NATURAL RESOURCES JOURNAL

Volume 27
Issue 3 *Summer 1987*

Summer 1987

Why Pesticides Received Extensive Use in America: A Political Economy of Agricultural Pest Management of 1970

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ABSTRACT

The network of factors facilitating the use of chemical pesticides in American agriculture are too numerous and interconnected to detail here. Broadly, they include: the structure of farm production and its husbandry by the State; the nature of chemical production, pesticide usefulness and their biological consequences; the implications of food processing, centralized marketing and consumer preferences; the obstacles to nonchemical pest management alternatives and to their publicly-funded research; the hurdles to restricting chemicals already in use; and the lopsided representation of interest groups and consequent institutional bias in pesticide policymaking. While acknowledging the existence of conspiratorial behaviors, this analysis of the wider range of contributing causes suggests that even if elements of conspiracy had been entirely absent, the outcomes of pesticide policy making would not have been greatly modified. For one whose normative sympathies are akin to those espoused by some conspiracy theorists, the interpretation of history offered here and prescriptions for change are vastly different because they are tempered by a more complex, yet still simplified, synthesis of events and causation.[†]

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**For helpful suggestions with early drafts I wish to thank the Natural Resource Journal editors, staff and anonymous reviewers, Jim Cramer, Bruce Dixon, Tom Dunlap, Mary Louise Flint, Ted Foin, Don Hadwiger, Dick Howitt, Fred Li, John Perkins, David Pimentel, Pete Rowland, Bob Rudd, Si Schwartz, Kevin Shea, Katie Striemer, Phyllis Tichinin and Jim Wilen.

†Inquiring into policy problems can never be free from the influence of values. Hence biases are best made explicit from the outset: It is the author's view that pesticide residues in food are ubiquitous, invisible to the public, and pose uncertain but potentially serious threats to health that are typically subject neither to 'proof', nor to disproof. Since these risks are imposed involuntarily without informed consent they violate the widely-held norms of consumer choice and individual liberty. Having sanctioned the use of chemicals, the federal government has a moral obligation to apply caution in the assessment of what will always be imperfect information, and imbalanced access to that information. Often as not the data needed to inform choices were not available to government, let alone to citizens. Health should not be lightly subverted for reasons that have little to do with the quality, quantity, and essential variety of food needed by humans.

INTRODUCTION

This paper explores the question of why chemicals became the most widely used pest-suppression technique in American agriculture. It analyzes the major factors and historical trends that favored pesticide[1] use during the period after their first appearance until 1970, but focuses mainly on the decades since World War II [WWII]. The complex history of the American pesticide scene is not easily portrayed, nor is this intended as a comprehensive account. Indeed much empirical detail remains unpublished. Where detail is available I often summarize, to suggest larger patterns and implications. But there is certainly information enough to suggest this synthesis of a political economy in pesticide use.[2]

The answer to our question of how we came to rely so heavily on chemical techniques of pest suppression is considerably more complicated than it appears at first glance. Analysis of this complex situation illuminates the forces that shaped government policy on pesticides for more

1. "Pesticide" is the generic term referring to most of the lethal chemical techniques employed by humans to limit/prevent pest damage to food products during growth and storage, and to fiber, health and habitation. By definition, "pests" are organisms that we declare or perceive as detrimental to our enterprise, or potentially so. Pests include insects, weeds, fungi, nematodes and rodents. The corresponding categories of pesticides are: insecticides, herbicides, fungicides, nematicides, and rodenticides. Use trends between these categories of pesticide differ over time and space. The most extensively applied pesticides in U.S. agriculture are insecticides and herbicides, with the use of herbicides greater since the 1960s.

This article focuses on agricultural pesticide use in general, even though the examples provided, and thus the apparent focus, is often on insecticides. In two instances this emphasis is justified by the facts: first, the first-generation pesticides (1850-1940) were almost exclusively insecticides. It was not until second-generation pesticides appeared that chemical control of competitive weeds, fungal disease and root worms became possible. Second, although most pesticides have some adverse effects on environment and health, technical failures such as pest creation and pest resistance to chemicals have been most conspicuous with insecticides. *See infra* notes 77-86. Genetic resistance in weeds is a comparatively infrequent failure of herbicides. *See generally*, HERBICIDE RESISTANCE IN PLANTS (H. LeBaron & J. Gressel eds. 1982). At the very least, insects are more genetically-adaptable then weeds because plants have both much longer generation times and overlapping generations due to extended seed dormancy.

Excepting these preceding situations, the emphasis on insecticides is not complete or intentional. In some instances, it reflects my ignorance of suitable herbicide or fungicide examples. Yet I am reluctant to confine the scope of this analysis to insecticides alone, because most of the factors examined apply in varying degrees to pesticides generally, and hopefully any significant over-reaching on my part will prompt useful rejections, clarifications or extensions of the framework put forward.

2. *See, e.g.*, Blodgett, *Pesticides: Regulation of an Evolving Technology*, in 2 CONSUMER HEALTH AND PRODUCT HAZARDS (S. Epstein & R. Grundy eds. 1974); Conway, *Policy Models*, in PEST AND PATHOGEN CONTROL 397 (G. Conway ed. 1984); T. DUNLAP, DDT: SCIENTISTS, CITIZENS, AND PUBLIC POLICY (1981); J. PERKINS, INSECTS, EXPERTS, AND THE INSECTICIDE CRISIS (1982); A. Whitaker, A History of Federal Pesticide Regulation in the United States to 1947, unpublished doctoral dissertation, Emory University (1974); J. WHORTON, BEFORE SILENT SPRING (1974). For more sweeping histories, see, V. DETHIER, MAN'S PLAGUE? INSECTS AND AGRICULTURE (1976); G. ORDISH, THE CONSTANT PEST (1976). Some aspects of the pesticide equation are difficult to authenticate. *E.g.*, the behaviors of individual farmers, chemical corporations and commercial food processors have not been examined thoroughly. Where sound empirical data are lacking, scholars have often theorized. This paper identifies such areas of hypothesis, uncertainty and contention.

than a century. The traditional orientation of the pesticide subgovernment toward its agricultural clients is revealed, as are the obstacles impeding those intent upon reducing our reliance on pesticide technology. The early 1970s provides a logical end point for this analysis because important changes began appearing at that time, and those episodes have been examined elsewhere.[3]

An historical perspective also offers a counterpoint to the tendency among those personally involved in pesticide affairs to explain their disappointments and vent their anger by seeking scapegoats. In particular, the critics of pesticide technology often imply or assert that there is a deliberate conspiracy, that the research scientists have been 'brought off', or government regulators corrupted, by the chemical industry.[4] Certainly pesticide manufacturers, farmers, agricultural scientists, and legislators tend to be self-interested, and they often find reasons to cooperate when pursuing their individual goals. However we shall see that they do this for many reasons other than greed. Rhetoric about subgovernment conspiracy may have been useful for swelling reformer ranks and galvanizing action but such single-factor explanations are often too simple; they identify only a fraction of the biological, economic, and political forces that encouraged pesticide uses over time. Cynicism about conspiracy rarely explains complex situations adequately. More important, by failing to consider persistent, non-conspiratorial causes, cynicism can promote reforms destined to be disappointing (while ignoring more promising avenues for reform). Still more significant than having reforms miss their mark, is the possibility that merely tinkering with interactive systems can produce unanticipated or adverse results the opposite of what was intended. The history of American government is replete with examples of such counter-intuitive phenomena; efforts at reforming pesticide policy are no exception.[5]

THE EXTENT OF PESTICIDE USE

A brief demonstration that we do use pesticides extensively is warranted before analyzing the reasons for this United States dependency upon synthetic chemicals to suppress destructive pests. Production and sales of pesticides grew steadily through the 1970s to a level exceeding half a

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3. *See infra* notes 127, 128.

4. *See, e.g.*, R. CARSON, SILENT SPRING 258-59 (1962); P. BOFFEY, THE BRAIN BANK OF AMERICA, at chp. 9 (1975); Rodgers, *The Persistent Problem of the Persistent Pesticides*, 70 COLUM. L. REV. 567 (1970); VAN DEN BOSCH, THE PESTICIDE CONSPIRACY (1978); H. WELLFORD, SOWING THE WIND (1971). Such attitudes have their counterpart among the pesticide manufacturers, see *e.g.*, DUNLAP *supra* note 2, at 228-39; also *infra* note 117.

5. This article highlights a number of examples. *See infra* note 40; text at note 59; text accompanying note 94; text preceding note 127.

billion pounds per annum. The economic value of these sales expanded even more rapidly (due to increased oil prices), with average yearly increases of twenty percent between 1972 and 1977. Domestic pesticide sales now exceed one billion dollars annually.[6] Further growth is anticipated. The chemical industry foresees annual increments to world-wide pesticide sales of more than thirteen percent in the next few years.[7]

Distribution of pesticides within the domestic market for 1974 was estimated in the following proportions: fifteen percent was being used for home and garden purposes; thirty percent was purchased by industrial, institutional, and government users; and fifty-five percent was put to agricultural uses.[8] Pesticide use is unevenly distributed in American farming. For instance, forty-seven percent of all agricultural insecticide use in the early 1970s occurred on cotton, a predominantly non-food crop (although chemical residues do appear in the cotton seed oil that is widely used in prepared foods). Excluding pasture from U.S. cropland, thirty-four percent of the total acreage in crops was treated with herbicides, twelve percent with insecticides, and two percent with fungicides. While grains, vegetables, and fruit accounted for relatively small fractions of the total volume of agricultural pesticide use, very large proportions of the area devoted to these high-value food crops did receive chemical treatments (spraying fifty percent of acreage is typical while seventy-five percent is not exceptional).[9]

Although estimates of productivity gains attributable to pesticide use vary, it is likely that U.S. farmers spend more than $2.2 billion a year applying chemical pest controls. This investment increases the value of their crop output by approximately nine percent, for an average return on their pest control dollar of around four dollars, or 400 percent.[10] In these absolute terms, the financial stakes in pest control are considerable.

6. For all these figures, see PERKINS, *supra* note 2, at 47-48, (citing U.S. INT'L TRADE COMMISSION, USITC REP. NO. 1099 (1980), SYNTHETIC ORGANIC CHEMICALS: U.S. PRODUCTION AND SALES (1979); and U.S. DEPT. OF AGRICULTURE, THE PESTICIDE REVIEW (1966-1978).

7. *A Look at a World Pesticide Markets*, FARM CHEMICALS, at 61 (Sept. 1979).

8. U.S. DEPARTMENT OF AGRICULTURE, THE PESTICIDE REVIEW (1975).

9. *See*, USDA ECONOMIC RESEARCH SERVICE, AGRIC. ECON. REPORT NO. 268, FARMERS USE OF PESTICIDES IN 1971 (1975); Pimentel, Krummel, Gallaham, Hough, Merrill, Schreiner, Vittum, Koziol, Back, Yen & Fiance. *Benefits and Costs of Pesticide Use in U.S. Food Production*, 28 BIOSCIENCE 772, 778 (1978) [hereinafter Pimentel].

10. These estimates are developed by Pimentel, *supra* note 9, at 781. Estimating crop losses from insect damage and benefits attributable to pesticides is difficult. For a discussion of these questions, see Pimentel, *supra* note 9; Conway, *Man Versus Pests*, in THEORETICAL ECOLOGY, (R. May ed. 1976); J. HEADLEY & A. LEWIS, THE PESTICIDE PROBLEM: AN ECONOMIC APPROACH TO PUBLIC POLICY (1967); Heuth & Regev, *Optimal Agricultural Pest Management with Increasing Pest Resistance*, 56 AM. J. AGRIC. ECON. 543 (1974); Norgaard, *The Economics of Improving Pesticide Use*, 21 ANN. REV. ENTOMOL. 45 (1976); Davidson & Norgaard, Economic Aspects of Pest Control, paper delivered at the Annual Meetings of the European and Mediterranean Plant Protection Organization, Brussels, (May 15, 1973); Hall & Norgaard, *On the Timing and Application of Pesticides*, 55 AM. J. AGRIC. ECON. 198 (1973); PERKINS, *supra* note 2, at 196-99, 266-67; Talpaz & Borosch, *Strategy for Pesticide Use*, 56 AM. J. AGRIC. ECON. 769 (1974).

However, our commitment to chemical techniques is not so compelling when examined in aggregate terms. If all pesticide use in American agriculture were to cease, the evidence suggests that the additional nine percent in crop losses would bring only temporary price increases but no food shortages.[11] Furthermore, adjustments in the market could quickly normalize food prices as increased plantings, dietary shifts and other factors offset the initial twelve percent rise in retail prices estimated to accompany such an unlikely cessation of use.[12] Pesticide use appears even less justified when these equivocal benefits are compared with the hidden costs and the available alternatives. Where the risks inherent to chemical contamination are palpable, and safer alternatives are economically viable, dependence on pesticides seems excessive and irrational in the minds of critics. While determinations of safety and economic viability are matters of judgment over which reasonable people routinely disagree, it is clear that by 1970 the combined influence of several factors had contributed to the extensive and rapidly expanding use of pesticides in food production.

FACTORS CONTRIBUTING TO PESTICIDE USE

Six aspects of the pest management situation that facilitate the use of pesticides can be identified. These include: the structure of agricultural production and the role of the state; the nature of pesticide production; use and biological consequences; the implications of food processing, marketing and consumption; the obstacles to nonchemical alternatives and to public research; the hurdles to restricting chemicals already in use; and the lopsided politics and institutional bias associated with pesticide policymaking. These six aspects are further disentangled in twelve factors, see Table 1. Some of the factors in Table 1 illustrates the strength of forces that encourage pesticide use and prevent their discontinuation, while others demonstrate the weakness of otherwise restraining influences.

AGRICULTURAL PRODUCTION AND THE ROLE OF THE STATE

The Economic Structure of Agriculture

Farm production in America has long been a keenly competitive cash-cropping enterprise in which individuals take large financial risks and sometimes fail to make adequate returns on their investment. This single

11. Pimentel, *supra* note 9, at 779-80. Historically it is clear pesticides were not introduced to boost aggregate food production and therefore alleviate human hunger. Second-generation insecticides were adopted at a time when American farmers were threatened with yet another ruinous series of crop *surpluses* as WWII ended. Perkins, *Insects, Food, and Hunger: The Paradox of Plenty for U.S. Entomology*, 1920-1970, 7 ENVTL. REV. 71-96 (Spring 1983).

12. Pimental, *supra* note 9, at 780-81.

TABLE 1
WHY PESTICIDES RECEIVED EXTENSIVE USE IN AMERICAN AGRICULTURE

FACTORS CONTRIBUTING TO PESTICIDE USE	HISTORICAL ORIGINS AND CONTINUING CAUSES
I. AGRICULTURAL PRODUCTION AND THE ROLE OF THE STATE	
a. Competitive commercial agriculture: many smaller risk-averse, profit-seeking firms producing for export to urban markets.	Urbanization, private ownership, mechanization, farm-to-city transportation, cheap fossil-fuel energy, inelastic demand for food, and the technological treadmill.
b. Government services for agriculture: research and active diffusion of improved techniques as well as marketing orders, price supports, favorable credit, tax and labor laws.	Production problems, climatic variation, insect pests, wartime demands, competition between both individual farmers and rural jurisdictions, overproduction and instability of farm incomes.
II. PESTICIDE PRODUCTION, USE AND CONSEQUENCES	
a. A dynamic pesticide industry: emphasis on continual research to discover new broad-spectrum pesticides.	War-time insect control needs, patent law, emergence of a petroleum-based chemicals industry, genetic resistance, high research and development costs including government regulations.
b. The nature of pesticide technology: immediate utility with hidden costs.	Broad-spectrum activity, inexpensive, competitive marketing, susceptible regional monocultures; novel chemical/biological behavior, oil-soluble residues, externality of costs.
c. The biological treadmill: increasing dependence on pesticides and eventual failures.	Abandonment of cultural practices, broad-spectrum activity, greater adaptability (migratory, reproductive and genetic) of pest species, and overexploitation of pest susceptibility (a common pool resource).
III. FOOD PROCESSING, MARKETING AND CONSUMPTION	
a. Consumer "preferences" for cosmetic perfection in food.	Overproduction, inelastic demand for food, fixed costs of transport/processing, competitive food marketing, commercial advertising, fastidious urban consumers, invisibility of pesticide residues, and government limits on insect-debris and defects.
IV. OBSTACLES TO THE ALTERNATIVES AND TO PUBLIC RESEARCH	
a. Barriers to the discovery and adoption of the alternatives to chemical pesticides.	WWII disrupted government research, chemicals preempted interest, patent law, research costs, narrow markets; cosmetic standards, contingent financing, risk-averse farmers, complexity.

FACTORS CONTRIBUTING TO PESTICIDE USE	HISTORICAL ORIGINS AND CONTINUING CAUSES
V. HURDLES TO RESTRICTING CHEMICALS ALREADY IN USE	
a. Irresolvable technical uncertainty: many costs, such as the cancer risk for humans, cannot be unequivocally proven by science.	Limitations of scientific method, inadequate control groups, long latency periods, moral aversion to human experiments, cost of laboratory tests, and imperfection of the animal-to-man analogy.
b. The law of nuisance: party challenging an economic activity must bear the burden of proof and sustain a balancing of inconveniences.	Traditional legal policies for encouraging economic development and employment, judicial conservatism and restraint.
c. Obstacles to gathering environmental intelligence on the risks of pesticide use.	Detection problems, irresolvable technical uncertainty, insufficient research support, costs slow to materialize, war research priority, academic career patterns and peer pressure, industry funding, and subgovernment hostility.
VI. LOPSIDED POLITICS AND INSTITUTIONAL BIAS	
a. Closed pesticide subgovernment: making favorable policy and blocking inimical reforms.	Constitutional structure, fragmentation of legislative power, veto advantages in Congress, disproportionate rural representation, broad delegations and administrative secrecy, irresolvable technical doubt, judicial and presidential reluctance to intrude (poorly mobilized citizen concerns).
b. Poorly mobilized citizen concerns about pesticide use and residues.	Competing concerns, invisibility of residues, technical uncertainty over risks, little media coverage, the free-rider problem and the costs of organizing for sustained political/legal activity.

feature, more than any other, has predisposed farmers to adopt technological innovations that reduce production costs and insure their investments against the vicissitudes of nature. While the precise details vary across time periods, regions, crops, and even particular pesticides, it is useful to construct a broad scenario of U.S. agricultural development for the first half of the twentieth century.[13] Historically, land ownership patterns with many small tenant farmers facilitated competition among growers. With increasing urbanization, economic prosperity, population growth and the development of farm-to-city transportation, American farmers experienced a rising demand for their produce. But that transformation from small local, to distant urban markets also undermined farmers'

13. *See generally*, Hadwiger, *Agricultural Policy*, in ENCYCLOPEDIA OF POLICY STUDIES (S. Nagel ed. 1983), W. COCHRANE, THE DEVELOPMENT OF AMERICAN AGRICULTURE: A HISTORICAL ANALYSIS (1979); WHORTON, *supra* note 2, at 3-35. For a brief case study of the U.S. Apple Industry see PERKINS, *supra* note 2, at 15-22.

economic bargaining power.[14] As commercial markets emerged and as mechanization and plant breeding revolutionized agriculture, growers tended to specialize in one main crop. Others emulated these early financial successes. The results were a regional shift toward monocultures which had the unintended consequences of making individual farms more vulnerable to pest outbreaks.[15]

While pests existed throughout history and periodically caused localized famines,[16] their economic significance grew by the turn of the century. This was due to the widespread adoption of monoculture, the associated decline in crop rotation practices, and the development of higher-yielding but more pest-susceptible crop varieties.[17] Also, several particularly destructive foreign pests were introduced accidentally as world commerce spread.[18] Not only did farm crops become more prone to pest outbreaks, markets became less tolerant of damaged produce. The expansion into

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14. The magnitude of United States' over-investment in agriculture, resulting from massive government land give-aways between 1868 and 1920, became apparent only after farmers shifted from economic self-sufficiency to cash crop production. As the number of American farms doubled, then trebled, and as productivity soared, declining prices undermined farm incomes. Cheap credit exacerbated this over-investment in farming. *See* K. MEIER, REGULATION 128 (1985). Farm-to-city freight rates also declined during this period, but did not fall as rapidly as farm prices. Farmers' resultant economic insecurity and their liberal democratic traditions led to the widespread emergence of rural populism. On rural populism see, L. GOODWYN, DEMOCRATIC PROMISE: THE POPULIST MOVEMENT IN AMERICA (1976); Hadwiger, *supra* note 13, at 504-505; S. LIPSET, AGRARIAN SOCIALISM (1950); G. MCCONNELL, THE DECLINE OF AGRARIAN DEMOCRACY 9 (1953); Brym, *Regional Social Structure and Agrarian Radicalism in Canada*, 15 CAN. REV. SOC. & ANTHRO. 339 (1978), Conway, *Populism in the United States, Russia, and Canada*, 11 CAN. J. POL. SCI. 99 (1978); Richards, *Populism: A Qualified Defense*, 5 STUD. IN POL. ECON. 5 (1981); Sinclair, *Class Structure and Populist Protest*, 1 CAN. J. SOC. 1 (1975). In placing blame for their plight, small farmers and merchants made scapegoats of the railroads. Eventually the populist sentiment succeeded in imposing regulation on those natural monopolies, the railroads. Kemp, *Political Parties, Industrial Structures and Political Support for Regulation* in PUB. POL'Y FORMATION 164 (R. Eyestone ed. 1984).

15. Pimentel, *The Ecological Basis of Insect Pest, Pathogen and Weed Problems*, in ORIGINS OF PEST, PARASITE, DISEASE AND WEED PROBLEMS 3 (J. Cherrett & G. Sagar eds. 1977); [hereinafter ORIGINS]; Way, *Pest and Disease Status in Mixed Stands vs. Monocultures; The Relevance of Ecosystem Stability*, in ORIGINS *id.* at 127; Norton & Conway, *The Economic and Social Context of Pest, Disease and Weed Problems*, in ORIGINS at 205; DETHIER, *supra* note 2, at 28-37; PERKINS, *supra* note 2, at 15, 249, 268; WHORTON, *supra* note 2, at 5. *See generally* NATIONAL ACADEMY OF SCIENCES, PRINCIPLES OF PLANT AND ANIMAL PEST CONTROL, Vol. 3, INSECT-PEST MANAGEMENT AND CONTROL (1969); NATIONAL ACADEMY OF SCIENCES PEST CONTROL: AN ASSESSMENT OF PRESENT AND ALTERNATIVE TECHNOLOGIES, Vol. 1, CONTEMPORARY PEST CONTROL PRACTICES AND PROSPECTS (1975).

16. On the significance of grasshoppers in early U.S. agriculture, see Schlebecker, *Grasshoppers in American Agricultural Hist.*, 27 AGRIC. HIST. 85 (1953).

17. The decline in crop rotation and other traditional practices exacerbated insect pest, crop disease, and weed problems. *See infra*, note 80. The introduction of high-yielding crops compounded these problems because the new varieties were usually more susceptible to disease and insect pests. *See* Ihde, *Pest and Disease Controls*, in 2 TECHNOLOGY IN WESTERN CIVILIZATION 85 (M. Kranzbergh, C. Pursell eds. 1967).

18. *See* Howard, *Danger of Importing Insect Pests*, in 1897 YEARBOOK OF THE UNITED STATES DEPARTMENT OF AGRICULTURE (1898); C. ELTON, THE ECOLOGY OF INVASIONS BY PLANTS AND ANIMALS (1958); DUNLAP, *supra* note 2, at 18-19; WHORTON, *supra* note 2, at ch. 1.

distant markets necessitated shipment only of premium quality fruit and vegetables of maximum durability. This was due to fixed transportation costs, and increasing selectivity among competitively supplied urban buyers and consumers. Under these biological and market circumstances, continuing farm prosperity depended upon the ability to control pests.

Once cost-effective crop protection and weed control technologies existed, *individual* farmers could hardly afford to go without them. With the exception of minor markets for organically-grown food, those farmers who did not adopt chemical innovations risked being forced out of business by their more progressive neighbors. As with advances in farm technology generally, the early adopters of pesticides temporarily reaped significant income benefits by lowering their own unit costs of production; when the laggards attempted to emulate these successes, aggregate production increased sufficiently to drive prices down and thus eliminate the short-run income gains. Farmers who for one reason or other did not adopt an improved technology were left with shrunken incomes since their unit costs of production remained high while prices received were falling. Cochrane[19] has fittingly termed this inexorable process "the agricultural treadmill."

Also, with the rising capital intensity and credit financing of agriculture, farmers may have become increasingly risk averse. Typically they are seen as adopting strategies to minimize chances of catastrophic crop failure (minimax).[20] In addition to increasing farm productivity, pesticides provide a measure of protection against uncertainty. Indeed many of the lending institutions offered farm credit contingent upon the use of pesticides—a form of crop and loan insurance.[21]

19. W. COCHRANE, FARM PRICES: MYTH AND REALITY 85 (1958); COCHRANE, *supra* note 13, at 378-409. *See also* PERKINS, *supra* note 2, at 13, 143, 268. Cochrane's theory is robust and particularly applicable to the post-WWII era, but detailed empirical assessments applying his theory to the adoption of pesticide technology are unknown.

20. The conventional view of agricultural economics views farmers as risk averse entrepreneurs who attempt to reduce year-to-year variability in net income, rather than maximizing gains in a given year. Regev, *An Economic Analysis of Man's Addiction to Pesticides*, in PEST AND PATHOGEN CONTROL, *supra* note 2, at 441. Other evidence suggests the theory may not be accurate. The advent of non-recourse loans using crops as collateral, under the Agricultural Adjustments Act of 1938, Feb. 16, 1938, ch. 30; 52 Stat. 31; 7 U.S.C. §§ 1281-1407 (1982), certainly reduced risks to recipient farmers. Moreover, in the current credit crisis of U.S. agriculture, and given existing bankruptcy laws, farmers face enormous incentives to take risk-loving strategies such as planting crops without pesticides. Rather than enrolling in crop insurance programs, it appears that many farmers rely upon governmental deficiency payments. Farmers may have been more risk averse in earlier times, before public institutions such as deficiency payments and limited bankruptcy provided a safety net. Even if risk aversion contributed little to their pesticide calculus, the economic treadmill (*supra* note 19), credit contingency (*infra* note 21), and the biological treadmill (*infra* notes 77-86) would have been compelling enough reasons for using chemicals, while desires for feeding the American people had no impact whatsoever (*supra* note 11).

21. *See* MCCONNELL, *supra* note 14; A. NELSON & W. MURRAY, AGRICULTURAL FINANCE 2, 188 (1967); PERKINS, *supra* note 2, at 219, 232, 268-69; Doutt & Smith, *infra*, note 62.

Because of technology-based productivity gains, United States agriculture became chronically prone to the economic trap in which the uncoordinated actions of many individuals leads to collective overproduction, market saturation, and plummeting prices. This happens because consumer demand for farm products has a low level of elasticity with respect to the quantity supplied.[22] Climatic variation and new technology tended to compound these uncertainties, as did the major wars. While wars increased the demand for agricultural goods, they also created labor shortages and sudden declines in demand with the cessation of hostilities.[23] Generally, it was the larger, more heavily-capitalized farmers who survived these disruptive forces[24] by staying at the leading edge of technical developments and thus perpetually reaping the short-run income gains. Indeed, the relative cost of farm inputs in the United States has encouraged the substitution of technology, energy and land for human labor throughout this century.[25] Government farm policies compounded the trend.

The extended agricultural depression, between the World Wars, saw the preceding factors and others operate in combination to drive thousands of small farmers from the land. When government intervened with price supports and acreage limitations in an effort to eliminate these destructive fluctuations, the result, once again, was to further encourage the use of technical innovations such as tractors, new plant varieties and fertilizer. By stabilizing farm incomes, price supports enabled larger farms to finance capital-intensive improvements that gave them an advantage over their labor-intensive neighbors.[26] Moreover, with restrictions only on the

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22. *See* Brandow, *Interrelations among Demands for Farm Products and Implications for Control of Market Supply*, PENN. STATE UNIV. BULL. NO. 680 (1961); COCHRANE, *supra* note 19, at 86-89; THE OVERPRODUCTION TRAP IN U.S. AGRICULTURE (G. Johnson & C. Quance eds. 1972). Per capita consumption of food (caloric intake) in America has changed little over this century. However, consumer demands changed as disposable income grew, as processed food became available, as storage and transport of fresh produce became more efficient, and as dietary preferences altered. For brief reviews of political responses to agricultural overproduction, see T. LOWI, THE END OF LIBERALISM 68-77 (1979); Hadwiger, *supra* note 13.

23. Under the Marshall Plan following WWII, prices were maintained through accelerated foreign-aid shipments of U.S. produce. *See* PERKINS, *supra* note 2, at 228.

24. For brief reviews of the socioeconomic dislocations caused by the U.S. agricultural revolution, see PERKINS, *id.* at 210; Shea, *American Agriculture: Who Stole the Revolution?*, 18 ENV'T 28 (1976); J. HIGHTOWER, HARD TOMATOES HARD TIMES (1972); Haynes, *Agriculture in the U.S.: Its Impact on Ethic and Other Minority Groups*, 2 AGRIC. & HUMAN VALUES 1 (Symposium issue, Summer 1985).

25. *See, e.g.*, Johnson, *The Impact of Farm Machinery on the Farm Economy*, 24 AGRIC. HIST. 58 (1950); Calvert, *The Technological Revolution in Agriculture, 1910-1955*, 30 AGRIC. HIST. 18 (1956); Rasmussen, *The Impact of Technological Change on American Agriculture*, 22 J. ECON. HIST. 578 (1962); MEIER, *supra* note 14, at 127; Ellickson & Brewster, *Technological Advances and the Structure of American Agriculture*, 29 J. FARM ECON. 827 (1947). Compare the situation in Japan, where land (not labor) has been in short supply. *See*, Y. HAYAMI & V. RUTTAN, AGRICULTURAL DEVELOPMENT: AN INTERNATIONAL PERSPECTIVE 133 (1971).

26. *E.g.*, PERKINS, *supra* note 2, at 227, 228. Several New Deal programs were intended to assist poor and often illiterate small-scale farmers. These programs were initially administered from Washington, D.C. During the war years, the Farm Bureau (a private organization representing the larger, more successful farmers) managed to have the New Deal programs decentralized and transferred to

number of acres planted, prosperous farmers shifted to a more intensive use of land, by substituting technologies such as hybrid seed, fertilizer, irrigation, and pesticides. Thus, while price supports may have enabled marginal farms to persist for some years, governmental intercession ultimately contributed to continuing overproduction, economic dislocations and further concentration within the industry. This result occurred because larger farms with stabilized incomes could finance the purchase of their small, less-competitive neighbors.[27]

Finally, few political jurisdictions were tempted to restrain the use of pesticides within their borders. Just as individual farmers had little choice in this matter, counties, states, and even nations relying heavily upon agriculture could not realistically restrict pesticide use. To have done so would have put their farmers at a competitive disadvantage vis-a-vis those in neighboring jurisdictions.[28] Beside sparking protest, such moves would selectively depress their own economy and tax revenues. Only when threatened with a loss of exports due to excessive arsenic residues, for example, was there some countervailing incentive to regulate locally.[29] Even when an agricultural jurisdiction did adopt restrictions, enforcement was often lax, so individual farmers were encouraged to violate those regulations. Farmers did not violate regulations because they are particularly greedy. Rather, competition has routinely selected against those who failed to insure their investments against the potential ravages of pests and other threats to viability.

Government Services for Agriculture

Historically, farm-based governments have devised many ways to nurture their unstable, export-oriented rural economies. As discussed above,

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state extension services of land grant colleges. Thereafter, larger farmers controlled access to credit through the U.S. Farm Credit Administration and reinforced the trend toward economic concentration. *See*, LOWI, *supra* note 22, at 73.

27. *See* COCHRANE, *supra* note 13, at 378-95; MEIER, *supra* note 14, at 135; PERKINS, *supra* note 2, at 226.

28. For a review of this literature and some recent data, see Rowland & Marz, *Gresham's Law: The Regulatory Analogy*, 1 POL'Y STUD. REV. 572 (1982). Moreover, the politicans were often farmers themselves, so the effective unity of goals among farmers and their elected representatives meant the prevailing ethos was one of "promoting pesticide use." Dubnick, *From Facilitation to Control: Changes in the Regulatory Relationship between Government and Agriculture*, paper presented at the Fourth Annual Hendricks Symposium, Univ. of Nebraska, Lincoln (Apr. 5, 1979). Restrictions on pesticide use were rarely contemplated. Indeed, some jurisdictions even mandated pesticide use (including compensation to the government for spray costs if a farmer refused to treat his crop himself) in an effort to control and quarantine economically important pests within their borders.

29. There is some evidence that agricultural jurisdictions do not voluntarily impose controls. *E.g.*, early in this century, Western United States apples were first seized for containing excessive residues of arsenic, not by local authorities, but by England and eastern North American's large cities. See WHORTON, *supra* note 2, at 95-175; *see also* Whitaker, *supra* note 2. For an analogous case involving import restrictions against diseased U.S. meat and animals, see A. DUPREE, SCIENCE IN THE FEDERAL GOVERNMENT 163-65 (1957).

public sponsorship has recently included price supports, acreage limitations, and reluctance to restrict pesticides (as well as favorable labor laws, tax treatment, marketing orders, import restrictions, transport infrastructure, and farm credit).[30] Government recognition of the economic significance and frailty of agriculture preceded the discovery of commercial pesticides.[31] For instance, the Constitution granted patent rights which still encourage the private invention of farm machinery. Then the United States Department of Agriculture [USDA], our first clientele-oriented administrative agency, was established in 1862 explicitly to serve agriculture by sponsoring research and collecting useful data.[32] At the time, the acceptable role of federal government was relatively limited, so a decentralized system emerged in which the U.S. government provided non-intrusive incentives for state action. The resulting land grant colleges (1862), agricultural experiment stations (1887), and the cooperative extension service (1914) were created to provide agricultural education, to perform research on new techniques, and to help transfer new knowledge into farm improvements in every rural county. Within this elaborate institutional setting, all studies, including those on pest control, were directed toward solving farm problems. Not surprisingly, research scientists dedicated themselves to devising techniques for increasing farm productivity and lowering unit production costs.[33] This utilitarian focus was eventually reinforced by clientele support for research funding.[34]

Historically, farmers had difficulty establishing effective political organizations.[35] Such a group finally emerged following the Smith-Lever Act of 1914,[36] which provided federal matching funds for the employment of county-level extension agents. The extension task, to transfer new

30. *See* COCHRANE, *supra* note 13; J. Wason, *Legislative History of the Exclusion of Agricultural Employees from the National Labor Relations Act 1935 and the Fair Labor Standards Act of 1939*, Library of Congress Legislative Reference Service (May 19, 1966).

31. *See generally* M. BENEDICT, FARM POLICIES OF THE UNITED STATES, 1790-1950 (1966); H. BREIMEYER, INDIVIDUAL FREEDOM AND THE ECONOMIC ORGANIZATION OF AGRICULTURE (1965); D. HADWIGER, THE POLITICS OF AGRICULTURAL RESEARCH, at ch. 2 (1982); WHORTON, *supra* note 2, at 3-35; E. WIEST, AGRICULTURAL ORGANIZATION IN THE UNITED STATES (1923).

32. *E.g.*,, Nelson, *A Short, Ironic History of American National Bureaucracy*, 44 J. POL. 747 (1982). As an intentionally clientele-oriented agency, the USDA was not entirely unprecedented. *See* Wilson, *The Rise of the Bureaucratic State*, 41 THE PUBLIC INTEREST 77 (1975). On the history of the USDA see W. RASMUSSEN & G. BAKER, THE U.S. DEPARTMENT OF AGRICULTURE (1972); DUPREE, *supra* note 29, at 157-61.

33. DUPREE, *supra* note 29, at 172-73; PERKINS, *supra* note 2, at 250-53. *See generally*, A. MARCUS, AGRICULTURAL SCIENCE AND THE QUEST FOR LEGITIMACY (1985). The early clientele-orientation of economic entomology was reinforced by the unscrupulous people who defrauded farmers with useless pesticide products, and by association, gave the professionals who recommended chemicals a bad name. PERKINS, *supra* note 2, at chs. 3, 5.

34. *See, e.g.*, HADWIGER, *supra* note 31, at ch. 2; PERKINS, *supra* note 2, at 242, 255-57; Buttel, *The Land-Grant System: A Sociological Perspective on Value Conflicts and Ethical Issues*, 2 AGRIC. & HUMAN VALUES 88, 92 (Spring 1985); Marcus, *The History of Agricultural Research*, in PUBLIC POLICY AND AGRICULTURAL TECHNOLOGY (D. Hadwiger & W. Browne eds. 1986).

35. *See* M. OLSON, THE LOGIC OF COLLECTIVE ACTION: PUBLIC GOODS AND THE THEORY OF GROUPS 148-59 (1971).

36. May 8, 1914, ch. 79; 38 Stat. 372; 7 U.S.C. §§341-49 (1982).

research and technologies onto the farm, necessitated that the county agents develop and maintain a receptive audience. That audience turned out to be the technically progressive elements, which usually consisted of the larger and more prosperous farmers.[37] Perceiving the benefits of government-sponsored research, those locally organized groups amalgamated statewide and then nationally in 1919 to form the American Farm Bureau Federation.[38] Following this innocent beginning, a comfortable mutual relationship evolved as the Farm Bureau and various commodity groups lobbied for government subsidies to solve farm production problems.[39] Meanwhile, the availability of government and industry funding created professional opportunities for research scientists, many of whom came both from farm backgrounds and service-oriented universities. It was a subtle process.

As others have pointed out, this research network soon aimed almost exclusively at surmounting the problems of *commercial* agriculture, where progressive farmers had access to the capital needed for adopting new technologies.[40] Pest suppression was high on the list of research priorities, particularly following WWII. Research on chemical methods thrived in this atmosphere of meeting the needs of a growing nation through service to commercial agriculture while other factors inhibited the development of nonchemical alternatives in pest management.

PESTICIDE PRODUCTION, USE AND CONSEQUENCES

A Dynamic Pesticide Industry

The chemical industry underwent a fundamental transition around WWII, as the production and use of pesticides increased dramatically.[41] Insec-

37. *See* BAKER, THE COUNTY AGENT (1939); MCCONNELL, *supra* note 14, at chs. 3, 5.

38. OLSON, *supra* note 35; J. SHIDLER, FARM CRISIS 1919-1923 (1957); S. BERGER, DOLLAR HARVEST: AN EXPOSE OF THE FARM BUREAU (1971).

39. *See, e.g.*, C. CAMPBELL, THE FARM BUREAU AND THE NEW DEAL (1962); BERGER, *supra* note 38; HADWIGER, *supra* note 31; LOWI, *supra* note 22.

40. Capital investment has been heavily subsidized by the tax system and further encouraged by easy access to farm credit.The great paradox of American agriculture is that while development was intended to benefit farmers, many thousands of farmers were ruined by the technological treadmill which created crop surpluses and therefore depressed prices, except during the war years. Almost all farmers purchased technological advances on credit. Those who adopted technology early were able to pay off their purchases, late adopters often experienced shrinking incomes and difficulty making loan repayments. This social effect and other implications of agricultural research and technology were disregarded by the government. The scientists were aligned with commercial agriculture and tended to ignore research or de-emphasize results that would embarrass their clients. PERKINS, SHEA & HIGHTOWER, *supra* note 24.

Government programs frequently help those least in need. P. SELZNICK, TVA, AND THE GRASS ROOTS (1949). Recent experiences suggest that inegalitarian outcomes are not always unanticipated in federal programs. *See*, Robertson, *Program Implementation Versus Program Design: Which Accounts for Policy "Failure"?* 3 POL'Y STUD. REV. 391 (1984); Gibson, Goodin & LeGrand, *Distributional Biases in Social Service Delivery Systems*, 13 POL'Y & POLITICS 109 (1983).

41. *See*, PERKINS, *supra* note 2, at 47-48; and Perkins, *Reshaping Technology in Wartime: The Effect of Military Goals on Entomological Research and Insect Control Practices*, 19 TECHNOLOGY & CULTURE 169 (1978). For a graph that dramatically represents growth at the aggregate level, see

ticides first received intensive use at the end of the nineteenth century, but only on the most valuable crops. That first era in pesticide technology employed inorganic materials (predominantly copper sulfate and salts of arsenic) and plant extracts (such as pyrethrum and nicotine).[42] Chemically simple or naturally occurring, these compounds were easily produced, so a fragmented market emerged with many small, sometimes itinerant dealers, and farmers often mail ordered and mixed the materials themselves. Such conditions made it easy to bilk farmers with adulterated or useless chemicals.[43] Fraud discouraged farmers from using pesticides, and this upset the large, more reputable manufacturers. Following initiatives by several states,[44] Congress responded with the Insecticide Act of 1910.[45] It was a simple statute designed to protect farmers (and thus the manufacturers) by requiring accurate labels that specified the minimum percentage of active ingredients in the arsenical pesticides. The statute also created a government bureau to enforce new standards.[46] By that time total annual sales were estimated at $20 million, with a dozen or so companies sharing most of that market.[47] The pesticidal properties of a few artificially-synthesized organic chemicals were discovered during and after WWI, but it was not until WWII that the second era in pesticide technologies took hold. The war precipitated an intense USDA search for useful pesticides. When a Swiss chemical company unveiled DDT to U.S. officials, the new material was rapidly evaluated and recommended for disease-control uses by the military.[48] DDT was a dramatic technological success that was turned to public health and domestic agricultural uses soon after the war. It was cheaper and more effective than all existing methods. Thus, DDT and a few other synthetic organic pesticides quickly displaced earlier pest control practices, including the use of arsenical sprays.[49]

The new products were sufficiently cheap and so effective as to stimulate their use against a wide variety of insects previously beyond the economic reach of chemical pest suppression.[50] The corporate response to this lucrative market was rapid. Total production of DDT by U.S.

Davis & Magee, *Cancer and Industrial Chemical Production*, 206 SCI. 1356 (1979). We can only theorize about individual pesticide enterprises, which are especially diverse, necessarily secretive, and difficult for scholars to probe.

42. *E.g.*, Blodgett, *supra* note 2, at 200-203; Dunlap, *The Triumph of Chemical Pesticides in Insect Control, 1880-1929*, 1 ENVTL. REV. 38 (Nov. 5, 1978).

43. *See*, Hadwiger & Miller, *Regulation of Pesticides by the State of Iowa*, 54 IOWA ST. J. RES. 65, 68 (1979). *See also* Whitaker, *supra* note 2; WHORTON, *supra* note 2.

44. *E.g.*, Hadwiger & Miller, *supra* note 43.

45. Apr. 26, 1910; ch. 191; 36 Stat. 335, *repealed by* Act of June 25, 1947, ch. 125, § 16; 61 Stat. 172; current version at 7 U.S.C. §§ 136-136(y)(1982).

46. *Cf.* Whitaker, *supra* note 2.

47. *Id.* at 101, 216.

48. *See* PERKINS, *supra* note 2, at 6-10.

49. *E.g.*, DUNLAP, *supra* note 2, at 253-54; PERKINS, *supra* note 2, at 11-12; Blodgett, *supra* note 2, at 202.

50. PERKINS, *supra* note 2, at 11.

firms increased from 10 million pounds in 1944 to more than 100 million pounds in 1951.[51] Over a similar period, between 1945 and 1953, manufacturers introduced some twenty-five new synthetic organic pesticides into commerce, among them some very effective herbicides.[52] In the span of a decade or so, profitable growth had transformed the production of pesticides from a relatively small, decentralized, and chemically-simple affair into a large scale industrial process for synthesizing pesticides, and other complex chemicals from fossil-fuel distillates. Reflecting that technological transition, by 1950 the chemical industry had become large, product-diverse, and politically well organized.[53]

This shift to second generation technologies and the industrial structure needed for pesticide discovery and production had several implications which appear to have promoted the farmer's reliance upon chemical methods of pest suppression, which worked and at affordable prices. There were more subtle influences as well. The synthetic organic pesticides are both considerably more research intensive to develop and more capital intensive to produce than their first generation counterparts—simple salts and plant poisons. High costs constrained the types of products that were developed and marketed in a manner that facilitated the widespread adoption of chemicals.

While estimates of research and development costs vary, they are high, and they are rising.[54] Because of these costs, companies must capture large markets if product-lines are to remain profitable. Hence corporate research seeks chemicals with a broad spectrum of effectiveness. Narrowly-selective products do not usually recoup development costs because their sales are restricted to a few susceptible pests.[55] Moreover, the cost of financing synthetic pesticide production may have reinforced the cor-

51. *Id.* at 13.

52. USDA PRODUCTION AND MARKETING ADMINISTRATION, THE PESTICIDE SITUATION FOR 1952-1953 (1953); *see also* Whitaker, *supra* note 2, at 407, 428-39.

53. The National Agricultural Chemicals Association [NACA] was established in 1933 and it began publication of a pesticide trade journal in 1946. *Agricultural Chemicals*. DUNLAP, *supra* note 2, at 73; Whitaker, *supra* note 2, at 424.

54. *See generally*, R. BROADMAN, PESTICIDES IN WORLD AGRICULTURE: THE POLITICS OF INTERNATIONAL REGULATION 35 (1986); L. Hatch, The Effect of Environmental Protection Agency Regulation on Research and Development in the Pesticide Industry, unpublished doctoral dissertation, Univ. of Minn. (1982); W. Lazarus, Optimal Management of a Common Property Pest under Risk: An Application to the Corn Rootworm, unpublished doctoral dissertation, Univ. of Ill., Urbana (1981) Von Rumker, Guest & Upholt, *The Search for Safer, More Selective, and Less Persistent Pesticides*, 20 BIOSCIENCE 1004 (1970); COUNCIL ON AGRICULTURAL SCIENCE AND TECHNOLOGY, IMPACT OF GOVERNMENT REGULATION ON THE DEVELOPMENT OF CHEMICAL PESTICIDES FOR AGRICULTURE AND FORESTRY (1980) (development costs are presently estimated at around $15 million for each new pesticide registered for use).

55. The obvious exception occurs when a particular pest or weed causes widespread damage in an economically important crop. While there are few incentives for the discovery of narrow-spectrum products, the development of less-persistent chemicals (fewer residues) is encouraged since they require more frequent use. NATIONAL ACADEMY OF SCIENCES (1975), *supra* note 15, at 139 (with Professor John H. Perkins as consultant). Narrow-spectrum are more desirable because they cause less disruption of non-target species and generate fewer secondary pests. The biological treadmill phenomenon is discussed, *infra* notes 77-86 and accompanying text.

porate predisposition for products likely to attract large markets through broad-spectrum activity.[56] Two additional factors tended to exacerbate manufacturer preference for widely-active pesticides. Soon after the new chemicals were introduced, it became apparent that pests could develop genetic resistance to them. The threat of resistance implied that the useful life of any particular pesticide would be limited.[57] This encouraged a strategy of competition by successive introduction of new chemicals—which, in turn, necessitated constant innovation and research.[58] Again, research facilities could only be paid for through larger sales. And more recently, the growing stringency of required safety tests contributed further to the corporate emphasis on broad-spectrum pesticides by increasing the cost of licensing new products for the market.[59]

While the search for broad-spectrum pesticides was certainly successful, their adverse social ramifications quietly mounted. Individual farmers were often confronted with competing products which, from their standpoint, were essentially indistinguishable. This feature, together with the need to educate users to the steady flow of new products, led manufacturers into extensive advertising campaigns and aggressive sales tactics.[60] Most farmers received their information exclusively from the trade tabloids and directly from company representatives. All this competition in sales may have kept pesticide prices down, but low prices also encourage excessive use by the risk averse.[61] Once the highly decentralized system of on-farm marketing was established it became possible (even necessary) for company salesmen to slip into promoting unnecessary and unsuitable uses. Given their personal experiences with crop failure, the fickle nature of their market, and their dependence upon credit financing, it was economically rational for individual farmers to resolve their doubts in favor of taking out insurance, in effect by applying pesticides more often than might be "strictly necessary."[62]

56. *E.g.*, *The Chemical Surge*, BUS. WK., Mar. 18, 1950, at 117.

57. *See, e.g.*, Smith, *Racial segregation in Insect Populations and its Significance in Applied Entomology*, 34 J. ECON. ENTOMOLOGY 1 (1941); NATIONAL ACADEMY OF SCIENCES, REGULATING PESTICIDES 74-75 (1980). *See also infra* note 78 and accompanying text.

58. Early in this century chemical manufacturers adopted the strategy of constant research and development. *E.g.*, A. CHANDLER, JR., THE VISIBLE HAND 374-75, 473-76 (1977).

59. For a general introduction, see *supra* note 54; Tucker, *Of Mites and Men*, 257 HARPER'S 43 (1978); TECHNOLOGICAL INNOVATION FOR A DYNAMIC ECONOMY (C. Hill & J. Utterback eds. 1979); Ashford & Heaton, *Regulation and Technological Innovation in the Chemical Industry*, 46 LAW & CONTEMP. PROBS. 109 (Summer 1983); Davies, *The Effects of Federal Regulation on Chemical Industry Innovation*, 46 LAW & CONTEMP. PROBS. *Id.* at 41 (Summer 1983).

60. *See, e.g.*, DETHIER, *supra* note 2, at 124-25; PERKINS, *supra* note 2, at 14; VAN DEN BOSCH, *supra* note 4, at 238-63; WELLFORD, *supra* note 4, at 280.

61. The price of DDT fell from over $1 per pound in 1945 to about 25 cents per pound by the mid-1950s. DUNLAP, *supra* note 2, at 254.

62. On the insurance quality of pesticide use see, *e.g.*, *supra*, notes 20, 21 and accompanying text; Doutt & Smith; *The Pesticide Syndrome—Diagnosis and Suggested Prophylaxis*, in BIOLOGICAL CONTROL (C. Huffaker ed. 1971); PERKINS, *supra* note 2, at 232, 268-69; WELLFORD, *supra* note 4,

Immediate Utility with Hidden Costs

New pesticides, more than many technical innovations, have benefits that are immediate and readily apparent while their costs are far less obvious and occur in the distant future.[63] Their benefits are virtually known in advance since it is the prospect of profitable breakthroughs that motivates the haphazard search for effective new chemicals. On the other hand, the potential costs associated with adopting a technical innovation are often obscure during the initial stages of discovery, and may remain uncertain even after the technology had been in use for several years.[64] Such temporal disparities in our accumulation of knowledge favor a presumption of using new technologies, especially in the case of pesticides where their costs are borne elsewhere (in time and space) by people other than the manufacturer/farmer beneficiaries.

This general bias in the appearance of information was compounded by historical circumstances at the time second-generation pesticides were being developed. While evaluating DDT for military uses, the federal government was careful to assess the new chemical's safety. However, under the pressures of war including limited time, dwindling supplies of imported botanical pesticides, and the certainty of disease epidemics, those tests emphasized the acute, short-term toxicity to persons directly exposed.[65] That truncated evaluation confirmed that the acute mammalian toxicity of DDT was indeed low, so the chemical was released for immediate military use. It was safe to apply, effective against a wide variety of pests, cheap, readily sprayable, and persistent. All of these qualities contributed to its substantial war-time successes against insect-borne disease. Extensive publicity portrayed DDT as one of the technologies that helped to win the war and this encouraged its rapid release to civilian uses. Although there were scientists who correctly viewed these gross manipulations of biological systems with skepticism, their protest was futile amid such popular acclaim and unprecedented technological optimism. DDT's early record was so impressive that many entomologists talked for the first time of eradicating the insect vectors of several important diseases.[66]

The cautionary response against DDT was delayed further for a number

at 238-63. The key problem according to economists is that pesticides are under-priced if the costs of long-term, collective use are ignored. Of course, these costs were rarely clear at the outset of pesticide manufacture and they were incurred outside the marketplace.

63. *See, e.g.*, Battista, *The Conviction of DDT*, 3 ENVT'L REP. (monograph No. 14 Jan. 26, 1973); Davis, *The Deadly Dust*, 22 AM. HERITAGE 44 (1971); W. LOWRANCE, OF ACCEPTABLE RISK, 155-73 (1976).

64. It was 15 years before the use of DDT resulted in actual injuries. Rodgers, *supra* note 4. For quantitative evidence of the delayed reporting of costs versus benefits, see HADWIGER, *supra* note 31, at 162-67.

65. *E.g.*, DUNLAP, *supra* note 2, at 61.

66. *See, e.g.*, PERKINS, *supra* note 2, at 12; Whitaker, *supra* note 2, at ch. 12.

of other reasons. At the time, pesticides could not be kept from the market place. The available legal recourse had evolved in response to the import restrictions sparked off by excessive arsenic residues:[67] provided pesticides were effective they were made available for unrestricted use. It was the residues appearing on food destined for human consumption that could be limited by administrative action. Acting largely on the basis of its experience in setting arsenic residue levels,[68] the Food and Drug Administration [FDA] in 1946 set the same threshold for DDT, as for arsenic, of 7 ppm in food products. The FDA also established a "zero tolerance" for DDT in milk, due to the importance of milk in the diet of infants and invalids.[69]

These FDA regulatory actions were imposed swiftly. They seemed stringent at the time because DDT was believed to be considerably less toxic than lead arsenate, the notorious chemical it superceded. However, analogizing DDT to arsenic turned out to be seriously misleading. As we later found out, DDT's behavior in the environment was dissimilar and its toxic effects were novel. Arsenic salts left residues when sprayed directly onto food, but they were otherwise immobile in the environment, due to their insolubility. Moreover, arsenic residues could be removed from food by careful washing. DDT proved to be entirely different.[70] As a synthetic organic, DDT is oil soluble so it is selectively incorporated into and retained by fatty tissues, which in turn, makes it highly mobile in the environment. DDT is also chemically persistent and thus likely to concentrate in organisms high on the food chain. When DDT was introduced, this chemical bio-concentration behavior was unknown, so it was unimaginable that DDT contamination would cause egg-shell thinning in some species of birds.[71] Experience with first-generation pesticides had provided no basis on which to anticipate the problems with DDT and other synthesized chemicals. Indeed, the understandable but incorrect analogy between DDT and arsenic created a false sense of security and delayed the critical examination of DDT.

We simply did not understand the chronic adverse impacts of DDT. The necessarily truncated war-time testing had not adequately assessed the potential impacts of long-term, low-level exposure. Even with ex-

67. *See, e.g.*, Anderson, *Pioneer Statute: The Pure Food and Drugs Act of 1906*, 13 J. PUB. L. 189 (1964); C. JACKSON, FOOD AND DRUG LEGISLATION OF THE NEW DEAL (1970); J. TURNER, THE CHEMICAL FEAST (1970); Whitaker, *supra* note 2, WHORTON, *supra* note 2.

68. The tendency to apply older technology to new problems with very different conditions is discussed by C. HOOD, THE LIMITS OF ADMINISTRATION, ch. 5 (1976) (citing Katzenbach, *The Horse Cavalry in the Twentieth Century*, 1958 PUB. POL'Y 120 (1958)).

69. *See* FED. SECURITY AD., FOOD & DRUG AD., ANNUAL REPORT OF THE FDA 6 (1946); Notice of Hearing, 21 C.F.R. § 120 (1949), WHORTON, *supra* note 2, at 246-47.

70. *E.g.*, Blodgett, *supra* note 2, at 200-201.

71. U.S. ENVIRONMENTAL PROTECTION AGENCY, DDT, OFFICE OF PESTICIDE PROGRAMS (1975).

tensive use, these costs did not show immediately. Knowledge of DDT's effects evolved slowly, and then largely because of the independent development of more sensitive techniques in analytical chemistry which made it possible to detect and measure the minute levels of pesticide residue that had become dispersed widely beyond their sites of application.[72] A thousand-fold increase in detection sensitivity made administrative and scientific nonsense of the FDA's "zero tolerance" for DDT in milk.[73] Whereas residues had previously gone undetected, around 1960 it became increasingly apparent that wildlife contamination and human exposure were virtually universal. Only as the methods of detection improved could the science of toxicology evolve. Toxicology was not then sufficiently advanced to definitively assess the significance of DDT exposures. The necessary information did not exist, and its development was to prove expensive and time consuming.

Competing manufacturers had little interest in incurring additional expenses for testing, and the law did not require them to do so. The costs of pesticide contamination were largely experienced outside the farm situation, so both the agricultural and pesticide producing sectors lacked incentives to reconsider their economically rational transactions.[74] Hence, the role of data collection fell by default to the government. A certain amount of inertia had to be surmounted before funding was forthcoming. In 1962, after successive improvements in instrumentation and years of investigation by concerned wildlife biologists, it was Rachel Carson who dramatically pointed to our woeful lack of knowledge. She called for systematic research on the environmental and chronic health impacts of pesticide contamination. While expressions of public concern soon waned, Carson's lasting legacy was the private and federal research effort stimulated by the official reaction to *Silent Spring*.[75] By the late-1960s DDT and a number of other synthetic pesticides were discovered to cause cancer in laboratory animals.[76]

72. *See, e.g.*, Blodgett, *supra* note 2, at 221-22; DUNLAP, *supra* note 2, at 135-37; LOWRANCE, *supra* note 63, at 21. *See generally*, Post, *Chemistry and the Law: A Review of Recent Developments*, 2 HARV. ENVTL. L. REV. 523 (1977).

73. "Zero-tolerance" was defined in operational terms as any residue level that was below the detection threshold. Hence, the concept became unworkable as detection sensitivity increased.As detection technology improved, previously tolerated contamination levels became illegal. *E.g.*, BOFFEY, *supra* note 4, at 208-09.

74. Farmers were directly affected by some "costs" of pesticides, e.g., persistent insecticides adversely impacted bees and native pollinators, and grapes were hypersensitive to herbicide drift. These internal on-farm costs were some of the aspects of pesticides use to be effectively regulated.

75. CARSON, *supra* note 4. For analyses of Carson's work, see Blodgett, *supra* note 2, at 213-15; P. BROOKS, THE HOUSE OF LIFE (1972); DUNLAP *supra* note 2, at 105-113; F. GRAHAM, SINCE SILENT SPRING (1970); HADWIGER, *supra* note 31, at ch. 5; PERKINS, *supra* note 2, at 31-33; J. PRIMACK & F. VON HIPPEL, ADVICE AND DISSENT 42-43 (1974); A. SCHNAIBERG, THE ENVIRONMENT: FROM SURPLUS TO SCARCITY (1980).

76. *E.g.*, PRIMACK & VON HIPPEL, *supra* note 75, at 133; Rodgers, *supra* note 4.

Only after three decades of extensive use had exposed all humans did the scientific.case against DDT became reasonably clear. In sharp contrast, the initial deployment of that new technology had been a military necessity, an essential humanitarian act in the face of debilitating diseases, and a continuing economic certainty for highly competitive agriculture. In hindsight, it is easy to argue that greater initial caution was warranted. Some people did. It must be remembered that our experience with post-WWII chemical technology has taught us what is now known and taken for granted. But once the chemical genie was unleashed, several factors operated against easy containment. It has taken time to translate knowledge about hazards into political action. The law has difficulty staying abreast of rapid technological change where the costs cannot be anticipated, are slow to be manifested, and ultimately remain uncertain.

The Biological Treadmill

While the adverse environmental and health effects of the organochlorine insecticides such as DDT were largely external to the farm setting, their heavy use eventually imposed other costs directly upon farmers who sprayed. The biological processes called forth by insecticide use have often necessitated that farmers subsequently make even larger and more frequent applications of these chemicals. The details of this syndrome vary depending on the particular combination of crop, pest, insecticide, and history of use, among other variables. But the eventual outcome is remarkably uniform. The net result of insecticide use has frequently been analogous to the process of drug addition: initial uses were followed by successively larger doses, then by troubled dependence, and eventually by some type of crisis.[77]

The mechanisms by which agricultural ecosystems respond to chemically-induced disruptions are now reasonably well understood. Simply, these mechanisms include insect pest resurgence, secondary pest outbreaks, and genetically-acquired resistance. Resurgence occurs when an insecticide eliminates the natural enemies (predatory or parasitic insects) of a pest species, and the surviving pest individuals quickly regain or surpass their initial numbers. Secondary pests are those potential pest

77. The analogy of pesticide use to drug addition is by no means perfect. Since the 1940s, crop losses due to insect pests have doubled, in spite of a 10-fold increase in insecticide use. However, agricultural productivity rose more rapidly than pest losses. Pimentel, *supra* note 9, at 778-79. For general overviews of the declining effectiveness of pesticides, see CARSON, *supra* note 4, at chs. 15, 16; Coaker, *Crop Pest Problems Resulting from Chemical Control*, in ORIGINS, *supra* note 15, at 313; P. DEBACH, BIOLOGICAL CONTROL BY NATURAL ENEMIES, at 1-22 (1974); DETHIER, *supra* note 2, at 105-32; PERKINS, *supra* note 2; R. RUDD, PESTICIDES AND THE LIVING LANDSCAPE, 141-48, 186-95, 268-79 (1964). For a more recent development, see FOX, *Soil Microbes Pose Problems for Pesticides*, 221 SCIENCE 1029 (1983).

species that suddenly attain harmful densities after their natural enemies, which had previously kept them scarce, have been killed by an insecticide. Pesticide resistance is the phenomenon caused when repeated selective pressure leaves a surviving population with an immunity to that chemical.[78]

Ironically, the very effectiveness of second generation insecticide technology predisposed it to these modes of failure. But it was some time before the rural sector acknowledged these problems. When secondary pests began to appear, instead of abandoning insecticides, farmers became even more dependent on them in a treadmill effect.[79] The dramatic successes initially offered by insecticides encouraged farmers to forego a variety of cultural practices that helped to suppress insect pests before the advent of effective, easily-applied chemicals.[80] By coming to rely largely on chemical technology, agriculture made itself especially vulnerable to the failures of insecticides. The broad spectrum of activity that characterized the early synthetic insecticides meant that they killed both beneficial and harmful insects indiscriminately. Resurgent, or secondarily-created pest outbreaks were then suppressed with more frequent and more massive applications. Abandonment of cultural practices and heavy reliance upon single, effective methods of pest control intensified the selective pressure, and thereby accelerated the onset of genetic resistance. Resistance was met by using different but equally indiscriminate pesticides. When those methods failed, various combinations of chemicals were used and so on.[81]

The failure of broad-spectrum insecticides was another hidden cost of the technology, but unlike the uncertain risks inherent in widespread contamination, this cost was experienced primarily by the farmers themselves. For farmers who perceived the limitations of pesticides there was no simple escape, because the biological processes of resistance only compounded the economic tyranny of the treadmill in agricultural technology. Single farms contribute little to the onset of pesticide resistance, so individual farmers have little incentive to modify their pest control

78. In several instances resistance developed very rapidly. It was recorded before WWII, and it was well known to science by the late 1950s. Brown, *The Progression of Resistance Mechanisms Developed Against Insecticides* in PESTICIDE CHEMISTRY IN THE 20th CENTURY (J. Plimmer ed. 1977). *See also, supra* note 57; Georghiou, *The Evolution of Resistance to Pesticides*, 3 ANN. REV. ENTOMOLOGY 122 (1972); Hueth & Regev, *supra* note 10; PERKINS, *supra* note 2, at 34-37; Pimentel, *supra* note 9, at 779. On weed resistance to herbicides, see LE BARON & GRESSEL, *supra* note 1.

79. *E.g.*, VAN DEN BOSCH, *supra* note 4, at ch. 3.

80. *E.g.*, PERKINS, *supra* note 2, at 11-12. The corn rootworm may be effectively controlled by crop rotation. However, in the Midwest the alternative crop is soy beans which are not presently as profitable, *See* Lazarus, *supra* note 54; PERKINS, *supra* note 11, at 89-90. Acreage limitations set by the government also reinforced farmer's abandonment of cultural practices that suppress insect pests.

81. *E.g.*, PERKINS, *supra* note 2, at 21, 37.

practices even though collectively their actions lead to declining profitability.[82] Once entire regions of expansive monoculture had been disrupted in this manner, there was often no retreat at all for the individual (by now credit-dependent), except to switch to another (less-profitable) crop or to abandon farming altogether.[83] Alternative methods were sought primarily when the failure of insecticides left insurmountable pest problems that literally threatened the economy of entire regions.[84]

This biological treadmill effect was a conspicuous cause of our growing use of pesticides through the 1950s and the '60s, but it also precipitated a reassessment of the accepted practices. It has been suggested that internal failings of the technology ". . . were ultimately more important in forcing change" than the external protest over environmental contamination and health risks.[85] It is not easy to disentangle these influences and determine their relative strengths. It is clear, however, that both worked toward the same effect, and the internal failure of pesticides eventually motivated some university entomologists, corporate farmers, and certain USDA officials to seek more sophisticated techniques of pest suppression. However, this shift in attitudes was far from unanimous.[86] And even though genetic resistance is now seen as inevitable, chemical manufacturers have retained their commitment to large-market, broad-spectrum, pesticides—which still receive extensive use both within and outside the U.S.

FOOD PROCESSING, MARKETING, AND CONSUMPTION

Consumer Preferences

When purchasing produce, consumers generally select the items they find most aesthetically pleasing. Other factors being equal, unblemished apples sell before those scarred by insects. And large, more colored oranges outsell their smaller pale rivals even though the latter may have

82. Pest susceptibility to a particular chemical is a common pool resource that invites overexploitation. The attendant social cost of overexploitation is the onset of genetic resistance and declining pest control. *See*, Heuth & Regev, *supra* note 10; Lazarus & Dixon, *Agricultural Pests as Common Property: Control of the Corn Rootworm*, 66 AM. J. ECON. 456 (1984); Regev, Gutierrez & Feder, *Pests as a Common Property Resource: A Case Study in Alfalfa Weevil Control*, 58 AM. J. AGRIC. ECON. 186 (1976).

83. Genetic resistance, the perceived loss of effective pest control, does not cause catastrophe if alternative cash crops are only slightly less profitable than the preferred crop. Compare corn and soy beans in the Midwest to cotton in the South where alternative crops are not closely profitable. *See* Lazarus, & Dixon, *supra* note 82.

84. *See, e.g.*, Doutt & Smith, *supra* note 62, at 8-14; PERKINS, *supra* note 2; at 19, 40-44, 260, 269.

85. PERKINS, *supra* note 2, at 42.

86. Moreover, some sectors, such as the California citrus industry, had long been committed to biological pest controls. *E.g.*, Howard, *A History of Applied Entomology*, 84 SMITHSONIAN MISC. COLLECTION 57, 153-55 (1930).

superior flavor. Consumer behavior provides the basis for a series of formal and informal standards that effectively exclude much cosmetically imperfect produce from the market. Cosmetic imperfections involve superficial damage or alteration of external appearance that does not significantly affect the taste, nutritional value, or storability of produce.[87] Farmers must comply with cosmetic standards or risk having their fruit, nuts, and vegetables rejected. With comparatively little bargaining power, growers respond by applying pesticides more frequently than they might otherwise choose. Thus our own fastidiousness as consumers is said to contribute substantially to pesticide usage.[88] Doubtless there is much to the charge, but what little analysis there is on this question suggests that the causality is at least more complex, and may even be reversed to some extent.[89]

Although fresh and processed foods are regulated differently, the outcomes for both farmers and consumers are much the same. The quality of processed foods, for example, has been regulated by the federal government since the scandals early in this century.[90] To protect consumers, the FDA maintains maximum allowable defect levels, which include tolerances for the presence of insect debris in processed food as it appears in the market. However, the food processing industry sets unofficial standards that are far more stringent. Processors frequently exceed the FDA standards by applying them to the raw produce as it comes from the farm, instead of intended point of regulation—their own cleaned and processed output. Furthermore, processors often contract growers to provide produce that is virtually free of insects, weeds or pest damage, and they sometimes stipulate preventative spraying schedules.[91] Condemnation of produce due to insect contamination is a ruinous prospect growers and

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87. M. BROWN, R. GARCIA, C. MAGOWAN, A. MILLER, M. MANN, D. PELZER, J. SCHWARTZ & R. VAN DEN BOSCH, INVESTIGATION OF THE EFFECTS OF FOOD STANDARDS ON PESTICIDE USE 10 (U.S. EPA CONTRACT 68-01-2602. National Technical Information Service, PB 278-976)(1976)[hereinafter BROWN].

88. *E.g.*, DETHIER, *supra* note 2, at 125-26; PESTICIDES AND HUMAN WELFARE 242, 254 (D. Gunn & J. Stevens eds. 1976); WELLFORD, *supra* note 4, at 275.

89. For a discussion of cosmetic standards in fresh produce, see BROWN, *supra* note 87. This Van Den Bosch report to EPA elicited concern and vigorous rebuttals. *See, e.g.*, Walsh, *Cosmetic Standards: Are Pesticides Overused for Appearances Sake?* 193 SCI. 744 (1976); Barnes, *Pesticide Use: CAST Review of EPA Report,* 194 SCI. 998 (1976); NATIONAL ACADEMY OF SCIENCE, supra note 57, at ch. 7; PERKINS, *supra* note 2, at 267-68; VAN DEN BOSCH, *supra* note 4, at ch. 10.

90. *See, e.g.*, JACKSON, *supra* note 67; O. ANDERSON, THE HEALTH OF A NATION (1958); U. SINCLAIR, THE JUNGLE (1906); WHORTON, *supra* note 2, at 95-132.

91. On the tenuous relationship between "actual needs" and scheduled applications of pesticides, see, *e.g.*, BROWN, *supra* note 87; M. GREEN, PESTICIDES—BOOM OR BANE?, at 55-60 (1976); NATIONAL ACADEMY OF SCIENCE (1975), *supra* note 15, at 287. In some instances the requirements of mechanical harvesting and processing means that weeds or molds cannot be tolerated. Bundy, *Consumer Expectation and Innovation in Processed Food Production*, in ORIGINS, *supra* note 15, at 227.

processors can ill afford. When the processor exceeds federal standards farmers have no option but to comply.

As with fresh produce, however, the real driving force is likely to be competition within the food industry. Food packers and processors use quality standards to reduce their own need for wasteful cleaning and culling, and to restrict the quantity they must buy from contracted growers in high-yielding years.[92] Thus, processors facing stiff competition shift costs back to the farmer to avoid being squeezed between their own fixed costs of processing and transportation, and the inelastic market demand for food. Processors also fear that consumers will turn to rival products (including increasingly available fresh produce) if cosmetically-damaged, or microscopically-defiled merchandise is encountered.[93] As the industry complied with, and actually exceeded existing FDA standards, the regulators have only compounded matters by periodically increasing the stringency of their defect action levels so as not to lag too far behind industry performance. Hence, by regulating harmless insect debris to absurdly low levels, the federal government actively contributes to excessive pesticide use and thereby contravenes its other mandate—to minimize pesticide residues in food.[94]

Cosmetic perfection in food is thus a logical outcome in our economic system, given the technical utility of pesticides, the relatively inflexible demand for food, and the strong tendency toward overproduction. However, it is in food advertising that the image of cosmetic perfection reaches it pinnacle, and presumably works its influence on consumer preferences. Only recently has our massive isolation from the land, and the advent of TV provided opportunities for food packers, processors and supermarkets to "create" demands that have little to do with fundamental nutritional qualities.[95] It is not an inevitable human trait to desire visibly immaculate but less-than-wholesome food. This demand is a consequence of our technical capabilities and our urbanized capitalist system.

Whatever the complex origins of cosmetic standards, they have a number of adverse implications including greater reliance upon pesticides.[96]

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92. *E.g.*, BROWN, *supra* note 87. *See generally*, J. HIGHTOWER, EAT YOUR HEART OUT: FOOD PROFITEERING IN AMERICA (1975). In low-yielding years processors appear to lower their own standards accordingly, but this behavior is not well documented.

93. *E.g.*, DETHIER, *supra* note 2, at 126.

94. Pimentel, Terhume, Dritschilo, Gallahan, Kinner, Nafuss, Peterson, Zareh, Misiti & Haber-Schaim, *Pesticides, Insects in Food, and Cosmetic Standards*, 27 BIOSCIENCE 178 (1977) [hereinafter *Standards*]. For similarly confused policy intentions in Britain, see Southwood, *Pesticide Usage, Prodigal or Precise?* 3 BRIT. CROP PROTECTION CONF.—PESTS & DISEASES, PROCEEDINGS 603, 607 (1979).

95. Retailers must do more than simply sell produce to attract customers away from competitors. Brown, *An Orange is an Orange*, 17 ENV'T 6 (May 1975).

96. Much only superficially defective fresh and processed food is kept from consumers. This wastage, together with the necessity of heavier pesticide use, means higher production costs and perhaps lower returns for some farmers. But where commodities face an inelastic demand, eliminating

Furthermore, the outward appearance of perfection, obtained through higher pesticide usage, implies an added, although inconspicuous, threat to health. Worse than elevating our dependence on pesticides, high cosmetic standards actively inhibit the use of alternative pest-suppression strategies. The omnipresent threat of crop-rejection due to a minimal presence of insects or their damage meant that farmers were understandably reluctant to utilize alternative controls, and it remained economic suicide for them to adopt these biological methods unilaterally. Cosmetic standards in food not only forced farmers to spray heavily, but by maintaining obstacles to the alternatives, they assured that this situation continued.[97]

OBSTACLES TO THE ALTERNATIVES AND TO PUBLIC RESEARCH

Barriers to the Alternatives

Unlike the second-generation pesticides which had many factors operating in their favor, alternative pest-suppression methods must surmount serious barriers to their initial discovery and scientific development, and then to their acceptance and use by farmers. The alternatives to relying solely on repeated applications of broad-spectrum synthetic pesticides are not easily characterized because they are diverse. They involve various combinations of techniques, among which are: biological control by naturally-occurring or artificially-augmented predators, parasites and diseases; cultural practices that interfere with pest survival and reproduction or facilitate biological controls; plant breeding for pest-resistance in crops; routine monitoring of insect populations in the field to allow minimally-disruptive and well-timed applications of conventional pesticides; and use of highly-specific, biologically-rational chemicals or processes that mimic the pest's own chemical signals and thereby pre-empt successful reproduction.

The common strategy is to rely simultaneously upon the careful integration of many different techniques, and not on one technique heavily enough to induce genetic resistance. The unifying objective is to suppress pest populations to levels just below their threshold for economic damage. Known as integrated pest management [IPM],[98] this approach and its

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excess supplies may be rational for growers if by preventing precipitous price collapses it maintains farm incomes. Indeed there is evidence suggesting that cosmetic standards are sometimes used for such purposes. BROWN, *supra* note 87.

97. BROWN, *supra* note 87; *Standards, supra* note 94.

98. For an excellent review of IPM strategies, see PERKINS, *supra* note 2. He also distinguished IPM from Total Population Management [TPM] where the objective is regional eradication; *see infra* note 107 and accompanying text. *See also* DEBACH, *supra* note 77; M. FLINT & R. VAN DEN BOSCH, INTRODUCTION TO INTEGRATED PEST MANAGEMENT (1981); HUFFAKER, *supra* note 62; NEW TECHNOLOGY OF PEST CONTROL (C. Huffaker ed. 1980); R. VAN DEN BOSCH, P. MESSENGER & A. GUTIERREZ, AN INTRODUCTION TO BIOLOGICAL CONTROL (1981).

variants have proved extremely effective in many instances, and they almost always result in reductions of both pesticide use and the costs of agricultural production.[99] Despite an impressive history of successes, and considerable potential for reducing pesticide use through new developments in IPM, by 1970 these alternatives remained a conceptual strategy more than a widely-applied method of control.[100]

The development of these new pest control strategies was impeded by serious economic constraints stemming from biological and institutional sources. Each of the alternatives suffers from one or more of the following problems. First, IPM solutions usually apply to a narrow range of situations—often to a single pest species, region or crop. Such narrow applicability confines their potential market. Second, IPM programs necessitate detailed knowledge of the complex dynamics within entire agro-ecosystems and consideration of various techniques in combination, instead of relatively simple data on the susceptibility of single target species to a limited number of chemicals and doses. Hence, their discovery tends to require large commitments, including costly international searches for useful predators, parasites and diseases, or other bio-rational methods.[101]Research-intensive methods require proportionately large markets if private development is to occur. Third, many IPM techniques involve living organisms and cultural practices that are not readily patented, thus further reducing the incentives for private research. This hurdle is occasionally surmounted, for instance, when beneficial insects need regular augmentation from commercially-raised populations, when IPM know-how can be sold as a service, and when a bacterium or bio-rational chemical offers to control pests of considerable economic significance. Even so, any additional burden for testing imposed by the government prior to registration can and has quickly discouraged private investors.[102]

Because they are highly-specific, knowledge-intensive, or nonpatentable, the IPM alternatives are logical candidates for public sector sponsorship.[103] Indeed, most of the environmentally-benign alternatives already

99. *E.g.*, HUFFAKER (1980), *supra* note 98, at 21; PERKINS, *supra* note 2, at 89. Among the successes of IPM are impressive biological controls of exotic weed infestations -including Klamath weed in California, and *Opuntia* in Australia.

100. *See, e.g.*, VAN DEN BOSCH, *supra* note 4, at 173; PERKINS, *supra* note 2. An important exception was the California citrus industry. Howard, *supra* note 86.

101. There are numerous examples where beneficial insects from overseas have been successfully introduced. DEBACH, FLINT & VAN DEN BOSCH, HUFFAKER, VAN DEN BOSCH, MESSENGER & GUTIERREZ, *supra* note 98. Some bio-rational techniques do not involve imported organisms. A notable example was the mass release of sterilized male Screw Worm Flies. PERKINS, *supra* note 2, at 97.

102. *See, e.g.*, Djerassi, Shih-Coleman, & Diekman, *Insect Control of the Future*, 186 SCI. 586 (1974); PERKINS, *supra* note 2, at 203, 282; Tucker, *supra* note 59; WELLFORD, *supra* note 4, at 280-92.

103. *E.g.*, Ruttan, *Changing Role of Public and Private Sectors in Agricultural Research*, SCI. 23 (1982). This case for public sector funding of IPM research is further strengthened since many of the of the benefits of IPM are collectively shared outside the farm sector, by the entire population of consumers. In contrast is the commercial attraction of genetic engineering, *e.g.*, Buttel, *supra* note 34, at 92-94.

in existence emerged from land-grant colleges and USDA laboratories. While clientele-oriented research on pest control has always flourished, the government's emphasis on nonchemical methods has necessarily been erratic. WWII seriously curtailed activity in this promising area. Hostilities closed down the search in foreign countries for bio-control agents. Wartime priorities redirected research, funding and personnel toward chemical techniques that promised immediate war-related pay-offs. Once the war intervened, other factors compounded the attrition. Broad-spectrum pesticides had proved so enormously successful that alternatives seemed entirely unnecessary, and research entomologists were understandably infatuated by the opportunities for funding and career development in chemical-related research.[104] Moreover, the pesticide industry has never been enamored of government-subsidized research into techniques that would compete with chemical sales.[105] Hence, funding for the biological control did not recover to pre-war levels until after 1950.[106] Recovery began only after the belated appearance of problems associated with pesticide use—their external costs (environmental contamination, health hazards) and their internal failures (resurgence, pest creation, resistance). Moreover, USDA and university researchers were strongly divided over how best to get off the treadmill created by these insecticide failures. Without a united front, the profession was less effective than it might have been in advocating rapid investigation and development of the alternatives, and thus reductions in our chemical dependence.[107] IPM research finally received substantial federal funding early in the 1970s.[108] Following an IPM development, the next serious barrier was convincing farmers to use such pesticide-sparing methods.

Farmers have been reluctant to adopt available IPM technology for several reasons. First, the economics of pest damage and crop protection are intrinsically uncertain so it was by no means clear to the farmer that alternatives held the advantage.[109] Second, IPM approaches do not eliminate the pest species but maintain them at levels below their threshold for damage. The concept that previously ruinous pests should not be eradicated was unsettling for financially-extended farmers. Third, production loans and growers contracts frequently required pesticide appli-

104. Indicative of the transition to chemical research, papers on the biology and biological control of pests reported in the J. ECON. ENTOMOLOGY fell from 33% in 1937 to 17% in 1947, while space devoted to chemical testing rose from 58% to 76%. Jones, *Agricultural Entomology*, in HISTORY OF ENTOMOLOGY 307, 326 (F. Smith, T. Mittler & C. Smith eds. 1973).

105. *E.g.*, PERKINS, *supra* note 2, at 68, 203-204.

106. *See, e.g.*, DUNLAP, *supra* note 2, at 73; HADWIGER, *supra* note 31, at 165; PERKINS, *supra* note 2, at 68.

107. Letter to author from Professor John H. Perkins, Dean of Science, Evergreen State College, Olympia, WA. (Jan. 27, 1985). *See also* PERKINS, *supra* note 2.

108. *See*, HADWIGER, *supra* note 31, at 166; PERKINS, *supra* note 2, at 85-89, 61-160.

109. *Supra* note 10 and accompanying text. Moreover, diffusing technical innovations is generally problematic, almost always exhibiting a threshold. *See* E. ROGERS WITH F. SHOEMAKER, COMMUNICATION OF INNOVATIONS (1971).

cations. Fourth, cosmetic quality standards that call for produce virtually free of insects and pest damage discourage IPM strategies. Fifth, IPM occasionally requires cooperation between farmers because the technique is not interchangeable with chemical use on a small scale and because farmers cannot unilaterally defy informal grade standards for cosmetic perfection.[110] Sixth, because IPM generally necessitates regular monitoring of insect populations, it implies both additional labor and expertise which farmers are sometimes reluctant to acquire.[111] Finally, the complexity and subtlety of IPM means that education is extremely important, yet many of the channels open to farmers are saturated with news about chemical innovations—channels that are economically and ideologically inimical toward IPM.[112]

Collectively these features of IPM considerably disadvantaged its commercial adoption, while pesticides continued to meet farmers' needs.[113] Chemicals are purchased in discrete quantities related exactly to needs. They require no cooperation with one's competitors or with government. They provide relatively inexpensive insurance against crop failure or market rejection, and their application requires little labor or information. As Perkins,[114] observes, "Chemicals also provided the illusion of complete mastery over nature: spray and your enemy was dead, usually before your very eyes." Therefore it is not surprising that the alternatives, which avoid relying solely on pesticides, have largely been adopted in situations where economically threatening pests were either intrinsically beyond the reach of conventional pesticide technology, or where insecticide failure after initial successes left insurmountable problems that literally threatened the economy of entire regions.[115] Even today farmers do not commonly adopt environmentally-benign, but less convenient, and more labor-intensive alternatives because they wish to reduce the social costs implicit in chemical use. So long as chemicals remain effective, they alone are the pest suppression technique best suited to the political, social and philosophical underpinnings of our highly-competitive, capital-intensive, and individualistic form of agriculture.[116]

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110. *Supra* notes 89-94 and accompanying text. *See also* Hall, *The Profitability of Integrated Pest Management*, 23 BULL. ENTOMOLOGY SOC. AM. 267 (1977). In situations where uncooperative neighbors continued applying chemicals extensively, the disruption to insect populations in surrounding areas jeopardized IPM programs. Highly individualistic farmers do not take readily to IPM plans for coordinated action, and in these instances the transaction costs have exceeded the capacity of existing institutions.

111. Hall, *supra* note 110.

112. *E.g.*, VAN DEN BOSCH, *supra* note 4, at ch. 13.

113. *Cf.* PERKINS, *supra* note 2, at 260.

114. *Id.*

115. *Supra* notes 83-84 and accompanying text.

116. PERKINS, *supra* note 2, at 265-87.

HURDLES TO RESTRICTING CHEMICALS ALREADY IN USE

Irresolvable Technical Uncertainty over the Risks

The risks inherent in pesticide use are usually unclear or poorly defined, even after there has been sufficient time and funding for scientists to gather relevant information. Whenever technical uncertainty over reputed adverse impacts cannot be resolved, the interests that benefit from a chemical's use can legitimately argue against the imposition of restraints by government (they may also ridicule and harass scientists who try to amass the case against their pesticides).[117] Consequently, irresolvable doubt about costs means that pesticides remain in use longer than they might otherwise.

The question of whether a pesticide causes cancer in humans, for instance, seems simple enough, but for several reasons we are usually unable to answer such questions from the strictly scientific viewpoint.[118] In attempting to resolve these matters it is first necessary to demonstrate that exposure occurs. Following three decades of heavy DDT use, there was still some technical debate over whether the residues detected by available instruments were actually DDT or PCBs—another persistent and ubiquitous environmental contaminant.[119] Second, once it has been established that we are exposed and that DDT is ubiquitous in human adipose tissue, it must also be shown that such exposures actually have harmful consequences, such as cancer production. Analysis shows that it is unlikely this question will ever be definitively answered by science.[120] It is extremely difficult to prove that something causes cancer in humans.[121] Even in such seemingly obvious cases as cigarette smoking, decades of expensive research have merely established a statistically-

117. *E.g.*, *supra* note 75 and accompanying text. Many critics see these instances as evidence of conspiracy, but like everyone else, the agri-chemical lobby is "inextricably bound up in its own need for symbolic reassurance". Wynne, *Redefining the Issues of Risk and Social Acceptance*, 15 FUTURES 13, 24 (1983). Even pesticide critics have manipulated data in a manner consistent with their ideology. *E.g.*, MacIntyre, *A Case Study: An Outsider's View of the DDT Decision* paper prepared for the Environmental Studies Board, National Academy of Sciences (1975). *See generally* Rushefsky, *Technical Disputes: Why Experts Disagree*, 1 POL'Y STUD. REV. 676, 679 (1982); Miller, *Psychosocial Origins of Conflict Over Pest Control Strategies*, 12 AGRIC., ECOSYSTEM, & ENV'T 235 (1985). In many instances the costs of technology are nevertheless borne disproportionately by the weak and disorganized.

118. Comparable doubts existed about most of DDT's reputed ill-effects on wildlife and the environment.

119. *E.g.*, DUNLAP, *supra* note 2, at 135, 168, 188.

120. Such answerable questions have been termed "trans-scientific". Weinberg, *Science and Trans-science*, 10 MINERVA 209 (1972). *See also* Blodgett, *supra* note 2, at 273-74; Green, *The Resolution of Uncertainty*, 12 NAT. RES. J. 182 (1972); McGarity, *Substantive and Procedural Discretion in Administrative Resolution of Science Policy Questions*, 67 GEO. L. J. 729 (1979); Rushefsky, *supra* note 117; Tversky & Kahneman, *Judgement Under Uncertainty*, 185 SCI. 1124 (1974).

121. *E.g.*, LOWRANCE, *supra* note 63, at 12-74.

significant correlation and not the precise cause of lung cancer.[122] In the case of DDT, the data on existing human exposures are subject to several unresolvable doubts, and experiments with laboratory animals are of questionable relevance to the human situation.[123] Without proof of harm to humans, those opposing pesticides are left strategically weakened in a society whose legal structure is committed to technically-driven economic growth.

The Law of Nuisance

Not only were the critics placed at a political disadvantage by the scientific difficulty of proving, among other things, that DDT disrupted bird populations and caused cancer in humans, the law was against them as well. Policy questions involving technical doubt always presuppose some allocation of the burden of proof. Whenever an issue is sufficiently uncertain that a case cannot be conclusively proven on either side, the party with the burden of proof automatically loses. Since that burden fell on the critics, technical uncertainty had the more serious consequence of precluding legal remedies against DDT use,[124] even though it had by then dispersed and accumulated in wildlife throughout the entire planet.

This tremendous bias, the common law of nuisance, was incorporated into the statutory law covering pesticides, implicitly at first, but then with increasing clarity: the Insecticide Act of 1910 was exclusively concerned that farmers should not be defrauded by ineffective or adulterated products.[125] So long as these chemicals were effective against pests, various

122. For decades, cigarette manufacturers have contested the evidence against tobacco smoking. *See*, A. FRITSCHLER, SMOKING AND POLITICS (1983).

123. *See, e.g.*, Consolidated DDT Hearings, 37 Fed. Reg. 13,369-13,376 (1972); Weinberg, *supra* note 120.

124. The legal allocation of burdens is crucial to understanding why second-generation pesticides received such unrestrained use. Traditional burdens of proof evolved in the courts during the era when industrial development, economic growth, and westward expansion were being greatly encouraged. *E.g.*, Krier, *Environmental Litigation and the Burden of Proof*, in LAW AND THE ENVIRONMENT 105-22 (M. Baldwin & J. Page eds. 1970). A person who challenged an enterprise had the burden of showing actual or impending harm to himself in order to obtain injunctive relief. W. PROSSER, HANDBOOK OF THE LAW OF TORTS 587 (4th ed. 1971); 42 AM. JUR. 2d INJUNCTIONS 587 § 39 (1969). For critiques of the burden of proof, see Note, *Imminent Irreparable Injury: A Need for Reform*, 45 S. CAL. L. REV. 1025 (1972); Comment, *The Burden of Proof in California Environmental Nuisance Cases*, 9 U. CAL. DAVIS L. REV. 679 (1976). If the plaintiff could meet the heavy burden of proof, he was then required to show that his loss outweighed any inconvenience to the entrepreneur and any detriment to the community-at-large. For critiques of this subsequent balancing of interests, see Note, *Right to Injunction in a Private Suite*, 19 U. KAN. L. REV. 549 (1971); Note, *Injuctive Relief Denied in Private Action for Nuisance Caused by Industrial Polluter*, 45 N.Y.U.L. REV. 919 (1970). On the significance of reversing these burdens, see Carmichael, *Strict Liability in Tort - An Explosion in Products Liability Law*, 20 DRAKE L. REV. 528 (1971); R. EPSTEIN, A THEORY OF STRICT LIABILITY (1980). The burden of proof and this balancing of interests precluded suits against uncertain, long-term pesticide hazards so long as agricultural benefits and public health purposes could be shown.

125. *Supra* note 43 and accompanying text.

laws actually encouraged innovation by providing patents, by sanctioning the presence of minimal residues in food, and by requiring strict proof of causation from those who claimed the technology harmed them. The statute was rewritten in 1947 to require federal registration of all "economic poisons" in order to more effectively protect farmers and homeowners against useless materials and unscrupulous sales. Fearing such a veto power over their profits, the manufacturers conceded to federal licensing only after the bill was modified to explicitly place the burden of proof on government.[126] Hence, new products would be registered automatically, "under protest" if necessary, until the USDA could show in court that a product was ineffective.

Sixteen years later, in 1963, after concerns for pesticide hazards finally reached the social agenda, the provision for protest registration was eliminated. However, Congress kept the evidentiary burden on government by providing manufacturers with three successive opportunities for appeal. While observers have commonly assumed that those amendments reversed the burden of proof, it was not until 1971 that a federal judge actually accomplished this reversal—in a deftly concealed sleight of hand.[127] Even then, the government continued to bear a considerable evidentiary burden, and it must still weigh costs against benefits when deciding for or against a pesticide. In those instances when administrators either want to keep or remove pesticides from the marketplace, they face an almost insurmountable burden. This is because the facts are rarely conclusive and the standards against which available evidence must be evaluated are themselves unclear and contradictory.[128] So, a significant outcome of these long-established rules of evidence was to encourage the invention and use of chemical pest suppression. This was accomplished simply by protecting pesticides from their detractors through a legal procedure.[129]

Obstacles to Gathering Environmental Intelligence

In addition to such unresolvable questions and this heavy burden of proof, the collection of information on the environmental and health effects of pesticide use is by no means automatic. Some of the factors

126. The legislative history of the statute clearly shows that the manufacturers wanted protection against fraudulent dealers and the growing variety of state regulations. Whitaker, *supra* note 2, at ch. 12.

127. Environmental Defense Fund v. Ruckleshaus, 439 F.2d 584 (D.C. Cir., 1971). For an analysis of this case, the legislative history of "protest" registration and the Court's manipulation of that history, see MacIntyre, *A Court Quietly Rewrote the Federal Pesticide Statute*, 7 L. & POL'Y 249 (1985). Congress subsequently ratified this judge-made law with the passage of FEPCA in 1972.

128. For a brief review see MacIntyre, *Administrative Initiative and Theories of Implementation: Federal Pesticide Policy*, 1970-1976, in PUBLIC POLICY AND THE NATURAL ENVIRONMENT, 4 PUBLIC POLICY STUDIES: A MULTI-VOLUME TREATISE 205, 211 (H. Ingram & K. Godwin eds. 1985).

129. *See also* Junger, *A Recipe for Bad Water: Welfare Economics and Nuisance Law Mixed Well* 27 CASE W. RES. L. REV. 3 (1976).

that complicate and delay intelligence gathering have been mentioned already: relative to their conspicuous benefits, the adverse impacts of pesticides are slow to materialize, sometimes entirely unanticipatable, and often socially inconspicuous even after scientific discovery.[130]

Pesticide residues in food are invisible to the unaided senses, their effects on wildlife are usually subtle and the human health questions are often unanswerable. Consequently growth in our understanding of the costs of pesticide use depended upon unrelated improvements in the sensitivity of detection instruments, independent research on wildlife populations, and Rachel Carson's ability to tip the political scales toward the costly funding of long-term feeding studies with laboratory animals by sources *outside* the agriculture arena. In addition to the expense, such research takes five or more years to complete, and was itself undergoing continual refinements in protocol. Also, the nascent ability to define and assess potential costs of pesticides was being inundated by the rate at which new chemicals were introduced into commerce. Moreover, pesticides are applied in highly dispersed and very decentralized settings that are not easily observed. While the health consequences of the more toxic pesticides can be immediate and very obvious to those occupationally exposed, farmworkers are neither well situated to remedy their own dilemma, nor is their situation easily comprehended by outsiders.[131] These intrinsic features of pesticide use make the study of its consequences difficult and expensive.

It is possible to distinguish conceptually between the foregoing, largely-incidental hurdles, and deliberate obstruction to the collection of information about the consequences of pesticide use.[132] Compounding such incidential hurdles as cost and invisibility, research into the drawbacks of pesticides has been further discouraged by professional norms and occasionally by political obstruction.

The public research establishment evolved in the service of commercial agriculture.[133] The tremendous success and apparent safety of synthetic pesticides were soon bolstered in the following manner: farmers and pesticide manufacturers provided the USDA and universities with political support for research on improved pesticide know-how. Congress funded research on pesticide effectiveness and explicitly discouraged critical research.[134] Meanwhile publicly-funded and industry-contracted researchers

130. *Supra* notes 63-64, 71-72, 118-23 and accompanying text.

131. *E.g.*, Greenstone, *Farmworkers in Jeopardy: OSHA, EPA, and the Pesticide Hazard*, 5 ECOLOGY L. Q. 69 (1975). *See generally* R. KAZIS & R. GROSSMAN, FEAR AT WORK: JOB BLACKMAIL, LABOR, AND THE ENVIRONMENT (1982).

132. On the significance of relative tractability in policy problems, see D. MAZMANIAN & P. SABATIER, IMPLEMENTATION AND PUBLIC POLICY 21-25 (1983).

133. *Supra* notes 32-40, 98-99 and accompanying text. University entomologists working on IPM alternatives to the pesticide treadmill also shared this utilitarian norm.

134. HADWIGER, *supra* note 31, at chs. 7, 8.

developed their careers in this lucrative field, becoming experts on, and champions of chemicals designed to increase the productivity of agriculture 'to feed a starving world'. An important consequence of these mutually-agreeable interactions was an over commitment of research capability to the discovery, production, and application of chemical technology.[135] Relatively few resources were expended to develop less-disruptive alternatives and even fewer to document the adverse impacts of pesticides. Funding independent from industry or government was virtually nonexistent. Within the land grant college establishment the narrow focus on chemical techniques was reinforced through training while the processes of academic peer review used in the funding, scrutiny and publication of research discouraged the expression of doubts about the beneficence of pesticide technology.

Occasionally these subtle peer pressures on scientific missions became so overt that political pressures were obviously being applied from outside the usual processes of academic review. Skeptical scientists have been harassed, and had their access to publishers threatened or blocked.[136] National Academy committees have been stacked with production-oriented scientists.[137] Government agencies have frustrated research efforts to evaluate the effectiveness of spray programs even when efficacy was in doubt.[138] Research results critical of pesticides have been unreasonably delayed from public release.[139] There has even been serious fabrication of toxicity test data (including efforts to cover this up) by a private research facility that relied solely on industry-funded research explicitly intended to meet regulatory requirements.[140] Only the blatant attempts at limiting the scope of conflict are detected while many more go unrecorded. Perhaps more important than all this deliberate obstruction, and certainly more continuous in effect, were the subtle and decentralized influences shaping

135. Both research opportunities and scientific manpower were biased toward chemical technology. *E.g.*, SCHNAIBERG, *supra* note 75, at 277-315.

136. *See, e.g.*, *Id.*; *supra* note 117 and accompanying text; GRAHAM, *supra* note 75; VAN DEN BOSCH 4, *supra* note 4, at 55-59, 90-95. For other USDA nonpesticide examples, see HADWIGER, *supra* note 31, at 53-54; Buttel, *supra* note 34, at 89, 91; A. SCHIFF, FIRE AND WATER: SCIENTIFIC HERESY IN THE FOREST SERVICE (1962). *See generally*, Martin, *The Scientific Straitjacket: The Power Structure of Science and the Suppression of Environmental Scholarship*, 11 ECOLOGIST 33 (1981); Miller, *Professional Dissent and Environmental Management*, 4 ENVIRONMENTALIST 143 (1984).

137. *See* BOFFEY, *supra* note 4, at ch. 9; Grobstein, *The Role of National Academy of Sciences in Public Policy and Regulatory Decision Making*, in LAW AND SCIENCE IN COLLABORATION (J. Nyhart & M. Carrow eds. 1983).

138. *E.g.*, The U.S. Forest Service has frustrated scientific efforts to investigate the benefits of spraying, even when a chemical's efficacy was doubtful. *E.g.*, VAN DEN BOSCH, *supra* note 4, at 78.

139. *E.g.*, PRIMACK & VON HIPPEL, *supra* note 75, at 74-86; Kolojeski, *Federal Administrative Trial of a Carcinogen*, ORIGINS OF HUMAN CANCER 1715, 1717 (H. Hiatt, J. Watson & J. Winsten eds. 1977).

140. *See* Schneider, *Faking It: The Case Against Industrial Bio-Test Laboratories*, 4 AMICUS J. 14 (No. 4, 1983); *IBT-Guilty: How Many Studies are No Good?*, 5 AMICUS J. 4 (No. 2, 1983); Dowie, Foster, Marshall, Weir & King, *The Illusion of Safety*, 7 MOTHER JONES 36 (1982).

the entire agricultural research agenda, and the sheer rate of pesticide innovation that continually swamped our limited capacity to assess adverse impacts which are far from obvious or certain. Nevertheless, it is the extreme examples of coercion or manipulative intrusion against critical research that fuel, and perhaps justify, fears of some "capitalistic" conspiracy.

When divining the significance of such influences, however, it is important to keep them in perspective. At least two facts mitigate allegations of an effective conspiracy. First, it is a serious mistake to equate massive imbalances in the distribution of research capability, on the one hand, with a consistent ability to convert those superior resources into favorable policy results.[141] Technical controversies in America are replete with David and Goliath stories, of which *Silent Spring* was one. Simply stated, it does take technical skills and other resources to demolish scientific analyses, but many fewer than are required to construct and defend the original argument or program.[142] Given sufficient government-sanctioned secrecy, conspiracy can be effective.[143] However, with the institution of administrative decisonmaking based upon an open and challengeable record, relatively weak elements can prevail, or at least exert countervailing influence disproportionate to their size. Moreover, deliberate obstruction, once revealed to the public, has sometimes disarmed the corporate giant in U.S. politics.[144] Second, deliberate obstruction of environmental intelligence gathering is but one of many factors that favored pesticide use over time. Collusive obstruction certainly contributed to the overall picture but without absolving subgovernment conspirators of responsibility for their part, this analysis suggests that many, and more fundamental, forces would have operated to much the same effect even if conspiratorial influences were entirely absent.

LOPSIDED POLITICS AND INSTITUTIONAL BIAS

Veto Power of the Pesticide Subgovernment

The American combination of congressional fragmentation, weak political parties, and delegation of law-writing authority to specialized com-

141. *E.g.*, Wilson, *Democracy and the Corporation*, Wall St. J., Jan. 11, 1978.

142. H. MARGOLIS, TECHNICAL ADVICE ON POLICY ISSUES 39 (1973).

143. The British utilized secret procedures to reach an opposite conclusion from the United States, which utilized identical information on the same pesticide considered in open procedures. Gillespie, Eva & Johnson *Carcinogenic Risk Assessment in the United States and Great Britain: The Case of Aldrin and Dieldrin*, 9 SOC. STUD. OF SCI. 265 (1979). On the role of secrecy in British government, see D. ASHFORD, POLICY AND POLITICS IN BRITAIN 16-17 (1981). A contrast similar to British v. U.S. decisionmaking exists between early USDA and EPA procedures that superseded them.

144. *E.g.*, the United States policymaking tide was reversed following the revelation that General Motors had spied on Ralph Nader. M. NADEL, THE POLITICS ON CONSUMER PROTECTION 137-54 (1971). Generally, Americans are sensitive to perceived inequities in the allocation of burdens and rewards. G. WALSTER & E. BERSCHEID, EQUITY: THEORY AND RESEARCH (1978).

mittees has long maximized opportunities for blocking controversial legislation. Yet chairmen of legislative committees retained considerable informal power to oversee agencies within their jurisdiction. Unless there is some concerted showing of outside pressure for change, congressional committees often defined policy discreetly in collaboration with an administrative bureau and the organized interests deeply affected by its operations. These tripartite coalitions, or subgovernments, frequently have the autonomy to adopt and implement seriously biased policies (the agricultural research subsystem is a case in point).[145] Powerful committee chairmen can protect their clientele, agencies and policies by resisting undesired initiatives simply with a veto or crippling compromise when corrective legislation is proposed by outsiders.

The agriculture committees and appropriations subcommittees of Congress routinely attracted members from rural electorates who sought to engage in the quiet logrolling that provided their constituents with access to federal largesse. For about one hundred-years these committees have served commercial agriculture, for example, by creating a clientele-oriented Department of Agriculture [USDA], by providing price supports, access to cheap labor, protective barriers against imported commodities, and by fostering the development of improved farm technologies.[146] In the case of pesticide policy, two distinct but complementary subgovernments have sponsored chemical pest suppression techniques first through favorable appropriations for chemical research, and second by regulating only against ineffective products and assuring a pro-pesticide bias by delegating licensing authority to the sympathetic USDA.

For decades these subgovernments made decisions with undisputed autonomy.[147] Their subject matter attracted little public attention, and even less interference, from the collective body of Congress, from the White House, the media, or non-farm groups. When criticisms of pesticides began surfacing in the late 1950s, each of the agriculture committees

145. For the literature on subgovernment (or "subsystem") policymaking, see D. CATER, POWER IN WASHINGTON (1964); Davidson, *Breaking Up Those 'Cozy Triangles': An Impossible Dream?*, in LEGISLATIVE REFORM AND PUBLIC POLICY 30 (S. Welch & J. Peters eds. 1977); L. DODD & R. SCHOTT, CONGRESS AND THE ADMINISTRATIVE STATE (1979); J. FREEMAN, THE POLITICAL PROCESS (1965); FRITSCHLER, *supra* note 122; E. GRIFFITH, CONGRESS: ITS CONTEMPORARY ROLE (1961); LOWI, *supra* note 22; A. MAASS, MUDDY WATERS (1951); R. RIPLEY & G. FRANKLIN, CONGRESS, THE BUREAUCRACY, AND PUBLIC POLICY (1976). For an excellent account of the historical origins of subgovernments emphasizing science-based policy, see DUPREE, *supra* note 29. The growth of public participation and litigiousness during the 1960s and the 1970s forced subgovernment coalitions to expand their active support. *See*, Heclo, *Issue Networks and the Executive Establishment*, in THE NEW AMERICAN POLITICAL SYSTEM (A. King ed. 1978); Wamsley, *Policy Subsystems as a Unit of Analysis in Implementation Studies*, paper presented at Erasmus University, Rotterdam (June 1983). On the agriculture subgovernment, see Hadwiger, *supra* note 13, at 506.

146. *E.g.*, Hadwiger, *supra* note 13; *supra* notes 30-40 and accompanying text.

147. *See, e.g.*, Blodgett, *supra* note 2, at 271; WELLFORD, *supra* note 4; GRAHAM, *supra* note 75; MacIntyre, *supra* notes 127 and 128.

effectively shielded and encouraged the USDA policy of unrestrained pesticide use. This was done by steadfastly blocking policy reforms responsive to emerging knowledge about the hazards and failures inherent in second-generation chemical technology.[148]

The agriculture committees proved especially capable of maintaining their hegemony over pesticides from WWII through the early 1970s. Rural interests were heavily over-represented in Congress until the Supreme Court ordered reappointment in 1964. Even after redistricting, conservative democrats from the rural South continued to dominate the legislature, particularly the House of Representatives.[149] In particular, Southerners controlled the entire agriculture jurisdiction in Congress, [150] so coalition building in agricultural price supports was dominated by cotton until 1973.

This predominance of conservative Southerners was significant for pesticide policymaking for two reasons. First, cotton had long been a

148. Blodgett, *supra* note 2, at 218-20, 271.

149. Due to their long tenure in the single-party South, and a strict seniority system for assigning committee chairmanships, Southern democrats held a disproportionate number of the important (veto) positions in Congress. *E.g.*, Rieselbach, *Legislative Change, Reform, and Public Policy*, in ENCYLOPEDIA OF POLICY STUDIES 359, 383, note 5 (S. Nagel ed. 1983); CONGRESS IN CHANGE 74 (N.J. Ornstein ed. 1975); J. BURNS, THE DEADLOCK OF DEMOCRACY 253 (1963); B. HINCKLEY, THE SENIORITY SYSTEM IN CONGRESS (1970). Thus, the Southern democrats elicited considerable deference from junior legislators who wanted access to the pork barrel, and from successive presidents who sought re-election, domestic policy changes, or civil rights reform.

150. *See, e.g.*, Barton, *Coalition-Building in the United States House of Representatives: Agricultural Legislation in 1973*, in CASES IN PUBLIC POLICYMAKING 141 (J. Anderson ed. 1976); Hardin, *Agricultural Price Policy: The Political Role of the Bureaucracy*, in THE NEW POLITICS OF FOOD (D. Hadwiger & W. Browne eds. 1978); MEIER, *supra* note 14, at 136.

Jamie Whitten (D-Miss.) came to Congress in 1941, joined the House Agriculture Appropriations Subcommittee the following year, and has chaired it since 1949. He is renowned for exercising detailed oversight and precise item vetoes in the annual allocation of research funding. *E.g.*, HADWIGER, *supra* note 31, at ch. 7. In so doing, he has championed the interests of commercial agriculture in general and cotton growing in particular. He is an ardent defender of pesticides . Indeed, with industry sponsorship, he authored a vehement rebuttal to Rachel Carson. *See*, M. GREEN, J. FALLOWS & D. ZWICK, WHO RUNS CONGRESS 80 (1972); J. WHITTEN, THAT WE MAY LIVE (1966). Since Chairman Whitten's views have long been important and well known in the agricultural research community, he has presumably encouraged the development and use of chemical pest control and effectively precluded and delayed research on the costs and failures of pesticides. *See, e.g.*, HADWIGER, *supra* note 31, at 125, 137, 163, & 166; RIPLEY & FRANKLIN, *supra* note 145, at 60-63, 84-85, 115-18. Congressman Whitten took a particular interest in funding Mirex spraying in the South to combat the imported fire ant. *E.g.*, BOFFEY, *supra* note 4, at 211-14; Maney, *The Fire Ant Controversy*, in HADWIGER & BROWNE, *supra* note 150; McGarity, *The Death and Transfiguration of Mirex*, 3 HARV. ENVTL. L. REV. 112, note 21; WELLFORD, *supra* note 4, at 286-309; Wolff, *Making Mountains Out of Fire Ant Mounds*, AUDUBON 138, 139 (July 1976).

Also, the House Agricultural Committee was chaired by three Southern democrats between WWII and 1974. But, the role of individual legislators should not be overemphasized. The structure of legislative institutions, the nature of interest representation, and the selection and socialization of members with historically-molded world views can promote policy continuity in the face of seemingly dramatic shifts of personnel. In 1975, the stability of attitudes in the House Agriculture Committee was notable even though the chairmanship went to a region outside the South for the first time in decades.

mainstay in the relatively undiversified Southern economy, and second, cotton production experienced perhaps the worst case of pesticide addiction, escalating chemical use, and successive technological failures. "The production of cotton has utilized more pesticides than any other single crop in the U.S. since about 1950."[151] Thus, while pesticide policy attracted almost no attention from outsiders, it proved especially salient to the Southern democrats presiding over both the budget for agricultural research and the jurisdiction for regulating pesticides.

This conservative, rural continuity left its mark on policymaking. When the pesticide law was rewritten in 1947 the emphasis remained almost entirely on providing economic protection for the commercial farmer, and reputable manufacturers.[152] Fraudulent sales had mushroomed during the war. The USDA correctly assumed that its mission was primarily to assure pesticide users of effective and unadulterated products that were adequately labelled for safe application.[153] Consumer health was a matter left to the FDA by setting and enforcing "safe" levels of exposure to pesticide residues.

Yet, when the furor erupted over previously unknown pesticide impacts, critics attempted to read into the pesticide statute, the objectives of environmental protection and consumer health.[154] Such novel objectives were not voiced during the legislative history of the Federal Insecticide, Fungicide, and Rodenticide Act [FIFRA] of 1947.[155] Throughout the 1960's, the regulatory subgovernment responded to critics with window-dressing but otherwise it refused to restrict pesticide use administratively, and blocked proposals to amend FIFRA since all such bills were eventually referred to the agriculture committees.[156] Congress has forcibly overridden its agriculture committees on publicly visible and vulnerable matters, such as sugar and milk subsidies, but pesticide policymaking did not

151. PERKINS, *supra* note 2, at 40.

152. *See*, Whitaker, *supra* note 2, at ch. 12; Dubnick, *supra* note 28.

153. *E.g.*, Blodgett, *supra* note 2; NATIONAL ACADEMY OF SCIENCES (1975), *supra* note 15, at 21.

154. *E.g.*, CARSON, *supra* note 4; Rodgers, *supra* note 4; WELLFORD, *supra* note 4. In fact, the law governing pesticide use was outdated due to rapid chemical innovation, outmoded understandings and documentation of the new technology, and archaic burdens imposed by traditional nuisance law. Blodgett, *supra* note 2.

155. Whitaker, *supra* note 2, at ch. 12. A criticism subsequently leveled at the USDA was that, like the Atomic Energy Commission [AEC], its developmental activities were inconsistent with its regulatory responsibility. The analogy is very misleading because, unlike the AEC, the 1947 pesticide statute never did impose comparable regulatory objectives upon the USDA (this happened only in 1970 when a court reinterpreted FIFRA, see, *supra* note 127). The protection of consumer health was the focus of an entirely separate statute under which the FDA set tolerances to limit chemical residues in food (although prior to 1934, the FDA's predecessor bureau *had* been located within the USDA).

156. *See* notes 147, 148 and accompanying text.

similarly suffer frontal confrontation or defeat.[157] An important factor contributing to this continuing deference on pesticide policy, even in the face of mounting technical evidence of policy failure, was the relative lack of public concern or organized support for pesticide reform.

Lack of Mobilized Citizen Concern

Ultimately, the imbalance in pesticide use and policymaking, was made possible by the absence of a broad-based popular opposition. The pluralist struggle for influence over regulatory policy was necessarily one-sided. While a diverse coalition of organized interests and government bodies had long supported pesticide use, countervailing pressures remain particularly difficult to organize. And these pressures have not been consistently expressed against pesticides in America or elsewhere.

These organizational difficulties begin with the nature of the pesticide issue. Even though every citizen is routinely exposed to many pesticides, unlike our more directly-experienced problems, these chemical residues are hidden from casual observation. Their invisibility and the subtlety of long-term chronic health risks have kept the pesticide problem far from the public mind.[158] Meanwhile, consumer "preferences" for visibly perfect produce only reinforced a more insidious defilement of our food. There was little media initiative to highlight this contradiction for urban dwellers.[159] Research began illuminating pesticide problems in wildlife which attracted attention from some newspapers, but coverage generally remained sporadic and light. Pesticide news was almost always generated by events or exposés staged by entrepreneurs who sought to change policy.[160]

157. *E.g.*, price supports for milk in 1973 and then sugar in 1974 were forcibly deleted from the Farm Bill after prices of commodities attracted the ire of consumer groups. Guth, *Consumer Organizations and Federal Dairy Policy*, in HADWIGER & BROWNE, *supra* note 150; RIPLEY & FRANKLIN, *supra* note 145, at 92-93. For an overview of urban-based intrusions upon other agricultural subgovernments, see MEIER, *supra* note 14, at 126, 131-34. Agricultural subsidies are increasingly salient during inflationary times. Also, subsidies are procedurally vulnerable in Congress because they require repeated affirmative legislative action (authorization and appropriation) which transfers the veto power to any opponents (defeat is assured by a simple majority in one house, but usually much less where delicate coalitions are involved). By comparison, persticide residues are both less visible and less salient than price supports. Moreover, in the case of pesticides it was the agriculture committees that held the veto advantage, since changing the status quo required new legislation (passage requires a super majority of both houses and presidential concurrence if reform is to be forced upon a reluctant and powerful subgovernment). Therefore, changes in pesticide law ultimately came from extra-congressional sources—from the judicial and executive branches. *See* notes 181-84 and accompanying text.

158. *E.g.*, MacIntyre, *supra* note 128, at 232 ("the case for bureaucratic activism").

159. During the 1940s and 1950s, there was virtually no media coverage of pesticide hazards or the associated regulatory statues. *See*, Whitaker, *supra* note 2, at 405, 426, 429, 431, 447; DUNLAP, *supra* note 2, at 74.

160. *See, e.g.*, HADWIGER, *supra* note 31, at 160; E. LAWLESS, TECHNOLOGY AND SOCIAL SHOCK 276 (1977).

In addition to being inherently unlikely to elicit sustained public attention, pesticides illustrate a more general policy dilemma known as the public goods (or bads) problem: any large assemblage of people seeking some public good, a widely-diffused and collectively-shared amenity, such as the protection of human health or lower income taxes, are at a considerable disadvantage vis-a-vis smaller, economically-motivated groups when it comes to organizing for voluntary action in their common interest.[161] Among the factors that undermine effective mobilization by large groups are the high costs of creating, and maintaining, large organizations. Similarly, where public goods are predominant among organizational goals, the free-rider phenomenon discourages participation because any public good secured by group action is available to everyone regardless of whether they contributed to its attainment.

The organizations supporting pesticide use were not immune from these problems.[162] For example, farmers share a collective interest in conserving insecticide effectiveness yet remain unable to organize to slow the onset of pest resistance.[163] They also had considerable difficulty organizing to lobby government, until government itself did the job for them when it established the cooperative extension service and marketing orders.[164] With sufficient time, economic concentration and government encouragement, organizing became easier. The pesticide industry was also at one time a fragmented jumble of small entrepreneurs.[165] The chemical industry, and more recently agriculture, have become less numerous and economically more concentrated and corporate. From around WWII, relatively focused economic interests in agriculture have been capable of coordinated lobbying by a resilient, if diverse and decentralized, farm sector. The farm sector included participants such as state departments of agriculture, the Farm Bureau, various commodity organizations, land-grant colleges, the National Agricultural Chemical Association, and the food processing and marketing chains. They certainly do not agree on every detail of agricultural policy but they soon become a formidable coalition when pesticide use is challenged.[166]

In stark contrast to this effective pro-pesticide representation, groups

161. *See, e.g.*, OLSON, *supra* note 35; R. HARDIN, COLLECTIVE ACTION (1982); A. MCFARLAND, PUBLIC INTEREST LOBBIES (1976); Mitchell, *National Environmental Lobbies and the Apparent Illogic of Collective Action*, COLLECTIVE DECISION MAKING: APPLICATIONS FROM PUBLIC CHOICE THEORY 89 (C. Russell ed. 1979); Walker, *The Origins & Maintenance of Interest Groups in America*, 77 AMER. POL. SCI. REV. 390 (1983).

162. *E.g.*, OLSON, *supra* note 35, at 145-46.

163. *See* note 82 and accompanying text.

164. *See* notes 35-39 and accompanying text.

165. *Supra* notes 41-53 and accompanying text.

166. *See* notes 32, 146 and accompanying text; Rowland & Dubnick, *Decentralization of Agriculture*, FOOD POLICY AND FARM PROGRAMS 212 (D. Hadwiger & R. Talbot eds. 1982); MacIntyre, *supra* note 128.

seeking pesticide reform became viable and politically aggressive only in the late 1960s.[167] Their relatively slow appearance, lack of an economic base, and continuing difficulties with survival, as well as public apathy over pesticides, have delayed and weakened the potential changes that otherwise might have been imposed on pesticide use.

Absent public concern and until recently, effective citizen groups, the impetus for pesticide reforms has depended largely upon the initiative of private crusaders such as Rachel Carson, and the civic-mindedness of non-elected officials. And due to the subgovernment's tight control over the legislative agenda, virtually the only strategy left to reformers was to *create* newsworthy incidents in the hope of generating enough public concern to force elected officials from outside the pesticide power triangle into this closed arena. For example, the possible health impacts of synthetic pesticide residues were first brought to national attention early in November 1959 when, without advising USDA, the Secretary of Health, Education, and Welfare (FDA's superior) announced that some cranberries were contaminated with a herbicide which gave rats cancer. The suspect berries were withheld from market but the spectre of cancer prompted many consumers to forego their traditional Thanksgiving accoutrement.[168] Then in the summer of 1962 Carson dropped her bombshell:[169] *Silent Spring* was the first plainly-written indictment of a technology previously considered humanity's salvation. Coincidentally, Senator Kefauver made a dramatic media event of America's narrowly-averted thalidomide tragedy thereby circumventing congressional hostility and presidential indifference toward drug safety legislation.[170] Notwithstanding that remarkable demonstration of the potential for consumer politics, pesticide hazards failed to develop the popular appeal of drug safety issues. Carson's charges were reviewed and cautiously vindicated by the President's Science Advisory Committee which made sweeping recommendations to President Kennedy, who took no concerted actions.[171] He had no desire to annoy Southern democrats whose support was essential to making legislative

167. For discussion of how environmental groups have surmounted the hurdles to successful collective action, see Mitchell, *supra* note 161.

168. *See, e.g.*, Blodgett, *supra* note 2, at 211-22; DUNLAP, *supra* note 2, at 107-8.

169. DUNLAP, *supra* note 2, at 97-102.

170. *See, e.g.*, *Id.*, at 104-105; GRAHAM, *supra* note 75, at 61; NADEL, *supra* note 144, at 121-30; Quirk, *Food and Drug Administration* in THE POLITICS OF REGULATION (J. Wilson ed. 1980). Media events about deleterious effects of thalidomide were important because the safety of pharmaceutical drugs and pesticide residues are of similar concern to segments of the public, they attract the attention of the same citizen organizations, and these issues raise similar policy dilemmas. The contemporaneous, though accidental, appearance of the thalidomide scare and *Silent Spring* had a synergistic impact on the emergence of a consumers' lobby.

171. *See*, Blodgett, *supra* note 2, at 216-17; DUNLAP, *supra* note 2, at 113-16; PRIMACK AND VON HIPPEL, *supra* note 75, at 43-45.

progress on his social priorities.[172] Moreover, although the debate over pesticide risks was no longer a closed, and strictly technical affair, public attention soon waned when civil rights, JFK's assassination, the Great Society, and then Vietnam crowded onto the public agenda.[173] However, Carson had planted a seed but it did not germinate until seven years later when DDT was implicated as cancer producing.

Pesticides, notably the adverse impacts of DDT and the Agent Orange herbicides,[174] regained national headlines in 1969 as a secondary concern within the popular environmental movement. Instead of visible pollution incidents, it was a rapid succession of initiatives by outsiders that challenged the pesticide subgovernment. In that year the National Cancer Institute announced that several pesticides including DDT caused cancer in mice (thus shifting the existing emphasis on wildlife impacts to focus debate squarely upon human health for the first time); the FDA seized large quantities of DDT-contaminated salmon; the General Accounting Office issued two devasting reports on pesticide policy; a non-agriculture House subcommittee held oversight hearings and then released its scathing report; a private group called the Environmental Defense Fund attained considerable publicity in its Wisconsin trial against DDT;[175] several states banned or restricted use of the chemical; and the Secretary of Health, Education & Welfare's [HEW] Commission on Pesticides recommended phasing out all non-essential uses of DDT within two years.[176] The USDA responded deviously to these pressures against DDT. It announced cancellations of almost all uses of DDT but quietly retained the registration for cotton accounting for two-thirds of use.[177] Try as they might, the few policy entrepreneurs focusing on pesticides could dislodge neither the

172. *See, e.g.*, Hadwiger, *Freeman and the Poor*, 45 AGRICULTURAL HISTORY 1, 22-23 (1971); T. MARMOR, THE POLITICS OF MEDICARE (1970); G. ORFIELD, THE RECONSTRUCTION OF SOUTHERN EDUCATION (1969); J. SUNDQUIST, POLITICS AND POLICY (1968).

173. *E.g.*, Blodgett, *supra* note 2; HADWIGER, *supra* note 31, at 160.

174. Agent Orange was the name given to a 50-50 mixture of 2,4,5-T and 2,4-D used by the U.S. forces in Vietnam as a defoliant to reduce ground cover for enemy troops. These two phenoxy herbicides have been used extensively in U.S. agriculture since WWII. Their ubiquitous contaminant, dioxin, was found to cause birth defects in laboratory animals at extremely low doses. For a brief introduction to the controversy surrounding dioxin and the use of these herbicides, see Rushefsky, *supra* note 177, at 676-82.

175. *See*, DUNLAP, *supra* note 2, at 129-76; GRAHAM *supra* note 75, at 224-30.

176. On the sequence of events, that preceded the ban on DDT, *see* Blodgett, *supra* note 2; Battista, *supra* note 63; DUNLAP, *supra* note 2; GRAHAM, *supra* note 75; PRIMACK & VON HIPPEL, *supra* note 75, at 128-42; WELLFORD, *supra* note 4.

177. For detail on the USDA "sham ban" of DDT, see PRIMACK & VON HIPPEL, *supra* note 75, at 133-35; WELLFORD, *supra* note 4, at 331-39. Because of the pest resistance associated with heavy DDT use in the past, its use on cotton crops declined rapidly during the late 1960s and early 1970s, even though its price was extremely low (17 cents per pound). What concerned the subgovernment most was the prospect that an outright ban on DDT might establish an undesirable precedent -the "domino theory" of rapid and successive restrictions on vital chemical technology.

USDA nor its congressional sovereigns. Even with these considerable efforts, public opinion reflected only the socially-conspicuous environmental problems—basically air and water pollution. So, although public concern for environmental quality reached unprecedented levels, within that overall movement, pesticide hazards remained a stepchild seemingly unable to penetrate the pesticide subgovernment's defenses.[178] Thus, agricultural committees could continue vetoing reform legislation, at a time when the White House and Congress were otherwise competing for credit over the more conspicuous environmental issues.

SUMMARY AND IMPLICATIONS FOR REFORM

Without making an apology for the status quo, by successively placing ourselves in others' shoes, seemingly irrational actions can be seen as logical outcomes of repeated interactions within a complex and changing system. Examining the pesticide situation in the preceding manner illuminates the historical causes of our readiness to embrace pesticide technology and provides an overview of the obstacles confronting critics as the 1960s drew to a close. It also suggests avenues through which reform might succeed, as well as the hurdles that policy innovations must continue to surmount even after reforms have been set in place.

Many of the relationships discussed in this paper are depicted in Table 1. Rather than chronology, the emphasis in that schematic summary is on exploring causal connections. Down the left-hand side of the table are the proximate causes of agriculture's heavy dependence on pesticide technology (the dependent variable). In the right column are the exogenous factors and second-order variables underlying the more proximate causes to the left. No single factor provides a sufficient explanation; instead it was their combined impact that facilitated the rapid growth of pesticide use in food production. As chemical pest suppression technology became available its use was essentially a fait accompli, and once established, there was tremendous inertia favoring its continuation.

Several important factors contributing to pesticide use lay outside the agricultural system and were therefore largely beyond the control of participants. These factors included nuisance law, patent law, the Constitutional design, legislative fragmentation and malapportionment, world wars, The Great Depression, climatic variation, cheap energy, urbani-

178. MacIntyre, *supra* note 128. The few opinion surveys that actually probed public attitudes on pesticides during the early 1970s revealed an increasing, but very modest concern, as contrasted with the more conspicuous (and more frequently polled) environmental problems of air and water pollution. *See* James McEvoy III, *The American Public Concern with the Environment: A Study of Public Opinion*, Institute of Governmental Affairs, Univ. of California at Davis, Davis, CA (1971). J. VILADAS, CO., PEOPLE AND THEIR ENVIRONMENT (survey contracted by U.S. EPA, 1973) (available from National Technical Information Service).

zation, the industrial revolution, continuing technical innovation and inelastic demand for food. The myriad implications of each of these exogenous factors further shaped events.

There are numerous causes of pesticide use which, although within society's grasp to change, have essentially remained immutable under relatively fixed conditions of American political culture and market economy. For example, competition within the food marketing industries inadvertently promotes pesticide use. Similarly, the central features of twentieth-century agriculture predisposed it to pesticide use. As labor-short entrepreneurs, farmers compete by borrowing capital which they invest to increase output while reducing their unit costs of production. This individualistic, free enterprise aspect led to collective overproduction which, because of the inelastic demand for food, virtually compelled farmers to adopt new agricultural technologies (including pesticides) which in turn only intensified economic difficulties for most of them (and our dependence on technology). Nor is it easy, or wholly desirable, to control overproduction in highly competitive farming.[179] For some new farm technologies, development fell within government's bailiwick, but much of it was undertaken by private enterprise (mechanical, chemical, some biological). Hence the enormous cultural and legal presumption favoring the development and the use of pesticides. Accidents of historical timing also intervened with the unavoidable consequence of encouraging our commitment to chemical approaches. For example, WWII disrupted public-sector research on bio-control just as effective and apparently safe chemicals became available.

Furthermore, several intrinsic qualities of second-generation pesticide technology encouraged use: initial cost-effectiveness and subsequent biological addictions; the common pool resource feature of pest susceptibility invites collective over-exploitation by risk-averse individuals; environmental and health consequences occurred off the farm and long after introduction; and residues were invisible to casual observation by otherwise preoccupied consumers. Likewise, we could not seriously expect pesticide manufacturers to produce selective, narrowly-applicable chemicals unless the crop-pest affected is economically significant.

The course of events portrayed here evokes images of a Greek tragedy. This is not to suggest their unfolding was wholly predetermined, or that chance, ignorance, and deliberate obstruction played no part. Indeed, reform might have occurred sooner if the pesticide subgovernment had

179. *E.g.*, since WWII, agricultural surpluses have been an important source of humanitarian aid abroad. Since the 1973 Oil Embargo, the federal government has encouraged farm production for export to help reduce the U.S. trade deficit. The developed world has adopted a similar strategy for farm exports, which has led to unmarketable surpluses, domestic farm crises and the prospect of a trans-Atlantic trade war.

not cooperatively resisted its critics. Such conspiracy, however, was only one cause of delay, and a more proximate one at that. While we must acknowledge the inertia contributed by the subgovernment's blockage, it is also important that we not overestimate the significance of conspiratorial elements because they do not provide a sufficient explanation of our dependence on pesticides. As Sowell[180] observes, "Where intention does exist among the individuals involved in a systemic process, that does not mean that their intentions determine the outcome."

An important conclusion of this paper is that the pesticide "conspiracy" was effective only to the extent that it coincided with, and reinforced numerous, more fundamental reasons. As suggested above these factors included the law of nuisance, the invisibility and uncertainty of pesticide risks, the public's apathy and preference for unblemished food, the late appearance of countervailing pressure groups, and of course, the susceptibility of Congress to pre-emptive vetoes whose reversal requires extraordinary majorities. But, starting in the late 1960s, actors from outside the pesticide subgovernment began seeking avenues around some of these obstacles. An important consequence of the subgovernment's blockage, and sparse expressions of public concern was that the agriculture committees were eventually circumvented by policy innovations from institutions outside the legislature: first, at the hands of a court; then in an executive re-organization, and ultimately by new administrators.

In response to litigation from EDF, a federal judge completely reversed the USDA's interpretation of the pesticide statute by granting standing to citizens' groups and by shifting the burden of proof onto the manufacturer (1970-1971).[181] Concurrently President Nixon transferred the pesticide jurisdiction away from the USDA into an Environmental Protection Agency in response to electoral competition over conspicuous air and water pollution problems (late 1970). New administrators were appointed who turned out to have responsive attitudes, different training, and a broader clientele. Consequently one partner in the original subgovernment had been drastically altered and the statute had been freshly reinterpreted.[182]

The agriculture committees sought to regain their hegemony while amending FIFRA in 1972, but the result largely ratified the changes imposed earlier by judicial and executive outsiders. A number of new regulatory powers were delegated but the agriculture committees simultaneously provided themselves (and thus pesticide interests) with additional opportunities to intervene.[183] EPA administrators, with little support,

180. T. SOWELL, KNOWLEDGE AND DECISIONS 151 (1980). *Cf.* G. MOODIE & R. STUDDERT-KENNEDY, OPINIONS, PUBLIC AND PRESSURE GROUPS 71 (1970).

181. MacIntyre, *supra* note 127.

182. MacIntyre, *supra* note 128. *See also,* MacIntyre, *Neglected Avenues to Policy Innovation: Regulating Pesticides in the 1970s* (for publication by Princeton University Press).

183. *Id.*

exerted tremendous initiative throughout the 1970s. They adopted stringent standards for pesticide registration which included a general presumption against cancer-causing chemicals. This was a significant accomplishment, particularly with respect to applications for the registration of new chemicals. However, severe resource constraints and pro-pesticide lobbying effectively stalled the retroactive implementation of EPA's anti-cancer innovation. While new products faced tough standards for the first time, little more than a handful of the 1,400 chemicals previously licensed were banned.[184]

Meanwhile, farm use of pesticides increased by more than fifty percent during that decade of environmental regulation. Agricultural uses of herbicides increased from 207 million pounds in 1971 to 451 million pounds in 1982. Over that same period, however, the use of insecticides declined from 126 million pounds to 71 million pounds.[185] Among the obvious contributions to this declining use of insecticides were the increasing incidence of insect resistance and technology failures, the large influx of federal funding for IPM research following 1970, and the consequent growth in practical applications of IPM by corporate agriculture since the mid-1970s. The growth in herbicide use on the other hand was sustained by the absence of clear-cut health risks or major weed resistance problems, by the decline in crop rotation as a weed control strategy, and by the recent shift toward minimum-till techniques to both conserve expensive fuel inputs and slow soil erosion. Thus the biological, economic, technological, legal and political forces that encouraged pesticide use have all been undergoing a gradual, if incomplete and uneven, metamorphosis. It remains to be seen how far and how rapidly the diminution in insecticide use will proceed, how successful IPM approaches have become, and whether herbicide use will continue to escalate.

What is clear, however, is that explanations of our shifting dependencies on pesticides have previously overestimated the impact of conspiratorial components. Likewise, the contribution of health and environment policy reforms in reducing our addiction should not be exaggerated.[186]

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184. MacIntyre, *supra* note 128.

185. U.S. DEPT. OF AGRICULTURE, THE PESTICIDE REVIEW (1972 through 1984).

186. Concern over the health and environmental pesticide effects has yielded reforms, to which public interest lobbies, including the Environmental Defense Fund [EDF], have made vital contributions. But these reforms have had relatively little retroactive impact on the chemicals registered prior to the mid-1970s. MacIntyre, *supra* note 128. Perhaps the greatest impact of EPA's increased regulatory stringency in testing and registering newly developed pesticides was its substantial contribution to the rising costs of developing and registering new pesticides. These escalated pesticide costs heightened the corporate interest in pesticides with wide marketability. Accordingly, disinterest in "minor use" pesticides increased the political demand and the economic justification for IPM alternatives to pesticides. Thus, the efforts of health and environmental reformers and EPA's regulatory stringency have contributed to the long-term viability of non-chemical pest suppression. Evaluating the impact of indirect contributions such as these is difficult. PERKINS, *supra* note 85 and accompanying text.

Many of the underlying biological, economic and technological factors are immutable, or they have their own dynamics which are not easily influenced by reformers, or by conspirators for that matter. Meanwhile, at the political level all of the pro-pesticide forces have persisted in the face of mounting opposition. Indeed the agriculture committees successfully retain congressional jurisdiction and the pro-pesticide coalition grows in number and resiliency despite its unexpected defeats in the early 1970s.[187] So, pesticide policymaking remains an arena of struggle that is subject to unpredictable outcomes.

187. MacIntyre, *supra* notes 127, 128.