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TE RAUHĪTANGA TAIAO

Pesticide Use in the Mahurangi Catchments

Assessment of Impact on the Aquatic Environment

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1.0 SUMMARY

Present levels of pesticide use in Mahurangi catchment have been assessed by means of a survey of representative properties. At present, about 67 % of the catchment is grazed pasture and 8 % is used for exotic forestry. Both of these land uses involve some low–intensity use of herbicides, that is unlikely to affect water quality in the catchment. The remainder of the catchment is mostly comprised of areas (urban development, native vegetation) in which pesticides are seldom used, or are used at low rates of application.

The most intensive use of pesticides is on horticulture, mostly on small blocks of 3.6 ha average area. Crops grown in the area were pipfruits (apples, nashi), citrus fruit and kiwifruit (a macadamia orchard was listed among the survey responses, but indicated that no pesticides were used). Screening tests of all the pesticide application rates, derived from survey responses, suggested that the use of diazinon and permethrin could potentially yield runoff concentrations that would be harmful to aquatic fauna, if undiluted. At present, horticulture occupies a very small area within the catchment (14 ha, or 0.4 % indicated in the survey) and is thus unlikely to have an impact on surface waters.

Future increases in commercial horticulture would involve more intensive use of pesticides, especially if recommended spray schedules were adhered to. The screening tests indicated that azinphos methyl, chlorpyrifos, diazinon, permethrin and copper might be used at sufficiently high application rates to yield potentially toxic residue concentrations in runoff – but only in the first major storm–runoff event after each application. This (worst–case) analysis takes no account of dilution by the receiving water, and assumes that all of the land potentially suitable for horticulture (about 450 ha) will be concentrated in large areas. Horticultural development in Mahurangi, in the past, and elsewhere in New Zealand, has tended to be patchy and to occupy flat–gently rolling land within catchments. Thus, runoff from horticulture tends to be diluted by upstream water and, in any case, the effects are generally ephemeral. The availability of suitable land for conversion to commercial horticulture is the major limitation to increases in intensive pesticide use within the Mahurangi catchment, and to the entry of undesirable residues to adjacent waterways.

A possible future change in land use might be the conversion to commercial forestry of large areas of steeply sloping land that is presently under pasture. This would involve a substantial increase in total pesticide use within the catchment, during the initial establishment phase. Such a change would be unlikely to present an increased hazard to aquatic organisms from residues in runoff, but may increase the chances of other undesirable consequences (spills, spray drift) occurring. Once pines were established the pesticide use, and associated environmental risks, would virtually be nil.

2.0 INTRODUCTION

The Auckland Regional Council (ARC) are currently assembling information that will enable a quantitative understanding of how present land uses/activities in the Mahurangi catchment affect the water quality of Mahurangi Harbour. An objective of this work is to have a reliable means of predicting changes in water quality as a result of major changes in land use, especially if there is a large increase in the use of agrichemicals. Horticultural development of land presently used for pastoral agriculture would most likely cause an increase in the use of agrichemicals (specifically, pesticides) and, as a consequence, result in some degradation of adjoining water quality. The ARC have commissioned NIWA Ecosystems to assess the ecological implications of present pesticide inputs to Mahurangi Harbour, and its adjoining water bodies, and to consider future development within the catchment.

This report assesses the use of pesticides in the Mahurangi catchments, both at present and in the future, allowing for some expansion of horticulture. The approach adopted has been to obtain accurate information by direct survey of pesticide use on the major land uses (pastoral agriculture, small "hobby" blocks, commercial horticulture), and make estimates of pesticide use in forestry (presently about 8 % of the total area) and future horticultural development. The estimates will also be based on survey information, but not necessarily from the Mahurangi catchment. The pesticides referred to in this report are primarily herbicides, insecticides and fungicides that are used extensively for plant protection, eradication and control.

Pesticide residues in agricultural runoff are significant nonpoint sources of water pollution that can be toxic to aquatic fauna (Weber et al. 1980, Willis and McDowell 1982, OECD 1984). Concern has been expressed in New Zealand about the possibility of pesticide residues in runoff, and from associated uses (storage and handling of bulk chemicals), affecting water quality and aquatic habitats in specific areas (Wilcock 1993a, b). Surveys of pesticide use in the North Island (1985–1988) and the South Island (1986–1989) were carried out to obtain a regional data base and to assess the liklihood of residue concentrations occurring in runoff, that might be harmful to aquatic fauna. Screening tests (based on pesticide application rates, toxicity to aquatic organisms and persistence in the environment) were used in these studies to assess land uses having the greatest potential to yield runoff concentrations of pesticides potentially harmful to aquatic fauna. Horticulture (pipfruit, stonefruit, citrus, kiwifruit, berryfruit and vegetable crops) involves intensive applications of insecticides and fungicides and, accordingly, was identified by the screening tests as having a higher potential for yielding harmful runoff than most other rural land uses (Wilcock 1993b).

3.0 METHOD

Data collection

Current landowners and occupants were surveyed for information about the amounts and types of pesticides they are presently using. Some indication of practices over the last few (3–5) years was also sought to get an estimate of typical usage in the catchment. The survey questionnaire (Appendix) also requested information about fertilizer use, for inclusion in a separate report assessing nutrient inputs to Mahurangi Harbour, in agricultural runoff. This report deals only with the information relating to pesticide use and, although not a complete survey of all properties, was intended to be representative of all the main land uses (K. M. Becker, pers. comm.).

Estimates of the amounts of pesticides used in commercial forestry were based on recent NIWA studies of pesticide (herbicides, copper and 1080) usage in a major pine forest over a period of 15 years and covering all phases of tree production. Detailed information was acquired in this study, including various options considered by forestry companies for establishment of replanted trees following clear–felling. The use of this data is unlikely to underestimate pesticide usage in the Mahurangi catchment, and will probably be an upper estimate of the contribution of forestry to pesticide runoff.

The amounts and types of pesticides used in horticulture in the North Island (including Rodney County) were summarised in an earlier report (Wilcock 1989). Some of the information about specific crops and pesticides may now be out of date, particularly as many larger blocks of land, formerly used for grazing stock, have been subdivided for smaller, "lifestyle" land units with varying degrees of horticultural development. Estimates of possible future pesticide use in the Mahurangi catchment have been based on the latest survey, and on typical patterns of use determined in the earlier survey (Wilcock 1989). Generic pesticide descriptions (e.g. organophosphate, pyrethroid) were used to assess environmental effects, where there was uncertainty about the products used. These estimates were then used for predicting future scenarios of potential pesticide runoff from (increased) horticulture.

Assessment of impact

In order to assess the effects of pesticide use in the Mahurangi catchment on aquatic organisms it was necessary to take into account the following factors: extent of pesticide use (areas affected, ha), intensity of application (rate, kg ha^{-1} y^{-1}), runoff potential (determined by pesticide physicochemical properties), formulation (emulsifiable concentrate, granules, aqueous emulsion, other), persistence (measured by soil half–life, the time taken for concentrations to fall to half their value, days) and acute toxicity (96–h LC50, g m^{-3}). Data relating to usage (areas, intensities) were obtained from responses to the questionnaire, and information about the products was provided in handbooks (Worthing and

Hance 1991, Anon 1993). Half–lives and runoff losses were obtained from the literature (Willis and McDowell 1982, Jury et al. 1984, Rao et al. 1985, Gustafson 1989, Wilcock 1993b).

Toxicities are most commonly expressed in the scientific literature as 96–h LC50 values, viz. the concentration that is lethal to 50 % of given test species during an exposure period of 96 hours. Rainbow trout *(Oncorhynchus mykiss)*, because of their sensitivity to a wide range of organic compounds (and the added protection that this confers on other, less sensitive species), are one of the most commonly cited test species and toxicity data is available for most pesticides. The relationship between LC50 values for rainbow trout and other species is discussed by Mayer and Ellersieck (1986).

The LC50 values used in this report (Table 6) have come from the following sources: Alabaster (1969), Pimental (1971), Tooby et al. (1975), Kenega (1979), Mayer and Ellersiek (1986), and Worthing and Hance (1991). Data have been supplemented by the tabulations of toxicities given annually in the June issues of Journal of the Water Pollution Federation (1980-1990).

Runoff estimates

Direct inputs of pesticides to surface waters were not considered to be a significant source of water pollution. Aerial spraying is not commonly carried out in the Mahurangi catchment. Spills and unlawful activities cannot be predicted with confidence, although it might be argued that large scale uses of pesticides are more likely to produce major hazards (of this kind) than are small scale uses. Users of the latter type may not be as careful with pesticides, as the former, but the consequences of misuse would not be as great.

Two means of indirect entry are possible: (i) surface runoff and (ii) subsurface flow.

(i) Surface runoff: Two methods have been derived for estimating *maximum* concentrations in surface runoff generated in storms occurring within 14 days of pesticide application (Wauchope and Leonard 1980, Wilcock 1993b). One of these methods (Wauchope and Leonard 1980) is based on data from 373 runoff experiments reported in the scientific literature and characterises pesticides according to their formulations and mode of application (Eq 1), while the other (Wilcock 1993b) is based upon average runoff losses published in the literature and surface runoff volumes (Eq 2). Calculated runoff concentrations from both methods have been compared with published toxicity values (LC50s), to yield two expressions for predicting loading rates (R, kg ha^{-1} $application^{-1}$) that may result in runoff that is harmful to aquatic fauna; viz:

$$R \geq 2330 \times LC50/A \qquad (1)$$

and

$$R \geq LC50/2r \qquad (2)$$

where r is the typical runoff loss as a % of the amount applied (Willis and McDowell 1982), and A is an "availability" index which takes into account pesticide properties and formulation, and the nature of the deposition site (A has values ranging from 300 to 10,000 ppb ha kg^{-1}) (Wauchope and Leonard 1980).

A detailed account of the derivations of Eqs 1 and 2, and of their applications and limitations as techniques for assessing pesticide runoff potential is given by Wilcock (1993b).

(ii) Subsurface runoff: Some soluble herbicides, notably picloram, amitrole and (to a lesser extent) atrazine and hexazinone may persist long enough to enter groundwater or enter streams in subsurface flow (Rao et al. 1985). A study on the subsurface movement of picloram and hexazinone to an adjacent stream (Neary et al. 1985) found low concentrations (<< 1 ppm) in groundwaters. Traces of hexazinone were found for a short time in the stream, but picloram was not detected at any time in the stream. The low toxicities of these chemicals, and of amitrole and atrazine, suggest that any subsurface inflows would be of little environmental consequence.

4.0 DATA ANALYSIS

Survey data

Results from the questionnaire survey are summarised in Table 1. Where property areas were not supplied by respondents estimates were made by visual comparison with other known areas, using photographs and cadastral maps of the catchment.

Responses to the survey were collected from 71 landowner/occupants, representing a total property area of 3,896 ha, or 34 % of the total catchment area of 11,500 ha (ARC 1993). The distribution of responses over the catchment is shown in Fig. 1, and represents a diversity of land uses. Areas ranged from 2 to 330 ha, and had a median value of 35.5 ha.

Only 23 responses, representing a total area of 843 ha, indicated that pesticides were not used. A summary of the amounts, types and rates of each pesticide (as active ingredient, a.i.) used on the 48 other properties is given in Table 2.

Table 1. Summary of responses to questionnaire.

Response No.	Surname/Owner	Principal land uses	Area (ha)	Pesticides used Y/N ?
1	McGee	grazing	34	Y
		forestry	4	
		native bush	2	
2	Rockford	mixed organic farming	20	N
4	Rowsell	apple orchard	6	Y
		grazing	3	
		native bush	1	
5	Grimmer	grazing	18	Y
		native bush	3	
6	Macey	grazing	31	N
7	Campbell	grazing	18	Y
		pine trees	0.2	
		native bush	6	
7A	anon	grazing	9.3	N
8	Civil Estate	dairy	196	Y
8C	anon	nashi orchard	3	Y
		grazing		
8D	Davey–Martin	dairy	65	Y
		forestry	0.5	
9	Memberry	dairy/sheep	≈ 100	Y
10	Warkworth Golf Club	golf course	≈ 33	Y
11	Bratty	beef	121	Y
12	Stevenson	dairy	110	N
12B	Munroe	citrus	3	Y
13	Graeme/Jackson	deer/cattle	≈ 200	Y
14	Adolph	dairy	≈ 60	Y
15	Hamilton	beef	150	Y
16	Carline	grazing	32	Y
		forestry	1	
		native bush	3	
17	Baddock	orchard	≈ 2	N
18	Nicolls	dairy	≈ 80	Y
19	Lawrie	grazing	16	Y
		native bush	8	
21	Simmons	grazing	9	Y
22	Ingham	grazing	58	Y
23	Gibson–Smith	trees/grazing	11	Y
24	Simperingham	grazing	23	Y
		lemons	0.8	
25	Young	grazing	10	N
26	Mahurangi CC Trust	grazing	47	Y
27	McLeod	dairy	87	Y
29	Silvester	dry stock	20	N
31	Wylie	dry stock	20	N
32	Wood	dry stock	35	N
33	Schollum	dry stock	28	N
34	White	native bush	23	Y
35	Jameson	hobby	3	N
37	Olliver	hobby	3	N
38	McCallum	grazing/pine trees	4	N

Table 1 continued

Response No.	Surname/Owner	Principal land uses	Area (ha)	Pesticides used Y/N ?
39, 40, 41	Marshall Farms	nashi/kiwifruit	7	Y
42	Fountain	beekeeping/cattle	≈ 35	N
43	Lawson	beef	≈ 120	Y
44	Bradnam	dairy	≈ 120	Y
45	Morrison	dairy/beef	20	Y
		forestry	8	
		native bush	32	
46	Smid	grazing	40	Y
47	Strong	beef	40	Y
48, 49	Edmonds	native bush	36	Y
		calves	4	
51	Teina	grazing	6	N
52	Pendred	hobby	3	Y
53	Edwards	grazing	330	Y
54	Lewis	beef	49	Y
55	Woolham	grazing	57	Y
56	Leibrand/Botcher	trees/horses/grazing	16	N
57	Dray	grazing	46	Y
58	Wijdeven	grazing	48	N
60	Shadick	native bush	4	N
61	Fairclough	native bush	5	N
62	Theyers	grazing	120	Y
63	Malmo	grazing	20	N
65, 66, 69	Wech	grazing	144	Y
67	Goodyear	grazing	16	Y
68	Prater	grazing	52	Y
70	E.B. Schollum	grazing/native bush	147	N
71	McEroy Trust	grazing	197	N
72	Perkinson	grazing	27	Y
73	B.N. schollum	grazing/native bush	189	Y
74	Craig	forest/macadamia nuts	70	N
75	Fraser	grazing	280	Y

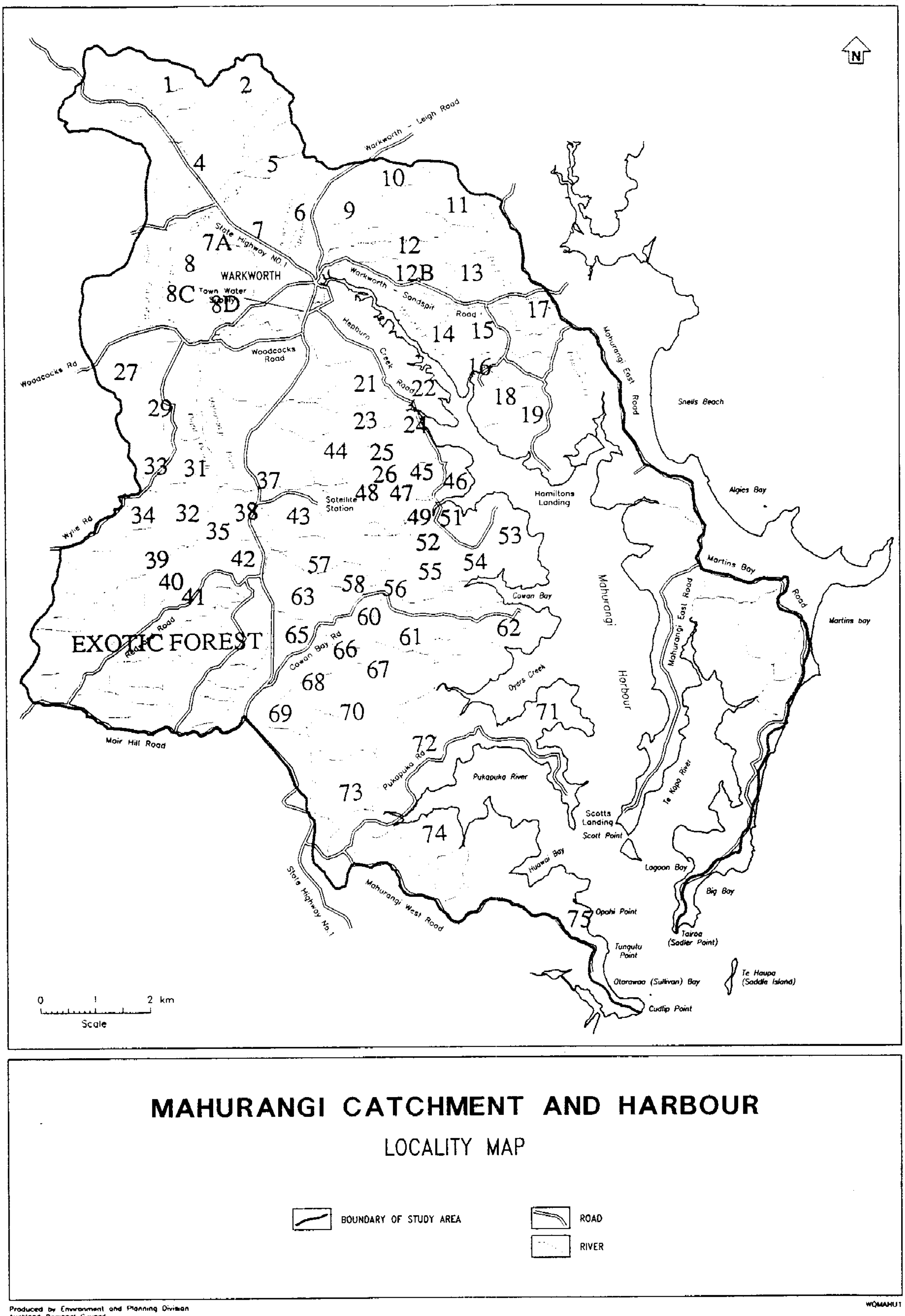

Fig. 1 Distribution of survey responses

Table 2. Present pesticide use in the Mahurangi catchment.

Response No	Principal land use	Pesticides used (a.i.)	Amount used (kg)	Area treated (ha)	Average rate (kg ha^{-1} y^{-1})
1	grazing	picloram	not specified	34	spot application
		glyphosate			
		MCPA			
4	apples	clofentezine	0.4	6	0.1
		captan	6.0		1.0
		copper	15		2.5
		diazinon	2.9		0.5
		mineral oil	120 (litres)		20 (l ha^{-1} y^{-1})
5	grazing	glyphosate	not specified	18	spot application
7	grazing	glyphosate	not specified	24	spot application
8	dairy	glyphosate	28.8	196	0.15
		triclopyr	24		0.12
		2,4–D	55.2		0.28
8C	nashi	azinphos methyl	3.0	2.4	1.3
		diazinon	2.9		1.2
		glyphosate	3.6		1.5
8D	dairy	2,4–D	45	65	0.7
		metsulfuron	0.15		spot application
9	dairy/sheep	2,4–D	55.2	64	0.86
		metsulfuron	0.6	4	0.15
		glyphosate	7.2	4	1.8
10	golf course	endosulfan	0.71	33	spot application
		glyphosate	3.5		0.1
11	beef	2,4–D	6.9	121	0.06
		metsulfuron	0.3		spot application
		triclopyr	12		0.1
12B	citrus	copper	8.4	3	2.8
13	deer	2,4–D	20.7	200	0.1
		glyphosate	3.6		0.02
		triclopyr	12		0.06
14	dairy	metsulfuron	0.06	60	spot application
		MCPA	45		0.75
		glyphosate	3.6		0.06
15	beef	2,4–D	210 (1:10 y)	150	1.4 (every 10 y)
		triclopyr	2.4		spot application
16	grazing	glyphosate	3.6	32	0.11
18	dairy	2,4–D	3.45	80	0.04
		glyphosate	1.8		0.02
		metsulfuron	0.24		0.003
		picloram	0.1		0.001
19	beef	metsulfuron	0.6	16	0.04
21	grazing	metsulfuron	not specified	9	spot application
		glyphosate			
22	grazing	2,4–D	13.8	58	0.24
		metsulfuron	not specified		spot application
		glyphosate			spot application
23	grazing	metsulfuron	not specified	5.2	spot application
		glyphosate			spot application
		triclopyr			spot application
24	grazing	2,4,5–T	1.2	23	0.05

Table 2 continued

Response No	Principal land use	Pesticides used (a.i.)	Amount used (kg)	Area treated (ha)	Average rate (kg ha^{-1} y^{-1})
26	grazing	metsulfuron	not specified	47	spot application
		glyphosate	1.8		0.04
27	dairy	2,4–D	17	87	0.02
		picloram	4.4		0.05
		triclopyr	not specified		unknown
34	bush	metsulfuron	infrequent	23	spot application
39,40,41	nashi/kiwi	hydrocyanic acid[1]	39	2.5	15.6
		diazinon			
		permethrin	15.6	2.7	5.8
		pirimiphos	0.6	2.5	0.2
		azinphos methyl	10.7	2.5	4.3
		glyphosate	0.2	0.2	1.0
			14.4	2.7	5.3
43	beef	2,4–D	31	30	1.0
		metsulfuron	1.3	30	0.4
44	dairy	2,4–D	6.9	120	0.06
		metsulfuron	0.3	120	0.003
		glyphosate	3.6	120	0.03
45	dairy/beef	2,4–D	not specified	20	spot application
		metsulfuron	not specified	20	spot application
		glyphosate	0.4	20	0.02
46	grazing	2,4–D	not specified	40	spot application
47	beef	metsulfuron	3	40	0.08
48,49	grazing	metsulfuron	not specified	4	spot application
52	bush	glyphosate	not specified	3	spot application
53	grazing	2,4–D	41.4	200	0.21
		glyphosate	7.2	200	0.04
54	beef	glyphosate	0.4	49	0.01
		MCPA	0.2	49	0.004
55	grazing	metsulfuron	1.0	57	0.02
		glyphosate	1.5		0.03
57	grazing	glyphosate	not specified	46	spot application
62	grazing	glyphosate	not specified	120	spot application
65,66,69	grazing	2,4–D	not specified	144	spot application
		glyphosate	not specified		
67	grazing	glyphosate	1.0	16	0.06
68	grazing	2,4–D	not specified	52	spot application
		glyphosate	not specified		spot application
72	grazing	metsulfuron	not specified	27	spot application
73	grazing	2,4–D	not specified	154	spot application
		metsulfuron	not specified		spot application
		glyphosate	not specified		spot application
75	grazing	haloxyfop	not specified	280	spot application
		glyphosate	not specified		spot application
		metsulfuron	not specified		spot application

[1] Hydrocyanic acid ("Hi–Cane") is a plant growth regulator

Forestry

Commercial forestry occupies an area of 896 ha and is located principally in the western (Redwood Road) part of the catchment (Becker 1993). The assessment of pesticide (principally herbicides and copper) use in Mahurangi is based on usage by a very large commercial forest (data held on file by NIWA). Trees in the Mahurangi forest are nearing the end of their growing period and will soon be felled (K. M. Becker, pers, comm.). It is reasonable to assume that the area will be replanted with *Pinus radiata,* following clearance of the land and that herbicides will be used to help establish the new trees. The major use of pesticides in exotic pine plantations is during the establishment phase. A typical establishment regime for a commercial *pinus radiata* forest is shown in Table 3.

Table 3. Typical forest establishment regime.

Rotation period	30 years
Year	Operation
−1	Escort/Roundup
−1	oversow
0	Escort/Roundup
0	oversow
0	plant
0	spot spray grass
0	spot spray with Velpar
1	spot spray grass
1	regeneration treatment

Herbicides are typically used over a 3 year period following land clearance operations, for the establishment of new trees. The preferred establishment preparation regime involves the use of herbicides prior to planting, followed by some post-planting spot-spraying for grasses and other unwanted plants.

Spot spraying is one of the principal means of applying herbicide and, even though the individual treated "spots" are only 1.0–1.6 m^2, it is carried out over large areas. Aerial application, by helicopter, involves the use of other chemicals, such as wetting agents (e.g. Delfoam, Triton, Pulse and Superspread). Although there is little information available about the toxicity or persistence of these substances, it may be concluded from their chemical genera together with the amounts being used, and their mode of application, that their use is unlikely to be harmful to stream life or to impact on water potability (Alabaster 1969, Ventullo et al. 1989, Anon 1993). Aerial spraying is restricted to planting areas and is thus not closer than 5 m from stream banks, although there may be some direct deposition into very small tributaries. Other chemicals used that may affect stream life and water quality, are copper compounds (for control of *Dothistroma* needle blight), and 1080 (sodium fluoroacetic acid) and cyanide used in possum baits. Given that 1080 does not persist in the aquatic environment and that even large scale applications do not yield significant residue concentrations in streams adjacent to the target area (Eason et al. 1992), it seems unlikely that forestry applications will yield harmful runoff levels of 1080. While there is less information available for cyanide usage in forestry it seems reasonable to assume that because of its solubility in water, its relatively low toxicity to aquatic organisms and the method (spot) of application, cyanide runoff is unlikely to be an environmental hazard.

Pesticides used in commercial forestry, and typical rates of application, are given in Table 4. These data were assumed to approximate the usage of pesticides in the Mahurangi forest.

Table 4. Typical pestides used, and application rates (median and range), in commercial exotic forests.

		Application rate (kg ha^{-1})	
Product	Active ingredient	Aerial release	Hand release
Roundup	glyphosate	3.12 (0.01–4.80)	—
Escort	metsulfuron	0.24 (0.11–0.26)	—
Velpar	hexazinone	4.50 (0.20–5.40)	0.68 (0.03–6.25)
Atradex	atrazine	5.04	0.94 (0.17–1.49
Versatill	clopyralid	0.90	—
Tordon 2G	picloram[1]	0.15 (0.11–0.80)	0.20 (0.10–0.30)
Tordon NF	triclopyr	0.45 (0.34–2.39)	0.60 (0.30–0.90)
Amitrol 4L	amitrole	1.52 (1.00–2.04)	—
Gardoprim	terbuthylazine	4.51 (1.71–7.31)	6.80 (074–7.50)
Copper	copper	0.66	—

[1] Data for picloram in Tordon 2G and Tordon NF have been combined

Future horticultural development

Horticulturalists in the Mahurangi catchment are presently using pesticides on pipfruit (apples and nashi), citrus and kiwifruit (Table 1). Data from Table 2 has been combined with earlier survey information from Rodney County horticulture (Wilcock 1989) to derive a list of pesticides and application rates that might be used in future expansion of horticulture in the catchment (Table 5.).

The application rates from Wilcock (1989) were averaged for all uses in Rodney County, and included a number of large commercial orchards following MAF pesticide guidelines. The rates derived from the Mahurangi survey (Table 2) are generally smaller than the earlier survey results, and are consistent with the general observation that small orchards supplying produce at the gate use substantially less pesticides than larger commercial enterprises (especially those exporting produce).

Pesticide properties

In order to estimate potential maximum runoff concentrations (Eqs 1 and 2) it is necessary to have information about the persistence (soil half–life and % runoff loss) and toxicity (96–h LC50) of individual pesticides. Data for the pesticides presently used (Table 2), or possibly used in the future (Tables 4 and 5), are given in Table 6. Also listed are present and estimated future average rates of pesticide application for each land use.

Table 5. Possible future horticultural pesticide use in the Mahurangi catchment.

Pesticide (a.i.)	Target crop	Rate of application (kg ha^{-1} y^{-1}) Table 2	Wilcock (1989)
Herbicide			
amitrole	pipfruit	—	0.53
diquat	pipfruit/citrus/kiwifruit	—	0.29
glyphosate	general use	1.5–5.3	0.2–2.9
simazine	pipfruit/citrus/kiwifruit	—	2.3
terbuthylazine	pipfruit/kiwifruit	—	1.3
Insecticide			
azinphos methyl	pipfruit/kiwifruit	1.0–1.3	3.6
chlorpyrifos	pipfruit/kiwifruit	—	4.1
clofentezine	pipfruit/berries	0.1	0.3
diazinon	pipfruit	0.5–5.8	3.8
permethrin	kiwifruit	0.2	0.1
phosmet	kiwifruit	—	11.3
pirimiphos methyl	kiwifruit	4.3	1.9
Fungicide			
captan	pipfruit	1.0	5.1
copper	pipfruit/citrus	2.5–2.8	11.8
metiram	pipfruit	—	12.6

5.0 DISCUSSION

Present land uses

All but two peninsulas in the SE of the catchment are represented by the survey. The unrepresented areas are strongly–rolling to steep (from Slope Class Map commissioned by NIWA for the Mahurangi study) and are, thus, unlikely to be further developed for horticulture. Given that present use of pesticides is largely confined to ad hoc applications of herbicides for controlling nuisance weeds, and that the chemicals used for this purpose in other parts of the catchment (Table 2) are fairly benign with respect to runoff toxicity potential, there is not a pressing need for survey data from the SE part of the catchment.

Pasture (67 %) is the dominant land use in the Mahurangi catchment, and has remained relatively static over the period 1984–1992. In the same period there has been a reduction (634 ha) in the total scrub area and an increase (790 ha) in native forest (ARC 1993). Exotic forest has reduced slightly from 1093 ha to 896 ha. Only 14 ha (0.4 %) was identified as being horticultural in the survey and it seems probable that the <u>total</u> amount of land used for horticulture in the catchment is unlikely to be very much greater (say, ≤ 25 ha).

Past studies (Wilcock 1989, 1993b) have shown that the use of pesticides on pasture and in exotic forestry in New Zealand mainly involves low–rate applications of herbicides that are not particularly toxic to aquatic organisms. Usage of pesticides on grazed land in this study (Table 2) is consistent with the earlier studies. Small–scale tree cultivation (agroforestry) does not require the same intensity of pesticide use as commercial forestry, and any increase in this land use is likely to reduce present levels of pesticide use in the catchment.

Table 6. Environmental properties of pesticides used in Mahurangi catchment

Pesticide (a.i.)	Use[1]	Runoff loss, r (%)	Soil half-life (days)	Toxicity to trout 96h-LC50 ($g\ m^{-3}$)	Average rate ($kg\ ha^{-1}\ y^{-1}$)
amitrole	F,H	2.21	10	50	2, 1
atrazine	F	2.21	100	8	1–5
azinphos methyl	H	0.85	10–40	0.014	1–4
captan	H	0.46	3	0.3	1–5
chlorpyrifos	H	0.85	54–63	0.003–0.02	4
clofentezine	H	0.60	?	>100	0.1–0.3
clopyralid	F	1.01	12–70	104	1
copper	F,H	1.01	persistent	9.6	1, 3–12
diazinon	H	0.85	32	0.09–3	0.5–6
diquat	H	1.94	deactivated	10	0.3
glyphosate	F,H,P	1.01	20–50	86	3, 3, 0.06
hexazinone	F	2.21	100	300	1–5
MCPA	P	1.01	6	10	0.4
metiram	H	0.46	14	17	13
metsulfuron	F,P	1.01	7–42	>12.5	0.2, 0.1
permethrin	H	0.60	32–64	0.007	0.1–0.2
picloram	F,P	1.01	140–200	20	0.2, 0.03
pirimiphos	H	0.85	10	1.6	2–4
simazine	H	2.21	56–75	100	2
terbuthylazine	F,H	2.21	58	4.6	5, 1
triclopyr ester	F,P	1.01	100	2.2	0.5, 0.1
2,4-D	P	1.01	10–15	2	0.3
2,4,5-T	P	1.01	15–55	20	0.05

[1] F = forestry; H = horticulture; P = pasture

Environmental assessment of present use of pesticides

Pesticide application rates were assessed to determine if they exceeded values that might yield harmful residue (critical) concentrations in runoff, using the two screening equations (Eqs 1 and 2). Land use data (areas and average application rates) are given in Tables 2 and 6, and key pesticide properties are listed in Table 6. Values of A, relating to formulation leachability, have been assigned according to the procedure of Wauchope and Leonard (1980).

The assessment showed that only diazinon (applied to pipfruit), permethrin (marginally) and pirimiphos methyl (on kiwifruit) are presently being used, in horticulture, at rates that might yield critical concentrations in runoff. Pirimiphos methyl, with a soil half-life of 10 days is unlikely to persist long enough for there to be runoff residues (Wauchope and Leonard 1980, Wilcock 1993). Thus, only diazinon and permethrin need be considered further. These applications refer to target areas of 6 and 3 ha, respectively and do not consitute a threat to adjoining surface waters. Furthermore, dilution of runoff by receiving waters will greatly reduce residue concentrations.

Herbicide use in forestry and grazed pasture was in every instance well below rates that might be considered problematic, and was consistent with earlier surveys (Wilcock 1989).

Future pesticide use

It has already been established that pesticide use on grazed pasture is at a sufficiently low rate of intensity not to constitute a hazard to the aquatic environment. Some other land "uses" in the catchment, such as agroforestry and re–establishment of native vegetation, similarly involve inconsequential amounts of pesticides. The only horticulture identified by the survey were six properties, each averaging about 4 ha, not all of which used pesticides.

An analysis of land use capability within the catchment (ARWB 1984) indicates a small area of Class II land in the lower valleys of the Mahurangi River, that would support increased market gardening and/or horticulture. Much of the north and east and a smaller area in the south of the catchment is Class IV land, some of which would be suitable for horticulture. Rough estimates of the land areas in Classes II and IVi available for conversion to horticulture, from inspection of the land use capability map (ARWB 1984), are 250 ha and 200 ha respectively. If we assume a "most intensive" scenario, then use of the following pesticides (used on commercial orchards following recommended pesticide application guidelines) (Anon 1993, Wilcock 1993) may yield critical runoff concentrations: azinphos methyl, chlorpyrifos, diazinon, permethrin (marginally) and copper. This case treats each of the potential horticulture areas as a single catchment. It is more likely that only a fraction of this land will be developed for horticulture and that properties used for this purpose will be interspersed with other land uses (notably pasture). Thus, horticultural runoff, with relatively elevated pesticide concentrations will be diluted by runoff from other land uses.

The runoff analysis used in this report to evaluate pesticide loadings for different land uses is based on the almost universal finding that environmentally significant pesticide runoff events occur during the first major storm following pesticide application, during which about 90 % of the available material is washed off the soil/plant surfaces. Thus, the assessment of pesticide use in this report relates only to the occurrence of possibly high concentrations in single storm events following pesticide uses, with subsequent events not being deemed to be as significant. This is largely because modern pesticides (unlike organochlorines such as DDT and dieldrin) have relatively short lives in the environment and either breakdown or are incorporated in a way that reduces bioavailability.

Perhaps a more likely scenario for future increased use of pesticides would be conversion of some of the steeply sloping land that is presently used for pasture, to commercial pine forest. Large blocks of land would be involved if such a change were to happen, and large quantities of pesticides (primarily herbicides and some copper) would be used in the catchment during the establishment phase. Very little pesticide material is used during the remaining 25 years following the establishment of new forest. The analysis of risk, using Eqs 1 and2, has shown that there is little chance of harm to aquatic fauna (or flora) deriving from runoff from commercial forestry pesticide applications. The use of large amounts of concentrated materials may at certain times present an increased risk of accidental spillage, or of damage to sensitive crops from spray drift – if aerial applications are made.

6.0 CONCLUSIONS

The analysis of pesticide use in the Mahurangi catchment has shown that present rural land uses involving pesticide applications are unlikely to have an effect on aquatic ecosystems. The major use of pesticides at present is on grazed pasture (about 67 % of the catchment area) and (probably) on exotic forest (8 %). Horticulture, although being an enterprise in which pesticides are used much more intensively, occupies only a tiny proportion of the catchment and is unlikely to yield runoff concentrations that are injurious to aquatic organisms.

It is hypothetically possible (from consideration of land use capability) to increase the total horticulture area to about 450 ha in three separate regions. At worst, large–scale commercial horticulture might involve pesticide applications that could generate potentially harmful residues of azinphos methyl, chlorpyrifos, diazinon, permethrin and copper. Horticultural development in Mahurangi, in the past, and elsewhere in New Zealand, has tended to be patchy and to occupy flat–gently rolling land within catchments. Thus, runoff from horticulture tends to be diluted by upstream water and, in any case, the effects are generally ephemeral.

The potential impact on the aquatic environment of pesticide use in the Mahurangi catchment, as a result of increased horticulture, is somewhat uncertain given the assumptions that need to be made. It does seem that the amount of suitable land available for such development is small and may limit resulting adverse effects to being practically unquantifiable.

Some conversion of pasture to commercial exotic forest would involve a substantial increase in total pesticide use within the catchment, during the initial establishment phase. This is unlikely to present an increased hazard to aquatic organisms from residues in runoff, but may increase the chances of other undesirable consequences (spills, spray drift) occurring. Once pines were established the pesticide use, and associated environmental risks, would virtually be nil.

The tiny amounts of pesticides presently being used in horticulture and other activities within Mahurangi catchment are unlikely to generate measurable amounts of residues in Mahurangi Harbour. Thus, oyster farms and other similar fish farming operations will not be affected by (present or anticipated future) pesticide use.

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Appendix

QUESTIONNAIRE FOR MAHURANGI STUDY

A DESCRIPTION OF LAND AND USES

NAME: ________________________________

LANDOWNER/MANAGER/TENANT/LEASE HOLDER/OTHER ?
(Circle one)

ADDRESS: ________________________________

MAP REFERENCE: ________________________________
(NZMS; Cadastral)
____

PRINCIPAL LAND USES: ________________________________
____
____
____

STOCK GRAZING: YES/NO
(Circle one)

TYPE OF LIVESTOCK: ________________________________

STOCKING RATE: ________________________________

DO YOU HAVE A FARM DAM ? YES/NO
(Circle one)

IF YES, WHERE IS IT ?
(Mark on 1:10,000 aerial bromide)

ESTIMATE MEAN DEPTH (m): ________________________________

SURFACE AREA (m^2): ________________________________

OTHER RELEVANT INFORMATION ?

B USE OF AGRICULTURAL CHEMICALS (fertilizer, pesticides)

You fill in this bit ——————————————><—— We fill in this bit ——

Product name	Amount applied	Area (ha)	When applied	Active ingredient	Other details