Effects of Weed Control on the Environment

By W. A. HARVEY
Extension Environmentalist
University of California, Davis

THE only reason for any weed control practice is to change the environment:

— to permit the production of food and fiber in quantities sufficient to feed and clothe our growing population.
— to provide beauty and recreation —attractive lawns, gardens, landscapes, camping sites, fishing, swimming and other outdoor sports.
— to insure safety from fire, from effects of traffic obstructions and from allergy sources — poison oak, ragweed, etc.

Control of vegetation is essential joyment of life. And vegetation control practices change the botanical environment around us. This is true regardless of the methods used for control—hand pulling, hoe- to our health, well being and en- ing, plowing, cultivating, burning, etc.

We know, then, that any successful weed control practice must affect the environment. We should expect this. Our concern is with possible effects outside the target area or on non-target organisms. Our principal concern is with herbicides, although we can get side effects with other control methods—soil erosion, soil compaction, air contamination with dust or smoke, etc.

We know that certain chlorinated hydrocarbon insecticides have come under heavy criticism. Organic herbicides have had relatively little criticism because most of them are low in mammalian toxicity and have short persistence in the environment under most conditions. The major challenge has been the 2,4,5-T uproar.

Let's review, briefly, what we know about environmental contamination by herbicides under four headings: entry, persistence, residues, effects on organisms.

ENTRY: Herbicides, to be effective, must become an intimate part of the environment of the target plants. It is only when they move away from the target site or persist sufficiently to affect later plantings that they become a problem. Herbicides can move by drift of particles at and soon after the time of application, by volatility from a treated area, by leaching, and by surface movement through wind or water erosion.

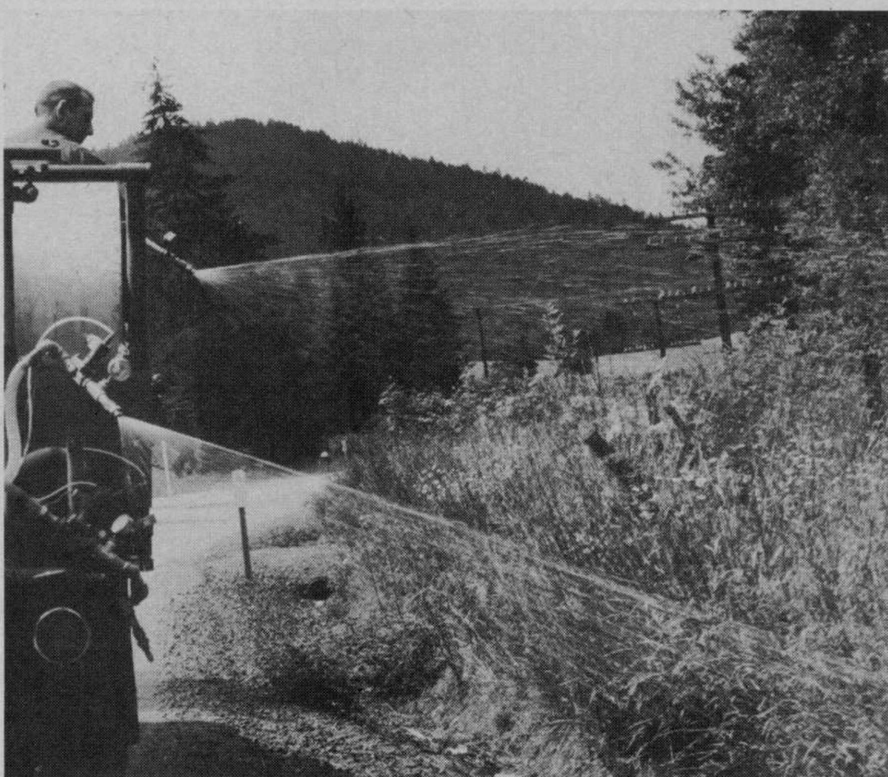
Drift. Small particles produced as the spray solution leaves the nozzle may remain suspended in the air for varying periods of time depending primarily on droplet size. The distance these particles will travel depends primarily on wind velocity. In any spray operation a certain fraction of the liquid will be in small particles or droplets and some drift is inevitable. The effect of this drift depends on the herbicide involved and the proximity of sensitive plants.

Volatility. Volatility results from movement of materials in a vapor phase from the treated area to other areas by wind or air mass movement.

Leaching. Leaching is movement of a chemical down into the soil profile with water movement. Our concern in terms of environmental contamination is not with movement in the soil itself but with vertical movement as a potential source of contamination of ground water supplies.

The amount of herbicide at different levels in the soil depends upon several factors. The soil type—sand, silt, clay, muck, etc. determines the depth of water movement in soil and consequently the depth to which any given herbicide will move. In addition the soil type has an effect through its properties for adsorption and holding molecules of the herbicide against leaching forces.

(Continued on page 16)



WEED CONTROL *(from page 14)*

The amount of water entering the soil either from rainfall or irrigation and the solubility of the herbicide in water are also important factors.

The final factor that affects leaching is the degradability of the herbicide itself from either chemical reactions or biological agents. The more rapidly a herbicide is broken down, the less time there is for leaching.

Because of the number of factors limiting leaching we have so far found no evidence of ground water contamination from field use of herbicides.

Surface Movement. A final method by which herbicides might move into the environment is through surface movement by wind or water, usually with soil particles. In field experience, water has been the major element in causing such surface movement. Factors affecting such movement include: slope or steepness of the area which affects run-off, permeability of the soil, amount and intensity of the precepitation, formulation of the herbicide (principally solubility), rate of application, and vegetative cover.

PERSISTENCE: Herbicides, particularly soil-applied herbicides, must persist in the environment for a long enough time to provide some period of weed control. Here we are faced with something of a dilemma.

In crop land we would like weed control during the growing period of the crop. But once the crop is harvested we may want to plant a different crop and perhaps one that is susceptible to the herbicide used in the first crop. So we don't want to jeopardize future crops with herbicide residues and yet we would like weed control throughout the growing period of any treated crop. We often must settle for a period of weed control during the germination and early growth of a crop and depend upon crop competition, cultivation, or repeated herbicide treatments to give season-long control. On non-crop sites we usually want at least one season of weed control per treatment.

Soil persistence is usually our major concern, and it is difficult to set exact values on the length of time any herbicide will remain in the soil. We know that herbicides such as the carbamates give weed control for something like six weeks whereas some of the triazines and the substituted ureas may persist for six months or more when used at crop selective rates. Soil persistence depends on several factors: rate and formulation of herbicide, soil type, temperature, moisture, organic matter, and microbial activity.

In general, soil breakdown is most rapid in warm, moist soils with good microbial growth. With some highly water soluble herbicides, leaching below the root zone may cause a rapid loss of immediate toxicity without actual breakdown. Cold soils, dry soils and sterile soils usually inhibit breakdown and prolong persistence.

Peristence in water is of concern for those herbicides used for aquatic weed control either when applied into the water itself as for submerged aquatics or when applied for emerged or ditchbank weeds when some portion of the treatment may get into canals or ditches.

There is less information on water persistence of herbicides than on soil persistence, but the literature in this area is increasing. It appears that breakdown in water is mostly microbial with definite evidence of removal from water by precipitation and by absorption on particulate matter. There is likewise evidence of peristence in bottom mud where anaerobic conditions may reduce activity of the particular microbes responsible for decomposition.

Recent studies show only minute amounts of herbicides appearing in irrigation water from ditchbank spray operations. It would appear that careful ditchbank application of current herbicides present no appreciable hazard to downstream vegetation or crop irrigations. Treatments to the water itself have caused no reported crop loss when used as directed. Most truly aquatic herbicides do affect other aquatic organisms, however, and their use is usually confined to irrigation canals where game fish are not resident.

Persistence of herbicides in air has not been widely studied. A study in Washington State over a period of 106 days during and following the wheat spraying season revealed minute quantities of 2,4-D in 80% of the air samples. Dilution by air mass and wash out by rainfall probably account for the disappearance of the limited amount of herbicides that get into the air, although

(Continued on page 40)

BOOK REVIEW

YOUR LAWN: HOW TO MAKE IT AND KEEP IT by R. Milton Carleton. 127 pages, illustrated. Retail price: $7.95.

About the Author: R. Milton Carleton is well-known as an author of books on gardening and as an editor of the periodical, **Chicago Today.** He has also pioneered in studies of new turf varieties and preemergence crabgrass controls. He is currently investigating the effects of artificial light and soil substitutes on plant growth.

About the Book: Your lawn consists of 14 chapters. Early in the book he answers the question, what is a lawn good for, by detailing the esthetic and environmental values. Chapter headings on drainage and grade and soil follow next. The next section deals with arriving at and maintaining a good nutritional balance. This is followed by a chapter on the importance of pH. Chapters 6-10 cover grass varieties, starting and maintaining your lawn, places where grass does not thrive, renovation, and rough lawns, respectively. The balance of the book involves discussions on pests—on and in the turf, weed control, lawn diseases and mechanical equipment. The book is well-written and easy to read. Maps and line drawings are interspersed throughout the book.

WEED CONTROL *(from page 16)*

decomposition by ultraviolet light has been suggested as an additional factor.

RESIDUES: The actual amount of herbicides in the environment has been studied in numerous monitoring surveys throughout the United States. We know, of course, that treated soils and waters contain herbicides for some period after treatment; otherwise we would not have weed control. Our concern is with the possibility of appreciable residues for long periods after treatment or the occurrence of herbicide residues in untreated or non-target sites.

Since residues are reported in terms of concentration — parts per million (ppm), parts per billion (ppb) and even parts per trillion (ppt)—it is important to recognize what these figures actually mean. The amount of soil covering an acre, one foot deep (usually called an acre foot of soil) weights about 3½ million pounds. Thus if we apply 3½ lbs. per acre of an herbicide and mix it throughout the upper foot of soil, the concentration will be 1 ppm. If we mix it only in the top 6 inches of soil the concentration will be higher — 2 ppm. It is the same amount of herbicide but mixed in less soil.

If we are concerned with water we should remember that water weighs 62.4 pounds per cubic foot and 8.33 pounds per gallon. Thus an acre foot of water (enough to cover an acre one foot deep) weighs about 2.7 million pounds and an herbicide application of 2.7 lbs. to an acre foot of water gives a concentration of 1 ppm. In terms of gallons, 8.33 pounds of herbicide are required to give a concentration of 1 ppm in a million gallons of water.

Some concept of the minuteness of 1 ppb can be obtained from a consideration of the population of the whole earth which is between 3 and 4 billion people. Thus 3 or 4 people represent 1 ppb of all the people on the earth today. Residue concentrations need interpretation in terms of amounts as well as concentrations!

Residues in soils have been monitored for some time. A detailed study in six areas over several years revealed only minor amounts of phenoxy herbicides. Out of 264 samples only 4 contained 2,4-D with an average concentration of 0.032 ppm. None contained 2,4,5-T. In none of these surveys has there been evidence of excessive accumulation of any herbicide in the soil environment.

Residues in water have likewise shown no evidence of accumulation. A monthly survey of 11 major streams in the Western U.S. in 1967 revealed no residues of 2,4-D, 2,4,5-T or silvex. A U.S. Geological Survey of 20 sites on Western streams using refined analytical methods showed only fractional parts per billion of 2,4-D, 2,4,5-T and silvex in a limited number of the several hundred samples analyzed. Again, there is no evidence of accumulation of phenoxy herbicides in any of the studies.

Residue data in plants are required for registration and breakdown curves and total amounts of residues are the bases for the tolerances set. There are pages of such data in every petition for a tolerance. Spot checks by regulatory agencies rarely reveal residues in crop plants in excess of established tolerance when the use pattern has followed label restrictions. There is no evidence of excessive herbicide residues in any of our food stuffs.

Residues in animal products have also been monitored. In 1969, the Consumer and Marketing Service, USDA, analyzed 240 samples of red meat fatty tissue from 44 locations across the U.S. for 2,4-D. More than 96% showed no residue, with only 3 samples showing more than 0.10 ppm and none as much as 1 ppm. There is also no evidence of accumulation in milk even when 2,4-D was fed directly to lacating cows.

Resides in the air have had only limited study, but as indicated earlier, drift or volatility may result in air contamination for brief periods. Usually the effects are evidenced on neighboring vegetation and rapidly diminish with distance.

EFFECTS ON ORGANISMS: An extensive bibliography on toxic effects of herbicides to a wide variety of organisms was published by the National Agricultural Library in 1968 and many publications cover effects of specific herbicides on specific organisms. Even extensive use of herbicides has produced changes in only limited areas and I know of no plant species that has been eliminated through the use of herbicides.

The majority of current herbicides must be fed in large quantity to produce any toxic symptoms. Extensive feeding tests are run on all herbicides prior to registration and the hazards, if any, are known. At normal rates of application our current widely used herbicides appear to have no direct effects on wildlife or farm animals. Residues have not appeared in milk or eggs. There is no evidence of wildlife destruction although changes in cover and possibly food plants on limited areas have caused population movements to other untreated areas.

For man, the only toxic effects have been from the direct ingestion of herbicides for intended suicide or accidental ingestion by children as the result of adult carelessness.

There is no evidence that the use of herbicides today contributes to deterioration of our environment.