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THE ALLOCATION OF FEDERAL EXPENDITURES: PLANT DISEASE AND PEST CONTROL PROGRAMS IN THE U.S. DEPARTMENT OF AGRICULTURE

by
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Dissertation Abstract

THE ALLOCATION OF FEDERAL EXPENDITURES: PLANT DISEASE AND PEST CONTROL PROGRAMS IN THE U.S. DEPARTMENT OF AGRICULTURE

By Russell C. McGregor

This study deals with the allocation of Federal expenditures among a set of programs--the plant pest control programs administered by the Agricultural Research Service of the Department of Agriculture. The purpose is to critically examine this allocation to determine whether it is the best that can be achieved as defined by economic concepts of optimality.

The losses due to pests and diseases in agriculture are discussed together with the public controversy that has recently enveloped the use of pesticides for their control. The history of Federal-State cooperative programs is briefly outlined, including the shifts in acceptable objectives. A number of models are presented for use in considering optimum allocations.

The concept of a protection supply function is developed and employed with data from the grasshopper program to illustrate its use in assisting public decisions on funding levels. The present allocation of funds is presented and there is a discussion of the process by which these allocations were determined, including a quantitative evaluation of the role played by each of the participants in the budgetary process.

The study concludes that a program data and analysis system needs to be developed to improve the present allocation by strengthening the role of economic and scientific considerations in the decision making process.

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CHAPTER 1. INTRODUCTION

The evaluation of Federal programs is an integral part of the process of budget formulation in the Executive Branch of the Federal Government. Program advocates recite from long lists of accomplishments, while antagonsists intone the litany of dollar restraints. A lengthy and complex planning process produces the President's budget for transmittal to the Congress each January. One objective of that process is to provide for a division of Federal funds among activities calculated to achieve the desired ends at least cost--an optimum allocation of expenditures. The desired ends encompass the intertwined considerations isolated by Musgrave[1]--allocation, distribution, and stabilization.

The rationalization of widely differing requirements is essentially a political process[2]--the art of politics being not confined to legislatures--but a vital ingredient of a healthy bureaucracy. There is opportunity here for economic analysis which has been little realized. The process of budgeting is terrifyingly elaborate, jargonized, and irregular in scope and timing. Those involved in the process find that the time constraints preclude all but the most perfunctory analysis. Those analyzing from outside often find their insights made irrelevant by the vicissitudes of

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[1] Richard A. Musgrave. The Theory of Public Finance. (McGraw-Hill Book Company, Inc. New York. 1959)

[2] Aaron Wildavsky. Politics of the Budgetary Process. (Atlantic, Little Brown and Company, Boston. 1964)

timing. Thus do we account for the lack of economic analysis in expenditure decisions.

This thesis provides an opportunity for one familiar with the process[3] to explore one of its many vexing occupational questions--"Is the division of funds provided in the budget among a particular set of programs an optimum allocation of Federal resources? What is meant by optimum, and how can it be measured? The appropriation act, which represents the culmination of the budget preparation process, incorporates many political and economic considerations. One alternative, therefore, is to assume that the distribution of funds contained in the appropriation act is an optimum.

Such a hypothesis is rejected for the following reasons: (1) Observation of the behavior of the participants strongly suggests that adequate participation by affected groups is often restricted; (2) The volume of decisions required often results in the lack of consideration of a significant number of items; (3) Domination of the process by a few individuals in key roles often results in biased decisions, particularly in the short run; (4) Quantitative economic information is seldom available, or it is not brought to bear on the decision in question.

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[3]For those not familiar with the budgetary process, these references are suggested: Arthur Smithies. The Budgetary Process in the United States. (McGraw-Hill Book Company, Inc. New York. 1955). The Bureau of the Budget, What it is - What it does. (U.S. Government Printing Office. 1964) Contains a bibliography of selected readings.

This study focuses on the last reason above, having in mind that there are many useful economic frameworks for assisting the process, even with a minimum of data. I shall define as an optimum mix those levels of program expenditure in which there is an equality of the marginal return from each program associated with the last dollar expended. If quantitative data could be assembled which would provide a schedule of the return per dollar expended in each of the programs composing the mix, then it would be possible to determine an optimum allocation. In the absence of detailed quantitative data, the formulation of the relationship between expenditures and returns may still yield a useful approximation.

Certain disease and pest control programs administered by the Agricultural Research Service (ARS) of the Department of Agriculture were chosen for analysis because:

1. They are a group of programs whose objectives are closely related.

2. A common economic basis for comparing the results of these programs would be useful. No such basis exists at present.

3. Data are available on which to build a crude analysis.

4. A rough analysis may demonstrate the effectiveness of the technique, leading to the collection of more precise data on which to build an aid to decision making.

5. Since the author is the budget examiner for these programs, there is an opportunity to obtain needed information and to act upon the findings.

Chapter 2 will discuss, in general terms, the phenomena of agricultural disease and pest control, including the current public controversy over the use of chemical methods. Chapter 3 provides specific information on the Federal programs under discussion. Chapter 4 deals with the concept of an optimum allocation and the economic framework for the analysis. Chapter 5 discusses the budgetary process and Chapter 6 the conclusions of the study.

CHAPTER 2. PESTS AND DISEASES IN AGRICULTURE

"That which the palmer-worm hath left hath the canker-worm eaten; and that which the canker-worm hath left hath the caterpillar eaten . . . a nation has come upon my land strong and without number . . . the field is laid waste, the land mourneth for the grain is destroyed, the new wine is dried up, the oil languisheth."

-Joel I

Agriculture seeks to provide a continuous reliable supply of the products of the land for human consumption. To perform effectively it has been necessary to learn how to cultivate crops, domesticate animals, and reduce the toll of man's competitors. The need for pest control is as old as the farm industry itself.

It is generally recognized that agriculture in the United States has advanced through three stages: 1. Opening new lands--largely terminated by World War I. 2. Mechanization-replacement of muscle power by machine power--World War I to World War II. 3. Application of the sciences-major impact being realized since World War II (although the systematic organized application of science to agriculture began 80 years earlier with the founding of the land-grant college system).

As of the 1960's, agriculture technology, based on scientific research, is generally farther advanced in the United States than in any other part of the world.

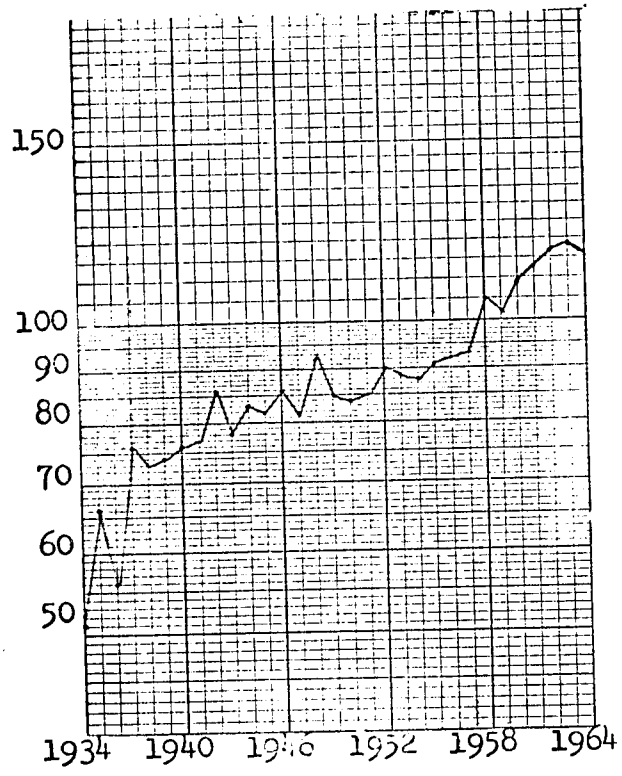
Much of the significance of that advance can be expressed in the progress in crop yields. Figure 1 illustrates the change in crop production per acre during the period 1934-1964. The changes are expressed by a series of index numbers which show the increased physical volume of crop production per acre. The control of agricultural pests and diseases has had a great deal to do with the growth and the stability of these yields.

For purposes of this study "pests and diseases" will include those insects, nematodes, plant diseases and parasitic plants which are of significance to agricultural production. The term "pest" will be used to encompass all of the aforementioned.

The basic goal of agricultural disease and pest control is protection--protection against loss. Protecting a farmer's crops increases the efficiency of his operations by reducing his costs and by increasing the predictability of his output. Pest control assists the consumer by insuring a more homogeneous, dependable product free of blemish, infestation, and undesirable biological or chemical residues.

FIGURE 1

Trend of Crop Production Per Acre
Index Numbers, 1934-1964[3]



[3]Compiled from U.S. Department of Agriculture. Agricultural Statistics.

LOSSES

"Instead of writing thick books or even little libraries on the nature and control of plant diseases, we would do better to assemble basic statistical data, to determine, by estimates, the average losses from diseases, so that we may avoid these losses by foresight."

-M. J. Schleiden, 1850

The century-old advice given by Schleiden, to systematically determine the extent of losses, has gone largely unheeded. It has been repeated many times by leaders in both entomology and plant pathology.[4] Livestock growers have also recognized the lack of information.[5] There is no systematic survey of losses to agricultural pests. A number of attempts have been made at the collection of loss information, but they have been sporadic, regional, and of uncertain accuracy.[6] These compilations will be discussed in the following section.

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[4]For examples of such pleas in the literature of entomology, see Parker's proposal to the American Entomological Society. J.R. Parker, "Annual Insect-Damage Appraisal", Journal of Economic Entomology, 35 (1942) 1. In plant pathology Chester's detailed evaluation of what has been done and still needs doing is a landmark. K. Starr Chester, "Plant Disease Losses: Their Appraisal and Interpretation", Plant Disease Reporter Supplement, 193 (1950) 189-362.

[5]"The simple fact is that no comprehensive information concerning animal losses--whether total losses from death or loss of profits through sickness--is at present obtainable. If the losses were known, their enormous proportions would probably quickly bring about remedial measures." B.T. Simms. 1944.

[6]Two compilations of losses in agriculture have been published. Agricultural Research Service, Losses in Agriculture: A Preliminary Appraisal for Review, ARS-20-1 (1954). Agricultural Research Service, Losses in Agriculture, Agriculture Handbook 291 (1965).

Information on livestock losses is in a far more primitive state than is our knowledge of crop losses; therefore, we shall concentrate on the crop portion of agriculture.

What do we mean by losses due to diseases and pests? Losses have been expressed in a variety of ways--as dollars of crop value or as the physical quantity of the crop which is not realized as a result of disease or pest attack. Or alternatively, there may be measured in terms of the resources devoted to agricultural production which are employed to "feed" the insects and diseases.

Basically the process of measuring losses depends upon establishing these key relationships:

1. Establish the amount of the disease or pest which is present. Both its prevalence, or areal distribution, and its intensity, or population per unit area, are needed.
2. Establish the physical loss, which will be related in some complex way to the pest population, as well as to other variables, such as crop maturity, weather, pace of pest development, etc. This physical loss may be expressed in production units, resources consumed, or as a percent of the potential, disease-free crop. The accurate assessment of physical loss which can be associated with various degrees of prevalence and intensity of infestation is usually the missing link in loss calculations.

3. Economic loss is dependent upon the quantity and distribution of physical losses. In calculating economic losses, care must be taken in pricing the lost units of product. On an aggregate basis these are worth less than the units produced, since we assume that greater production, given the inelastic demand for agricultural products, would result in smaller price per unit. Economic loss results from the reduction in quantity and the altered quality, the latter being the more subtle of the two effects and the most difficult to assess.

Losses take place throughout the production, distribution, and consumption chain of events. There are the losses which occur in the field and are borne directly by the farmer. In addition, there are losses sustained during processing, storage, transportation, display, and finally in the homes of consumers themselves. We are dealing only with those losses sustained during production on the farm.

The initial impact of production losses is upon the farm unit; whether it is measured as the greater cost due to the additional inputs needed, or considered as the loss in product available for sale.

The distribution of losses among farmers is a matter of public policy concern. Governmental pest control in the United States probably originated in 1888 when the Massachusetts Legislature sought the control of Gypsy Moth. The grasshopper control program,

originated by the Federal Government in 1935, was aimed primarily at relieving the economic distress of Great Plains farmers where severe drought accompanied spectacular grasshopper outbreaks. The program was launched to forestall catastrophic losses to individual farmers.

Today Federal expenditures for programs such as the witchweed program are often justified on the grounds that this is a suitable arrangement for enabling cornbelt farmers to protect themselves from an infestation in the Carolinas.

The distribution of physical losses can be modified or controlled by the cooperative action of various levels of government and the citizens affected. To the extent that losses are not controlled we can devise arrangements for more equitable sharing of the economic losses. The points of the impact of losses are determined by political, social, and institutional relations.

What is the value of loss information? Why do we need information on losses? Among the reasons that have been advanced for needing an annual appraisal of damage are:[7,8]

1. To aid in the justification of public activities for entomology, pathology, etc.
2. To provide an accounting of the funds invested.

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[7]Parker, op. cit.

[8]Chester, op. cit.

3. To aid in allocating public funds among different activities for control, research, extension.
4. To improve the efficiency of control measures.
5. To aid in the detection of new pests easily detected.
6. To aid in the prediction of outbreaks.
7. To improve our knowledge of the distribution of loss.
8. To provide a better balanced picture of the causes of loss and prevent concentration on the spectacular.
9. To help overcome the concept of certain regular losses as normal, and present the idea that there are losses which might be made subject to control.
10. To replace "guesses" with data of known variability.

Before we can really understand the dimensions of physical loss we must have more research in population dynamics. Only when we have a better understanding of the dynamic interactions among natural populations, including their pests and diseases, will we be in a position to know the consequences of control action.[9]

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[9]Pioneering work in the construction of mathematical models to simulate the changes in the natural population of a pest in relation to its environment has been done by Watt and by Waters. See for example: Kenneth E.F. Watt, "Mathematical Models for use in Insect Pest Control." The Canadian Entomologist. 93 (1961) Supplement 19. R.F. Morris, Ed. "The Dynamics of Epidemic Spruce Budworm Populations." Memoirs of the Entomological Society of Canada. No. 31 (1963). In addition Watt has experimented with computers for the design of appropriate control strategies. Kenneth E.F. Watt. "Dynamic Programing, Look Ahead Programing, and the Strategy of Insect Pest Control." The Canadian Entomologist. 95 (1963) 525-536.

Building the linkage between physical and economic loss requires experimental research. Chester[10], in his classic monograph, presented numerous examples of how this might be done in the field of plant pathology. Among the difficulties in coping with such biological phenomena is the sporadic character of some plant diseases. This introduces a substantial element of uncertainty.

In 1959 the National Academy of Sciences gave support to this problem. A conference on losses due to agricultural pests was held and a resolution was adopted calling for a program of research on the losses caused by agricultural pests. However, to this date no systematic program of research or data collection has been initiated.

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[10]Chester, op. cit.

LOSS DATA

"How can we expect practical men to be properly impressed with the importance of our work and to vote large sums of money for its support when in place of facts we have only vague queries to give them . . . ? Determination of loss is a difficult and complicated matter, but I believe that we should seriously attempt it."

-G. R. Lyman, 1918

Information on the precise extent of losses has attracted interest for a long time, but it was not until about 1920 that the first serious attempt to gather data was made by Marlott. The available data are still very scanty. In spite of this, the United States is regarded as having the best data available.[11]

Table 1 is a compilation of U. S. loss estimates down through the years. We know that these are little more than guesses in the early years, and "educated estimates" in later years. There are problems of consistency in the definitions. In general, the reference is to crop losses sustained in the field primarily as a result of the activities of insects, nematodes, and diseases.

In spite of our agricultural efficiency, it is impressive to note the potential which remains to be realized in cutting down losses and thereby increasing total production. The more we learn about losses, the greater they appear to be. There appears to be a tendency for losses to increase as a percent of total crop value over time.

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[11] George Ordish. Untaken Harvest - Man's Loss of Crops from Pest, Weed and Disease. (Constable, London. 1952).

TABLE 1

Crop Loss Estimates and Crop Values
(In current dollars)

Year	Source	Basis for Estimate	Crop Value[12] (In millions)	Loss (In millions)	Percent of Loss
1891	Fletcher	10% of U.S. crops	$3,800	$380	10
1904	Marlott	Fletcher's 10%	7,590	759	10
1918	Cooley	At least 10%			
1920	Marlott	Survey		1,500	
1920	Howard	Insects destroy the work of one million people/yr.		2,200	
1938	Hyslop		5,412	1,900	35
1954	ARS	Compilation of expert guesstimates.	18,890	5,770	30
1965	ARS	Compilation of expert guesstimates.	21,000	6,936	33

[12] U.S. Department of Agriculture. Agricultural Statistics.

The only current summary of loss data is contained in the publication Losses in Agriculture, published in 1965.[13] It represents expert opinion based on incomplete data. It states that total crop losses during production, evaluated at 1951-1960 average prices, averaged about $7 billion per year--about one-third of potential production. As illustrated in Table 2, these losses are estimated to represent more than one-third of all the losses sustained in agricultural production, processing, transportation, and marketing of farm and forest products. This overall table also illustrates a number of new sources of loss such as air pollution and losses due to mechanical harvesting.

The dollar value assigned to these losses does not give a true picture of loss to the producer since it does not take into account the lower price of product which would prevail if the losses had been prevented and the correspondingly larger production had actually been marketed.

There are three kinds of losses included in the compilation:

1. Losses that are unpreventable with present technological knowledge.
2. Losses that are presumably preventable, but only through the use of control measures that are not

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[13] Agricultural Research Service. 1965 op. cit.

TABLE 2

Losses in Agriculture[14]

	Estimated Average Annual Loss 1951-1960 ($ in millions)
During Production	
Plant diseases, nematodes and injurious insects	$6,936
Air pollutants	325
Weeds	2,460
Fire and inefficient operations	511
Forest trees and nurseries	254
Harvesting losses	998
Livestock and poultry	2,787
Total	$14,272
After Production	
Storage, marketing, processing, meat and poultry condemnations, etc.	$2,280
Soil and Water Losses	
Erosion and water losses from irrigation, evapotranspiration and weeds	$3,878
Total Losses in Agriculture	$20,430

[14] Adapted from Table 59 in Agricultural Research Service. 1965. op. cit.

economically feasible with present technical knowledge and under current economic conditions

3. Losses that are preventable with present technical knowledge and under current economic conditions.

Altogether this is an interesting collection of expert speculations. It does suggest that there is a significant unrealized production. The variability of the figures is unknown and no time series is available. Thus, the value of these estimates for analytical purposes is practically nil.

CONTROL

"But if against this plague no art prevail
The Trojan Arts will do it, when others fail
A woman barefoot with her hair untied
And naked breasts must walk as if she cried
And after Venus' sports she must surround
Ten times the garden beds and orchard ground
When she has done, 'tis wonderful to see
The caterpillars fall off from the tree,
As fast as drops of rain, when with a crook
For Acorns or Apples the tree is shook."

-Columella, C. 60 B.C.

As a social activity, agricultural pest control involves the ability to control the competitive forces of disease and pestilence in order to provide adequate supplies of biological raw materials, to insure that the burden of the remaining losses is shared in an equitable manner, and that the means of control does not jeopardize other values. These considerations involve a far-reaching complex of biological, technical, social, economic, and political values. We shall be mindful of these broader questions as we proceed with a partial analysis. Our immediate focus will be on the economic considerations, as opposed to the biological, political, technical, and social.

We may distinguish indirect control, a strategic longer-range approach, from direct control, a more immediate set of methods.[15] Indirect controls include nutritional--alteration of the host, climatological--disturbance of physical factors, and

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[15] A.D. Voute. Cultural Control of Forest Insects. 5th World Forestry Congress. GP/165/III/C 15 pp. 1960.

biological--parasites, predators, diseases. Direct controls may be classified as (1) antibiosis--killing of pests or reducing their viability, (2) exclusion--preventing establishment by barriers or legislative quarantines, and (3) avoidance--removal of the material to be attacked.

The programs with which we will deal are concerned almost exclusively with antibiosis--the direct destruction of pests, although the other methods may often constitute an alternative.

Although certain pests have been eradicated or temporarily eliminated from the U.S. (e.g. Mediterranean fruit fly) these are exceptions. Relative to the magnitude and complexity of the biological phenomena involved, these accomplishments represent only a hopeful beginning. As improved technology provides opportunities for eradication, new alternatives will become available. In the meantime, the typical problem is deciding upon the appropriate extent of control. Nor does this bar us from examining many programs which are labeled as eradication since in most cases this is a long range goal, rather than an immediate objective.

What degree of control ought we to have? Who shall bear the costs of its establishment? How will it effect the distribution of losses? Our objective is to find at least partial answers to these questions.

We have little information on the extent of control practices in agriculture. The rapid expansion of chemical controls since World War II gives us an indirect means of measuring the extent of control activities. Approximate figures on the total production of pesticide chemicals are available, but data on the application of the chemicals is fragmentary and incomplete.[16]

The use of pesticides has been growing rapidly. For example, from 1952 to 1958 the extent of spraying and dusting on farms expanded from 60 to 96 million acres.[17] Expenditures for all pesticide uses in the United States in 1965 were about $1.2 billion.[18] As shown in the following table,[19] they were purchased by consumers for household and for lawn and garden use, by institutions, and by agriculture.

	Billions of Dollars
Agricultural production	0.6
Households	0.2
Lawn and garden	0.2
Institutions	0.2
Total expenditure	1.2

[16]The U.S. Tariff Commission collects data on total production, but there is little quantitative information available on where chemicals are being used or by whom on a total basis.

[17]Economic Research Service. Extent of Spraying and Dusting on Farms, 1958 - with Comparisons. Statistical Bulletin 314 (1962).

[18]Agricultural Stabilization and Conservation Service. The Pesticide Situation.

[19]Unpublished estimates provided to the author by the Economic Research Service.

Agricultural uses were about one-half of domestic pesticide shipments or about $600 million. Based on a survey conducted in 1964, about 94 percent of all farmers used pesticides--85 percent for crops, 11 percent for livestock and poultry and 4 percent for other uses.[20]

Residential and institutional users consumed nearly $600 million of pesticides. Consumer purchases for the residential market were two-thirds of the total, about equally divided between household formulations and lawn and garden uses. Public utilities, federal, state, and local governments, and various institutions and agencies consumed over $150 million of pesticides. Approximately $50 million, 5 percent of the total pesticide expenditures, was purchased by federal agencies.

Cotton farmers use more pesticides than any other type of farm. These farmers spent $86 million on pesticides in 1964. A survey of practices in 15 cotton-growing areas showed that four-fifths of the cotton acreage was treated with insecticides one or more times. The cost of insecticides in some areas exceeded the costs of fertilizer. (Overall weighted averages: Insecticides $6.56/acre; Fertilizer $9.22/acre.)[21]

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[20]Paul Andrilenas, Theodore Eichers, and Austin Fox. Farmers Expenditures for Pesticides in 1964. USDA ERS Agricultural Economics. Report No. 106, 1967.

[21]E.S. Langsford. Extent and Cost of Using Chemicals in Cotton Production, Selected Areas, 1961. USDA ERS. 155 (1964).

Large scale collective action against pests has been made possible by technological advances, particularly improved chemical controls. Levels of control which were not economically feasible in the past are now within reach and production costs have decreased while product quality has increased. New standards of cleanliness and freedom from blemish have been made possible.

The advancing state of the art has called for new institutional arrangements to provide collective action on a broad scale. Collective action becomes particularly necessary when a pest might build up in one area and then move on to threaten another--the interests of one producer become closely allied with the interests of all.

Protection against pests is somewhat analogous to forest fire protection wherein the individual land owner cannot be expected to deal with the phenomena independently, but must rely on community or collective action.

The Federal Government assumes the responsibility of establishing barriers to the entrance of foreign pests. The performance of quarantine inspection, closely associated with customs inspection, is based on the principle that the Federal Government has the responsibility to exclude pests of foreign origin.

Some observers reason that if an exotic pest does get into the country, it becomes exclusively a Federal responsibility to slow down its rate of spread, keep it under control, or develop means of eradication.

PUBLIC CONTROVERSY

"You can kill a sheep with incantations provided you put sufficient arsenic in them."

Voltaire

The chronic public issue on pesticides, recently sharpened by Miss Carson's polemic "Silent Spring," is not a question of major alternatives, i.e., "pests or pesticides."[22] It involves the control of pesticide use, and the knowledge of non-target effects. The issue often confuses an argument over the values of non-target organisms with scientific judgments on effects.

There is no scientific evidence to support claims of damage to human health from food residues under present farm production practices. Such damage may exist, of course, resulting from chronic low-level effects. As of 1967, however, it has not been possible to disprove the null hypothesis that there is no evidence of damage.

Operational hazards, as distinguished from residue or food hazards, have not increased significantly. Mortality

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[22]Miss Carson's book is reviewed by I.L. Baldwin in Science 137: 1042, 1962 who says, in part: "Rachel Carson dramatizes in an effective fashion the losses that society has suffered from its use of new pesticides. . . . The author has made an exhaustive study of the facts bearing on the problem. It is not, however, a judicial review or a balancing of the gains and losses; rather, it is the prosecuting attorney's impassioned plea for action against the use of these new materials which have received such widespread acceptance, acceptance accorded because of the obvious benefits that their use has conferred. . . ."

associated with acute poisonings has shown a slow and steady decline since World War II and there has been no change associated with the increased use of pesticides.[23]

Unfortunately, those who place a high value on some of the organisms which receive the side effects of present pesticide uses are equipped with meagre quantitative evidence of the impacts. It would be difficult enough to calculate the values at stake in the absence of a pricing system, but when, in addition, the physical losses are unknown, the issues soon become polemical.

The issue is complex and public misunderstanding is not surprising. For example, much is said of toxicity without appreciating the relative nature of the term. Since toxicity is only the capacity to produce injury, and is completely dependent upon the details of proposed use, it must be coupled with the concept of hazard to be truly useful.[24]

So far, the public policy discussion seems to have accomplished little except to undermine public confidence. We

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[23] W.J. Hayes, Jr. "Accidental Poisonings" Archives of Environmental Health. 9 (1964) 621. In his summary of the NAS-NRC Symposium on Pest Control, Dr. E.F. Knipling says, in part: "Accidental deaths due to pesticides have remained remarkably stable for many years and the death rate did not increase substantially after the introduction of the wide variety of new organic pesticides." E.F. Knipling. "New Horizons and the Outlook for Pest Control" in Scientific Aspects of Pest Control. NAS-NRC Publication 1402 (1966).

[24] George C. Decker. "Pros and Cons of pests, pest control, and pesticides." World Review of Pest Control. 1 (1962) 6-18.

may yet benefit if some of the energy is directed toward providing us with an alert scientific community dedicated to expanding our knowledge of chemical and biological interrelationships and informing the public of their findings.[25]

The present situation has been summarized by Gosselin[26]:

> "Never before has a society produced so many biologically active chemicals and integrated them so fully into its economy and its culture. The services for which we are indebted to the economic poisons are many and undeniable. The control of arthropod-borne disease is an example of one such achievement. The pesticides have also demonstrated their capacity to improve human nutrition by contributing significantly to a rise in agricultural productivity. On the debit side of the ledger is the capacity of many of these substances to produce severe intoxication in man. Accidental poisonings have and probably will continue to occur, but in this country the incidence of severe toxic insults is not alarming even among those engaged in such relatively hazardous occupations as farming. The threat of chronic injury from cumulative exposure has been materially reduced by legislation which prohibits pesticides residues on agricultural commodities in excess of conservatively prescribed limits. Any remaining risk of chronic poisonings is remote and justified by all the benefits that society derives from the use of these materials. The safety issue can never be settled by polemics or fiat. In the ultimate analysis the good health of our farmers and the wholesomeness of our food supply can be guaranteed only by a scientific community that stays alert."

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[25] The following are the key public policy documents in the recent debate: PSAC. Use of Pesticides. The White House. 1963; PSAC. Restoring the Quality of Our Environment. The White House 1965; NAS-NRC. Scientific Aspects of Pest Control. Publication 1402. 1966; U.S. Congress. Senate. Interagency Coordination in Environmental Hazards (Pesticides). 1964-66; U.S. Congress. House. Effects, Uses, Control and Research of Agricultural Pesticides. 1965.

[26] R.E. Gosselin. "Economic Poisons in Relation to Man's Health," Journal of Chronic Diseases. 9 (1959) 169.

The public controversy over the use of chemicals for pest control in agricultural production is a conflict of values. Farmers, agricultural suppliers and consumers are all interested in a larger supply of better quality food at lower prices. Conservationists, hunters, fishermen, and consumers are primarily concerned with the impact of the use of these chemicals on non-target organisms and their presence in foods.

There are a number of forces at work within the framework of this issue. The order in which these forces are listed does not imply any priority or relative importance.

1. Pest control technology: The biological facts about the total environmental impact are inadequate and will probably continue to lag behind the knowledge of the impact of chemicals on targets. New control methods are being derived together with more sophisticated combinations of known methods.
2. Politicians' aims: To the extent that the issue arouses public fear, a political opportunity exists for the emergence of "a shining white knight" as a public protector.
3. Public view: This is a complex issue which can be over-simplified and dramatized by the press, creating unsophisticated public viewpoints and demands.

4. Bureaucratic jurisdiction: Three major departments (Agriculture; Health, Education and Welfare; and Interior) have been assigned statutory responsibilities which overlap. Result: bureaucratic conflict and an organizational power struggle.

5. Producer's dilemma: Agricultural producers are being caught between conflicting agency directives and may need recourse to the courts for settlement.

6. Conservationists crusade: The "back-to-nature" interest groups seek to solve the problem by banning or restricting chemical use. The impact on food supplies is not their direct concern.

7. Industrial interest: The chemical industry has a substantial financial interest in the use of their products by farmers and consumers.

8. Legal questions: In addition to the problem of overlapping authorities there are questions of interpretation and adequacy of existing statutes.

9. Agency-clientele relations: Each of the Federal agencies involved has traditional clientele groups which influences its behavior.

For analytical purposes we can consolidate this variety of forces into two predominant groups--the "agriculturists" and the "naturalists".

The "agriculturists" point of view has Malthusian roots and can be characterized as believing that we must expand the supply of food and fiber else we shall be overcome by malnutrition and poverty. It regards the present excess capacity of agriculture in the United States as a temporary imbalance. Included in this group are most of the farmers; the farm supply industry, including the manufacturers of pesticide chemicals; a number of Congressmen and Senators from farm States; the Department of Agriculture; the Colleges of Agriculture, the Experiment Stations and Extension Services at the Land-Grant Colleges in each of the States; and many powerful interest groups, such as the Farm Bureau, the Farmer's Union, the National Grange, etc.

The "naturalists", who found their champion in Rachel Carson, share a more or less Schweitzerian ethic which may be stated as a concern for and a sense of responsibility to the natural environment. At its extreme, this point of view may suggest that nothing be done to interfere with the balance of nature, but the modal position of the group is to try to achieve harmony with nature and prevent unnecessary damage and interference not only to protect nature but to enrich men's lives. They focus upon "amenities" rather than commodities. Recognizing that we have an abundance of agricultural products, this group would curb production practices which appear to be damaging to the environment. The principal spokesmen are garden clubs, organic gardeners, and the wildlife societies; a number of Congressmen and Senators from urban States; the Department of the Interior; and some portions of the medical and health community.

We might treat these opposing points of view diagrammatically as a bargaining situation in welfare economics. Suppose that the agriculturists have a preference map as illustrated in Figure 2A. The set of indifference curves (A_1, A_2, A_3) express the preference of the group between commodities and "amenities."* At point P_1, the agriculturists are satisfied with the relative amounts of commodities (quantity OX) and "amenities" (quantity OY). They would also be satisfied with any other mix of commodities and "amenities" as expressed by all of the points composing the indifference curve labeled A_2. For example, at point P_2 they would be satisfied with additional commodities (quantity OX') and fewer "amenities" (quantity OY'). They are willing to substitute commodities and "amenities" for one another at some rate. Hence the slope of the indifference curve expresses the marginal rate of substitution between commodities and "amenities" for the group.

The relationship is relatively "flat", expressing the opinion of the group that commodities are relatively more dear than "amenities." It is non-linear since the relative preference of the group for commodities over "amenities" changes as the mix changes, i.e., there is not perfect substitutability throughout the range.

The agriculturists would be better off if they could move from any point on curve A_2 to any point on curve A_3, e.g. point P_3, since they would have a greater combined total of commodities and "amenities."

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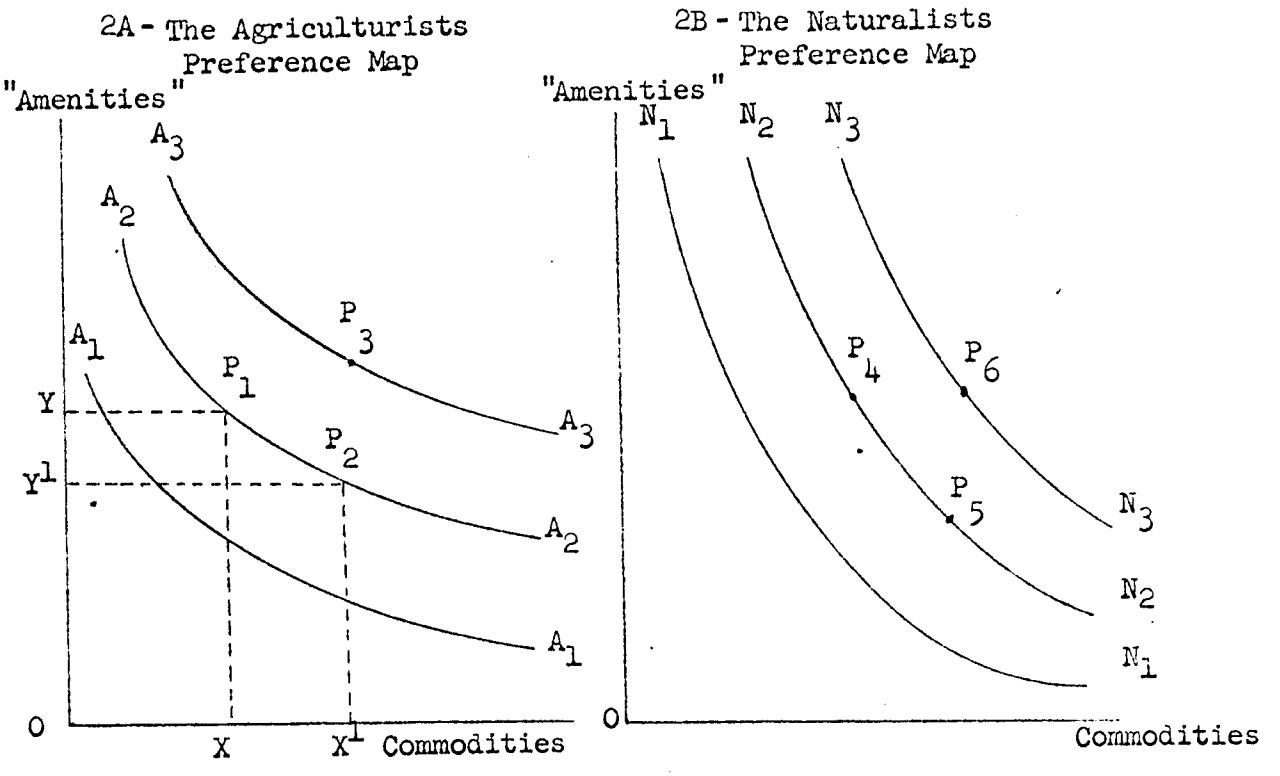
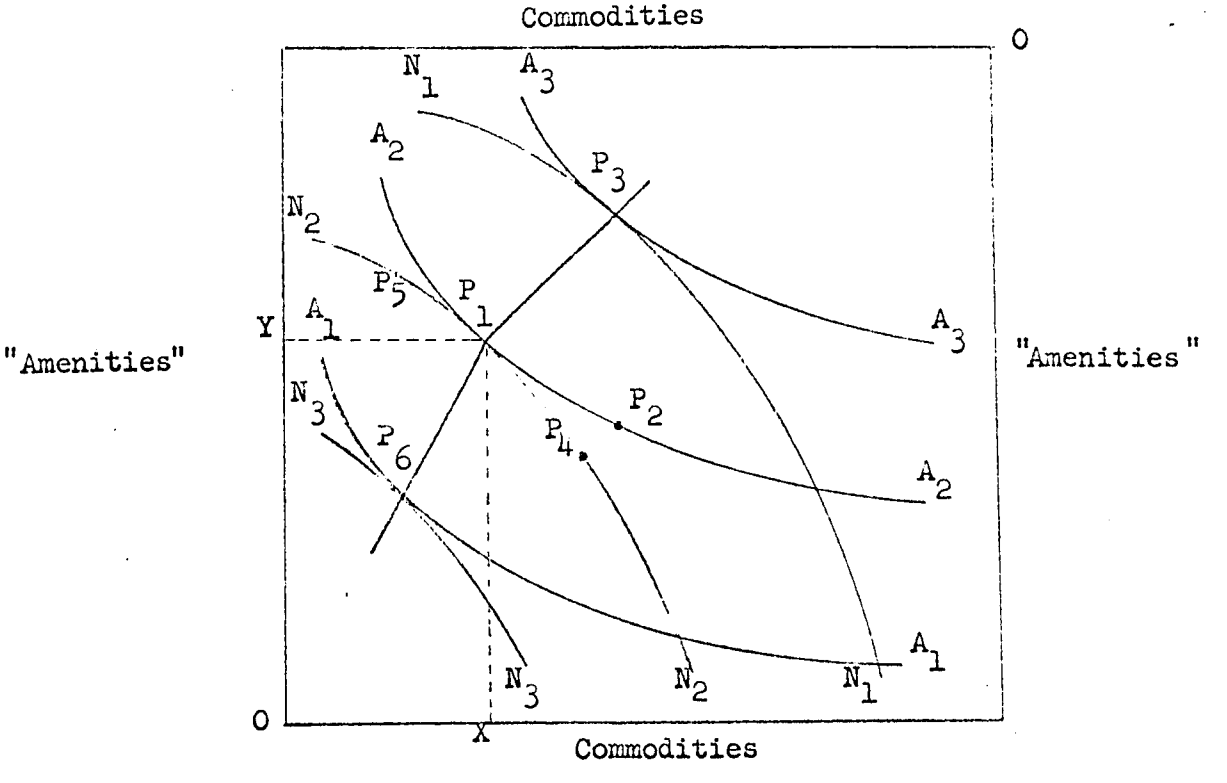
*The term "amenities" is being used to describe a set of natural resources whose condition is such as to inspire a feeling of pleasantness or attractiveness.

FIGURE 2

Preference Maps for the Agriculturists and Naturalists



2C - The Bargaining Model



The naturalists viewpoint is expressed in a similar preference map, Figure 2B. Note that these indifference curves are relatively "steep" since this group tends to favor "amenities" relatively more than commodities. The group considers itself equally well off at any of the points (e.g. P_4, P_5) lying on the curve N_2, but would, of course, prefer any of the positions on curve N_3 (e.g. P_6).

The bargaining model, Figure 2C, is formed by tipping and rotating the naturalists preference map, Figure 2B, so as to superimpose it upon the agriculturists preference map, Figure 2A. Suppose that the agriculturists contend that they would like to be at position P_1 with OX commodities and OY "amenities." We know that they would be equally well satisfied to be at any point of curve A_2, for example P_2. The naturalists are contending for the mix at P_4, but we know that they would be equally well satisfied at any point on line N_2, for example P_1. Thus P_1, the point of tangency, becomes the compromise position where we actually find ourselves.

But what about the demands of the agriculturists to increase total welfare by providing more "amenities" and a great deal more commodities, a position on curve A_3, for example P_3? Such a move cannot be made without decreasing the welfare of the naturalists who would have to accept a smaller mix of commodities and "amenities." Conversely, a move by the naturalists to position P_6 on their higher indifference curve N_3 would adversely affect the welfare of the agriculturists. Thus we have a contact line running in both directions from point P_1. Any move along this line will benefit one group at the expense of the other.

Does this really describe the conflict situation in which we find ourselves? In its essential elements, I believe that it does. However, there are factors exogenous to the model which will allow us to increase the total welfare of both groups. For one thing preferences, i.e., values, are changing over time. One of the products of the interaction between the groups can be a modification of the views of each. This means that the preference maps are being altered as the issue continues. Another major factor is increasing efficiency and more precise control over the side effects of agricultural production. Fortunately, this is proceeding at a rapid pace and will enable us to have more "amenities" and more commodities simultaneously.

CHAPTER 3. FEDERAL PROGRAMS

Federal programs for pest control are primarily concerned with the prevention of losses. The benefits of these programs consist of the avoidance of loss and thus a reduction in the cost of production for a particular firm.

Most of the programs have been underway for a considerable span of time. The Gypsy Moth program, for example, originated in 1907.

Some of the programs appear to have unrealistic goals[27], but such goals may have been established because of strategic and political considerations. The goal may be stated as "eradication" even when we know that present technology provides little hope for complete elimination; because we don't have the biological knowledge, the resource requirement is unreasonably high, or the extent of the operations required might unduly disrupt production or distribution patterns.

The technical and economic feasibility of reducing losses from a particular pest assumes different proportions when a government program is undertaken, since economies of scale may result. We can recognize these aspects of feasibility:

1. Technological.
2. Economic - economies of scale with a large operation.

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[27] President's Science Advisory Committee. The Use of Pesticides. 1963.

3. Legal - authority for quarantines is restricted to the States, except for international quarantines which are a Federal responsibility.

4. Administrative.

Each of these factors will influence whether or not action is taken on a pest, and by whom--Federal, State, or local governments or an individual farmer.

The Agricultural Research Service administers 21 programs in plant pest control, each of them dealing with a particular agent (insect, nematode or disease) capable of causing significant losses during production. Table 3 contains a listing of these programs classified by agent. The reduction or elimination of losses may provide immediate benefits to farmers by lowering production costs and ultimate benefits to consumers through improved product quality and lower prices.

Comparative evaluation of the programs within this group is difficult because of their diversity.

The following ten points will be used to illustrate that diversity:

1. Type of pest--

   Includes insects, nematodes, and plant diseases (see Table 3).

2. Origin--

   Some are native (grasshopper), while others have been imported (Gypsy Moth).

TABLE 3

ARS PLANT PEST CONTROL PROGRAMS BY AGENT

INSECTS

Boll weevil

Cereal leaf beetle

Citrus blackfly and Mexican fruit fly

European chafer

Grasshopper and Mormon cricket

Gypsy Moth

Imported fire ant

Japanese beetle

Khapra beetle

Mediterranean fruit fly

Pink bollworm

Southern green stinkbug

Sweetpotato weevil

White-fringed beetle

NEMATODES

Burrowing nematode

Golden nematode

Soybean cyst nematode

DISEASES

Barberry (wheat rust)

Hoja blanca

Phony peach and peach mosaic

Witchweed

3. Specificity--

Ranges from those confined to a particular crop species (soybean cyst nematode) to those attacking a wide range of plant life (grasshopper).

4. Rate of spread--

Varies from the relatively stable pests which depend primarily upon transportation by man (witchweed) to the rapid spread of flying insects (Mediterranean fruit fly).

5. Extent of damage--

Some of the pests are primarily a nuisance (fire ant), whereas others can be responsible for catastrophic losses (grasshopper).

6. Geographic distribution--

Certain pests are restricted to only a few counties (golden nematode), while others can be found in almost every part of the nation (Barberry).

7. Character of geographic area--

Some are found in metropolitan areas or their environs (Mediterranean fruit fly), or in storage facilities (Khapra beetle), while others are on the open prairie (grasshopper).

8. Duration of the program--

Certain programs have been in continuous operation for more than 50 years, while others have been crash efforts of 4 or 5 years' duration.

9. Program objective--

Program objectives range from immediate and complete eradication (Mediterranean fruit fly) to learning to live with a pest and slowing its rate of spread (Japanese beetle).

More than $1 billion had been expended in control and eradication programs through fiscal year 1964. Approximately one-half of the funds were provided by the Federal Government and the remainder came from State and local governments and from private sources. An estimate of the present rate of expenditures in the various programs is provided in Table 4 which shows fiscal year 1964 obligations.[28] As the number of programs increases

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[28]The term "obligation" refers to a commitment made to pay out money. Obligations are incurred when personnel are employed, loan agreements are approved, and when contracts for equipment or construction are made. They are authorized by the obligational authority granted by the Congress and precede expenditures. Expenditures generally consist of checks issued and cash paid. In these programs obligations are customarily used as a measure of program activity. They will differ very little from expenditures. Federal obligations are cited for a fiscal year, i.e. fiscal year 1964 includes the period July 1, 1963 through June 30, 1964.

TABLE 4

ARS PLANT PEST CONTROL PROGRAMS RANKED BY OBLIGATIONS

Program	Federal Obligations Fiscal Year 1964 ($ in thousands)
Witchweed	2,838
Imported fire ant	2,446
Pink bollworm	1,749
Grasshopper	1,168
Gypsy Moth	1,069
Japanese beetle	1,069
White-fringed beetle	933
Barberry	785
Khapra beetle	600
Soybean cyst nematode	467
Citrus blackfly and Mexican fruit fly	443
Burrowing nematode	427
Cereal leaf beetle	408
Golden nematode	308
Sweetpotato weevil	271
Boll weevil	201
Phony peach and peach mosaic	167
Mediterranean fruit fly	150
European chafer	145
Hoja Blanca	21
Southern Green Stink Bug	18
TOTAL	15,683

and improved technology makes possible effective collective action against still more pests, improved methods of choosing among alternative programs becomes increasingly valuable in the interests of Government economy and efficiency. As McKean has pointed out,[29] this particular set of programs is readily adaptable to the modern techniques of operations research in which marginal analysis is the core concept.

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[29] Roland M. McKean. Efficiency in Government Through Systems Analysis. John Wiley and Sons. New York 1958.

SHIFTS IN OBJECTIVES

Public programs for agricultural pest control began with the action of the Massachusetts Legislature in 1890, providing funds to eradicate the Gypsy moth, introduced accidentally 21 years earlier. By 1905 the moth had spread to three of the neighboring States and in 1906 the Congress voted aid to all of the infested States.[30]

The Cooperative Gypsy Moth program began in 1907, and by 1915 the concept of Federal participation with States and producers was well accepted. Within a few years other programs aimed at eradicating foreign invaders were started: Citrus canker (1915); White pine blister rust (1916); Pink bollworm (1917); Barberry eradication (1918); European corn borer (1919); and Japanese beetle (1920).

By 1930, all of these programs were still short of their announced objective of eradication, but it was evident that there was value in preventing the spread of foreign invaders even though complete eradication was not achieved. The eradication of the Mediterranean fruit fly did underscore the fact that under the right conditions eradication was possible.

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[30] William L. Brown, Jr., "Mass Insect Control Programs: Four Case Histories", Psyche. 68 (1961) 75-111. Brown's essay deals with the Gypsy moth, the imported fire ant, the Mediterranean fruit fly, and the screwworm.

By 1935 a completely new kind of objective was firmly established--the control of an endemic pest to reduce income losses to farmers. The catastrophic grasshopper attacks on the Plains during the drought of the late twenties and early thirties, coupled with the low farm incomes of the depression, spawned a Federal-State-Producer program dedicated to control of this endemic pest as a means of reducing income losses. This program continues to operate as a joint effort to restrict losses. Programs for the control of citrus blackfly and dutch elm disease were also begun at this time.

By 1950 the Japanese beetle was spreading steadily westward and even the Gypsy moth had extended its range. The first program against a nematode--a pest against which the prevention of spread promised to be extremely difficult--was inaugurated in 1946. These facts suggest that it was then recognized that even slowing the spread of a foreign invader might be a worthy objective. Two more nematode programs were added in 1955, and 1956, and the Japanese beetle and the Gypsy moth continued to spread.

The first major advance in pest control technology in the 1940's brought the chlorinated hydrocarbons into widespread use and increased the efficiency of insect control programs enormously. In addition, it encouraged an optimistic outlook which permitted the continuation into the 50's of programs which had long since failed to achieve their objectives. But just as the successful eradication

of Medfly in 1931 encouraged the continuation of programs in the 30's, a repeat performance in 1958 encouraged a trial of the second major technical advance of the century--the sterile male technique on the screwworm fly.[31] As it happened, this program was aimed primarily at Florida where two successive Medfly eradications had occurred. The program was an unqualified success--completely eradicating the insect from the Southeastern U.S. It has moved on to the Southwest where similar success now appears certain. Thus at the beginning of the 60's still another objective was accepted as a valid public policy--eradication of an endemic pest.

This experience would appear to demonstrate that in the area of agricultural pest control, public policy has responded to technological change and to actions of benefit to agricultural producers. Table 5 summarizes the historical experience with pest control objectives.

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[31]The development of this technique by Knipling and Bushland of the Department of Agriculture is well documented in the literature and will not be repeated here. See for example, E.F. Knipling "A New Era in Pest Control: The Sterility Principle." Agricultural Science Review Vol. 1 (1963). 2-12. Even more significant than the development of the technique for this particular insect is the new concept of pest control upon which it is based.

TABLE 5

PEST CONTROL OBJECTIVES 1890-1960

Year[32]	Objective	Examples
1890	Eradicate foreign invaders (State)	Gypsy moth (Massachusetts)
1915	Eradicate foreign invaders (Federal participation)	Gypsy moth, barberry, Medfly, pink bollworm
1930	Prevent spread of foreign invaders	Gypsy moth, pink bollworm, Japanese beetle
1935	Control an endemic pest to reduce income loss	Grasshopper
1950	Reduce rate of spread of foreign invaders	Japanese beetle, nematodes
1960	Eradicate an endemic pest	Screwworm[33]

[32]Approximate year by which we may assume general acceptance of an objective.

[33]Strictly speaking, the screwworm fly was not indigenous to the Southeast, but it was so well established as to be popularly regarded as a native insect.

CHAPTER 4 OPTIMUM ALLOCATION MODELS

The consideration of what is optimum and the process of evaluating an existing phenomena to determine how it may compare with a normative set of values must begin by defining the universe. Up until now we have been describing the programs with which we are concerned in a rather general way. We shall now define more explicitly the universe of our concern and then consider some conceptual frameworks which may be useful in an evaluation.

We shall begin by defining some of the considerations with which we are not concerned as a means of focusing on our universe.

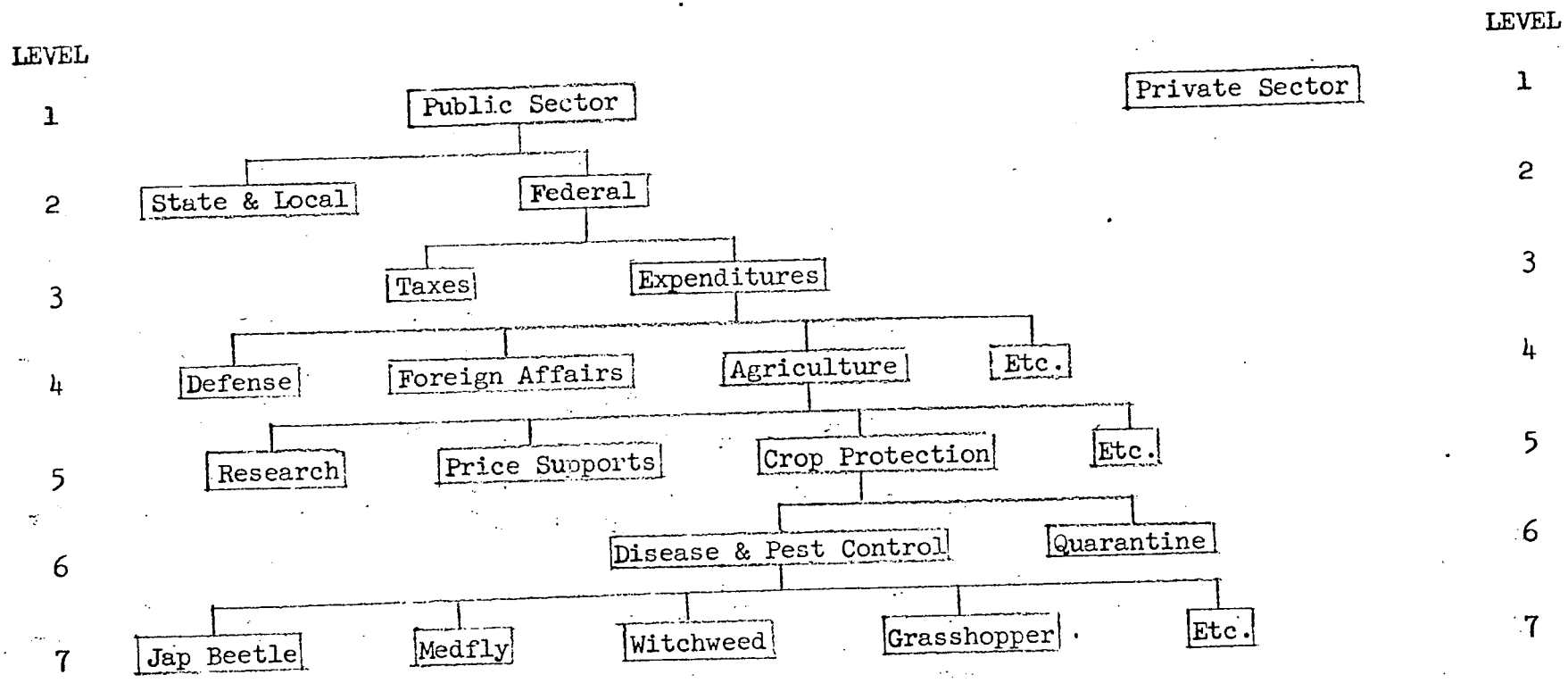
We are not concerned with the total relationship between the public and private sectors. Nor are we considering the question of the appropriate roles of Federal versus other governmental units. This study focuses on the expenditure side--we shall not be concerned with the relationship between taxes and expenditures. We shall also take as given the distribution among major Federal functions and shall not concern ourselves with the relative shares of, say, agriculture versus defense. We are directly concerned only with evaluating the allocation of expenditures within the category of disease and pest control as a part of the broader activity of crop protection.

Figure 3 illustrates diagrammatically the levels of optimization.

Our separation is, of course, not clean. We are primarily interested in optimizing at level 7. We shall, of course, be somewhat concerned with level 6 where the total

FIGURE 3

Levels of Optimization



allocation is arrived at for the entire set of programs. Indeed, our analysis of decision at level 7 must inevitably reflect the constraints imposed from each of the "higher" levels. For example, there are certain agreed-upon jurisdictional relationships between the Federal Government and other elements of the public sector at level 2 which determine what areas of pest control activity are appropriate for the Federal Government and thereby constrain the allocation at level 7.

In addition, the public and private sectors are interwined in many ingenuous ways. While a separation may be useful for analytical purposes, it is important to remember that there is concert in the performance.

Lastly, we shall assume that the private sector provides the background against which we will measure the efficiency of public sector activity. Not in the belief that there is any inherent superiority in private sector performance but only because this is the traditional approach, offering ready-made theoretical tools for our use.

IS THERE AN OPTIMUM?

What is meant by an optimum allocation of funds among the elements described at any of the levels diagrammed above? What is best? Do we have a normative prescription to tell us how we should divide our society between the public and private sectors (level 1)? Of course not. Do we have any better basis, then, for deciding the best allocation between grasshopper and Japanese beetle control (level 7)? Perhaps. At least we have six "higher" levels to provide constraints and guidance.[34]

Thus a decision to eradicate Gypsy Moth or Mediterranean fruit fly will not only raise expenditures for the Department of Agriculture but may be formulated in such a way as to increase the Federal share of public sector activity and may even enlarge the relative activity of the public sector itself. On the other hand, a decision to decrease overall Federal activity may curtail or eliminate a particular pest control program.

There is an explicit attempt to rationalize a set of program levels in the process of budgeting. Is the budget for these programs an optimal budget? If this year's budget is not optimal, was last year's? Is there some span of years over which

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[34] We must not assume, however, that allocation decisions move "downward" sequentially from level 1 to level 7. In fact, decisions may be made at one or more levels simultaneously and communicated to other levels in an irregular pattern.

to consider optimality? What criteria are there for determining whether a budget is optimal ex-ante or ex-post?

One possibility is to assume that the optimum is what the executed budget is--that our institutions and our process are organized to express the will of the people and to give the body politic what it desires (or deserves!).

But, we can be more sophisticated and explore what economics and political science may have to offer which is relevant. In Chapter 6 we shall outline the performance of the process itself.

ECONOMIC OPTIMUM

When economics is defined to be the study of value, there is nothing which limits the marginal concept to the private sector or the market economy.[35] The marginal theory developed in economics to describe the optimum condition of a market economy can provide a useful approach to our problem.

We will begin by examining how an individual farmer might optimize his pest control expenditures in a farm firm in a market economy where his problem is simply to maximize profits.

Next we will examine the aggregate effects of a number of farm firms operating in a market economy where the impact of aggregate decisions on pest control will influence supply-demand relationships.

Public programs are aimed at a particular pest and had their beginnings in an attempt to prevent catastrophic losses to farmers as a group--to prevent the economic disaster of grasshopper depredations which effected whole States in the 1930's. Over time, the objectives of these programs have been shifted to the idea of collective action as new technologies have made such action possible (e.g., screwworm).

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[35] It should be noted that "private sector" and "market economy" are not synonymous terms. Many components of the public sector operate as indistinguishable parts of the market economy and behave as though they were operated by private entrepreneurs. Conversely, the private sector contains forms of enterprise which are so constrained as to behave like public activities. These exceptions to the norm illustrate the rich diversity of a mixed society.

We can hypothesize the existence of a "protection supply function"--a probabilistic response curve to expenditure inputs whose shape is altered over time by technological change. This will assist in finding society's least cost combination or economic balance point--where private losses and joint public-private costs are minimized.

The concept of the marginal efficiency of capital can encompass all considerations provided we define returns correctly. Our problem of defining returns is complicated by changes in public values. Pest control illustrates this change nicely. "Other values" (non-agricultural) have become an important part of the public controversy. The damaging spillover effects from "crude and inefficient control techniques" together with changing public values[36] and food supply taken for granted have all contributed to the public controversy.

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[36]John K. Galbraith. "Economics and the Quality of Life." Science. Vol. 145. (1964) 117-123.

THE FARM FIRM

In the case of a single farm, the traditional "theory of the firm" in economics provides a theoretical explanation of how much pest control will be utilized. Ordish[37] has dealt with the concepts and the calculations involved. In addition, Hillebrandt[38,39], has surveyed the behavior of farmers in the South of England with regard to how far they indulge in pest control. The author was unable to find any evidence of similar analysis for U. S. conditions.[40]

In an individual farm firm costs will increase as a function of the amount of treatment that is performed. Benefits will also increase as treatment is expanded. Let us suppose that all other inputs to crop production are held fixed including acreage. The curves in Figure 4 illustrate how we may hypothesize that costs and benefits vary with the amount of pesticide treatment.

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[37] George Ordish. "Economics and Pest Control". World Review of Pest Control. I (1962) 30-38.

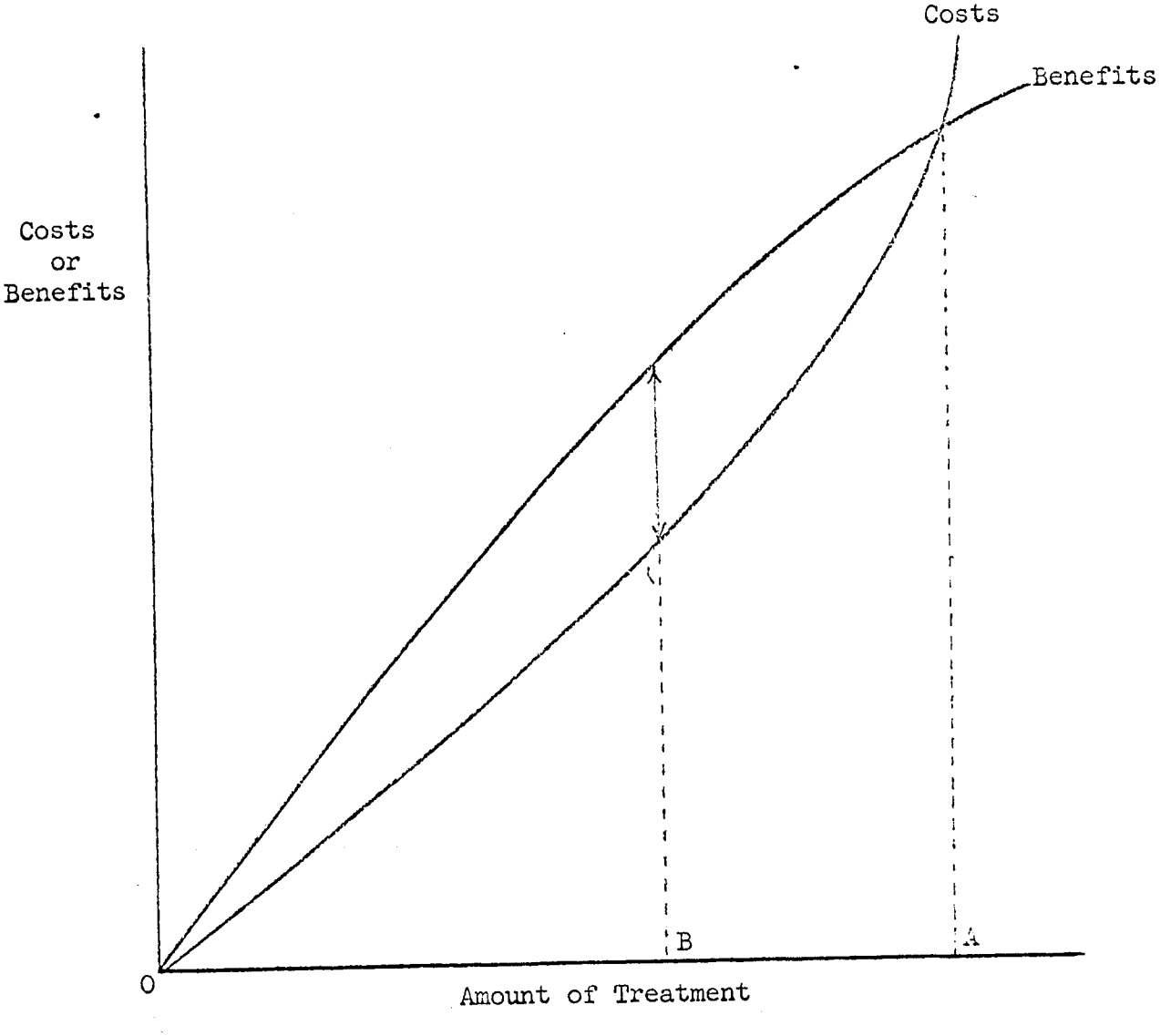
[38] Patricia M. Hillebrandt. "The Economics of the use of Selective Weedkillers". Farm Economist. 9 (1959) 209.

[39] Patricia M. Hillebrandt. "Farmer's Reasons for Using Weedkillers". World Review of Pest Control. I (1962) 18-24.

[40] Economic research related to pesticides is just beginning in the United States. See: Austin S. Fox and Paul Andrilenas. "Economic Research of Pesticide Use in Agriculture". Talk presented at the Weed Society of America, St. Louis, Missouri, February 8, 1966.

FIGURE 4

Model of a Farm Firm



At all treatments up to amount OA, the economic benefits exceed the costs, at amount OA they are equal, and at amounts greater than OA the costs will exceed the benefits.

There are economic benefits to the farmer by applying treatment up to amount OA, and this corresponds to Ordish's concept of the "maximum economic potential" (MEP). This is the point at which the cost of pesticide application starts to outweigh the benefits of crops saved or increased. Is this, therefore, the extent of treatment to be undertaken by a producer? No. Not if he seeks to economize in the use of resources, i.e., obtain maximum returns from his investment.

The optimum economic potential is really obtained by treatments in the amount OB. Here total costs and total benefits are the greatest distance apart. This is also the point where marginal cost and marginal benefits are equal. Beyond treatment OB the producer receives less than a dollar of return for each additional dollar of cost which he incurs.

No rational calculating operator would go beyond treatments in the amount OB. Treatment OA may be the desired level if you seek to maximize output (or the sale of pesticides) but treatment OB will be the desired level if you seek the maximum economic potential in the employment of resources. That is, maximum return on the investment.

It should be noted that a farmer's alternatives are usually discrete rather than continuous, and may even consist

simply of a yes or no decision to spray. In addition, Hillebrandt's study shows that although most farmers aim to maximize profits, their performance falls short because of inertia, prejudice, and inadequate knowledge.

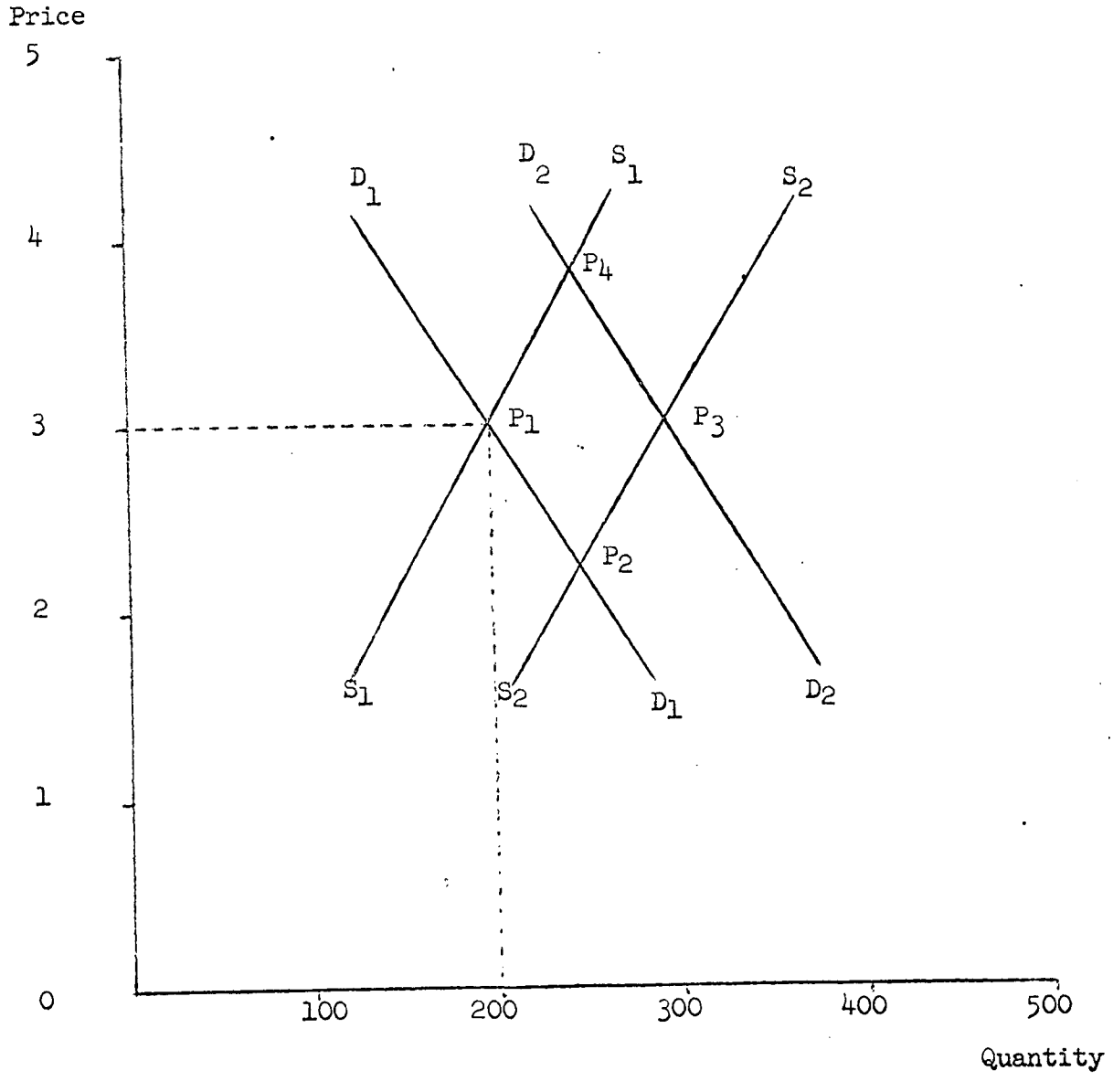
THE PRODUCER GROUP

As Ordish points out, as the individual growers adopt greater crop protection in an effort to optimize, total production will expand. If the rate of this expansion exceeds the growth of demand, then the expanded supply is likely to reduce price given the relative inelasticity of agricultural products. Thus, the grower ultimately reduces his own margins and may weaken his profit position. A campaign of crop protection in a commodity with inelastic demand will result in lower returns to farmers unless the area grown is reduced (i.e., total production is not allowed to increase). This phenomena can be illustrated in the traditional supply and demand framework as shown in Figure 5. In Figure 5 let us assume that D_1 represents the demand for a particular agricultural product, S_1 the available supply and P_1 the existing price. If we are able to achieve a greater degree of pest control, then the supply of production can be expanded, shifting the supply curve to the right, to position S_2. If demand remains the same, then price will fall to P_2; or if demand expands sufficiently, to position D_2, then price may remain the same, P_3. Note that if there is an increase in demand to position D_2 without a corresponding increase in supply, then price will rise to P_4.

From this model we conclude that an expansion in the use of pest control technology, at a rate exceeding the growth of

FIGURE 5

The Producer Group



demand, will produce a lower price for the commodity; or if demand expends relatively more rapidly than supply, a higher price will result.

A substantial move in either direction is of consequence since there are public policy commitments to farm income stabilization as well as to the control of inflation.

Note that although the behavior of the individual producer depends upon the marginal analysis for his own unit, the organized producer group would not want to expand production faster than demand, recognizing that if they do so it may lead to a fall in price. Perhaps this explains why an organized commodity group will press for collective action on an introduced pest while preferring to handle an established pest on an individual producer basis. An individual operator dealing with an established pest has the opportunity for a larger profit than his neighbor through superior entrepreneurship, that is, more precise calculation of his marginal analysis of how much to spend on pest control. A fall in price, however, is an advantage to the consumer, processor, or other purchases of agriculture products. A rationalization of this inherent conflict will be achieved in a political bargaining process to be discussed in a later chapter.

THE CONCEPT OF PROTECTION

The origins of Federal agricultural pest control programs were described in Chapter 3. Note that these programs were aimed at a particular pest, whereas the above analysis applies to the control of a complex of pests upon a single commodity. Each of the Federal programs has its individual history associated with the characteristics of a particular insect, disease, nematode, etc. There is no public program aimed at the systematic control of all pest losses. For each program the impact of the pest has been considered and a specific quantity of funds has been made available for its control. In the course of these individual decisions, a pattern of change in objectives has developed.

In the course of development of pest control programs over the last half century, the concept of an acceptable public policy objective has continuously expanded until today there is precedent for public participation in a variety of actions against both exotic and endemic pests. As discussed in Chapter 3, there is no apparent limit to the type of pest control programs which may be authorized. This means that the question of how much public money is used in the control of which pests is no longer constrained by focus on a limited set of objectives and the problem of allocation of resources has become more complex.

The extent of reallocation possibilities among programs depends in part upon the existence of alternatives within a particular program. We can readily hypothesize that any of these

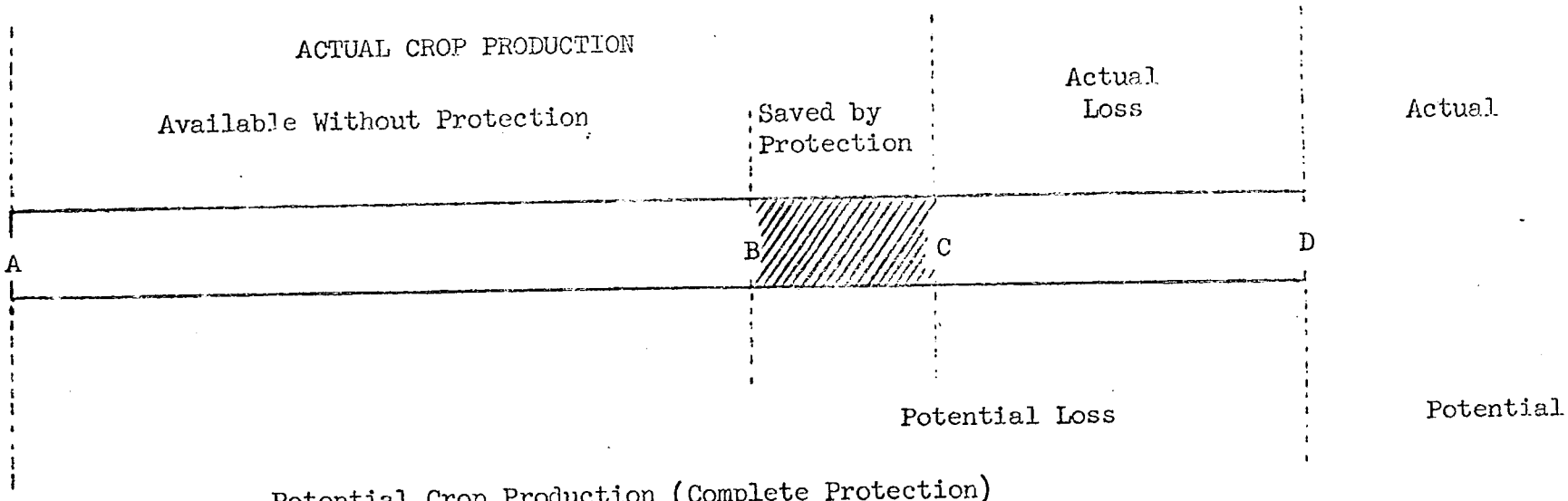
programs can be subject to analysis to find society's least-cost maximum benefit combination or economic balance point. This could be defined as the point where private losses and joint public-private costs are minimized and the greatest gain per total input is realized.

The relationships are illustrated in Figure 6. The distance A D represents the total potential crop production if there were no losses to pests--complete protection. This quantity is taken as given and all of the variables affecting crop production are held constant. Then, an examination of the pest population provides an estimate of the potential loss B D. This relationship is very difficult to predict and has been established for only a few pests and crops. (See Chapter 2) The amount of loss actually realized C D, will be the potential loss minus any savings achieved by protection action B C. The quantity to be saved by protection B C is our point of focus. We wish to know how many crop units it pays to save, or, conversely, by how much potential loss ought to be reduced.

Note that the quantity of loss itself is not very relevant. It is only a residual value. In recent years a great deal of attention has been focused on trying to determine the losses in agriculture. Such estimates tell us something about the total physical potential of present production techniques assuming complete protection. But this is an irrelevant consideration, since it is very doubtful that complete protection or anything

FIGURE 6

The Concepts of Protection and Loss



approaching it will be economically feasible. The relevant focus of attention is the economic calculation of how much of the potential loss it pays to prevent. Such a calculation must be based on basic physical information. This is the subject of the following section.

A PROTECTION SUPPLY FUNCTION

The number of crop units that should be saved depends upon their value in relation to the costs of saving them. First, we shall need to know how many crop units can be saved per dollar of control expenditure.[41] Such a relationship would constitute a physical production function. Then, we shall have to establish a revenue function to give us the value of those crop units that have been saved.

The direct approach to determining a protection supply function would be to establish the number of additional crop units associated with a scale of protection inputs. Under field conditions this is very difficult to observe since crop production is a joint product of a number of inputs. Controlled experiments are needed in which the other variables can be held constant while the amount of pest control is varied.

The number of crop units saved is a function of the expenditures for protection and the potential loss. Potential loss is in turn dependent upon potential production, the extent of infestation and the intensity of infestation.

A time series approach would be to estimate actual losses each year together with the amount of crop saved by protection measures. By summing the values of actual crop losses and the

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[41] Technically, the numbers we shall use represent obligations rather than expenditures (see footnote p. 34). We shall use the more common term in this section.

value saved by protection, we can arrive at the potential loss, as discussed in the last section. We can then compute the percentage of the potential loss which was saved by protection in each year. Then by assuming that expenditures for control are the determining input, we shall have a protection supply function. This function expresses the percentage of potential crop production realized as solely dependent upon control expenditures.

What would be the shape of such a function? Since some quantity of the crop, say 25 percent of the potential, will be available without any expenditure by the growers for protection[42], the function will have a positive intercept on the Y axis (see Figure 7).

Many present day crop species have been bred for disease and insect resistance as well as greater productivity. This means that there is a built-in investment in crop protection. Thus it is sometimes argued that we can have no modern commercial production of crops without some expenditure for protection. In this analysis, however, we are focusing on the direct expenditures for protection during the production process. We will treat as parameters the genetic character of the plant as well as the other influences on its growth and development, even though we acknowledge that there are interactions between these parameters and the pests.

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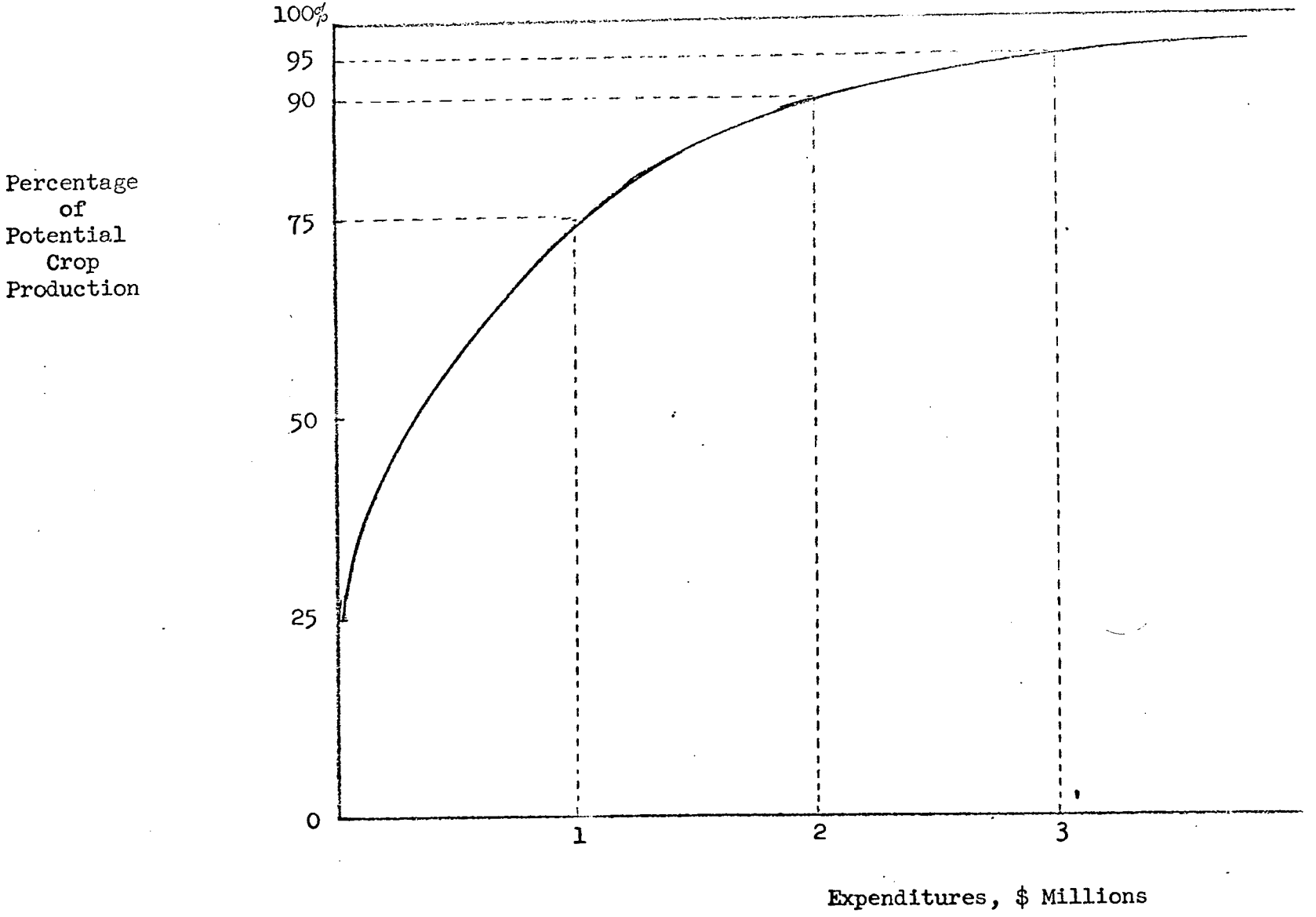
[42]Many commercial crops will not be grown without some protection, however, since no salable product would result.

FIGURE 7

A Hypothetical Protection Supply Function



Positive action begins with an expenditure of $1 million for protection. This action results in an increase in the quantity of crop produced and the realization of a higher proportion of the potential crop production. Thus, in our example, the input of $1 million results in an increase in the proportion that the actual crop is of the potential crop from 25 to 75 percent, an increase of 50 percentage points. The expenditure of $2 million increases the proportion of the potential from 75 to 90 percent, an increase of 15 percentage points. A third dose which now triples the first expenditure results in an increment of only 5 percentage points. Thus we have a declining marginal response, as shown in the table below:

Millions of dollars of expenditures	Percentage of Potential Crop Production	Marginal Return (Change in percentage per unit of expenditures)
0	25	--
1	75	50
2	90	15
3	95	5

The number of units saved per dollar of protection expenditure decreases as the total quantity of expenditures increases. Therefore, the function expresses a steadily declining rate of increase. We can regard the function as asymptotic to the 100 percent limit, on the assumption that complete protection is not attainable or desirable. It would be attained, of course, if the

pest were eradicated. But, eradication is usually not technically feasible--we have a long way to go in the development of pest control technology. Even in those cases where we know how to eradicate a pest, or to achieve almost complete protection, the cost may be so high that we do not know how to reckon it, or the biological side effects may be so deleterious that on balance eradication is undesirable.

A value can be attached to the crop units saved. We need a revenue function which establishes the value of the crop in relation to its total supply. Since the demand for agricultural products is relatively inelastic, we know that in a free market this would not be a linear function--at some point the increase in supply would have a depressing effect on price and the value per unit of the crop saved would decline. Nevertheless, we shall assume a linear revenue function, meaning that the units of the crop saved by protection will be equal in value to the units available without protection. To evaluate all the crop units lost on this basis might be unreasonable, since these units would represent a major addition to total supply. However, since we are concerned only with a relatively narrow range of action at the margin, we assume that the impacts on total supply will be relatively small. In addition there is substantial "stickiness" in agricultural prices due, in part, to the price support program.

A CASE: GRASSHOPPER CONTROL

As discussed in Chapter 2, our information on losses is very limited and even our data on use is rather primitive. In the words of the Tukey report:[43]

> "Attempts to compare relative effectiveness and costs of bioenvironmental and pesticide chemical control programs in forestry and agriculture are difficult because detailed and comparable statistics are not generally available. Specifically, detailed information on sales and uses of pesticides and the costs of applying bioenvironmental control measures have not been assembled regularly. Moreover, there are relatively few satisfactory statistics on the value of the crop saved. Although there are many statistics that show the presumed loss of the crop without control, or the loss of the crop in spite of control, there are almost no valid comparisons."

There are, however, fragments of data available.[44] The grasshopper program is the only one for which a time series could be located showing the values saved by control measures in relation to loss estimates. These data are shown in Table 6. Unfortunately, the series is limited to the period 1937-47. Even this record is incomplete, since not all states reported in each year. The data have been adjusted, for purposes of the following analysis, by estimating the missing state reports in order to obtain a more consistent time series. Summing the values destroyed each year and the values saved by control provides us with a figure for the potential loss.

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[43] PSAC Restoring the Quality of Our Environment. The White House, November 1965. p. 267.

[44] For examples of dollar estimates of losses (and gains) see: G.J. Haeusller. Losses Caused by Insects. Yearbook of Agriculture 1952 Insects USDA. PSAC op. cit. pp. 267-280.

TABLE 6

Estimated Value of Crops Destroyed by Grasshoppers and Saved by Control Measures, 1937-1947

Year	Estimated Value of Crops ($ in millions)		
	Destroyed by Grasshoppers	Saved by Control	Potential Loss
1937	$66.1	$102.8	$168.9
1938	83.8	176.4	260.2
1939	48.8	128.5	177.3
1940	24.3	44.9	69.2
1941	23.8	35.6	59.4
1942	16.2	30.0	46.2
1943	15.9	7.3	23.2
1944	14.3	23.4	37.7
1945	12.7	29.7	42.4
1946	23.0	41.3	64.3
1947	22.6	50.5	73.1

Adapted from: Claude Wakelund. Effectiveness of Grasshopper Control in the United States. ARS-81-1, May 1955.

In Table 7 is shown the percentage of the potential value which has been saved together with the expenditures on control, including Federal and cooperator costs, for each year. For purposes of simple graphic analysis, these estimates have been converted to three-year moving averages. Plotting this relationship graphically, as in Figure 8, produces a function that is similar to our hypothetical figure. The degree of protection rises rapidly for the first one million dollars, from an extrapolated protection level of about 26 percent with no expenditures at all to a level of about 52 percent at an expenditure of one million dollars. The second increment of a million dollars results in an additional 10 percent protection, while the third increment provides only an additional 8 percent, as shown in the following table.

Millions of dollars of expenditures	Percentage of Potential Crop Production	Marginal Return (Change in percentage per unit of expenditures)
0	26	--
1	52	26
2	62	10
3	68	6
4	72	4
5	74	2

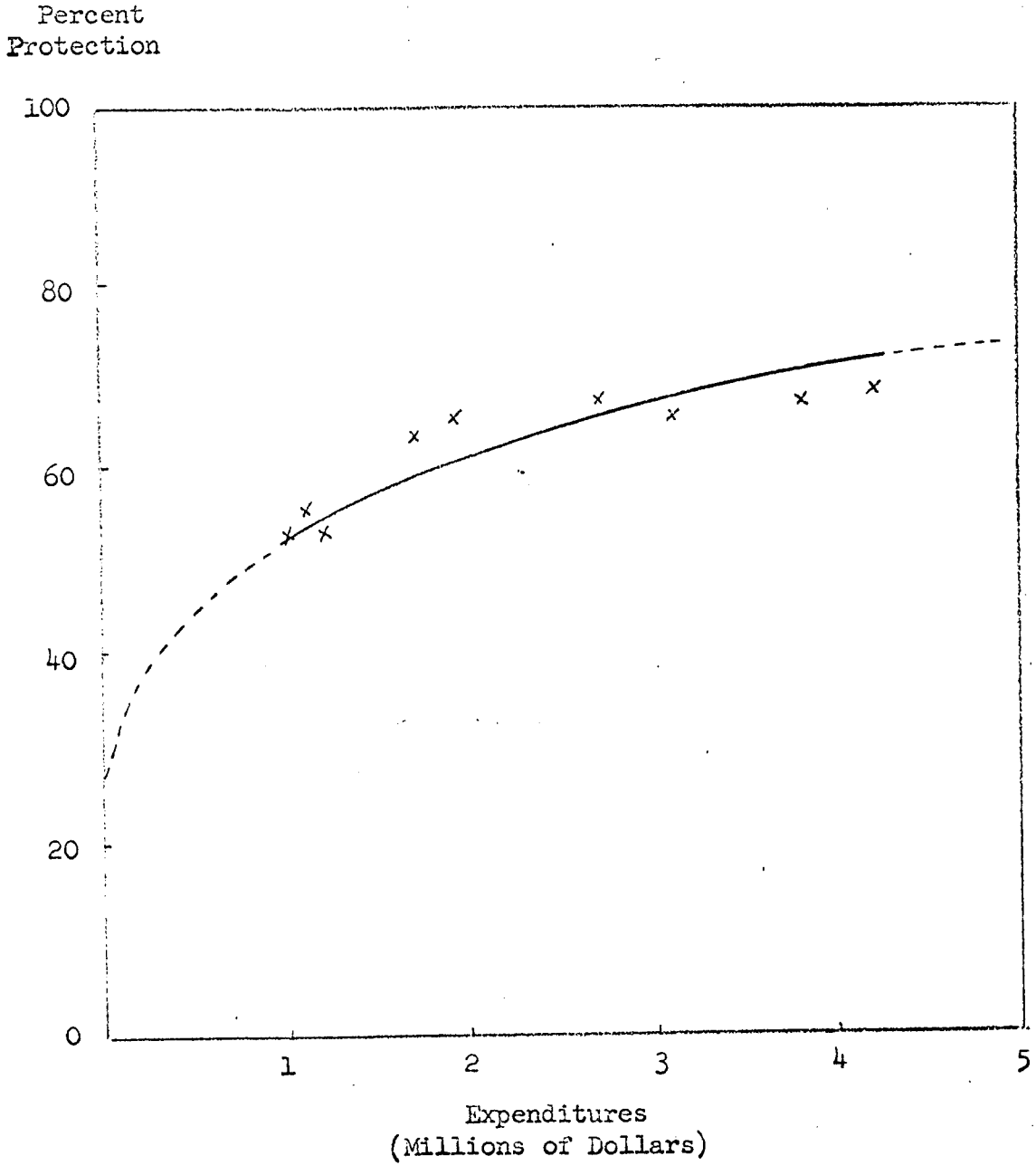
TABLE 7

Comparison Between Values Saved and Expenditures for Grasshopper Control

Year	Percent of Potential Value Saved (3-year moving averages)	Expenditures ($ in millions)
1938	67.0	$3.8
1939	68.2	4.2
1940	65.6	3.1
1941	63.2	1.7
1942	52.2	1.0
1943	52.9	1.2
1944	54.6	1.1
1945	65.5	1.9
1946	67.8	2.7

FIGURE 8

The Protection Supply Function in Grasshopper Control



A more sophisticated analysis is not worthwhile, given the weakness of our data. But this simple analysis does seem to verify our assumed functional relationship.

This analysis suggests that the amount of protection supplied is subject to diminishing returns. It is very high up to about two million dollars. There is a real increase up to about three million but beyond that the amount of protection purchased per additional dollar of expenditure slackens rapidly. This does not mean that expenditures beyond three million do not pay, it only suggests that expenditures in excess of this amount should be carefully scrutinized. It may be that they are more valuable elsewhere.

We may also presume that the protection supply function will change over time as the result of new technology. In grasshopper control there is little doubt that the introduction of aerial spraying of chlorinated hydrocarbons was more efficient than the ground distribution of baits. Whether, in fact, this raised the function significantly, producing greater protection for a given expenditure, we were not able to show conclusively with the data available.

To complete our model we must establish a revenue function. We can hypothesize that the value of the units saved depends upon the number of units saved, the units saved as a percent of normal supply, and the elasticity of demand.

If we assume that price is relatively constant and thus, in effect, there is considerable dampening of the impact of changes in supply and in the elasticity of demand then the value of units saved is directly related to price and we can express the total value added in direct relation to the number of units saved. Diagramatically, this is shown in Figure 9 as function OA or OB.

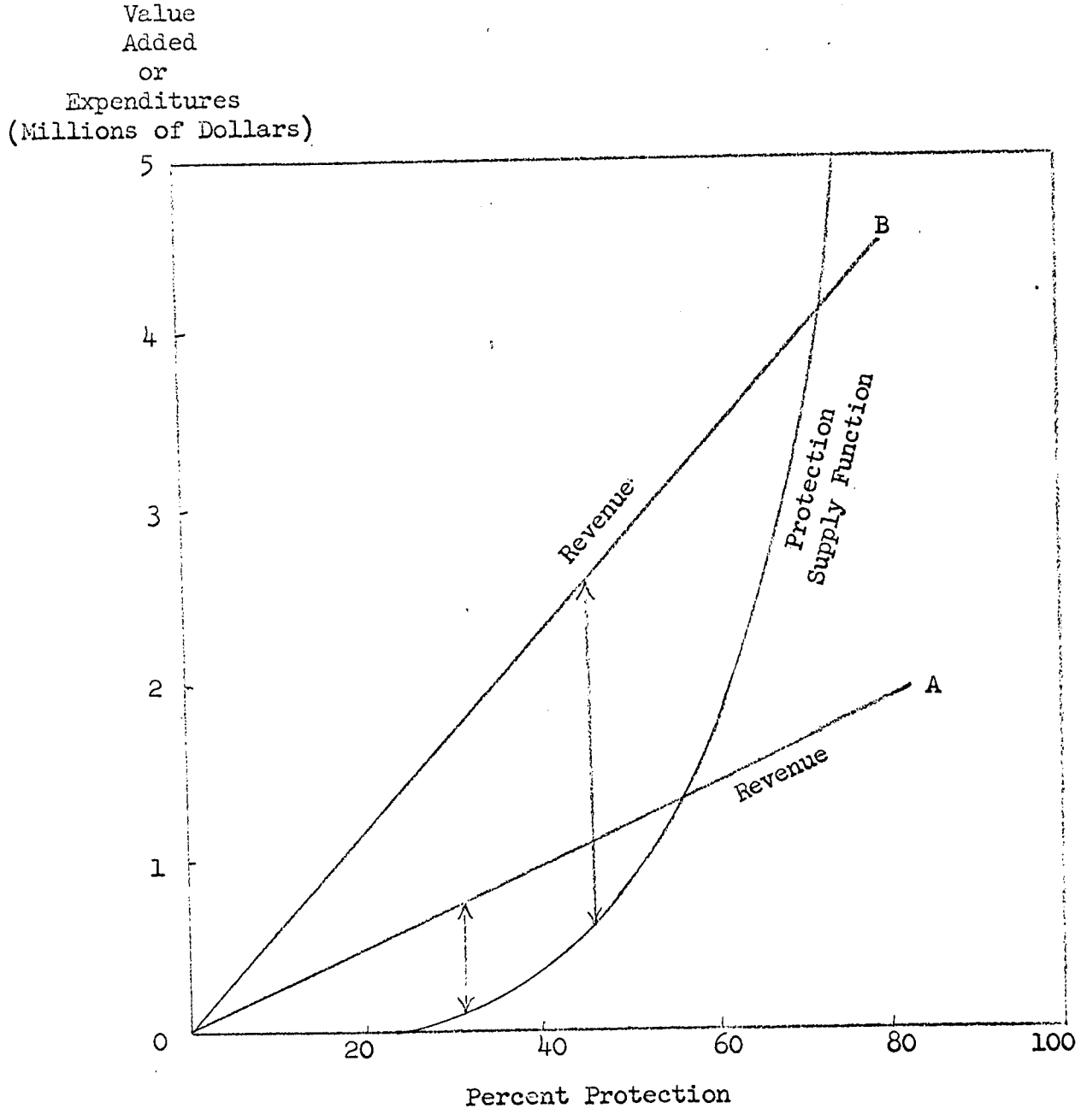
By reversing the axis of the protection supply function of Figure 8, and placing it on the same graph, we can then determine the optimum point to which to carry expenditures. If the revenue function lies along OA, we should spend about $750 thousand and settle on a protection level of 30 percent. If, however, we assume a revenue function OB, then we should spend about $3 3/4 million and aim for a 45 percent protection level. Diagramatically, these are the points where the slopes of the two lines are equal, that is, where marginal revenue equals marginal cost. In the absence of data for the values added by grasshopper protection, we can only bracket the relevant range of expenditures.

Unfortunately data for programs other than grasshopper are not available. The desirability of collecting such data has been discussed for years by entomologists, but no systematic program for the collection of data has been inaugurated on a nationwide basis.

If similar data were available for other programs, it would be possible, using the model described above, to develop a protection supply function for each of them. If in fact, programs

FIGURE 9

The Optimizing Model



were found to be above or below the optimum points, then shifts in resources could be made from one program to another.

One kind of technological change might be noted here. Suppose that the sterile male technique is adapted by research to a new insect and it is proposed that the insect can be eradicated in 5 years at an expenditure of $20 million.

This suggests that the protection supply function shifted upward and that it intersects the 100 percent protection line at $20 million. Whereas, originally an expenditure of $20 million over the 5 year time period might have produced only 80 percent protection. Whether or not we should expend the $20 million for complete eradication or continue to receive 80 percent protection by an expenditure of $10 million will then become an appropriate question. There is no apparent reason why the mere existence of eradication technology should commit us to an eradication program.

Under some conditions the complete removal of a species from the environment might only provide an opportunity for competing species to fill the gap. We would have to consider whether the latter species might be a more costly pest than the former. When all the values are considered and alternative expenditures have been weighed, eradication may not be the best alternative.

OTHER VALUES

Throughout the discussion of models presented above, we have assumed a revenue function based on the market value of the crop saved. In so doing we have been balancing the joint expenditures of public and private funds against private revenues. This may not have been as irrational as it seems during the early development of public pest control programs. This was a period when there was a high degree of public interest in insuring an adequate and stable supply of agricultural products. But many other kinds of programs have been developed to achieve these objectives and public participation in the present programs can no longer be justified solely on that basis.

In addition, there is evidence that public values have shifted from production efficiency to the amenities. There is certainly no reason to assume that the consensus of public values remains constant. Indeed, among the factors bringing about a change in public values is the enormously successful effort to achieve an efficient agriculture producing a reliable food supply. The efficiency of such production is taken for granted, as it is in so much of our industrial production as well.

Among the amenities on which public values now focus is environmental pollution--the rather obvious pollution of our air, water, etc., resulting from expanded resource use by a rapidly growing population.

Public policy seeks a response and many new Federal and State programs have begun as a result. Environmental health is one of these programs. But clearly, this is also a matter of amenities and not just health. Most of the scientific evidence of damage to human health is either speculative or potential. Esthetic values often play the major role in anti-pollution campaigns.

Present technology for pest control is exceedingly primitive relative to the possibilities recognized in the laboratories and the potential inherent in our most sophisticated biological knowledge. The massive release of broad spectrum chemical pesticides into the environment is surely a very crude and expensive way to control an agricultural pest. Compare this method with the relatively more delicate techniques aimed at a single species, the screwworm fly. A canister of these flies is treated with just the right dosage of gamma rays to sterilize the male gonads without interferring with the insect's essential vitality. This represents a spread in technological development which illustrates the crudeness of present methods.

Another measure of the inherent weakness of our technology is the development of resistance to pesticides by various species of insects. It is not a very powerful control technique which can be so readily negated by the breeding of a few generations of insects.

Certainly the agricultural research community, Federal, State and private has an opportunity and a challenge.

At the moment we seem to be in the early stages of a major public shift. The agricultural community was put on the defensive by the appearance of "Silent Spring." Fish and wildlife and health interests (both tied up with amenities)[45] will continue to keep the pressure on. Much of the agricultural community tends to be somewhat rigid and conservative in thinking. Undoubtedly it will continue to devote substantial resources to "fighting back" and to protection of the status quo, rather than the aggressive pursuit of new techniques and approaches. But many signs point to an end of such resistance as both the political and economic power of farm producers decline. This will, of course, be offset to some extent by the growth of the supply marketing and distribution sectors, some elements of which align themselves with producers.

It is clear that a consideration of values in determining the allocation of resources among these programs must consider a changing set of values many of which are not quantifiable in traditional economic models. Many of today's programs and increasingly tomorrow's will be launched as a collective effort to take advantage of new technology under Federal leadership.

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[45] These communities are not monolithic in their viewpoints. Fish and wildlife interests are often concerned with the control of species as well as their protection. Health interests are concerned with the insect vectors of such diseases as malaria--which is of world-wide concern--in addition to pollution of the environment.

The frameworks which we have considered will be helpful in evaluating them. The decision will be made in the political arena through the budgetary process. The performance of that process is the subject of the following chapters.

CHAPTER 5. THE ALLOCATIONS

This chapter will discuss the present allocation of funds among the ARS plant pest control programs. A review of these facts is prefatory to the discussion of the process by which these allocations were derived. That is the subject of Chapter 6. First we will review the allocation among the individual programs and how this has changed over time. Secondly, we will look at the allocation of funds on a geographic basis.

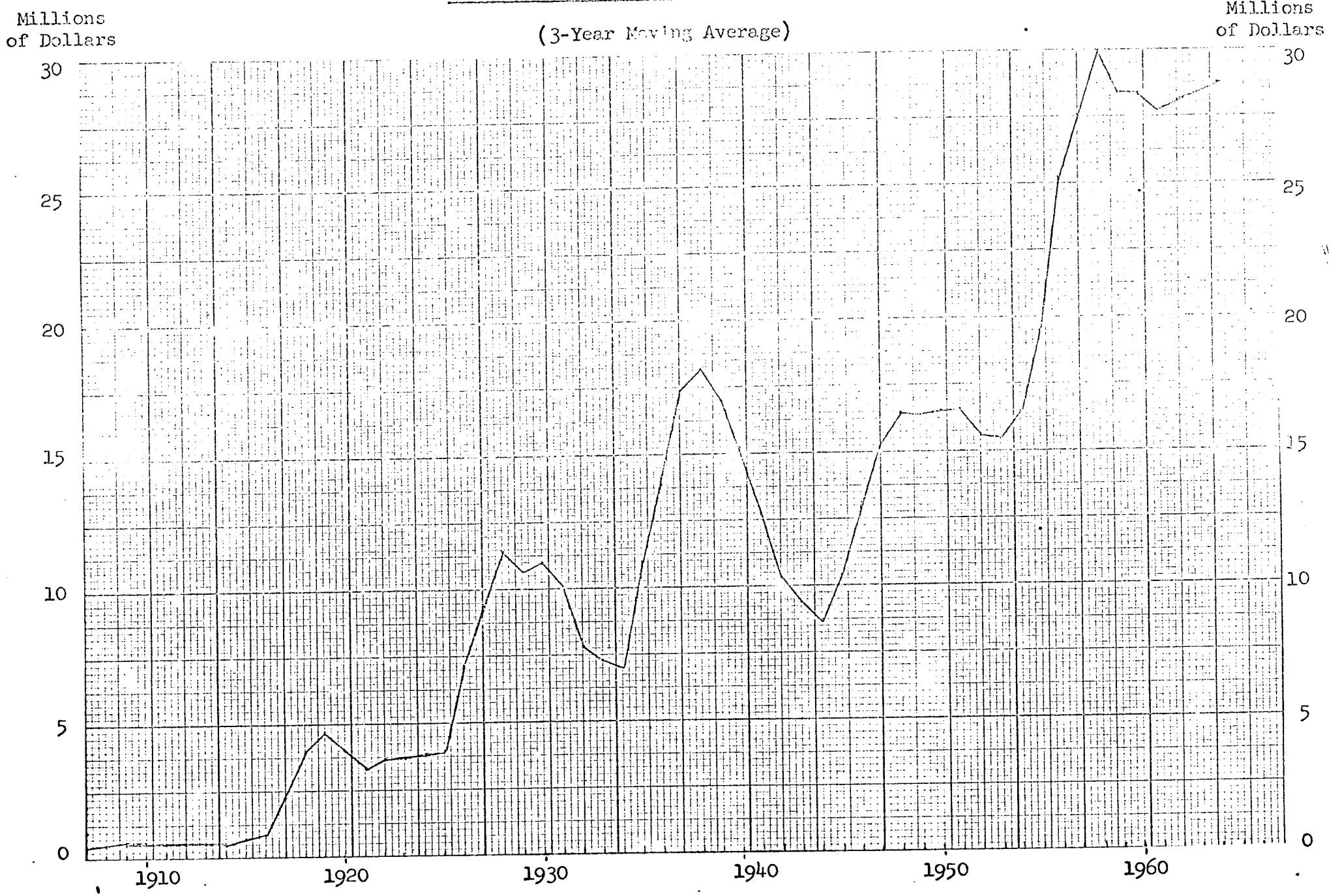
The total funds available for the cooperative plant pest control programs from Federal, State and local sources have grown from $0.4 million in 1907 to $28.7 million in 1965. This growth in activity is illustrated in Figure 10. A three year moving average has been employed to smooth out minor irregularities.

The substantial bulge in the late 1920's is due to the more than $10 million expended for the eradication of the Mediteranean fruit fly. The bulge in the late 1930's is due to funds expended to combat the severe grasshopper outbreaks of those years. The rapid increase in the 1950's is due to another outbreak of Medfly, together with the beginning of new programs for Khapra Beetle, several nematodes, Witchweed and Fire Ant.

FIGURE 10

Growth in Pest Control Funds, 1907-1965

(3-Year Moving Average)



THE FEDERAL SHARE

As illustrated in Figure 11, the trend in the share of funds for all plant pest control programs supplied by the Federal Government has varied. Changes in the proportion of the Federal share reflect actions on the part of State and local participants as well as changes in Federal funding. The Federal share has varied from as little as 35.9 percent in 1909 to as much as 80.5 percent in 1938. Figure 11 is plotted on the basis of a five-year moving average in order to dampen the effect of decisions on individual programs and provide an insight into the trend in Federal sharing. An analysis of the illustration indicates that four phases may be distinguished:

Phase I (1909-1931). The early period. During this phase the Gypsy Moth program dominated the scene and fluctuations in the Federal share were due primarily to State actions.

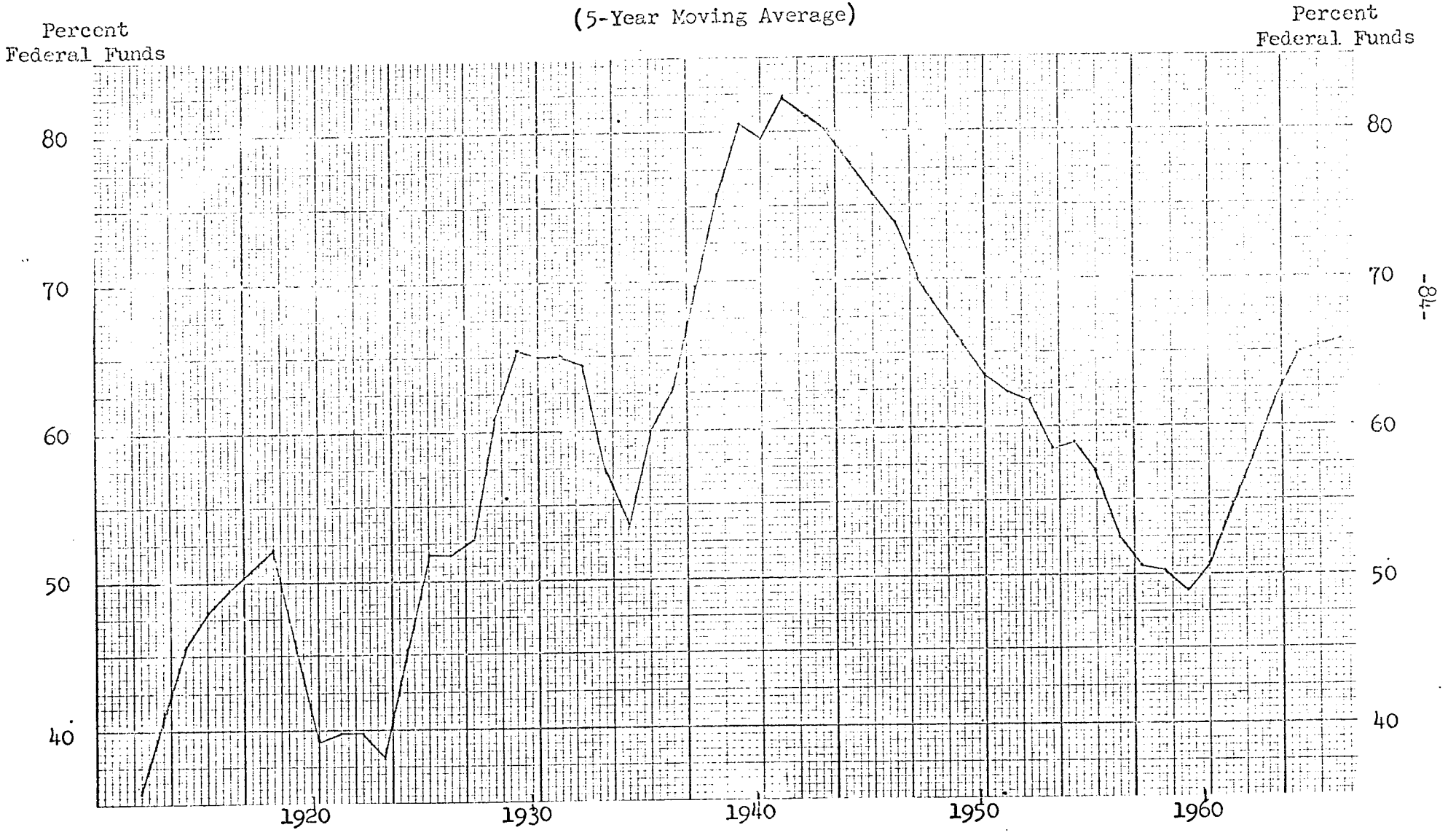
Phase II (1931-1940). Increase. During this phase the Federal share increased steadily and many new programs began. The increase in the Federal share was due primarily to a decline in State participation.

Phase III (1940-1956). Decline. During World War II, and for almost a decade afterward, the Federal share declined. Federal funds increased during this period, but the funds supplied by cooperators increased more rapidly.

FIGURE 11

Change in the Federal Share of Funds
For Pest Control Programs, 1907-1965

(5-Year Moving Average)



Phase IV (1956-1963). Upturn. Ever since 1956 the Federal share in the programs has steadily increased. This is occurring apparently because of the beginning of a number of new programs in which the Federal share is quite high, e.g., Khapra Beetle, 65 percent; Witchweed, 80 percent; Fire Ant, 63 percent.

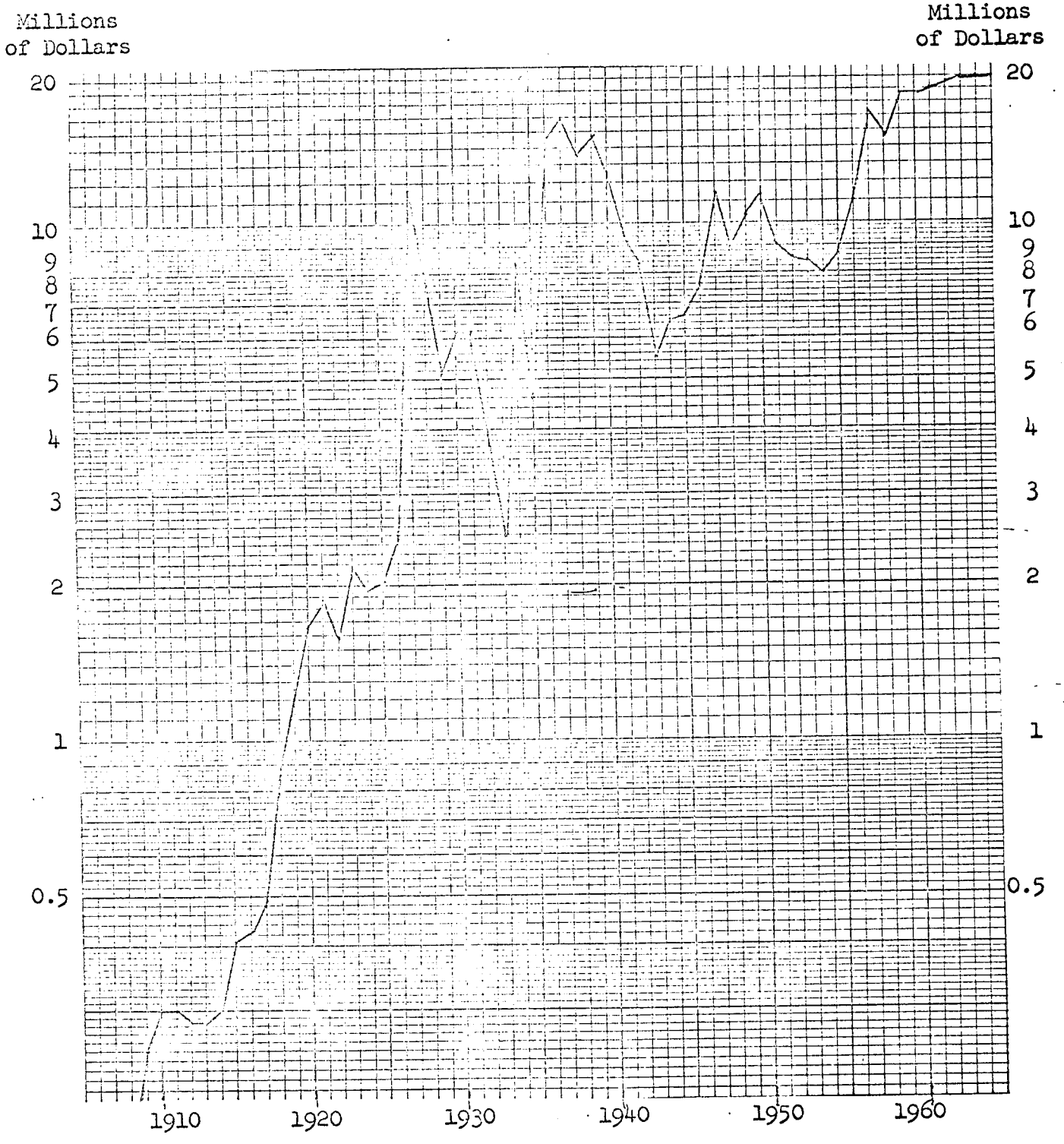
Not only do these movements reflect the decisions of the Federal and State Governments and the cooperators, they are also a composite of decisions on the individual plant pest control program. The aggregate movements, however, reflect major political, economic and fiscal changes. A discussion of these changes is beyond the scope of this analysis. The upturn in Phase IV (1956-1963) represents the need to employ increasingly sophisticated pest control technology over wider geographic areas where the Federal Government must take the leadership.

The percentage of funds supplied by the Federal Government for particular programs varies from about 20 to 85 percent. These shares are determined by negotiations between the Federal Government, the State Governments, and agricultural producers.

Federal expenditures have steadily increased. Figure 12 illustrates the trend from 1908 to 1965. The rate of increase has been gradually declining--the rate of increase in the last twenty years has been substantially less than the rapid growth of the first two or three decades.

FIGURE 12

Trends in Federal Expenditures
for Pest Control Programs
1908-1965



THE PROGRAM MIX

In the history of plant pest control there have been organized programs against about two dozen pests. However, only about eight of these programs can be considered major in the sense that they represent current annual expenditures of over one million dollars a year and have continued for an extended period.

Table 8 displays the allocation of total funds for these eight major programs at selected five-year intervals. The amount of dollars expended on each program is given to the nearest one-tenth million together with the proportion of all plant pest control programs which that amount represents.

Note that the Gypsy Moth program has declined over the years in its relative-share of the total funds, whereas most of the other programs have tended to grow about as fast as the total program grows. The grasshopper program has fluctuated widely (from 4 percent to 22 percent) in order to meet epidemic conditions on the plains. The two new programs, Witchweed (1957) and Fire Ant (1958), less than a decade old, consume more than one-quarter of the funds available.

TABLE 8 - Allocation of Total Funds Among Eight Major Programs by Selected Years, 1910-1965
(In millions of dollars. Figures in parenthesis are percentages)

Program and Year Started	1910	1915	1920	1925	1930	1935	1940	1945	1950	1955	1960	1965
Gypsy Moth 1907	$0.7 (100)	$0.6 (75)	$1.1 (37)	$1.4 (38)	$1.9 (17)	$1.8 (27)	$2.1 (14)	$1.5 (16)	$1.9 (11)	$2.8 (14)	$1.5 (5)	$2.0 (7)
Pink Bollworm 1917			0.6 (20)	0.4 (11)	1.2 (11)	0.4 (6)	1.1 (7)	0.9 (10)	1.4 (8)	1.7 (9)	3.4 (13)	2.6 (9)
Barberry 1918			0.2 (7)	0.5 (13)	0.5 (4)	0.5 (7)	1.1 (7)	0.4 (4)	0.9 (5)	0.9 (4)	1.1 (4)	1.2 (4)
Japanese Beetle 1920			0.1 (3)	0.3 (8)	1.1 (10)	0.4 (6)	0.6 (4)	0.7 (8)	0.9 (5)	0.9 (5)	1.5 (5)	1.9 (7)
Grasshopper 1934						0.2 (4)	2.9 (19)	1.2 (13)	3.7 (22)	2.4 (12)	1.1 (4)	1.7 (6)
White Fringed Beetle 1938							0.8 (5)	0.8 (9)	1.3 (8)	1.4 (7)	1.5 (5)	1.5 (5)
Witchweed 1957											3.1 (11)	3.2 (11)
Fire Ant 1958											4.4 (16)	4.2 (15)
Sub-total, Major Programs	0.7 (100)	0.6 (75)	2.0 (67)	2.6 (70)	4.7 (42)	3.3 (50)	8.6 (56)	5.5 (60)	10.1 (59)	10.1 (51)	17.6 (63)	18.3 (64)
Other Programs		0.2 (25)	1.0 (33)	1.1 (30)	6.6 (58)	3.4 (50)	6.6 (44)	3.6 (40)	7.0 (41)	9.7 (49)	10.2 (37)	10.4 (36)
TOTAL, All Programs	0.7 (100)	0.8 (100)	3.0 (100)	3.7 (100)	11.3 (100)	6.7 (100)	15.2 (100)	9.1 (100)	17.1 (100)	19.8 (100)	27.8 (100)	28.7 (100)

GEOGRAPHIC DISTRIBUTION

The distribution of expenditures for plant pest control programs among the States might be expected to relate to their relative agricultural importance. Yet certain States of lesser rank in agricultural importance receive substantial allocations of funds.

Table 9 shows a comparison between the nineteen States that rank highest in agricultural importance and the proportion of pest control funds allocated to them. The top ten States receive only 27.5 percent of the total funds.

There may be some significance to the fact that the Chairman of the House Subcommittee on Appropriations is from Mississippi, and the Chairman of the Senate Subcommittee on Appropriations is from Florida. We will test the possibility of such a relationship and compare the State distribution of political influence in the Appropriations Committees with the allocation of funds for plant pest control among the States.

Subjective observations suggest that most of the power lies in the hands of the subcommittee chairman. We will score two points for each year that a State provides a subcommittee chairman. The overall chairman of the Appropriations Committee in each body yields about one-half the influence of the subcommittee chairman. Therefore, we will score one point for each year that a State has a man in that role. A third position of influence is that of ranking minority member of the subcommittee.

TABLE 9

Comparison Between Agricultural Importance and Pest Control Fund Allocation (1933-64)

Agricultural Importance		Allocation of Funds	
Rank	State	Percent	Cumulative Percent
1	California	3.1	--
2	Texas	6.5	9.6
3	Iowa	0.6	10.2
4	Illinois	0.7	10.9
5	North Carolina	12.5	23.4
6	Minnesota	1.5	24.9
7	Ohio	1.2	26.1
8	Indiana	0.5	26.6
9	Kansas	0.3	26.9
10	Wisconsin	0.6	27.5
11	Missouri	0.8	28.3
12	Nebraska	0.3	28.6
13	Mississippi	8.7	37.3
14	Michigan	3.7	41.0
15	Kentucky	0.4	41.4
16	Georgia	8.6	50.0
17	Arkansas	1.8	51.8
18	Oklahoma	0.5	52.3
19	Florida	6.6	58.9
	31 Other States	41.1	100.0

We will score one-half point for each year that a State has a man in that role. This means that we are judging the subcommittee chairman to be four times as influential as the ranking minority member. The results of this ranking are presented in Table 10.

In the relationship between political influence and agricultural importance, note that only two of the top ten States in political influence (Minnesota and Illinois) rank among the top ten States in agricultural importance, and five of the top ten in political influence do not even rank among the top nineteen in agricultural importance.

This rough analysis does indicate that political influence is a significant factor in the geographic distribution of funds. Six States (Georgia, Mississippi, Arizona, Texas, Florida, and Louisiana), whose representatives have exercised control of the Appropriations Committees in both houses of the Congress for many years, received 40 percent of all plant pest control funds--during the period 1933-1964.

From the point of view of economic loss and equity among citizens, there is little doubt that the present system for making allocation decisions discriminates in favor of certain areas, certain commodities and groups of producers, e.g., cotton or citrus. Small grain producers for example, do not have an equal opportunity for Federal action on their behalf. This may be because they are not as well represented in the power structure of the Appropriations Committees.

TABLE 10

Comparison Between Political Influence and Pest Control Fund Allocation (1933-64)

Political Influence		Allocation of Funds	
Rank	State	Percent	Cumulative Percent
1	Georgia	8.6	--
2	Mississippi	8.7	17.3
3	Missouri	0.8	18.1
4	North Dakota	0.3	18.4
5	Virginia	1.5	19.9
6	Illinois	0.7	20.6
7	Minnesota	1.5	22.1
8	Arizona	3.7	25.8
9	Texas	6.5	32.3
10	Florida	6.6	38.9
11	Louisiana	5.7	44.6
12	New Hampshire	0.3	44.9
13	Colorado	0.6	45.5
14	Kansas	0.3	45.8
15	New York	6.2	52.0
16	Tennessee	2.1	54.1
17	Oregon	0.3	54.4
18	Washington	0.4	54.8
	32 Other States	--	100.0

How much power does the Congress have in determining the allocation of Federal funds for plant pest control in relation to the Executive Branch? How does this process of decision-making operate? That is the subject of Chapter 6.

CHAPTER 6. THE ALLOCATING PROCESS

In the private sector the price system is the principal mechanism for the allocation of resources. In a mixed society the role of the price system is modified by governmental action that now assumes substantial proportions. Federal expenditures represent about one-sixth of the Gross National Product and their influence extends far beyond this measure of importance.

The objectives of the public economy are to supplement and/or to supplant market sector activities so as to overcome deficiencies in performance and to provide for certain functions which the private economy cannot or will not furnish. The allocating mechanism in the public sector is the budgetary process.

Budgeting is basically a political process in which decisions are made as to who gets how much. Funds are collected as taxes on the basis of one distribution pattern and expended in a different pattern. Neither of these distributions are neutral in their economic, political, and social effects.

In this Chapter, we shall examine the performance of the Federal budgetary process as it relates to the allocation of funds for pest control programs. In doing so, we shall be primarily concerned with political behavior.

Musgrave's Theory of Public Finance provides a useful approach to understanding the total purposes of the budgetary

process--a means of interpreting and explaining the phenomena. He separates three component functions--allocation, stabilization, and distribution. We are interested only in allocation.

Pest control expenditures have been a part of agricultural enterprise throughout recorded history. They are a cost of production and most of them are still borne by individual farm firms. Whenever there is public participation in pest control, there will be redistribution effects on income. Funds derived from taxation are expended to assist a particular group of farm enterprises. The benefits are not limited to farmers, but are reflected in lower prices to consumers as well. The character and significance of these redistribution effects will not be explored.

Public expenditures for pest control have declined as a proportion of total public and private inputs. In the 1930's public expenditures for grasshopper control may have had significant affects on the stabilization and distribution of farm income. Since that time the growth of total pest control activity has been very rapid relative to the growth of public programs. Consequently, the relative importance of distribution and stabilization effects has probably declined.

Since the 1930's there have been programs adopted that were specifically aimed at stabilization and distribution objectives, especially the price support and credit programs. As these have come to the fore, the relative importance of pest control in meeting the objectives of stabilization and distribution has declined.

Musgrave's theory refers to budget allocation as a process which influences a society's total allocation of resources. We will use the term allocation in a rather narrow sense, to refer to the division of funds among Federal programs. Because of their cooperative nature and the requirements for State matching, the funds allocated to Federal pest control programs influence the allocation of resources by State and local units of government.

In addition, the public pest control programs influence the allocation of farm firms by encouraging their participation and by substituting for part of their pest control costs.

THE FEDERAL BUDGETARY PROCESS

The Federal budgetary process consists of three sequential stages: (1) Formulation; (2) Enactment; and (3) Execution. We will describe the process only briefly.[46]

Budget formulation takes place in the Executive Branch beginning in March and ending the following January with the transmission of the President's Budget to the Congress for the year beginning July 1 next. The enactment stage is the responsibility of the Congress, and both houses participate during the six or more months devoted to determining the amounts and purposes to be specified in the various appropriation acts. The execution of the enacted budget is the prime responsibility of the agency to whom the funds are appropriated; but the Congress, through the General Accounting Office and the Appropriations Subcommittees, exercises an audit and oversight function in addition to the apportionment and appraisal functions carried out by the Bureau of the Budget for the Chief Executive.

More or less involved in each of these stages are a set of direct performers. We shall distinguish these performers from the indirect participants who remain largely behind the scenes. Although the total process is structured in time and in organization, it is actually played rather fast and loose, and outcomes are often difficult to predict. A description of the behavior of the performers and the participants is essential to an understanding of the process.

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[46] For a chronological and graphic description of the process, see Wildavsky, op. cit., p. 194-199.

THE BEHAVIOR OF PERFORMERS

Three performers dominate the actions of the formulation stage: (1) a bureau[47], often referred to as an agency--in this case the Agricultural Research Service; (2) an agency, the Department of Agriculture; and (3) the Bureau of the Budget[48]. The activity of these units is consumated in the executive budget document, the format in which the decisions of the President are transmitted to the Congress.

During the enactment stage decisions are made by the subcommittees of the appropriations committee of each body--the House and the Senate. The results are usually agreed to by the

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[47] It should be recognized that a bureau is an arbitrary starting point. There is a considerable struggle for resources which takes place among the organizational units of a government bureau. The Division is the principal component around which individual loyalties tend to focus and within which a mission may be defined. The set of programs under consideration here is contained in such a unit in the Agricultural Research Service--The Plant Pest Control Division.

[48] A subject of interest is the question of who actually makes the decisions, i.e., to what extent does the Budget Bureau make decisions independently of the President? To what extent do agency decisions actually reflect those of the Secretary? This is partly a question of the role and power of staff. Given the timing and the large number of decisions involved, it is inevitable that many decisions are initially formulated by the staff and often given only cursory review by the responsible officials. These hypotheses are suggested: (1) whenever a large number of decisions is required, it becomes inevitable that a proportion will be performed by staff; (2) permitting a number of staff decisions is the method by which the total number of decisions is reduced to manageable proportions; (3) the quality of overall decision-making is probably improved as a result of such decentralization, since the alternative may be consolidation into unwiedly and meaningless aggregates. A major determinent in the extent of staff power is the personal preference of the responsible official. An Eisenhower may delegate many decisions, whereas a Johnson may choose to personally decide a large number of issues in relatively unconsolidated form.

full Appropriations Committee. A conference committee consisting of representatives from the two bodies is used to settle disagreements.[49]

Budget execution involves all of the same performers. Each of them has tools for modifying the decisions reached in the enactment. The bureau must interpret the decisions and recommendations of the two houses and the conference committee and assign funds through its allotment system. The agency has legal authority to shift some of the funds from one appropriation to another. The Budget Bureau, through the apportionment system, controls the overall rate of expenditure and on rare occasions may reserve funds from use by the agency. The Subcommittees of the House and the Senate are very active in their oversight function, approving certain program actions, disapproving others, and making suggestions for organization and management, which an agency and a bureau dare not ignore.

As this brief description implies, the Executive and Legislative Branches share the responsibility for the administration of programs. How do their roles differ? They differ because each of the performers has special qualifications such as scientific competence, or fiscal outlook. In this situation

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[49]Under the rules of both bodies the function of the conference is that of negotiation between two established positions. In fact, new positions may be injected and the conference may be institutionalized into an additional component of the process. On occasion a new proposal may arise in conference which has not been presented to either house, even though this violates the rules of both bodies.

of shared power, there is also shared competence. None of the performers can claim a monopoly on a particular qualification. There is general agreement among the performers as to the special qualifications of one another. The following table outlines these qualifications:

Performers	Special Qualifications
Bureau	Scientific--technical
Agency	Bureaucratic
Bureau of the Budget	Fiscal--economic
Appropriations Subcommittees	Political

These special qualifications constitute a set of forces which interact throughout the stages of formulation, enactment and execution.

When the occasion warrants, each performer is in a position to disallow the judgment of another even though doing so may involve a challenge to the special qualifications of the other performer. For example, an astute bureau often pits its political judgment against the Appropriations Subcommittee.

The scientific and technical knowledge of pest control is a special qualification of the Agricultural Research Service and it has a responsibility to make recommendations thereon. However, if it desires to achieve success in the budgetary process, it must contemplate bureaucratic, fiscal-economic, and political considerations, and then adopt appropriate strategies. It must consider its program proposals in the light of dealing with other departmental bureaus. It must consider the fiscal constraints laid down by the Budget Bureau. And it would be foolish indeed not to give attention to the political and economic consequences of its proposals.

The special qualification of the agency or department is bureaucratic. It is in a unique position to take actions to settle disputes among bureaus and to promote equity among them. It is also in a position, as a major element of the bureaucracy, to consider its relation with other major elements, e.g., the Department of Health, Education, and Welfare, or the Department of the Interior.

The Bureau of the Budget, as the review and assembly point for the President's Budget is responsible for formulating the fiscal situation. The formulation stage is the time for consideration of the economic consequences of the budget plan. The Council of Economic Advisory, the Treasury and the Federal Reserve Board interact in making this evaluation.

To say that politics is the special qualification of the Congress is not to suggest that the President's Budget is apolitical. Nothing would be more untrue. Political consideration is crucial in the formulation of the executive budget. In a larger sense, the very process of budget formulation is a political process.

The Congress has a great deal to say about fiscal and economic considerations. In the case of ARS, the congressional oversight function has developed to the point where it is intimately concerned with bureaucratic relationships. And, on occasion, political necessity may require the Congress to challenge the scientific and technical judgment of ARS, substituting its own decision.

Decisions are made by individuals, not by groups. As individuals, the performers are divided into politicians and bureaucrats. These are not wholly separable categories. Some appointed officials in the Executive Branch behave more like politicians than bureaucrats. Conversely, some of the committee staff in the Legislative Branch are part of institutionalized structures and their behavior is more akin to the bureaucrats than it is to the politicians whom they serve.

Self preservation ranks high among a politician's values. To achieve it, he must be able to make the process work for him. He must deliver the goods. The creation of an organized program for agricultural pest control has an immediate and visible impact on the constituency of a Member of the Congress. His attitude toward a going program may vary according to whether his clients have recently been sprayed like Gypsy Moths, or whether they have been eaten out of their incomes by grasshoppers or pink bollworms.

The influence of the government officials who devote their professional careers to pest control is substantial. They are respected by the politician, viewed as shining white knights by the producers, loved by the suppliers, kicked by the taxpayers, ignored by the consumers and hated by the nature groups. But, regardless of the reactions to their performance, they are the source of expertise in an increasingly sophisticated technology. When research has provided a better way to do the job (or a means of doing it at all), they are not shy salesmen.

One hypothesis is to assume that the bureaucrats who administer this set of programs behave as though they were the managers of a private firm. In the conduct of program operations, there is a similarity to the business entrepreneur. The business manager gives weight to the interests of stockholders and Boards of Directors and thereby seeks to perpetuate his entrepreneurship. The bureaucrat seeks favor in the eyes of the political power structure to perpetuate his position. Just as with many businessmen who work to place their product in every home, so the bureaucrat seeks to eradicate a pest knowing that he will achieve personal prestige when it is accomplished. Thus, the bureaucrat attempts to allocate his stock of program resources according to his estimate of equal marginal political utilities.

THE ROLE OF PARTICIPANTS

At all stages of the budgetary process the performers have an insatiable appetite for information. Timely, relevant "intelligence" is the key to power in the decision-making process, since those who possess it gain advantage over those who do not.

There are a large number of interest groups who maintain representatives or "lobbyists" in Washington. The more alert members of this community have learned the value of information and the technique for acquiring and dispensing it as a marketable commodity. They become participants at one or more stages in the budgetary process. The most sophisticated technique used by these lobbyists is to establish contact with one or more influential individuals in each of the performing groups. In this way the lobbyist can assure that his point of view influences the process at every stage.

Why would a performer allow the intrusion of an informal participant? More often than not because the participant has information to supply which can enhance the role of the individual performer among his peers.

The activities of the lobbyists have many values. They provide communication among the hierarchical layers in the bureaucracy, keeping the total situation "loose" and preventing the hardening of bureaucratic arteries. They often serve as an informal link between the Executive and Legislative Branches under circumstances where direct communication is not allowable under the "rules" of the process.

In short, these are often valuable citizens, and it is a wonder how few interest groups seem to understand the possibilities for effective action that is offered by such informal roles.

In agricultural pest control, the groups whose influence is felt as participants in the budgetary process are discussed in the paragraphs that follow.

Producers - The individual farmer is a biological businessman engaged in running an enterprise as a means of earning a living. His decisions on pest control may involve use of the marginal analysis calculation outlined in Chapter 4. Under some circumstances, he cannot handle the pest alone, it is a legal obligation of the Federal Government to do so, or he may prefer group action. But regardless of the form of action he chooses, his objective is to lower his cost of production and/or to increase his income. He may endorse group action even though he knows he will not improve his income relative to that of others in the same group. He may do this in order to forestall disaster, to provide greater predictability and stability to his enterprise and his commodity, or he may do so with varying degrees of ignorance of the consequences.

Producer groups - Farmers producing the same or closely allied commodities often organize as a group. Among their objectives are disaster protection and greater yield predictability. In addition, there is a disadvantage if the demand for the produce is relatively inelastic with respect to price. The increased supply that is likely to be generated by the lowering

of production costs for the entire group may cause the price to fall and adversely effect the income of every individual who produces the commodity, unless the fall in price for a particular farmer is more than offset by his increased product.

The effectiveness of the producer group will depend upon social, political, and economic factors. What is the degree of organization and how acceptable is collective action? What is the political strength of the group? Is it a major political faction? How much economic power does it have to use in bargaining for what it seeks?

Suppliers - There are many companies or groups of companies engaged in selling inputs to producers, e.g., pesticide formulaters and manufacturers, manufacturers of spray equipment, etc. These suppliers have a keen interest in the expansion of organized pest control since it will tend to increase the sale of their products. Technological break-throughs which permit eradication may be inimical to their interests by terminating major markets.

Consumers - The very actions which injure the producers by increasing supply and lowering price are of benefit to consumers. Organized pest control programs which result in increased stability of supply and improved product quality are also of benefit. Note that if consumers are to be benefited at the expense of producers, it may make good sense to finance pest control programs through the public sector. A major beneficiary of pest control programs has been the consumer.

Taxpayer - The taxpayer seeks to have his taxes kept to a minimum and opposes public programs that take away his individual choice of expenditures and substitute a group choice. He seeks to have governmental expenditures reduced except on those programs where he can see a direct benefit.

Nature Groups - The more rational members of this group seek to have pest control programs carried out with a minimum of disturbance to the natural environment, particularly certain selected components to which they attach a high value, e.g., wildlife, fish, certain bird species, etc. There is a lunatic fringe which seeks the banning of all chemicals used in agriculture as "unnatural." The nature group is just as specialized in its way as is the producer group and there are many commercial interests in this group whose livelihood depends upon the continued existence of a particular species of fish or wildlife.

Outdoor recreation interests - Hunters and fisherman are particularly well organized to protect their interests. In the prairies, the interests of the wheat farmers are often directly opposite to the efforts to maintain food and cover for the migratory waterfowl that are so important to hunters.

Commercial fishing industry - Estuarine environments are of great importance to certain segments of the fishing industry as production areas. They are also very sensitive to contamination by pesticide residues. This has led the industry to concern itself with the impact of pest control programs.

Water pollution control organizations - These people seek to establish certain standards of water quality. They are particularly interested in tracing the translocation of pesticides in order to prevent the contamination of water by pesticide residues.

TOTAL PROGRAM CHANGES

Before we give attention to the division of funds among pest control programs, we shall examine the roles of the performers in determining the total funds available for pest control activities. This total is set by the formulation and enactment stages. Shifts in the total may occur during budget execution, but they are minor.

How does the total amount of pest control funds change during the process? Illustrative data were obtained for the thirteen most recent years, showing the dollar amounts made available at each stage. These data are shown in Table 11. The funds made available by the prior year act were taken as the starting point or base. The ARS initial request is expressed as a percentage above that prior year base. Then the amount made available at each stage is expressed as a percentage above the base. The result is a series of figures for each year showing the percentage change from the prior year amount at each stage of the process.

For example, in fiscal year 1, the ARS request is 4.4 percent above the prior year, the Department request is 16 percent below the prior year, etc., until the appropriations act provided for a decrease from the prior year amounts of 1.3 percent.

TABLE 11

PER CENT OF CHANGE IN AVAILABLE PEST CONTROL FUNDS

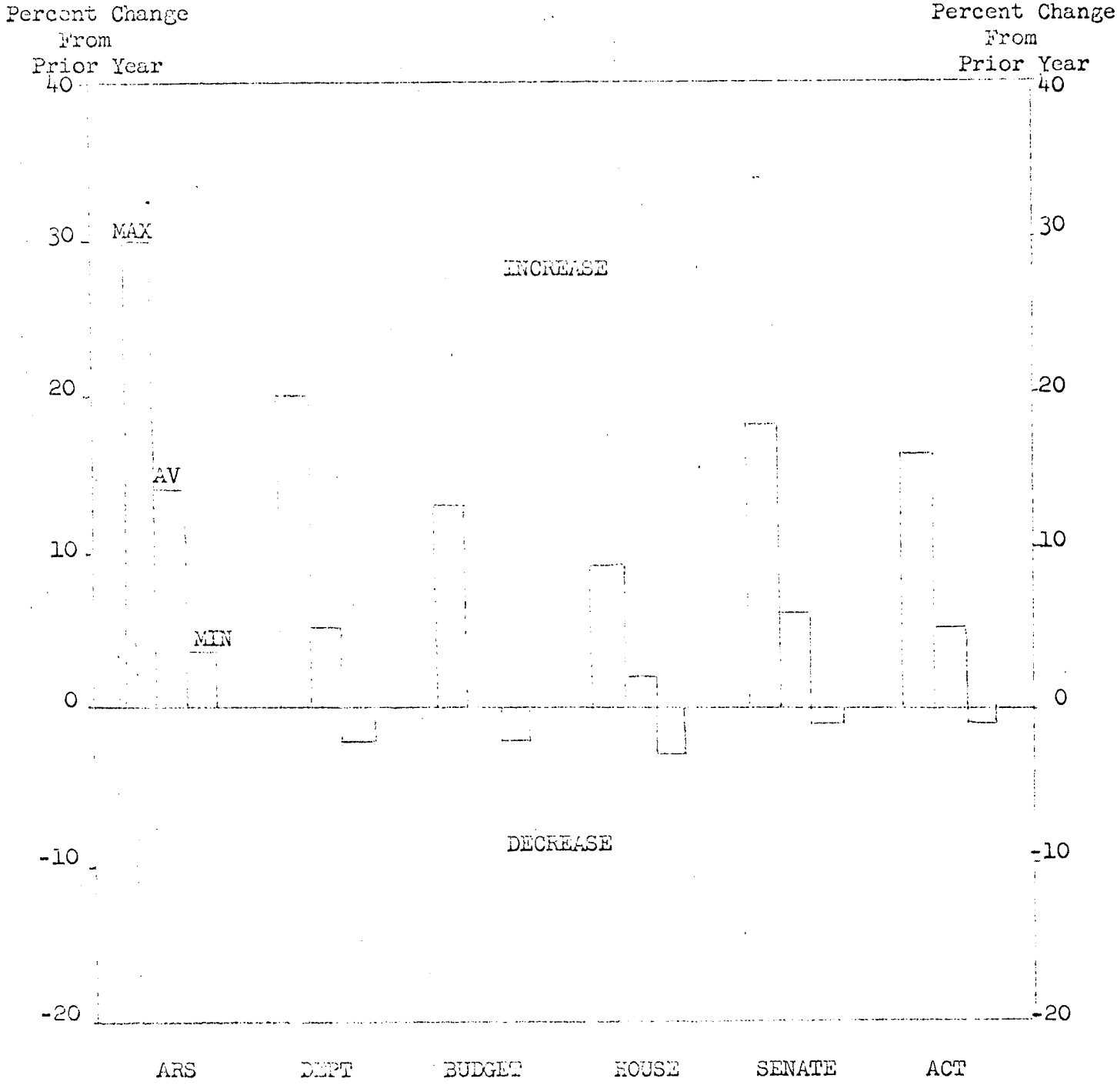
FROM THE PRIOR YEAR BASE BY

BUDGETARY STAGES FOR A 13-YEAR PERIOD

Fiscal Year	Formulation			Enactment		
	ARS	Dept.	Budget	House	Senate	Act
1	4.4	-16.0	-16.3	-2.6	-0.6	-1.3
2	22.9	15.5	12.7	8.8	18.5	16.5
3	35.5	33.9	33.6	10.1	41.9	39.4
4	5.5	-11.8	-10.0	-13.7	4.5	1.1
5	23.0	29.0	58.2	52.7	75.0	76.1
6	6.8	-6.7	-7.4	8.9	-3.8	-6.2
7	7.2	-2.0	-2.1	4.4	4.9	4.9
8	13.0	7.9	8.2	6.8	8.5	7.7
9	11.2	17.6	6.2	1.7	6.6	4.7
10	19.4	10.0	4.7	0	8.1	3.7
11	29.7	20.4	8.2	1.4	7.3	7.0
12	19.1	17.3	2.2	1.0	6.6	5.5
13	13.3	2.1	-8.1	1.7	8.0	6.4

FIGURE 13

MAXIMUM, AVERAGE, AND MINIMUM CHANGES IN TOTAL FUNDS AVAILABLE FOR PEST CONTROL AS PROPOSED IN BUDGETARY STAGES 13-YEAR PERIOD



The first step in summarizing these data was to eliminate year 3 and year 5 as atypical. They represent a range of experience which is of a different order of magnitude than other years. Then the data have been analyzed in a variety of ways to provide answers to a number of significant questions. Figure 13 summarizes the maximum, average and minimum changes in total funds at each stage.

1. What is the "usual" change from the prior year adopted by the performers at each stage of the process? As shown in the table below, the ARS request averages 14 percent above the prior year and the Department request averages 5 percent. Typically, the increment has disappeared entirely during the formulation of the President's budget. The House advocates a 2 percent increase, the Senate a 6 percent increase, and the final outcome is equivalent to the Department's initial request to the Budget Bureau of 5 percent.

	ARS	Dept.	Budget	House	Senate	Act
	(Percentage change from the prior year)					
Usual change.....	+14	+5	0	+2	+6	+5

2. How much variation is there in their "usual" behavior? As shown in the table below, the ARS request for increases ranged from 30 percent to 4 percent during the period studied, the Department requests ranged from 20 percent to 2 percent, etc. The ARS requests for increases form the limits to the range, since the other performers do not usually initiate

programs. In fact, with the exception of the Senate, which acts as a counterweight to the conservatism of the House, the range in requested increases diminishes at each step.

	ARS	Dept.	Budget	House	Senate	Act
	(Percentage change from the prior year)					
Largest increase....	+30	+20	+13	+9	+18	+16
Smallest increase...	+4	+2	+2	+1	+5	+1

3. How often are decreases proposed by the performer? As shown in the table below, ARS never requested a decrease in overall funds from the prior year. However, each of the other performers have requested decreases. The Department requests a decrease in the programs in more than 1/3 of the years, and the President's budget has requested a decrease almost one-half the time. The two bodies of the Congress have advocated decreases during two of the eleven years (18 percent of the time).

	ARS	Dept.	Budget	House	Senate	Act
	(Percentage of time)					
Frequency of decreases.....	0	36	45	18	18	18

4. What is the size and range of decreases proposed? As shown in the table below, proposed decreases have ranged in size from 1 percent to 16 percent. The Department and the Budget Bureau tied for first prize as axemen (16 percent), followed closely by the House whose deepest cut was 14 percent. The powerful role of the Senate as a counter force in the process is revealed again in these data. The Senate's greatest cut

was 4 percent, substantially less than the others, and its least cut was 1 percent, also smaller than that of the other performers.

	ARS	Dept.	Budget	House	Senate	Act
	(Percentage change from the prior year)					
Largest decrease.....	--	-16	-16	-14	-4	-6
Smallest decrease....	--	-2	-2	-3	-1	-1

5. How does each performer usually alter the decision of his predecessor? As shown in the table below, the Department usually cuts the ARS request by 9 percent. In turn the Budget Bureau cuts the Department's request by 5 percent, thus completing the elimination of the average ARS requested increase of 14 percent. At this stage in the process, there is no increase above the prior year. Usually the House raises the Budget by 2 percent, Senate comes in 4 percent above the House, and the appropriation act comes out 1 percent below the Senate proposal.

	ARS	Dept.	Budget	House	Senate	Act
Change from past performer.....	--	-9	-5	+2	+4	-1

Based on this analysis, the role of each of the performers is characterized in the following paragraphs.

ARS usually requests about 14 percent more funds than it had in the prior year and may ask for as much as a 30 percent increase or as little as a 4 percent increase. It has never asked for a decrease in funds. ARS can expect to receive, on the average, about 36 percent of its initial request, about a 5 percent increase over the prior year.

The Department usually requests about a 5 percent increase above the prior year, cutting the ARS request by 9 percent. More than 1/3 of the time the Department requests a decrease from the prior year, under the prodding of the President and the Budget Bureau to hold down on its overall annual request. The largest increase requested was 20 percent and the largest cut suggested was 16 percent below the prior year.

The Budget Bureau performs its role by eliminating the remaining 5 percent increase requested by the Department and the budget usually contains no increase. To state it differently, the budget contains a decrease about one-half the time, which has been equivalent in percentage of the increases that were requested on the remaining one-half of the occasions.

The House usually increases the budget by 2 percent, but its conservative role is reflected in the fact that a 9 percent increase is as high as it is willing to go. The House recommends net decreases about 18 percent of the time, and when it cuts, will go almost as deeply (-14 percent) as the Budget Bureau and the Department (-16 percent).

The Senate determines the outcome. Its usual increase of 6 percent is very close to the final outcome of a 5 percent increase in the act. It is liberal minded, since its maximum increase of 18 percent is twice that of the House and although it is also willing to cut back 18 percent of the time, its largest decrease is only -4 percent. It raises the House decision by 4 percent, twice the increment the House places on the budget.

The action of the performers is not independent of one another. Not only does the Bureau's original request for an increase contain elements of strategy, but so do the actions of each of the others. In spite of the variations, there is a characteristic institutional behavior with considerable stability. This is in agreement with the conclusion by Davis et al[50] that the behavior of the process conforms to rules that are linear and temporally stable. It is my opinion, however, that the degree of simplicity and the extent of stability depend upon the level of aggregation chosen for analysis. During the actual process, one is impressed by the complexity and the variation in the interaction among performers.

There is sufficient predictability to enable the participants to design strategies for dealing with one another. ARS starts high recognizing that it will be trimmed by both the Department and the Bureau of the Budget. The Department cuts back a bit and its net increase estimates the final outcome very closely. The Bureau of the Budget cuts back the Department in an effort to reduce expenditures, but recognizes that the Congress will probably restore the cut. The House takes a characteristically

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[50]Otto A. Davis, M.A.H. Dempster, and Aaron Wildavsky. A Theory of the Budgeting Process. American Political Science Review. Vol. LX No. 3, September 1966, 529-547.

conservative view, while the Senate is more liberal. Each is conscious of the balancing effect of the other body.[51]

Note that the focus of this analysis is on the extent of the increase. Actions to trim the budget below the prior year are uncharacteristic. No one really tampers with the Bureau's base funds. Adjustments are made as additions at the margin, producing a strong upward bias over time. During the period of this sample, these programs increased by more than $55 million, a total of 309 percent.

Although the behavior of each of the performers has a degree of predictability, events bearing on the program make a difference. What a bureau or agency says about those events certainly influences the outcome.

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[51]The relationship between the House and the Senate has, on occasion, dissolved into conflict. A thoughtful study of the nature and causes of the conflicts between the two bodies during the process of considering appropriations has been made by Pressman. Jeffrey L. Pressman. House vs. Senate; Conflict in the Appropriation Process. New Haven and London, Yale University Press, 1966.

CHANGES IN THE PROGRAM MIX

New programs or entries to the mix arise because a new foreign pest arrives, an earlier arrival gets out of control, or a new technology provides an opportunity to achieve greater control or even eradication. The request to take action is expressed very quickly through the political system. Not only are the bureau officials appraised of the situation, but so are the members of the Congress.

An economic calculus of costs and benefits usually occurs after the fact. Typically, some analysis is produced as justification to support a request for additional funds. The bureau official has little need for economic justification, for he can usually predict the outcome of congressional action with a high degree of confidence. He is more likely to be a political entomologist than an economic entomologist. He is likely to be pressed for economic justifications during the budgetary process only by the Bureau of the Budget.

A principal deterrent to any analysis is the shortage of time. Budgeting is a "busy" process with tight deadlines which tend to preclude a detailed analysis. Time is employed by the participants as a strategic element. It is the leverage used by one participant in the process against another. By limiting a decision-makers time you can prevent him from critically examining the point at issue.

The actions which begin or terminate a program may originate at any stage of the process. Yet the bureau, as the responsible administering organization, is heavily involved even when it appears to play a relatively passive role.

CHAPTER 7. CONCLUSION

As a result of the foregoing discussion and analysis, it is concluded that the allocation of Federal funds among plant pest control programs could be improved in a number of ways.

First, a review of the available information on losses shows that the data is inadequate to serve the needs of objective decision-making. Second, it has been demonstrated that there are possibilities in the use of concepts and models developed in economics which warrant further exploration. Third, a study of the present allocations and the process of their derivation indicates the need to strengthen the role of economic and scientific considerations.

The information on losses, reputed to be the best available for any nation in the world, suffers from a lack of conceptual understanding. The attempts to refine the existing data through more systematic collection or through establishing the variability of the estimates are missing the heart of the matter. As pointed out in Chapter 4, it is the concept of protection that should be the focus of attention. That is, the difference between potential loss and the actual loss due to pests and diseases. Estimates of actual loss are attempts to measure the physical amount by which production falls short of ultimate perfection. This amount may be of academic interest to the physical scientist, but it is irrelevant to decision-makers. We need a schedule of data which provides the amount of the potential loss which has been saved by control actions.

It was hypothesized that a protection supply function could be established as a useful guide to decision-makers in determining how much should be spent to control a particular pest. In spite of their obvious inadequacies, existing data for the grasshopper program are used to demonstrate the usefulness of such a model. This is a deliberate strategy to explore the need for the collection of more adequate data. If similar data were available for other programs, it would be possible, using marginal analysis, to develop an optimum trade-off between these programs in an economic sense. Such data, to be derived from field and laboratory experiments, are needed before further progress can be made in dealing with the question of economic optimization.

The span of time required for the budgetary process and the significant program changes which occur may have an adverse affect on administration efficiency. In addition, the need to couple program operation to the biological realities of pest development and control leads to a difficult and sometimes unmanageable situation.

The apparent bias toward certain States in the distribution of pest control funds may indicate that too little objective information is available on the economic consequences of a wide variety of pests. If the data suggested above were available and were analyzed, such information could provide an objective basis for deciding where to allocate Federal dollars for the greatest

return. So long as such information is not available, the budgetary process makes the decision in the manner described in Chapter 6. If ARS has sound scientific, technical, and economic reasons for its annual request of a 14 percent increase in funds, and I believe that it does, then the annual loss of two thirds of that request, during the budgetary process suggests that these reasons are not well supported. This is particularly true, since within the Executive Branch, no increase is awarded, and it is only through the largesse of the Senate that any increase is received. It would not be very costly for ARS to establish a data and analysis system for the objective evaluation of all plant and pest control needs. Such a system could result in an improved allocation of the limited Federal funds available for plant pest control in the United States.

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