Use of Pesticides in Pacific Northwest Agriculture, A Regulatory Perspective

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INTRODUCTION

This project is an attempt to provide basic background on agricultural use of pesticides in the Pacific Northwest and to outline circumstances that may affect future use. Two approaches were used. The first, a quantitative one, examines crop production and pesticide usage in the area in the recent past in order to find trends which may indicate future crop production. From future crop production it may be possible to predict future pesticide usage. The second approach, a qualitative one, involved interviewing experiment station scientists, university scientists, and various persons involved directly in agriculture. From these interviews and an examination of current pesticide usage, it was hoped that the influences shaping the future might become more evident.

Conclusions

° Northwest agriculture is more intensive — involving greater use of irrigation, higher mean investment, and higher value crops — than U.S. agriculture as a whole.

° Animal products and grains, principally wheat, are the dominant products of Northwest farms; but there is a continuing shift to row crops, orchards, and specialty crops, where the region's share of national output is disproportionately great.

° Registration under FIFRA is a precondition for marketing a pesticide in the U.S. The process is time consuming and costly, and a significant influence on the nature and availability of agricultural use of pesticides.

° Agricultural experiment stations and county extension agents are the principal influences on pesticide application practices of Northwest farmers.

° There is a great number of pesticides available to farmers. That number increases rapidly through new product development, product modification, and product rotation.

° Direct toxicity of all classes of pesticides appears to be increasing progressively. Regulation enforces, or at least contributes to, the trend by imposing an implicit tradeoff between toxicity and persistence or carcinogenicity.

° Pesticide use is increasing faster on Northwest farms than U.S. farms generally; and Northwest farmers who employ pesticides apply them more intensely than the average U.S. farmer.

° Pesticide use is an integral feature of intensive agriculture, increasing as share of farmland devoted to crops increases, and as value of farm output increases.

° Herbicides are the dominant type of pesticide applied; and their use is associated primarily with production of grains.

° Use of insecticides, disease controls, and growth regulators is associated with row crops and orchards.

° Nematocide use is closely correlated with irrigation and with production of grasses.

° Proliferation of pesticides is a consequence of development of resistance by target species through the operation of natural selection, so the tendency appears to be irreversible.

° There is no mechanism, other than the file of pesticide registrations, in place at this time for monitoring any aspect of pesticides production or use.

° Major policy issues relating to pesticide use and regulation occur outside the provenance of EPA Region 10.

I. The Agricultural Economy of the Pacific Northwest

A. Characteristics of Northwest Agriculture

Agriculture is the principal resource based industry of the Pacific Northwest, accounting directly or indirectly for seven to eight percent of the region's personal income.

Northwest farms, on average, are larger, better capitalized, and more efficient that other U.S. farms. They mount a greater investment in cattle, equipment, and irrigation per farm and per acre, and extract larger sales revenues both per farm and per acre.

Table 1
Comparison of U.S. and Pacific Northwest Farms, 1982

Variable	US	Idaho	Oregon	Wash.	PNW	PNW @ % US
No. of Farms	2,240,976	24,714	34,087	36,080	94,881	4.2
Farmland, 1000A	986,797	13,922	17,740	16,470	48,131	4.9
Mean Size Farm, A	440	563	520	456	507	115.3
Cropland Harvested, 1000A	326,306	4,888	3,306	5,279	13,472	4.1
Irrigated Land, 1000A	49,002	3,450	1,808	1,638	6,897	14.1
Equipment Investment,						
$ Millions	93,663	1,454	1,257	1,653	4,364	4.7
per Farm, $	41,919	59,016	37,044	45,947	45,991	109.7
Cattle on Farms	104,475,827	1,925,419	1,618,005	1,321,820	4,865,244	4.7
No Farms with						
≥ 500 cattle	23,381	680	617	309	1,606	6.9
Farm Products Sold,						
$ Millions	131,900	2,232	1,641	2,831	6,703	5.1
Crops,						
$ Millions	62,256	1,161	936	1,715	3,811	6.1
Animal Products,						
$ Millions	69,644	1,071	705	1,116	2,892	4.2
Mean Sales per Farm	$58,858	$90,297	$48,130	$78,470	$70,651	120.0

In some respects the agricultural efficiency of the Northwest is anomalous. Though area of farmland is large in proportion to number of farms, the area of cropland harvested is somewhat less than average. Yet crop sales per farm and per acre are distinctly higher than average — sales per farm in 1982 were $40,166 vs. $27,781 for the nation, sales per acre of cropland harvested were $283 vs. $191. Thus, despite the extensive pattern of farm size and of equipment investment, the agriculture of the region functions intensively, characterized by a combination of high yields and high value commodities. The converse is true of animal culture. Clearly, the mean area available for range and pasture in the Northwest farm is greater than the U.S. average, the number of large animal holdings is disproportionately great in the Northwest, and mean number of cattle per farm (51.3 cattle and calves) is greater than the national mean (46.6). Yet at $30,485 per farm in 1982, sales of livestock and animal products in Northwest states were slightly below the U.S. average of $31,078.

The reasons for such departures from national norms are to be found in the distinctive character of Northwest agriculture and its evolution over the last forty years.

Nature did not intend the region for large scale agriculture. Much of the area, including virtually all of that western portion of Oregon and Washington with sufficient summer precipitation to produce dependable crops, is mountainous. The bulk of the eastern uplands and river valleys where topography is suited to farming is arid or semi arid. Oregon's Willamette Valley, the initial focus of settlement, is the only sizeable tract of land that is naturally favorable for farming. As a consequence, the distribution of agricultural effort in the first third of the century was narrow and specialized: belts of intensive truck farming and dairying around each sizeable community; diverse specialty farms — the largest concentration in the Willamette Valley — producing orchard and berry crops and vegetables (notably green peas, snap beans and lima beans) sufficient to support modest canneries; the bulk of the farm land spread across elevated grasslands east of the Cascades devoted to either winter wheat (watered by snowmelt, since virtually all precipitation occurs in winter) or to grazing.

That format was modified only slightly by privately or cooperatively sponsored local irrigation in the Yakima, Walla Walla and Snake River valleys. But from the mid thirties until World War II, a series of reclamation projects advanced the prevalence of irrigation in the Northwest. And after the war, larger and more ambitious projects extended irrigation sufficiently to transform the character of Northwest farming.

Irrigation allowed the introduction of field crops — hay, potatoes, sugar beets, and field corn — on a massive scale. Equally significant, with irrigation larger and more diverse vegetable and fruit production became possible. Animal feeding and extensive dairy production developed to complement grazing and local dairying. Agricultural specialization and food processing scaled to national markets followed quickly. The area devoted to wheat shrank. Grazing was relegated to increasingly marginal lands.

By the early sixties, opportunities for economic irrigation projects had virtually been eliminated. Sites for storage, for diversion and gravity transmission of water over large distances, and of broad tracts adaptable for surface irrigation had been exhausted by the rapid pace of reclamation.

Yet the value of a dependable water supply to arid farmland had been sufficiently demonstrated — on average, it increased crop sales per acre by a factor of three, increased land value by up to an order of magnitude — that private capital has supported its extension at a near constant rate once large public project possibilities were exhausted. On both the Snake Plain and on Washington's Columbia Plateau, deep wells and sprinkler irrigation have continued to extend the reach of irrigation.

The record is summarized, in terms of agricultural land use changes, in table 2.

Table 2
Long Term Agricultural Land Use Trends in the PNW

	Farms	Farmland(A)	Cropland(A)	Pasture(A)	Irrigated Land(A)
1950	169,931	50,921,120	11,103,357	30,559,039	4,033,082
1954	158,356	53,053,240	11,335,834	32,938,803	4,593,072
1959	127,820	55,185,671	11,363,081	34,482,643	4,967,833
1964	114,992	54,863,353	11,408,337	34,416,803	5,559,001
1969	88,571	49,993,558	11,215,495	N/A	5,504,511
1974	79,843	49,177,605	12,690,869	N/A	5,729,503
1978	83,739	49,444,896	13,044,803	29,008,539	6,995,414
1982	94,881	48,131,099	13,472,291	27,607,970	6,896,795
Mean Annual Shift	-2,751	-154,790	72,736	-144,219	86,477
r	-.91	-.66	.88	-.65	.96

The total amount of farmland has receded steadily, declining at the rate of almost 155,000 acres a year. Some loss has been a consequence of urbanization and development, the replacement of agriculture by buildings, roads, and reservoirs. The larger share appears to have been the consequence of abandonment, with marginal farmland being allowed to revert to forest or desert.

Loss of farmland has been confined to the last twenty-five years — during the period of aggressive reclamation, amount of farmland increased irregularly — and has occurred as a reduction in amount of idle land and in land employed as range and pasture. Idle land — the portion of farms allowed to lie fallow, used exclusively as woodland, or on which crop failure occurred — declined at the rate of 70,447 acres peryear ($r = -.92$) in the period 1950 - 1982. Land employed as pasture and range dropped at a smoothed annual rate in excess of 144,000 acres per year.

On balance, the bulk of the lapsed pasture has been converted to crop bearing land. Northwest cropland has expanded at the rate of almost 73,000 acres per year. The spread of irrigation has been even more pronounced, exceeding 86,000 acres a year. The net effect has been that growth of irrigation has allowed 73,000 acres of pasture a year to be converted to cropland, 13,000 acres of dryland farming to be upgraded. (Obviously, the pattern is neither that simple nor that regular. Irrigation comes on in blocks, is employed in many instances as an intermittent supplement to natural precipitation, and is not uncommonly employed on improved pasture. The statement is intended to describe net effects, not the actual course of events.)

In common with the rest of the nation, the Northwest has experienced a process of farm consolidation that has reduced the number of farms and increased their average size. Overall, almost 2,800 farms per year have been eliminated over the course of the last three decades. As a consequence, mean size has increased 69%, from 300 acres to 507 acres. Given the steady rise in land under cultivation, the average acreage harvested has more than doubled, rising from 65 to 142 acres per farm.

More recently, the trend toward fewer and larger farms has reversed itself in the Pacific Northwest. Since 1975 there has been a slight but continuous rise in number of farms in the region. The tendency, which is revealed in the various state yearbooks of agriculture, is common to all three states and has occurred in every year of the period. It is not known whether the tendency is part of a larger, national process; and it would be pointless to speculate about its sources. What is clear is that the trend is entirely consistent with the postwar evolution of Northwest agriculture to progressively more intense farming practices.

B. Major Crops

Wheat is the principal crop, in terms of both acreage and sales value, in each of the Northwest states. Together, the three states account for more than a ninth of total U.S. wheat production. The crop is predominantly soft, white winter wheat, preferred for production of pasta and crackers. The region accounts for the major portion of U.S. soft wheat production, with most of the output going to export.

Hay, principally alfalfa, which stands second in acreage planted, ranks low in value of direct sales. The crop is consumed in the region, more often than not at the farm of origin, and derives its market value through its contribution to sales of animal products. In spite of its sizeable production of feed and forage, the Northwest has been, and remains, a net importer of animal feed.

Together the principal feed grains, barley, oats, and field corn, almost match acreage devoted to hay. But while the Northwest produces a substantial portion of the nation's barley, its output of the other feed grains is minor; and sorghum production is negligible.

While less acreage is devoted to field crops other than grain and animal feed, they are of more consequence to the U.S. economy and nutrient balance than either wheat or feeds. The Northwest produces about a third of the nation's dry beans, dry peas and lentils. The first is produced under irrigation, with production concentrated in the Twin Falls area. Dry peas and lentils are the principal non-grain product produced in the absence of irrigation. Production is centered in the Palouse area and the Lewiston-Clarkston area of Northwest Idaho/Southeast Washington, and is principally for export. The Northwest also produces almost half of the nation's potatoes, a sixth of its sugar beets, a fifth of its sweet corn, a sixth of its dry onions, all under irrigation, as well as almost half of the nation's field and grass seeds, a good share of it in the Willamette Valley and without benefit of irrigation.

Both orchard and vegetable products are of large and growing significance. Apples rank just behind wheat in value of crop sales in Washington, are not unimportant in Idaho and Oregon. Plums and prunes, berries — particularly caneberries, but including cranberries and strawberries — cherries, and pears are grown in significant amount. Green peas, asparagus, and snap beans are the major vegetable crops other than sweet corn, with the Northwest producing a disproportionate share of all four. It also produces virtually the entire U.S. supply of hops, mint and filberts.

Table 3
Major Crops

	Oregon		Idaho		Washington		Pacific Northwest		
	Acres	Rank	Acres	Rank	Acres	Rank	Acres	Output	% US Totl.
Wheat	1,179,942	1	1,507,775	1	2,716,305	1	5,404,022	275×10^6bu	11.6
Hay	1,016,904	2	1,222,726	2	724,940	3	2,964,570	8.5×10^6T	6.6
Barley	250,291	4	1,090,811	3	751,963	2	2,093,065	131×10^6bu	28.1
Lentils, Dry beans/Peas	15,306	18	315,495	5	295,314	4	626,115	10.3×10^6CWT	31.7
Field&Grass Seeds	361,036	3	87,504	8	60,427	9	508,967	NA	43.3*
Potatoes	52,297	7	320,019	4	104,738	7	477,054	156×10^6CWT	46.6
Corn (feed/seed)	72,400	6	135,745	7	177,587	5	385,732	36.1×10^6bu	0.5
Apples	11,633	19	8,408	13	145,630	6	165,671	2.9×10^9lbs	38.7
Sugar Beets	10,751	20	137,902	6	–	–	148,653	3.4×10^6T	16.3
Oats	76,317	5	42,155	9	28,811	11	147,283	9.8×10^6bu	2.0
Sweet Corn	48,258	8	23,330	10	52,305	9	123,893	NA	19.3*
Green Peas	30,002	10	9,541	12	60,955	8	100,498	NA	35.7*
Nursery Pdts	23,046	13	15,942	11	23,919	14	62,907	NA	
Mint	32,263	9	6,153	14	14,920	17	53,336	4.0×10^6lbs	74.8
Pears	19,896	13	268	22	21,477	15	41,641	763×10^6lbs	53.2
Hops	7,706	22	3,688	16	28,290	12	39,684	76×10^6lbs	98.4
Snap Beans	26,838	12	3,104	17	2,526	22	32,468	NA	11.7*
Cherries	16,599	15	871	21	14,277	18	31,747	180.8×10^6lb	35.8
Asparagus	759	25	–		29,878	10	30,637	NA	31.5*
Grapes	2,589	24	250	23	26,728	13	29,567	276×10^6lbs	2.5
Walnts/Flbrts	28,491	11	14	25	758	24	29,263	38.8×10^6lbs	9.0
Berries	15,437	16	116	24	8,055	19	23,608	NA	17.4*
Dry Onions	10,530	21	4,727	15	4,449	20	19,706	NA	16.8*
Plums&Prunes	5,307	17	1,232	19	2,345	23	8,884	49×10^6lbs	4.9
Other Vegs	18,427	14	1,619	18	19,057	16	39,103	NA	
Other Fruits	4,826	23	888	20	4,370	21	10,084	NA	

A variety of other crops that occupy little acreage but are grown under intense cultivation practices are worthy of note. Over 60,000 acres of nursery occur in the region, mostly within metropolitan areas of western Oregon and western Washington. Most significant of these are Puget Sound bulb farms which produce a notable portion of the world supply of tulips, daffodils and narcissus. Willamette Valley rhododendron and azalea farmers are also internationally active. And in addition to the major fruit and vegetable products, farms in the region grow such diverse commodities as lima beans, beets, broccoli, brussels sprouts, cabbage, melons, carrots, cauliflower, cucumbers, lettuce, garlic, peppers, pumpkin and squash, radishes, rhubarb, spinach, tomatoes, turnips, apricots, nectarines, and peaches.

* based on acreage harvested

C. Shifting Crop Patterns

Agriculture probably adjusts more readily to market shifts than any other American industry. Land, the basic productive resource, is, within climatic and topographic constraints, suitable for production of a variety of commodities; and — with the exception of living capital such as orchards, vineyards, and breeding stock — capital tends to be highly flexible. Thus one year's change in price or demand is inevitably followed by a change in the next year's planting regimen.

It follows that short term shifts in agricultural land use are erratic and difficult to interpret. One year's surplus crop may depress prices and cause a drop in the following year's production that, in turn, creates shortage, higher subsequent plantings, another surplus. Year to year adjustments, then, may be deceptive and obscure long term trends.

Over a period of years, however, longer term developments make themselves obvious. And as a stock of capital is accumulated or reduced — not merely agricultural capital, but warehousing, transportation, food processing and marketing infrastructure necessary to secure the servicing of the ultimate market for a commodity — the persistence of that trend is reinforced.

The most durable of the agricultural trends being played out in the Pacific Northwest is the region's emphasis on livestock and animal products. Herds continue to grow and value of sales to rise, in spite of the current vicissitudes of producers of animal products.

That tendency is most pronounced in the instance of dairying, where the Northwest, with little more than three percent of the nation's population, housed 4.5 percent of its milk cows in 1982. Despite a virtually flat value of per-capita consumption of dairy products and dramatic increases in unit milk production over the last thirty years, Northwest dairy herds have continued to expand in numbers and to lead the nation in milk production per animal.

Growth of numbers of beef cattle has stopped in the last decade, as Americans have reversed a trend as old as the Republic to increase per-capita consumption of beef. But Northwest herds have continued to grow, though more slowly, as the national herd has declined. As a consequence, the region has increased its share of beef production from one tenth of the total to one-eighth of the total.

Similarly in the case of sheep, Northwest herds have declined more slowly than average, increasing the region's share of the total market. Mutton has never been a significant component of the American diet; so the erosion of sheep herds traces to the decline of U.S. textile and clothing industries and competition from synthetic fibres rather than shifting dietary preferences. While the quality of Northwest rangeland may enable the region to extend its lead in production of sheep and wool in the future, sheep remain one of the weaker elements in the area's agricultural economy.

The opposite situation applies in the case of poultry, predominantly the production of broiler chickens. Americans have increased their consumption of chicken prodigiously over the last decade, and Northwest producers have taken advantage of the change in consumption patterns to not only match but to exceed the general rate of growth. Still a net importer of poultry in 1978, the Northwest had become self sufficient on balance by 1982, and may well have added poultry to the long list of commodities in which it is a net exporter by the appearances of the next Census of Agriculture.

Table 4
Shift in Pasture and Animal Inventories, 1974-82

	Number on Farms				% of U.S. Total		
	1974	1978	1982	Mean Ann. Shift	1974	1978	1982
Beef Cattle	4,308,412	4,220,199	4,377,074	+8,593	10.4	12.3	12.8
Milk Cows	391,226	418,041	487,470	+12,031	3.7	4.1	4.5
Sheep	1,206,633	1,019,550	1,046,199	-20,054	7.9	8.3	8.4
Swine	238,929	289,600	264,967	+3,255	0.5	0.5	0.5
Chickens	8,402,691	9,831,055	11,135,275	+341,573	2.5	2.8	3.1
Turkeys	21,454	202,453	95,349	NM	NA	0.6	0.2
Cropland Pastured, A	2,377,147	2,061,325	2,232,925	-18,028	2.9	2.8	3.4
Woodland Pastured, A	2,427,677	4,073,518	4,122,300	NM	NA	8.7	9.5
Other Range Pastured, A	21,964,886	22,486,722	21,252,745	-89,018	NA	5.2	5.1
Total Pasture, A	26,769,710	28,981,565	27,607,970	NM	NA	5.2	5.2

It is the persistent vitality of Northwest livestock farming, together with steady increase in yields, that has had the largest influence on area cropping shifts over the last decade. Feed grains — barley, corn, and oats — occupied 1.1 million more acres in 1982 than in 1974, with barley accounting for almost 85% of the increase. The bulk of the increase, over 618 million acres, took place on irrigated land.

The shift in acreage devoted to feed grains was greater by more than an order of magnitude than that experienced by any other crop group. There was significant increase in acreage of orchards, 66,000 acres or 24%, with apples and grapes, predominantly in Washington, accounting for most of the increase. Field seeds, dry peas, lentils, and nursery products also experienced notable increases in acreage; while filberts and hops — crops in which the Northwest holds a virtual monopoly — displayed significant proportional increase, though total acreage involved was slight.

Surprisingly, acreage planted in vegetables dropped sharply. Big gains in plantings of asparagus and sweet corn and modest increases in a variety of minor vegetable crops were outweighed by losses in what had been the region's prime vegetable crops, green peas and snap beans.

Table 5
Shift in Cropland Harvested, 1974–1982

Crop	Shift in Harvested Acreage PNW	Oregon	Idaho	Wash.	Shift as Fraction of 1982 Harvest
Barley	926,795	63,258	365,925	497,612	.443
Corn (grain)	163,650	34,705	22,891	106,054	.424
Apples	56,844	4,722	2,409	49,713	.300
Nursery Pdts.	40,625	16,977	10,733	12,915	.646
Dry Beans, etc.	38,889	2,334	−13,602	50,157	.062
Oats	28,640	24,872	2,793	975	.195
Misc. Vegetables	16,926	3,182	−944	14,688	–
Sweet Corn	14,495	6,489	−2,305	10,311	.117
Potatoes	13,862	−3,314	4,912	12,264	.029
Field&Grass Seed	11,322	38,945	−19,902	−7,721	.022
Grapes	8,179	NA	NA	8,179	.277
Hops	8,053	2,150	NA	5,903	.203
Nuts	6,324	6,324	NA	NA	.216
Cherries	2,732	−383	NA	3,115	.086
Pears	2,144	−111	NA	2,255	.052
Dry Onions	610	576	34	NA	.031
Berries	−588	−755	NA	167	−.025
Plums & Prunes	−3,882	−3,274	−608	NA	−.437
Other Fruit	−6,043	−6,084	41	NA	−.599
Mint	−8,799	−4,150	−352	−4,297	−.165
Snap Beans	−12,182	−12,182	NA	NA	−.375
Sugar Beets	−15,927	−2,736	48,533	−61,724	−.107
Hay	−27,082	35,937	−44,829	−18,190	−.009
Green Peas	−33,594	−12,228	76	−21,442	−.334
Wheat	−276,623	−70,177	100,110	−306,556	−.051

As it has for many years, the area of expanding crops was drawn primarily from reduction in area devoted to pasture or planted to wheat. Since herd sizes and wheat harvest increased over the period, higher yields resulting from more intense agricultural practices obviously offset the acreage tradeoff, to result in a significant increase in overall production of food.

In addition to crop shifts made possible by productivity improvements, there were four significant instances of reductions in plantings that were caused by altered demand. The U&I Co.'s mid-seventies decision to withdraw from sugar refining eliminated the market for sugar beets in Washington and portions of eastern Idaho, a consequence of a general reduction in demand for beet sugar. Similarly, snap beans, green peas, and mint all experienced radical erosion of demand that was reflected in nation wide reduction in plantings. Since the Pacific Northwest is the leading producer of all three commodities, much of the impact was concentrated in the region.

Aside from the shifting composition of the crop mix produced by the last decade, the notable feature of the period was its continued adherence to the post World War II scenario for Northwest agriculture. Irrigation continued to advance, and with it the progressive reduction in land employed in grazing and the culture of wheat. Agricultural specialization increased, with broad increases in row crops and orchards; but with a narrowing spectrum of commodities sharing the increase. Consistent with that general movement, though opposite in its manifestation, there was a strong underlying expansion in acreage planted in a number of vegetables that was offset by reductions in demand for the region's principle vegetable crops.

In short, the agriculture of the Northwest continues to become more intensive and irrigation dependent, more specialized in its output, more dependent on mass national markets produced by food processing and on foreign trade for its commodity sales. Specialization makes it more vulnerable than ever before to financial and marketing conditions, makes the quest for continued productivity essential to the survival of the individual farm operator.

III. Pesticide Use Characteristics in Northwest Agriculture

A. Comparative Use

Pacific Northwest farmers spent $211.7 million, equal to 3.2% of the value of their commodity sales, in 1982 to treat 12.2 million acres with chemicals other than fertilizers or lime. Almost half of all northwest farms utilized some form of chemical treatment during the year; and the gross area treated — i.e. including double counting of acreage receiving more than one form of treatment — was equal to almost 91% of the area of cropland harvested. Dollars spent for treatment with pesticides by Northwest farmers accounted for 4.9% of national agricultural outlays for the purpose; and the area treated comprised 4.4% of the agricultural area treated in the U.S. (The Northwest provided 4.9% of the nation's farmland, 4.1% of the cropland harvested, and 5.1% of the value of farm products sold.)

It would appear that pesticide use in the region conforms generally to national patterns, but that applications are somewhat higher than average, based on the relationship between cropland harvested and land treated in the U.S. and in the Pacific Northwest. A more detailed comparison of pesticide usage in agriculture, presented in table 9, indicates that such is, indeed the case.

Table 9
Comparative Pesticide Use Characteristics, 1982

	Pesticide Using Area				
	US other than PNW	PNW	Idaho	Oregon	Washington
Outlays for Treatment $(10^6)	4,070.5	211.7	52.7	56.7	102.3
Percent of Farms Treating	50.3	47.8	51.2	43.6	49.3
Outlay per Farm Treating, $	3,769	4,672	4,158	3,818	5,751
Outlay per Acre Treated, $	15	17	13	20	19
Percent of Farmland Treated with					
Insecticides	7.5	5.3	6.5	3.1	6.6
Nematocides	0.8	0.5	0.7	0.3	0.5
Disease Controls	1.1	2.1	1.8	1.7	2.6
Weed Controls	18.0	16.6	18.3	10.7	21.4
Defoliants & Growth Cntrls	0.9	1.0	1.3	0.4	1.4
Shift, 1978–1982, percent					
Total Acres Treated	+2.2	+14.9	+18.1	+15.0	+12.6
Acres treated for Weed Cntrl	+6.9	+20.9	+31.2	+13.4	+18.3
Acres treated for othr purps	−5.1	+4.5	+0.4	+18.2	+3.0

The values suggest that Northwest farmers are very like their counterparts elsewhere in the nation in their propensity to employ pesticides; but that their use per acre is likely to be more intense, that they are significantly less likely to employ agents against insect pests, significantly more likely to use herbicides, and that their use of both insecticides and herbicides is increasing more rapidly than use elsewhere.

It is noteworthy that internal differences — i.e. the distinction between level of pesticide use in Oregon and the other two Northwest States — are greater than the difference between use in the Northwest and the rest of the nation. Even allowing for the intermittence of pest problems, the fact supports the hypothesis that agricultural use of pesticides is modified, if not governed, by locational circumstances and agricultural specialization.

To test that hypothesis, and to derive some measure of the nature of locational aspects of pesticide use in the Northwest, the area has been divided for analytical purposes into ten agricultural districts. Six of the ten represent large areas, groups of counties considered together because of common topographic and climatic conditions. Four smaller areas were abstracted from the physically homogenous sets on the basis of the relative intensity of their agriculture.

The ten areas are these:

1) A Coastal Strip is composed of twenty-one of the twenty-two Oregon and Washington counties that border the Pacific Ocean or Puget Sound. (Lane County, Oregon is included among Willamette Valley rather than Coastal counties.) The area is mountainous rain forest, with its northern portion heavily urbanized and industrialized, and is largely unsuited to general farming. Only 7.2% of its 18 million acres is farmland; and only 26.8% of its farmland is harvested. Dairying, the predominant agricultural activity, provides 50.2% of the value of gross farm income, sales of other livestock products 27.9%. A limited number of specialty farms, mostly in the Puget Sound area, obtain significant revenues from nursery, orchard and vegetable sales.

2) The Willamette Valley consists of nine Oregon counties that occupy the sloping plain between the Coast and Cascade mountain ranges that is drained by the Willamette River. It is the only sizeable Northwest agricultural area with sufficient summer precipitation to sustain general agriculture. Although its borderlands are mountainous and forested, and its 8.4 million acres contain all three of Oregon's metropolitan areas, 21.5% of the land area is farmland and 53% of the farmland is harvested. The agriculture is the Northwest's most diverse and among its most intense, with relatively small farms producing a balanced commodity mix: 33% of sales are of fruit and specialty crops, 19.8% are of livestock products, 12.5% of dairy products, 13.2% hay and seeds, I1.5% vegetables, and 9.8% grains.

3) The Eastern Slopes of the Cascades contain fifteen Washington and Oregon counties, exclusive of Yakima County which is categorized separately. The area is semi-arid. Its mountainous western portion is mostly forest that becomes progressively more sparse as the land drops to the high Columbia Plateau. Area is 24.9 million acres, 23.9% of it farmland. Only 15.1% of the farmland is harvested, 9.8% is irrigated. Grazing and production of meat animals dominate land use, with range and pasture taking up 74.9% of farmland. But livestock products sales account for only 32.5% of farm revenues and dairying 7.5%. Orchards and — less significant — row crops, both almost entirely irrigated, provide 42.1% of total farm sales.

4) Yakima County, with only 2.7 million acres, produces nearly as much farm revenue as all of the rest of the Cascades region. Exactly five-eighths of the land area is included in farms; 16.4% of the farmland is cropland, 16.2% of the farmland is irrigated. The commodity mix is similar to that of the rest of the Cascades region, though orchards — predominantly apples — and row crops, including hops, account for a greater share of sales, 52.1%. Livestock products bring 31.2% of sales, dairy products 6.2%.

5) The Columbia Plateau, high, flat, and arid, includes both natural grasslands capable of supporting low intensity grain plantings or grazing and true desert totally unsuited for agriculture. The area covers 33.6 million acres, 50.9% of it classified as farmland. But 18.5% of that farmland is idle. Cropland amounts to 29.4% of farmland; and where irrigation water can be supplied, the land is extremely productive. Ten percent of the farmland is irrigated, almost a quarter of the total irrigation occurring in Grant County Washington. Grains, predominantly wheat, produce 41.4% of gross farm income, livestock 23.8%. Row crops, particularly potatoes produced under irrigation in Grant County and scattered other locations, bring 20.6% of gross farm income.

6) Walla Walla County can be distinguished from the rest of the Columbia Plateau on the basis of the intensity of its agriculture, an intensity that is a compound of two circumstances. No less than 93.6% of the county's total area is farmland; and the Walla Walla, Touchet, Snake and Columbia Rivers make it possible to irrigate 12.8% of that farmland. Thus, though the county adheres to the wheat/cattle pattern of agriculture that characterizes most of eastern Washington and Oregon — they account, respectively, for 29.3% and 52% of farm sales — substantial revenues are also derived from vegetables and from row crops and fruits, which together provide 11% of farm sales and support a sizeable local food processing industry.

7) The Palouse hills, a region composed of four Washington and three Idaho counties, may be North America's most intensely cultivated and productive wheatland. Eighty percent of the area's 4.3 million acres is included in farms; and 47.7% of the farmland is harvested, though only 3.3% is irrigated. Grains, mostly wheat, produce 82.4% of farm revenues, cattle 8.9%.

8) The Mountain Country of Northwest Washington and Northern Idaho is limited by topography to sparse, small scale agriculture. Only 15.8% of its 26.6 million acres is considered to be farmland. The bulk of that, 58.7%, is devoted to grazing. Cropland, principally hay, occupies another 23.5% of the farmland. Livestock produce 56.1% of revenues, meat animals bringing 44%, dairy products the reminder. Wheat and other grains account for another 29.4% of sales.

9) The largest of the Northwest's agriculture regions, both in terms of area and of farm income produced, is the Snake Basin. Its 36.8 million acres is 35.1% farmland, and 29.5% of the farmland is cropland, 23.6% of it is irrigated. As with the Columbia Plateau, which is almost as large in area and includes considerably more farmland, cattle and grains are the largest revenue producers, accounting respectively for 37.5% and 24.3% of

gross farm income. But the farm economy of the Snake Basin is, because of the high prevalence of irrigation, more diversified. Row crops, notably potatoes, sugar beets, and dry beans produce 21.6% of farm income, dairying 9.6%, hay and seeds 5.0%.

10) The Boise Basin includes three Idaho counties whose total area is only 3.0 million acres, 31.2% of which is farmland. Yet value of the area's agricultural output, which is based on extensive irrigation, rivals that of the Yakima and far exceeds the Palouse. Distribution of farmland is similar to that of the larger Snake Basin area that contains the Boise, with 41.5% of the farmland occupied by cropland and 44.0% of the farmland irrigated. Cattle are the prime revenue source, accounting for 64.5% of farm income, with row crops providing another 19.7%, grain 10.4% and dairy products 10.3%.

Table 10
Agricultural Sub-regions of the Pacific Northwest

	1000 Acres			Value of Sales		
	Area	Farmland	Percent Farmland	$1000's	Percent of Total	Per Acre Farmland
Coastal Counties	17,956	1,295	7.2	652,198	9.4	$504
Willamette Basin	8,450	1,820	21.5	650,650	9.4	$358
Cascades Counties	24,940	5,962	23.9	591,047	8.6	$ 99
Yakima Basin	2,743	1,715	62.5	467,733	6.8	$273
Columbia Plateau	33,640	17,098	50.8	1,655,852	24.0	$ 97
Walla Walla Basin	807	755	93.6	230,117	3.3	$305
Palouse Counties	4,324	3,458	80.0	313,746	4.5	$ 91
Mountain Counties	26,638	4,216	15.8	164,346	2.4	$ 39
Snake Basin	36,863	12,936	35.1	1,758,451	25.4	$136
Boise Basin	3,012	941	31.2	430,425	6.2	$458
Total	159,373	50,196		6,914,565		
Average			31.5			$138

The propensity to employ pesticides has been expressed quantitatively for each of these agricultural districts (as for the three Northwest states and the U.S. excluding the Northwest) as the fraction of total farmland treated with each of the five pesticide classes distinguished by the Census of Agriculture. The sum of the five categorical values may be construed to measure overall propensity to employ pesticides. Values are presented, ranked according to overall propensity to employ pesticides, in table 11.

(Clearly, there are large deficiencies in the measure. It conveys neither the frequency of treatment nor the amount of chemical agents applied; and it treats as equivalents compounds of vastly different nature. But as a first approximation of relative intensity of pesticide use in separate agricultural regions, the measurement would seem to be superior to hypothesizing on the basis of crop type and pesticide registrations, the technique generally applied to this time.)

Table 11
Relative Propensity of Agricultural Regions to Employ Pesticides

Area	Acres Treated/Acres of Farmland					
	Sum	Insectcde	Nematocde	Disease Ctl	Weed Ctl	Defoliants etc
Walla Walla	.6398	.1384	.0055	.0901	.3720	.0338
Willamette	.5573	.1112	.0123	.0832	.3403	.0103
Palouse	.5247	.1045	.0038	.0424	.3681	.0059
Boise	.4276	.1105	.0210	.0467	.2255	.0239
Yakima	.3489	.0814	.0021	.0269	.2104	.0281
Washington	.3255	.0657	.0050	.0262	.2143	.0143
Idaho	.2855	.0653	.0065	.0181	.1825	.0131
Columbia Plateau	.2846	.0502	.0045	.0198	.2017	.0084
U.S. excl. PNW	.2834	.0749	.0078	.0114	.1799	.0094
Snake	.2231	.0515	.0053	.0122	.1422	.0119
Coast-Puget	.2007	.0549	.0035	.0128	.1231	.0064
Oregon	.1626	.0310	.0031	.0174	.1067	.0044
Cascades	.1086	.027	.0023	.0115	.0605	.0073
Mountainous	.0850	.0097	.0001	.0039	.0694	.0019

B. Factors Governing Pesticide Use

In the short run the factors that determine pesticide use are largely physical and biological: virulence and frequency of pest episodes, climatic mediation, efficacy of pesticides. In the longer run, however, price and technology may be expected to pose a more regular pattern based on agricultural specialization and cultural practices. Thus current agricultural practices in the Pacific Northwest may be considered to represent an equilibrium whose elements — including the use of pesticides — should remain fairly static until some technological or demand shift disturbs it.

If that is so, recognition of the general characteristics governing pesticide use in the region should be useful in implementing existing regulatory programs, and in detecting shifts in agricultural practices that may influence future program alterations.

The most obvious of the variables that affect propensity to employ pesticides is the relative intensity of agriculture. It is axiomatic that more intense cultural practices involve greater use of pesticides, in that use of pesticides is one of the elements that define agriculture intensity. But there is no reason to assume either that a high propensity to employ pesticides is an invariable aspect of intensive agriculture, or that significant differences of degree in propensity to employ pesticides are not associated with separate aspects of intensity.

To test the correspondence between pesticide use and other measures of agricultural intensity, the linear correlation between propensity to employ pesticides and three other measures — sales per acre of farmland, percent of farmland irrigated, percent of farmland harvested — has been derived for a set composed of the ten agricultural sub regions, the three Northwest states, and the U.S. exclusive of the Pacific Northwest. Results are presented in table 12.

Table 12
Measures of Agricultural Intensity vs. Propensity to Employ Pesticides

	Sales per Acre			Percent Irrigated			Percent Cropland		
Propensity to Employ	intrcpt	slpe	r	intrcpt	slpe	r	intrcpt	slpe	r
Insecticides	.0414	.0001	.55	.0561	.0010	.28	-.0097	.0025	.83
Nematocides	.0016	.00002	.58	.0008	.0004	.74	-.0016	.0002	.55
Disease Controls	.0126	.0001	.46	.0245	.0004	.16	-.0267	.0018	.81
Weed Controls	.1581	.0002	.29	.1963	.0002	.26	-.0313	.0071	.87
Defoliants & Growth Ctls	.0065	.00003	.47	.0068	.0004	.48	.0053	.0053	.31

The correlations are instructive, and tend to bear out the hypothesis that pesticide use is an invariable aspect of intensive agriculture. Correlation is positive in each case, though the most compelling coefficients of correlation and steepest slopes occur in the relationship between pesticides and use of farmlands as cropland. (An exception is propensity to employ nematocides, where irrigation has the strongest association, presumably a consequence of soil moisture.) The inference, then, is that the propensity to employ pesticides is substantially stronger in growing crops for harvest than in producing animal products.

That evidence is strengthened by correlation of pesticide use with source of farm income. When animal products sales as a percentage of total farm sales are correlated with pesticide usage, modestly negative correlations with dairying occur for all five pesticide categories. In the case of other livestock products, correlations with all classes of pesticide use other than weed control are slightly positive, but the combination of animal feeding with intense agriculture in the Walla Walla, Boise and Yakima farm districts suggests that the positive correlation may be coincidental, the consequence of an association of intense farming with large proportional animal sales rather direct consequence of livestock activities. (Table 13)

Table 13
Relative Sales of Livestock Products vs. Propensity to Employ Pesticides

	Dairy Products			Other Livestock Products		
Propensity to Employ	Intercept	Slope	r	Intercept	Slope	r
Insecticides	.0775	-.0007	-.22	.0644	.0002	.05
Nematocides	.0060	-.00001	-.03	.0015	.0001	.31
Disease Controls	.0373	-.0006	-.28	.0279	.0001	.03
Weed Controls	.235	-.0031	-.36	.265	-.0019	-.23
Defoliants & Growth Ctls	.0152	-.0002	-.27	-.0005	.0007	.24

That factor of possible coincidence makes it risky to attempt to pursue the propensity to employ pesticides through correlations with particular crops. For the most part, the agriculture of the Pacific Northwest is so diversified that it is not possible to associate a particular practice with a given crop in the absence of detailed information. There are simply too many potentially affective variables to assign a reasonable association to any particular one.

But if the propensity to employ pesticides cannot be determined for specific crops, there remains the possibility of separating the propensities associated with major crop groups, that is, detecting the effect of agriculture specialization on the propensity to employ pesticides.

To sharpen distinctions between crop groups, given the overall environment of crop diversity, the measure chosen to represent specialization is dollar value of crop group sales per acre of total cropland harvested. Four crop groups are distinguished: grains, hay and seeds, vegetables, and the combination of row crops, orchards, berries and specialty crops. The dollars per acre of cropland standard allows sharp delineation of comparative specialization, as table 14 demonstrates.

Table 14
Comparative Specialization, Sales Dollars per Acre of Total Harvested Cropland

	Dollars per Acre, Crop Group			
Agricultural Region	Grain	Hay & Seeds	Vegetables	Other
Walla Walla	172.05	23.70	30.80	34.05
Willamette	65.95	89.35	77.25	222.35
Palouse	156.55	3.65	3.00	.85
Boise	115.05	49.15	23.40	217.05
Yakima	87.15	20.95	65.70	869.40
Washington	129.90	19.65	20.35	154.95
Idaho	113.50	24.25	5.75	87.85
Columbia Plateau	136.35	21.05	9.25	67.70
U.S., excluding PNW	111.50	6.20	12.50	56.75
Snake	112.10	23.05	8.20	99.40
Coast-Puget	10.15	18.45	86.65	276.45
Oregon	86.20	47.15	30.80	118.85
Cascades	58.55	33.40	6.60	276.80
Mountainous	48.70	17.75	.05	4.05

Results of the regression calculations are presented in table 15.

Table 15
Crop Group Sales per Cropland Acre vs. Propensity to Employ Pesticides

Propensity to Employ	Grains			Hay, Seeds			Vegetables			Other		
	incpt	slpe	r	incpt	slpe	r	incpt	slpe	r	incpt	slpe	r
Insecticides	.0235	.0005	.56	.0598	.0003	.21	.0596	.0004	.29	.0680	pos	.06
Nematocides	.0037	.00002	.19	.0023	.0001	.53	.0053	.00002	.13	.0061	neg	−.05
Disease Cntrols	.0053	.0002	.41	.0124	.0006	.51	.0213	.0003	.35	.0308	neg	−.03
Weed Controls	.0512	.0015	.64	.1791	.0007	.16	.1819	.0007	.19	.2069	neg	−.08
Defoliants & Growth Cntrols	.0029	.0001	.46	.0128	neg	0	.0108	.0001	.23	.0096	.00002	.42

Clearly, the values demand further interpretation. The relationship between grain sales and weed controls is unequivocal. There is a strong positive correlation between the variables; and the upward slope of propensity to employ weed controls is twice or more greater for grains than for the other three crop groups. Since weed controls are far and away the most broadly employed pesticide group, accounting for 65% of total acres receiving pesticide treatment in the Northwest in 1982, the association is unquestionably significant. But in other cases, relationships are insufficiently outlined to draw dependable conclusions. At best, they seem to indicate that as income per acre for any crop group increases, that increase is accompanied by an increase in treatment by pesticides, a simple restatement of the intensity relationship.

A sharper definition of the relationship between the various classes of pesticides and the several crop groups can be obtained by exaggerating both variables — that is, by applying the demonstrated correlation between percent of farmland employed as cropland and propensity to employ pesticides. To conduct the exercise, acres treated with each class of pesticide have been expressed as a fraction of cropland, eliminating that major portion of farmland held idle or employed for grazing. Results are presented in table 16.

Table 16
Acres Treated by Pesticide Classes as a Fraction of Cropland

Fraction of Cropland Harvested							
Insecticides		Disease Controls		Weed Controls		Defoliants, etc	
Yakima	.4977	Walla Walla	.1739	Palouse	.7710	Yakima	.1715
Walla Walla	.2671	Yakima	.1646	Walla Walla	.7181	Walla Walla	.0653
Boise	.2662	Willamette	.1571	Columbia PL	.6856	Boise	.0576
(U.S.	.2247)	Boise	.1126	Willamette	.6422	Cascades	.0486
Palouse	.2189	Palouse	.0888	Boise	.5434	Snake	.0402
Willamette	.2098	Cascades	.0764	(U.S.	.5399)	Columbia PL	.0287
Coast	.2046	Columbia PL	.0674	Yakima	.4988	(U.S.	.0282)
Cascades	.1788	Coast	.0478	Snake	.4821	Coast	.0238
Snake	.1750	Snake	.0414	Coast	.4584	Willamette	.0195
Columbia PL	.1706	(U.S.	.0342)	Cascades	.4014	Palouse	.0124
Mountains	.0412	Mountains	.0164	Mountains	.2950	Mountains	.0082

The procedure causes a distinct reshuffling of the ranking of the agricultural sub-region's use of the various categories of pesticides, and sharply narrows the range of inter-regional variations in pesticide use. Clearly the Northwest's system of agriculture is one that features areas of farming intensity (made possible mainly by irrigation) that are separated by broad expanses of either range or wheatland. Within those pockets of intensity, over-all propensity to employ pesticides would seem to be similar. It is noteworthy, too, that with the exception of insecticides, most Northwest farming areas exceed the national average in terms of percent of cropland treated with major categories of pesticides.

Correlation of the values with dollar value of output in major crop categories gives the results presented in table 17.

Table 17
Crop Group Sales per Cropland Acre vs.
Percent of Cropland Treated by Pesticide Class

	Insecticides			Disease Controls			Weed Controls			Defoliants, etc		
Crop Group	incpt	slpe	r	incpt	slpe	r	incpt	slpe	r	incpt	slpe	r
Dairy	22.17	.001	.02	10.10	-.0046	-.24	56.76	-.0131	-.24	4.98	-.0016	-.10
Livestock	13.37	.034	.62	7.22	.0085	.32	59.02	-.0155	-.21	1.22	.0135	.60
Grains	17.93	.045	.20	5.42	.042	.39	33.18	.2262	.77	3.90	.0089	.10
Hay & Seeds	22.01	.001	.02	6.42	.1015	.43	53.78	.0393	.06	5.23	-.0156	-.08
Vegetables	17.04	.169	.49	7.13	.075	.45	54.57	.0125	.03	3.37	.0446	.31
Other Crops	14.62	.037	.83	7.52	.0094	.44	57.88	-.0141	-.24	1.42	.0162	.87

The values, taken together with the data from which they were developed, produce a fairly firm set of findings.

Both insecticides and the defoliant/growth control category of pesticides are strongly associated with orchards and row crops. The apparent correlation of the two pesticide groups with animal products other than dairying may safely be dismissed as an accident of association — highest values of animal sales per acre of cropland occur in cattle feeding agricultural regions where orchards and row crops predominate (e.g. Boise, Yakima).

While weed controls are the most prevalent of pesticides, that breadth of use would appear to be a consequence of the ubiquity of grains in Northwest agriculture. Use of weed controls has a low coefficient of correlation with the cropping of hay, seeds, and vegetables, a negative correlation with animal culture, orchards, and row crops.

Employment of disease controls would appear to be associated with agricultural intensity rather than any particular crop group. The modestly positive correlation with all commodity groups but dairying is suggestive of a situation in which applications are based on need, grower awareness, and financial capability rather than specific susceptibility or common practice associated with given groups of crops.