Ecological Aspects of Agricultural Policy

by

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ECOLOGICAL ASPECTS OF AGRICULTURAL POLICY

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INTRODUCTION

In recent decades, the fertile cropland of the United States and many technical innovations in agriculture have made this country the major food producing nation in the world. This high production level has caused a gradual degradation of some cropland. It has depleted other resources as well, such as the fossil fuel used to run agricultural machines and to make fertilizers and pesticides.

Today as never before, the United States is faced with diminishing supplies of arable land, water, and energy.[1] Yet the need for a nutritional and adequate food supply in this country and in the world is expected to increase.[2] Conservative projections predict that the world population will increase from more than four billion to six billion in the next 20 years. To feed this population, food production will have to be increased at least twofold over present levels.[3] Dwindling resources make this task difficult.[4] To achieve substantially increased production, future agricultural policy must be based on an understanding of sound ecological principles.

In this article, we consider two policy areas related to food production: land conservation and pesticide use. In neither area have government policies been tailored to maximize food output, nor do present government policies always make sense from a broader ecological perspective. We will focus on those policies that have had the most significant impact on agriculture and on our environment.

LAND CONSERVATION

About 25 percent of the land of the United States—some 470 million acres—is arable land, naturally suited for crop production.[5]

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1. Pimentel, Terhune, Dysun-Hudson, Rochreau, Samls, Smith, Derman, Reifschneider & Shepard, *Land Degradation: Effects on Food and Energy Resources,* 194 SCI. 149 (1976) [hereinafter cited as Pimentel I].

2. NATIONAL ACADEMY OF SCIENCES, WORLD FOOD AND NUTRITION STUDY (1975).

3. Pimentel I, *supra* note 1, at 149.

4. *Id.;* Pimentel, Dritschilo, Krummel & Kutzman, *Energy and Land Constraints in Food-Protein Production,* 190 SCI. 754 (1975) [hereinafter cited as Pimentel II].

5. Pimentel I, *supra* note 1, at 149.

At present about 80 percent of this land is under cultivation.[6] Although an additional 75 million acres of land could be improved by draining swamps and irrigating desert land, these strategies are expensive in both energy and capital.[7] Thus, crop acreages with potential for food production in the United States cannot easily be increased by mobilizing vast tracts of marginal land.[8] The need is to preserve the high quality of existing cropland so that maximum crop yields can be realized. There are two principal ways in which arable land is lost to production. The first is diversion of the land from agricultural to some other use. The second is degradation in quality of the land that continues to be farmed.

Land Loss to Highways and Urbanization

Croplands have been shifted out of production predominantly on the eastern border of the United States and in parts of the Great Plains and Great Lakes States.[9] Since 1945, the total cropland lost to highways, urbanization, and other related uses has been about 45 million acres—an area nearly that of the state of Nebraska.[10] The development of highways accounts for 50 percent of the total loss.[11] Increasing human populations, growing urban populations, and industrialization account for the remainder.

Even though population growth is concentrated in urbanized areas, much agricultural land is destroyed. Historically, cities have tended to grow where some of the best farmlands occur. Throughout the world, humans have settled in easily accessible river basin areas where fertile, deep soils, level topography, and ample water were available.[12] Also, highways and railroads within and between urban areas have generally followed the flat river basins that contain some of the best agricultural land.

Today, 13 percent of the best agricultural land in the United States falls within the 242 standard metropolitan statistical areas (SMSAs).[13] In addition, almost 15 percent of the better grades of

6. U.S. DEP'T OF AGRICULTURE, OUR LAND & WATER RESOURCES, CURRENT AND PROSPECTIVE SUPPLIES AND USES (1974) (Publication No. 1290).

7. WATER RESOURCES COUNCIL, THE NATION'S WATER RESOURCES (1968).

8. Pimentel II, *supra* note 4.

9. ECONOMIC RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, AGRICULTURE AND THE ENVIRONMENT 481 (1971).

10. *Id.*

11. Pimentel I, *supra* note 1, at 149.

12. ECONOMIC RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, ORIGINS OF THE STATE AND CIVILIZATION (1975).

13. U.S. DEP'T OF AGRICULTURE, *supra* note 6. An SMSA is a county or group of counties defined by the Census Bureau as an entire area in and around a city or community of more than 50,000 inhabitants in which the activities form an integrated socioeconomic system.

farmland is found in these areas. The SMSAs presently account for 17 percent of all farms and 24 percent of farm income.[14] As for crops, about 60 percent of the vegetables, 43 percent of the fruits and nuts, and 17 percent of the corn produced in the United States are grown on SMSA land.

Although at present only 10 percent of the area within SMSAs is actually urbanized,[15] there is a steady increase in the number of people residing in SMSAs. About 85 percent of the U.S. population increase during the 1960s occurred in these areas.[16] Over the years, about 80 percent of the cropland urbanized in SMSAs has been excellent agricultural land.[17] If rapid loss of agricultural land is not slowed through protective measures, food supplies will be affected in the future. Until now, annual increases in productivity of about six percent per year have been accomplished by increased energy inputs (through fertilizers and pesticides, for instance) while land use has declined.[18] With such energy resources now at a premium, the United States cannot afford to permit the elimination of valuable cropland to continue.

Land Use Policies

Although serious loss of agricultural land is recognized, little action has been taken to preserve the existing U.S. farmland. The problem is complex. Each state faces a different set of physical and political factors that are important not only to the feasibility of enactment but also to the ultimate success of a land use policy designed to protect cropland.

One of the primary considerations in formulating a land use policy is the degree of urban pressure present in an area. As one moves from rural areas to semi-suburban areas, farmland sells for many times more than its farm value.[19] Land prices in semi-suburban areas have reached what one author describes as "trigger-levels"—prices at which farmers can sell their land, use the profit to buy an equivalent amount of equal or better farmland in another location, and cover all costs of selling and relocating as well.[20] Thus, cropland continues to disappear and farmland prices continue to increase.

There are a variety of land preservation policies in effect across the

14. *Id.*
15. *Id.*
16. *Id.*
17. *Id.*
18. Pimentel I, *supra* note 1; U.S. DEP'T OF AGRICULTURE, AGRICULTURAL STATISTICS 1977 (1977).
19. W. F. Bryant, Farmland and Preservation Alternatives in Semi-Suburban Areas (April 1, 1975) (Agr. Econ. Dept., Cornell Univ.).
20. *Id.* at 4.

nation (Table I). While no one farmland preservation policy is adaptable to all conditions, certain generalizations can be drawn about the relative effectiveness of various policies by measuring the nature and extent of farmland being preserved, the costs, the administrative difficulties, and the political acceptability of the policy alternatives.

TABLE I.

STATE PROGRAMS FOR PRESERVATION OF FARMLAND BY TYPE OF PROGRAM

	Differential Tax Assessment	*Agricultural Districts*	*Agricultural Zoning*	*Developmental Rights Transfer*
ALABAMA	s			
ALASKA	s			b,s
ARIZONA	s			
ARKANSAS	s			
CALIFORNIA	s		b	
COLORADO	s			
CONNECTICUT	s			s
DELAWARE	s			
FLORIDA	s			
GEORGIA				
HAWAII	s		s	b
IDAHO	s			
ILLINOIS	s			
INDIANA	s			
IOWA	s			
KANSAS	s			
KENTUCKY	s			
LOUISIANA	s			
MAINE	s			s
MARYLAND	s,b			s,b
MASSACHUSETTS	s			s
MICHIGAN	s			
MINNESOTA	s,b			
MISSISSIPPI				
MISSOURI	s			
MONTANA	s			
NEBRASKA	s			
NEVADA	s			
NEW HAMPSHIRE	s			b
NEW JERSEY	s			s,b
NEW MEXICO	s			
NEW YORK	s	s		b
NORTH CAROLINA	s			
NORTH DAKOTA	s			
OHIO	s	b		
OKLAHOMA	s			
OREGON	s		s	
PENNSYLVANIA	s	b		
RHODE ISLAND	s			

SOUTH CAROLINA	s			
SOUTH DAKOTA	s			
TENNESSEE	s			
TEXAS	s			
UTAH	s			
VERMONT	s			
VIRGINIA	s	s		b
WASHINGTON	s,b			
WEST VIRGINIA	s			
WISCONSIN	s		s	
WYOMING	s			

Source: Modified after R. Davies & J. Belden, A Survey of State Programs to Preserve Farmland (1979) (paper presented at the National Conference of State Legislators, Washington, D.C.).

s = statute or program b = bill

The most prevalent farmland preservation tool in use today is differential tax assessment; over 40 states have adopted it in varying forms.[21] Basically, the method involves assessing land according to its farm use value. Since a farmer's property holdings are generally large in comparison to his income, his property taxes are likely to embrace a significant percentage of his income. The aim is to maintain farm property taxes at levels that farmers can afford.

Yet the efficacy of differential assessment as a tool to preserve agricultural land remains in question. Four reasons account for its ineffectiveness. First, although differential assessment laws do lessen the tax burden, their effect is diminished if a farmer faces a high tax rate within his locale. Second, differential assessment provides no assurance that a critical mass of agricultural land will be preserved. Third, when a farmer is offered a high price for his land, a mere reduction in real estate taxes will seldom prevent the land sale. Rollback taxes, if employed in conjunction with differential assessment, will recapture part of the taxes that otherwise would have been due, but they, too, will do little to discourage the conversion of farmland to non-farm uses. Fourth, states have found it difficult to limit the tax benefits to bona fide farmers.[22] This not only results in loss of state revenues, but also creates administrative complications. The consensus is that differential assessment should be combined with other land use methods if agricultural land is to be preserved.[23]

A second land preservation tool involves the exercise of state police powers. Restrictions are imposed on the use of private land

21. R. Davies & J. Belden, A Survey of State Programs to Preserve Farmland (1979) (paper presented at the National Conference of State Legislators, Washington, D.C.).

22. Bryant, *supra* note 19, at 9.

23. T. HADY & A. SIBOLD, STATE PROGRAMS FOR DIFFERENTIAL ASSESSMENT OF FARM OPEN SPACE LAND (1974).

through exclusive agricultural zoning. In most instances, states have delegated this power to units of local governments. As a result, zoning has proven to be an ineffective land preservation tool.

Political considerations tend to become important in the process of enacting local zoning measures. Landowners who have high expectations of selling farmland for non-farm uses at tremendous profits often oppose attempts by local governments to prevent them from realizing these economic gains. Local zoning is only a short-term solution, for there is no guarantee that future political pressures will not lead to an abdication of agricultural zoning as the monetary stakes grow higher.

Hawaii is the only state that has experienced a measure of success with agricultural zoning.[24] All the land within the state has been placed into urban, rural, and agricultural districts by a state commission. It is state policy to encourage the continuance of agriculture within the specified areas. Although zoning can be justified as a measure enacted to protect the food supplies of the nation, without the unique pressures that fall on island economy, the impetus to enact strong and lasting zoning measures is lacking. Public sentiment runs against what amounts to government control over private property, especially since compensation does not accompany zoning controls.

Another farmland preservation method, employed by New York State, combines incentives to encourage farming within specified areas (designated as agricultural districts) with disincentives to discourage development, either residential, industrial, or commercial, from locating within farm areas.[25] Specifically, an eligible farmer is exempt from taxation on the value of his land in excess of its value for farming.[26] He is also protected from local or state government actions that would restrict farm practices or farm structures beyond the extent necessary for health and safety.[27] The right of public agencies to acquire farmland by eminent domain is also limited.[28]

The creation of such agricultural districts is left to the initiative of local farmers.[29] The only requirement is that each district contain a minimum of 500 acres.[30] This is a particularly significant aspect of the district concept because it preserves a critical mass of farmland.

24. Bryant, *supra* note 19, at 6.
25. N.Y. AGRIC. & MKTS. LAW § § 300-307 (McKinney 1972).
26. *Id.* § 305(1)(b) (McKinney Supp. 1979).
27. *Id.* § 305(2).
28. *Id.* § 305(4)(a-f).
29. *Id.* § 303.
30. *Id.*

In actuality, the average size of agricultural districts formed in New York State is much larger; most contain over 10,000 acres.[31]

The law does provide the Commissioner of Environmental Conservation with the power to create districts of 2,000 acres or more if he deems the land to be unique and irreplaceable.[32] According to latest reports, however, no district has been formed through the exercise of this governmental power.[33] If it were used, this power could be an effective weapon against farmland dissipation.

Under the New York plan, once a district is formed, farmer participation is no longer voluntary. Although land may be released from a district, the decision to do so lies with the county and the state, not with the individual farmer-landowner.[34] Moreover, such a decision cannot be made before the expiration of an eight-year period, thus giving the program some permanence.[35]

As measured by the extent of participation in this program, however, the incentives have not yet proven sufficiently attractive. Two hundred districts, totaling about 2.5 million acres of farmland, have been formed in the state, but none has been formed in the semi-suburban areas where the largest acreage of good farmland exists.[36] The district program evidently does not provide landowners in the semi-suburban areas with adequate compensation to cover the loss of control and land value that results from participation.

Of all the land use policies surveyed here, the development rights purchase technique implemented in one New York county appears to offer the most promising means of conserving farmland.[37] Under this policy the government purchases only the development rights of the land, leaving all other property rights with the farmer. A development right is defined as "the permanent legal interest in the use of agricultural lands and the right to restrict, prohibit, or limit the use of such lands for any purpose other than agricultural production."[38]

Participation in the program, as in the agricultural districting program, is voluntary. However, initial experience suggests that participation in the development rights purchase plan will be widespread. Acceptability of the plan to farmers is due in part to the

31. Bryant, *supra* note 19, at 12.
32. N.Y. AGRIC. & MKTS. LAW § 304 (McKinney 1972).
33. NEW YORK DEP'T OF ENVIRONMENTAL CONSERVATION, ENVIRONMENTAL PLAN FOR NEW YORK STATE (preliminary ed. 1973).
34. N.Y. AGRIC. & MKTS. LAW § 303 (McKinney 1972).
35. *Id.* § 303(8).
36. Bryant, *supra* note 19, at 13.
37. N.Y. GEN. MUN. LAW § 247 (McKinney 1972); Suffolk County, N.Y. Local Law No. 19 (1974).
38. Suffolk County, N.Y. Local Law No. 17 (1974).

amount and kind of compensation offered.[39] Under the plan, the farmer continues to farm while receiving payment for the non-farm increment in the value of his land. In addition, property tax assessments based on non-farm uses no longer pose a threat to the farmer; he is taxed only on the farm value of his land in succeeding years. Above all, the farmer is still free to sell the land for farming purposes, at a competitive price, whenever he wishes.

The development rights purchase technique has proven beneficial to the implementing county as well. The technique has been effective in checking county population, curbing degradation of life and environment, and restraining soaring public service costs by preventing further urbanization.[40] It also secures land for a county where the physical resources are well suited to agricultural production and the major industry is farming. It guarantees the amenities of open space. Once the development rights have been sold to the government, the farmland can never be sold for any purpose other than farming.

An obvious disadvantage of the plan is its high monetary cost to taxpayers in the district. This cost may limit its acceptability and adaptability to other geographic settings.

Soil Degradation by Erosion

The potential for producing food has been lost on several million acres of U.S. farmland[41] that has been ruined by soil erosion.[42] Erosion has also removed at least one-third of the topsoil on the cropland remaining in use, thus reducing its productivity.[43] Crop productivity is affected because of (1) selective removal of plant nutrients and organic matter by wind and water;[44] (2) removal of organic matter and the finer soil particles by wind and water, leading to compaction of the soil; (3) gross removal of topsoil by erosion; and (4) increased water runoff associated with erosion, reducing

39. Bryant, *supra* note 19, at 19.

40. *Id.*

41. GENERAL ACCOUNTING OFFICE, TO PROTECT TOMORROW'S FOOD SUPPLY, SOIL CONSERVATION NEEDS PRIORITY ATTENTION (1977) (Report to the Congress No. CED-77-30).

42. SOIL CONSERVATION SERVICE, U.S. DEP'T OF AGRICULTURE, CROPLAND EROSION (1977).

43. LAND PLANNING COMMITTEE, U.S. NATIONAL RESOURCES BOARD, SOIL EROSION, A CRITICAL PROBLEM IN AMERICAN AGRICULTURE (supplemental report 1935); BIOLOGY AND THE FUTURE OF MAN (P. Handler ed. 1970).

44. The annual loss of 50 million tons of plant nutrients is estimated to cost about $6.8 billion per year. C. WADLEIGH, WASTE IN RELATION TO AGRICULTURE AND FORESTRY (1968) (U.S. Dep't of Agriculture Misc. Publication No. 1065).

water availability to crops[45] and causing flood damage to other crops.[46]

Soil erosion is continuing. It is possible to compensate for erosion losses by using fossil energy in the form of fertilizers and other inputs to offset the decline in productivity.[47] However, consumption of fuel as fertilizer is a high price to pay every year for preventable land degradation.

Unchecked soil erosion has economic and environmental effects that go beyond diminished land quality. As a result of erosion by water in the United States, approximately four billion tons of soil per year finds its way into waterways.[48] About three-fourths of this soil comes from valuable agricultural lands.[49] About one-quarter of waterborne sediments end up in the ocean, while the rest settles in reservoirs, rivers, and lakes.[50] As a result, some 450 million cubic yards of sediment must be dredged from U.S. rivers and harbors at an annual cost of about $250 million.[51] Sedimentation also costs the nation about $50 million per year by materially reducing the useful life of reservoirs.[52] Total sediment damages are estimated to cost a total of $500 million each year.[53]

Moreover, soil sediments containing nitrogen, phosphorus, potassium, and pesticides have a serious ecological impact upon stream fauna and flora. The added nutrients often increase aquatic plant productivity and result in eutrophication. In contrast, suspended sediments reduce light penetration and diminish the productivity of aquatic ecosystems.[54] With reduced food, fish populations also

45. U.S. DEP'T OF AGRICULTURE, YEARBOOK OF AGRICULTURE 1938, SOILS AND MEN (1938).

46. An estimated $1.3 billion in crops and forages is lost annually by floodwater sediment. AGRICULTURAL RESEARCH SERVICE, U.S. DEP'T OF AGRICULTURE, LOSSES IN AGRICULTURE (1965) (Agricultural Handbook No. 291).

47. An estimated 5 gallon-equivalents of fuel per acre is being used to offset the soil erosion loss on cropland. Thus, on the estimated 380 million acres annually in production, a total of about 2 billion gallons of fuel equivalents is used just to offset past soil erosion losses. This amount of fuel is equivalent to 50 million barrels of oil. Pimental 1, *supra* note 1.

48. Pimentel, *The Energy Crisis: Its Impact on Agriculture,* ENCICLOPEDIA DELLA SCIENZE E DELLA TECNICA (Milan, 1976); GENERAL ACCOUNTING OFFICE, *supra* note 41.

49. *Id.*

50. A National Program of Research for Environmental Quality–Pollution in Relation to Agriculture and Forestry (1968) (report prepared by a joint task force of the Department of Agriculture and directors of Agricultural Experiment Stations).

51. *Id.*

52. Stall, *Soil Conservation Can Reduce Reservoir Sedimentation,* 93 PUB. WORKS 125 (1962).

53. Wadleigh & Dyal, *Soils and Pollution,* AGRONOMY & HEALTH 9 (1970).

54. Herbert & Merkens, *The Effect of Suspended Mineral Solids on the Survival of Trout,* 5 INT. J. AIR-WATER POLLUTION 46 (1961).

decline. In addition, sediments interfere with salmon and trout spawning and reduce survival of their eggs.[55] Indirectly, fish fry are also harmed by sediments because predation on young fish is much greater when sediments cover substrate interstices and eliminate hiding places.[56]

Wind erosion of soil is generally considered to be less severe than water erosion, although this depends on the region in question.[57] The more arid portions of the United States suffer greater damage from wind erosion than other areas. For the United States as a whole, it has been estimated that about one-quarter of the total soil erosion is due to the wind.[58] Conservatively, we estimate that wind accounts for a loss of about one billion tons of soil each year.[59]

Changes in agricultural practices also affect levels of soil erosion. The decline of crop rotation and the increase of crops grown in continuous culture, for example, have increased soil erosion.[60]

To balance soil depletion, it is important to understand that, although soil is continuously being lost through erosion, it is also continuously being formed. The rate of soil formation is difficult to measure, however, and depends on climate, vegetation, soil disturbances, and the nature of the subsoil.[61] Under crop production conditions, soil may be formed at a rate of about one inch in every 100 years.[62] This is about 1.5 tons of topsoil formed per acre per year. In all, soil is being lost faster than it is being replaced. The erosion problem is only expected to increase as more land is intensively cultivated to meet the demand for food.

Soil Erosion Legislation

Only limited success has been achieved in reducing soil erosion in the United States, even though the agricultural practices for conserving the nation's soil are well known.[63] Some of the more

55. Herbert, et al., *The Effect of China-Clay Wastes on Trout Streams*, 5 INTL. J. AIR-WATER POLLUTION 56 (1961).

56. Chapman, *Effects of Logging Upon Fish Resources of the West Coast*, 60 J. FORESTRY 533 (1962).

57. GENERAL ACCOUNTING OFFICE, *supra* note 41; SOIL CONSERVATION SERVICE, *supra* note 42; H. BENNETT, SOIL CONSERVATION (1939); U.S. DEP'T OF AGRICULTURE, *supra* note 45.

58. C. WADLEIGH, *supra* note 44.

59. Pimentel 1, *supra* note 1.

60. SOIL CONSERVATION SOCIETY OF AMERICA, CONSERVATION TILLAGE (1973).

61. Grant, *Erosion in 1973-74: The Record and The Challenge*, 30 J. SOIL WATER CONSERVATION 29 (1975).

62. Personal communication with R. J. McCracken, U.S. Dep't of Agriculture.

63. SOIL CONSERVATION SOCIETY OF AMERICA, *supra* note 60.

common methods of erosion control are contour planting,[64] crop rotation,[65] application of livestock manure,[66] "no-tillage" and "minimum tillage" crop production technology,[67] cover crop planting (green manure) during the eight or nine months when the crop is not on the field,[68] interseeding a legume with a crop in late summer, and building structures to trap sediment and stabilize stream channels.[69]

Why, if these practices have proven so successful, are they not regularly employed by a majority of the farmers? Several studies attempting to answer this question reveal a variety of reasons: the farmers' failure to appreciate the need for recommended practices because of "custom and inertia;"[70] the farmers' desired layout of the farm including fields and roads;[71] the large number of corporate and rented farms whose operators have little incentive to maintain long-term soil quality;[72] and the farmers' need for immediate income.[73]

Economic considerations discourage many farmers from employing soil conservation techniques. Often the benefits that accrue from their use are diminished by added production costs. For example, contour planting results in a five to seven percent increase in both farm labor and fuel use.[74] No-till corn has the advantage of requiring less labor[75] and conserving soil moisture,[76] but it increases pest problems and ultimate pesticide usage.[77] High fixed costs are often

64. A. GUSTAFSON, CONSERVATION OF THE SOIL (1937).

65. Carreker & Barnett, *Runoff and Soil Loss Measurements by Cropping Periods,* 30 AGRICULTURAL ENGINEERING 173 (1949); M. Miller, Cropping Systems in Relation to Erosion Control 366 (1935) (Mo. Agricultural Experimental Station Bull.).

66. U.S. Soil Conservation data as cited in H. BENNETT, *supra* note 57, at 162; Moldenhauer & Amemiya, *Save Tomorrow's Soils–Control Erosion From Rowcropping Today,* 21 IOWA FARM SCI. 3 (1967).

67. N. L. Hartwig, Crownvetch–a Perennial Legume Cover Crop For No-tillage Corn (1974) (report prepared for the Department of Agronomy, Penn. State Univ.).

68. Pimentel I, *supra* note 1.

69. Nicol, Madsen & Heady, *The Impact of a National Soil Conservancy Law,* 29 J. SOIL & WATER CONSERVATION 204 (1974).

70. M. Blase & F. Timmons, Soil Erosion Control in Western Iowa: Progress and Problems (1961) (Iowa Agricultural Home Econ. Experimental Station Res. Bull. No. 498).

71. *Id.*

72. *Id.*

73. *Id.*

74. Personal communication with K. J. Nicol.

75. OFFICE OF PLANNING AND EVALUATION, U.S. DEP'T OF AGRICULTURE, MINIMUM TILLAGE: A PRELIMINARY ASSESSMENT (1975).

76. Rask, et al., *A Cost Analysis of No-tillage Corn,* 52 OHIO REP. 14 (1967).

77. U.S. DEP'T OF AGRICULTURE, *supra* note 75; Pruess, *Western Corn Rootworm Egg Distribution and Adult Emergence Under Two Corn Tillage Systems,* 61 J. ECON. ENTOMOLOGY 1424 (1968); G. Musick, Insect Problems Associated With No-tillage Corn Production (1970) (in Proceedings of the Northeastern No-tillage Conference, Chevron Chemical Co.); Musick & Collins, *Northern Corn Rootworm Affected by Tillage,* 56 OHIO REP. 88 (1971); Musick & Petty, *Insect Control in Conservation Tillage Systems,* in SOIL CONSERVATION SOCIETY OF AMERICA, CONSERVATION TILLAGE (1973).

associated with the incorporation of soil conservation techniques into a farm operation because new management skills, improved varieties of plants, new machinery, and different chemicals may be needed. Nevertheless, most investigators report that soil conservation eventually results in a net revenue increase realized through increased crop yields. For example, in Texas, yields of cotton grown on contour were 25 percent greater than cotton grown with the slope.[78] Illinois experimenters report yield increases from contouring for corn (12 percent), soybeans (13 percent), and wheat (17 percent).[79] Yields of cotton grown in rotation were increased 30 percent when soil erosion was reduced from 23 to 14 tons of soil per acre.[80]

During the past four decades, soil conservation legislation has proliferated and billions of dollars have been spent to help farmers control erosion and preserve topsoil. The emphasis of the legislation has been on offering technical and economic assistance rather than on imposing soil loss restrictions.

The Conservation Operations Program (COP), authorized in 1935, represents one of the major legislative attempts to persuade farmers to incorporate soil conservation techniques on their land.[81] The Soil Conservation Service (SCS) is responsible for the implementation of this program. SCS assists farmers and ranchers through local soil and water conservation district boards, which are legal subdivisions of state governments managed by citizens familiar with local problems.[82] Each district has the legal responsibility of developing a conservation plan and carrying it forward. Since the severity of soil erosion depends on soil type, soil depth, slope of the land, length of the slope, amount of organic matter present, cultivation practices, crops grown, rotation schedule and duration, and intensity of wind and rainfall, local management of the districts is more logical than either state or federal control.

Cooperation with these local programs is voluntary. Thus the districts are primarily service organizations, providing education and on-the-land application of conservation measures. The educational programs offer valuable information that, if applied by farmers,

78. Burnett & Fisher, *The Effect of Conservation Practices on Runoff, Available Soil Moisture and Cotton Yield,* 18 SOIL SCI. SOC. AM. PROC. 216 (1954).

79. Sauer & Case, *Soil Conservation Pays Off,* 111 AGRICULTURAL EXPERIMENTAL STATION BULL. 575 (1954).

80. B. HENDRICKSON, et al., RUNOFF AND EROSION CONTROL STUDIES ON CECIL SOIL IN THE SOUTHERN PIEDMONT (1963) (U.S. Dept. Agriculture Tech. Bull. No. 1281).

81. 16 U.S.C. § § 590a-590f (1976).

82. Smith, *Role of The Soil Conservation District,* SOIL CONSERVATION SOCIETY OF AMERICA, CONSERVATION TILLAGE (1973).

would curb the amount of soil loss. Although SCS has developed conservation plans for about 44 percent of all the farm and ranch operating units in the United States, the overall success of the program, as measured by the annual erosion rates, has been discouraging.[83]

Several factors account for the ineffectiveness of COP programs. First and foremost, the law is gratuitous in nature. It offers a service to farmers who may accept or reject it at will. Second, the SCS does not aggressively or systematically seek out farmers whose lands have the most critical erosion problems.[84] Instead the SCS remains passive, assisting only those farmers who request advice and who volunteer to participate in the program. Third, most time and effort is devoted to developing elaborate conservation plans, rather than to providing technical assistance to carry out those plans.[85] Finally, many conservation plans become inoperative because SCS does not provide the necessary technical and followup assistance.[86]

Acknowledging the economic impediments to optional participation in soil preservation programs, Congress enacted the Agricultural Conservation Program (ACP) in 1936.[87] The program is designed to encourage the application of sound soil and water conservation practices by providing cost-sharing assistance under both annual and long-term conservation agreements with farmers. The program authorizes the government to pay 50 to 75 percent of the cost of an approved conservation practice.[88] The Agricultural Stabilization and Conservation Service (ASCS) administers this program through state and county committees. SCS provides technical guidance to participating farmers and committees.

Participation in this program has been low. In 1977, fewer than 14 percent of the country's farmers and ranchers received cost-share payments for implementing approved conservation practices.[89] Moreover, fewer than half of the participants were carrying out practices which had enduring and authentic erosion control benefits.[90]

As a result of congressional tampering with two provisions of the

83. NATIONAL ACADEMY OF SCIENCES, PRODUCTIVE AGRICULTURE AND A QUALITY ENVIRONMENT (1974) (National Research Council, Comm. on Agriculture and the Environment); T. R. Hargrove, Agricultural Research: Impact on Environment (1972) (Special Rep. No. 69, Agricultural Home Econ. Experimental Station, Iowa State Univ. Sci. Technol., Ames, IA).

84. GENERAL ACCOUNTING OFFICE, *supra* note 41, at 10.

85. *Id.* at 11.

86. *Id.* at 13.

87. 16 U.S.C. § § 590g-590o, 590p(a), 590q (1976).

88. GENERAL ACCOUNTING OFFICE, *supra* note 41, at 2.

89. *Id.*

90. *Id.* at 28.

ACP, the program has shifted to provide proportionately more funding for practices which, although eligible for program funding, are minimum-conservation or production-oriented practices. The first change was the modification of the national list of eligible practices. Up until 1970, 60 practices were designated as eligible for cost sharing under ACP.[91] In response to criticism voiced about including practices that were primarily production-oriented or had minimal conservation benefits, the national list was reduced to 15.[92] In 1975, however, legislation was enacted which allowed all 60 practices previously approved to be eligible for cost-sharing under ACP once again.[93]

Congress also changed the cost-sharing approval system. Prior to 1976, states and counties selected the conservation practices eligible for ACP cost-sharing, subject to approval by the Department of Agriculture.[94] The new provision places final approval authority at the county level.[95] The premise was that because individual farmers know what practices their land needs and what they are willing to expend, the local field offices should have complete authority to select the appropriate conservation practices. The legislature failed to consider the impact that farmer profit motivations might have on the selection process.

Many of the critically needed erosion control measures cannot compete with practices that provide large financial returns. This is unfortunate because the highly production-oriented practices have sufficient economic incentives to encourage farmers to carry them out at their own expense. Federal funds should be preserved for those conservation practices which farmers ordinarily would not undertake.

Attempts to increase congressional oversight of the conservation program and to restrict the funding of production-oriented practices have met with defeat.[96] As the law stands, it is likely that critical erosion needs will continue to be neglected.

Cognizant of the shortcomings of existing erosion control legislation, Congress enacted additional legislation in an attempt to curb soil sedimentation occurring in the nation's waterways. One portion

91. *Id.*
92. *Id.*
93. Act of Oct. 21, 1975, Pub. L. No. 94-122, 89 Stat. 611.
94. Act of Dec. 31, 1974, Pub. L. No. 93-563, 88 Stat. 1822.
95. Act of Oct. 21, 1975, Pub. L. No. 94-122, 89 Stat. 611; Act of July 12, 1976, Pub. L. No. 94-351, 90 Stat. 851.
96. Two bills, S. 2081 and S. 3299 were introduced during the 94th Congress. However, S. 2081 was pocket vetoed by the President, and S. 3299 did not clear the Senate.

of the Federal Water Pollution Control Act (FWPCA)[97] focuses on this soil erosion problem. The act provides for nationwide assessments of soil contamination levels within reservoirs, rivers, lakes, and streams. Once the surveys are completed, area-wide management programs are to be devised and implemented. The Congress, under the Clean Water Act of 1977, appropriated funds for cost-sharing assistance for participating farmers.[98]

Still to be decided is whether participation in these management programs will be mandatory. The Environmental Protection Agency opposes forcing farmers to participate because of the difficulty in assigning blame for soil sedimentation between neighboring farms.[99] The agency points out that, although scientists are able to measure the extent of sedimentation, it is a costly procedure to determine soil loss rates on individual farms. On the other hand, many agriculturalists favor mandatory participation because voluntary soil erosion programs have proven ineffective.[100] They maintain that an approximate measure of an individual farmer's responsibility could be determined by examining the land management practices he employs. It is too early to tell how this controversy will be resolved, because no soil management programs have been launched yet. If participation becomes voluntary, FWPCA is unlikely to have any greater impact on annual soil erosion rates than any of the previous programs.

Government Price Control Policies

Closely related to the problem of land use policies that promote the loss or degradation of agricultural land are those policies which encourage the inefficient use of such land. There have been nationwide efforts to control the production of our basic crops since 1933, under the authority of the Agricultural Adjustment Acts.[101] The goal underlying this legislation is to stabilize commodity prices in order to assure favorable financial conditions for the farmers.[102]

Land retirement is one device chosen to achieve the price-support objective. Each year, the Secretary of Agriculture determines a

97. Act of Oct. 18, 1972, Pub. L. No. 92-500, 86 Stat. 816 (codified at 33 U.S.C. § § 1251-1376 (1976)).

98. Pub. L. No. 95-217, 91 Stat. 1578, amending 33 U.S.C. § § 1251-1376 (1976).

99. Personal communication with Professor Douglas Haith, College of Agriculture and Life Sciences, Cornell University (1979).

100. *Id.*

101. Agricultural Adjustment Act, ch. 25, § 1-21, 48 Stat. 31 (1933) (current version at 7 U.S.C. § 1281 (1976)).

102. 7 U.S.C. § 1282 (1976).

national acreage allotment for a particular crop and apportions it among the states. The state committees reapportion it among the counties, which then reapportion it among the local farms. To understand the enormity of the program, we note that in 1974 as many as 58 million acres were taken out of production.[103] The annual taxpayer cost to support this program is immense, reaching a high of $4 billion in 1972.[104]

Studies comparing United States agriculture under the land retirement program with a free land market situation reveal that to produce equal quantities of agricultural commodities, the total acreage needed under the land retirement program is considerably more than under the free land market situation. For example, 5.2 million acres are required to produce about 10 million bales of cotton under government controls, whereas only 4.4 million acres are required to produce the same quantity of cotton without such controls.[105] In part, this discrepancy occurs because the land retirement program restricts production on a portion of the highly productive land, forcing crop production onto less productive land in other areas.[106] Consider the situation with respect to cotton production in the rich delta cropland of the southern central United States. Based on soil moisture and insect conditions, some of the most productive cotton land is in this region. However, under land retirement roughly 50 percent of the land that once grew cotton in the delta is now idle from production.[107] Individual growers obviously retire their poorer land, but the "poorer" land in the delta region is still significantly more productive on the average than the land outside the delta. As a result, yields are lower and more land must be used to guarantee an adequate cotton supply. Cotton production is marginally profitable in this poorer production region because the price support program artificially raises the price of cotton on the market.

Government land controls also result in higher production costs. Extra equipment and additional fertilizer and insecticide applications are necessary to compensate for poorer soil and pest conditions.

103. 3 C.J.S. *Agriculture* § 41 (1973).

104. U.S. DEP'T OF AGRICULTURE, ALTERNATIVE FUTURES FOR U.S. AGRICULTURE, A PROGRESS REPORT, Part 1 (1975) (Comm. on Agriculture & Forestry, U.S. Senate).

105. Pimentel & Shoemaker, *An Economic and Land-use Model For Reducing Insecticides on Cotton and Corn*, 3 ENVT'L. ENTOMOLOGY 10 (1974).

106. *Id.*; Heady, et al., Future Water and Land Use: Effects of Selected Public Agriculture and Irrigation Policies on Water Demand and Land Use (1972) (report of the Center for Agricultural & Rural Development, IA State Univ. Sci. Technol., prepared for National Water Committee).

107. U.S. DEP'T OF AGRICULTURE, AGRICULTURAL STATISTICS 1971 (1971).

Without even including the cost of the government price support system, production costs are roughly 50 percent higher for cotton under the government land retirement program.[108]

Economic efficiency and land conservation would result if acreage controls were abandoned. For example, in cotton production without acreage controls, production would shift away from the southeast and concentrate more in the western, south central, and southwestern regions.[109] This is significant because the cotton boll weevil is a more serious pest in the southeastern region. In addition, the very treatment for the boll weevil often serves to destroy the natural enemies of two other cotton pests, the boll worm and bud worm, thus magnifying the pest problem. In order to recoup losses caused by these pests, it is necessary to increase both the amount of insecticide used and the number of acres of land planted.

There is a movement in the Department of Agriculture to redirect the farm policy now in existence.[110] Expansion of markets for farm products, especially export markets, has increased the opportunity for farmers to earn adequate incomes in the competitive marketplace. The decreasing number of acres retired in recent years is evidence that a change is underway. A complete termination of acreage control programs, however, cannot be accomplished quickly because of the production and marketing systems currently in practice. In any case, a substantial change in policy is likely to be strenuously resisted by those who desire to maintain the status quo—farmers who fear low prices and bankruptcy, local agribusinesses who fear the decline of local production of a particular commodity, and state and local officials who hope to minimize the population drain from their rural constituencies or retard the influx of unskilled people into the inner city.[111]

Successful farmers from the large farm enterprises are receiving the overwhelming proportion of program payments. The program is of little help to the rural poor whose farms are too small to reap much in the way of benefits. Ideally, future policymakers will be sensitive to waning world food supplies and will withstand pressure from those who stand to gain personally from the continuation of the program.

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108. Pimentel & Shoemaker, *supra* note 105.

109. D. PIMENTEL, et al., ALTERNATIVES FOR REDUCING INSECTICIDES ON COTTON AND CORN: ECONOMIC AND ENVIRONMENTAL IMPACT (1977) (report for the Environmental Protection Agency).

110. U.S. DEP'T OF AGRICULTURE, *supra* note 104.

111. *Id.* at 7.

PEST CONTROL AND PESTICIDES

Crop Losses to Pests

Pest populations, including insects, pathogens, and weeds, destroy a large portion of the world's food supply. At present, pre-harvest and post-harvest infestation by pests destroys nearly half the world's food every year.[112] The figures for the United States, where total annual losses to pests are estimated to be nearly 40 percent, are hardly better.[113] Although improved mechanical cultivation and herbicide weed control technologies have reduced losses from weeds since the 1940s, there has been a nearly twofold increase in crop loss from insects despite a tenfold increase in insecticide use during this time.

In part, the increases can be accounted for by changes that have taken place in crop production technology and governmental policies.[114] These include: (1) the planting of crop varieties that are susceptible to insect pests;[115] (2) reduced crop rotations and crop diversity with increased reliance on continuous culture of the same crop;[116] (3) reduced sanitation, including destruction of infected fruit and crop residues; (4) reduced tillage, with more crop remains left on the land surface; (5) culturing crops in climatic regions where they are more susceptible to insect attack; (6) increased pesticide resistance in insects;[117] (7) destruction of natural enemies of certain pests, resulting in the need for additional pesticide treatments; (8) use of pesticides that alter the physiology of some crop plants, making them more susceptible to insect attack;[118] and (9) reduced FDA tolerance and increased "cosmetic standards" by processors and retailers for fruits and vegetables. The remainder of this paper focuses on the agricultural and ecological implications of some current pest control policies.

112. Pimentel, et al., *Pesticides, Insects in Foods, and Cosmetic Standards*, 27 BIO. SCI. 178 (1977).

113. *Id.* In dollar amounts, our loss of food and fiber is equal to about $35 billion, or enough to pay for U.S. oil imports in 1976.

114. Pimentel, *Socioeconomic and Legal Aspects of Pest Control*, in PEST CONTROL STRATEGIES (E. Smith & D. Pimentel eds. 1978).

115. *Id.*

116. Pimentel, *Species Diversity and Insect Population Outbreaks*, 54 ANN. ENTOMOLOGY SOC. AM. 76 (1961); D. PIMENTEL, *supra* note 109.

117. D. PIMENTEL, ECOLOGICAL EFFECTS OF PESTICIDES ON NON-TARGET SPECIES (1971); Georghiou, *The Evolution of Resistance to Pesticides*, 3 ANN. REV. ENTOMOLOGY 122 (1972); Pimentel & Goodman, *Environmental Impact of Pesticides*, in SURVIVAL IN TOXIC ENVIRONMENTS (M. Kahn & J. Bederka eds. 1974); R. J. Hance, Ecological Aspects in the Long Term Use of Pesticides (1977) (paper presented at Southeast Asian Workshop on Pesticide Management, Bangkok, Thailand).

118. Oka & Pimentel, *Herbicide (2,4-D) Increases Insects and Pathogen Pests On Corn*, 193 SCI. 239 (1976); Pimentel, *supra* note 112.

Benefits and Costs of Pesticide Use

The dominant pest control technologies in the United States are nonchemical controls.[119] For example, weed control on about 80 percent of the acreage is carried out primarily by mechanical cultivation,[120] whereas herbicidal controls are used on only 22 percent of the crop acres.[121] For the control of plant diseases, some host plant resistance is used on about 95 percent of the acreage,[122] whereas fungicide treatments are used on about one percent of the acreage.[123] With respect to insect control, nonchemical controls are employed on about nine percent of the crop acres,[124] and insecticidal controls are used on nine percent of crop acreage.[125]

There are, however, many reasons why pesticide usage in the United States has received so much attention from scientists and lay people alike. First, although the percentage of acreage treated with pesticide controls is relatively small, the total amount of pesticides applied to our agricultural land is large. Not only are about 800 million pounds of pesticides applied in agriculture annually,[126] but pesticide usage continues to rise at an alarmingly rapid rate. As noted earlier, there has been a tenfold increase in pesticide use in the last 30 years. Furthermore, pesticide use in agriculture is not evenly distributed.[127] For example, of the herbicidal material applied, 70 percent is used on corn, soybeans, and cotton. In the case of fungicides, almost all is applied to fruit and vegetable crops with only a small amount used on field crops. As for insecticides, 64 percent is applied to cotton and corn crops.

The concern voiced here about the use of pesticides is not a condemnation of them. On the contrary, if all pesticides were withdrawn from use and readily available nonchemical control methods were substituted where possible, crop losses based on dollar figures would

119. Pimentel, *World Food Crisis: Energy and Pests,* 22 BULL. ENTOMOLOGY SOC. AM. 20 (1976); PRESIDENT'S SCIENCE ADVISORY COMMITTEE, RESTORING THE QUALITY OF OUR ENVIRONMENT (1965) (report of the Environmental Pollution Panel, the White House, Washington, D.C.).

120. Pimentel, *supra* note 119; 2 NATIONAL ACADEMY OF SCIENCES, WEED CONTROL, PRINCIPLES OF PLANT AND ANIMAL PEST CONTROL (1968).

121. U.S. DEP'T OF AGRICULTURE, FARMERS' USE OF PESTICIDES IN 1976 (1978) (Econ. Res. Service, Agricultural Econ. Rep. No. 418).

122. Pimentel, *supra* note 119.

123. U.S. DEP'T OF AGRICULTURE, *supra* note 121.

124. Pimentel, *supra* note 119.

125. U.S. DEP'T OF AGRICULTURE, *supra* note 12.

126. Berry, *Pesticides and Energy Utilization,* in CONTEMPORARY ROLES IN AGRICULTURE, HEALTH AND THE ENVIRONMENT (T. J. Sheets & D. Pimentel eds. 1979).

127. U.S. DEP'T OF AGRICULTURE, *supra* note 121; 5 U.S. BUREAU OF THE CENSUS, CENSUS OF AGRICULTURE 1969, Parts 1, 4-6 (special reports 1973).

increase a calculated nine percent.[128] The withdrawal of pesticides from use would also affect the availability of some foods we are accustomed to eating. Without pesticides, quantities of certain fruits and vegetables such as apples, peaches, plums, onions, tomatoes, and peanuts would be drastically reduced.[129]

In sum, the dollar loss to the nation from eliminating pesticide use would be considerable. Including the added costs of alternative methods, an estimated $8.7 billion would be lost in crops.[130] With current pesticide treatment costs estimated to be $2.2 billion, the return per dollar invested in pesticide control is about four times the expense.

Cost estimates of benefits, however, do not include the monetary value of the "indirect costs" of human poisonings and environmental destruction. These costs have only recently been given attention. It is easy to understand why. After all, everyone knows that food is essential to life, so crop yields per dollar invested are logical criteria to use. Unfortunately, it is not quite so apparent to many that maintaining the quality of the environment is equally essential. Indeed, crop plants and livestock are but some of the living species of our ecosystem; most of the estimated 200,000 species of plants and animals in the United States are an integral and vital part of this system.[131] Many of these species help renew atmospheric oxygen. Some prevent us from being buried by human and agricultural wastes, while others help purify our water. Trees and other vegetation help maintain desirable climatic patterns. In addition, some insects are essential for pollinating forage, fruit, and vegetable crops. No one knows how much the population numbers of these 200,000 species could be reduced or how many species could be eliminated before agricultural production and public health would be threatened.

The impact of pesticides on the total environment as well as on public health is significant. The effects are varied and complex and, all too often, they are ignored when total assessments of benefits and costs are calculated. Pesticides have influenced the structure and function of ecosystems, altered natural communities, and reduced species population numbers in certain areas. They have changed the normal behavior patterns in animals, stimulated or suppressed growth in animals and plants, and modified the reproductive capacity in

128. Pimentel, *Benefits and Costs of Pesticide Use in U.S. Food Production*, 28 BIOSCIENCE 772 (1978).

129. *Id.*

130. *Id.*

131. Pimentel & Goodman, *supra* note 117.

some animals. In addition, their use has altered the susceptibility of certain plants and animals to diseases and predators and has affected the natural evolution of species populations.[132]

Besides causing measurable damage to many species of birds, fishes, and beneficial insects, careless pesticide use has caused health problems for some humans. The individuals especially prone to pesticide poisonings are pesticide production workers, farm field workers, and pesticide applicators. Estimates are that as many as 45,000 individuals may be nonfatally poisoned by pesticides in a given year, while an additional 200 are fatally poisoned.[133]

At present, overall pesticide residue levels appear to be sufficiently low to present no known danger to human health in the short term.[134] Unfortunately, little is known about the effects of long-term, low-level dosages of pesticides on public health. Furthermore, the possible interaction between low-level dosages of pesticides and the numerous drugs and food additives that the public consumes has not yet been studied.

It is estimated that in the United States, the annual indirect cost of pesticide use reaches nearly one billion dollars annually.[135] Included in this cost estimate are: numerous pesticide poisonings; direct honey bee losses; reduced fruit crops and reduced pollination from the destruction of wild bees and honey bees; livestock losses; commercial and sports fish losses; bird and mammal losses; destruction of natural enemies of pests, resulting in outbreaks of other pests; pest problems that result from pesticide effects on the physiology of crop plants; and increased pesticide resistance in pest populations.

The benefit/cost ratio of pesticide use is difficult to calculate because it is comprised of numerous variable factors. For instance, a change from one pest control practice to another alters the costs as well as the benefits. Shifting from ground application to aircraft application of pesticides is one example. The transition may reduce application costs, but it will increase the environmental costs. Under aircraft application, only 20 to 80 percent of the pesticide reaches the crop target area; the remainder poses a threat to nontarget species outside the target area.[136] At present about 65 percent of all

132. *Id.*

133. Pimentel, et al., *Pesticides: Environmental and Social Costs*, in PEST CONTROL: CULTURAL AND ENVIRONMENTAL ASPECTS (D. Pimentel & J. Perkins eds. 1980).

134. U.S. DEP'T OF HEALTH, EDUCATION AND WELFARE, REPORT OF THE SECRETARY'S COMMISSION ON PESTICIDES AND THEIR RELATIONSHIP TO ENVIRONMENTAL HEALTH (1969).

135. Pimentel, *supra* note 133.

136. *Id.*

agricultural pesticides are aircraft applied, since this is an easy way to treat large farm acreages.[137]

A second factor which affects the benefit side of the equation is that the degree of insecticide effectiveness against one crop pest is often different from the success rate against another. For example, significant advances have been made in reducing insect losses in potato crops, where yield losses gradually have declined from 22 percent in 1919-35[138] to about 11 percent in 1975.[139] In contrast, losses in corn crops due to insects are reported to have increased significantly—from 3.5 percent in 1950 to 12 percent[140] in the present—as the percentage of crop acres treated with insecticides has increased from six percent to 52 percent in this period.[141] The increased insecticide use has actually led to corn rootworm resistance in some populations.

Yet another factor which affects the benefit/cost ratio of pesticides is the degree to which a particular pesticide harms untargeted species and ecosystems. For example, some herbicides weaken the resistance of corn to insect and pathogen pests.[142] On the other hand, a shift from a more persistent pesticide to a less persistent pesticide lessens the "costs" by lowering pesticide residue levels and environmental mobility.

Pest Control Policies

1. Tolerance Policies for Insects and Insect Parts in Foods

Current government policies on the acceptable levels of insect parts in food are not aimed at controlling pests that actually impair food production. On the contrary, these policies result in an unwise allocation of resources to control harmless pests. At the same time, they make less, rather than more, food available for human consumption.

In the early 1900s, the quality of fruits, vegetables, and other food products was significantly below the standards of our markets today.

137. U.S. DEP'T OF AGRICULTURE, FARMERS' USE OF PESTICIDES IN 1971 . . . EXPENDITURES (1975) (Econ. Res. Service, Agricultural Econ. Rep. No. 296).

138. J. HYSLOP, LOSSES OCCASIONED BY INSECTS, MITES, AND TICKS IN THE UNITED STATES (1938) (E-444, U.S. Dept. of Agriculture).

139. Pimentel, *supra* note 112.

140. U.S. DEP'T OF AGRICULTURE, LOSSES IN AGRICULTURE (1954) (Agricultural Res. Service 20-1); Pimentel, *supra* note 116.

141. *Id.;* U.S. DEP'T OF AGRICULTURE, LOSSES IN AGRICULTURE (1965) (Agricultural Res. Service Agricultural Handbook No. 291); U.S. DEP'T OF AGRICULTURE, EXTENT OF FARM PESTICIDES USE ON CROPS IN 1966 (1968) (Agricultural Econ. Rep. No. 147, Econ. Res. Serv.); U.S. DEP'T OF AGRICULTURE, *supra* note 128.

142. Oka & Pimentel, *supra* note 118.

The food was sometimes contaminated with insects and insect parts and with rat and mice feces. Our food is still contaminated with all of these substances, but modern levels of contamination are greatly below the levels tolerated half a century ago.

The Federal Food, Drug and Cosmetic Act of 1938[143] and its several amendments represent an attempt to place controls on and set standards for the foods we eat, the drugs we take, and the cosmetics we use. One of the responsibilities handed over to the Food and Drug Administration under the statute was reducing the level of defects allowed in food.

Accordingly, the agency adopted standards with respect to levels of insects and insect parts in food, both processed and fresh. These standards, called defect action levels (DALs), were established "on the basis of no hazard to health."[144] The agency's goal of protecting health was easy to meet, since all herbivorous insects present in and on fruits and vegetables are known to be nonpathogenic to man.[145] The presence of insects may even contribute to the nutritional value of many foods. Defoliart and Taylor assembled data on the nutritional values of several insects, and these values compare favorably with those of shrimp, lobster, and crayfish, which are also arthropods.[146] No digestive upsets are known to have followed consumption of the quantities of tiny herbivorous arthropods such as mites, thrips, aphids, leaf miners, fruit flies, and flour beetles that are commonly found in foods in the United States.[147]

Since insect tolerance levels are not determined by health requirements, the dominant consideration of the FDA in setting DALs has been the reduction of insect infestation to levels that are considered reasonable based on the state of insect control technology (provided that the insects or insect parts remaining are not visible).[148] A report in *Food Purity Perspectives* states that FDA standards for small insects in vegetables and other foods were established because the presence of insects indicates that the crop had insufficient insect

143. Federal Food, Drug and Cosmetic Act, Pub. L. No. 75-717, § 406, 52 Stat. 1040 (1938) prior to 1977 amendments, 21 U.S.C.A. § § 301-____(1979).

144. FOOD AND DRUG ADMINISTRATION, CURRENT LEVELS FOR NATURAL OR UNAVOIDABLE DEFECTS IN FOOD FOR HUMAN USE THAT PRESENT NO HEALTH HAZARD (5th rev. 1974).

145. *Id.*

146. Defoliart, *Insects as a Source of Protein,* 21 BULL. ENTOMOLOGY SOC. AM. 161 (1975); R. TAYLOR, BUTTERFLIES IN MY STOMACH (1975).

147. Pimentel, *supra* note 112; Mills & Pepper, *The Effect on Humans of the Ingestion of the Confused Flour Beetle,* 32 J. ECON. ENTOMOLOGY 874 (1939).

148. Food and Drug Administration, Revision of Defect Action Levels for Spinach (December 14, 1972) (inhouse memorandum).

control, was improperly washed, or was unsatisfactorily inspected, not because eating insects necessarily is harmful to human health.[149] Indeed, a strong sentiment exists in the United States against the presence of any insects or insect parts in food, even though they may not be noticeable.

Nevertheless, everyone consumes some insects in fruits and vegetables. If a zero tolerance were established for insects and insect parts, many foods, such as raspberries, strawberries, and catsup, would be eliminated from the marketplace because it is impossible to produce these products without insects.[150] To eliminate insects and insect parts from other fruits and vegetables would require tremendous dosages of insecticides. In fact, this elimination would pose a "very real danger of exposing consumers to potential hazards from residues of these chemicals."[151]

As mentioned, minute thrips, aphids, and mites are practically impossible to eliminate from many foods. The FDA has sensibly set DALs accordingly. For example, recognizing that it is difficult to clean raspberries and blackberries without damaging them, FDA set the DAL at an "average of 4 (insect) larvae per 500 grams (*excluding* thrips, aphids, and mites)."[152] On the other hand, frozen broccoli, which can be washed during processing, has a DAL of an "average of 60 aphids, thrips, and/or mites per 100 grams."[153]

Overall, this government policy of reducing the tolerance levels for insects in foods has had two pronounced effects. First, it has inadvertently increased crop losses. This increase has resulted from classification of a larger proportion of food as no longer suitable for commercial use because it cannot meet the stricter DAL standard. If FDA inspectors find any food with an insect infestation above the DAL, the lot is seized and disposed of promptly. During 1950, for example, 535,909 pounds of spinach out of a total of 205.5 million pounds produced were seized and destroyed because of insects.[154] This was the largest amount of spinach seized for insect infestation. A similar seizure has occurred with broccoli.[155] Although the percentage of both crops seized was small (about 0.2 percent of the

149. *Amounts and Kinds of Filth in Foods and the Parallel Methods for Assessing Filth and Insanitation,* 3 FOOD PURITY PERSPECTIVES 19 (August 1974).

150. Pimentel, *supra* note 112.

151. FOOD AND DRUG ADMINISTRATION, *supra* note 144.

152. *Id.*

153. *Id.*

154. FOOD AND DRUG ADMINISTRATION, NOTICES OF JUDGMENT UNDER THE FEDERAL FOOD, DRUG AND COSMETIC ACT (1944-66).

155. *Id.*

total crop), in light of present food shortages any wastage is cause for concern.

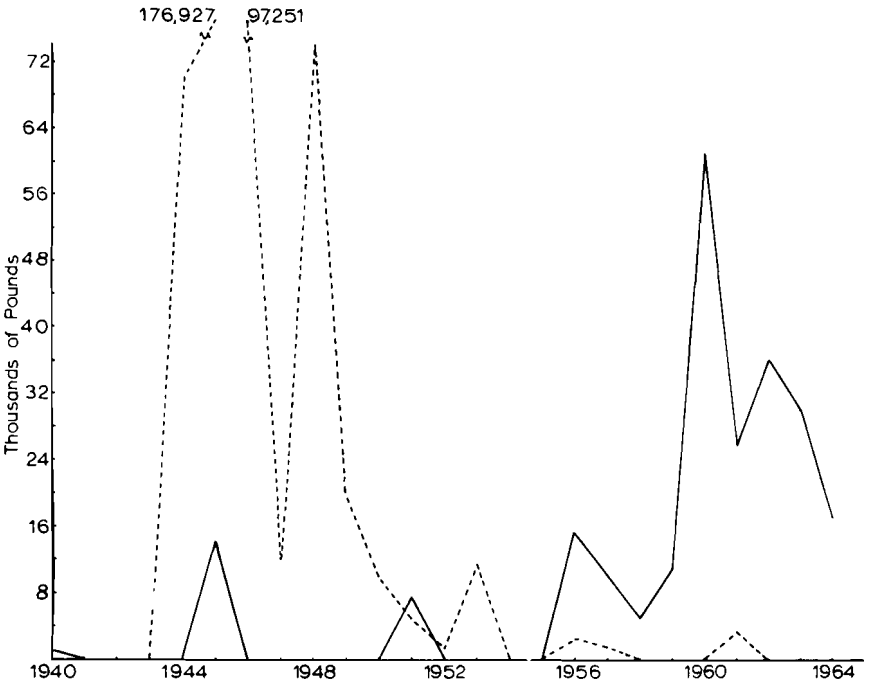
In addition to adding to crop losses by condemnation, the FDA policy has resulted in the intensification of insecticide treatments to reduce the incidence of insects in food and thereby meet the DAL guideline. For example, since 1950 the use of insecticides in spinach production has increased two- to threefold.[156] In more general terms, based on both an overall examination of insecticide use on some fruit and vegetable crops and on data showing a two- to tenfold increase in insecticide usage on those crops, we estimate that from 10 to 20 percent of the insecticide applied to fruits and vegetables is used in an effort to meet stringent DALs set by the FDA.[157]

Insecticide use is not accomplished without a price. In terms of dollars there is the cost of labor and machinery for pesticide applications, as well as the cost of the pesticide itself. Pesticide use also costs in fossil energy--a valuable, nonrenewable resource.[158] To the consumer, these costs are translated into food prices. Simply, then, an increase in insecticide use ultimately means higher food prices. Moreover, attendant to pesticide use is the myriad of environmental ills discussed above. Since no health benefit accrues from stringent DALs, the intensification of insecticide application offers no advantages. Instead, the effects are all on the "cost" side of the benefit/cost balance.

Paradoxically, increased insecticide use to meet FDA insect standards has also led to seizures of some crops for exceeding the FDA regulatory tolerances for pesticide residues. Before 1956, only a few leafy-type vegetables were seized for having pesticide residues, but in 1956 and for several years afterward, quantities of the same group of vegetables were seized for high levels of pesticide contamination (Figure 1). The data available for these vegetables indicates that there has been a shift from seizures for high insect numbers based on DAL guidelines to seizures for high pesticide residues.[159]

The trend in governmental policy to reduce DALs even further is disturbing. According to FDA administrators and a statement appearing in the Federal Register, DALs will continue to decline "as technology permits."[160] Again, spinach is a prime example of this policy trend. During the 1930s the DAL was 110 aphids allowable per 100

156. Personal communication with W. H. Lange, Jr., University of California at Davis, 1976.
157. Pimentel, *supra* note 112.
158. Pimentel, *supra* note 119.
159. Pimentel, *supra* note 112.
160. 38 Fed. Reg. 854 (1973).



Source: Pimentel, et al., *Pesticides, Insects in Foods, and Cosmetic Standards*, 27 BIO. SCI. 178 (1977). Data for 1966-74 were requested from the FDA but were not compiled comparably to the 1944-66 data.

FIGURE 1

Seizures of leafy vegetables by the FDA for contamination with insects (dashed line) and with pesticides (solid line).

grams of spinach.[161] This guideline was based on information on market sample findings and on achievement at that time of a successful method of aphid control in fresh spinach.[162] In the early 1940s, pressure from FDA's District Laboratories resulted in a reduction in the DAL to 60 aphids per 100 grams of spinach.[163] This DAL remained in effect until 1974, when it was reduced further to 50 aphids per 100 grams,[164] or less than half the 1930 standard for aphids in spinach.

In sum, this government policy, responding to a different set of

161. Food and Drug Administration, *supra* note 148.
162. *Id.*
163. *Id.*
164. FOOD AND DRUG ADMINISTRATION, *supra* note 144.

pressures, has worked against an effective systems management program for pest control. In light of the prognosis for world food needs and supplies, the program should be re-evaluated.

2. Pesticide Registration and Environmental Protection

Since 1947, pesticides have been under national control through the registration procedures of the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA).[165] FIFRA was designed to ensure that farmers would receive effective products with sufficient safety instructions. The United States Department of Agriculture (USDA) was directed to take charge of the pesticide registration procedures.

As public interest grew to include concern over pesticide effects on the ecosystem as a whole, environmental groups attempted to use FIFRA as a possible way to curb the indiscriminate and unnecessary use of pesticides. These efforts culminated in a series of court decisions which exhibited the inadequacy of FIFRA to meet both the original product safety purposes and the new environmental responsibilities placed on it. Judicial examination of FIFRA identified three major deficiencies which prevented adequate environmental and health considerations from being introduced into the regulation of pesticides: (1) there was no allowance for public input into the decision-making process;[166] (2) there were no standard decision-making criteria with which to check agency discretion;[167] and (3) there was no system for monitoring pesticide use.[168]

The USDA response to public discontent led to the transfer of authority to the newly established Environmental Protection Agency (EPA).[169] The shift from an agency designed to aid farmers and promote agricultural production to an agency designed to protect and enhance environmental quality symbolically suggested that the narrow basis for FIFRA enactment had given way to a broader basis.

The mere transfer of authority, however, did not quiet the discontent. Indeed, several suits were brought against EPA after the transfer. Even EPA voiced discontent with FIFRA:

165. 7 U.S.C. § § 135-136y (1976) (formerly 7 U.S.C. § § 121-134).

166. Environmental Defense Fund v. Hardin, 428 F.2d 1093 (D.C. Cir. 1970); Environmental Defense Fund v. Ruckelshaus, 439 F.2d 584 (D.C. Cir. 1970).

167. Environmental Defense Fund v. Ruckelshaus, 439 F.2d 584 (D.C. Cir. 1970); Environmental Defense Fund v. Environmental Protection Agency, 465 F.2d 528 (D.C. Cir. 1972).

168. Nor-Am Agricultural Products, Inc. v. Hardin, 435 F.2d 1133 (7th Cir. 1970); Continental Chemists Corp. v. Ruckelshaus, 461 F.2d 331 (7th Cir. 1972); Stearns Electric Paste Co. v. EPA, 461 F.2d 293 (7th Cir. 1972).

169. 42 U.S.C. § 4321 (1976).

> [T]he courts are currently taking the initiative in attempting to correct the deficiency of the current law. It would indeed be unfortunate if the courts were to assume the responsibility for deciding the very delicate issues that arise in dealing with the use of pesticides. The recent development of extensive litigation on these matters reflects an upsurge of public dissatisfaction with the present regulatory framework.[170]

The congressional response to mounting judicial and public interest group criticism of FIFRA was the enactment of the Federal Environmental Pesticide Control Act of 1972 (FEPCA).[171] This act makes several improvements on FIFRA. First, FEPCA adopts many of the judicial endeavors to break the closed administrator/manufacturer registration procedures of FIFRA. The right of public interest groups to participate in emergency suspension order hearings is granted through a provision which allows any person adversely affected to file briefs with the EPA.[172] Also, the availability of judicial review of administrative orders is expanded to give the consumer a ready remedy for agency action and inaction.[173]

Second, FEPCA places a floor on agency discretion by articulating the criteria upon which an administrator must rely in decisions of pesticide registration or suspension.[174] Pesticide orders are to be based on a balancing of benefits and dangers to the public welfare stemming from use of a product. Under FIFRA, a product was to be suspended when it created an imminent hazard to the public. The new regulations require that a manufacturer give increased proof that his product can perform its intended functions and be used in accordance with widespread and commonly accepted practice without causing "unreasonable adverse effects on the environment."[175] The change in phraseology represents a shift in regulatory emphasis from mere agricultural effectiveness and product safety to more extensive considerations of environmental and public health hazards.

Although the new standards ensure a consideration of environmental factors, they do not set an explicit danger threshold level. Essentially, the agency decision maker is free to decide what weight to give varying factors in the balancing equation, whether to count

170. Statement by William H. Ruckelshaus before the Subcommittee on Agricultural Research and General Legislation of the Senate Committee on Agriculture and Forestry, 92nd Cong., 1st Sess. (1971).

171. Pub. L. No. 92-516, 86 Stat. 973, amending Federal Insecticide, Fungicide and Rodenticide Act, 7 U.S.C. § § 135-136y (1976).

172. 7 U.S.C. § 136a(c)(5) (1976).

173. 7 U.S.C. § § 136n(a), (b) (1976).

174. 7 U.S.C. § § 136(bb), 136a(c)(2) (1976).

175. 7 U.S.C. § 136a(c)(5) (1976).

potential effects as much as known effects, and how severe an effect must be before the effects of a product can be considered "unreasonably adverse" to the environment. Experience under the amendments has shown that pesticide registration/cancellation depends in part on the biases of the particular decision maker.[176]

It is doubtful, however, whether much more could be expected at this time. After all, it is impossible to quantify all the risks or benefits in terms of dollars. Translation of even quantifiable factors into a set of numbers is itself a subjective process. At present it seems reasonable to live with the present system in order to maintain flexibility in decision making, rather than to get locked into a mathematical equation that leaves no room for modifications as our knowledge expands.

There is one major deficiency in the present balancing equation, however, that could be improved through legislation. As the act stands now, EPA is prohibited from refusing to register a chemical on the grounds that an equally effective product is already in use or that effective bioenvironmental pest controls could be used instead.[177] FEPCA nullified an earlier judicial interpretation of FIFRA[178] that had required a finding of true need and benefit for each pesticide developed and sold for use in view of the important interests at stake.

Another shortcoming of FEPCA is its system of use control. If use of a product in accordance with directions may nonetheless result in injury to human health, the product is registered for restricted use and may only be used under the direct supervision of a certified applicator.[179] Although this scheme lays a workable foundation for protecting public safety, it does little to make pesticide application environmentally safe. The sanctions present in the act apply when a pesticide is used in violation of the manufacturer's instructions, which are necessarily general and broad since pesticide products are used in a variety of circumstances, for a variety of reasons, and by a differentially competent population of users.[180] The limited provision for sanction in the act makes it extremely difficult ever to establish a violation.

The lack of explicit standards is especially dangerous in this area. More often than not, the persons applying the chemicals have a

176. McCarey, *Pesticide Regulation: Risk Assessment and Burden of Proof*, 45 GEORGE WASH. L. REV. 1066, 1093 (1977).

177. 7 U.S.C. § 136a(c)(5) (1976).

178. Environmental Defense Fund v. Environmental Protection Agency, 465 F.2d 528, 539 (D.C. Cir. 1972).

179. 7 U.S.C. § 136a(d)(1) (1976).

180. Large, *Pesticide Control Act*, 3 ECOLOGY L. Q. 277, 305 (1973).

vested interest in the use of the pesticide. Understandably, profit motivations such as considerations of crop yields and economic costs of other pest controls are foremost in their minds. Even though the user is benefitted by a high quality environment and therefore gains if its quality is protected, the environmental benefits are more indirect than the immediate economic benefits of pesticide application and are often not readily apparent to him.

Unfortunately, users typically do not give adequate consideration to the benefits that a quality environment offers to them and to the general public as well. Nor do they weigh the alternative—the cost to the general public of misuse, overuse, or unnecessary use of pesticides. As in any externality problem, there is no incentive for the user to make these considerations in deciding what and how much pesticide to use. This situation indicates the need for the government to intervene and supply the needed incentives, either positive or negative, through its lawmaking powers. At present, FEPCA fails to put the burden on the pesticide user for both the direct and indirect costs of use.

An alternative suggested by some is the establishment of a system of pesticide use by permit only, similar to use of medical drugs by prescription.[181] This system would involve teams of experts, knowledgeable about both the indicated need and the environmental sensitivities of the areas in question.[182] These experts would be in charge of permitting, modifying, or denying pesticide use requests. Such a review would place the decision in the hands of persons who are well informed and able to weigh impartially all relevant factors of pesticide application. This procedure would also enforce consideration of alternative means of pest control.

The political viability of such a system, however, is doubtful. In fact, Congress has already rejected it.[183] That rejection does not preclude the states from taking appropriate action. But it seems wishful to hope for widespread acceptance of this practice, especially in those states where the primary industry is farming, since public sentiment appears to run against government intervention. Unfortunately, it is precisely those areas that need the controls, since the amount of land and environment affected there is far greater than in nonagricultural states. Perhaps a federally initiated permit system run at the local or state level would be a more viable political possibility.

181. *Id.*

182. *Id.*

183. *Hearings on S. 232, S. 272, S. 660 and S. 745 Before the Subcommittee on Agriculture and Forestry*, 92nd Cong., 1st Sess. 144 (1971); 293 H.R. REP. NO. 92-511, 92nd Cong., 1st Sess. (1971).

Overall, the new act has contributed to making pesticide regulation an environmental and public health measure. As pointed out, however, inadequacies do exist that may jeopardize the responsiveness of the legislation to greater environmental concerns.

CONCLUSION

Some of our past and current government policies are having a significant impact on the natural resources essential for successful agriculture. Their influence is being felt throughout the ecosystem. The effects reach considerably beyond cropland and touch society as a whole. The past has witnessed an ad hoc approach to agricultural policy, but this is no longer a viable way to solve complex resource management problems. When we acknowledge that productive agriculture is but one part of our entire environmental and social system and begin to consider all the interacting components, we will be able to solve our problems through policies that protect our valuable natural resources.