Improved management practices that reduce pesticide use

Integrated pest, disease and weed management practices in Oregon

Integrated Pest Management (IPM) is a scientifically driven approach to the control of pests, diseases and weeds. It has evolved over more than 30 years, and national targets for IPM adoption have been established in the United States. Definitions of IPM, of which there are many, tend to share the following elements:

1. Pests co-exist with crops, and are subjected to control measures if populations or infections exceed a level above which economic losses may be expected to at least exceed the costs of control. Pests are managed to exist below this "economic injury level". IPM systems therefore require adequate methods of assessment of population density or infection and current injury with regard to established economic injury levels.
2. Management of pests is achieved through the harmonious use of all available control tactics. These fall into four main classes: chemical, biological, host-plant resistance, cultural and physical.
3. IPM systems are designed to maximize producers' economic benefits from control measures, minimize adverse environmental side-effects and maximize social benefits.
4. Pest and injury level assessments support a decision-making process that takes into account cost-benefit ratios expressing, in economic terms, not only the impact of pests, diseases and weeds and the methods of their control, but also environmental and social costs.

The highly diversified agroecosystems of the Willamette Valley for example, present a number of challenges to the development of sustainable IPM practices. More than 90 commodities are grown in the Valley, under many spatial scales and patterns. These commodities are grown in a wide variety of combinations. Certain pests, particularly spider mites, are the subject of control strategies that encompass large numbers of crops, with some acting as sources or refuges for predatory mites that invade crops and suppress pest mite populations. Pesticides that are less toxic to predatory mites are used, and field populations may be enhanced by introductions in crops that lack local reservoirs, including field boundary vegetation. Control strategies of this form may take decades to develop, the adoption of IPM principles for all major crops and pest problems is a long way from being achieved. A summary of the IPM status of a number of crops in the WillametteValley (Kogan et al, 1999) found deficiencies and scope for improvement in most commodities.

Conclusions: methods of measuring IPM adoption are being actively discussed throughout the USA at present. Oregon is an active participant in these discussions, and the measures that are adopted nationally should become a significant part of the integrated measure of sustainable agricultural practices. So-called Level III IPM, explicitly acknowledges the surrounding ecosystem, and exploits ecologically-derived means of pest, disease and weed suppression. Systems that adopt these practices are healthier in terms of sustainable yield, productivity, biodiversity and reduced environmental impact.

Pesticide use trends in Oregon drainage basins

Approximately 250 to 300 pesticide active ingredients are used in Oregon, excluding anti-microbials. Based on pesticide use surveys conducted by Oregon State University Agricultural Chemistry Extension Program between 1990 and 1996, approximately 13.4 million pounds of pesticide active ingredients are applied annually in Oregon. These surveys were undertaken within agricultural commodities and exclude forestry, non-crop weed management and rights-of-way maintenance, industrial uses and homeowner use. There are no surveys at present that provide estimates of use for these sectors of the pesticide market, and it should not be assumed that off crop residues, such as those in ground and surface waters, derive solely from agriculture. It should also be noted that environmental risks are not simply a function of the mass applied, but of toxicity and exposure also. There may have been significant differences in the risks posed by pesticides in different years, despite the similarity in the total amounts used in agriculture over the last decade or so.

The total pounds pesticide active ingredient in each basin are roughly correlated with agricultural acres. In the high-use basins, a few pesticides account for most of the poundage. The fumigants metam-sodium and 1,3-dichloropropene (Telone) account for nearly three quarters of the pesticide usage in the Umatilla Basin. Metam sodium, Telone, and sulfur account for nearly two thirds of the pesticide usage in Malheur Basin. Sulfur and oil account for nearly three quarters of the pesticide usage in Hood River Basin. Telone accounts for most of the pesticide usage in Klamath Basin.

Pesticide use in Oregon by crop for each basin is given in the SOER Appendices (Progress Board Web site; www.econ.state.or.us/opb). The use data were obtained from the Oregon Pesticide Use Database (OPUD) and collected through surveys conducted by Agricultural Chemistry Extension at Oregon State University. These pesticide use estimates represent most agricultural crops grown in Oregon, but they do not include other important uses such as urban use, rights-of-way, range land, and forestry.

In 1998, the data used to produce the pesticide use estimate reports were organized by crop within the Oregon's drainage basins. The individual basin pesticide use estimates were then sent to 84 county Extension agents, OSU Experiment Station personnel, and OSU specialists for review. Based on these reviews, the basin pesticide use estimates were updated in 1998, to reflect current cropping and pesticide use practices.

The OPUD can be used to estimate the amount of pesticide applied over an approximately 20-year period in a number of agricultural commodities. Although by no means a rigorous guide to the mass or distribution of pesticides used, these data may be used to determine trends. Overall, pesticide use does not seem to have changed a great deal over the pest 20 years. Use in 1981 was estimated to be 13,800,000 pounds, rising to 16,050,000 in 1987, with an estimated 13,375, 056 pounds being applied per annum between 1990 and 1996. Commodities where pesticide use has decreased include small grain, declining from 2,500,000 pounds per annum in 1981 to 743,000 pounds per annum in 1994. Commodities where usage has increased include nurseries, an expanding industry, increasing use from 184,000 pounds in 1981, to 342,000 pounds in 1992. Commodities where use has remained relatively stable include tree fruits and small fruits. None of these estimates have been weighted for potential hazards.

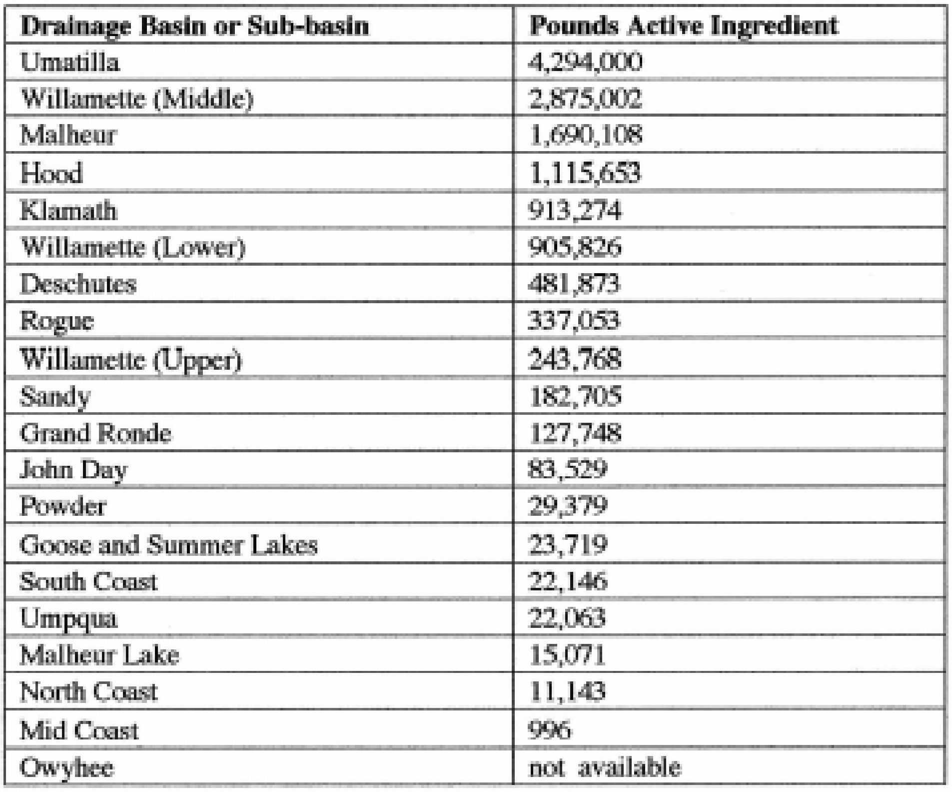
Pesticides in streams and ground water

The U.S. Environmental Protection Agency (EPA) is responsible for programs designed to prevent further groundwater contamination by pesticides. In support of this effort, EPA is asking the states for: 1) Generic Pesticide State Management Plan; 2) Pesticides in Groundwater Database, and; 3) Pesticide Specific Management Plans for atrazine, cyanazine, simazine, alachlor, and metolachlor. EPA has indicated that in the future it will require additional Pesticide Specific Management Plans.

As a part of this effort, the OSU Agricultural Chemistry Extension Program has compiled a database of pesticides found in Oregon groundwater (Jenkins et al, 2000) . It includes monitoring data collected by various state and federal agencies over the last 15 years, and sent to a central data repository, called STORET. Participating agencies include Oregon Department of Environmental Quality (DEQ), Oregon Health Division (OHD), U.S. Geological Survey (USGS), and U.S. Bureau of Reclamation (USBR).

The majority of the data are from DEQ. These data have gone through additional quality control by DEQ personnel following retrieval from STORET. In addition, individual agency initiatives have determined the scope of data collection and analysis. In all cases except the OHD program, groundwater

Table 3.9-6. Yearly Pesticide Use Estimates for Oregon Drainage Basins (1990-1996)



Drainage Basin or Sub-basin	Pounds Active Ingredient
Umatilla	4,294,000
Willamette (Middle)	2,875,002
Malheur	1,690,108
Hood	1,115,653
Klamath	913,274
Willamette (Lower)	905,826
Deschutes	481,873
Rogue	337,053
Willamette (Upper)	243,768
Sandy	182,705
Grand Ronde	127,748
John Day	83,529
Powder	29,379
Goose and Summer Lakes	23,719
South Coast	22,146
Umpqua	22,063
Malheur Lake	15,071
North Coast	11,143
Mid Coast	996
Owyhee	not available

Compiled by Jenkins J., Buchwalter D. and Thomson P., Oregon State University.

sampling was targeted. For example, DEQ sampling is often focused on nitrate detections associated with real estate transactions. The Oregon Groundwater Protection Act requires DEQ to conduct intensive sampling in Groundwater Management Areas, such as northern Malheur County and the lower Umatilla basin. USGS sampling was targeted at shallow groundwater in alluvial aquifers in the Willamette basin, and USBR sampling was specific to the city of Hermiston's Groundwater Recharge Project. Agencies also may employ different sampling and analysis methods. Of particular interest are the limits of quantitation used in reporting "non-detects." For example, USGS uses analytical methods that allow much lower limits of quantitation than the other agencies. Their lower limits of quantitation result in "detections" that would not be reported by other agencies.

The very low detection limits achieved by USGS highlight the need to compare monitoring data to health-based standards. EPA has established Health Advisories (HAs), which are non-enforceable guidelines for chemical residues in drinking water, for approximately 200 chemicals, including about 50 pesticides. In addition, as a part of rulemaking under the Safe Drinking Water Act, the agency has established the Maximum Contaminant Level (MCL) for about 25 pesticides in drinking water. In determining the lifetime HAs and MCLs, the estimated dose is based on a 70 Kg person consuming 2 liters per day. For non-carcinogens, lifetime HAs and MCLs are derived from the drinking water equivalent to the Reference Dose. The Reference Dose is an estimate of total human daily exposure to contaminants that are unlikely to result in adverse health effects over a lifetime. For carcinogens, the excess cancer risk associated with lifetime ingestion of drinking water is estimated. The target for the lifetime HA is a concentration in drinking water that results in less than 1 in 10,000 (1×10^{-4}) excess lifetime cancer risk. In addition, for a few pesticides for which no MCL or HA is available, the World Health Organization guidelines are reported. Finally, in the absence of these standards or guidelines, the adjusted DWEL, or Drinking Water Equivalence Level (EPA, 1989), is given. The DWEL was determined using the Reference Dose and assuming a 70 Kg person consumes 2 liters per day for a lifetime. The DWEL has been adjusted assuming that drinking water comprises 20% of the allowable daily intake. Use of the adjusted DWEL assumes that there is no non-threshold lifetime cancer risk, or the HA calculated for cancer risk would be greater than that calculated using the adjusted DWEL.

Over the years groundwater has been analyzed for roughly 100 pesticides. Monitoring programs have included all basins except Klamath, Powder, and Sandy. In a number of basins, monitoring programs found no detectable pesticide residues; these basins include Grande Ronde, Hood, John Day, Malheur Lake, Mid Coast, South Coast, and Umpqua. Note, the South Coast basin does not include the Chetco River drainage south of Gold Beach, which extends into Northern California.

Since 1984, 29 pesticides and pesticide metabolites have been detected in Oregon's groundwater. For the majority of pesticide active ingredients, detections are isolated to single basin. Those pesticides found in groundwater in the Goose and Summer Lakes Basin are not associated with agricultural or other uses but are the result of DEQ monitoring of an old disposal site at Alkali Lake. The most frequently detected pesticide in Oregon ground water is Dacthal or DCPA, followed by atrazine. Both pesticides have been found in five basins. Dacthal and atrazine are also the pesticides most frequently looked for in Oregon groundwater. The number of Dacthal detections by basin follows: Malheur-1,400, Owyhee-170, Rogue-1, Umatilla-38, and Willamette-3. On average, Dacthal was detected in 65% of analyzed samples.

Although the parent compound Dacthal has been reported in Oregon groundwater, Dacthal usually degrades within a few days to the mono- and di-acid metabolites. These metabolites are more persistent and mobile in soil. Therefore, the majority of the results reported as Dacthal are actually the primary metabolite, Dacthal di-acid. Although there is no health standard or guideline for the di-acid metabolite, because it is considerably more water soluble than the parent, it is likely to be less toxic.

All Dacthal and/or metabolite levels detected in Oregon groundwater are orders of magnitude below 4,000 ug/l, the lifetime Health Advisory for Dacthal in drinking water. The highest levels of Dacthal and/or metabolites were found in the Malheur basin, which averaged 77 ug/l, followed by Owyhee at 5.2 ug/l, Umatilla at 3.0 ug/l, Willamette at 0.7 ug/l, and Rogue at 0.3 ug/l. In addition, Dacthal and/or metabolites were detected in more than 80% of the samples analyzed from Malheur and Owyhee basins, as compared to the other basins for which the frequency of detection ranged from 2 to 8% of analyses. Higher levels and frequency of detection of Dacthal and/or its metabolites in Malheur and Owyhee basins can be attributed to a number of factors, which include pesticide use practices, irrigation practices, prevalence of sensitive soils, and shallow groundwater. Since the results of groundwater monitoring were first reported in the early 1990s, there has been a substantial effort on the part of the grower community, as well as Oregon State University Agricultural Experiment Station and Extension personnel, to develop and implement pesticide use and irrigation practices that will prevent further groundwater contamination.

The number of atrazine detections by basin were: Deschutes-7, Malheur-1, North Coast-2, Umatilla-18, and Willamette-29. In addition, USGS reported 16 detections of the metabolite desethyl atrazine in Willamette basin groundwater. With the exception of detections of 3.9 ug/l and 10.2 ug/l from the North Coast basin, all levels of atrazine or its metabolites detected in Oregon groundwater are below 3 ug/l, the Maximum Contaminant Level for atrazine in drinking water. Atrazine levels in groundwater from the remaining basins ranged from 0.003 to 1.5 ug/l and averaged 0.46 ug/l. On average, atrazine was detected in 5% of the samples analyzed. Excluding the monitoring data samples from the Akali Lake disposal site, the average detection frequency for all pesticides found in Oregon groundwater was 9%.

Of the remaining pesticides found in Oregon groundwater, excluding those associated with the Akali Lake disposal site, dieldrin, dinoseb, heptachlor, and pentachlorophenol (PCP) were detected at levels that exceed drinking water standards or guidelines. Dieldrin, dinoseb, and heptachlor are no longer used in Oregon. PCP use in Oregon has declined significantly over the last 10 years and is restricted to a few wood treatment facilities.

In compliance with the Safe Drinking Water Act, Oregon Health Division requires that community and non-transient drinking water systems test for pesticides. Between 1991 and 1996, four systems reported a total of six detections. 2,4-D was detected twice and pentachlorophenol (PCP) was detected once in a public drinking system in the lower Willamette basin; and PCP was detected in one sample in the Deschutes basin; all are well below their maximum contaminant levels. However, ethylene dibromide (EDB) was detected in one sample in the Umatilla basin at the maximum contaminant level of 0.05 ug/l. EDB is no longer used in Oregon.

Surface water detections are more frequent than ground water detections for any given pesticide, and chlorinated hydrocarbons occur in fish tissues, despite the fact the use was banned in the 1970s. In an analysis by Wentze *et al*(1988), eight pesticides were found to exceed criteria of safety for drinking (azinphos-methyl (3% detection frequency), dieldrin (1%), diuron (53%), and dinoseb (1%), aquatic life (gamma-HCH (4%), or both (atrazine (85%), diazinon (35%). The fish and clam tissue samples found eight organochlorine pesticides at detectable levels, and sediment sample found ten organochlorines still to be at detectable concentrations.

Conclusions: Use of the most hazardous pesticides is likely to be in decline as a result of improvements in the availability of reduced risk active ingredients. This will, over time, reduce ecological risks associated with pesticide use. There has been no systematic tracking of chemical use however, and environmental impact has rarely been measured directly within the state. We therefore rely at present upon survey data, of the kind reported above, and measures of residues in critical environmental compartments. A greater emphasis upon decision aids for the selection of active ingredients, buffer strips, and unsprayed field boundaries could serve to reduce off site contamination. Concentrations of some herbicides, organophosphate, carbamate and organochlorine insecticides exceed the limits of safety, and it is likely that there has been some direct harm to ecosystems.

Fertilizers and animal wastes and a source of excess nutrients in aquatic systems

Nitrates

Nitrates are the most common chemical contaminant of Oregon's groundwater. Historically, DEQ has monitored well water for nitrates along with other standard water quality measurements. More recently, nitrate data, along with information on land use, soil types, and aquifer characteristics, have been used by DEQ to target areas for pesticide sampling. Nitrate levels in wells sampled for pesticides by DEQ between 1984 and 1996 are given in the **Table 3.9-7**. Because the STORET retrieval was specific to wells sampled for pesticides, the data in the table does not represent all wells in Oregon sampled for nitrates.

Common sources of nitrate contamination include faulty septic systems, agricultural fertilizers, animal wastes, municipal wastes, and dairy operations. Nitrogen can be present in the soil in many forms including nitrogen, ammonia, ammonium ion, urea, nitrates, and incorporated into organic matter. Depending on soil and plant conditions (and other factors), nitrogen cycles between its various forms. Nitrate nitrogen is the most mobile form of nitrogen. Therefore, excess nitrogen as nitrates has the greatest potential to move through the soil profile with infiltrating water and contaminate groundwater. Compared to pesticides, nitrates are usually present in the soil at much higher levels, are more persistent, are very soluble in water, and do not bind to soil. Consequently, wells with detectable nitrates indicate the potential for pesticide contamination. However, even when nitrates are detected in groundwater, the likelihood of groundwater contamination is still low for many pesticides. This is due to a number of factors including physical or chemical properties that result in low persistence and mobility in soil, lower application rates, as well as methods of application and timing and frequency of application.

Nitrate concentrations are greatest where aquifer permeability is greatest. Groundwater in aquifers with low permeability tends to be older, and because nitrogen fertilizer application rates have increased in recent decades, older groundwater would be expected to contain lower nitrate concentrations. Irrigation promotes ground water contamination by nitrates, but this may also reflect a tendency for irrigated crops to be treated with high fertilizer rates. There is evidence that some