vol. 4, 1959, pp. 251-276.

Reviews the use of insects to solve weed problems. Discusses the literature on principles and concepts involved, also risks and possibilities of success. About half the article deals with examples of biological control in various parts of the world. Although somewhat technical, the first sections of the article provide the general reader with some idea of what is involved in this method of control and its opportunities and limitations. Bibliography of 124 articles.

Jacobson, M., "Chemical Insect Attractants and Repellents," *Annual Review of Entomology*, Vol. 11, 1966, pp. 403-422.

Lists the main recent advances in the field of chemical attractants and repellents which have occurred since 1960. Includes lists of insects which use sex attractants and of those in which repellent secretion have been identified. Gives suggested references to further discussion on topic. Lists 186 articles in bibliography.

Knipling, E. F. "Alternative Methods in Pest Control," in *New Developments and Problems in the Use of Pesticides*. Proceedings of a Symposium Held on Nov. 29, 1962, in Connection with the 12th Annual Meeting of the Liaison Panel of the Food Protection Committee. National Academy of Sciences-National Research Council, Publication 1082, Washington, D.C., 1963, pp. 23-38.

A short non-technical discussion of alternative methods—their current status, their limitations and potentialities. Covers cultural control, parasites and predators, microbial agents, varietal resistance, sterile-male approach and insect attractants. A discussion and evaluation rather than a review of technical findings, by the director of the Entomology Research Service. Includes some excellent comments on the more general problems involved, the costs of developing alternative methods versus present costs, and necessity for community rather than individual action.

Nickel, John L. *Biological Control of Rice Stem Borers: A Feasibility Study*—International Rice Research Institute Technical Bulletin 2, Los Baños, Laguna, Philippines, Aug., 1964. 111 pp.

An analysis of technical data to determine whether research expenditures on biological control are warranted. Emphasis on principles employed makes it a good example of the method of analysis. Also has added advantage of stressing biological control as part of an integrated program to achieve control at least cost. (Does not, however, try to compare the cost of various levels of control). Includes a 15 page historical review of biological control in world perspective and 219 item bibliography. Has an excellent appendix, not found elsewhere, listing all cases in which biological control was successful, by plant or insect type introduced, the countries to and from which it came, plus cited reference on effect.

Reitz, L. P. (Ed.) *Biological and Chemical Control of Plant and Animal Pests*. American Association for the Advancement of Science, Publication No. 61.

The general emphasis of the articles is on eradication of the pests, (with no account of any costs, externalities, etc.) however, articles discuss more effective methods of eradication, that involve non-chemical means. Article by Fleschner presents a broad, somewhat superficial historical sketch of parasites and predators which can be used for pest control and gives details of work in avocado orchards.

Picket describes projects of integrated control in Nova Scotia Orchards. Knipling discusses control of screw worm fly by atomic radiation, a more easily followed description of the project than some others listed.

Smith, E. H., and Salkeld, E. H. "The Use and Action of Ovicides," *Annual Review of Entomology*, Vol. 11, 1966, pp. 331-368.

Review of work on the use of pesticides on the eggs of insects, a method which could be important as a part of integrated control measures. The vulnerability of the egg, the practices and toxicants which can be used and their mode of action are discussed. Includes examples of use of method. Sections on modes of action are somewhat technical but a good and clear section on prospects and promises. Points out that overwintering eggs are vulnerable in a period when non-target species are absent, and residue problems can be avoided.

Stern, Vernon M., Smith, Ray F., Vanden Bosch, Robert, et al. "The Integrated Control Concept," *Hilgardia*, Vol. 29, No. 2, Oct. 1959,

pp. 81-101.

One of the articles referred to in any review of the topic. Provides an excellent description and discussion of the concept. Although a review by biologists, they use important economic criteria. This is the first of three articles covering the use of integrated control against the spotted Alfalfa Aphid in California.

Vanden Bosch, R., and Stern, V. M., "The Integration of Chemical and Biological Control of Arthropod Pests," *Annual Review of Entomology*, Vol. 7, 1962, pp. 367-386.

A more technical discussion than that by the same authors in *Hilgardia*. They do, however, review a large number of studies and articles on the topic (there are 128 references in the bibliography). There is also a useful discussion of the factors affecting the development of integrated control programs. A good follow-up to the earlier mentioned article, which also gives an introduction to the literature.

U.S. Dept. of Agriculture, Agricultural Research Service. *Use of Diseases to Kill Plant Insect Pests, a Research Progress Report*, ARS 22-74, Oct., 1961, 17 pp.

This report is designed primarily to inform Extension and other agricultural leaders about research developments in microbial pest control. It provides some simple basic information on how microbial insecticides work, and some specific information on the commercial products for Japanese beetles, for numerous caterpillars, and for some forest pests (e.g. sawflies and bark beetles). Examples are given to indicate lines along which research progress is encouraging. No bibliography is included.

Section 4

WILDLIFE AND PESTICIDES

DeWitt, James B. and George, John L. *Bureau of Sports Fisheries and Wildlife: Pesticide-Wildlife Review, 1959*. U.S. Dept. of the Interior, Fish and Wildlife Service Circular No. 84, 36 pp.

This is the first of a series of annual reviews. It, therefore, gives a short account of general pesticide-wildlife questions—the scope of the problem, the legislative developments of the previous few years, and the Bureau's recommendations for use of pesticides with minimum harm to wildlife. The main sections, however, review the current activities and findings of the Bureau. These are discussed in sections— toxicology, direct and indirect effects on field populations, with sub-groupings for work on, e.g., effects of imported fire ant control, or Mediterranean fruit fly and forest insect control. The details of the results are not listed. There is no attempt to make any overall evaluation of these results or to set them in the framework of overall aims or criteria for the research program. This lack of integration curtails the usefulness of the results for any overall analysis using an economic criterion.

Ayres, M. T. *An Introduction to the Literature of the Effects of Biocides on Wildlife and Fish: A Select Bibliography*. Calgary, Alberta: Dept. of Biology, University of Alberta at Calgary, September, 1964.

Intended chiefly for wildlife and fishery biologists, but a good guide to anyone looking for literature on this topic. Covers a number of general reports and reviews not listed in this bibliography—as well as large sections covering specific areas, e.g., fish, waterfowl, mammals, etc. Also includes a good coverage of work on insect resistance and biological control. Copies may be obtained from the Biology Department of the University of Alberta at Calgary.

National Academy of Sciences—National Research Council. *Pest Control and Wildlife Relationships: Part I. Evaluation of Pesticide-Wildlife Problems*. National Academy of Sciences—National Research Council Publication 920-A, 1962. v, 28 pp.

This is a report by the Subcommittee on evaluation of pesticide-wildlife problems of the committee on pest control and wildlife relationships. It gives a somewhat superficial discussion of the problems. Although the authors point out in the introduction that decisions rest on weighing advantages to public welfare against the disadvantages, they do not really look at the criteria which are involved or exactly in what areas benefits

and costs need to be evaluated by decision makers. They describe the advantages of pesticides to agriculture, forestry and public health, and the losses to wildlife that have occurred. Their general conclusion is that scientists should try to minimize wildlife losses by trying to identify and evaluate specific hazards of present usage, and develop corrective measures for objectionable practices. They suggest that most wildlife hazards are from incorrect use of pesticides. This seems to be a rather limited view of the problems and how they might be corrected.

National Academy of Sciences—National Research Council. *Pest Control and Wildlife Relationships: Part II, Policy and Procedures for Pest Control*. National Academy of Sciences National Research Council Publication 920-B, 1962 IX, 53 pp.

This is a short report which just mentions the issues involved and makes recommendations of a general nature. Nevertheless, the approach is a great deal more useful than most similar reports.

National Academy of Sciences—National Research Council. *Pest Control and Wildlife Relationships: Part III, Research Needs*. A report by the subcommittee on Research Needs of the Committee on Pest Control and Wildlife Relationships, Division of Biology and Agriculture. Publication 920-C. Washington, D.C.: National Academy of Sciences—National Research Council, 1963. viii, 28 pp.

Lists committee recommendations for areas of research requiring increased attention and support. These are listed in general terms (at times somewhat vague) under subject headings e.g., basic investigations; biological control; resistant plant varieties; sex sterility; chemical control; equipment; research on wildlife; testing toxicity; integrated controls; fate of pesticides after application. The report gives an exhaustive coverage of research areas. However, it does not discuss these within a framework which might allow priorities to be assessed. Mention is made of the economic evaluation of pesticide use but the economics involved in research decisions are not mentioned. The goals of research effort are not discussed or evaluated in any detail. Although recommendations are made for cooperative research, the goals set out in other sections are often so limited (e.g. to lower deaths where they are severe) that the full re-evaluation of priorities, methods and goals which such a co-operative approach might require are not considered.

U.S. Dept. of the Interior, Fish and Wildlife Service, Bureau of

Sport Fisheries and Wildlife. *Effects of Pesticides on Fish and Wildlife in 1960*. Fish and Wildlife Service Circular No. 143, 52 pp.

This report is not organized as usual, but in sections, by different authors reviewing wildlife, fish, etc. but otherwise presents a similar review to the previous year.

U.S. Dept. of the Interior, Fish and Wildlife Service. *Pesticide—Wildlife Studies: A Review of Fish and Wildlife Service Investigations During 1961 and 1962*. Fish and Wildlife Service Circular 167, ix, 109 pp.

Similar format to earlier years. Separate accounts of commercial and sports fishery investigations—but has a further breakdown of wildlife studies into those at each regional station. There seems to be even less attempt to do more than describe what has been done. Otherwise, comments are like those for previous issues.

U.S. Dept. of the Interior, Fish and Wildlife Service. *Pesticide—Wildlife Studies, 1963: A Review of Fish and Wildlife Service Investigations During the Calendar Year*. Fish and Wildlife Service, Circular 199. v, 130 pp.

Comments as for earlier issues.

U.S. Dept. of the Interior, Fish and Wildlife Service. *The Effects of Pesticides on Fish and Wildlife: 1964 Research Findings of the Fish and Wildlife Service*. Circular 226, Aug., 1965, vi, 77 pp.

The introduction to this report states that it "reflects an increasing effort to determine the physiological effects of pesticides, particularly those related to reproduction and survival under conditions encountered in the natural environment."

Various projects are reported on effects of pesticides in birds of prey and waterfowl; on pesticides in the environment; on the meaning and measurement of pesticide residues in animals; on toxicity in captive wildlife; on acute and chronic toxicity; on pesticide surveillance and monitoring activities. However, the review does not yet seem to attempt to provide a coordinated picture of the overall effects (including interrelations) of pesticides within the natural environment.

Section 5

LEGAL REFERENCES

Chemical Specialties Manufacturers Association, Inc. *Compilation of Federal and State Economic Poison Laws; Regulations, Rulings, and Other Explanatory Matter*. New York: Chemical Specialties Manufacturers Association Inc.

Contents explained in title—covers labeling laws.

Council of Europe. *Agricultural Pesticides*. Document Prepared by the Working Party on Poisonous Substances in Agriculture, Subsidiary Organ of the Public Health Committee (P.A.) of the Council of Europe, Strasbourg, 1962, 142 pp.

Valuable for recommendations made by expert working party on what toxicity and residue data should be required by national authorities. Can be compared with U.S. and Canadian laws. A short introduction on the terms of reference and progress of the committee also of interest. Main section of book covers technical matters.

The Council of State Governments. *The Pest Control Compact*. MS-36, Chicago: 1965, 16 pp.

A draft act suggested for use by state governments cooperating in controlling insect infestations. Provides for setting up an insurance fund for such purposes.

Harris, T. H., and Cummings, J. G. "Enforcement of the Federal Insecticide, Fungicide and Rodenticide Act in the United States," *Residue Reviews*, Vol. 6, 1964, pp. 104-135.

Article presents an account of the administration of the above Act. Labeling requirements and types of information needed to support registration under the Act are discussed in detail, including sections on proof of efficacy, toxicity data and residue data. Enforcement activities of the Departments are also listed and discussed.

Miller, Eric J. "The Pesticides Safety Precautions Scheme," *Residue Reviews*, Vol. 11, 1965, pp. 100-118.

The present arrangements in Great Britain for the safe use of pesticides in agriculture and food storage are described. Includes references to reports of various official committees studying pesticide problems.

National Agricultural Chemicals Association. *Manual of Pesticide Use and Application Laws; A Guide to Laws Affecting the Use and Application of Pesticides*, Revised Edn., Washington, D.C.: National Agricultural Chemical Association, 1965. unpagged.

Contains three sections, 1) chart for quick checking of laws regulating pesticide use, 2) 'model' acts drawn up by N.A.C. Association to cover 2,4-D, and custom applicators, 3) texts of present laws and regulations covering use and application of pesticides. A very useful source book where state laws are concerned.

Suzuki, I. "Japanese Laws and Regulations Concerned with Pesticide and Food Additive Residues in Foodstuffs," *Residue Reviews*, Vol. 4, 1963, pp. 9-16.

A short summary of Japanese laws.

U.S. Laws, Statutes, etc. *An Act to Amend the Federal Food, Drug and Cosmetic Act with Respect to Residues of Pesticide Chemicals in or on Raw Agricultural Commodities*, Approved July 22, 1954, Public Law 518, 83rd Congress, Second Session, Ch. 559, HR7125, Washington, D.C.: U.S. Government Printing Office, 1954.

Provides for tolerances on raw agricultural commodities. The Secretary of Health, Education and Welfare is made responsible for establishing tolerances. Details the role of the Secretary of Agriculture.

U.S. Laws, Statutes, etc. An Act to Amend the Transitional Provisions of the Act Approved Aug. 7, 1959. Entitled "*Nematocide, Plant Regulation, Defoliant and Desiccant Amendment of 1959*," Approved March 29, 1961, Public Law 87-10, 87th Congress, Second Session, S. 1028, Washington, D.C.: U.S. Government Printing Office, 1961.

U.S. Laws, Statutes, etc. *An Act to Regulate the Interstate Distribution and Sale of Packages of Hazardous Substances Intended or Suitable for Household Use*. Approved July 12, 1960, Public Law 86-613, 86th Congress, Second Session, S. 1283, Washington, D.C.: U. S. Government Printing Office, 1960.

Sometimes known as the "Federal Hazardous Substances Labeling Act." Provides for labeling substances in interstate commerce as hazardous, sets penalties and lists exemptions.

U.S. Laws, Statutes, etc. *An Act to Amend the Federal Insecticide*,

Fungicide and Rodenticide Act So As to Include Nematocides, Plant Regulations, Defoliant and Desiccants and for Other Purposes, Approved Aug. 7, 1959, Public Law 86-139, 86th Congress, Second Session, H.R. 6436, Washington, D.C.: U.S. Government Printing Office, 1959.

U.S. Laws, Statutes, etc. *An Act to Regulate the Marketing of Economic Poisons and Devices and for Other Purposes*. Approved June 25, 1947, Public Law 104, 80th Congress, 1st Session, HR 1237, Washington, D.C.: U.S. Government Printing Office, 1947.

This law repealed the Insecticide Act of 1910 and is known as the "Federal Insecticide, Fungicide, and Rodenticide Act." It defines "Economic poisons" and various other terms such as insecticide, etc. Provides for labeling, registration and enforcement. Responsibility is given the Secretary of Agriculture for enforcement assisted by the Secretary of the Treasury where imports are involved.

Section 6

PESTICIDE STATISTICS EMPHASIZING AGRICULTURE

Badenhop, M. B. and Thomas K. Hunter, *Utilization of Pesticides by Tennessee Vegetable Growers*, Tennessee Agricultural Experiment Station Bulletin 499, Knoxville, Tennessee, Nov. 1968, 34 pp.

Examines the pesticide market in Tennessee; equipment and application of pesticides by commercial vegetable growers; pesticides purchased; influence of deliberateness and knowledge on purchasing decision and factors affecting the volume used. Some interesting statistics and an application of sociological research methods to the pesticide question.

Brodell, A. P., Strickler, P. E. and Phillips, H. C. *Extent and Cost of Spraying and Dusting Farms—1952*, U.S. Dept. of Agriculture, Agricultural Research Service, Statistical Bulletin No. 156, April 1955, 25 pp.

Reports results for 1952 of mailed survey of 23,500 voluntary crop correspondents. Similar tables on acreages and equipment as listed in 1958 publication. Gives some comparative figures for 1949. However, also presents data on costs. This is incomplete. Total costs of spraying of materials are listed only for custom operators. No costs of labor or equipment are calculated for farmers who use, rent or borrow equipment. Only state totals are given, with no details on the exact makeup of costs on the farm.

Eichers, Theodore, *et al*, *Quantities of Pesticides Used by Farmers in 1964*, U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 131, January 1968, 37 pp.

Reports in tabular form the results of the 1964 survey on pesticide use by farmers. Based on 10,800 farm interviews nationwide. Gives total quantities of compounds used by farmers classified by use and type of compound such as organic and inorganic. Shows amounts applied to crops by type of farming regions for the 48 contiguous states.

Eichers, Theodore, *et al*, *DDT Used in Farm Production*, U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 158, April 1969, 7 pp.

Based on 1964 pesticide use survey. Reports production and use of DDT. Shows farm use on crops with particular emphasis on cotton. In-

icates that farmers are the major domestic users.

Fox, Austin, *et al*, *Extent of Farm Pesticide Use on Crops in 1966*, U.S. Department of Agriculture, Economic Research Service, Agricultural Economic Report No. 147, October 1968, 23 pp.

Presents data from the second pesticide use survey done in 1966. Based on a survey of 9600 farmers. Shows trends in number of farmers using pesticides for various types of control and trends in acres treated. Gives percent of acres treated, by regions, by crop, and by value of farm sales for types of pesticides such as insecticides, herbicides and fungicides. Useful benchmark data.

Strickler, Paul E., and Hinson, William C. *Extent of Spraying and Dusting on Farms, 1958 With Comparisons*. U.S. Dept. of Agriculture, Economics Research Service, Statistical Bulletin No. 314, May, 1962, 28 pp.

Presents estimates based on 20,500 replies to questionnaires mailed to crop reporters of the Statistical Reporting Service. Farmers reported (1) acreages of principal crops, plants and acreages on which they used chemical treatments for control of weeds, insects and diseases or for defoliation (2) the percentage treated by ground equipment (3) whether equipment used was a) their own b) borrowed or rented or c) supplied by custom operators. Reporters often could not give names of chemicals, therefore it was not possible to isolate usage of major chemicals. No attempt was made to measure quantities of pesticides, etc. used (although the average # of treatments is listed); nor the effect on yields. Neither are any cost estimates included. Tables list data by regional totals or averages. Comparative figures for 1952 are included. The major findings are listed.

U.S. Department of Agriculture Economic Research Service, Farm Production Economics Division, *Extent and Costs of Using Chemicals in Cotton Production*—Selected areas 1961, ERS—155, Washington, D.C.

Information on practices by cotton farmers on use of insecticides, fertilizer, herbicides and defoliant collected from 2,200 farms in 15 areas where boll weevil caused significant damage.

Farmers interviewed were asked; whether control practices were used; number of acres sprayed; kinds of materials used; number of applications; quantity used; method of application; costs of insecticides; and cost of ap-

lication.

United States Department of Agriculture, Production and Marketing Administration. *The Pesticide Situation for 1952-53*, Washington, D.C., March, 1953.

The first annual series which provides a basic source of pesticide data. Gives estimates of total usage for various years before 1950, and lists total domestic disappearance for the nine major chemicals then in use for years 1950 through 1952. Estimated requirements are given for DDT and benzene hexachloride as a shortage existed at this period. DDT production is listed for 1944 to 1952. Comments made on each individual chemical; data on most other insecticides is incomplete—a number were just coming into production, and came from only one manufacturer.

United States Department of Agriculture, Commodity Stabilization Service.

The Pesticide Situation for 1953-54

The Pesticide Situation for 1954-55

The Pesticide Situation for 1955-56

The Pesticide Situation for 1956-57

The Pesticide Situation for 1957-58

The Pesticide Situation for 1958-59

The Pesticide Situation for 1959-60

Washington, D.C.

Further Annual reports in this series. Addition to data in previous volumes is listed. Those marked (*) do not necessarily appear annually in later volumes. (+) Comments on sources and problems with these data should be sought in reports from which data were taken.

1953-54: A short rather vague outlook statement on production and likely infestations and consumption. Listing of quantities for chemicals exported 1949 to 1954, and of quantities of chemicals used in aerial applications of dusts, sprays, & defoliants.

1954-55: Breakdown of aerial applications into use categories, e.g. towns, (+) areas of soil treated with insecticides in Iowa, 1952-54; (+) quantities and areas of herbicides used in Minnesota 1954; (*) and sales of pesticides for livestock use 1940, 1945, 1951 and 1953; manufacturers end-of-year stocks.

1955-56: Discussion of insect control programs, areas, quantities and insects; (+) Another herbicide acreage survey, South Dakota; (+) estimated acreage of cotton treated with defoliants.

1956-57: As before, rather more data on various individual insecticides, herbicides, etc.

1957-58: General comments on insect populations;* estimated quantities used on cotton in various states; acreages under U.S.D.A. programs, Forest Service programs and National Highway program.

1958-59: (+) Quantities of cotton insecticides used in 1958 in certain states.

1959-60: Average weekly quotations of wholesale prices per period, of fifteen major pesticide materials 1956-59. (Note: A new important series.)

United States Department of Agriculture, Agricultural Stabilization and Conservation Service

The Pesticide Situation for 1960-61

The Pesticide Situation for 1961-62

The Pesticide Situation for 1962-63

The Pesticide Situation for 1963-64

The Pesticide Situation for 1964-65

The Pesticide Review — 1966

The Pesticide Review — 1967

The Pesticide Review — 1968

Washington D.C.

(+) Comments on sources and problems of these data should be sought in reports from which data are taken. Further annual reports in series. Additions to previous volumes are listed. Those marked * do not necessarily appear annually.

1960-61: (+) Acreages treated for agricultural pest control, and acreage's crops. California, 1960; (+) Trends in cash expenditures for cotton insecticides in various production areas 1947-49 and 1956-59.

1961-62: (+) Value of distribution of 1958 shipments and sales of agricultural insecticide and fungicide by class of customer; *re-exports of foreign pesticides; DDT exports to individual Asian and African countries 1959-61; *trends in exports to certain Latin American countries of copper sulphate compared to other fungicides.

1962-63: (+) Breakdown into quantities of individual chemical imports of synthetic organic pesticides 1959-61; *acres treated in aerial application by F.A.A. region by activity; *estimated value of sprays and dusts handled by farm cooperatives 1951-52 to 1959-60.

1963-64: (+) *Value of U.S. pesticide imports (aggregate) 1958-62; *average value per pound of U.S. pesticides exported 1959-63; (+) Sources of farmer purchases of pesticides in Midwest and South, 1962.

1964-65: (+) Value of U.S. pesticides exported in 1964 by countries and continents. (+) Reports on U.S.D.A. study on cost of pest control in cotton.

1966: Gives quantities and values for benzenoid pesticides and sheep dip imported. (Note, states no statistics are available on total U.S. pesticide imports.) (+) Acres of crops treated for insects and weeds and livestock treated, by state (1964 census); (+) cash expenditures on cotton farms, types of pesticides and other chemicals 1957-59, 1963-65; (+) comparison of estimated extent and cost of chemical weed control in the United States, 1959 and 1962.

1967: Title was changed, cooperative pest control programs; pesticide purchases for foreign aid; pesticide prices; pesticide sales in Canada, (+) reports results of 1964 pesticide survey by USDA, other items the same as previous issues.

1968: Same basic data as 1967 updated; (+) further reports from 1964 pesticide survey by USDA; *consumption of principal wood preservatives.

U.S. Dept. of the Interior, Federal Water Pollution Control Administration, *Pollution-Caused Fish Kills*. Annual reports for years from 1960. Washington, D.C.: U.S. Government Printing Office.

These reports table statistics from the investigation by state officials in 44 states of pollution-caused fish kills. They comprise those fish-kills which are reported to state agencies by fishermen or other citizens and are evaluated by state officials. Hence, there is considerable variation in the coverage and detail and the statistics cannot be taken as a complete documentation. However, they are useful to determine the relative importance of pesticide kills in the total, and to get some idea of the variation between states and between years. There are tables which summarize fish kills by operations subgroup. Agricultural operations are divided into insecticides, fertilizers and manure-silage drainage. The number of reports and the number of fish reported are listed for each year.

Section 7

PESTICIDES IN AGRICULTURE

Brindley, T. A. and Dicke, F. F., "Significant Developments in European Corn Borer Research," *Annual Review of Entomology*, Vol. 8, 1963, pp. 155-176.

An exhaustive review of work on biology, host plants, population statistics, biological and chemical control measures of this important pest. Summarizes the findings. Large amount of literature (157 references) in useful short sections, without too much technical detail. An excellent source of the available literature for anyone looking for data with which to analyze the likely gains or losses from changing pesticide use on this insect.

Brown, A. W. A. *Insecticide Resistance in Arthropods*, World Health Organization Monograph Series, No. 39, 1958. 240 pp.

The author describes in detail the appearance, history and geographical distribution of insecticide resistance and assesses the importance of the phenomenon for each of the 40 species of arthropods examined. A review of available literature over the last ten years. Provides technical background information.

Georghiou, G. P. "Insect Resistance to Organic Insecticides: Underlying Principles and Future Prospects," in *Proceedings of the Third Annual Conference on the Use of Agricultural Chemicals in California*. Davis, Calif., 1964.

A non-technical review of research on factors affecting development of resistance; or types and extent of resistance; and on methods to overcome the problem. Bibliography (21 entries) included.

Headley, J. C., "Estimating the Productivity of Agricultural Pesticides," *American Journal of Agricultural Economics*, Vol. 50, No. 1, February, 1968, pp. 12-23.

Reports an attempt to statistically estimate the contribution of pesticides to agricultural output. Results of multiple regression analysis for 1963 are shown and interpreted.

Hillebrandt, Patricia M. "The Economic Theory of the Use of Pesticides: Part I," *Journal of Agricultural Economics*, Vol. 13, Jan., 1960, pp. 464-472.

This is an article basic to any analysis of the economics of pesticide use. It is the only one in which a model is set out to determine the optimal economic application of pesticides on the farm level. The basic production function is a dosage response curve relating yield of crop to dosage of pesticides. It is suggested that the basic form is one with first increasing then decreasing marginal returns with additional chemicals. Factors which modify the shape of this curve (effect of pesticide on crop, effect of application process, and interaction of the pesticide with other factors affecting the crop) are set out; also the effect of level of insect infestation. Simple diagrams make it easy to see that the optimum application is determined by the relationship between price of chemical and price of crop, and the response curve is also clearly shown diagrammatically. Other cost factors are also discussed. The author concludes that the lower the price of the chemical or the higher the price of the crop, the lower the degree of infestation it is profitable to treat and the greater the acreage that should be treated. The article has relevance to the problem of social costs. Chemicals are often cheap in relation to the value of crops which may make large inputs of pesticide profitable to the farmer, despite small marginal insect kills; the socially optimal dose may be much less.

Hillebrandt, Patricia M. "Farmer's Reasons for Using Weedkillers." *World Review of Pest Control*, Vol. 1, Part 3, 1962, pp. 18-24.

Reports an investigation by British farmers on reasons behind decisions on weed killers. Specific questions involve importance of profit motive; criteria on when to spray; criteria for buying spray machinery; reasons farmers did not use weed killers. Concludes that failure to treat as much as would be economically feasible attributable to prejudice, inertia, lack of practice in use and lack of economic knowledge.

Hillebrandt, Patricia M., "The Economics of the Use of Selective Weedkillers," *Farm Economist*, Vol. 9, No. 5, 1959, pp. 209-224.

Reports an investigation on (1) the extent of use of selective weedkillers on wheat in S.E. England in 1954-56 (2) costs and benefits of use. Data largely from two surveys. Calculation of benefits and costs; a good example of how combinations of prices and costs for different infestation levels (or yield increases by use) can be presented in a useful manner. (in both graphical and tabular forms)

Hillebrandt, Patricia M. "The Economic Theory of the Use of Pesticides, Part II Uncertainty," *Journal of Agricultural Economics*, Vol.

14, June 1960, pp. 52-61.

An extension of the theory outlined in part one to take into account that in the real world the dosage response curve and the price of the product are subject to uncertainty. More complex than Part I—but shows that it is possible, at least in theory, to determine the optimum rate of application of pesticide in this situation if a subjective estimate can be made of the degrees of potential surprise connected with various levels of profit and on indifference curves for gain and risk.

Basic Documents Submitted by Dept. of Agriculture Relating to the Use of Pesticides, Appendix I to Part I, 1964, U.S. Government Printing Office, Washington, D.C., vii, 178 pp.

Inter-agency co-ordination on Environmental Hazards (pesticides). Hearings before the subcommittee on Reorganization and International Organizations of the Committees on Government Operations, United States Senate, 8th Congress, 2nd session, Agency co-ordination study, (Pursuant to S. Res. 28, 88th Congress).

Radeleff, R. D., "The Toxicity of Insecticides and Herbicides to Livestock," *Advances in Veterinary Science*, Vol. IV, 1958, pp. 265-276.

Sets out the toxic and non-toxic levels for sheep, cattle, and pigs for various formulations of chlorinated hydrocarbons, organic phosphates and herbicides. Includes a short, straight-forward discussion. Points out that rate of application, particle size of emulsions, as well as, toxicity are important in evaluating the toxicity of any pesticide to animals.

Sheets, T. J. and Harris, C. I. "Herbicide Residues in Soils and their Phytotoxicities to Crops Grown in Rotation," *Residue Reviews*, Vol. 11, 1965, pp. 119-140.

This article reviews the experimental work done in the above field. It gives a clear, reasonably nontechnical account of the results to date. The authors review studies on persistence of herbicides in soils, the effect of residues on later crops, and methods to reduce or eliminate such carryover hazards. Includes a bibliography of technical articles.

Timmons, F. L. *Weed Control in Western Irrigation and Drainage Systems. A Joint Report of the United States Agricultural Department, Agricultural Research Service and the United States Depart-*

ment of the Interior, Bureau of Reclamation, ARS 34-14, Sept. 1960. 22 pp.

Reports survey of aquatic and ditchbank weed infestation; and the damage and water loss caused thereof in 47 irrigation districts in 17 western states. Uses results to estimate costs of weed damage and weed control. Control methods do include use of herbicides, but the net value due to herbicides is not calculated separately. For the overall calculations, the assumptions made are that the market cost of water transpired is a measure of the losses from weeds coupled with the costs of weed control.

U.S. Department of Agriculture, Agricultural Research Service—*Suggested Guide for Chemical Control of Weeds*. ARS 22-67, April, 1961, 60 pp.

A publication to make information on suggested new weed-control practices available to Extension workers. It is therefore not too technical. Contains useful data on properties of herbicides, and their oral toxicities to warm blooded animals; also on recommended dose rates and herbicide uses for each field crop. This provides more information than conventional farmers' recommendations. Includes a note on how to estimate per acre output of sprayers. Useful semitechnical reference for economic research work at the farm level.

U.S. Department of Agriculture—*Insects*, Yearbook in Agriculture, 1952, U.S. Government Printing Office, Washington, D.C., 1952, xviii, 780 pp. LXII Plates.

Provides quite a good introductory background to many of the aspects of the topic. However, some information is now out of date (e.g. losses in agriculture); also detail is insufficient for many purposes. Includes short articles on the role of insects in aiding man; insects as pests; the nature and application of insecticides; and resistance. It also has short articles on particular insects.

U.S. Department of Agriculture, Agricultural Research Service, *Losses in Agriculture*, Agricultural Handbook No. 291, Aug. 1965, V, 120 pp.

The losses listed include those potential production losses due to diseases of crops and ornamental plants, to nematode damage; to crop plants; to injurious crop insects, to weeds; to insect pests of livestock and poultry; to forest product losses due to insect and disease losses. The fig-

ures given are percentage, quantity and value estimates of the losses which have occurred despite control measures. The estimates were made from average national annual values taken over the ten year period 1951-61 for losses and potential yields and were arrived at by surveys or by the judgment of specialists. Some care should be taken in interpreting these results. For example, the report admits wide variations occur in losses from year to year but does not give figures for any of the crops covered, nor any estimate of the probability of 'average' losses. Often crop losses occur due to a number of factors—the percentage due to any one factor when based on survey or judgment is a very subjective figure. Loss in value terms is calculated using market price—account of the effect of extra production on market price is not attempted. The loss figures are extremely aggregated—e.g. 'field crops' is one category. No account of the method of aggregation or individual estimation is given.

Costs of control programs are also listed. Unfortunately, these are aggregated so costs of pest control cannot be separated. Again insufficient detail is given.

Brazzel, J. R., Davich, T. B. and Harris, L. D., "A New Approach to Boll Weevil Control," *Journal of Economic Entomology*, Vol. 54, Aug., 1961, pp. 723-730.

Reports successful experiments on late-season applications of methyl parathion to cotton fields to reduce over-wintering populations of boll weevils (used 4 applications on 12-14 day schedule starting just prior to harvesting) The delay in buildup of boll weevils the next season allowed a later start for conventional pesticide controls, and a marked saving in cost. This is an example of ecological knowledge being used to combine biological and chemical controls effectively.

Fye, R. E., and Hopkins, A. R., *Cotton Yields with Recommended and Experimental Insecticides, 1928-1958*, U.S. Dept. of Agriculture Technical Bulletin No. 1264, ARS, USDA/South Carolina Agricultural Experiment Station, Clemson, S.C., May 1962, 41 pp.

A summary of results of experiments on the use of various insecticides to control boll worm and boll weevil. Lists yield average from treated and untreated plots for each year. Different chemicals were used on different plots—the average yields from the treated areas could be undervalued in some cases, as yields from unsuccessful treatments were included.

No details were included from which to determine the effect this might have in different years.* The number of treatments per year are

listed, but not the dose rates. There are only a few qualitative remarks about infestation levels. Only plot trials were used—no mention was made of interaction problems.

*Using inorganic chemicals, the average yield increase of treated over untreated was 23.6 percent; since 1945 using organic compounds (combination not listed), the average increase for the period was 53.9 percent. These averages could be misleading. Insufficient data were included to make a more detailed and accurate analysis.

Gaines, R. C., *Ecological Investigations of the Boll Weevil, Tallulah, Louisiana, 1915-1958*, U.S. Dept. of Agriculture, Agricultural Research Service, Technical Bulletin 1208, Aug., 1959, 20 pp.

A review of some of the most comprehensive long-term studies of the boll weevil and its control. Data on insect numbers and cotton yields with trash levels, winter temperatures and summer rainfall are tabulated. Correlation coefficients between most of the variables have been determined. The percentage increase in yield due to insecticides is listed for years 1915 to 1958. A useful source of data, although the author has not attempted to relate the data to any hypothesis relating insecticides and ecological factors.

Lloyd, E. P., and Merkl, M. E., "A Field Cage Study of Population Dynamics of the Boll Weevil," *Journal of Economic Entomology*, Vol. 59, Feb. 1966, pp. 83-86.

Tabulates experimental data of infestation levels and cotton yields for year 1961 and 1962. These are important variables in any economic study of pesticide production functions. The study is one of a recent series investigating ecological relationships of the boll weevil. Its object is to determine the relationship of the size of overwintered boll weevil populations to final infestation and to cotton yields.

Lloyd, E. P., Merkl, M. E., and Crowe, G. B. "The Effect of Boll Weevil Infestation on Yield and Quality of Cotton," *Journal of Economic Entomology*, Vol. 55, 1962, pp. 225-227.

This reports a recent experiment to determine the effect of different levels of boll-weevil infestation on earliness, yield and quality of cotton lint. The yields achieved are tabulated. Significant differences in yield but not quality between infestation levels were found. No pesticides were applied.

National Research Council, National Academy of Sciences, *Report of Committee on Persistent Pesticides to Administrator, Agricultural Research Service, U.S. Department of Agriculture, National Academy of Sciences, Washington, D.C., May 27, 1969, 34 pp.*

A report of a select committee of scientists examining progress since the report of the President's Science Advisory Committee in 1963. Basically, a consensus of opinions on the need for pesticides, monitoring, residues, alternative forms of control and recommendations. A document that may have an impact on agricultural pesticide policy.

Parencia, R. "Comparative Yields of Cotton in Treated and Untreated Plots in Insect-Control Experiments in Central Texas, 1939-1958," *Journal of Economic Entomology*, Vol. 52, No. 4, August 1959, pp. 757-758.

This article lists for each of the relevant years, the number of experiments, number of plots, acres and average number of applications of types of insecticides, times of spraying, pounds of seed cotton under treated and nontreated conditions and a percentage gain of 40.6 percent is calculated for the period. Note, however, that the between year range of gain varies from 9 percent to 156 percent. Reasons for this wide range are not discussed. No data on infestation levels are included—an average infestation is assumed.

Trials were carried out in small and large plot experiments and at field and community wide levels.

Watson, T. F., and Sconyers, M. C., "Comparison of Insecticide Application Schedules for Control of Cotton Insects," *Journal of Economic Entomology*, Vol. 58, No. 6, Dec. 1965, pp. 1124-1227.

The experiments reported show the role of biological control of cotton insects and the effect of pesticides on beneficial insects. The author examines a series of application schedules—from a weekly spraying schedule or weekly after an infestation of 10 percent of squares to spraying only when 24 percent of squares were infected. There was no statistical difference between the yields achieved under each method. Author suggests cost could be reduced if control measures were applied only when population pressure of cotton insects was too great for biological control. Note his criterion is minimum cost for same yield—he does not consider the case of reduced cost and reduced yield where prices and costs must be compared.

Section 8

HEALTH ASPECTS OF PESTICIDES

Barnes J. M., *Toxic Hazards of Certain Pesticides to Man*. World Health Organization, Monograph Series No. 16, Geneva, 1953. 129 pp.

Describes risks of poisoning from pesticides during manufacture, application and from traces in food products. Includes 200 item bibliography on references to toxic hazards. Refers to problems and methods of control in firms which formulate pesticides. Uses the legislation in California as an example of application control. Reviews hazards by method of application. Does not consider residue analysis problems in any detail.

Cook, Warren A., "Safe Handling of Toxic Materials by the Pest Control Operator," *Industrial Medicine and Surgery*, Vol. 25, No. 5, May, 1956, pp. 205-212.

Discusses precautionary measures for workers in formulation plants and for applicators. General information to be found in many other places, interesting because it is discussed by industrial health experts, who outline specific requirements.

Hayes, W. J., Jr. "Pharmacology and Toxicology of DDT," in *DDT: the insecticide Dichlorodiphenyltrichloroethane and Its Significance*, Vol. II: *Human and Veterinary Medicine*, ed. Paul Muller. Basel: Birkhauser Verlag, 1959, pp. 11-247.

Gives a detailed and exhaustive account of material on all aspects of the above topic. Much of this is not likely to interest the general reader, but chapters on toxicity of DDT to man, the exposure of workers and the problem of residues are valuable as they give details of experimental work in these fields which have not been collected elsewhere. Chapters on hazards to fauna are less useful—they present research findings without attempting to relate or synthesize them. Provides an exhaustive, 30 page bibliography of work on DDT up to 1958.

Hayes, W. J., Jr., Quinby, G. E., Walker, K. C., et al., *Archives of Industrial Health*, Vol. 18, 1958, pp. 398-406.

Measurement of DDT storage in the fat of groups of people with different degrees of dietary, environmental and occupational exposure revealed that those who lived near treated fields show only a trivial increase of DDT in body fat as compared with people in the general population.

Hayes, Wayland J., Jr., "Pesticides in Relation to Public Health," *Annual Review of Entomology*, Vol. 5, 1960, pp. 279-404.

A clear, comprehensive and not too technical review of research in the above field. Includes a short section on public health benefits but primarily covers studies of toxicity and potential hazards of pesticides. Includes data on deaths and illnesses attributed to pesticides. (Latter resulted from acute poisoning, pesticides were not found to be a cause of chronic effects.) Reports studies on man to determine pesticide toxicity and safe levels of exposure including experiments to determine DDT in body fat. Stresses the importance of dermal exposure as a source of occupational poisoning—has occurred only when chemicals were not used correctly. Therefore proper labeling and education in use are stressed. Covers 112 references.

Ortega, P., Hayes, W. J., Jr., Durham, W. F., et al. *DDT in the Diet of the Rat—Its Effect on DDT Storage, Liver Function and Cell Morphology*, U.S. Public Health Monograph No. 43, 1956.

This is the article referred to by Rachel Carson in "Silent Spring", as giving evidence of liver damage from DDT storage at levels of 5 p.p.m. The authors found after an extensive series of tests on rats, that liver cell necrosis occurred only with dosages in excess of 1,000 p.p.m. At 5 p.p.m. histological changes occurred in liver cells, with formation of fat deposition bodies. Increased severity of changes was noted with increasing dosage. Authors concluded cellular change demonstrable at 5 p.p.m., however, they considered it possible that the occurrence depended also on some unidentified secondary substance. They also pointed out that changes are mild, readily reversible and are imperfectly correlated with liver function.*

* Not all sources of data cited by the principal protagonists of the pesticide controversy have been checked or listed in this bibliography. However, as this example shows, data cited in general analysis (especially of the polemic type) should be checked before being accepted as evidence.

Ortelee, M. F., *Archives of Industrial Health*, Vol. 18, 1958, pp. 433-440.

A report on examination of 40 formulating plant workers. It indicated that 26 had absorbed DDT at a rate equal to or higher than 35 mg per man per day. The men had been exposed at this rate for 0.5 to 6.5 years (mean = 3.5-yrs.) but showed no ill effects as judged by medical examinations, their own reports, or their work-attendance records.

Quinby, G. E., Walker, K. C., and Durham, W. F. "Public Health Hazards Involved in the Use of Organic Phosphorus Insecticides in Cotton Culture in the Delta Area of Mississippi," *Journal of Economic Entomology*, Vol. 51, Dec., 1958, pp. 831-838.

A report of an investigation of suspected causes of poisoning by cotton insecticides (malathion, methyl parathion and Guthion) in Mississippi Delta in 1955. The authors evaluate 91 illnesses suspected of being examples of such poisoning. Their discussion includes some technical detail, but provides a good example of the methods used to investigate suspected poisonings.

Simmons, Samuel W. "The Use of DDT Insecticides in Human Medicine," in *DDT: the Insecticide Dichlorodiphenyltrichloroethane and its Significance*, Vol. II: *Human and Veterinary Medicine*, ed. Paul Muller. Basel: Birhauseser Verlag, 1959, pp. 251-502.

A detailed account of work on use and effects of DDT against insect-borne diseases in all parts of the world. An excellent reference work on any aspect of the topic. Reviews over 600 articles.

Syracuse University Research Corporation, Microbiological and Biochemical Center. *Bibliography of Organic Pesticide Publications Having Relevance to Public Health and Water Pollution Problems*, Project No. GL-WP-3. Prepared for New York State Dept. of Health. Ithaca, May, 1963, viii, 122 pp.

A bibliography prepared for public health personnel and laboratories. Titles are listed under 3 main headings: analysis, effects and general. The analysis section is very technical. The effects section covers toxicity, metabolism, degradation of residues and aspects of pollution. Includes some very technical material but also has one of the largest bibliographies of technical articles of general interest on effect of pesticides on poultry, fish, and wildlife.

West, Irma, and Milby, Thomas H. "Public Health Problems Arising from the Use of Pesticides," *Residue Reviews*, Vol. 11, 1965, pp. 141-159.

Presents data for California on non-fatal and fatal pesticide poisonings. Points out that the number of non-fatal poisonings in agriculture went from 226 in 1953 to 746 in 1963. No change in fatalities took place. Points out that until prompt medical reporting of all deaths and poison-

ings attributed to pesticides is made mandatory, figures for morbidity are not likely to be complete. The article then discusses factors involved in examples of accidental fatal pesticide poisonings. Also lists evidence for environmental contamination, and recommends that because fish and wild-life concentrate certain persistent pesticides in their fat, they should be brought into the pesticide food monitoring programs and subject to tolerances established for agricultural commodities. Concludes that deaths and illnesses occurred which were preventable and that workers were not sufficiently trained or protected. Also suggests greater evaluation of environmental sources of pesticides other than food, and further research and regulation of public health problems of pesticides not related to food residues.

Wilson, C. W. and Baier, W. E. "Toward an Equitable Basis for Assignment of Residue Tolerance Values," *Residue Reviews*, Vol. 4, 1963, pp. 1-8.

A short article presenting arguments for two possible new bases for assigning residue tolerances, calorific food basis and nonaqueous matter content of food.

World Health Organization. *Insecticide Resistance and Vector Control*. 13th Report of the World Health Organization Expert Committee on Insecticides, Geneva, 1962, Technical Report No. 265, 1963. 227 pp.

Reports changes in the number of insect species resistant to one or more insecticides. Describes present and new methods to gauge susceptibility. Presents revised version of vector control recommendations. Discusses trends in vector control, with special reference to environmental sanitation methods and the manipulation of biological, nutritional and genetic factors.

World Health Organization. *Specifications for Pesticides, Insecticides, Rodenticides, Molluscides and Spraying and Dusting Apparatus*, 2nd Addition 1961. 523 pp.

Manual contains the specifications established by the WHO Expert Committee on Insecticides, for pesticides against vectors of diseases of man, and for apparatus for applying those pesticides. Specifications give lists under divisions shown above. For insecticides, for example, specifications are given for technical grade insecticides, water dispersable, power concentration, emulsion, concentrated dusting powders and larvicides.

World Health Organization. *Principles Governing Consumer Safety in Relation to Pesticide Residues*. Report of a Meeting of a WHO Expert Committee on Pesticide Residues Held Jointly with the FAO Panel of Experts on the Use of Pesticides in Agriculture, Rome, 1961, Technical Bulletin Series, No. 267. 24 pp.

Discusses four basic requirements for adequate control of potentially dangerous residues of pesticides—a) supervision by qualified agricultural advisers; b) analytical facilities for determining residues; c) the establishing, with toxicological advice, the amount of pesticide which may be ingested daily without ill-effect; d) joint consultation between all authorities concerned. Various methods of controlling pesticides are considered, special stress being laid on registration and adequate labeling. The distinction between acceptable daily intake, permissible level, and tolerance is set out, together with methods of computation. Recommendations are made for research; and for a pesticide information service. Reasonable summary, but does not consider alternative bases for residue determination—e.g. benefit/cost.

World Health Organization. *Toxic Hazards of Pesticides to Man*. 12th Report of the Expert Committee on Insecticides, Geneva, 1961. Technical Report Series 227, 1962, 32 pp.

Considers the potential toxic hazards to field operators and occupants of treated dwellings from the use of pesticides in the field of public health. Includes a brief discussion of signs and symptoms, a treatment of poisoning and a slightly lengthier section on protection of operators against exposure. The most interesting sections are those recommending minimum precautions for operators, and suggestions to governments on areas requiring legislative control.

World Health Organization. *Occupational Health Problems in Agriculture*. Fourth Report of the Joint ILO/WITO Committee on Occupational Health, Geneva, 1962, Technical Report Series no. 246, pp. 16-25.

The short section referred to discusses protection of agricultural workers against toxic hazards (especially pesticides). Covers criteria for hazard classification of chemicals for any broad control system—the major one being toxicity which in turn depends on mode of use and formulation. Sets out minimum requirements for government control of use, marketing, and labelling. These recommendations are of interest, because they are the minimum considered necessary by experts for any part of the world. Can be used as a standard of comparison with U.S. or U.K. regulations.

Section 9

ECONOMIC THEORY APPLICABLE TO THE PESTICIDE PROBLEM

Bain, Joe S., "Criteria for Undertaking Water Resource Development," *American Economic Review*, Vol. 50, May, 1960, pp. 310-320.

Provides useful comments on four issues: a) the general investment criterion, b) the interest rate to be used in discounting future benefits and costs, c) the timing of investment and the avoidance of premature investment and d) the problems of intangible benefits and of appropriate pricing. In this last area, suggests that the implicit ignoring of non-quantifiable benefits can lead to non-optimal social decisions; also that one set of subsidized prices should not be used in benefit calculations, but various alternative pricing systems investigated.

Brandow, G. E. *Interrelations Among Demands for Farm Products and Implications for Control of Market Supply*, Pennsylvania State University, Agricultural Experiment Station Bulletin No. 680, August, 1961, 104 pp.

This bulletin presents an integrated description of the long-term demand structure for farm products in the United States. Quantitative estimates are derived for price-quantity inter-relationships among these commodities, at both retail and farm level. Although in many cases estimates could not be precise, this study is important because it is an integrated system of analysis through which important interactions can be traced, rather than a series of studies dealing with just one commodity. It is a useful data source for any attempt to estimate benefits to agriculture from pesticides, as demand effects on changes should be considered.

Buchholz, H. E., Judge, G. G. and West, V. I. *A Summary of Selected Estimated Behavior Relationships for Agricultural Products*, University of Illinois Agricultural Experiment Station Research Report AERR-57, October, 1962, 131 pp.

This report presents reviews and abstracts of the demand and supply studies done on various agricultural products in the U.S. The major quantitative estimates derived are listed for each study. This could be a source of demand data for estimates of agricultural benefits of pesticides, which should include demand effects.

Castle, Emery N., "The Market Mechanism, Externalities and Land

Economics," *Journal of Farm Economics*, Vol. 47, No. 3, August, 1965, pp. 542-556.

This article emphasizes that criteria for judging the adequacy of market and nonmarket institutions for natural resource management must be capable of treating the indivisibilities and externalities characteristic of these resources. It raises important questions concerning the evaluation of alternative institutional arrangements; and suggests useful areas for research in resource management. It also includes references to empirical work concerned with ways of dealing with specific externalities and indivisibilities.

Ciriacy-Wantrup, S. V. *Resource Conservation: Economic and Policies*. University of California Press, Revised Edition 1963, 395 pp.

Includes sections on the objectives and criteria of public conservation policy and the implementation of such policy. Chapter 17 gives a brief but useful introductory summary to topics such as social revenues and costs, valuation of collective extra-market goods, and problems of interpersonal valuation. Chapter 18 looks at the advantages and disadvantages of the safe minimum standard as an objective. This has some relevance to the problem of residue requirements.

Heady, Earl O. and Dillon John L. *Agricultural Production Functions*. Ames: Iowa State University Press, 1960, 687 pp.

A comprehensive review of studies on production functions, together with theoretical analysis and discussion of problems of estimation. Includes relations between inputs and outputs for technical units e.g. acres of wheat, hogs and for whole farm. Pesticide inputs are not treated separately, though they are included in operating cost in a number of studies listed.

This book gives an excellent background to the basic technical and economic relationships involved in analysis of pesticides, and to the problems involved in getting and using quantitative estimates based on production functions.

Knetsch, Jack L. "ECONOMIC ASPECTS OF ENVIRONMENTAL POLLUTION", *Journal of Farm Economics*, Vol. 48, No. 5, Dec. 1966, pp. 1256-1263.

Brief discussion of a framework for a generalized pollution analysis. Includes notes on a model of demand and supply of environmental products. Emphasizes problems caused by externalities and irreversibility of

supply curves. Useful for generalized rather than 'commodity' approach, and for wide range of examples. Does not however investigate solutions.

Krutilla, John V., "WELFARE ASPECTS OF BENEFIT—COST ANALYSIS", *Journal of Political Economy*; Vol. 69, No. 3, June 1961, pp. 226-235.

Discusses the use of benefit cost analysis to determine which alternative should be preferred. Assumes that government decisions made from these results will improve general welfare as defined in economic theory, yet this necessarily occurs only under assumptions which are not really met in the real world. The effect on welfare of these assumptions not being met are therefore discussed, e.g. the effect of such changes occurring are reviewed, and the effect of non-efficient allocation and prices. This is a technical article, but is valuable to the non-technical reader for obtaining an understanding of some of the real problems involved in the welfare implications of decisions based on benefit-cost analysis.

Nelson, R. R., "SIMPLE ECONOMICS OF BASIC SCIENTIFIC RESEARCH", *Journal of Political Economy* Vol. 64, June, 1959, pp. 297-306.

Article sets out a basic economic framework in terms of externalities for analyzing investment in scientific research. Discusses the roles of private and government investment, and the characteristics of firms who are likely to carry out basic research. A useful general introductory statement. Does not look at criteria on which to base specific investment decisions.

Nerlove, Marc. *The Dynamics of Supply: Estimation of Farmers' Response to Price*. The Johns Hopkins Press, Baltimore, 1958, pp. 222-235.

This section of the book looks at welfare losses under alternative price support programs for agriculture. There is an excellent short definition of consumers' and producers' surplus and the limitations of the concept, and useful diagrammatic illustrations of the surpluses associated with support programs, together with statistical estimates of such surpluses, using the author's estimates of supply and demand elasticities.

Turvey, R. "ON DIVERGENCES BETWEEN SOCIAL COST AND PRIVATE COST", *Economica*, Aug. 1963, pp. 309-313.

An article which reviews the theoretical analysis of the application of

taxes or subsidies to overcome externalities. The paper is somewhat technical but makes useful points clearly and concisely. Discusses how voluntary agreements may theoretically be effective, and sets out what is required for decisions in the non-negotiable situation. It also points out that the cost of achieving the optimum must be considered.

Wallace, T. D. "MEASURES OF SOCIAL COSTS OF AGRICULTURAL PROGRAMS", *Journal of Farm Economics*, Vol. 44, No. 2, May, 1962, pp. 580-594.

Paper presents an attempt to compare three agricultural policy proposals (production quotas, price subsidy, and input restriction) on the basis of social costs. He uses the concept of consumer's surplus to get a quantitative measure of such benefits. It is in part fairly technical, but shows the application of consumer's surplus analysis in an agricultural policy situation. The case of restriction of inputs bears some relation to the pesticide case.

Section 10

EXAMPLES OF PUBLIC DECISION MODELS

Dorfman, Robert (ed.) *Measuring Benefits of Government Investments*, Papers presented at a Conference of experts held Nov. 7-9, 1963, The Brookings Institution, Washington, D. C., 1965.

Topics of these papers were chosen to illustrate the scope as well as the problems of evaluating and measuring benefits and costs of different types of government investments. The seven papers cover research and development projects, education programs, federal aviation expenditures, highway programs, urban renewal, and syphilis control. They are excellent illustrations, both of the variety of ways the concepts of benefits and costs can be applied and of the difficulties involved in obtaining meaningful measures.

The introduction provides a useful short definition of "benefit-cost" and the economic rationale for the role of government in decision making, as well as critical comments on the papers.

The papers of greatest direct relevance to evaluating pesticides are those on research, health and recreation. The study on research is, however, limited by being confined to only the most applied aspects—applying the results of research already carried out. The problem for pesticide research is one of how much expenditure should be allocated for basic research. However, the discussion on cost effectiveness is useful, although the authors' use of direct estimates of benefits using grading by technical experts seems to have serious shortcomings. The issues faced in evaluating recreation benefits are similar to those faced in wildlife benefit measurement. The problems of dollar valuation of these benefits are well summarized.

Eckstein, Otto. *Water Resources Development: The Economics of Project Evaluation*. Harvard University Press, Cambridge, Massachusetts, 1958, XIII, 300 p.

One of three studies which are basic references in the field of economic analysis of government decision making. All suggest procedures to evaluate the efficiency of water resource development projects.

One useful feature is the discussion of the theoretical basis of benefit-cost calculation. This is somewhat technical, but its rigorousness means that the important assumptions are made explicit.

Griliches, Zvi. "Research Costs and Social Returns: Hybrid Corn and Related Innovations", *Journal of Political Economy*, Vol. 66,

Oct., 1958, No. 5, pp. 419-431.

The author uses the concept of loss in consumer surplus if hybrid corn did not exist to measure gross value of hybrid corn to society, and compares it to the cost of additional resources devoted to production of hybrid seed, to obtain net social return, which he then compares to estimates of research expenditures. Annual fluctuations in production are ignored. Alternative rates of return on hybrid corn research expenditures are calculated. This is an important example of an attempt to value returns from research expenditures in agriculture (ex-post) and also illustrates an economic framework useful in estimating agricultural benefits of pesticides.

Haveman, Robert H., *Water Resource Investment and the Public Interest*. 1965, Vanderbilt University Press, Nashville, Tennessee, XIII, pp. 199.

Presents an empirical analysis of the allocative efficiency and income redistribution impact of Federal expenditures on water resources in ten Southern states between 1946 and 1962. Author calculates benefits and costs using the methods of McKean, Krutilla and Eckstein and compares them to the estimates actually used. Has significant sections on the actual criteria and actions of Congress; and on the possibilities of evaluating allocative and income effects using a single weighted welfare function.

Herfindahl, Orris C., and Knesse, Allen V.; *Quality of the Environment: An Economic Approach to Some Problems in Using Land, Water and Air*; Washington, D. C.; Resources for the Future 1965, distributed by the Johns Hopkins Press, Baltimore, Md., VIII, 96 pp.

The authors look at problems of water pollution, air pollution, pesticides, urban development, and recreation areas within the framework of externalities, i.e. the activities of an individual firm, which affect the environment external to it. In these five areas, they review briefly the technical information available, in order to identify the problem areas and suggest needed research required to determine how controls can be applied. Their discussion is not technical, but provides a useful introduction to each area. A short bibliography of basic material is included.

The pesticide chapter provides a review of both beneficial and detrimental aspects, and points out some of the needs for quantitative information and the significance of uncertainty about effects. There is a useful section on problems of added legislation and institutional requirements. It provides an economically oriented background rather than a rigorous

framework for analysis.

Hitch, Charles J. and McKean, Roland N. *Economics of Defense in the Nuclear Age.* Harvard University Press, Cambridge, 1960, VIII, 422 pp.

Important as an example of economic analysis which has been applied in public decision making. Brings up questions relevant to many other public decision areas. See, for example, the introduction covering the types and levels of decision making and the appropriate economic analysis. The authors provide an excellent non-technical discussion of the various economic problems involved. Topics covered include decisions on the size of the defense budget; the indirect effects of defense spending; possible criteria for efficient allocation; the problems of uncertainty, time and institutional arrangements. Considerable ingenuity is shown in finding economic models appropriate for specific and complex defense problems.

Kneese, Allen V. *The Economics Regional Water Quality Management.* Baltimore: The Johns Hopkins Press for Resources for the Future, Inc., 1964, XII, 215 pp.

A study of problems of water pollution, i.e. economic resource allocation as it relates to waste disposal. Discusses the important problem of "off-site" costs on subsequent users. In Chapters 3, 4, and 6 it gives a clear non-technical (bar Appendices) account of technological external dis-economies, and methods for decision makers to redress cost distortion caused by wastes. Compares the use of taxes and subsidies to the traditional requirement laws. Illustrates with empirical studies. The book should be useful in formulating ways of and criteria for regulating pesticide use.

The problem of appropriate criteria and how to discount for time are also discussed in some detail, though this is less important to the pesticide case.

Some of the most useful analysis is found in the case studies which cover government decisions on flood control, navigation, irrigation and electric power—which show how the factors involved in the economic analysis can be determined in specific situations.

Krutilla, John V., and Eckstein, Otto. *Multiple Purpose River Basin Development; Studies in Applied Economic Analysis,* Published for "Resources for the Future" by the Johns Hopkins Press, Baltimore, Md., 1958, 301 pp.

One of three studies that are basic references in the field of economic

analysis of government decision making. All suggest procedures to evaluate the efficiency of water resource development projects.

The major emphasis of the study is on evaluating the comparative efficiency of alternative ways of developing multi-purpose water resource projects where there are alternatives in the degree and form of government participation. There are also evaluations of the alternative distributions (by income group and region) of costs and benefits.

The development of efficiency criteria based on a model of perfect competition and taking into account indivisibilities and externalities is on a slightly more technical level than McKean, but its rigorousness is useful.

McKean, Roland N., *Efficiency of Government Through Systems Analysis: With Emphasis on Water Resources Development*, Rand Corporation Research Study. Operations Research Society of America, Publication No. 3, John Wiley and Sons, Inc. New York, 1958, 336 pp.

One of three studies which are basic references in the field of economic analysis of government decision making. All suggest procedures to evaluate the efficiency of project water resource development, so that decisions will maximize national welfare. The major emphasis of this book is on the conceptual problems and criteria involved in economic analysis of government projects. It provides an excellent introduction to the field, as it covers the general methodological problems as well as those applying specifically to water resources; and is clear and non-technical. Any lack of explicit economic rigorousness can be overcome by consulting the other two studies.

The discussion covers the important topics of selection of criteria; problems of appropriate alternatives and of suboptimization; intangibles; uncertainty; and problems of maximization of goals over time. However, how or what alternative investment possibilities should be chosen are not discussed. Also, the implicit assumption is that input and output prices are given despite subsidies, supports etc. Agricultural output is also valued at market prices—the effect of increased supply or price is not considered. The methods used to express goals and to deal with benefits occurring after future time are different from the other two studies. They are critically appraised in the article by Margolis.

Margolis, Julius, "The Economic Evaluation of Federal Water Resource Development" *American Economic Review*, Vol. 49, No. 1, March, 1959; pp. 96-111.

This is a review of the three books, McKean-Eckstein, Krutilla-Eckstein, listed above. It should be read in conjunction with them, both as a summary of their analyses and as an excellent critical discussion. The reviewer himself makes further comments on some concepts and issues involved in goal selection; alternatives; time; uncertainty; constraints and investment criteria; and technological external economies; and makes specific criticisms of the methods and assumptions of the three authors.

Muskin, Selma, J., "Health As An Investment", *Journal of Political Economy*, Vol. 70, No. 5, Part 2, Oct. 1962, pp. 129-157.

This article is one of a group published to emphasize investment in human capital. It discusses similarities and differences of health and education as means of adding to human capital. Provides a good review of methods of measuring human capital formation and cites examples of estimates of costs of various illnesses. A good list of references are cited in the article that point to other studies of health economics.

Western Resources Papers, *New Horizons for Resources Research: Issues and Methodology*, 1964, University of Colorado Press, Boulder IX; 315 pp.

New issues and methodology in resources research are discussed in a series of papers on four major areas—outdoor recreation, water pollution, regional problems, and shale oil development. The general approach, and the first three areas especially, is useful to any public decision making in the natural resource area.

The problem of how to measure demand for recreation has direct relevance to problems of pesticides and wildlife, and is clearly analyzed. There is also an interesting analysis of what people require of wilderness.

The articles on water pollution are again relevant to the pesticide case. Two articles set up computerized systems incorporating all technical interdependencies—models which are also necessary to an integrated approach in analysis of pesticides. These should be seen together with the articles reporting attempts to measure benefits associated with each level of pollution control.

The third section is a case study of an example of the problems of conflicts of regional and national objectives and the legislative methods which may be used. This also has direct relevance to pesticide decision making.

Proposed Practices for Economic Analysis of River Basin Projects, Re-

port to the Federal Inter-Agency River Basin Committee Prepared by the Subcommittee on Benefits and Costs, May, 1950.

Useful for its discussion of methodological problems raised when a method of economic analysis—benefit cost analysis is actually applied in government evaluation of projects.

Ruttan, Vernon W. *The Economic Demand for Irrigated Acreage: New Methodology and Some Preliminary Projections, 1954*, Baltimore: The Johns Hopkins Press, for "Resources for the Future," Inc. XI, 139 pp.

Useful both as a good example of the type of framework required for public decision making and the methods used to provide quantitative evidence for such models; for its discussion on the limitations of the requirement approach for demand projections; and for the specific use of production functions in the analysis. The analysis of production functions is an important part of estimating benefits of pesticides in agriculture.

The author attempts to replace the demand requirements approach with a framework to evaluate the relative profitability of future public and private investment in irrigation development.

He also carries out an empirical analysis of three resource productivity models which emphasize different aspects of the problem. His discussion of the difficulties and limitations of these studies, as well as the inferences that can be made, is particularly useful and includes important references to resource productivity literature.

Weisbrod, Burton A., *Economics of Public Health, Measuring the Economic Impact of Disease*, Philadelphia: University of Pennsylvania Press, 1961. XV, 127 pp.

Health is viewed as a commodity that is purchasable in varying quantities. Attempts to (1) set forth a procedure to aid in making rational choices among alternative public health projects, and (2) to evaluate quantitatively, certain benefits to society from eliminating cancer, tuberculosis and polio. The book discusses the public demand for good health, money costs of poor health and concludes that in 1954, cancer was the most costly of the three diseases studied, approximating one percent of national income annually. He suggests that a similar analysis is needed for all major diseases to determine priorities for allocating public health resources. The general method should have application to the health aspects of pesticide use.