Pesticide Use: Environmental Risks and Alternatives

by Jennifer Decker

INTRODUCTION

Of the 1.1 billion pounds of pesticide chemicals used nationwide in 1984, seventy-seven percent or 861 million pounds were used in agriculture. The California Public Interest Research Group (CALPIRG) reports that sixty to eighty percent of pesticides used are to enhance the cosmetic appearance, and not the life, of the produce. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry,* U.S. Senate, February 9, 1990 (statement by Mr. Richard Reed, California Action Network). Nationally, eleven percent of the pesticides used are fungicides, twenty-three percent are insecticides, and sixty-six percent are herbicides. Mattes, *Kicking the Pesticide Habit, AMICUS* Journal, Fall 1989, Volume 11, Number 4, p. 16. In California alone, farmers use over ninety-three million pounds of pesticides and nearly five billion pounds of fertilizers each year. Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry, U.S. Senate, February 9, 1990 (statement by Ms. Jennifer Curtis, Research Associate of Natural Resources Defense Council).

Nationally, pesticide use has increased dramatically in the latter part of this century, without a corresponding reduction in pest damage. Pesticide chemical use has increased thirty-three fold since 1945 (Hileman, *Alternative Agriculture, Chemical and Engineering News*, March 5, 1990, at 29), yet crop loss from insects has increased twofold, from about seven percent to thirteen percent. *Id.* See also Mattes, *Kicking the Pesticide Habit* at 10. According to Dr. Pimentel, a professor of insect ecology and agricultural sciences at Cornell University, society turned to chemicals during the 1940's as an easy solution to agricultural pests. He believes society's resulting reliance on a chemical solution to every pest problem was misguided, creating costly environmental and health problems. Dr. Pimentel suggests that the only longterm answer to pest control is through a highly complex "ecological approach" to farming. *Id.* at 17.

This article surveys problems with pesticide use and a number of "ecological approaches" to farming that are currently used or being tested by U.S. farmers. Some of these methods have been around for centuries and are being rediscovered in this country; others are being developed through university and government research programs. These programs have a number of common benefits including their dramatic reduction pesticide usage and reduction of water waste from irrigation. *Id.* at 17.

THE PROBLEMS: HUMAN HEALTH AND THE ENVIRONMENT

Pesticide use affects the health of farm workers and consumers and damages the environment. EPA's experts rank pesticides as a more serious public health risk than hazardous waste sites. Johnson, *Congress Again Tries Rewriting Pesticide Law, San Francisco Examiner*, July 31, 1987. Scientists, however, disagree about the degree of health danger from any given pesticide. Because EPA's testing of over 600 chemical agents is decades behind schedule and terribly underfunded, answers will not come quickly.

The potential health problems from pesticide exposure can be divided into two classes: acute effects and chronic effects. Acute effects result from contact with high levels of a chemical over a short duration, usually causing immediate signs of contamination. These effects include nausea, skin irritation, and other minor problems. U.S. Environmental Protection Agency, *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy, Office of Pesticides and Toxic Substances*, December 1987, p. 25.

Chronic effects from pesticide exposure are harder to document because of the long latency period between exposure and the onset of symp-

toms. Many effects are known, however, including cancer, mutations, birth defects, and immunological problems. Scientists agree that there are risks from drinking pesticide-laden ground water, but they are unsure about the exact health effects of low level exposure to specific pesticides. *Id.* Although gaps exist in scientific data, there is consensus that pesticide use is an endemic problem that threatens our health. Currently, an average of three California farm workers report pesticide poisoning each day, and officials estimate that at least eleven additional cases of poisoning go unreported. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry*, U.S. Senate, February 9, 1990 (statement by Mr. Richard Reed, California Action Network). The general public is exposed on a daily basis through fruit and vegetable consumption. We are further exposed through drinking pesticide-contaminated water.

PESTICIDES AND GROUND WATER

Pesticide monitoring began in the 1970's, and by 1986 nineteen different pesticides had been detected in ground water in twenty-four states. Today, twenty-six states report ground water contamination. *Id.* Most contamination comes from non-point sources, such as agricultural applications, rather than from spills or concentrated point sources. U.S. Environmental Protection Agency, *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy,* Office of Pesticides and Toxic Substances, December 1987, at 21-22. Pesticide-contaminated aquifers are particularly troublesome where they are the primary or sole source of drinking water, such as in smaller communities (like the Island of Oahu); aquifer contamination means importing water at a great expense.

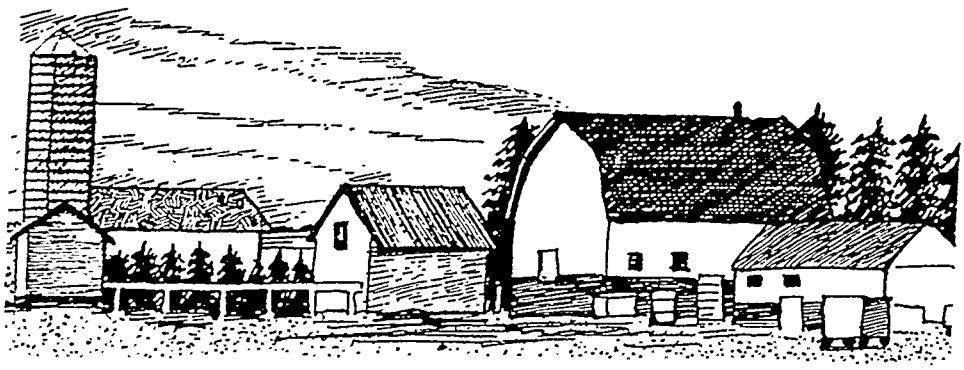
Nationally, EPA's Superfund program has halted any site investigation where non-point source pesticide contamination is suspected. Contamination from legally applied pesticides is so widespread that any attempt to cleanup the potential Superfund sites would bankrupt the program's budget.

Currently in California, approximately fifty-seven different pesticides have been detected in groundwater, one-half of these being attributed to legal pesticide application and one-half to point sources or unknown causes. The result is that many Californians risk greater pesticide exposure than people from most other states. For example, nearly 700,000 Californians may have been exposed to dibromochloropropane (DBCP) in 1987 from 2500 DBCP-contaminated drinking water wells; sixty percent of these wells had levels above the State standard. *Id.* at 22. California's environmental problems from pesticides are not unique. The state monitoring programs only confirm the problems. In Long Island, New York, 1,000 aldicarb-contaminated wells contained levels about the state standard of 7 parts per billion (ppb). *Id.* at 22. In Florida, 1,200 drinking wells have been closed due to aquifer contamination; ten percent of the public and private wells there contain ethylene dibromide (EDB). A 1986 Minnesota survey reported pesticide contamination in fifty-two percent of 225 private wells. *Id.* at 22.

MOVEMENT OF PESTICIDES FROM THE TOP SOIL TO THE GROUNDWATER

Natural factors, as well as agricultural practices, affect the potential for pesticides to contaminate ground water. These factors include the physical properties of the chemicals and the soil, and climactic conditions.

The chemical properties of the pesticides affect their longevity in the soil and their rate of movement



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from the surface soil to the aquifer. For example, water solubility determines a pesticide's propensity to dissolve in water, making the chemical more able to migrate through the soil and into an aquifer. Hydrolysis is the rate of degradation of a pesticide in water; if the pesticide leaches below top layers of soil, beyond biological activity, hydrolysis becomes the only process available to decompose a pesticide. Dragun, Kuffner, and Schneiter, *A Chemical Engineer's Guide to Groundwater Contamination, Chemical Engineering*, Nov. 26, 1984, p.66.

Once the soil and pesticides begin to interact, their combined chemical properties create molecular reactions, forming new molecular bonds. Chemicals tend to bind to soil particles in a process known as adsorption, which slows the pesticide migration processes. Adsorption is most greatly affected by the soil type, soil moisture, and soil organic matter content. *Id.* at 67.

This propensity for soils and pesticides to bond affects the rate of pesticide migration in different types of soils. For example, clay soils have a high surface area which encourages adsorption. *Id.* The chemical properties of clay allow positively-charged chemicals to easily bind with the clay fraction in the soil. The percentage of clay or sand or silt in the soil is called the soil texture. Soil texture affects the pesticide's ability to leach, moving slowly in fine or cement-like clay soils, and more quickly and deeper in course or light soils. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy*, EPA, Office of Pesticides and Toxic Substances, December 1987, p. 22. The larger structure of soils also affects their propensity to bind with chemicals or allow chemicals to readily pass by. Large soil structure is determined by the way soil particles bind together into larger units. Dragun, Kuffner, and Schneiter, *A Chemical Engineer's Guide to Groundwater Contamination* at 66.

The most simple soils are made of uniform grains. However, soils can also bind themselves into plates or clumps or other shapes. The manner in which the soil clumps contributes to the propensity for water and dissolved pesticides to migrate through spaces between the clump. The more pore space between soil groupings the higher the porosity; the higher the porosity of the soil, the quicker the percolation of pesticides toward the aquifers. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy* at 22.

Pesticide persistence in the soil also determines the longterm effect of these chemicals. Persistence is essentially a chemical's expected lifespan. It is measured as the time required for one-half of the pesticide's residue to degrade to a non-detectable level. Persistence is an inherent characteristic of the chemical itself. Dragun, *A Chemical Engineer's Guide to Groundwater Contamination* at 66.

Once pesticides are sprayed onto a field, they have the potential to migrate deep into the soil and into the aquifers below. The downward movement of a pesticide in the soil is driven by competing processes of degradation and leaching. *Id.* If the chemical is degraded by biological or chemical processes before it leaches, it never reaches the aquifer. If the chemical has high persistence, is not degraded, and also does not bind with soil, it is very likely to leach into and contaminate the ground water. *Id.*

Climactic conditions also greatly affect the likelihood that pesticides in soils will reach the groundwater. One of the most important variables is the amount of precipitation in the area. As rain falls onto the soil, the rain water binds with the chemicals and carries them through the soil particles to the ground water below. Air temperatures compete with this process since evaporation reduces the water available for migration. *Id.* The depth of the aquifer from the surface soils is also key to how quickly an aquifer can become polluted. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy* at 35-37.

AGRICULTURAL PRACTICES AFFECTING PESTICIDE CONTAMINATION

Many agricultural practices affect the level of environmental contamination from pesticide use. These practices include:

* Application Rates: The amount of pesticides applied correlates directly with the amount of pesticides available for leaching into the soils and groundwater.

* Timing of Application: Timing the spraying relative to rainfall events, season of the year, and the presence or absence of a crop affects the net amount of chemicals reaching the soil. *Id.* at 36.

* Method of Application: Pesticides are applied in a number of ways. These include spraying them directly on the crops or on bare soil, dissolving them in irrigation water, or injecting the chemicals

beneath the soil surface. Subsurface injection and direct surface spraying are the methods most likely to contaminate groundwater. *Id.* at 36-37.

* Cultivation Practices: Tillage used to decrease soil erosion can increase a soil's porosity, which hastens the percolation of soluble pesticides.

* Irrigation: Irrigated soils are highly permeable. The amount of irrigation water commonly reaching subsurface soil is estimated to be twenty to forty percent of the applied water. *Id.* at 39. As this water leaches, it carries the soluble pesticides and their residues with it.

* Aerial Application: The common practice of spraying pesticides from aircraft spreads the chemicals where they are not needed. Only 0.1 percent of the chemicals applied reach their actual target. Mattes, *Kicking the Pesticide Habit* at 10.

* Affects of Pesticide Use: Pesticides create the need for more pesticides. Insecticides breed insecticide-resistant insects and kill bugs' natural enemies. Herbicides and fungicides create resistant weeds and pathogens. They also may increase the susceptibility of crops to insects and disease. *Id.* at 10.

Six crops account for about ninety percent of pesticide applications. These are alfalfa, corn, cotton, sorghum, soybeans, and wheat. This concentration of pesticide use on a few major crops means that the application is heavily concentrated in certain major agricultural areas. Herbicides currently form the largest and most rapidly growing class of pesticides. Applications of herbicides now account for nearly ninety percent of the acreage of all major crops treated. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy* at 31.

COSTS OF PESTICIDE USAGE AND CONTAMINATION

Pesticide use costs a great deal in terms of the affects on public health, farm workers' lifespans, damages to the ecosystem, and food costs. Crop losses, decline in property values, medical costs, and law suits are just a few of the other indirect costs resulting from pesticide use. According to Dr. Pimentel, a conservative estimate suggests that the environmental and social costs of pesticide use in the U.S. amount to about $1 billion annually; the potential costs are much higher. Mattes, *Kicking the Pesticide Habit* at 12.

Measuring the costs of pesticide usage to society is a difficult task. A USDA report by Nielson and Lee in 1987 estimated the costs of avoiding risks imposed by pesticides in ground-water contamination. Household well water monitoring costs alone were an estimated $1.4 billion. Installing home-water treatment units or obtaining alternative drinking water supplies are viable options, but the costs are high. *Agricultural Chemicals in Ground Water: Proposed Pesticide Strategy* at 26.

Cleanup of all point-source contaminated aquifers is not economically feasible. Cleaning up nonpoint sources resulting from pesticide application would be even more expensive and may not be technologically feasible for most areas. The Nielson study estimated that hazardous waste site cleanups cost from $1.9 million to $6.1 million. *Id.* at 26-27. These cleanups involve groundwater monitoring, pumping, and treating. The cost variables include the size of the cleanup area and the volume of groundwater being pumped. Based on current Superfund costs, actual costs are more than ten times Nielson's estimates.

THE DEMAND AND NEED FOR ALTERNATIVES TO PESTICIDES

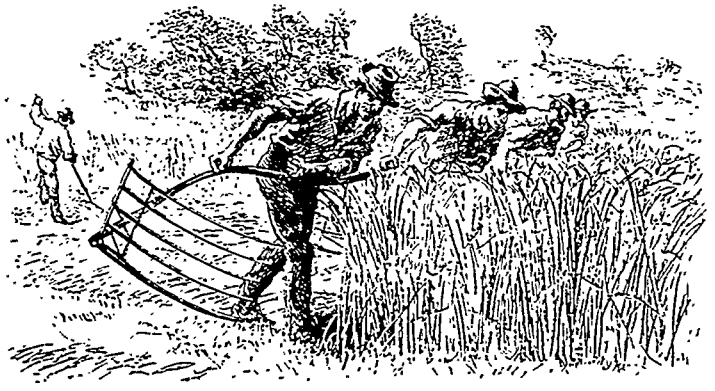
Farmers are asking the federal government to help develop alternatives to pesticide use because of market pressures, the cost of pesticide usage, and con-

cern for their health. According to a University of California study, seventy-seven percent of California adults are concerned about food safety in general. and forty-eight percent are concerned specifically with pesticides in food. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry*, U.S. Senate, February 9, 1990 (statement by Mr. Richard Reed, California Action Network, quoting Dr. Christine Bruhn, University of California). Consumers are demanding lower pesticide residues in their food products, as indicated by the strong California organic (meaning no synthetic fertilizers or pesticides) food market. Organic sales are increasing yearly, totalling over $1 billion in 1988. Fifteen states have recently passed laws or adopted regulations defining "organic" for labeling purposes. Hileman, *Alternative Agriculture, Chemical and Engineering News*, March 5, 1990, at 38.

International concerns about pesticide use are growing as well. Dr. Pimentel was recently invited to Sweden to advise officials there on a new national policy aimed at reducing pesticide use by fifty percent within the next four years. Denmark will follow with a similar national plant to reduce pesticide use by 1997. Mattes, *Kicking the Pesticide Habit* at 12.

OVERHAUL OF FEDERAL PESTICIDE POLICIES

In response to growing concerns over pesticides, the Senate Subcommittee on Conservation and Forestry of the Committee on Agriculture, Nutrition and Forestry has held hearings on the use of alternative agricultural practices and their economic viability. One force driving these hearings is Senator Wyche Fowler (D-Georgia) and his proposed *Farm Conservation and Water Protection Act.* The hearings highlighted the Department of Agriculture's (USDA) economic policies that restrict farmers' abilities to utilize pesticide alternatives and innovative agricultural techniques.



The time seems to have come for our weak national pesticide policies to be overhauled. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry*, U.S. Senate, February 9, 1990 (statement by Dr. Bill Liebhardt, Director, Sustainable Agriculture Research and Education Program, University of California, Davis). As Senator Fowler stated, "Man created the (pesticide) problem, and we ought to be able to find a way to do it better." *Id. (*quoting Senator Fowler). However, in finding a way to "do it better," policies must be formulated that do not place all the risks on innovative farmers.

Reforming pesticide policies must also include reforming the numerous and complex federal and state programs and authorities which directly or indirectly address pesticide-related issues in ground-water. For example, EPA currently administers five major statutes that address some aspect of pesticide contamination in ground water, including the Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), Safe Drinking Water Act (SDWA) , Clean Water Act (CWA), Resource conservation and Recovery Act (RCRA), and Comprehensive Environmental Response, Compensation and Liability Act (CERCLA). The U.S. Department of Agriculture, the US geological Survey, and the Department of Interior also play roles. In addition, state agencies and statutes address pesticide problems and often conflict with federal goals, policies, and contamination levels. All of these federal and state agencies and acts must be coordinated into a coherent means of confronting the damages posed by pesticide usage.

MISGUIDED FEDERAL POLICIES

Federal tax and support incentives currently encourage monocultures or large-scale single crop fields, which are less resistant to adverse conditions than diversified crop systems. Planting corn on corn, year after year, for example, intensifies the insect problem, weeds and diseases. Mattes, *Kicking the Pesticide Habit* at 10. Existing laws only give price and income support for a few crops such as feed grain,

cotton, wheat, rice, sugar and soybeans. By changing crops to any but these, the farmer loses financial incentives and rewards. Hileman, *Alternative Agriculture* at 36. The federal government's support of monocultures has indirectly encouraged widespread abandonment of crop rotation, increasing the need and use of insecticides. According to the Natural Resources Defense Council, in 1945 when farmers universally rotated corn and used no insecticides, crop loss to insects was 3.5 percent; today the loss is twelve percent. Mattes, *Kicking the Pesticide Habit* at 10.

ALTERNATIVES TO PESTICIDES AND MONOCULTURES

A. Integrated Pest Management

Integrated Pest Management (IPM) is an alternative pesticide control system. Eleven years ago, IPM became part of our national agricultural policy. However, since then overall pesticide use has increased, and there has been no corresponding reduction in pest damage. The program has not an overwhelming success to date due largely to low funding. According to NRDC, federal funding for IPM has remained at only $7.5 million for the past eight years. *Id.* at 12.

California state funding for IPM research and alternative farming experimentation is nearly $2 million per year. This state funding includes a competitive grant program awarding $760,000 to forty different projects on commercial farms by university researchers and county based advisors. Mattes, *Kicking the Pesticide Habit* at 15. There are fifteen different elements of the research programs in five basic areas: cultural, environmental, physical, biological, and chemical needs.

Cultural control of pests involves soil mix, growing methods, pest-resistant crops, and timing and quantity of watering. Environmental control requires temperature and humidity regulation. Physical control includes weeding, disposal of diseased or infested plants, and insect traps. Biological control education increases awareness of life cycles and the encouragement of natural enemies. Chemical control allows for only limited use of targeted insecticides, fungicides, and herbicides.

Using IPM, at each stage of pest and weed control, decisions are based on the "economic threshold" -- the point at which the cost of potential crop loss without control out weighs the cost of control. The entire ecosystem is considered in the analysis, not just the short term need to eradicate an insect.

In practice, farmers are sometimes hesitant to use IPM since the proposed actions mean making changes to their current practices. However, IPM has been very successful in many farms where the program has been fully implemented. For example, fifteen years ago, six or seven pesticides were used on San Joaquin Valley cotton crops. Today, only one is used per year. Mattes, *Kicking the Pesticide Habit* at 15 (quoting Mary Louise Flint, acting Director of IPM education and publications for the University of California). In addition, the New York 1988 IPM Annual Report showed a continuing decrease nationwide in pesticide use. IPM Potato growers, for example, used twenty-one percent less fungicides and seven percent less insecticides by better understanding crop life cycles. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry*, U.S. Senate, February 9, 1990 (statement by Ms. Jennifer Curtis, Research Associate of Natural Resources Defense Council). In Texas, the use of insecticides on cotton dropped by eighty-eight percent between 1966 and 1974; similar results in other states have shown a reduction of insecticide use on grain sorghum, cotton and peanuts by from forty-one to eighty-one percent. *Id.*

Over forty-two colleges and universities offer IPM Extension education programs while a state IPM coordinator reports to the program leader in Washington. A 1987 USDA report states that 250,000 clients participated in 150 separate IPM programs incorporating twenty-seven million acres of crop land. Mattes, *Kicking the Pesticide Habit* at 16-17. IPM's most significant accomplishment to date has

been its effect on farmer's attitudes about their farm and its integrated environment. The IPM program's most glaring gaps are its lack of research programs and its sole focus on insects and pathogens without concern for weeds.

B. Pesticide Reduction

Dr. Pimentel just released a study exploring the results of cutting pesticide use by fifty percent on forty different crops. See *Environmental and Economic Impact of Reducing U.S. Agricultural Pesticide Use,* to be published in the *Handbook on Pest Management in Agriculture* (CRC Press) this year. This effort is based on exhaustive research by seminar students with crop-by-crop information and illustrations. By reducing pesticide use to half its current level, concludes Pimentel, farmers would spend about $830 million on pesticides and food costs would rise a slight 0.5 percent. Mattes, *Kicking the Pesticide Habit,* at 16-17. Farmers now spend $4.1 billion per year on pesticides, with the price of the petroleum-based chemicals steadily rising. Other savings by society as a whole would more than make up for the minor food cost increases. Crosson and Rosenberg, *Strategies for Agriculture, Scientific American,* September 1989, Volume 261, Number 3, at 135.

C. Low Input Sustainable Agriculture

Another alternative method for farming is LISA or Low-Input Sustainable Agriculture. LISA theoretically encompasses every aspect of an agroecosystem, ranging from fertilizer and irrigation use to erosion control and tractor fuel. LISA minimizes human input and emphasizes maintaining the resources of the land.

Pilot projects are underway to test LISA. Administered by USDA in conjunction with state agencies and private organizations, the pilot program evaluates low-input experiments in areas such as cover crops, soil balance, and livestock systems, in all regions of the country. Federal funding began in 1988 at $3.9 million and in 1989 totals only $4.5 million. Mattes, *Kicking the Pesticide Habit* at 17. Wide-scale research and implementation are not close and profitability is, as yet, unknown.

NRDC reports on a highly successful experimental farm using LISA at the Rodale Research Center in Emmaus, Pennsylvania. Wheat and corn were rotated on farm plots with nitrogen fertilizer coming from plowing down legumes in previous seasons. After 4 years of low production, corn in the low-input plots yielded sixteen bushels more per acre than corn grown with recommended chemical fertilizers and pesticides. Yields have equaled or exceeded those of conventional corn ever since. *Id.* at 10.

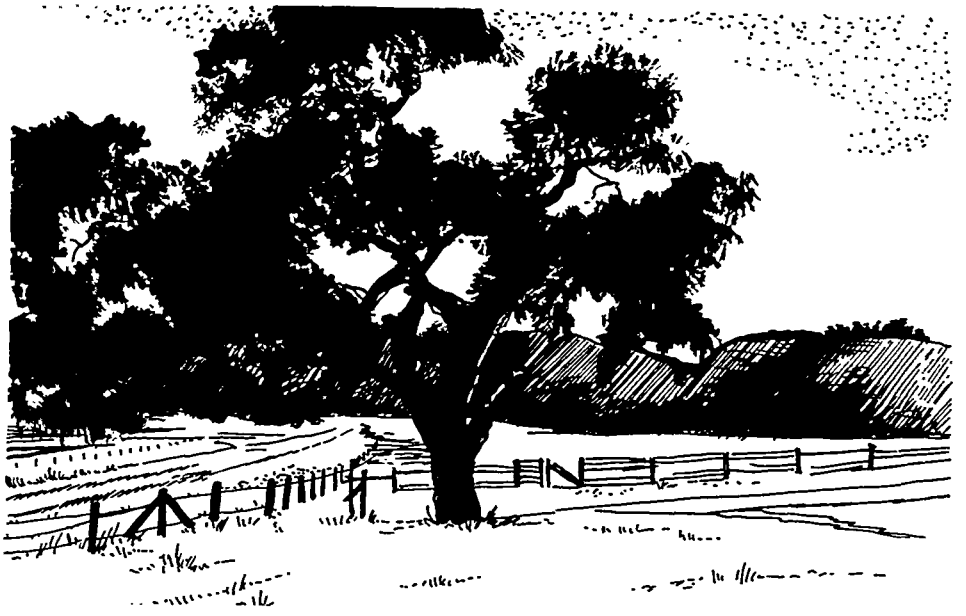
D. Multiple Cropping

Agricultural innovations today often incorporate ancient farming principles such as crop integration. The concept of multiple cropping takes in crop rotations, intercropping (sometimes with trees and annual crops sharing the same field), overseeding legumes into cereals, and also double cropping. Pre-Columbian practices in Central America continue to this day by growing maize, beans, and squash together. The maize provides a trellis for the beans; the beans enrich the soil with nitrogen; and the squash provides ground cover which reduces erosion, soil compaction, and weed growth. Multiple cropping can sharply increase crop yields. Crosson and Rosenberg, *Strategies for Agriculture* at 133.

In the Midwest, farmers have grown corn with other low ground-cover plants. In one Nebraskan experiment, corn windbreaks were spaced every fifteen rows throughout a field of sugar beets. The wind shelter provided by the corn increased the sugar yield by eleven percent. The greater sunlight penetration and more rapid replenishment of carbon dioxide to the corn's leaves increased the yield of corn by 150 percent from previous years' outputs. *Id.*

Multiple cropping has another important advantage. In fields where crops are rotated regularly, pests, including weeds, insects, and pathogens, cannot adapt themselves to a single set of environmental conditions and therefore do not multiply as quickly. Predators in one crop are kept down by predators in the other.

Cotton growers in Texas have successfully tried multiple cropping by mixing cotton varieties that



mature early. This changes the environment to one hostile to the most common cotton pests. The farmers also encourage predators that consume the common pests, and then they burn the fields after the harvest to destroy larvae. *Id.* at 133.

E. Biotechnological Innovations

Biotechnology's creation of genetically altered plants is another possible way to reduce pesticide use. A variety of large businesses are involved in developing this technology, including Union Carbide, Eastman Kodak, Monsanto, and General Foods. There are plenty of criticisms of biotechnology, including the exceptionally high costs associated with research and development. *Agriculture Practices and the 1990 Farm Bill Hearings Before the Subcomm. on Conservation and Forestry and Comm. on Agric., Nutrition and Forestry*, U.S. Senate, February 9, 1990 (statement by Mr. Richard Reed, California Action Network). The technology risks the creation of unforeseeable hazards and the release of unintended new life forms. Other criticisms include more subtle consequences, such as locking farmers into new uses for chemical manufacturers' products. It is still not known whether the ultimate use of biotechnology and whether the benefits will go to the chemical companies' sales rather than to reduce chemical use in the environment.

F. Water Use Problems and Trickle Irrigation Solutions

Only 2.59 percent of the earth's water is located on land. Most of that water is in the form of ice and snow or groundwater. Water is a very limited and valuable resource that is not adequately conserved.

Averaged on a world-wise basis, only about thirty-seven percent of all irrigation water is taken up by agricultural crops; the rest is never absorbed by the plants and can be considered lost. Much water can be saved by using trickle or drip irrigation systems that send water directly above the individual plant's root system. Crosson and Rosenberg, *Strategies for Agriculture* at 90.

Trickle systems, along with some others, not only increase efficiency in the use of irrigation water but also offer new approaches to prevent salinization. One new strategy emphasizes keeping salts and pesticides on the land, rather than passing them back into the water supply. This is done by cycling wastewater back into the farm's irrigation system and strategically reapplying it to the fields at times and in ways that minimize the effects of the salt. *Id.* at 92-94.

Trickle irrigation is particularly helpful in this regard. Much of the damage from salt occurs when large concentrations remain after repeated watering and irrigation. High concentrations of salt outside the roots of plants lower the osmotic pressure and make it more difficult for the plant to take water in from the surrounding soil. In trickle systems, the plant roots are continuously supplied with water, and the salts do not build up enough to make water uptake difficult. *Id.*

G. Information Dissemination

There are other ways to increase farmers'

understanding of pesticide alternatives and the risks and benefits of one system or product over another. The New Farm magazine, for example, is written by and for farmers. Its readership is over 100,000 and growing. Topics in the magazine include reports on insect-tolerant crop varieties, nutrient recycling, crop/weed interactions, and biological pest control. In addition, the magazine includes case studies of the particular successes or failures of innovative agricultural techniques.

Pest control advisors (PCA) can also be a valuable resource by providing crucial information to farmers and a support network for new ideas. Chemical salesmen typically play this role; however, they are backed by the National Agricultural Chemical Association. For about every 500 farms in NY, there are ten chemical agents and only one government funded or "extension" agent. Mattes, *Kicking the Pesticide Habit* at 16. More of these independent PCAs or "plant health doctors of the future" are needed since they offer advice without conflicts of interest. *Id. a*t 16 (quoting Jim Tette, NY Extension coordinator at Cornell U.) As more is learned about alternative techniques, PCAs can help spread information about new agricultural methods and serve as consultants to the farmers.

UPCOMING LEGISLATION

The legislature may help reverse many of these problems with the 1990 Farm Bill and its companion *Farm Conservation and Water Act* (S. 970) sponsored by Senator Wyche Fowler, Jr. (D-Georgia), cosponsored by Alan Cranston and Albert Gore (D-Tennessee). The proposals aim to change many of the inflexible rules that make little sense agronomically or environmentally. Hileman, *Alternative Agriculture, Chemical and Engineering News*, March 5, 1990, at 38. The bills would give farmers more flexibility in deciding which crops to plant without losing federal financial support, such as tax incentives and benefits. The proposals include giving positive incentives to farmers to encourage practices that reduce soil erosion and groundwater contamination. *Id.* at 38. Most importantly, the bills include increased federal support for low-input and sustainable agricultural research and information dissemination. It includes wetland and groundwater safeguards, recommends national low-input certification, and provides crop insurance and credit incentives to farmers making the transition away from pesticides.

CONCLUSION

Farmers will generally remain skeptical of new agricultural practices until large scale economic success using these techniques becomes a reality. Financial backing and educational support for low pesticide use experiments on portions of crops are needed. This will encourage information collection and dissemination without risking a farmer's entire investment. Mattes, *Kicking the Pesticide Habitat* at 13 (quoting Carol Glenister, IPM Laboratories, Inc.). Highly trained field PCAs could help find answers to specific problems and direct research in the right direction.

With the increased interest in Washington, D.C., more bills will be sponsored to fund research. The market is shifting and is driving this change in agricultural practices. Consumer expectations are rising, and farmers are seeing the health and economic benefits of shifting their practices away from methods employing heavy pesticide use. Traditional farming techniques --many long forgotten -- are making a comeback as ecologically healthy and economically viable alternatives to chemicals.

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Farmer; Ms. Jennifer Curtis, Research Associate of Natural Resources Defense Council; Mr. Richard Reed, California Action Network; Dr. Brian Baker, Coordinator, Technical Program California Certified Organic Farmers; Mr. James P. Knutzon, Senior Vice President, Nutri-Clean, Inc.; Steven R. Beckley, General Manager of the California Fertilizer Association)

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