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Where is the Next Strategic Place to Decrease Pesticide Use?

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FOREWORD

People are worried about pesticides.

To learn whether we should worry more or less, the logical course is first learning the quantity of pesticide used and, especially, whether their quantity and toxicity are increasing or declining. Stephen Hitchcock and Bradford Robinson of the Department of Environmental Protection (DEP) have faithfully recorded the sales of the most potent pesticides sold in Connecticut and generously allowed me to examine the records and compile the information in this bulletin.

The quantity and toxicity of the most potent pesticides sold changed little from 1979 to 1984.

An important outcome of analyzing the records of sales is learning that a large portion of the potent pesticides is used to manage pests in the soil. Thus the answer to "Where is the next strategic place to decrease pesticide use?" is "In the soil." Fortunately, at The Connecticut Agricultural Experiment Station in New Haven and Windsor, three entomologists and plant pathologists and five soil scientists have taken up the investigation of soil pests and the movement and degradation of pesticides in soil and groundwater in Connecticut.

In the future with the cooperation of the DEP, The Station will publish the quantity of potent pesticides sold in the state in its annual bulletin of analyses of pesticides on sale in Connecticut.

Paul E. Waggoner
Director

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Pests from rats and insects to nematodes and microbes can be reservoirs and carriers of disease. They can destroy food and landscape. Managing these enemies is an important reason life today is happier than in the 17th Century when Hobbes wrote, "The life of man, solitary, poor, nasty, brutish and short". Often we manage the pests by pesticides, which must be toxic to do their job.

Unfortunately, pesticides may have adverse effects after their beneficial job is done. They may persist. Also they may hit more than the intended target, either immediately on the spot or later, perhaps years later, after they have been transformed or moved by wind or water. Thus, common sense demands we use no greater quantity or toxicity than necessary to reap the benefits of pesticides.

Although every campaign to decrease use by even a drop may help, every minute and dollar spent in one battle cannot be spent in another. A general would say we need strategy—the art of employing our forces to afford the maximum support to the adopted policy of decreasing the undesired effects of pesticides. Common sense also demands that we expend our efforts where they will be most effective. Hence the question "Where is the next strategic place to decrease pesticide use?", which is an important question for The Station that Connecticut has chartered to investigate plants and their pests, soil and water.

A first step towards an answer is learning the kind and amount of pesticide manufactured. A table entitled "Synthetic organic pesticides" in the Statistical Abstract of the United States shows that in 1982 56% of the quantity of organic pesticides was manufactured to control weeds, 34% to control insects and 10% to control fungi. It does not show the toxicity of these three classes of pesticides or the pesticides for controlling rodents, nematodes or bacteria.

The table shows, however, that in 1982 the total quantity manufactured to control fungi is about a third less than in 1960. After increasing eightfold from 1960 to 1975, the quantity of herbicides has leveled off. And after increasing about half from 1960 to the 1970s, the quantity of insecticides fell in 1980 almost to the 1960 level. Although crop production increased by two thirds from 1960 to 1982, the weight of synthetic organic pesticides used per unit of crop production was about the same in 1982 as in 1960 after passing through a maximum in the 1970s. Relating pesticides to crop production neglects the considerable quantity of pesticide used outside farm fields. Since the table tells us the surprising news that pesticide use in America has not burgeoned during a quarter century of increasing technology, we should examine the strategy we have been following before looking for the next strategic place to decrease pesticide use.

For at least a score of years, our strategy has been selfconsciously asking "is this spray necessary?" Many forces have been at work. Education, exemplified by Rachel Carson's Silent Spring, makes everyone cautious about pesticides. Regulation restricts the application of the most potent pesticides to applicators who have been tested for their knowledge of pests and pesticides. Biological control from resistant varieties makes some fungicides unnecessary. Pest forecasts sometimes allow pesticide application to be postponed, and scouting as for gypsy moth eggs may sometimes allow it to be avoided. Careful measurements have produced guidelines to how many pests can be tolerated. Rising prices of pesticides make reward for conservative use immediate, and more sensitive chemical detection makes penalties for unneccesary use quicker.

In the 1970s these many forces began to be called "Integrated Pest Management". A new name does not, of course, make the forces new. In the 1920s Director Emeritus James Horsfall of this Station scouted for cotton pests and is called the "first integrated pest manager". Long ago The General Assembly caused The Station Entomologist to survey and predict gypsy moth outbreaks when called by the chief officers of towns. Nevertheless, more selfconsciously asking "Is this spray necessary?" has for twenty years helped limit spraying.

Looking ahead, however, we ask, "Where is the next strategic place to decrease pesticide use?" It is likely where the most potent pesticides are used.

Since the national statistics on pesticide production do not reveal what is going on in Connecticut nor which pesticides adversely affect the environment, we turn to information on the sale of potent pesticides in our state. Section 22a-50 of the Connecticut General Statutes specifies that pesticides that may adversely affect the environment shall be classified for "restricted use" by the Commissioner of Environmental Protection. The law states: "In the event that the commissioner determines that the pesticide, when applied in accordance with its directions for use, warnings and cautions and for the uses for which it is registered, or for one or more of such uses, or in accordance with a widespread and commonly recognized practice, may generally cause, without additional regulatory restrictions, unreasonable adverse effects on the environment, including injury to the applicator, he shall classify the pesticide, or the particular use or uses to which the determination applies, for restricted use ...." Thus, examining the restricted pesticides is examining the potent ones.

The Department of Environmental Protection (DEP) also monitors the sales of restricted pesticides in Connecticut. Stephen Hitchcock and Bradford Robinson of the DEP have faithfully recorded the sales of restricted pesticides sold in Connecticut and generously allowed me to analyze their records. The quantity of pesticide sold, of course, does not precisely show use. Use is the sales in the state, plus the pesticides bought outside the state and used here, and minus the pesticides bought here and used elsewhere. Since our purpose is finding where potent pesticides are used in large quantities rather than tabulating precise quantities, knowing sales of restricted pesticides will serve our purpose. My discussion below concerns only restricted pesticides in the belief that they are more significant environmentally than those that can be purchased over the counter by the homeowner.

During 1979-84, ninety-eight active ingredients in restricted pesticides were sold. The pests that were the targets of the ingredients are shown in Table 1.

The quantity of active ingredients sold during

Table 1. The active ingredients in restricted pesticides sold in Connecticut during 1979-1984. The ingredients are classified according to their targets. The uses of the 98 ingredients sold during the six years were found in the Handbook of Farm Chemicals published by the Meister Publishing Co., Willoughby, OH in 1984. Subcategories within the target "Soil pests" are shown. Since an ingredient used against soil pests is not listed in another category, the ingredients listed under "Fungi" and "Insects" are generally sprayed whereas the "Soil pest" ingredients are generally injected into or incorporated into the soil against the targets shown within the class. The category "Other" includes the herbicidal dye aquashade, the gaseous methyl bromide, elmosan and pival that have no published LD50s; it also includes two repellents (avitrol and mesurol); the "Other" were sold in less than 2 kg quantities except in 1983 when 57 kg was sold. The abbreviations Ca, Cl and Cu indicate calcium, chloride and copper. Some active ingredients below are found in general use (non-restricted) pesticides in formulations not deemed hazardous when used according to directions.

Weeds	Fungi	Insects	Rodents	Soil pests	Other
alachlor	captafol	acephate	brodifacoum	Fungi:	aquashade
atrazine	chlorothalonil	amitraz	bromadiolone	banrot	avitrol
Cu sulfate	dichlone	baytex	chlorophacinone	lesan	elmosan
cutrine	dodemorphacetate	bendiocarb	diphacinone	PCNB	mesurol
2,4-D	dodine	bladafume	fumarin	truban	methyl bromide
devrinol	glyodin	Ca arsenate	vacor		pival
dinoseb	mercuric Cl	Ca cyanide	zinc phosphide	Insects:	
diquat	mercurous Cl	carzol		chlordane	
endothall	metalaxyl	ciodrin		chlorpyrifos	
eptam	parnon	DDVP		disulfoton	
glyphosate	pentachlorophenol	dicrotophos		dyfonate	
kerb	phygon	dioxathion		isofenphos	
metolachlor	triforine	endosulfan			
nitrofen		endrin		Insects &	
paraquat		ethion		Nematodes:	
picloram		fenvalerate		aldicarb	
pramitol		guthion		carbofuran	
simazine		lindane		dasanit	
2,4,5-T		methamidophos		diazinon	
tebuthiron		methomyl		oxamyl	
		methyl parathion		terbufos	
		mevinphos			
		nicotine		Fumigants:	
		omite		vapam	
		parathion		vorlex	
		permethrin			
		phorate			
		phosalone			
		phosphamidon			
		propetamphos			
		propoxur			
		systox			
		tetradifon			
		temephos			
		vendex			

each year for each target is shown in Table 2. The change during the six years is shown in Table 2 by relating the weight sold in each year to the quantity sold in 1979. Practically, there was no trend.

The percentages of the total weight directed against rodents, weeds, the fungi that cause plant disease, insects in foliage and dwellings, or pests in the soil are also shown in Table 2. Roughly a quarter of the weight of restricted pesticide was to control weeds and an eighth to control insects outside the soil. The quantities of rodenticide and fungicide sold were small. More than half the quantity of restricted pesticides sold was directed against soil pests, year after year.

A pound of one pesticide is not as hazardous in the environment as a pound of another, even among the restricted pesticides. An ingredient may be hazardous because it resists decomposition or because it is put in a place where it is shielded from destruction by the ultra-violet of sunlight. It may be hazardous because it is used near man as in our homes or used in the soil where it can be leached to groundwater. The most common measure of hazard is the ability of an ingredient to kill mammals. This ability, which I call Hazard, is determined by i) the quantity and ii) the toxicity per unit quantity of the ingredient.

The toxicity of a unit weight of one ingredient is most frequently measured by feeding increasing doses to a lot of rats and observing the LD50 or Lethal Dose to kill 50% of the lot. LD50 is expressed as milligrams (mg) of the ingredient per kilogram (kg) of body weight of the rats. The Hazard of the ingredient is then its (quantity/LD50) or kg/(mg/kg). The Hazard of the combined quantities of several ingredients was calculated by adding the (quantity/LD50)'s for each ingredient. The change in the Hazard of the entire quantity of ninety-two of the restricted pesticides sold is shown by referring it to 1979 in Table 3. Although the Hazard of the entire quantity sold first rose and then fell, it did not change substantially during the six years.

The contribution of the classes is shown in Table 3 as the percentage they contributed to the total Hazard for each year. Several classes contributed little: rodenticides because little is used, herbicides because they have relatively low toxicity and fungicides because they are relatively low in toxicity and use. The contribution of the chemicals for control of soil pests is even greater than the table reveals because ethylene dibromide (EDB) was used to control soil pests but was not included in Table 3 because none was sold in the state. Further, methyl bromide is sometimes used to control soil pests but is not included in Table 3.

The quantity of pesticides directed against different soil pests was calculated for the four subcategories shown beneath "Soil pests" in Table 1. The composition of the 56% of the total quantity sold to control pests in the soil in 1984 was: Fungi, <1%; Insects, 14%; Insects & Nematodes, 12%; and Fumigants, 30%. Similarly, the composition of the 70% of the total Hazard sold to control soil pests was: Fungi, <1%; Insects, 6%; Insects & Nematodes, 63%; and Fumigants, 1%.

The contributions of individual ingredients are indicated in Table 4 by listing them from the greatest to the least Hazard sold in 1984. An ingredient may have a low Hazard either because little was sold or it has a high LD50 and a low toxicity. The Hazard, of course, does not reflect its proximity to man or adverse effects on the environment other than measured by the LD50.

Although sales of restricted pesticides in Connecticut show that neither their quantity nor Hazard is burgeoning, they leave little doubt that the Hazard is mainly in the pesticides used in managing soil pests. The Hazard of the ingredients

Table 2. The quantity of the 98 active ingredients in restricted pesticides sold in Connecticut. To show the trend in sales, the quantity of all is referred to the 98 metric tons sold in 1979. To show the targets, the use against each is shown as the percentage of the annual total. The gaseous fumigant, methyl bromide, is tabulated separately from the "Other".

Target	1979	1980	1981	1982	1983	1984
Weight of 98 ingredients as a percent of 1979.						
All	100	104	115	95	86	100
Weight of ingredients directed against 5 targets as a percent of all sold during the year.						
Rodents	<1	<1	<1	<1	<1	<1
Weeds	23	24	33	28	23	18
Fungi	2	9	5	2	2	1
Insects	10	11	11	8	10	13
Soil pests	60	50	42	57	58	56
Methyl bromide	5	6	9	5	8	12
Other	<1	<1	<1	<1	<1	0

Table 3. The Hazard of the quantity of restricted pesticides sold in Connecticut. Hazard is calculated as (quantity/LD50). The LD50s for 92 of the 98 ingredients sold during the six years were found in the Handbook of Farm Chemicals. Among the missing six classified "Other", only the gaseous fumigant, methyl bromide, was sold in large quantities, and it is tabulated separately in Table 2; the remaining five (aquashade, avitrol, elmosan, mesurol and pival) were sold in quantities less than 2 kg except in 1983 when 57 kg were sold. To show the trend, the Hazard of all is referred to 1979. The Hazard directed against each target is shown as the percentage of the sales for the year.

Target	1979	1980	1981	1982	1983	1984
Hazard of 92 ingredients as a percent of 1979.						
All	100	127	132	107	88	91
Hazard of ingredients directed against 5 targets as a percent of all sold during the year.						
Rodents	<1	<1	<1	<1	<1	1
Weeds	2	1	1	1	2	1
Fungi	<1	<1	<1	<1	<1	<1
Insects	21	17	20	15	21	28
Soil pests	76	82	78	84	76	70

directed against Insects and Nematodes is particularly great. Although every campaign to decrease use by even a drop while still controlling the pests that make life nasty, brutish and short may be beneficial, the wise strategy is to employ our forces to find ways of managing insects and nematodes in the soil with less pesticide. Analysis of the sales of restricted pesticide in the future will show whether we are succeeding.

Table 4. The 92 active ingredients in restricted pesticides sold in Connecticut during 1979-1984 arranged in order of Hazard calculated as (kg sold in 1984)/(mg/kg LD50). In 1984 the ingredients in the two columns on the right had Hazards less than 1 kg/(mg/kg). Ingredients directed against soil pests are identified by an asterisk.

Active ingredient	kg/(mg/kg)
aldicarb *	1877
guthion	840
carbofuran *	637
oxamyl *	463
methyl parathion	231
isofenphos *	154
endosulfan	86
methomyl	83
disulfoton *	79
parathion	59
vorlex *	57
terbufos *	52
dinoseb	43
chlorpyrifos *	30
systox	26
brodifacoum	24
dasanit *	22
mercuric Cl	20
chlordane *	20
phosphamidon	18
carzol	9
DDVP	6
bendiocarb	6
alachlor	6
paraquat	5
diazinon *	4
zinc phosphide	4
methamidophos	4
dyfonate *	3
bladafume	2
2,4-D	2
Cu sulfate	1
phosalone	1
ethion	1
mevinphos	1
endothall	1
propoxur	1

Active ingredient [<1 kg/(mg/kg)]	
glyphosate	fumarin
lesan *	kerb
Ca arsenate	metalaxyl
propetamphos	metolachlor
lindane	nitrofen
pentachlorophenol	omite
fenvalerate	orthene
vapam *	parnon
mercurous Cl	PCNB *
diquat	phorate
dicrotophos	phygon
glyodin	tebuthiron
nicotine	tetradifon
dodine	temephos
Ca cyanide	triforine
pramitol	truban *
permethrin	vacor
dioxathion	vendex
simazine	
banrot *	
bromadiolone	
captafol	
cutrine	
diphacinone	
dodemorphacetate	
picloram	
2,4,5-T	
amitraz	
atrazine	
baytex	
chlorophacinone	
chlorothalonil	
ciodrin	
devrinol	
dichlone	
endrin	
eptam	