OREGON PESTICIDE USE REPORTING SYSTEM
Analytical Review

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IV. USABILITY OF PESTICIDE USE DATA

Ranking Usefulness of Data

The information provided from pesticide use reporting would have a wide range of uses in both the environmental and health sectors. The quality and ultimate utility of the data should determine what data comes to be collected. Provided below are four separate matrices for each reporting category (agriculture, urban commercial non-agriculture, other commercial non-agriculture and public applications) (Tables 9-12), with a ranking (most useful, useful, less useful, not useful) for 10 areas of investigation, as well as the usefulness in data management, assuring data quality, and assessing trends. We have also included a full discussion of each program and areas of research that would benefit from the information provided by a state-wide pesticide use reporting system. These include:

Integrated Pest Management
Water Quality
Drinking Water
Fish and Wildlife
Human Epidemiology
Risk Assessment
Public Health
Worker Health and Safety
Food Quality Protection Act

Within each of these individual discussions, there is a summary that evaluates the usability of each of the data points considered for pesticide use reporting

Table 9. Ranking of the usefulness of data potentially collected from the Agriculture & Forestry (commercial and private) reporting category.

	Data Usability											
Reporting fields	Water	Drinking	Fish &		Human	Public	Risk		Worker	Data	Data	
REQUIRED	Quality	Water	Wildlife	IPM	Epi	Health	Assessment	FQPA	H&S/WPS	Quality	Management	Trends
Location												
Street	3	3	3	3	3	3	3	3	3	3	3	3
City	2	2	2	2	2	2	2	2	2	3	2	2
County	1	1	1	1	1	2	1	1	1	3	1	1
Zip Code	2	2	2	2	2	2	2	2	2	3	2	2
1/4 Section	3	3	3	3	3	3	3	3	3	3	3	3
Section	2	2	2	2	2	2	2	2	2	3	2	2
Range	1	1	1	1	1	1	1	1	1	3	1	1
Watershed*	3	3	3	3	1	3	3	3	1	2	3	3
Product and site												
Product Name	3	3	3	3	3	3	3	3	3	3	3	3
EPA Registration #	3	3	3	3	3	3	3	3	3	3	3	3
Quantity of Product applied	3	3	3	3	3	3	3	3	3	3	3	3
Site/Crop	3	3	3	3	2	3	3	3	3	3	3	3
Pest (Purpose)	3	3	3	3	1	3	3	3	3	3	3	3
Month of Application	2	2	2	3	2	2	2	3	2	3	2	2
Frequency of Reporting												
7 days Post application	2	1	2	3	1	2	2	2	3	2	1	1
Month Post application	3	2	2	3	2	2	2	2	2	2	2	1
Quarterly	3	3	2	2	2	3	2	2	2	2	2	2
Annual	2	3	3	2	3	2	3	3	2	1	1	1
Other Fields												
Date of Application	3	3	3	3	3	3	3	3	3	3	3	3
Time of Application	1	1	2	2	1	1	2	2	2	2	2	2
Units	3	3	3	3	3	3	3	3	3	3	3	3
Adjuvants and Additives	2	2	2	2	2	2	2	2	2	2	2	2
Application rate	3	3	3	3	2	2	3	3	2	3	3	3
Use Dilution	2	2	2	3	2	2	2	2	2	1	1	1
# Acres Planted	3	3	2	3	1	1	2	3	2	1	1	2
# Area Treated (acres or sq ft)	3	3	3	3	2	2	2	3	3	3	3	3
Application Method (type)	2	2	2	3	3	2	2	2	3	2	2	2
Application Equip	1	1	1	3	3	2	1	1	3	1	1	1

Table 9. Continued.

	Water Quality	Drinking Water	Fish & Wildlife	IPM	Human Epi	Public Health	Risk Assessment	FQPA	Worker H&S/WPS	Data Quality	Data Management	Trends
Business Name	3	3	3	3	3	3	3	3	3	3	3	3
License Number	3	3	3	1	3	3	3	3	3	3	3	3
Month/Yr of Reporting	3	3	3	1	3	3	3	3	3	3	3	3
Applicator Name	2	2	2	2	2	2	1	2	3	3	3	2
Applicator License #	3	3	3	1	2	2	1	2	3	3	3	3
Business Phone Number	3	3	3	3	2	2	2	3	3	3	3	3
Other Requested Fields												
Weather Conditions	2	2	2	3	2	2	2	1	2	0	1	2
Neighbor Notification	1	1	0	1	1	2	1	1	0	0	1	1
Protective Equipment	1	1	0	1	2	2	1	2	3	0	1	1
Nearby wells	2	3	0	3	3	3	2	2	2	0	1	2
Nearby Sensitive areas (water, wetlands, schools)	3	3	3	3	3	3	3	3	2	0	1	3
Disposal Methods	2	2	1	2	1	3	2	3	2	0	1	2
Harvest Date (Preharvest Interval)	0	0	0	3	2	3	2	3	2	0	1	2
Active Ingredient	3	3	3	3	3	3	3	3	3	3	1	3
Water application	3	3	3	3	2	3	3	3	1	0	1	1
Reentry					2	3	2					
	Most useful	3										
	Useful	2										
	Least useful	1										
	Not useful	0										

Table 10. Ranking of the usefulness of data potentially collected from the Commercial Urban (PCO and ornamental) reporting category.

Reporting fields	Data Usability											
	Water	Drinking	Fish &		Human	Public	Risk		Worker	Data	Data	
REQUIRED	Quality	Water	Wildlife	IPM	Epi	Health	Assessment	FQPA	H&S/WPS	Quality	Management	Trends
Location												
Street	3	3	3	3	3	3	3	3	3	3	3	3
City	2	2	2	2	2	2	2	2	2	3	2	2
County	1	1	1	1	1	2	1	1	1	3	1	1
Zip Code	2	2	2	2	2	2	2	2	2	3	2	2
1/4 Section	0	0	0	0	0	0	0	0	0	0	0	0
Section	0	0	0	0	0	0	0	0	0	0	0	0
Range	0	0	0	0	0	0	0	0	0	0	0	0
Watershed*	3	3	3	3	1	3	3	3	1	2	3	3
Product and site												
Product Name	3	3	3	3	3	3	3	3	3	3	3	3
EPA Registration #	3	3	3	3	3	3	3	3	3	3	3	3
Quantity of Product applied	3	3	3	3	3	3	3	3	3	3	3	3
Site/Crop	3	3	3	3	3	3	3	3	3	3	3	3
Pest (Purpose)	3	3	3	3	2	3	3	3	3	3	3	3
Month of Application	2	2	2	3	3	2	2	3	2	3	2	2
Frequency of Reporting												
7 days Post application	2	1	2	3	1	2	2	2	3	2	1	1
Month Post application	2	2	2	3	2	2	2	2	2	2	1	1
Quarterly	2	3	2	2	2	3	2	2	2	2	2	2
Annual	3	3	3	2	3	2	3	3	2	1	1	1
Other Fields												
Date of Application	3	3	3	3	3	3	3	3	3	3	3	3
Time of Application	1	1	2	2	1	1	2	2	3	2	2	2
Units	3	3	3	3	2	2	3	3	3	3	3	3
Adjuvants and Additives	2	2	2	2	2	2	2	2	2	2	2	2
Application rate	3	3	3	3	2	2	3	3	2	3	3	3
Use Dilution	2	2	2	3	2	2	2	2	3	1	1	1
# Acres Planted	3	3	2	3	1	2	2	3	2	1	1	2
# Area Treated (acres or sq ft)	3	3	3	3	2	2	2	3	3	3	3	3
Application Method (type)	2	2	2	3	2	2	2	2	3	2	2	2

Table 10. Continued.

	Water Quality	Drinking Water	Fish & Wildlife	IPM	Human Epi	Public Health	Risk Assessment	FQPA	Worker H&S/WPS	Data Quality	Data Management	Trends
Application Equip	1	1	1	3	2	2	1	1	3	1	1	1
Business Name	3	3	3	3	3	3	3	3	3	3	3	3
License Number	3	3	3	1	3	3	3	3	3	3	3	3
Month/Yr of Reporting	3	3	3	1	3	3	3	3	3	3	3	3
Applicator Name	2	2	2	2	2	2	1	2	3	2	2	2
Applicator License #	3	3	3	1	2	2	1	3	3	3	3	3
Business Phone Number	3	3	3	3	2	2	2	3	3	3	3	3
Other Requested Fields												
Weather Conditions	2	2	2	3	2	2	2	1	2	0	1	2
Neighbor Notification	0	0	0	1	1	2	1	1	1	0	1	1
Protective Equipment	0	0	0	1	2	2	1	2	3	0	1	1
Nearby wells	2	3	0	3	3	3	2	2	2	0	1	2
Nearby Sensitive areas (water, wetlands, schools)	3	2	3	3	3	3	3	3	2	0	1	3
Disposal Methods	2	2	1	2	1	3	2	3	2	0	1	2
Harvest Date (Preharvest Interval)	0	0	1	3	2	3	2	3	2	0	1	2
Active Ingredient	3	3	3	3	3	3	3	3	3	3	1	3
Water application	3	3	3	3	2	3	3	3	1	0	1	1
Reentry					2	3						
	Most useful	3										
	Useful	2										
	Least useful	1										
	Not useful	0										

Table 11. Ranking of the usefulness of data potentially collected from the Commercial other (ROW, industrial) reporting category.

Reporting fields	Data Usability											
	Water	Drinking	Fish &		Human	Public	Risk		Worker	Data	Data	
REQUIRED	Quality	Water	Wildlife	IPM	Epi	Health	Assessment	FQPA	H&S/WPS	Quality	Management	Trends
Location												
Street	3	3	3	3	3	3	3	3	3	3	3	3
City	2	2	2	2	2	2	2	2	2	3	2	2
County	1	1	1	1	1	2	1	1	1	3	1	1
Zip Code	2	2	2	2	2	2	2	2	2	3	2	2
1/4 Section	3	3	3	3	3	3	3	3	3	3	3	3
Section	2	2	2	2	2	2	2	2	2	3	2	2
Range	1	1	1	1	1	1	1	1	1	3	1	1
Watershed	3	3	3	3	3	3	3	3	1	2	3	3
Product and site												
Product Name	3	3	3	3	3	3	3	3	3	3	3	3
EPA Registration #	3	3	3	3	3	3	3	3	3	3	3	3
Quantity of Product applied	3	3	3	3	3	3	3	3	3	3	3	3
Site/Crop	3	3	3	3	2	3	3	3	3	3	3	3
Pest (Purpose)	3	3	3	3	2	3	3	3	3	3	3	3
Month of Application	2	2	2	3	3	3	2	3	2	3	2	2
Frequency of Reporting												
7 days Post application	2	1	2	3	1	2	2	2	3	2	1	1
Month Post application	2	2	2	3	2	2	2	2	2	2	1	1
Quarterly	2	3	2	2	2	3	2	2	2	2	2	2
Annual	3	3	3	2	3	3	3	3	2	1	1	1
Other Fields												
Date of Application	3	3	3	3	3	3	3	3	3	3	3	3
Time of Application	1	1	2	2	1	1	2	2	2	2	2	2
Units	3	3	3	3	3	3	3	3	3	3	3	3
Adjuvants and Additives	2	2	2	2	2	2	2	2	3	2	2	2
Application rate	3	3	3	3	2	2	3	3	3	3	3	3
Use Dilution	2	2	2	3	2	2	2	2	3	1	1	1
# Acres Planted	3	3	2	3	1	2	2	3	2	1	1	2
# Area Treated (acres or sq ft)	3	3	3	3	2	2	2	3	3	3	3	3
Application Method (type)	2	2	2	3	3	2	2	2	2	2	2	2
Application Equip	1	1	1	3	3	2	1	1	2	1	1	1

Table 11. Continued.

	Water Quality	Drinking Water	Fish & Wildlife	IPM	Human Epi	Public Health	Risk Assessment	FQPA	Worker H&S/WPS	Data Quality	Data Management	Trends
Business Name	3	3	3	3	3	3	3	3	3	3	3	3
License Number	3	3	3	1	3	3	3	3	3	3	3	3
Month/Yr of Reporting	3	3	3	1	3	3	3	3	3	3	3	3
Applicator Name	2	2	2	2	2	2	1	2	3	2	2	2
Applicator License #	3	3	3	1	2	2	1	3	3	3	3	3
Business Phone Number	3	3	3	3	2	2	2	3	3	3	3	3
Other Requested Fields												
Weather Conditions	2	2	2	3	2	2	2	1	2	0	1	2
Neighbor Notification	1	1	0	1	1	2	1	1	1	0	1	1
Protective Equipment	1	1	0	1	2	2	1	2	3	0	1	1
Nearby wells	2	2	0	3	3	3	2	2	2	0	1	2
Nearby Sensitive areas (water, wetlands, schools)	3	2	3	3	3	3	3	3	2	0	1	3
Disposal Methods	2	2	1	2	1	3	2	3	2	0	1	2
Harvest Date (Preharvest Interval)	2	1	1	3	1	2	2	3	2	0	1	2
Active Ingredient	3	3	3	3	3	3	3	3	3	3	1	3
Water application	3	3	3	3	2	3	3	3	1	0	1	1
Reentry?					2	2	3	3	3			
	Most useful	3										
	Useful	2										
	Least useful	1										
	Not useful	0										

Table 12. Ranking of the usefulness of data potentially collected from Public (Schools, parks) reporting category.

Reporting fields	Data Usability											
	Water	Drinking	Fish &		Human	Public	Risk		Worker	Data	Data	
REQUIRED	Quality	Water	Wildlife	IPM	Epi	Health	Assessment	FQPA	H&S/WPS	Quality	Management	Trends
Location												
Street	3	3	3	3	3	3	3	3	3	3	3	3
City	2	2	2	2	2	2	2	2	2	3	2	2
County	1	1	1	1	1	2	1	1	1	3	1	1
Zip Code	2	2	2	2	2	2	2	2	2	3	2	2
1/4 Section	3	3	3	3	3	3	3	3	3	3	3	3
Section	2	2	2	2	2	2	2	2	2	3	2	2
Range	1	1	1	1	1	1	1	1	1	3	1	1
Watershed*	3	3	3	3	1	3	3	3	1	2	3	3
Product and site												
Product Name	3	3	3	3	3	3	3	3	3	3	3	3
EPA Registration #	3	3	3	3	3	3	3	3	3	3	3	3
Quantity of Product applied	3	3	3	3	3	3	3	3	3	3	3	3
Site/Crop	3	3	3	3	3	2	3	3	3	3	3	3
Pest (Purpose)	3	3	3	3	1	2	3	3	3	3	3	3
Month of Application	2	2	2	3	2	3	2	3	2	3	2	2
Frequency of Reporting												
7 days Post application	2	1	2	3	1	2	2	2	3	2	1	1
Month Post application	2	2	2	3	2	2	2	2	2	2	1	1
Quarterly	2	3	2	2	2	3	2	2	2	2	2	2
Annual	3	3	3	2	3	3	3	3	2	1	1	1
Other Fields												
Date of Application	3	3	3	3	3	3	3	3	3	3	3	3
Time of Application	1	1	2	2	1	1	2	2	2	2	2	2
Units	3	3	3	3	3	3	3	3	3	3	3	3
Adjuvants and Additives	2	2	2	2	2	2	2	2	2	2	2	2
Application rate	3	3	3	3	2	2	3	3	2	3	3	3
Use Dilution	2	2	2	3	2	2	2	2	2	1	1	1
# Acres Planted	3	3	2	3	1	2	2	3	2	1	1	2
# Area Treated (acres or sq ft)	3	3	3	3	2	2	2	3	3	3	3	3
Application Method (type)	2	2	2	3	3	2	2	2	2	2	2	2
Application Equip	1	1	1	3	3	2	1	1	2	1	1	1

Table 12. Continued.

	Water Quality	Drinking Water	Fish & Wildlife	IPM	Human Epi	Public Health	Risk Assessment	FQPA	Worker H&S/WPS	Data Quality	Data Management	Trends
Business Name	3	3	3	3	3	3	3	3	3	3	3	3
License Number	3	3	3	1	3	3	3	3	3	3	3	3
Month/Yr of Reporting	3	3	3	1	3	3	3	3	3	3	3	3
Applicator Name	2	2	2	2	2	2	2	2	3	2	2	2
Applicator License #	3	3	3	1	2	2	2	3	3	3	3	3
Business Phone Number	3	3	3	3	2	2	2	3	3	3	3	3
Other Requested Fields												
Weather Conditions	2	2	2	3	2	2	2	1	2	0	1	2
Neighbor Notification	0	0	0	1	1	2	1	1	1	0	1	1
Protective Equipment	0	0	0	1	2	2	1	2	3	0	1	1
Nearby wells	2	3	0	3	3	3	2	2	2	0	1	2
Nearby Sensitive areas (water, wetlands, schools)	3	2	3	3	3	3	3	3	2	0	1	3
Disposal Methods	2	2	1	2	1	3	2	3	2	0	1	2
Harvest Date (Preharvest Interval)	0	0	1	3	2	2	2	3	2	0	1	2
Active Ingredient	3	3	3	3	3	3	3	3	3	3	1	3
Water application	3	3	3	3	2	3	3	3	1	0	1	1
Reentry?					2	2						
	Most useful	3										
	Useful	2										
	Least useful	1										
	Not useful	0										

Integrated Pest Management (IPM)

Economically and environmentally sustainable pest management requires an integrated approach. Pesticides are one of many tools used in integrated pest management. Judicious use of pesticides demands practical knowledge of their fate and effects in urban and agricultural settings, and natural ecosystems. This knowledge is required for the advancement of science-based management strategies that prevent or mitigate unacceptable adverse impacts on human and environmental health.

Pesticides are initially distributed in the environment at application, with the intent of maximizing efficacy while minimizing off-site movement and adverse impacts on human and environmental health. The Food Quality Protection Act (FQPA) has de-emphasized efficacy and set stricter standards for acceptable risks to human and environmental health. Consequently, a better understanding of initial distribution and redistribution via processes such as airborne loss, run-off and leaching is necessary to characterize both human occupational and non-occupational exposure, and assess risks to biota in surrounding ecosystems. Understanding the initial distribution in the environment at the landscape scale (watershed, county) requires information on pesticide use practices.

Responsible use of soil, air and water resources for the production of food, feed and fiber, and other human endeavors, must be balanced with the need to minimize impacts on human health, and preserve ecosystems and the biodiversity they support. As pesticides remain a cornerstone of pest management in the U.S., there is a continuing need to critically evaluate use practices in assessing risk and in the development of mitigation strategies. Research is needed to provide a mechanistic understanding of fate and effects, beginning at the molecular level, and including systems analysis at the landscape scale. Such efforts will allow to a greater degree science-based decision making as a foundation for policy regarding the use of pesticides in the U. S.

Human endeavors that require pest management need a variety of sustainable options tailored to each situation and setting. In this context, human and ecological risks associated with the use of pesticides in pest management will continue to be re-evaluated. The adoption of more refined risk assessment and risk management strategies by state and federal regulatory agencies has resulted in more general recognition of the reality of unintentional and unavoidable pesticide exposures.

Accurate estimation of the extent of human and wildlife pesticide exposure is critical to evaluation of food safety, water quality, work practices, handling and application technologies, and strategies to reduce or minimize exposure. In many cases direct measurement of pesticide exposure is not feasible or practical, and we must rely on exposure estimates. Detailed and accurate information on pesticide use practices can provide information appropriate for risk assessments that rely on exposure estimates.

Required Data Fields

U.S. EPA Registration Number. This number indicates that the product is registered in the U.S. and is useful in identifying pesticides with ambiguous product names. The standardization provided by this field also allows linkage to product databases maintained by EPA and others.

Product Name. The product name is used to reference product label information required by law. In addition to the product name, the label will provide specific information on product identity, chemical composition, and recommended use, including types of crops or sites, target pests, and rate, timing, and frequency of application.

Quantity Applied. This data item will provide information on the amount of material applied. The data is useful in combination with Product Name to define the amount of active ingredient released into the environment.

Location. Reporting of applications at specific addresses or other location ID will provide maximum flexibility in aggregating data to higher levels (county, watershed, eco-region) for describing use patterns by geographic area. This information will be useful in understanding pest pressure and developing IPM strategies.

Purpose of Application. IPM is based on integrating a variety of tactics for pest control, and only using pesticides when needed. To meet this objective, identifying the purpose of the application is critical. Many IPM strategies are based on the concept of an "economic threshold," an amount of pest damage that below which pest control may not be necessary.

Treated Area Size. This data item is useful in understanding the extent of pesticide use within the application site, or on a county, regional, or watershed scale. In the absence of rate information, treated area size, together with quantity applied, can be used to determine application rate. As pests often do not recognize field boundaries, IPM strategies often rely on control tactics that are implemented in concert on more than one treatment site. Together with *acres planted*, information on the size of the area treated is useful in both area wide IPM strategies and also in resistance management. In addition, IPM strives to reduce environmental impacts. The size of the treated area is useful in understanding the extent of pesticide use as a measure of potential environmental impacts.

Reporting Frequency. The interval between use and reporting to the central database has relevance to in terms of data accuracy. Of greatest concern is the increased potential for reporting recall bias (errors in reporting associated with long periods between pesticide application and reporting) if submission of forms is required quarterly or yearly.

Other Candidate Data Fields

Name of Applicator. This data item may be useful in targeting individuals for educational outreach and other information services.

License/Certification Number of Applicator. This data item is most useful in data validation and quality assurance.

Date and Time of Application. Application date is useful in understanding pesticide application relative to pest pressure. For example, for a number of crops, pest emergence in the spring can often be predicted by heating degree days. Understanding general use practices relative to predicted pest emergence will help fine tune IPM strategies. Some IPM strategies require that pesticide applications are made on a diurnal basis, i.e., early morning or at night. In addition pesticide application may be timed with other crop production practices, such as irrigation.

Application Rate or Amount of Material/Solution Applied. This data item is potentially relevant to the understanding of the initial distribution of the pesticide. IPM strategies that use pesticides at reduced rates should be identified. The amount and type of diluant may also be optimized to deliver to pesticide to the target site while minimizing impacts on beneficial and non-target species. The amount and type of diluant can also determine pesticide distribution between foliage and soil which can influence soil leaching and loss with runoff.

Application Method. Application method can determine both efficacy and the potential for environmental impacts, both are important to the development and evaluation of IPM strategies.

Name of Carrier and Adjuvants. The tank mix, including the pesticide product, carrier, adjuvants and additives (buffers, spreaders, stickers, drift retardants) can greatly influence efficacy of the product and environmental impacts, both are important to the development and evaluation of IPM strategies.

Water Quality

Drinking Water

Oregon Health Division (OHD) Drinking Water Monitoring Program

Prior to 1981, the EPA staffed an Oregon office to implement the original federal Safe Drinking Water Act (SDWA). In 1981, the Oregon Legislative Assembly created the Oregon Drinking Water Program when it passed the Oregon Drinking Water Quality Act (ORS 448). Included in the Act is the requirement that the state develop and enforce drinking water quality standards. In 1986, the SDWA gave the Health Division primary responsibility (primacy) for Oregon’s activities under the SDWA, making the Division solely responsible for administering both state and federal drinking water regulations. States may develop their own drinking water standards, provided these standards are no less stringent than federal standards. The goal of the Oregon Drinking Water Program is to “assure all Oregonians safe drinking water.”

1. Oregon Public Water Systems

Oregon has over 3,550 public water systems, most of which serve very small communities. Of these systems, approximately 375 use surface water and 3,175 use groundwater. Public water systems may be classified as community, noncommunity, transient, nontransient, or state regulated. Community water systems provide water to 15 or more service connections or 25 or more year-round residents. They include cities, water districts, mobile home parks, water associations, and rural subdivisions. Nontransient-noncommunity systems do not serve residential populations, but they regularly serve at least 25 of the same people during 6 months a year or more. Examples include schools and factories. Transient-noncommunity systems serve transient populations of at least 25 people per day for at least 60 days per year. Examples include parks, campgrounds, motels, highway rest areas, and stores. State-regulated systems are those systems that are too small to be covered by federal laws. In Oregon, state-regulated systems provide 3-15 service connections or serve 10-25 year-round residents. Examples include small mobile-home parks, rural residential systems, and small subdivisions.

The SWDA requires that community and non-transient systems test for pesticides. Most Oregon public water systems are small and lack the financial resources, treatment facilities, and technical and managerial expertise necessary to comply with all state and federal standards. Many systems rely on part-time or even volunteer system operators and may not be adequately maintained. Oregon Drinking Water Program staff typically work with larger systems first and address smaller systems as resources allow. This allows them to maximize the number of people served within their budget constraints. Many 1997 SDWA amendments are aimed at easing the financial burdens of small systems by increasing the flexibility of and resources available to smaller systems. Pesticide-use estimates are included in this report to help small communities tailor their groundwater testing to pesticides used in their areas.

OHD requires the analysis of approximately 30 pesticides as stipulated under the SDWA. OHD maintains a database of monitoring results. Between 1991 and 1996, 16,383 pesticide analyses were performed by 402 public systems that rely primarily on groundwater as their source of drinking water. Pesticide use data will allow for more focused monitoring by community and non-transient systems in Oregon and may suggest analysis of additional pesticides in areas of high use for which testing is not currently required.

2. Oregon’s Drinking Water Protection Program

One of the best ways to ensure safe drinking water is to develop a plan designed to protect against any potential contamination problem. The 1986 Amendments to the federal Safe Drinking Water Act required that each state develop a wellhead protection program. A wellhead-protection area is defined as "the surface or subsurface area surrounding a water well or wellfield, supplying a public water system, through which contaminants are reasonably likely to move toward and reach such water well or wellfield." Oregon developed a voluntary wellhead protection program for public water supplies. The US EPA granted formal approval of this program in 1996.

Also in 1996, new amendments to the federal Safe Drinking Water Act provided opportunities for Oregon to expand the drinking water protection program to incorporate protection of surface water sources in addition to groundwater sources of public water supplies. These 1996 amendments provided resources for source water assessment and protection. The process for assessment and protection involves delineate the area that serves as the source of the public water supply, inventory the potential risks or sources of contamination, determine the areas most susceptible to contamination, assemble a local "Drinking Water Protection team," develop a plan to protect the supply, develop a contingency plan to address the potential loss of the system, and certify (optional) and implement the "Drinking Water Protection Plan." This approach allows for the local development of site-specific management plans and, thereby, lowers the costs associated with water quality monitoring requirements. The Department of Environmental Quality and the Oregon Health Division are the two Oregon agencies responsible for implementing the Drinking Water Protection Program and assisting local communities in the development of Drinking Water Protection Plans.

<u>DEQ implementation of the Clean Water Act</u>

The Clean Water Act (CWA) is the primary legislation responsible for protecting the nation's waters. The Oregon Department of Environmental Quality is the lead agency for carrying out both federal and state water quality programs under the Clean Water Act and under the State Water Quality Statutes and Administrative Rules. Section 305(B) of the Clean Water Act directs DEQ to report water quality findings to EPA every two years. (Those interested in an overview of water quality in the state should consult DEQ's Biennial Water Quality Status Report or 305(b) Report.)

The Oregon Department of Agriculture laboratory in Salem typically performs the laboratory analyses for pesticide residues in DEQ monitoring activities.

DEQ conducts four types of groundwater studies: reconnaissance surveys, intensive investigations, trending networks, and aquifer characterization studies. Reconnaissance surveys are conducted in areas where there is a paucity of groundwater quality data and where DEQ has concerns about potential problems. Intensive investigations are large-scale studies designed to gain a complete understanding of the extent and nature of groundwater contamination. Other trending studies are groundwater monitoring efforts in areas where intensive studies have been performed in the past. They are designed to track water quality over time. Aquifer Characterization Studies are performed cooperatively with the Oregon DEQ to characterize the hydrogeology of various regions of the state.

Groundwater in Oregon

Oregon groundwater is an important source of water for drinking, irrigation, and industry. Groundwater is also important as the source of base flow for most rivers, streams, wetlands, and lakes. Approximately 89% of Oregon's public drinking water systems rely on groundwater for permanent or emergency drinking water sources. Half of the state's population depends on groundwater for their daily needs (Oregon Health Division, Drinking Water Program. February 1996. Public Water Supply Database). Oregonians use approximately 860 million gallons of groundwater per day. The demand for groundwater has doubled in the past 20 years (Water Resources Department, December 1996. Well Record Database). Researchers anticipate that Oregon's population growth will result in a continued increase in water demand and consumption. It is imperative that pesticide-use practices in Oregon are protective of water resources. Once groundwater is contaminated, it is difficult to remediate. That is why EPA and state initiatives focus on *preventing* pesticide contamination.

United States Geological Survey (USGS)

1. National Water-Quality Assessment

The National Water-Quality Assessment (NAWQA) Program of the U.S. Geological Survey is charged with (1) describing the status and trends in water quality of large, representative portions of the nation's water resources; and (2) increasing knowledge of the natural and anthropogenic factors that affect the quality and quantity of water resources. USGS laboratories are well positioned to conduct technically challenging water quality studies. The analytical equipment and expertise that support the NAWQA Program are state-of-the-art and give the program the ability to routinely detect pesticides at considerably lower levels than what is achievable by state regulatory agencies and most private analytical laboratories.

2. USGS Projects in Oregon

The Willamette Basin is one of 60 NAWQA study units in the United States. The project has both surface water and groundwater components. As part of the Willamette Basin study, researchers sampled groundwater for pesticides and other contaminants between 1993 and 1995. The study focused on shallow groundwater (<25 meters) in alluvial aquifers of the Basin. Shallow groundwater from the alluvium is more vulnerable to contamination from human activities than deeper groundwater. Shallow alluvial groundwater is an important resource that represents 80% of the groundwater pumped in the Willamette (Hinkle, 1997).

The groundwater study was designed to investigate regional and urban groundwater quality. An intensive Study-Unit Survey (Hinkle, 1997) was conducted between June and August, 1993 and focused on groundwater quality in shallow groundwater under Willamette Basin agricultural lands. The Study-Unit Survey chose 70 domestic wells via a grid-based, random selection process. All wells were less than 25 meters deep, with a median depth of 18 meters. The median depth of penetration of wells below the water table was 12 meters. The median penetration depth of wells below the open interval below the water table was 9 meters. A small-scale urban land-use study (Hinkle, 1997) conducted in 1995 focused on shallow alluvial groundwater in the Portland metropolitan area. Ten shallow Portland area wells were installed in alluvial aquifers. Well drilling locations were chosen non-randomly in older neighborhoods to represent residential land use. Anderson et al. (1996) report the occurrence of selected trace elements and organic compounds (including pesticides) in surface water and their relation to land use in the Willamette Basin. USGS has plans to do further research in the Willamette NAQWA. More accurate pesticide use data coupled with land use practices has the potential to greatly enhance their evaluation of the relevance of monitoring results in relation to sources of pollution. Such information may be key to the development of best management practices to further reduce or prevent pesticide off-site movement into surface and ground water.

Pesticides in Oregon Surface Water. There has been no routine monitoring for pesticides in Oregon surface waters. However, from 1992 to 1994 USGS conducted Phase I and II of the Willamette Basin Study. The purpose, in part, was to define the relation of pesticides in water to land use activities to include: forested, agricultural, urban, mixed use. Water samples were collected from small tributaries of the Willamette River during the spring and fall. USGS collected 93 water samples from 39 locations. Samples were analyzed for 94 pesticides and metabolites. Forty-three pesticides or metabolites were detected. In 1996 USGS conducted Phase III, in which pesticides were monitored in small streams in 16 randomly selected agricultural and 4 urban sub-basins. The purpose of Phase III was to document excedance of water quality criteria, identify importance of upstream land use, and to assess seasonal effects. Ninety-five water samples analyzed for 86 pesticides. Thirty six pesticides were detected; usually < 1 ug/l (part per billion). USGS was limited in their ability to associate their findings with land use practices because the only source of pesticide use data was the 1987 survey conducted by Oregon State University. This data was based on estimates rather than full use reporting. Clearly, with more accurate and timely information on pesticide use, USGS scientists and others will be better equipped to (a) Identify the cause of water quality degradation; (b) implement watershed-scale improvement programs; (c) evaluate and monitor the efficacy of the improvement programs implemented; (d) assess the costs and benefits of water quality management practices that are developed; and (e) conduct evaluations closing the loop and improving our understanding of the drivers of water quality degradation.

Oregon's population depends equally on ground and surface water for daily consumption. However, there are signs that in the future, Oregon will increasingly rely on surface water as a source of drinking water. Recently, after careful consideration of alternatives, the city of Willsonville has decided to use treated Willamette water as a source of drinking water. The cities of Tigard and Sherwood have also considered the Willamette River as a source drinking water. During the decision making process, concerns regarding pesticides in the Willamette River were raised at a number of public meetings. As a result, a retrospective analysis of pesticide monitoring in the Willamette Basin and associated risks was provided to policy makers and the public. This type of evaluation, while useful at some level in predicting future risks, does not specifically address future upstream land use practices that may effect the quality of raw river water. Only with detailed information on land use practices and associated pesticide use practices can future trajectories and rates of change be predicted, along with associated uncertainties. Pesticide use information is also useful in focusing future monitoring efforts, and identifying data, information and research needed to reduce future uncertainties.

Required Data Fields

U.S. EPA Registration Number. This number indicates that the product is registered in the U.S. and is useful in identifying pesticides with ambiguous product names. The standardization provided by this field also allows linkage to product databases maintained by EPA and others.

Product Name. The product name is used to reference product label information required by law. In addition to the product name, the label will provide specific information on product identity, chemical composition, and recommended use, including types of crops or sites, target pests, and rate, timing, and frequency of application.

Quantity Applied. This data item will provide information on the amount of material applied. The data is useful in combination with Product Name to define the amount of active ingredient released into the environment.

Location. Reporting of applications at specific addresses or other location ID will provide maximum flexibility in aggregating data to higher levels (county, watershed, Basin) for describing use patterns by geographic area. This information will be useful in understanding the application location relative to ground and surface water resources of concern.

Purpose of Application. Pesticides should not be introduced into the environment unless there is a benefit. Identifying the purpose for application will allow evaluation of economically viable alternative control strategies, while reducing risks of ground and surface water contamination.

Treated Area Size. This data item is useful in understanding the extent of pesticide use within the application site, or on a county, regional, or watershed scale. In the absence of rate information, treated area size, together with quantity applied, can be used to determine application rate. The size of the treated area is useful in understanding the extent of pesticide use as a measure of potential for ground and surface water contamination.

Reporting Frequency. The interval between use and reporting to the central database has relevance in terms of data accuracy. Of greatest concern is the increased potential for reporting recall bias (errors in reporting associated with long periods between pesticide application and reporting) if submission of forms is required quarterly or yearly.

<u>Other Candidate Data Fields</u>

Name of Applicator. This data item may be useful in targeting individuals for educational outreach and other information services on protecting ground and surface water resources.

License/Certification Number of Applicator. This data item is most useful in data validation and quality assurance.

Date and Time of Application. Application date is useful in understanding pesticide application relative to rainfall and other climatic conditions which may influence runoff into surface water or percolation to groundwater.

Application Rate or Amount of Material/Solution Applied. This data item is potentially relevant to the understanding of the initial distribution of the pesticide. For foliar applied pesticides, both rate and dilution will determine, in part, initial distribution to soil. Distribution between foliage and soil can influence soil leaching and loss with runoff.

Application Method. Application method can be critical to understanding the potential pesticide off-site movement to ground and surface water. Pesticides that are applied to, or injected into, the soil, such as pre-emergent herbicides, have a greater potential risk to groundwater as compared to pesticides that are applied to foliage, such as an airblast application to a grassed orchard.

Name of Carrier and Adjuvants. The tank mix, including the pesticide product, carrier, adjuvants and additives (buffers, spreaders, stickers, drift retardants) determines the efficacy of the product and environmental impacts, including the potential for ground and surface water contamination.

Fish and Wildlife

Fish and wildlife habitat can be divided into three landscape zones of interest: upland, riparian, and aquatic. In many of the Pacific Northwest eco-regions, species abundance and diversity is greatest in riparian and aquatic habitats, while pesticide applications occur primarily in the upland zone. Landscape features determine the proximity of application to riparian and aquatic habitats, and, in part, determine risk. Preventing pesticide contamination of ground and surface water has been a concern for many years. Recently, there has been increased interest in the Pacific Northwest regarding pesticide impacts on the riparian zone. Riparian zones are defined by Gregory et al. (1991) as three-dimensional area of direct interaction between terrestrial and aquatic ecosystems. Riparian zones are considered important habitats by biologist and regulators alike, and as such are regulated on private and state forest lands by the Oregon Forest Practices Act (Oregon '97). As described above, the majority of the regulations concerned with forest use pesticides are targeted at water quality issues, either from a wildlife, particularly fish, or a human health standpoint. However, stream banks or riparian zones are also important locations for assessment of chemical impacts.

In-stream communities have numerous links with, and requirements of, the adjacent terrestrial habitat (Vannote, '80, Gregory '91). These links include; alteration of the microclimate (light, temperature, humidity) (Gregory et al '91), changes in dissolved nutrients (Lickens & Bormann '95), deposition of allochthonous material (Harmon et al '86), deposition or erosion of soil and gravel (Harmon et al '86, Gregory '91), and service as a filter for sediments (Karr & Schosser '78), fertilizer runoff (Lowrance et al '84), and herbicides (Paterson & Schnoor '92, Lowrance et al '96). Aquatic–terrestrial interactions become more closely linked in lower order or ephemeral streams, common in a variety of Oregon watershed landscapes. As a result of increased shading and allochthonous input, reflected in a depression of the primary production / respiration ratio, a stream community has even greater dependence on the adjacent riparian zone in smaller streams than in larger ones (Vannote '80).

Terrestrial as well as aquatic impacts must also be assessed to address ecological impacts in streams. Recent reports concerning the distribution and feeding habits of several riparian organisms highlights the connectedness between aquatic and terrestrial ecosystems. In particular, almost all aquatic insects require terrestrial habitats during some stage of their life cycle, and the type and degree of this requirement has been used to suggest evolutionary relationships between taxa (Wallace & Anderson '96). More recently, trophic linkages between instream and terrestrial habitats have been realized (Meehan '96, Wipfli '97, Hering & Platcher '97), and are reviewed briefly below.

For example, in a 3-year study conducted on 8 different Oregan streams, Meehan ('96) found that Collembola accounted for 6.1% of the stomach contents on juvenile coho salmon (*Oncorhynchus kisutch*). In addition, that report described macroinvertebrate diversity found in various sampling techniques. Collembola account for less than 1% in drift or benthic samples, but over 30% of floating traps that only catch things falling into the stream. This indicates a terrestrial origin for the Collembola found in salmon stomachs. A similar study supporting this conclusion was conducted in small streams of old growth forests in Southeast Alaska. There, Wipfli ('97) found that 'terrestrial-derived' invertebrates were "equally important prey" as 'aquatic-derived invertebrates' in the diet of juvenile coho salmon, cutthroat trout (*Oncorhynchus clarki*), and Dolly Varden (*Salvelinus malma*). Thus, examination of riparian terrestrial arthropods can be informative in understanding the diet in-stream fishes such as salmon.

A higher diversity of species is suggested in riparian zones because of diverse habitats, unique microclimates, and frequent disturbance. In vegetation stands of Oregon's McKenzie river valley which range in age from recently harvested to old-growth, riparian communities contained approximately twice the number of species observed in upslope communities (Gregory et al '91). The increased abundance of most species in the riparian zone is supported by a 2-year pitfall trapping study of forest soil arthropods conducted by Moldenke et al ('97). They found that 49 of the 52 different arthropod species identified in the upslope areas, from both clear-cut and forested sites, were also found in the riparian zone. Furthermore, those 49 species in the riparian zone were all more abundant than in upslope regions.

Several families of ground beetles are known to inhabit streambanks. In particular, the carabid beetles show higher abundance in riparian zones (Thiele '77, Hering & Platchter '97). The higher humidity of riparian habitats prevented desiccation in sensitive egg and larval stages of a Bembidiini sp. (Coleoptera: Carabidae) (Andersen '85). In addition, tolerance to flooding has been suggested as one evolutionary adaptation of carabid beetles (Arens & Bauer '87). Arens and Bauer ('87) showed the Carabid beetle *Blethisa multipunctata* (L.) was capable of staying submerged for two hours and that they exploited a physical gill to increase oxygen exchange (Arens & Bauer '87). In a study of predation by ground beetles in a German alpine floodplain, Hering & Platcher ('97) found aquatic invertebrates from 34 to 89% of the potential prey items. Differences in abundance of food sources along the shoreline of small and large streams were correlated with surface drift (Hering & Platcher '97). Emerging aquatic insects and terrestrial immigration into the riparian zone were sources of the remaining prey items found in that study, but were not responsible for explaining the differences in abundance.

Thus, riparian zones are areas abundant with representatives of the overall wildlife community, sources of nutrients and food sources for stream organisms, and unique habitats with functions important in maintaining in-stream health and water quality. Pesticide use data coupled with information of the potential for off-site movement of the chemical components will allow more detailed assessment, on a landscape scale, of exposure potential to both fish and wildlife at the interface of treatment sites and natural environments.

<u>Required Data Fields</u>

U.S. EPA Registration Number. This number indicates that the product is registered in the U.S. and is useful in identifying pesticides with ambiguous product names. The standardization provided by this field also allows linkage to product databases maintained by EPA and others.

Product Name. The product name is used to reference product label information required by law. In addition to the product name, the label will provide specific information on product identity, chemical composition, and recommended use, including types of crops or sites, target pests, and rate, timing, and frequency of application.

Quantity Applied. This data item will provide information on the amount of material applied. The data is useful in combination with Product Name to define the amount of active ingredient released into the environment.

Location. Reporting of applications at specific addresses or other location ID will provide maximum flexibility in aggregating data to higher levels (county, watershed, Basin) for describing use patterns by geographic area. This information will be useful in understanding relative to fish and wildlife habitats of concern.

Purpose of Application. Pesticides should not be introduced into the environment unless there is a benefit. Identifying the purpose for application will allow evaluation of economically viable alternative control strategies, while reducing risks to fish and wildlife.

Treated Area size. This data item is useful in understanding the extent of pesticide use within the application site, or on a county, regional, or watershed scale. In the absence of rate information, treated area size, together with quantity applied, can be used to determine application rate. The size of the treated area is useful in understanding the extent of pesticide use as a measure of potential adverse impacts on fish and wildlife.

Reporting Frequency. The interval between use and reporting to the central database has relevance to in terms of data accuracy. Of greatest concern is the increased potential for reporting recall bias (errors in reporting associated with long periods between pesticide application and reporting) if submission of forms is required quarterly or yearly.

<u>Other Candidate Data Fields</u>

Name of Applicator. This data item may be useful in targeting individuals for educational outreach and other information services on protecting fish and wildlife, particularly threatened or endangered species.

License/Certification Number of Applicator. This data item is most useful in data validation and quality assurance.

Date and Time of Application. Application date is useful in understanding pesticide application relative to fish or wildlife behavior that may influence exposure potential. Exposure may be direct or through the food chain.

Application Rate or Amount of Material/Solution Applied. This data item is potentially relevant to the understanding of the initial distribution of the pesticide. For foliar applied pesticides, both rate and dilution will determine, in part, initial distribution to soil. Distribution between foliage and soil can influence soil leaching and loss with runoff. Runoff may result in off-site movement into riparian areas and surface water, resulting in an increased potential for fish and wildlife exposure.

Application Method. Application method can be critical to understanding the potential pesticide distribution in the environment, the potential for off-site movement, and fish and wildlife exposure potential. For example, pesticide granular applications that are incorporated into the soil are not available to avian species which feed at the soil surface. By contrast, pesticides that are applied to foliage, such as an airblast application to an orchard, may pose a greater risk to both avian species and surface dwelling beneficial and non-target organisms.

Name of Carrier and Adjuvants. The tank mix, including the pesticide product, carrier, adjuvants and additives (buffers, spreaders, stickers, drift retardants) determines the efficacy of the product and environmental impacts, including the potential for ground and surface water contamination. For example, off site movement due to drift may be reduced by the addition of a drift retardant, thereby reducing potential fish or wildlife exposure down wind.

Human Epidemiology

Purpose

It is anticipated that the major objective of most epidemiological studies using the data contained in the Pesticide Use Reporting System will be to determine the effect of exposure on disease occurrence in community or occupational groups. The purpose of this section is to introduce the principles of epidemiological study design and related methodological issues for evaluating potential causal relationships between exposure to pesticides and disease. More extensive presentations of epidemiological methods are available in several texts (Kleinbaum, Kupper, and Morgenstern 1982; Kelsey, Thompson, and Evans 1986; Steenland 1993; Steenland and Goldsmith 1996; Rothman and Greenland 1998). This section also presents several examples of ways that the Pesticide Use Reporting System could be used to support epidemiological research, and makes recommendations for the types of data elements needed.

General Problems in Epidemiology of Pesticides

There are several general problems in observational studies of the health effects associated with pesticides that tend to limit causal inference: rare diseases, long latent periods, low-level exposures, errors of exposure measurement, and small effects. These problems are not unique to pesticides, but rather are generic problems in environmental epidemiology (Goldsmith 1986). The features are important to delineate because they shape study design decisions.

Rare Diseases. The relatively low incidence of conditions such as cancers or Parkinson disease, make cohort designs (see next section) impractical because of the large numbers of subjects who must observed. Following large numbers of exposed and unexposed persons until diseases are diagnosed requires substantial effort and is expensive, and loss to follow-up may introduce error.

Long Latent Periods. The interval between exposure to chemicals, and the onset of symptoms or diagnosis of disease, may be many years or even decades. This latency may be attributed to a prolonged induction period, in which years are needed for physiological changes to develop to the point where function is impaired, symptoms are noticeable, and disease is detectable by medical technology. Long latent periods produce important practical constraints on an investigator's ability to measure exposures. In cohort study designs, subjects must be observed for many years, and in case-control designs the investigator must rely on historical records to measure exposure. Furthermore, the level of exposure to pesticides changes over time, thereby complicating the choice of exposure measures (long-term average exposure, short-term (peak) exposure).

Low Level Exposures. In the urban setting, exposures typically occur at low levels, making analysis of pesticides in air, water, soil, and food difficult. Further, measuring total exposure through the multiple pathways of inhalation, ingestion, and skin absorption can be difficult.

Errors in Exposure Measurement. A major objective in epidemiological studies is obtaining an accurate estimate of each individual's exposure to the agent under scrutiny. Often, this task is made very difficult by lack of information. In the case of pesticides, sources of exposure may be unknown, and exposure varies in frequency and magnitude over long periods of time. Many exposures are imperceptible, and any individual's recall of proximity of sources and the circumstances of exposure are imperfect. Reliable and specific biomarkers of exposure, such as metabolites in urine, are not available for most pesticides, and when available these indicators are usually impractical to obtain on large numbers of persons because of cost. Inaccuracies in the measurement of exposure causes bias in epidemiological studies, and loss of precision.

Small Effects. Often, the effects of most pesticide exposures are likely to be subtle. Therefore, epidemiological studies require large samples sizes to detect low relative risks and meet statistical objectives.

The problems listed above are not insurmountable, but they do present substantial challenges to epidemiologists. Systematic errors or bias must be avoided, as must random errors of estimation (chance).

The Basic Observational Designs

The basic designs in epidemiology may be classified as cohort, case-control, cross-sectional, and ecological designs.

Cohort Study Designs. In a cohort study, a sample of people is followed for the development of disease or illness and the exposures of individual subjects are monitored over the entire period of follow-up. If surveillance is prospective, classification of exposure and disease status can be complete and accurate. Retrospective designs are also possible, and involve the use of historical records and/or recall by subjects. In cohort designs, the measure of association between exposure to the agent of interest and the development of disease is the "relative risk", which is the ratio of the incidence of disease in the exposed group divided by the incidence of disease in the unexposed (less exposed) group. The major strengths of this design include the avoidance of selection bias because disease status cannot influence the selection of subjects. Also, the principle of this design ensures that exposure precedes the development of disease. Potential weaknesses associated with cohort designs include loss of subjects due to attrition (e.g., migration, death), and practical considerations of following large numbers of subjects to precisely characterize the incidence of rare diseases. Thus, cohort designs are most efficient when applied to common diseases with short induction periods. A prospective cohort study could use data from the Pesticide Use Reporting System to examine neurotoxic effects, such as learning disabilities in children. Chronic health effects, such as cancer could be performed using historical cohort designs that measured exposure over years to decades using data from the Pesticide Use Reporting System.

Case-Control Study Designs. Case-control designs are distinguished from other basic study designs by the sampling strategy used. All individuals with the disease of interest, the "cases", are identified in a specified population. From this same population, a sample of individuals who do not have the disease, the "controls", are selected. In case-control designs, exposure is generally measured retrospectively to account for the disease latency. Historical records or recall information is used to classify exposure status, such as infomration from the pesticide use reporting database.The measure of association in the case-control design is the odds ratio, which is the odds of exposure in the cases divided by the odds of exposure in the controls. The case-control design is efficient for studying rare diseases and diseases with long latency, such as cancer. However, this design is susceptible to bias associated with the selection of controls, if the base population cannot be defined. Information bias, particularly recall bias, may also occur in case-control designs.

Cross-Sectional Design. In a cross-sectional study, the prevalence of disease in a specified population is ascertained at one point in time, and exposure in the sample is ascertained from current status or retrospectively. The statistical analysis of cross-sectional data resembles the analysis of cohort and case-control data, and disease prevalence is compared between exposure groups or the prevalence odds of exposure are compared among persons with and without the disease of interest. Cross-sectional designs are less expensive than cohort studies because there is no follow-up. The design is useful for screening hypotheses but has limited capability to provide strong causal inference because the method cannot determine that exposure (or accumulation of exposure) occurred before disease occurrence because the duration of disease in prevalent cases is not ascertained.

Ecological Designs. Studies that use population or aggregate level data to examine the relationship between disease occurrence and exposure level are termed "ecological" studies. In this type of analysis, the disease rate and average exposure level or distribution are known at the level of a group, but not at the level of individuals. The joint distribution of exposure and disease in the population is not known, therefore it is not possible to estimate causal relationships with confidence. This methodological limitation is commonly termed the "ecological fallacy". Bias in the estimated or the true effect at the individual level may be caused by measured risk factors in groups, and if risk factors and effect modifiers are distributed unequally among the groups. In ecological designs, it is always possible that an individual's group affiliation has an effect on disease occurrence that reflects more than simply the individual's exposure status. Despite these limitations, ecological designs are frequently used because of the lack of resources to accurately measure environmental exposures in populations. It is possible to reduce ecological bias by selecting areas that minimize within-region exposure variation and maximize between-region variation. These goals are often achieved by using the smallest unit of analysis for which the required data are available (e.g., census tracts or blocks). This strategy of using smaller area units may not provide perfect homogeneity of exposure, and the use of smaller groups might increase the problem of migration between areas. Statistical adjustment for other known determinants of disease (e.g., smoking, degree of urbanization, movement between exposure areas) is often performed in an attempt to reduce ecological bias, however, the joint distribution of covariates with the exposure and disease are often not known, and substantial bias can occur even with these adjustments in ecological models. Several types of ecological designs could be applied to pesticide and health data, and include exploratory studies of spatial and temporal patterns, time-trend analysis, and space-time cluster studies.

Application to Epidemiology

House Bill 3602 requires that the Pesticide Use Reporting system collect, at minimum, the following information:

- U.S. EPA Registration Number
- Product Name
- Quantity Applied
- Location
- Reporting Frequency (at least annual)
- Purpose of Application
- Type of application

Other information about the circumstances of use that are under consideration for inclusion in the reporting system include:

- Date and time of application
- Name of the person who applied the pesticide
- The License/certification number of the applicator or user (if applicable)
- Name of person or entity for whom the application is made (if different from the applicator /user)
- Size of the area treated
- Application rate or amount of material/solution applied
- Application method
- Name of carrier and/or adjuvants if added
- Amount of carrier and/or adjuvants
- Crop, commodity, product, or site to which the pesticide was applied
- Target organisms

In this section, the potential utility of these data for epidemiological research is evaluated using the methodological contexts described above. Respecting the associated costs of collection, editing and verification (quality control), and database management, recommendations are made for the detail and resolution required for support of epidemiological research.

Required Data Fields

U.S. EPA Registration Number. The standardization provided by this field allows linkage to databases maintained by the U.S. Environmental Protection Agency on product characteristics (active ingredient, adjuvant, carrier, concentration), toxicity, environmental behavior, and approved purposes of application.

Product Name. This data item will provide specific information on product identity and recommended applications. It may also provide insights on product use that is helpful in classifying exposure status. For example, labeling on a product containing Dursban (Chlorpyrifos) will likely include instructions for use in residential and non-food areas of industrial, commercial, and institutional buildings. Although the actual use of this product in the community cannot be easily ascertained, Product Name may be useful as a surrogate measure of end user behavior with regards to types of uses and aspects of application (e.g., spray or brush, location of application in building or outdoors), and a surrogate measure of persistence in the environment and opportunity for exposure.

Quantity Applied. This data item will provide information on the amount of material applied. The data are useful in combination with the Product Name to define the amount of active ingredient released into the environment and available for dispersion and exposure. (It is assumed that concentration of the active ingredient is known from the Product Name.)

Location. Reporting of commercial applications at specific addresses will provide maximum flexibility in aggregating data to higher levels (census tract, zip code, county, and region) for describing potential exposure by geographic area, and for use in dispersion modeling and exposure assessments. The collection of specific addresses, when linked to Census and other social and economic data, will provide characterization of exposure in the population by age, gender, and race/ethnic group. Reporting of specific commercial agriculture use by location will allow linking to databases containing occupational health data and the evaluation by region.

Highly specific data on location of application may also be useful in case-control studies of certain (possibly pesticide-related) illnesses, where it will be necessary to reconstruct the exposure history of community members or workers to environmental factors, including pesticides. For example, recent studies of leukemia in children exposed to organophosphate pesticides through routine use of pesticides in and around the home suggest elevated risks (Leiss and Savitz 1995; Infante-Rivard et al. 1999). However, the findings of these studies are limited by poor classification of exposure. The investigators were forced to rely on parental recall of exposures during pregnancy and early life of the child, and no data on potential exposures were available from a resource such as the proposed Pesticide Use Reporting System.

Reporting Frequency. The interval between use and reporting to the central database has relevance for epidemiological studies in terms of accuracy. If log books are maintained by commercial applicators, and reporting is done by abstracting from these logs on an annual cycle, it may not be possible to verify suspect information on applications that occurred as long as 12 months previous. However, this type of error may be minimized by the design of log books and auditing daily record keeping by commercial applicators. Given the long latency of most diseases of interest, annual reporting frequency is sufficient for the likely epidemiological research uses of these data.

Purpose of Application. This field may be useful in identifying conditions of treatment that may lead to exposure and disease. For example, "extermination of bugs in lawn and yard" by a commercial applicator who applies chlorpyrifos at a residence would provide information on proximity of the application to the household occupants, likely persistence in the outdoor environment, and opportunity for exposure.

Type of Application. The type of application (structural, agricultural, aquatic) may be used as a surrogate for estimating fate and dispersion of toxic components in the environment, and as a surrogate measure of opportunity for population exposure.

<u>Other Candidate Data Items</u>

*Date and Time of Application: T*he date of application is (most likely) sufficient to allow calculation of the frequency of application and estimation of cumulative exposure. Combined with data on the Product and amount applied, "peak" exposures may also be estimated.

Name of Applicator. This data item does not have obvious relevance for epidemiological research or quantitative risk assessment, however, it may be useful for regulation and public health protection. The individual subjects may sometimes act as sentinels (first case to be identified) for disease outbreaks.

License/Certification Number of Applicator. This data item does not have obvious relevance for epidemiological research or quantitative risk assessment, however, it may be useful for regulation and public health protection.

Name of Person or Entity for Whom the Application is Made. This data item would be useful in cohort and case-control studies. However, matching of names in linking databases is difficult because of variations in the manner in which names are recorded, changes of surname due to marriage and divorce, and typographical errors. Names of individuals are not needed for aggregate level research. The names of persons and entities at the site of application may be useful for regulation and public health protection.

Size of the Area Treated. This data item is relevant to characterizing concentration in the environment and opportunity for exposure. However, the large variability in human behavior associated with contact of the treated area severely limits the usefulness of this information. The quantity applied (above) is likely to be a sufficient metric of potential exposure and dose. However, size of area treated may be useful for characterizing opportunity for fate and dispersion of pesticides in the environment (e.g., runoff into surface water systems).

Application Rate or Amount of Material/Solution Applied. This data item is potentially relevant to exposure assessment in cohort and case-control designs. While data on the total quantity applied is probably the most useful metric for exposure in studies, specific data on application rates may be useful in studies of occupational exposures and health.

Application Method. This data item is potentially very useful for exposure assessment in detailed analyses on small numbers of subjects. Its usefulness as an indicator of exposure in research on large numbers of subjects at the regional level is not obvious, but it may be a useful indicator of the degree for dispersion or misapplication leading to increased exposure. It is assumed that the number of methods are limited and would be simple to report (e.g., spray, brush, air blast, aerial spray).

Name of Carrier and Adjuvants. This data item is potentially relevant to exposure and dose assessment in detailed analyses on small numbers of subjects, because the carrier and adjuvants may affect rate of absorption and dose. However, its usefulness as an indicator of exposure and determinant of dose in the study of large numbers of subjects at the regional level is not obvious.

Crop, Commodity, Product, or Site to Which the Pesticide Was Applied. The target of the application may determine opportunity for human exposure, and therefore may be an important surrogate for quantifying exposure.

Target Organisms. The target of the application may determine opportunity for human exposure, and therefore may be an important surrogate for quantifying exposure.

Summary

The overarching goal of epidemiological analysis is to make inferences about effects on individual risks of illness or to make ecological inferences about effects on group rates. The reality of limited resources compels investigators to obtain the most information about possible health effects with minimal or the available resources. Therefore is likely that the database of the Pesticide Use Reporting System will be primarily used to support ecological studies.

An example of the application pesticide use data to the analysis of cancer incidence rates is the report by Mills from the Cancer Registry of Central California (1998). For each county in the state, the total number of pounds of active ingredient applied during 1993 was used as an indicator of population exposure to pesticides. In a correlation analysis, level of pesticide use in each county was compared to the average annual number of newly diagnosed cases of cancer for the preceding five-years (1988-1992). For most types of cancer, in most racial/ethnic groups, the correlation coefficients were very close to zero or negative in sign, indicting no correlation between pesticide use and cancer incidence. However, correlations were elevated for Hispanic and black males for certain types of cancer, including leukemia, testicular, and prostate cancers. Historically, these groups have been employed as farm workers and therefore have had a high potential for exposure to pesticides. These findings have motivated more rigorous study of cancer in farm workers using case-control methods. Reconstruction of exposure history will be required and data from California's pesticide use reporting system will be used to estimate cumulative lifetime exposure.

Only one other example of an epidemiological study using data from a pesticide use reporting system is available in the published literature. Weinbaum, Schenker, and colleagues (1997) examined agricultural use data reported to the California Department of Food and Agriculture (now Cal-EPA) during 1984 to 1988 and its relationship to organophosphate-related systemic illnesses recorded by California Worker Health and Safety Branch. A relative "illness-to-use" ratio was calculated using pesticide use data, such as pounds applied, number of applications, and acres treated. The data were analyzed by geographic area, season, the crop treated, the specific pesticide applied, and method of application. The highest risks for systemic illness were associated with applications to fruit tree crops and aerial applications. These findings are now being used to evaluate strategies to reduce poisonings and illnesses among agricultural workers.

Similar approaches are likely to be used in Oregon. As was done in the California studies, data in the Pesticides Use Reporting System can be linked with health data from population registries, such as the Oregon State Cancer Registry, state Occupational Health and Safety, and state Vital Records.

Currently, it is not practical to measure pesticide exposures at the individual level for large numbers of subjects. Data from the Pesticide Use Reporting System will provide information on exposure at the population or regional level. Although it is yet to be demonstrated, ecological measures of exposure derived from the Pesticide Use Reporting System could provide improved measures of exposure that accurately reflect averages for groups of workers or community members. In turn, these data can be used to ecological study designs. Understanding disease rates among population groups will likely be of importance to decision makers and regulators, particularly when there is interest in evaluating the effect of interventions such as new programs, policies, or legislation.

Therefore, assuming that the probable unit of epidemiological analysis will be at the level of the population (or worker group), the potential usefulness of the proposed data items for the Pesticide Use Reporting System are summarized in Table 13.

Table 13. Usefulness of data items in epidemiogical studies.

Data Item	**Range**	**Level of Usefulness**	**Comment**
EPA Reg. No.	Numeric string	Very useful	Required by legislation.
Product Name	Approx. 500 Products (CHECK)	Very useful	Required by legislation.
Quantity Applied	Lbs., Gallons	Very useful	Required by legislation.
Location of Application	Street address to county level	Very useful; recommend record street address and city	Required by legislation; specific street address will allow aggregation to any geographic level
Reporting Frequency	7 days after application to 1 year	Annual reporting is sufficient	A minimum of annual reporting is required by legislation; rare

			diseases with long latency reduce time urgency; but opportunity for data editing and verification is reduced
Purpose of Application	Multiple classes	Moderately useful	Required by legislation; will improve understanding of exposure
Type of Application	Residential, commercial, or agriculture	Moderately useful	Required by legislation; will improve understanding of exposure
Date and Time of application	Date only to inclusion of time of day	Time is not useful.	Date information is essential to quantifying long-term exposure
Applicator Name	Name of commercial applicator	Not useful	Possible sentinel identification (See public health sector)
Applicator License No.	Numeric string	Not useful	Possible sentinel identification (See public health sector)
Name of Person / Entity	Name of person or institution	Not useful in ecological study designs	Unspecified persons are also exposed.
Size of the Area Treated	Estimate of surface area treated	Not useful in ecological designs	Difficult for applicator to estimate
Application Rate	Concentration and amount applied per area	Useful for determining opportunity for exposure	Simple to record and potentially could improve exposure estimation
Application Method	Spray, brush, air blast, aerial spray	Useful for determining opportunity for dispersion	Simple to record and potentially could improve exposure estimation
Name of Carrier	Type of carrier and / or adjuvant	Moderately useful	May be useful to determine exposure and bioavailability
Crop, Commodity, Product, or Site	Multiple classes	Moderately useful	May be a useful surrogate to approximate exposure
Target Organisms	Multiple classes	Moderately useful	May be a useful surrogate to approximate exposure

Risk Assessment

Purpose

It is reasonable to anticipate that data from the Pesticide Use Reporting System will also be used for risk assessment. Risk assessment is a quantitative method which systematically organizes evidence about exposure and dose, to characterize the potential hazard to a population of interest (National Research Council 1983; Rodricks 1992; Fan and Chang 1996; The Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). Quantitative risk assessment can inform decision-makers about the management of risks associated with exposure to a hazard, and can provide an estimate of the attributable burden of disease.

Most risk assessments follow the four-step sequence outlined in the 1983 National Research Council (NRC) "Red Book":

Step 1. *Hazard Identification* - Review of the relevant biological, chemical and toxicological information on the chemical.

Step 2. *Dose-response Characterization* - Review of relevant toxicological information on internal dose and the relationship to incidence of adverse health effects.

Step 3. *Exposure-Assessment* - Characterization of the magnitude, duration, frequency, and route of exposure in the population of interest.

Step 4. *Risk Quantification* - The integration and summary of data in the previous steps to estimate the attributable risk. Ideally, the risk estimate is presented with assumptions and uncertainties associated with the risk estimate.

Quantitative risk assessment is distinguished from epidemiology because it is an inherently theoretical exercise that in most cases cannot be validated by experimentation in the laboratory or observation in the field (Brown 1985). Often, the methods of quantitative risk assessment are applied to problems where the risks are quite low, making it impossible to detect the excess with any reasonable level of statistical significance using epidemiological methods. Quantitative risk assessment may be viewed as a method to systematically organize data to allow the evaluation of uncertainty and variability in the calculation of risk.

The process of developing and evaluating regulatory actions to reduced risk is termed “risk management” (NRC 1983; The Presidential/Congressional Commission on Risk Assessment and Risk Management 1997). Risk management follows risk assessment, and uses the risk model to evaluate the impacts of various interventions on public health. Economic, social, and political consequences of regulatory actions can also be considered.

It is conceivable that risk assessment will be applied to both cancer and non-cancer outcomes associated with exposure to pesticides. This section illustrates how data from the Pesticide Use Reporting System might be used to estimate population risks.

In the first step of a risk assessment, hazard identification, laboratory and field observations of adverse health effects associated with pesticides would be gathered and synthesized. In evaluating the potential hazard posed by a particular pesticide, risk analysts would assemble evidence from chemical toxicity testing and structure-activity relationships. These data would include *in vitro* evidence from cell and tissue culture testing, and *in vivo* evidence from animal bioassays. If available, data from controlled human exposure experiments and epidemiological studies, would be evaluated. These data would be more strongly weighted in the evaluation because they avoid the extrapolation of findings from artificial test systems and other species to the human being. Knowledge of routes of entry into the body and mechanisms of toxic action are integrated in this step to establish the plausibility that a hazard exists.

If it is determined that a hazard exists with a particular pesticide, then the dose-response relationship would be quantified. Data from toxicological testing is extrapolated from high to low dose, and extrapolated from animal models to humans. At this point, the analysts must also characterize the physiologic and metabolic processes linking dose at the site of toxic action, to exposure. Ultimately, an exposure(dose)-response relationship appropriate for estimating risk in the population must be derived. Data from controlled human exposure experiments and epidemiological studies, if available, are very useful in this aspect of the analysis. These data, though useful, may still require extrapolation from highly exposed occupational groups to lower levels more typical of community exposure, and extrapolation across age groups and gender. Nevertheless, epidemiological data are strongly weighted in this evaluation because it characterizes the exposure-response relationship in the natural setting, and represents the full range and time course of exposure, interaction with other pollutant exposures, and variation in susceptibility.

It is in the next step, exposure assessment, that data from the Pesticide Use Reporting System would be used. Presumably, data on pesticide use would allow the construction of distributions of exposures in the population. Lacking actual measurement data, models would be used to estimate exposure distributions from data on pesticide use. These estimates are subject to substantial uncertainty, and ideally, should be validated by exposure assessments using questionnaires to assess behavior, monitoring instrumentation to measure microenvironment and personal exposures, and biomarkers. Thus, the Pesticide Use Reporting System could provide data essential to characterizing the degree and patterns of the population’s exposure to pesticides.

Finally, in the last step of this hypothetical analysis, data on population exposure would be combined with the exposure-response relationship to estimate the population risk. It is important to recognize that data on uncertainty and variability must be considered in the interpretation of the findings of a risk assessment. Care must be taken to acknowledge uncertainty when evaluating central estimates of risk, and sensitivity analyses should be performed to quantify the consequences of uncertainty in the model’s parameters.

House Bill 3602 requires that the Pesticide Use Reporting system collect, at minimum, certain data. Other information describing the circumstances of use have also been suggested by the Oregon Department of Agriculture, the Governor’s Working Group on Pesticide Use Reporting, and by experts in other states with reporting systems.

In this section, the potential utility of these data for risk assessment is evaluated using the methodological context described above. Respecting the associated costs of collection, editing and verification (quality control), and database management, recommendations are made for the detail and resolution required for support of risk assessment.

Required Data Fields

U.S. EPA Registration Number. The standardization provided by this field allows linkage to databases maintained by the U.S. Environmental Protection Agency on product characteristics (active ingredient, adjuvant, carrier, concentration), toxicity, environmental behavior (persistence), and approved purposes of application. From this perspective, the EPA Registration number provides a valuable link to data useful for hazard identification.

Product Name. This data item will provide specific information on product identity and recommended applications. It may also provide insights on product use important for understanding potential exposures. For example, labeling on a product containing Dursban (Chlorpyrifos) will likely include instructions for use in residential and non-food areas of industrial, commercial, and institutional buildings. Although the actual use of this product in the community cannot be easily ascertained, Product Name may be useful as a surrogate measure of end user behavior with regards to types of uses and aspects of application (e.g., spray or brush, location of application in building or outdoors), and a surrogate measure of persistence in the environment and opportunity for exposure.

Quantity Applied. This data item will provide information on the amount of material applied. The data is useful in combination with Product Name to define the amount of active ingredient released into the environment and available for dispersion and exposure. (It is assumed that concentration of the active ingredient is known from the Product Name.)

Location. Reporting of commercial applications at specific addresses will provide maximum flexibility in aggregating data to higher levels (census tract, zip code, county, and region) for describing potential exposure by geographic area, and for use in dispersion modeling and exposure assessments. The collection of specific addresses, when linked to Census and other social and economic data, will provide characterization of exposure in the population by age, gender, and race/ethnic group.

Reporting Frequency. The interval between use and reporting to the central database has relevance to risk assessment in terms of accuracy. If log books are maintained by commercial applicators, and reporting is done by abstracting from these logs on an annual cycle, it may not be possible to verify suspect information on applications that occurred as long as 12 months previous. However, this type of error may be minimized by the design of log books and auditing daily record keeping by commercial applicators. Risk assessments require considerable effort, and are not likely to be conducted at frequent intervals. Therefore, reporting on an annual schedule is sufficient for research use of these data.

Purpose of Application. This field may be useful in identifying conditions of pesticide use that may lead to exposure. For example, “extermination of fleas in lawn and yard” by a commercial applicator who applies chlorpyrifos at a residence would provide information on proximity of the application to the household occupants, likely persistence in the outdoor environment, and opportunity for exposure.

Type of Application. The type of application (structural, agricultural, aquatic) may be used as a surrogate for estimating fate and dispersion of toxic components in the environment, and as a surrogate measure of opportunity for population exposure.

Other Candidate Data Items

Date and Time of Application. Because of the persistence of these compounds in the environment, the date of application is sufficient to allow calculation of the frequency of application and estimation of cumulative exposure. Combined with data on the product and amount applied, “peak” exposures may also be estimated.

Name of Applicator. This data item does not have obvious relevance for quantitative risk assessment, however, it may be useful for regulation and public health protection (see below).

License/Certification Number of Applicator. This data item does not have obvious relevance for quantitative risk assessment, however, it may be useful for regulation and public health protection (see below).

Name of Person or Entity for Whom the Application is Made. This data item does not have obvious relevance for quantitative risk assessment, however, it may be useful for regulation and public health protection (see below).

Size of the Area Treated. This data item is relevant to characterizing concentration in the environment and opportunity for exposure. However, the large variability in human behavior associated with contact of the treated area severely limits the usefulness of this information. The quantity applied (above) is likely to be a sufficient metric of potential exposure and dose. However, size of area treated may be useful for characterizing opportunity for fate and dispersion of pesticides in the environment (e.g., runoff into surface water systems).

Application Rate or Amount of Material/Solution Applied. This data item is potentially relevant to exposure assessment. While the total quantity applied is probably the most useful metric for exposure, data on application rate may be useful in occupational studies.

Application Method. This data item is potentially very relevant to exposure assessment in detailed analyses on small numbers of subjects. However, its usefulness as an indicator of exposure in research on large numbers of subjects at the regional level is not obvious. Application method may be a useful indicator of the degree for dispersion or misapplication leading to increased exposure. It is anticipated that number of methods are limited and would be simple to report (e.g., spray, brush, air blast, aerial spray).

Name of Carrier and Adjuvants. This data item is potentially relevant to exposure and dose assessment in detailed analyses on small numbers of subjects, because the carrier and adjuvants may affect rate of absorption and dose. However, its usefulness as an indicator of exposure and determinant of dose in the risk assessments is not obvious.

Crop, Commodity, Product, or Site to Which the Pesticide Was Applied. The target of the application may determine opportunity for human exposure, and therefore may be an important surrogate for quantifying exposure.

Target Organisms. The target of the application may determine opportunity for human exposure, and therefore may be an important surrogate for quantifying exposure.

<u>Summary</u>

The two major components of risk assessment are exposure assessment and effects assessment. The data in the Pesticide Use Reporting System is most relevant to the first activity, and has the potential to characterize variability and to reduce uncertainty associated with quantification of population exposure.

Using data from the system, risk analysts can address the following questions:

- How many persons are exposed?
- What are the characteristics of the exposed population?
- What are the sources of exposure?
- What are the magnitudes of exposure?
- What are the time patterns of exposure?

From the perspective of risk analysis, potential usefulness of each of the proposed data items, and their ideal levels of resolution are summarized in Table 14.

Table 14. List of data points usable in risk assessment.

Data Item	Range	Level of Usefulness	Comment
EPA Reg. No.	Numeric string	Very useful	Required by legislation.
Product Name	Approx. 500 Products (CHECK)	Very useful	Required by legislation.
Quantity Applied	Lbs., Gallons	Very useful	Required by legislation.
Location of Application	Street address to county level	Very useful; recommend record street address and city	Required by legislation; specific street address will allow aggregation to any geographic level
Reporting Frequency	7 days after application to 1 year	Annual reporting is sufficient	A minimum of annual reporting is required by legislation; risk assessments will not be frequently performed
Purpose of Application	Multiple classes	Moderately useful	Required by legislation; will improve understanding of exposure
Type of Application	Residential, commercial, or agriculture	Moderately useful	Required by legislation; will improve understanding of exposure
Date and Time of application	Date only to inclusion of time of day	Time is not useful.	Date information is essential to quantifying long-term exposure
Applicator Name	Name of commercial applicator	Not useful	
Applicator License No.	Numeric string	Not useful	
Name of Person / Entity	Name of person or institution	Not useful	
Size of the Area Treated	Estimate of surface area treated	Not useful	Difficult for applicator to estimate
Application Rate	Concentration and amount applied per area	Useful for determining opportunity for exposure	Simple to record and potentially could improve exposure estimation
Application Method	Spray, brush, air blast, aerial spray	Useful for determining opportunity for dispersion	Simple to record and potentially could improve exposure estimation
Name of Carrier	Type of carrier and / or adjuvant	Moderately useful	May be useful to determine exposure and bioavailability
Crop, Commodity, Product, or Site	Multiple classes	Moderately useful	May be a useful surrogate to approximate exposure
Target Organisms	Multiple classes	Moderately useful	May be a useful surrogate to approximate exposure

Public Health

Purpose

In addition to meeting the needs of human and ecological risk assessment, and epidemiology, the design of the Pesticide Use Reporting System must also consider the promotion and protection of public health. In its 1988 report, *The Future of Public Health*, the Institute of Medicine (IOM) defined public health as " a public enterprise having a mission to fulfill society's interest in ensuring the conditions in which people can be healthy, a structure comprised of organized community efforts aimed at the prevention of disease and promotion of health, and activities organized within both the formal structure of government and the associated efforts of private and voluntary organizations and individuals." Thus, public health is defined as a process, rather than a quality, state, or condition.

This landmark IOM report also described the three primary activities comprising the practice of public health:

1. *Assessment.* Surveillance of health and environmental quality, identification of community needs, analysis of the cause of problems, case finding, forecasting trends, research, and evaluation of intervention outcomes.
2. *Policy Development.* The process by which society makes decisions about problems, chooses goals and the proper means to reach them, handles conflicting views about what should be done, and allocates resources.
3. *Assurance.* Guaranteeing the delivery and accessibility of services to protect and improve the health of the public.

Congruent with these process definitions, the Pesticide Use Reporting System should be designed to inform the process of public health protection. With regard to pesticides in Oregon, many government and non-government groups, and individuals, participate in the development of policies to protect human and ecosystem health. These groups include the State Department of Agriculture, other state and local agencies, and business, labor, and citizen groups. The choice of essential data elements to be included in the system, and their level of resolution, should reflect the potential needs and interests of these stakeholders.

Application to Public Health Protection

House Bill 3602 requires that the Pesticide Use Reporting system collect, at minimum, certain data. Other information describing the circumstances of use have also been suggested by the Oregon Department of Agriculture, the Governor's Working Group, and by experts in other states with reporting systems.

In this section, the potential utility of these data items for public health protection are evaluated. Respecting the associated costs of collection, editing and verification (quality control), and database management, recommendations are made for the detail and resolution required for public health practice.

Required Data Fields

U.S. EPA Registration Number. The standardization provided by this field allows linkage to databases maintained by the U.S. Environmental Protection Agency on product characteristics (active ingredient, adjuvant, carrier, concentration), toxicity, approved purposes of application. From this perspective, the EPA Registration number provides a valuable link to data useful for hazard identification.

Product Name. This data item provides specific information on product identity and recommended applications. It may also provide insights on product use important for understanding potential exposures and the opportunity for adverse health effects, including poisonings.

Quantity Applied. This data item provides information on the amount of material applied. These data are useful in combination with Product Names to define the amount of active ingredients released into the environment and available for dispersion and exposure. (It is assumed that concentration of the active ingredient is known from the Product Name.)

Location. Reporting of commercial applications at specific addresses will provide maximum flexibility in aggregating data to higher levels (census tract, zip code, county, and region) for describing potential exposure by geographic area, and for use in dispersion modeling and exposure assessments. The collection of specific addresses will establish a record of application sites useful for ensuring the protection of potentially susceptible individuals (e.g., those with chemical sensitivity, asthmatics) and groups (e.g., day care centers, schools).

Reporting Frequency. The interval between use and reporting to the central database has relevance to protection of public health in terms of early detection of improper applications. If reported applications differ from recommended (or required) practice, early intervention to change behavior may avert adverse events. While House Bill 3602 specifies at least annual reporting, a more frequent reporting interval, such as quarterly reporting, may allow early detection and response by ODA.

Purpose of Application. This field may be useful in identifying conditions of pesticide use that lead to exposure, and improper use.

Type of Application. The type of application (structural, agricultural, aquatic) may indicate applications that differ from standard practice, and in turn, may create situations of increased exposure and health risk.

Other Candidate Data Items

Date and Time of Application. For most uses, date of application is likely to be sufficient.
Name of Applicator. This data element may be useful for regulation and enforcement activity.

License/Certification Number of Applicator. This data element may be useful for regulation and enforcement activity.

Name of Person or Entity for Whom the Application is Made. This data element helps to characterize the segments of the community who use pesticides.

Size of the Area Treated. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to the population exposure is essential.

Application Rate or Amount of Material/Solution Applied. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to the population exposure is essential.

Application Method. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to the population exposure is essential.

Name of Carrier and Adjuvants. This data element has low utility for routine surveillance but could provide important information on exposure of a sentinel subject (help in recognizing an outbreak of an illness)

Crop, Commodity, Product, or Site to Which the Pesticide Was Applied. Information on the target of the application will provide information on the activity of commercial applicators and may identify opportunities to reduce improper or inefficient activity and thereby reduce population exposures.

Target Organisms. Information on the target of the application will provide information on the activity of commercial applicators and may identify opportunities to reduce improper or inefficient activity and thereby reduce population exposures.

Summary

The three core functions of public health practice are assessment, policy development, and assurance. These activities are not only performed by the public agencies, but also by the private sector, non-governmental organizations, citizens groups, and individuals. The Pesticide Use Reporting System should provide surveillance data useful for the assessment of population exposure and human health risk. Surveillance data describing patterns of use, and the findings of epidemiology and risk assessments, will provide the basis for policy discussions among the stakeholders. Consistent with the 1996 report of a committee of the National Research Council, *Understanding Risk: Informing Decisions in a Democratic Society*, broad participation in risk characterization and management, involving all stakeholders must be anticipated. An iterative process of analyses and deliberation will occur. It is also likely that analyses of the pesticide use database will go beyond the simple numeric expression of harm to consider economic, social, and political consequences of regulatory actions. These consequences are also part of the practice of public health protection.

From the perspective of public health, potential usefulness of each of the proposed data items, and their respective ideal level of resolution are summarized in Table 15.

Table 15. Use of data points in public health.

Data Item	Range	Level of Usefulness	Comment
EPA Reg. No.	Numeric string	Very useful	Required by legislation.
Product Name	Approx. 500 Products (CHECK)	Very useful	Required by legislation.
Quantity Applied	Lbs., Gallons	Very useful	Required by legislation.
Location of Application	Street address to county level	Very useful; recommend record street address and city	Required by legislation; specific street address will allow aggregation to any geographic level
Reporting Frequency	7 days after application to 1 year	Quarterly reporting	A minimum of annual reporting is required by legislation; more frequent reporting may allow intervention to reduce health risk
Purpose of Application	Multiple classes	Moderately useful	Required by legislation; will improve understanding of settings of use and opportunity for population exposure
Type of Application	Residential, commercial, or agriculture	Moderately useful	Required by legislation; will improve understanding of settings of use and opportunity for population exposure
Date and Time of application	Date only to inclusion of time of day	Date is sufficient; time of day is not needed	
Applicator Name	Name of commercial applicator	Useful	Useful for enforcement and intervention. Possible sentinel identification
Applicator License No.	Numeric string	Useful	Useful for enforcement and intervention. Possible sentinel identification.
Name of Person / Entity	Name of person or institution	Useful	Potentially useful for understanding class of user
Size of the Area Treated	Estimate of surface area treated	Moderately useful	Potentially useful for poisoning and illness outbreak investigations
Application Rate	Concentration and amount applied per area	Moderately useful	Potentially useful for poisoning and illness outbreak investigations
Application Method	Spray, brush, air blast, aerial spray	Moderately useful	Potentially useful for poisoning and illness outbreak investigations
Name of Carrier	Type of carrier and / or adjuvant	Moderately useful	Potentially useful for poisoning and illness outbreak investigations
Crop, Commodity, Product, or Site	Multiple classes	Moderately useful	May be useful to identify opportunity for intervention and training on proper use
Target Organisms	Multiple classes	Useful	May be useful to identify opportunity for intervention and training on proper use

Worker Health and Safety

Purpose

Protection of worker safety and health is mandated by federal law under the William-Steiger Occupational Safety and Health Act. In passing this Act in 1970, it was the intent of Congress "to assure, as far as possible, every working man and woman in the country safe and healthful working conditions." The Act assigned responsibility for the development of specific workplace health and safety standards to the Secretary of Labor. Shortly after passage of the Act, the Secretary established the Occupational Safety and Health Administration (OSHA) as a separate agency within the U.S. Department of Labor to administer all aspects of the Act. The Act also mandated the creation of the National Institute for Occupational Safety and Health (NIOSH) within the U.S. Department of Health and Human Services to provide scientific research to develop and support workplace health and safety policies.

The Occupational Safety and Health Act allows states to assume responsibility for administering their own workplace safety and health programs, but only if states submit, and obtain approval of, a plan that meets rigorous criteria. In states without approved plans, responsibility for workplace safety and health remains with OSHA. Oregon has an approved state plan that is administered by the Oregon Occupational Safety and Health Agency (OR-OSHA). Oregon is required to submit any new standards or enforcement regulations developed by the State to federal OSHA for approval. As well, Oregon is required to respond to any federally initiated changes. The performance of OR-OSHA is closely monitored by federal OSHA. Despite the many requirements imposed on the State by the federal government, states with their own plans, such as Oregon, benefit from a higher level of local participation in workplace safety and health activities by stakeholders. Local surveillance data on exposure to potential hazards, and local medical surveillance, provides information that is essential to the development of policies tailored to the needs of Oregon workers.

The proposed Pesticide Use Reporting System has the potential to provide special surveillance on the magnitude and frequency of exposure to pesticides by agricultural workers and commercial applicators. The choice of essential data elements to be included in the System, and their level of resolution, should reflect the potential needs and interests of OR-OSHA, and the employers, employees, and labor unions involved in the commercial use of pesticides.

Application of Pesticide Use Reporting System Data to Worker Health Protection

House Bill 3602 requires that the Pesticide Use Reporting system collect, at minimum, certain data. Other information describing the circumstances of use have also been suggested by the

Oregon Department of Agriculture, the Governor's Working Group, and by experts in other states with reporting systems.

In this section, the potential utility of these data items for public health protection are evaluated. Respecting the associated costs of collection, editing and verification (quality control), and database management, recommendations are made for the detail and resolution required for protection of worker safety and health.

Required Data Fields

U.S. EPA Registration Number. The standardization provided by this field allows linkage to databases maintained by the U.S. Environmental Protection Agency on product characteristics (active ingredient, adjuvant, carrier, concentration), toxicity, approved purposes of application. From this perspective, the EPA Registration number provides a valuable link to data useful for hazard identification.

Product Name. This data item provides specific information on product identity and recommended applications. It may also provide insights on product use important for understanding potential exposures and the opportunity for adverse health effects, including poisonings.

Quantity Applied. This data item provides information on the amount of material applied. These data are useful in combination with Product Names to define the amount of active ingredients released into the environment and available for dispersion and exposure. (It is assumed that concentration of the active ingredient is known from the Product Name.)

Location. Reporting of commercial applications at specific addresses will provide maximum flexibility in aggregating data to higher levels (census tract, zip code, county, and region) for describing potential exposures within a geographic area.

Reporting Frequency. The interval between use and reporting to the central database has relevance to protection of worker health in terms of early detection of improper applications. If reported applications differ from recommended (or required) practice, early intervention to change behavior may avert adverse events. While House Bill 3602 specifies at least annual reporting, a more frequent reporting interval, such as quarterly reporting, may allow early detection and response by OR-OSHA.

Purpose of Application. This field may be useful in identifying conditions of pesticide use that lead to unnecessary worker exposure, and improper use.

Type of Application. The type of application (structural, agricultural, aquatic) may indicate applications that differ from standard practice, and in turn, may create situations of increased exposure and health risk to workers.

<u>Other Candidate Data Items</u>

Date and Time of Application. For most uses, date of application is likely to be sufficient.

Name of Applicator. This data element may be useful for regulation and enforcement activity as well as indentifying exposures of a sentinel case of an illness outbreak and identifying workers with work-related chemical exposures.

License/Certification Number of Applicator. This data element may be useful for regulation and enforcement activity and identifying exposures of a sentinel case of an illness outbreak and identifying workers with work-related chemical exposures.

Name of Person or Entity for Whom the Application is Made. This data element is not necessary for protection of worker safety and health.

Size of the Area Treated. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to the worker exposure is essential.

Application Rate or Amount of Material/Solution Applied. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to the worker exposure is essential.

Application Method. Outside of large-scale agricultural applications, this data element has low utility for routine surveillance. However, in illness outbreak investigations, information on the circumstances leading to worker exposure is essential.

Name of Carrier and Adjuvants. This data element has low utility for surveillance and protection of worker health.

Crop, Commodity, Product, or Site to Which the Pesticide Was Applied. Information on the target of the application will provide information on the activity of commercial applicators and may identify opportunities to reduce improper or inefficient activity and thereby reduce worker exposures.

Target Organisms. Information on the target of the application will provide information on the activity of commercial applicators and may identify opportunities to reduce improper or inefficient activity and thereby reduce worker exposures.

Summary

The Pesticide Use Reporting System should provide surveillance data useful for the assessment of worker exposure and health risk. Surveillance data describing patterns of use, and the findings of medical surveillance (e.g., Oregon Pesticide Analytical and Response Center), will provide the basis for policy discussions among the stakeholders.

One example of an occupational epidemiological study using data from a pesticide use reporting system is available in the published literature. Weinbaum, Schenker, and colleagues (1997) examined agricultural use data reported to the California Department of Food and Agriculture (now Cal-EPA) during 1984 to 1988 and its relationship to organophosphate-related systemic illnesses recorded by California Worker Health and Safety Branch. A relative "illness-to-use" ratio was calculated using pesticide use data, such as pounds applied, number of applications, and acres treated. The data were analyzed by geographic area, season, the crop treated, the specific pesticide applied, and method of application. The highest risks for systemic illness were associated with applications to fruit tree crops and aerial applications. These findings are now being used to evaluate strategies to reduce poisonings and illnesses among agricultural workers. From the perspective of protection of worker health, the potential usefulness of each of the proposed data elements, and their respective ideal level of resolution, are summarized in Table 16.

Table 16. Use of data points in worker health and safety.

Data Item	Range	Level of Usefulness	Comment
EPA Reg. No.	Numeric string	Very useful	Required by legislation.
Product Name	Approx. 500 Products (CHECK)	Very useful	Required by legislation.
Quantity Applied	Lbs., Gallons	Very useful	Required by legislation.
Location of Application	Street address to county level	Very useful; recommend record street address and city	Required by legislation; specific street address will allow aggregation to any geographic level
Reporting Frequency	7 days after application to 1 year	Quarterly reporting	A minimum of annual reporting is required by legislation; more frequent reporting may allow intervention to reduce health risk
Purpose of Application	Multiple classes	Moderately useful	Required by legislation; will improve understanding of settings of use and opportunity for population exposure
Type of Application	Residential, commercial, or agriculture	Moderately useful	Required by legislation; will improve understanding of settings of use and opportunity for population exposure

Date and Time of application	Date only to inclusion of time of day	Date is sufficient; time of day is not needed	
Applicator Name	Name of commercial applicator	Essential	Necessary for enforcement and intervention, and sentinel case identification and tracking
Applicator License No.	Numeric string	Essential	Necessary for enforcement and intervention, and sentinel case identification and tracking
Name of Person / Entity	Name of person or institution	Not useful	
Size of the Area Treated	Estimate of surface area treated	Moderately useful	Potentially useful for worker poisoning and illness outbreak investigations
Application Rate	Concentration and amount applied per area	Moderately useful	Potentially useful for worker poisoning and illness outbreak investigations
Application Method	Spray, brush, air blast, aerial spray	Moderately useful	Potentially useful for worker poisoning and illness outbreak investigations
Name of Carrier	Type of carrier and / or adjuvant	Not useful	
Crop, Commodity, Product, or Site	Multiple classes	Moderately useful	May be useful to identify opportunity for intervention and training on proper use
Target Organisms	Multiple classes	Useful	May be useful to identify opportunity for intervention and training on proper use

Food Quality Protection Act of 1996

The Food Quality Protection Act (FQPA) of 1996 amended the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA) and the Federal Food, Drug, and Cosmetic Act (FFDCA). These amendments fundamentally changed the way EPA regulates pesticides. The requirements included a new safety standard[reasonable certainty of no harm] that must be applied to all pesticides used on foods. See http://www.epa.gov/oppfead1/fqpa/index.html

EPA regulates pesticides under two major federal statutes. Under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA), EPA registers pesticides for use in the United States and prescribes labeling and other regulatory requirements to prevent unreasonable adverse effects on health or the environment. Under the Federal Food, Drug, and Cosmetic Act (FFDCA), EPA establishes tolerances (maximum legally permissible levels) for pesticide residues in food.

The new law establishes a strong, health-based safety standard for pesticide residues in all foods. It uses "a reasonable certainty of no harm" as the general safety standard. A single, health-based standard eliminates longstanding problems posed by multiple standards for pesticides in raw and processed foods. In addition, FQPA requires EPA to consider all non-occupational sources of exposure, including drinking water (aggregate exposure), and exposure to other pesticides with a common mechanism of toxicity (cumulative exposure) when setting tolerances.

The new law incorporates language virtually identical to the recommendations of the National Academy of Sciences report, “Pesticides in the Diets of Infants and Children”, requiring an explicit determination that tolerances are safe for children, consideration of an additional safety factor of up to ten-fold, to account for uncertainty in data relative to children, and consideration of children’s special sensitivity and exposure to pesticide chemicals.

Unlike FIFRA as amended, which contained an open-ended provision for the consideration of pesticide benefits when setting tolerances, FQPA places specific limits on benefits considerations in risk assessments. Consideration of benefits can only be applied to non-threshold effects of pesticides (i.e., carcinogenic effects), and cannot be taken into account for reproductive or other threshold effects. Benefits assessment is further limited by three “backstops” on the level of risk that could be offset by benefits considerations. The first is a limit on the acceptable risk in any one year – this limitation greatly reduces the risks. The second limitation is on the lifetime risk, which would allow EPA to remove tolerances after specific phase-out periods. The third limitation is that benefits could not be used to override the health-based standard for children. FQPA incorporates provisions for endocrine testing, and also provides new authority to require that chemical manufacturers provide data on their products, including data on potential endocrine effects.

FQPA requires distribution of a brochure in grocery stores on the health effects of pesticides, how to avoid risks, and which foods have tolerances for pesticide residues based on benefits considerations. Specifically, it recognizes a state’s right to require warnings or labeling of food that has been treated with pesticides, such as California’s Proposition 65. FQPA requires that all tolerances be reviewed within 10 years to make sure they meet the requirements of the new health-based safety standard. States may not set tolerance levels that differ from national levels unless the state petitions EPA for an exception, based on state-specific situations. National uniformity, however, would not apply to tolerances that included benefits considerations.

FQPA requires EPA to periodically review pesticide registrations, with a goal of establishing a 15-year cycle, to ensure that all pesticides meet updated safety standards. The new law expedites review of safer pesticides to help them reach the market sooner and replace older and potentially more risky chemicals. Because of concern for a lack of alternatives for minor use crops, FQPA establishes minor use programs within EPA and USDA to foster coordination on minor use regulations and policy, and provides for a revolving grant fund to support development of data necessary to register minor use pesticides, and encourages minor use registrations through extensions for submitting pesticide residue data, extensions for exclusive use of data, flexibility to waive certain data requirements, and requiring EPA to expedite review of minor use applications. These incentives are coupled with safeguards to protect the environment.

In the 3 years since its enactment, FQPA has drastically changed the way pesticide risk assessments are conducted. Although primarily focused on addressing the risks of human dietary exposure to pesticides, its implementation has resulted in much more complex risk assessments, requiring more sophisticated risk assessment methods, for a broad spectrum of risks to both human and environmental health. This has created opportunities for the regulated industry to provide more precise data necessary for the refined assessments now underway. A major data gap is information on pesticide use and usage at various landscape scales, including the application site, production region, watershed, county, state, and national level. Without accurate data on pesticide usage, EPA is forced to use default assumptions in estimating human and wildlife exposure which have historically greatly over estimated use. For example, without accurate information on pesticide use and usage, EPA may be forced to assume that the maximum label rate is used on all of the acreage of the crop in question. In practice, this is rarely the case. Estimates of exposure based on limited pesticide use data have not been a serious problem in the past; however default assumptions on pesticide use in newer risk assessment models, which take into account both aggregate and cumulative exposures, and address the potential for adverse impacts on sensitive sub-populations, such as children, have the potential to greatly reduce the margin of exposure for pesticides evaluated prior to FQPA. Only with accurate use information will many of these pesticides retain their registration status under FQPA.

Required Data Fields

U.S. EPA Registration Number. This number indicates that the product is registered in the U.S. and is useful in identifying pesticides with ambiguous product names. The standardization provided by this field also allows linkage to product databases maintained by EPA and others.

Product Name. The product name is used to reference product label information required by law. In addition to the product name, the label will provide specific information on product identity, chemical composition, and recommended use, including types of crops or sites, target pests, and rate, timing, and frequency of application.

Quantity Applied. This data item will provide information on the amount of material applied. The data is useful in combination with Product Name to define the amount of active ingredient released into the environment.

Location. Reporting of applications at specific addresses or other location ID will provide maximum flexibility in aggregating data to higher levels (county, watershed, Basin) for describing use patterns by geographic area. This information will be useful in risk assessments conducted under FQPA. Without exact location, EPA may be forced to aggregate data at a higher level requiring more conservative assumptions when conducting risk assessments for dietary exposure, as well as evaluation of other human and environmental risks.

Purpose of Application. Pesticides should not be introduced into the environment unless there is a benefit. Identifying the purpose for application will allow evaluation of economically viable alternative control strategies. Viable alternatives will be considered by EPA when making risk mitigation decisions under FQPA.

Treated Area size. This data item is useful in understanding the extent of pesticide use within the application site, or on a county, regional, or watershed scale. In the absence of rate information, treated area size, together with quantity applied, can be used to determine application rate. The size of the treated area is useful in understanding the extent of pesticide use as a measure of potential adverse impacts human and environmental health. This information will aid in landscape scale risk assessments under FQPA.

Reporting Frequency. The interval between use and reporting to the central database has relevance to in terms of data accuracy. Of greatest concern is the increased potential for reporting recall bias (errors in reporting associated with long periods between pesticide application and reporting) if submission of forms is required quarterly or yearly.

Other Candidate Data Fields

Name of Applicator. This data item may be useful in targeting individuals for educational outreach and other information services on impact of the FQPA.

License/Certification Number of Applicator. This data item is most useful in data validation and quality assurance.

Date and Time of Application. Information on application date and/or time may be useful in some refined risk assessments under FQPA. Restricting date and time of application may be a mitigating measure that will allow the continued use of a pesticide product under conditions which are compatible with IPM strategies and minimize adverse impacts on human and environmental health.

Application Rate or Amount of Material/Solution Applied. One objective of current EPA and USDA pest management initiatives is to reduce both pesticide use and risk. Information on widespread use of a pesticide product at reduced rates may allow further evaluation to determine effectiveness and future recommendations on its use. In addition, this information may provide a mitigation option for pesticides under evaluation by EPA.

Application Method. Application method can be critical to understanding the potential pesticide distribution in the environment, the potential for off-site movement, and exposure potential. Such information may be important to the determination of mitigating measures designed to reduce or prevent adverse impacts to human and environmental health under FQPA.

Name of Carrier and Adjuvants. The tank mix, including the pesticide product, carrier, adjuvants and additives (buffers, spreaders, stickers, drift retardants) determines the efficacy of the product and human and environmental impacts. For example, off site movement due to drift may be reduced by the addition of a drift retardant, thereby reducing exposure potential down wind.