Oregon Department of Forestry: Aerial Pesticide Application Monitoring Final Report

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Acknowledgements

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Introduction

Forest pesticides, which include herbicides, fungicides, insecticides, and rodenticides, are commonly used to aid in the re-establishment, growth, and survival of forest tree species throughout Oregon. In 1997 the Oregon Board of Forestry revised forest practice rules governing application of pesticides and other chemicals (OAR 629-620). The rule revision process committed the Oregon Department of Forestry to monitor the effectiveness of the rules and report those findings to the Board of Forestry (OAR 620-620-700). In particular, the goal of this study was to test the effectiveness of the forest practice rules in protecting fish-bearing (Type F) and domestic use (Type D) streams from unacceptable drift contamination during aerial applications of forest pesticides.

This study was designed through a subcommittee of the rule revision committee. The subcommittee members (page IV) represented the National Coalition for Alternatives to Pesticides, private landowners, Department of Environmental Quality, Oregon Department of Agriculture, Oregon State University, city water commissions, National Council for Air and Stream Improvement, private monitoring consultants, and Oregon Department of Forestry. This subcommittee reviewed and approved the methods described and implemented for this study.

<u>Rules and Regulations</u>

The Oregon Department of Forestry (ODF) regulates forestry operations on non-federal forestland. Landowners and operators are subject to the *Oregon Forest Practices Act* when they conduct any commercial activity relating to the growing or harvesting of trees. The Oregon Forest Practices Act (FPA) was adopted in 1972. The overarching objective of the act is to:

> "encourage economically efficient forest practices that assure the continuous growing and harvesting of forest tree species and the maintenance of forestland for such purposes as the leading use on privately owned land, consistent with sound management of soil, air, water, fish and wildlife resources and scenic resources within visually sensitive corridors as provided by ORS 527.755 that assures the continuous benefits of those resources for future generations of Oregonians." (ORS 527.630 Policy, Oregon Forest Practices Act)

The Oregon Board of Forestry has been vested with exclusive authority to develop and enforce statewide and regional rules. The forest practice rules are designed to address the resource issues identified in the FPA objective. The rules are categorized into divisions, and each division has a description of purpose. The purpose statements further refine the broad objectives of the rules and act.

The focus of this monitoring project was on a subset of Division 620: Chemical and Other Petroleum Product Rules. The purpose of the Division 620 rules is to "ensure that chemicals used on forestland do not occur in the soil, air or waters of the state in quantities that would be injurious to water quality or to the overall maintenance of terrestrial or aquatic life." While "chemicals" is defined in Oregon Administrative Rule 629-600-100 (11) as all classes of pesticides, plant regulators, petroleum products used as carriers, and adjuvants (e.g. surfactants, control additives), this study only monitored herbicides and fungicides. Note that the rule does not require that all measurable concentrations of chemicals in the waters of the state be avoided. Instead, the rule focuses on requiring best management practices that are intended to ensure that chemicals do not reach the waters of the state at concentrations that could be injurious to water quality and terrestrial or aquatic life.

In addition to compliance with ODF regulations, operations involving the use of pesticides are also subject to related laws administered by the Oregon Department of Agriculture, Department of Environmental Quality, Occupational Safety and Health Division, Water Resources Department, and the Health Division (OAR 629-620-000).

As stated earlier, this study focused on aerial applications of herbicides and, to a lesser extent, fungicides. The rules regarding aerial application of these pesticides maintain that operators shall only apply them under weather conditions that will protect non-target resources and comply with the product label (OAR 629-620-400 (3)). Direct aerial herbicide application may not occur within 60 feet of significant wetlands, Type F or D streams, large lakes, other lakes with fish use, and other areas of open water larger than one-quarter acre at the time of application (OAR 629-620-400 (4)). No herbicide application buffer is specified in the chemical rules for streams which are neither Type F nor D (Type N streams). However, all herbicide applications must be conducted in compliance with the product label and also ensure the retention of the riparian vegetation components required by the forest practices water protection rules.

Direct aerial application of fungicides may not occur within 300 feet of significant wetlands, Type F or D streams, large lakes, other lakes with fish use, other areas of open water larger than one-quarter acre at time of application, and within 60 feet of flowing Type N streams (OAR 629-620-400 (7)). This study focused on Type F and D streams, although three Type N streams were sampled. These Type N streams had overstory vegetative buffers, a practice not required for Type N streams. See Table A-1 in Appendix A for details on buffer requirements for all aerial chemical applications.

<u>Forest Practices Monitoring Program</u>

The Aerial Pesticide Application Monitoring Project is just one component of the forest practices monitoring program (Dent 1998) and is an example of effectiveness monitoring. A set of monitoring questions has been developed which guide monitoring efforts in determining if the forest practice rules are *effective (effectiveness monitoring), implemented properly (compliance monitoring),* and based on *accurate assumptions (validation monitoring)*. The monitoring questions were formulated with significant input from the public and vested interest groups during the 1994 strategic planning process. The forest practices monitoring program currently coordinates separate projects to monitor compliance with forest practice rules and the effectiveness of forest practice rules with regard to landslides, riparian function, stream temperature, juvenile fish passage, and sediment delivery from forest roads. Validation monitoring is being conducted to test the basic assumptions underlying the riparian forest practice rules.

Past Findings With Regard to Aerial Application of Pesticides

<u>Water Sampling Results</u>

Forest pesticide monitoring has taken place in Washington and Oregon over the past 16 years. Results from three different studies indicate that the majority of the 24-hour-average composite samples contained either no detectable residue or less than 1.0 ppb of the applied pesticide (Figure 1). From 1980 to 1987, ODF implemented a water-sampling program to assess the effectiveness of the forest practice rules (in effect at the time) at protecting the waters of the state (Oregon Department of Forestry, Forest Practices Monitoring Program 1992). A representative subset of total pesticide applications was monitored totaling 153 water samples. Of 153 samples analyzed, 86 percent (132 samples) resulted in no detectable pesticide residue. A subsequent study was carried out from 1989 to

1990 by ODF to assess herbicide applications again. Of 52 samples analyzed, 83 percent (43 samples) resulted in no detectable herbicide.

The Washington Timber Fish and Wildlife Program (TFW) intensively monitored six operations during 1991 (Rashin and Graver 1993). Of six samples analyzed, 83 percent (5 samples) contained 0.13 to 0.56 parts per billion (ppb) of the applied herbicide. Results of these three studies indicate that under most conditions, pesticide concentrations greater than 1 ppb are relatively rare as a result of forest operations.

Peak Concentrations Generated By Precipitation

Additional peaks in pesticide concentrations may occur after the first rainfall and subsequent runoff. Sufficiently large precipitation which expands the ephemeral stream system can result in flowing water coming into contact with pesticide deposits (Ice 1994; Norris 1980). The potential for subsequent peaks depends on the elapsed time between the pesticide application and the first runoff event, the expansion of the channel, the decay rate of the pesticide and the antecedent storm conditions. Professional judgment must be used to determine when there is sufficient rainfall to produce runoff. In the TFW study, the authors determined that rainfall events that occurred within the first 72 hours of the operation were the most important. They recommended sampling within the initial 12 hours after runoff begins.

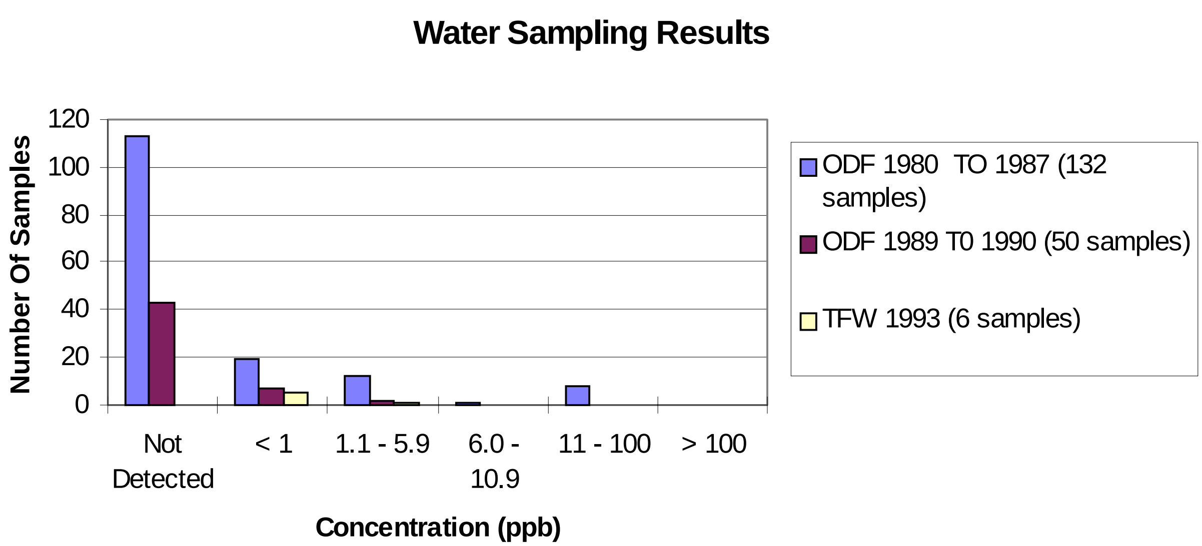

Figure 1. Pesticide Monitoring Results From Three Studies in Washington and Oregon

A 1999 study (Michael et al.) conducted in Alabama (in which hexazinone was applied well above the legal Oregon FPA level), found that the concentration of herbicide peaked several times from increased streamflow as long as 30 days after application. However, this study was designed to test the effects of hexazinone on aquatic insects. The application rate was three times the operationally prescribed rate, most likely in an attempt to assure that herbicide contamination would occur, and involved the application of pellet and liquid form of hexazinone.

Study Design

<u>Monitoring Questions</u>

This project was designed to answer the following monitoring questions:

Are forest practice rules protecting water quality from drift contamination during aerial applications of pesticides?

Are forest practice rules protecting riparian vegetation during aerial applications of herbicides?

In order to answer these questions ODF collected water quality samples on 26 volunteered herbicide and fungicide applications and surveyed riparian vegetation on 24 RMAs from 14 randomly selected harvest units. The 40 operations monitored in this project represent 2.1% of the average number of herbicide and fungicide applications (1,896) completed each year in the 1990's. However, this annual average (1,896) number of operations includes all aerial, hand, and roadside herbicide and fungicide applications. Therefore, the 40 sites monitored and surveyed for this study actually represent a portion of *aerial* applications at some level greater than 2.1%.

Trained field crews under the supervision of the ODF monitoring coordinator implemented the majority of this monitoring project. Other forest practices staff, landowners, and operators coordinated on different aspects of the project. Water quality monitoring took place in the spring and fall, while the vegetation surveys took place in the summer and fall. The Oregon Department of Agriculture (ODA) laboratory analyzed the water quality samples.

<u>Water Quality Sampling Design</u>

Nineteen sites were sampled in the Fall of 1997 and seven sites in the Spring of 1999. The sites were treated with either herbicides or fungicides. There were no insecticide operations conducted during the sampling period so this practice could not be monitored. Six samples were collected at each spray operation: one before the operation (control), and one each at 15 minutes, 2 hours, 4 hours, 8 hours, and 24 hours after the operation.

<u>Sample Location</u> Samples were collected approximately 0 to 200 feet downstream of the treatment unit boundary. Sample sites were accessed without walking or driving through the treatment units. The collection sites, had a uniform cross-section (no backwater or eddies) and had adequate flow to facilitate sample collection.

<u>Sample Timing</u> A control sample was collected within approximately one to two hours prior to application. The post-operation samples were timed to capture set intervals after the parcel of stream water that would have been in the unit during the application flowed through the sample location. The timing of sample collection was, therefore, based on the travel time of the water moving through the treatment unit. For example, the time of collection for the 15-minute sample was calculated as follows:

$$L / v / 60 \text{ seconds} + 15 \text{ minutes} = 15 \text{ minute sample time}$$

L = length (feet) of stream between top of treatment unit and sample point plus length (feet) of stream between bottom of treatment unit and sample point divided by 2

v = average stream velocity (ft / sec), measured with a velocity meter before control sample collection

Runoff Sampling The goal of ODF was to implement runoff sampling at all sites where a runoff event occurred within the first 72 hours of the pesticide application. This was not implemented for the 19 operations sampled in 1997 due to lack of resources. However, runoff-generating precipitation events were noted during the first 24 hours after spray for three of the Fall 1997 sample sites, effectively making seven of the preset-interval samples collected for these three sites runoff samples. The 72-hour runoff sampling procedure was implemented for the 1999 sample operations. However, no runoff-generating events occurred within 72 hours of application for any of the seven 1999 sample operations.

Collection Procedures The Oregon Department of Agriculture (ODA) laboratory has defined specific container and storage temperature requirements for given chemicals. These procedures were followed for ODF's sampling program. Monitoring personnel arrived at the sampling site without physical contact with vehicles or personnel from the spray operation and complied with the following procedure:

1. All equipment was clean and free of chemical residues. For each sample, a new pair of surgical-type sanitary gloves and pick up container were used.
2. Two labels were filled out and placed on bottle and lid. When using a plastic container, the sample number was written directly on the bottle as well as on the label.
3. Samples were taken while standing downstream of the sample location. Clothing was not allowed to make contact with the water.
4. Triple-rinsing of the sample container was done at the sample site, with rinse water emptied downstream.
5. While facing upstream, container was slowly sunk into the main flow of the water column until the lip was just below the surface and filled container.
6. ODF Water Quality Sampling forms were filled out (Figure A-3, Appendix A).

Sample Storage and Delivery to ODA Laboratory Samples were immediately put into watertight cold storage with a leak-proof cooling device (blue-ice, frozen water jugs, double-bagged ice cubes) and remained so until analyzed. Samples were transported to the laboratory as soon as possible. At no time were samples in contact with personnel directly involved with the pesticide application.

Selecting the Test Pesticide and Method Detection Limits
Often times, more than one chemical was applied in solution to a given site. The pesticide active ingredient applied at the highest concentration was selected for testing. After obtaining the brand name and the ounces per acre of all chemicals applied (from the landowner/operator) in the solution, the following formula was used to identify the pesticide active ingredient being applied with the highest concentration:

(% Concentration)*(Applied ounces per acre) = Actual ounces per acre

This is the chemical that was tested for in the lab. Percent concentrations of chemicals were derived from label information. Table A-2 in Appendix A provides information for commonly encountered brand names.

The method detection limit (mdl) defines the lowest concentration at which the indicated contaminant can be detected. Samples from 21 sites were tested at an mdl of 1 ppb. This means that if the pesticide active ingredient was present at levels of 1 ppb or greater, the lab would have detected it. The remaining samples from five sites were tested at mdls of 0.04, 0.1, 0.5 ppb. These samples were tested at a lower limit due to a miscommunication with the lab. All these detection limits are well below what is currently considered injurious to human health and aquatic and terrestrial life (see Evaluation Methods section in this paper). Such low mdls were selected in the event that the current state of knowledge regarding these "toxicity criteria" should change.

Riparian Vegetation Protection

Effectiveness of forest practice rules in protecting riparian vegetation during aerial herbicide applications was evaluated as part of the ODF's Best Management Practices Compliance Monitoring Project (BMPCMP). The BMPCMP is an ongoing project (1998-2001) that evaluates randomly-selected harvest operations throughout the state for compliance with various forest practice rules. During herbicide applications, the riparian vegetation identified by the water protection rules must be protected. "Protection" means no direct application and no damage resulting in the loss of function of the riparian area. Protection of understory and overstory vegetation from aerial herbicide applications was surveyed on 24 RMAs from 14 randomly selected harvest operations. Herbicide application occurred six to eighteen months prior to the field evaluation.

Evenly spaced transects were established every 100 to 200 feet depending on the length of the RMA, with transects perpendicular to the stream. Along each transect the crew surveyed understory and overstory vegetation for impacts from aerial herbicide applications (e.g. deformed or curled leaves, spotting, or dead vegetation).

Operator Questionnaire. The operators/landowners filled out a questionnaire (Table A-4, Appendix A) describing the aerial application. This questionnaire provided information on chemicals applied, weather conditions, application rates, flight and equipment specifications, and offset from stream edge.

Site and Operation Characteristics

Sixteen sites were located in the Coast Range georegion, eight in the Interior georegion, and two in the Western Cascades georegion. Figure 2 shows the general location of each sample site. Twelve small, nine medium, and five large streams were sampled from these georegions. Twenty-one were Type F streams, three were Type D streams, and two were Type N streams. The Type N streams (both small) had overstory canopies similar to those found along Type F streams, a practice not required for small Type N streams. Table 1 displays the characteristics for each site. Stream widths averaged nine feet, with average velocity and stream flow of one foot per second and one cubic foot per second, respectively. The average stream length through the harvest unit was approximately 2000 feet.

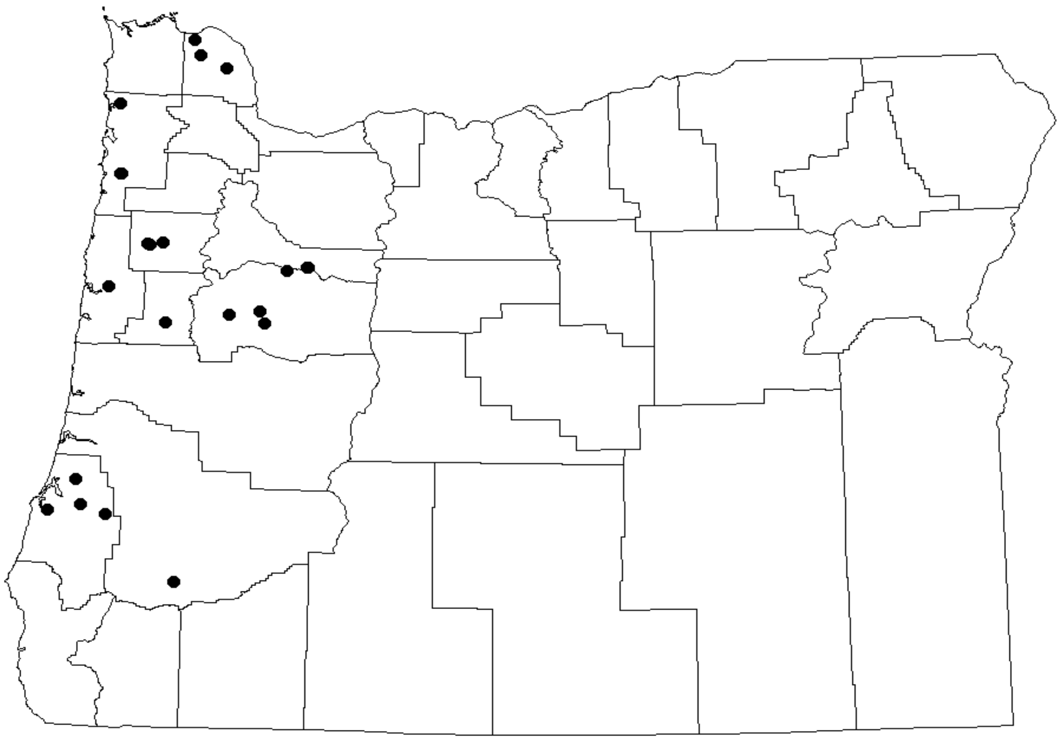

Figure 2. Water Quality Monitoring Operation Locations. Oregon with county lines; dots represent sampling locations.

Operation characteristics such as weather conditions, application rates, and application methods are detailed in Table 2 and Table 3. Average wind speed was 1 mph. Average relative humidity and air temperature was 79% and 64°F, respectively. Flight altitude and speed averaged 34 feet and 46 mph, respectively. On average, aerial herbicide and fungicide applications along Type F and D streams and fungicide applications along flowing Type N streams (all 26 sites) were 100 feet away from stream edges (60-foot buffer required by FPA). The two aerial applications of fungicide along Type F streams stayed 300 feet away from the stream edges (300-foot buffer required by FPA). See Table A-1 in Appendix A for complete buffer requirements.

In general, aerial pesticide applications consisted of mixtures of multiple products along with surfactants (Table 3). Water quality samples were tested for the pesticide present in the highest concentration at each site. There were seven different pesticides that appeared in highest concentrations and were tested for. They included 12 sites with glyphosate; four with chlorothalonil; three with 2,4-D ester; two each with tryclopyr, clopyralid, and hexazinone; and one with sulfometuron (see Table 3). See Table B-1 in Appendix B for operational equipment used and Appendix C for site maps showing spray boundary and sampling location.

Table 1. Site Characteristics

Site #	Year	Geo-region*	Stream Size	Stream Type	Avg. Vel. (ft/s)	Stream Flow** (ft3/s)	Wetted Width (ft)	Length of Stream (ft)	Sample Dist. to Unit (ft)	FPA Required Buffer (ft)
1	1997	CR	S	F	0.81	-	-	1000	150	300
2	1997	CR	S	N	0.74	-	-	1000	125	60
3	1997	IN	S	D	0.05	-	-	1300	100	60
4	1997	CR	S	N	0.74	-	-	1000	200	60
5	1997	CR	S	F	0.81	-	-	1000	200	300
6	1997	CR	L	F	0.27	-	26	1932	44	60
7	1997	CR	S	F	0.05	0.27	-	1600	227	60
8	1997	IN	S	F	0.81	0.34	2.5	4500	189	60
9	1997	CR	M	F	1.8	-	-	1000	50	60
10	1997	CR	L	F	3	-	-	1500	50	60
11	1997	CR	M	F	2.5	4.87	4.5	3000	150	60
12	1997	IN	M	F	2	1.14	3.5	1000	100	60
13	1997	WC	S	D	3	-	-	600	0	60
14	1997	WC	S	D	3	-	-	100	700	60
15	1997	CR	M	F	0.27	0.2	2.5	1400	170	60
16	1997	IN	S	F	1	-	-	1600	200	60
17	1997	CR	L	F	0.5	-	25	1500	10	60
18	1997	CR	M	F	0.4	2.72	4	400	0	60
19	1997	CR	S	F	0.28	0.25	3.5	3850	150	60
20	1999	CR	S	F	0.23	-	3	800	200	60
21	1999	CR	M	F	1.8	-	11	3900	164	60
22	1999	CR	M	F	1.31	-	8	1300	165	60
23	1999	IN	L	F	1.9	-	18	7780	160	60
24	1999	IN	M	F	4.56	-	9	2300	100	60
25	1999	IN	M	F	1.63	-	9	3200	143	60
26	1999	IN	L	F	1.43	-	11	3920	150	60
		Average			**1**	**1**	**9**	**2019**	**150**	
		Maximum			**0.05**	**0.2**	**2.5**	**100**	**0**	
		Minimum			**4.56**	**4.87**	**26**	**7780**	**700**	

* CR = Coast Range, IN = Interior, WC = Western Cascades.

** - = No data available

[shaded box] = sites 1, 2, 4, and 5 were fungicide applications, all others were herbicide applications

Table 2. Weather Conditions and Operations Characteristics

Site #	Applicat. Season	Runoff Event	Wind Speed** (mph)	Wind Direction*	Relative Humid. (%)	Air Temp. (°F)	Flight Altitude (ft)	Flight Speed (mph)	Actual Buffer Width
1	Fall	No	0	NA	89	55	10	40	300
2	Fall	No	0	NA	75	61	10	40	250
3	Fall	No	4	SE	54	58	15	37	257
4	Fall	Yes	0	NA	100	65	10	40	200
5	Fall	Yes	0	NA	100	65	10	40	300
6	Fall	No	0	NA	90	62	30-150	45	60-100
7	Fall	No	0	NA	95	55	40-50	45	60-100
8	Fall	Yes	-	-	-	-	-	-	-
9	Fall	No	1-2	N	82	54	10-50	55	-
10	Fall	No	-	-	-	-	-	-	-
11	Fall	No	0-2	SW	65	71	30	45	60-100
12	Fall	No	0-3	E	75	65	<50	45	60-100
13	Fall	No	1-2	SE	-	-	-	-	-
14	Fall	No	1-3	SE	-	-	-	-	-
15	Fall	No	2-3	SW	93	64	40-60	45	60-100
16	Fall	No	0	NA	58	67	varies	55	>60
17	Fall	No	1-3	SE	88	57	40-60	45	60-100
18	Fall	No	-	-	-	-	-	-	-
19	Fall	No	0	NA	94	62	40-60	45	60-100
20	Spring	No	0	NA	76	54	40	45	>60
21	Spring	No	1-2	E	56	54	10-20	50	60-100
22	Spring	No	1-2	NE	83	83	10-20	50	60-100
23	Spring	No	0	NA	65	65	30	49	>100
24	Spring	No	2-3	NW	74	74	20-70	45	>100
25	Spring	No	1-5	NE	91	91	60	45	60-100
26	Spring	No	2-3	SW	65	65	25	50	100
		Average	**1**		**79**	**64**	**34**	**46**	**110#**
		Maximum	**4**		**100**	**91**	**90**	**55**	**257**
		Minimum	**0**		**54**	**54**	**10**	**37**	**60**

* NA = Wind direction not applicable for wind speeds of zero.
** - = Data not available
# = Average spray buffer from stream for herbicide applications only, excludes fungicide applications
[shaded box] = sites 1, 2, 4, and 5 were fungicide applications, all others were herbicide applications

Table 3. Target Pest, Chemicals Applied and Rate Information

Site #	Spray Target	Pesticide Brand Name	Use Rate (oz/ac)	Pesticide Active Ingredient	Percent Concen. (%)	Actual Rate (oz/ac)	Other Pestic.	Use Rate* (oz/ac)	Surfactant Added	Use Rate* (oz/ac)	Carriers Used**	Mix Rate** (gal/ac)
1	Swiss Needle Cast	Bravo Weather Stik	88	Chlorothalonil	54	47.5	None	NA	None	NA	-	30
2	Swiss Needle Cast	Bravo Weather Stik	88	Chlorothalonil	54	47.5	None	NA	None	NA	-	30
3	Alder	Weedone LV6	32	2, 4-D ester	83.5	26.7	None	NA	None	NA	water	10
4	Swiss Needle Cast	Bravo Weather Stik	88	Chlorothalonil	54	47.5	None	NA	None	NA	-	30
5	Swiss Needle Cast	Bravo Weather Stik	88	Chlorothalonil	54	47.5	None	NA	None	NA	-	30
6	Misc. brush and maple	Accord	48	Glyphosate	41.5	19.9	Arsenal Oust Escort	6 3 1	Sylgard 309	3.2	water	10
7	Misc. brush and grasses	Accord	64	Glyphosate	41.5	26.6	Escort Oust	3 1	Activator 90	8	water	10
8	-	Accord	64	Glyphosate	41.5	26.6	Oust	3	R-11	8	-	-
9	Misc. brush and grasses	Accord	48	Glyphosate	41.5	19.9	Arsenal Oust Escort	4 4 1	NU-Film	4	water	-
10	-	Accord	48	Gyphosate	41.5	19.9	Arsenal	5	Activator 90	2	-	-
11	Misc. brush and grasses	Accord	48	Glyphosate	41.5	19.9	Oust	3	LI 700	2	-	-
12	Maple and grasses	Accord	80	Glyphosate	41.5	33.2	Oust	3	Sylgard 309	3.2	water	10
13	-	Garlon 4	32	Triclopyr	61.6	19.7	Oust	2	Bivert STA-PUT	6 4	water	-
14	-	Garlon 4	32	Triclopyr	61.6	19.7	Oust	2	Bivert STA-PUT	6 4	water	-
15	Misc. brush and maple	Accord	40	Glyphosate	41.5	16.6	Oust	3	Activator 90	2	water	5
16	Misc. brush and maple	Accord	64	Glyphosate	41.5	26.6	Arsenal Oust	6 3	Sylgard 309	3.2	water	10
17	Grasses and maple	Accord	40	Glyphosate	41.5	16.6	Oust	3	Activator 90	2	water	5
18	-	Accord	48	Glyphosate	41.5	19.9	Arsenal Oust	8 3	R-11	16	water	5
19	Misc. brush and maple	Accord	40	Glyphosate	41.5	16.6	Oust	3	Activator 90	2	water	
20	Misc. brush and grasses	Transline	8	Clopyralid	0.41	3.3	Oust	2	None	NA	Water	5
21	Misc. weeds and grasses	Transline	8	Clopyralid	0.41	3.3	Oust	2	None	NA	Water	-
22	Misc. weed and grasses	Velpar	64	Hexazinone	0.25	16	Oust	2	None	NA	Water	-
23	Madrone and oak	Low Vol 6	46	2,4-D	83.5	38.4	Garlon 4	61.6	None	NA	Water Diesel	6 3.5
24	Misc. brush and grasses	Velpar	64	Hexazinone	0.25	16	Oust	3	None	NA	Water	10
25	Misc. brush and alder	Low Vol 6	64	2,4-D	88.8	56.8	None	NA	STA-PUT	6.4	Water	-
26	Misc. brush and grasses	Oust	3	Sulfometuron	0.75	2.25	None	NA	None	NA	Water	10

* NA = Not applicable
** - = Data not available
[shaded box] = sites 1, 2, 4, and 5 were fungicide applications, all others were herbicide applications

Table 4. Surface Water Quality Criteria for Forest Chemicals. (Provided by Dr. N. I. Kerkvliet, OSU Extension Toxicology Specialist). Water Quality Criteria expressed as an average 24-hour concentration in surface water.

All values in parts per billion (ppb)

CHEMICAL	HUMAN HEALTH (10 day HA[a])	FISH 48- or 96-hr LC_{50}[aa] (100-fold safety factor)	INVERTEBRATES 48- or 96 hr LC_{50}
MOST COMMONLY APPLIED FOREST HERBICIDES			
2,4-D amine	300	salmon 3500	daphnia 4000
2,4-D ester	300	bluegill 7	daphnia 100
Atrazine	100	trout 45	midge 720
Clopyralid	500[ab]	trout 1030	daphnia 2.25×10^5
Glyphosate (w/o surfactant)	17500	salmon 6800	daphnia 9.3×10^5
Glyphosate (w/surfactant)	17500	trout 13	daphnia 300
Hexazinone	2500[b]	trout 3200	daphnia 52000
Imazapyr	10000[bb]	trout 1100	daphnia 3.5×10^5
Metsulfuron methyl	2500[c]	trout 1500[d]	daphnia 1.5×10^5[d]
Sulfometuron methyl	1000[e]	trout 125[f]	daphnia 12500[f]
Triclopyr amine	50[g]	trout 1170	daphnia 1.2×10^5[h]
Triclopyr ester	50	trout 7.4	no data found
MOST COMMONLY APPLIED FOREST INSECTICIDES			
<u>Bacillus</u> <u>thuringiensis</u>	exempt	trout>12×10^9spores/L	N/A
Carbaryl	1000	brook trout 6.9	stonefly 1.7 to 29 daphnia 5.6
Diflubenzuron	200[i]	trout 1350	stonefly 2.0 daphnia 0.015
MOST COMMONLY APPLIED FOREST FUNGICIDES			
Chlorothalonil	200	trout 0.5	daphnia 70
FERTILIZERS			
Free Ammonia	no data	salmon 83	general 53 to 22,800
Nitrate –N	10,000[j]	no data	no data
Ammonia-N	500	no data	no data
Ammonium sulfamate	30,000[k]	carp 10,000	no data
DIESEL (used as a carrier)	no data	fish 1.9	no data

<u>Footnotes to Table 1</u>:

a) unless otherwise indicated. HA = health advisory
aa) LC_{50} = lethal concentration for 50% of population
ab) based on Reference Dose (RFD) of 0.5 mg/kg/day
b) 90-day HA
bb) based on rabbit no observed effect level (NOEL) of 400 mg/kg/day, 400-fold safety factor
c) based on RFD of 0.25 mg/kg
d) based on LC_{50} > 150 mg/L
e) based on RFD of 0.1 mg/kg
f) based on LC_{50} > 12.5 mg/L
g) based on 1-yr dog No Observable Effects Level (NOEL) of 0.5 mg/kg/day
h) based on 21-day calculated oncentration which retards 50% of growth (EC_{50})
i) based on 1-yr dog NOEL of 2 mg/kg/day
j) MCL = Maximum Contaminant Level
k) lifetime HA

Evaluation Methods

Protection of Water Quality

Since the forest practice rules allow for minute, but measurable, concentrations of applicable chemicals to reach waters of the state, rule effectiveness depends on determining if such concentrations are considered injurious to water quality or terrestrial or aquatic life. Therefore, the forest practices staff, with input from Dr. Nancy Kerkvliet (Oregon State University) and Dr. Robert Pratt (Portland State University), developed Surface Water Quality Criteria for Forest Chemical Operations (Table 4). These criteria, expressed as the 24-hour average concentration, were developed in 1996 from current toxicological studies as a basis for evaluating pesticide and fertilizer monitoring results. The water quality results of this monitoring study were compared against these values to evaluate whether identified drift contamination levels were a cause for concern for aquatic biota and human health.

The surface water quality criteria are based on extended (chronic) pesticide and fertilizer exposure, even though it is assumed that drift contamination from a forest operation should only result in short-term (acute) exposure. Therefore, it was assumed that these criteria represent concentrations at which it is highly unlikely that any long-term adverse impacts would occur for humans, fish, or aquatic invertebrates (Kerkvliet, et. al 1996). Even so, it must also be emphasized that these numbers are not intended to represent permissible pollution levels (Norris and Dost 1992). A more appropriate interpretation is to view the criteria as “thresholds of concern” that should trigger more intensive monitoring if often exceeded even though BMPs are followed.

Protection of Riparian Vegetation

Effectiveness of the rules in protecting riparian vegetation was determined based on visible damage or destruction of overstory and understory riparian vegetation that resulted from aerial herbicide applications. The percent of the riparian area damaged was measured and reported.

Results

Protection of Water Quality from Drift Contamination

One control sample and five post-spray samples were collected on each of 26 sites, for a total of 130 post-spray samples. Each of these samples were analyzed individually to determine concentrations of the pesticide throughout time. There was no detectable pesticide in any of the control samples. The remainder of this section addresses the post-spray samples.

Samples from 21 sites (105 post-spray samples) were tested at a method detection limit (mdl) of 1 ppb. The 24-hour sample from site 24 was lost during analysis, so a result for this sample is not available (bringing this total down to 104 post-spray samples).

The detection limit was even lower than 1 ppb for samples from the remaining five sites. These 25 post-spray samples were tested at mdls that ranged from 0.04 to 0.5 ppb (Table 5). The detection limits used in analyzing all the water quality samples (at least 1 ppb) are well below the concentrations listed in the surface water quality criteria (Table 4).

No pesticide was detected at concentrations $\geq$ 1 ppb. Pesticide was only detected in a subset of the samples tested at mdls < 1ppb. Hexazinone and 2,4-D were detected in samples from two of the five sites tested at mdls below 1 ppb (Figure 3). For site 22, Hexazinone was detected in all five of the post-spray samples (mdl = 0.1 ppb). The concentrations were 0.9, 0.34, 0.51, 0.56, and 0.1 (for the 15 min, 2-, 4-, 8-, and 24-hour samples, respectively)

(Figure 4). For site 25, 2,4-D was detected in two of the five post-spray samples (mdl = 0.1 ppb). The concentrations were 0.14, and 0.14 for the 4 and 8 hour samples (Figure 4). There were no pesticides detected in the samples for the three other sites (15 post spray samples) that were tested at mdls of 0.5 and 0.04 ppb. This includes results from one site (five post-spray samples) treated with oust and tested at an mdl of 0.04 ppb.

Operation Characteristics for Sites with Drift Contamination

Original plans for this project were to analyze the operation and weather data for sites with detectable drift contamination. However, because all detected contamination levels were below 1 ppb and only five sites were tested at an mdl below 1 ppb, analysis of these conditions would not be statistically valuable. Stream, wheather, application, chemical, and equipment data are provided in Tables 1, 2, 3, 4, and Table B-1 Appendix B and discussed in the Site and Operation Characteristics section.

Protection of Water Quality from Runoff Contamination

Measurable runoff-generating precipitation occurred during the first 24 hours following pesticide application for three of the sites sampled in 1997. For sites 4 and 5, the 4-, 8-, and 24-hour samples were affected by precipitation and initial runoff, as well as the 24-hour sample for site 8. No detectable levels (mdl = 1 ppb) of pesticides were found in any of the seven samples for these three sites. There were no runoff-generating precipitation events within the first 24 hours following application nor within the 72 hours for any of the 1999 sample sites.

Protection of Riparian Vegetation

Twenty-four RMAs adjacent to aerial pesticide applications were evaluated by the BMP Compliance Monitoring Project (BMPCMP) for protection of riparian vegetation from direct herbicide application or spray drift. These RMAs were on seven small, eight medium, and nine large Type F streams from 14 operations. RMA lengths varied from 200 feet to 2500 feet. The RMA widths varied from 10-100 feet, and riparian prescriptions included no-harvest buffers, harvest to basal area standard target, site specific prescriptions, and hardwood conversions (Table 6).

The BMPCMP found no herbicide application damage to the riparian vegetation that is required to be protected by the water protection rules. As well, this study found no evidence of direct herbicide application within the 60-foot offset required by the forest practice rules along Type F and D streams. Please refer to the BMPCMP protocol (Dent and Robben 1998), Pilot Study Report (Dent and Robben 1999), and final report (due in late 2001) for further information on compliance monitoring.

Table 5. Water Sample Pesticide Analysis Results

Site #	Season	Length of Unit (ft)	Chemical Tested	Method Detection Limit (ppb)	Runoff Samples	Sample Results * Control 1	15 min 2	2 hr 3	4 hr 4	8 hr 5	24 hr 6
1	Fall 97	1000	Chlorothalonil	1	None	NDL	NDL	NDL	NDL	NDL	NDL
2	Fall 97	1000	Chlorothalonil	1	None	NDL	NDL	NDL	NDL	NDL	NDL
3	Fall 97	1320	2, 4-D ester	1	None	NT**	NDL	NDL	NDL	NDL	NDL
4	Fall 97	Unk.	Chlorothalonil	1	# 4,5,6	NDL	NDL	NDL	NDL	NDL	NDL
5	Fall 97	Unk.	Chlorothalonil	1	# 4,5,6	NDL	NDL	NDL	NDL	NDL	NDL
6	Fall 97	1932	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
7	Fall 97	1600	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
8	Fall 97	4500	Glyphosate	1	# 6	NDL	NDL	NDL	NDL	NDL	NDL
9	Fall 97	1000	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
10	Fall 97	1500	Gyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
11	Fall 97	3000	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
12	Fall 97	1000	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
13	Fall 97	400	Triclopyr	1	None	NDL	NDL	NDL	NDL	NDL	NDL
14	Fall 97	900	Triclopyr	1	None	NDL	NDL	NDL	NDL	NDL	NDL
15	Fall 97	1400	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
16	Fall 97	1600	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
17	Fall 97	1500	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
18	Fall 97	400	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
19	Fall 97	3850	Glyphosate	1	None	NDL	NDL	NDL	NDL	NDL	NDL
20	Spring 99	800	Clopyralid	0.5	None	NDL	NDL	NDL	NDL	NDL	NDL
21	Spring 99	3900	Clopyralid	0.5	None	NDL	NDL	NDL	NDL	NDL	NDL
22	Spring 99	1300	Hexazinone	0.1	None	NDL	0.9	0.34	0.51	0.56	0.1
23	Spring 99	7780	2,4-D	1	None	NDL	NDL	NDL	NDL	NDL	NDL
24	Spring 99	2300	Hexazinone	1	None	NDL	NDL	NDL	NDL	NDL	NA***
25	Spring 99	3200	2,4-D	0.1	None	NDL	NDL	NDL	0.14	0.14	NDL
26	Spring 99	3920	Sulfometuron	0.04	None	NDL	NDL	NDL	NDL	NDL	NDL

* NDL = No detectable level
** NT = control sample not tested
*** NA = Sample lost, result not available

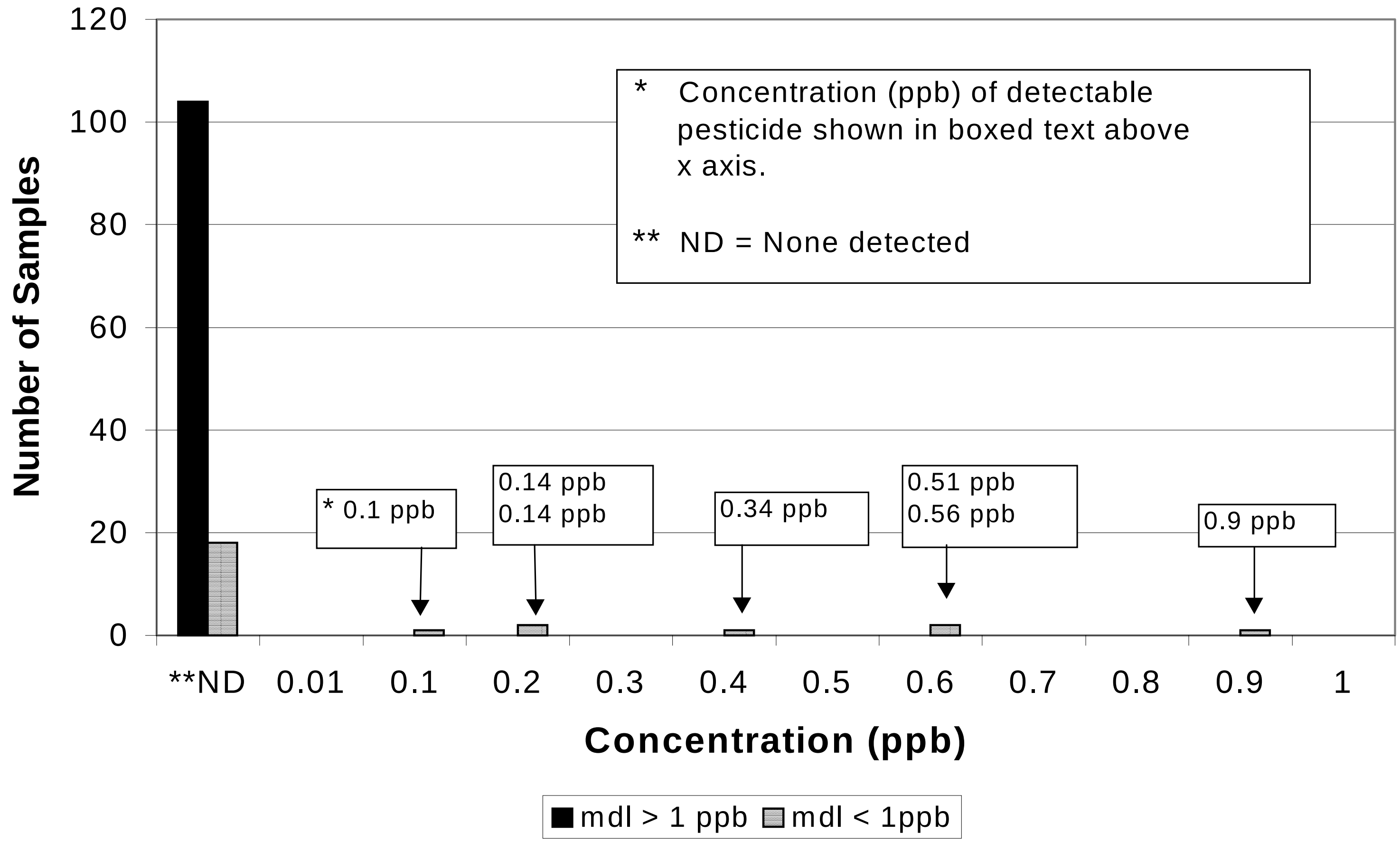

Figure 3. Concentrations of Pesticides Detected in 129 Post-Spray Samples from 26 operations (mdl = 0.04-1.0). Seven out of 25 samples tested at mdl < 1 ppb contained trace concentrations of pesticide.

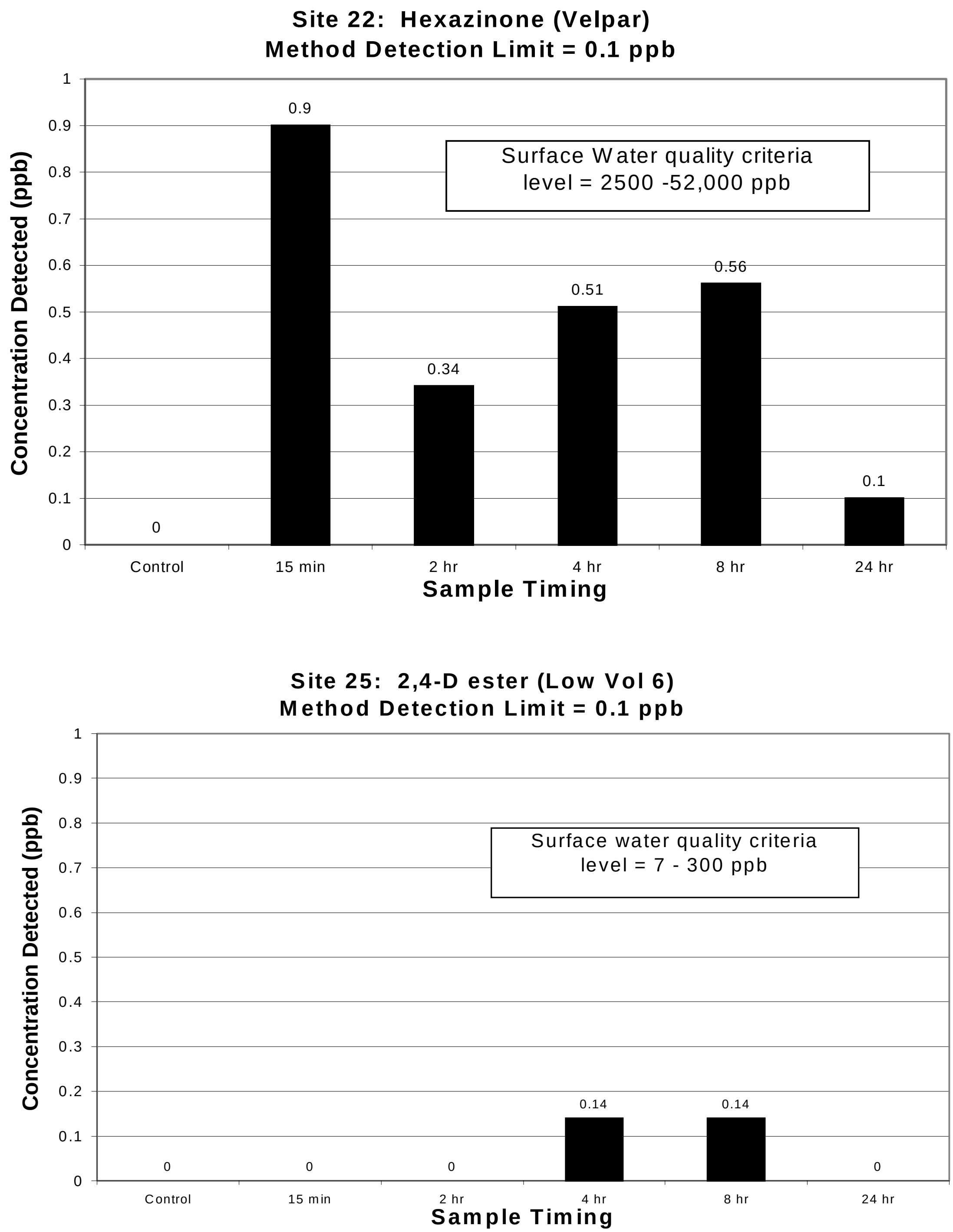

Figure 4. Pesticide Concentration Levels Detected in Water Samples from Sites 22 and 25.

Table 6. Impacts to Riparian Vegetation from Aerial Herbicide Applications. Assessed by the ODF Best Management Practices Compliance Monitoring Project.

BMPCMP RMA #	Year Surveyed	Stream Size	Stream Type	Stream Length (ft)	RMA Prescription (code)*	Riparian Overstory Canopy Wd.(ft)#	RMA Spray/Drift Impacts
5A	1998	M	F	900	BW	70	No
5B	1998	M	F	900	BW	70	No
5C	1998	L	F	2500	BW	100	No
14A	1998	M	F	400	BW	70	No
14B	1998	S	F	500	BA	42	No
14C	1998	S	F	1350	BA	32	No
18A	1998	S	F	800	SS	50	No
19A	1998	M	F	1200	BW	70	No
25A	1998	M	F	1200	SS	34	No
28A	1998	L	F	4000	BW	100	No
30A	1998	L	F	2600	BA	80	No
30B	1998	L	F	1200	BA	82	No
31A	1998	S	F	2500	BW	50	No
31B	1998	M	F	1000	BW	69	No
38A	1998	M	F	1500	BA	-	No
38B	1998	M	F	1890	BA	-	No
40A	1998	S	F	740	BW	49	No
40B	1998	S	F	2000	BW	50	No
41A	1998	S	F	200	BW	50	No
52A	1998	L	F	600	HWC	10	No
52B	1998	L	F	200	HWC	30	No
52C	1998	L	F	550	HWC	10	No
21A	1999	L	F	500	BW	93	No
77A	1999	L	F	1500	BW	100	No

* BW = Buffer width, no RMA harvest
BA = Basal area general prescription
SS = Site specific RMA prescription
HWC = Hardwood conversion (Alternate Prescription # 2)

- = Data not available, standing buffer width not measured

Summary and Conclusions

The Oregon Department of Forestry conducted a project to monitor the effectiveness of forest practice rules in protecting water quality and riparian vegetation during aerial application of pesticides. The project was implemented in 1997 and 1999. One control and five post-spray water samples were collected from 26 streams adjacent to aerial forest pesticide applications in western Oregon. Samples from 21 sites were tested at an mdl of 1ppb. Samples from five sites were tested at an mdl of less than 1 ppb. Three sites (seven samples) were affected by runoff generating rainfall within the first 24 hours of applications. Riparian vegetation surveys were conducted on an additional 24 RMAs from 14 operations to determine if riparian vegetation is adequately protected from aerial applications of herbicides.

Monitoring Question #1

Are forest practice rules protecting water quality from drift contamination during aerial application of pesticides?

Based on current understanding of the toxicity of commonly used forest pesticides with regard to human health and aquatic biota, the authors conclude that forest practice rules are effective at protecting water quality during aerial herbicide and fungicide applications on Type F and D streams. These results pertain to contamination from drift or direct application on Type F and D streams. The Type N streams sampled here had vegetation and spray-boundary offset buffers similar to those of Type F streams. Issues concerning other mechanisms of contamination were not addressed with this study. Furthermore, the effectiveness of water quality protection on streams without overstory riparian buffers or offset spray boundaries (typical practice on Type N streams) was not evaluated.

No pesticide contamination levels at or above 1 ppb were found in any of the post-spray samples analyzed. Seven of the 25 post-spray samples (for 2 of 5 sites) that were tested at levels lower than 1 ppb (mdl 0.5 to 0.04 ppb) were found to contain trace levels of the applied pesticide. Contamination levels ranged from 0.1 to 0.9 ppb. The contaminants included hexazinone from site 22 and 2 4-D ester from site 25. The forest practice rules allow for some level of contamination as long as it is not harmful to aquatic or terrestrial life, human health, or water quality.

Current literature and ODF monitoring criteria indicate that thresholds of concern for human health and aquatic biota start at levels much higher than 1 ppb (see Table 4). The surface water quality criteria for hexazinone (found in five samples from site 22) are 2500 for human health, 3200 for trout health, and 52,000 ppb based on daphnia mortality. The surface water quality criteria for 2 4-D ester (found in two samples from site 25) are 300 ppb for human health, 7 ppb based on bluegill health, and 100 ppb based on daphnia mortality (Table 4).

The hexazinone thresholds were confirmed with an Alabama study that looked at the effects of hexazinone on aquatic insects (Michael et al. 1999). The authors observed maximum concentrations of the herbicide hexazinone at 422 and 473 ppb. These concentrations resulted from intentional direct spray of the stream. The authors concluded that aquatic insects were not sensitive to hexazinone even at these levels.

Runoff-generating precipitation did not result in detectable contamination levels in any of the applicable samples from three sites (seven samples). Efforts were made to collect additional data on runoff contamination but were not completed due to lack of runoff within 72 hours of application or because of coordination issues.

Monitoring Question #2

Are forest practice rules protecting riparian vegetation during aerial application of pesticides?

Forest practice rules are effective at protecting understory and overstory riparian vegetation on Type F and D streams during aerial application of herbicides. There was no damage to riparian vegetation protected by the FPA water quality rules that occurred as a result of herbicide applications on 24 RMAs along Type F streams.

Recommendations

When this protocol was adopted, current research indicated the highest peaks of contamination occurred within 24 hours of a forest pesticide application. Additional peaks were considered possible if a runoff generating event occurred within 72 hours of application. This study assessed water quality protection primarily on Type F and D streams. The focus was on the first 24 hours after aerial application with a secondary goal of looking at runoff contamination that might occur within 72 hours of the application. Therefore, the conclusions apply to potential contamination resulting from drift or direct spray on streams that have overstory riparian buffers as required under current Oregon forest practices rules.

Future Monitoring

This study was not able to address the issues of delayed impacts to water quality that might occur as a result of other mechanisms besides drift or direct applications. Currently, there is no significant research was identified to indicate that contamination will occur from runoff events occurring beyond 72 hours of a typical forest operation, such as those represented by these data. Until such time as research demonstrates other mechanisms and timing of water quality contamination, chemical monitoring is a low priority for the Forest Practices Section. Continued water sampling will occur as needed to respond to public complaints and to facilitate enforcement action.

If chemical monitoring is prioritized in the future, the focus should consider a number of topics that were not addressed by this study. One of the goals of this study was to monitor the effectiveness of the new rules with regard to non-biological insecticides. There were no large-scale insecticide applications during the course of this study and so this goal was not met. Therefore, the highest priority for future monitoring should be on non-biological insecticides.

This study also did not address water quality protection of streams that do not have an overstory riparian buffer (small Type N streams). Furthermore, this study did not address surfactants, “inert” ingredients, or fertilizers. This study was not selective in terms of a particular herbicide focus. Future monitoring should consider if there is any reason to focus efforts on particular herbicides. For example, Oust (sulfometuron) was commonly used but in such small concentrations that it was only tested for once. In addition, the ODA laboratory only recently developed the methodology to test for it.

Policy

These results indicate that the rules are effective at protecting water quality on Type F and D streams. If the current scientific knowledge of hazard levels for human and aquatic biota do not change, no changes are recommended to the forest practice rules.

The department, in partnership with the research community, should continue to refine the surface water quality criteria to address new pesticides (e.g. clopyralid) and to incorporate new information derived from toxicological studies.

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Appendix A:
Buffer Requirements, Pesticide Label Information, and Field Forms

Table A-1. Buffer Requirements for Different Types of Water Bodies When Chemicals are Applied on Forestland Under the Forest Practice Rules

Required Chemical Application Buffers for Waters of the State	Herbicides, rodenticides, biological insecticides, and All other chemicals except fungicides, Non-biological Insecticides, and Fertilizers.		Fungicides and Non-biological Insecticides		Fertizers	
	Aerial Applications	Ground Applications	Aerial Applications	Ground Applications	Aerial Applications	Ground Applications
Aquatic areas of fish bearing streams with no domestic use (most Type F streams)	60 feet	10 feet	300 feet	10 feet	No direct application	No direct application
Aquatic areas of domestic use streams (all Type D and some Type F streams)	60 feet	10 feet	300 feet	10 feet	100 feet	100 feet
Aquatic areas of other streams (Type N streams)	No Buffer Specified	No Buffer Specified	60 feet if flowing at time of application	No Buffer Specified	No direct application to large and medium streams	No direct application to large and medium streams
Significant wetlands	60 feet	10 feet	300 feet	10 feet	No direct application	No direct application
Aquatic areas of lakes larger than 8 acres	60 feet	10 feet	300 feet	10 feet	No direct application	No direct application
Aquatic areas of other lakes with fish use.	60 feet	10 feet	300 feet	10 feet	No direct application	No direct application
Other standing water larger than ¼ acre at time of application.	60 feet	10 feet	300 feet	10 feet	No direct application	No direct application
All other waters	No Special Buffer required	No Buffer Specified	No Buffer Specified	No Buffer Specified	No Buffer Specified	No Buffer Specified

Table A-2. Test Pesticide Selection

Often times more than one chemical is applied in solution. The pesticide applied at the highest concentration will be tested for. After obtaining the brand name and the applied ounces per acre from the landowner/operator, use the following formula and Table 3 to identify the pesticide being applied with the highest concentration. This is the chemical that will be tested for in the lab.

(% Concentration)*(Applied ounces per acre)= Actual ounces per acre.

Table A-2. Forest pesticides brand names, active ingredients and concentrations

Brand Name	Active Ingredient	% Concentration
Herbicides:		
Low Vol 6	2,4-D	88.8
Amine 4 2,4-D	2,4-D	46.5
Weedar 64	2,4-D	46.8
Weedone LV4	2,4-D	60.8
Weedone LV6	2,4-D	83.5
Amine 4	2,4-D	47.3
Lo Vol-4	2,4-D	67.2
Lo Vol-6	2,4-D	87.3
Tordon 101	2,4-DP	49.8
Aatrex Nine-O	Atrazine	85.5
Atrazine 90 DF	Atrazine	85.5
Conifer 90	Atrazine	85.5
Accord	Glyphosate	41.5
Velpar	Hexazinone	25
Arsenal	Imazapyr	53.1
Chopper	Imazapyr	3.6
Escort	Metsulfuron methyl	60
Access	Picloram, Triclopyr	17.1, 32.5
Oust	Sulfometuron methyl	75
Garlon 4	Triclopyr	61.6
Garlon 3A	Triclopyr	44.4
Pathfinder	Triclopyr	16.7
Transline	Clopyradil	40.9
Fungicides:		
Bravo 720	Chlorothalonil	54
Insecticides:		
DiPel 6AF	Bacillus thuringiensis (BT)	2.15
Thuricide 48LV	Bacillus thuringiensis (BT)	2.4
Thuricide 32LV	Bacillus thuringiensis (BT)	1.6
Sevin 4-OIL ULV	Carbaryl	47.5
Sevimol	Carbaryl	40
Rodenticides:		
ORCO	Strychnine	0.5

Figure A-3. Water Quality Pesticide Sampling Form

Obtain or draw schematic map of unit, streams, buffers, and flight patterns.
Notification number:____
Stream name: ____
Applied pesticide: ____
Basin name: ____
Monitoring personnel name(s): _____________________________________
Spray start time: ____

Average stream velocity (*v*): ____________(ft/sec)
Distance from closest spray boundary to sampling area (*l*): ____________
Distance from lower boundary to upper boundary (*L*): ____________
'15 minute' sampling time: (*L*+*l*)/2 * 1/*v* * 1/60 seconds + 15 = ________ minutes

Determine which pesticide to test for:

	Chemical	**% Concentration**	**Applied ounces per acre**	**Actual ounces per acre**
1)				
2)				
3)				
4)				

Get 'chemical' and the 'applied ounces/acre' information from the landowner. Use Table 3 to determine the % concentration for a given pesticide. Multiply '% concentration' by 'applied ounces/acre' to determine 'actual ounces/acre' for every pesticide that is applied. The pesticide with the highest value for actual ounces per acre will be tested for in the laboratory.

Pesticide to test for at the < or = 2ppb level of concentration: ________________
Sampling start time: _______________ Date: __________________

SAMPLE DESCRIPTION	SAMPLE COLLECTION		SAMPLE ID NUMBER
	DATE	TIME	
Control Sample			
'15 minute'			
2 hour			
4 hour			
8 hour			
24 hour			
Runoff Sample #1 (opt)			
Runoff Sample #2 (opt)			
Runoff Sample #3 (opt)			

Figure A-4. Operator Questionnaire: Weather, Chemicals, Application, and Equipment

Landowner: ____
Person completing questionnaire (name): ___________________________
Unit Name: ____
Date of Application: _______________________________________

Weather Conditions:
Please fill in measurements of:

Time	____	____	____	____	____	____	____	____
Wind speed	____	____	____	____	____	____	____	____
Wind Direction	____	____	____	____	____	____	____	____
Relative Humidity	____	____	____	____	____	____	____	____
Temperature	____	____	____	____	____	____	____	____

Chemical Application
Start time _________
End time __________
On average, the chemical was applied 0-40 40-60 60-100 100+ feet from the stream. (Circle one)

Target vegetation/pest: ____________________________________
Active ingredient pesticide: _____________ oz/acre applied_____________
Active ingredient pesticide: _____________ oz/acre applied_____________
Active ingredient pesticide: _____________ oz/acre applied_____________
Surfactant added: ________________ oz/acre______________
Carriers used: ____
EPA Registration number ______________Trade Name__________________

Operation
Helicopter model: ________________________
Flight altitude: __________________________
Air speed: ______________________________
Boom length: ___________________________ Boom Pressure__________
Flight centerline offset from edge of buffer: _____________
Half Boom used ____ Yes ____ No
Nozzle type, size, angle, orientation: ________________
Number of nozzles: _______________________

Appendix B:
Pesticide Application Operational Data

Table B-1. Application Equipment Used

Site #	Vehicle Used	Flight Altit.* (ft)	Flight Speed (mph)	Boom Length (ft)	Pressure (psi)	Half Boom Used	# of Nozzles	Buffer Offset (ft)
1	Helicopter	10	40	32	32	Y	31	200
2	Helicopter	10	40	32	32	Y	31	200
3	Helicopter	15	37	30	30	Y	30	25
4	Helicopter	10	40	32	32	Y	31	200
5	Helicopter	10	40	32	32	Y	31	200
6	Helicopter	30-150	45	33	28	Y	34	0
7	Helicopter	40-50	45	32	25-30	Y	32	16
8	Helicopter	-	-	-	-	-	-	-
9	Helicopter	10-50	55	36	25	Y	37	30
10	Helicopter	-	-	-	-	-	-	-
11	Helicopter	30	45	33	28	Y	34	-
12	Helicopter	<50	45	34	30	Y	38	25
13	Helicopter	-	-	-	-	-	-	-
14	Helicopter	-	-	-	-	-	-	-
15	Helicopter	40-60	45	31	25	Y	36	-
16	Helicopter	varies	55	36	25	Y	37	varies
17	Helicopter	40-60	45	31	25	Y	36	-
18	Helicopter	-	-	-	-	-	-	-
19	Helicopter	40-60	45	31	25	Y	36	-
20	Helicopter	40	45	36	25	Y	37	-
21	Helicopter	10-20	50	40	23	Y	38	20
22	Helicopter	10-20	50	40	23	Y	38	20
23	Helicopter	30	49	40	20	Y	40	-
24	Helicopter	20-70	45	35	30	Y	38	100
25	Helicopter	60	45	32	25-28	Y	28	-
26	Helicopter	25	50	40	-	Y	38	20
	Average	34	46	34	27		35	81
	Maximum	10	37	30	20		28	0
	Minimum	90	55	40	32		40	200

* - = Data not available

Appendix C: Site Maps