Review of Trends in Agricultural Pesticide Use in New Zealand

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1. EXECUTIVE SUMMARY

Current usage of pesticides in New Zealand has been established on a tonnage basis with division of pesticides into categories and classes according to FAO. Further sub-classes were generated for some specific pesticides of current or growing importance in New Zealand. The overall use data relied mainly on AGCARM annual survey data although this source does not cover all sales and the classification scheme differs from FAO. A comparison was undertaken between the current usage and data gathered in previous surveys. Although there were some uncertainties as to the full comparability of the data sets, the overall conclusions were that total pesticide use (excluding mineral oil) grew between 1984 and 1994 reaching a peak of about 3700 tonnes of active ingredient per annum and has declined to the 1998 total of 3300 tonnes. Herbicides continue to dominate pesticide use (68%) followed by fungicides (24%) and insecticides (8%). About two thirds of total use is concentrated in four classes of pesticides (phenoxy hormones, phosphonyls, inorganic fungicides, dithiocarbamates) which have excellent records of very low human and environmental risks when used as directed.

Changes in use of the major pesticide classes were tracked over the past decade There were significant declines in ‘other’ hormone herbicides, organophosphorus insecticides and dicarboximide fungicides, while phosphonyl herbicides (mainly glyphosate), triazine herbicides, sulfonylurea herbicides and pyrethroid insecticides all increased. These changes reflect trends in land use (more forestry), cost-effectiveness (more glyphosate and sulfonylureas, less ‘other’ hormone herbicides) and adoption of IPM (more biologicals, less organophosphates, less dicarboximides).

Detailed end-user data were also gathered at the sector level. This unique data set serves as a baseline to measure future trends and has provided insights on specific plant protection issues and strategies within each sector. Pesticide use in pastoral agriculture is static or declining and focuses almost solely on herbicides for broadleaf and brush weed control. Cereals and other arable crops also mainly use herbicides, with resistant cultivars and IPM techniques contributing to reduced insecticide and fungicide inputs. Orchard crops overall still have relatively high uses of pesticides despite increased adoption of IFP strategies. However the Kiwigreen (IFP) and organic production systems used by all the kiwifruit industry are notable successes for more biologically oriented insect and disease control.

Pesticide use in process vegetables such as asparagus, green peas and sweetcorn is relatively low and is mainly concentrated on early season weed control. In contrast, fresh vegetables such as lettuce, brassicas and potatoes tend to have intensive spray programmes throughout the growing season. Onions receive very frequent pesticide applications and there are concerns over the sustainability of current plant protection strategies in this crop.

Pesticide use in plantation forestry is concentrated on weed control during the first 1-2 years establishment phase of the crop rotation. Consequently the overall impacts of pesticide use in the timber production cycle are minimal.

Overall, control of weeds is often the main priority with herbicides continuing to be the most cost-effective technology. IPM techniques are making significant contributions to reductions in use of insecticides in most areas of agriculture. However fungal diseases continue to provide many challenges for more sustainable plant protection in horticultural and cropping sectors. The rapid increases in organic production in all agricultural sectors will have an effect on pesticide use statistics in the future. Although no detailed risk analysis was undertaken, some key drivers for change in the area of pesticide use were highlighted for further development as part of strategies to enhance the sustainability of agricultural production systems.

2. INTRODUCTION

Pesticide use statistics have a number of important uses:

- Policy making with respect to agrochemical registration.
- Policy making and negotiations in relation to international trade agreements.
- Research and policy making regarding agricultural production systems.
- Research and regulation of environmental impacts of pesticides through off-site losses.
- Commerical decision making in regard to agrochemical market size and location.
- Informing the general public and NGOs.

These uses of the information can be national, regional or sector based.

Such information if gathered on a regular basis is also useful in establishing trends. Changes in the pattern of pesticide use are indicators of changing agricultural production systems, profitability of farming, shifts in pest and disease status and changes in the availability, cost-effectiveness and registration status of particular pesticides. These are important inputs to the above uses of pesticide statistics.

New Zealand, unlike many countries does not have a system in place to gather detailed statistics on pesticide use. Ministry for Agriculture and Forestry (MAF), the Pesticides Board, NZ Association for Animal Health and Crop Protection (AGCARM) and agricultural producer boards do obtain some of this information. However it is generally confidential, often disparate in nature and not complete for the purposes above.

The last systematic study of pesticide use patterns in New Zealand was carried out by the DSIR Water Quality Centre for the period 1986-1988 (Wilcock 1989, 1990). It was mainly based on information from retail sources and the data were reported in adequate detail to ascertain individual pesticide use (quantities per year) on a district basis. However the use patterns of the pesticides in particular agricultural sectors were not established except by reference to registered uses. Over the intervening decade the Wilcock reports have proved invaluable for the purposes outlined above. However even a cursory examination shows that the data are not an adequate guide to current uses. Heavily used materials such as 2,4,5-T and phosmet have been withdrawn, many newer materials are in widespread use and the patterns of use have changed (e.g. the decline in pastoral agriculture and increases in horticultural and forestry plantings).

The influential Penman report "Pesticides: Issues and Options for New Zealand" (Ministry for the Environment, 1989) also gave statistics for pesticide use during the 1980s. Summaries of data from AGCARM and other sources gave sales quantities by broad categories of pesticide type and sector of use. The main focus of this report was on the broader issues of the regulation and effects of pesticide use in New Zealand. It concluded that the nation's health and environment were being subjugated by the heavy use of pesticides in the export agricultural sectors. While this controversial contention has not been substantiated, the report did highlight the importance of public attitudes at home and abroad in influencing pesticide policies. The report also advocated wider and more rapid adoption of alternative plant protection strategies such as Integrated Pest Management (IPM) and increasing the production of low- and no-chemical residue food products. Many of these challenges have been taken up, particularly in the horticultural sector. There have also been increases in production by organic methods.

Other more recent publications have made reference to patterns of pesticide use in New Zealand including the proceedings of a symposium 'Plant Protection – costs, benefits and trade implications' (Suckling and Popay ed. 1993), the polemic 'The Poisoning of New Zealand' (Watts, 1994) and a review of New Zealand's environmental performance (OECD, 1996a).

The Penman report called for restructuring of pesticide regulatory authorities to upgrade their environmental protection and public health statutory responsibilities. In fact over the past decade regulation of pesticides has largely been unchanged with the Pesticides Act (1979) remaining the key statute as overseen by the Pesticides Board and administered by MAF. However the Hazardous Substances and New Organisms (HSNO) Act (1996) and the complementary Agricultural Compounds and Veterinary Medicines (ACVM) Act (1997), will form the basis for future regulation of pesticides. The Resource Management Act (1991) as administered by territorial authorities is also beginning to influence use of pesticides, particularly in relation to discharges to air and water.

As a decade has passed since any detailed evaluation of national pesticide use patterns had been undertaken, MAF Policy determined that information on current uses was required. A short-term contract was given to HortResearch to undertake this review.

Project Goal: To develop robust information on pesticide usage at the regional level to support national and regional decision making.

Description: The national use pattern for major categories of pesticides will be established (tonnes active ingredients, 1998 year) using the FAO classification (disaggregated sub-groups of active ingredients). In addition more detailed information will be gathered on the use patterns in four regions (Waikato, Bay of Plenty, Hawkes Bay, Canterbury) to form baseline data for future research. Trends will be examined in relation to past survey data and the main factors influencing pesticide use. Recommendations will be made for methods by which MAF can efficiently gather pesticide use statistics on an annual basis in future.

3. SCOPE AND METHODOLOGY

Information was gathered on quantities of insecticides, fungicides, herbicides and plant growth regulators used in various agricultural sectors. Ectoparasiticides, rodenticides, vermin control agents and timber treatment chemicals were not included due to limitations of time and resources. The UN-FAO classes of pesticides were used as a basis for reporting (FAO, 1996). This classification divides the four broad categories above into classes based on chemistry and mode of action e.g. organophosphates, triazines etc. There were some errors and obvious anomalies in the list as supplied which have been corrected. Where the FAO classes were too broad to explore key New Zealand trends, some further sub-classes were generated e.g. phosphonyls (glyphosate, glufosinate-ammonium) was separated from the FAO 'Other herbicides' class. A listing of the pesticides registered in New Zealand and their classifications is given in Appendix 1. A few pesticides are included which are no longer registered. In this Appendix, and in the rest of this report, individual pesticide active ingredients are described and discussed in terms of their ISO common names. Pesticides as formulated and packaged for sale in New Zealand are described by their product names registered with the Pesticides Board. The same active ingredient may be available in several products and some products contain more than one active ingredient. Compilations of registered products and their uses are published regularly which include cross-references to the active ingredients by their common names (e.g. Novachem Manual 1998).

AGCARM was the principal source of information for the national statistics in this report. Annual sales data of pesticides summarised by kilograms of active ingredient (ai) in various categories was supplied for the year ending 30 June 1998 and for several years previously. A postal survey was undertaken of agrichemical companies who are not members of AGCARM and do not participate in their surveys. Information on national herbicide sales was also available from a published summary of retail surveys undertaken by a professional market analysis company (AC Nielsen, 1999). The dollar retail sales value of herbicide products was reported for 1997 and 1998 with an estimated 75% capture rate. This included an analysis of the sales by region, agricultural sector and chemical type (broadly matching FAO categories).

Four regions were chosen for detailed study to gather statistics on agricultural use patterns: Canterbury, Hawkes Bay, Waikato/Pukekohe and Bay of Plenty/Rotorua. This choice was based on the broad and representative patterns of pastoral agriculture, cropping, horticulture and forestry encompassed by these regions. The time frame and resourcing for the project precluded gathering national statistics by surveying uses across all regions and all economic sectors.

A range of land uses was chosen for detailed study within these regions based on their regional and national significance (Table 1).

Table 1: Land use categories surveyed for pesticide use patterns.

Arable farming	Cereal (wheat and barley)
	Maize (grain and green feed)
	Herbage seed crops (grasses, legumes)
Horticulture	Apples
	Kiwifruit
	Grapes
	Avocado
	Citrus
	Berryfruit (blackcurrant, boysenberry, blueberry)
Vegetable production	Potatoes
	Onions
	Asparagus
	Sweet corn
	Field tomatoes
	Field peas
	Brassicas (cabbage, cauliflower and broccoli)
	Lettuce
Pastoral agriculture	Sheep and beef
	Dairying
Forestry	Exotic plantations

For each production sector two classes of information were sought:

1. **Land area statistics**
   Statistics NZ/MAF data for 1994, 1996 and 1998 (forestry only) provided some data on the areas of land in the various uses. However for the agricultural sectors more weight was put on current data supplied by the producer boards, grower groups, individual companies and other agricultural statistics (Petrie & Bezar 1997, Seed Certification Statistics 1999, VegFed 1998).

2. **Pesticide spray programmes**
   Producer boards, grower groups, individual companies and agricultural consultants were approached to release information on pesticide use. For most of the horticultural crops this information was supplied in the form of spray diaries from a selection of individual growers. The number of diaries studied for each region was in the range of 5-30% of growers. These voluminous data sets were analysed in detail to give an accurate picture of the average pesticide use in each crop. For the other sectors, major agricultural/forestry companies were approached to provide typical patterns of pesticide

use in each crop. This consisted of some 'typical' spray diaries or estimates of the pesticide use (% area treated), rates and number of applications.

Spreadsheets were used to tabulate individual pesticide usage for each land use or sector as Rate (kg ai/ha), % Use (mean proportion of land treated) and Number of applications (mean across the region). The rates were generally based on the product label recommendations but more detailed information was available for some crops. The usage generally covered 1 July 1998 – 30 June 1999, reflecting one seasons use. These spreadsheets were then used to collate the data into the FAO categories and sub-categories, to provide the required summary data for reporting.

Three use statistics were routinely calculated for each pesticide class in a sector/ region:

Use (%) – the percent of land area that received at least one application of a pesticide in the class in the year (usually 1998).

Where more than one individual pesticide was used within a class, decisions were required as to whether this represented either different growers making alternative choices (Use for class = Sum of % uses for individual pesticides) or all were applied by each grower (Use for class = Mean of individual % uses). The delineation was often not clear cut e.g. three insect growth regulators (IGRs) were commonly used on apples with several applications. Some growers used only one IGR throughout the season and others alternated products. Therefore the Average Use for the IGR class in apples lies somewhere between the sum and the mean of the individual % uses. For crops where this was a common situation, a separate analysis of the spray diary information grouped by pesticide class was undertaken to establish more accurate Average Use values.

Loading – the average amount of pesticide active ingredient in each class applied per unit area of treated land in the year.

Loading (kg ai/ha) = Sum (% Use x Number applications x Rate)/ Use)

The average is over land which received at least one application of a pesticide in the class and only where the Average Use reaches 100% does it equate to the loading over all the land in a sector.

Quantity – the total quantity of pesticide active ingredient in a class applied to land in that sector/region in the year.

Quantity (tonnes ai) = Area x Sum (% Use x Number applications x Rate)/100,000

The sum is made over all pesticides in the class and Area is the total area of land for the sector and region in ha (conventionally the cropped or canopy hectarage, or 80% of farm area for pastoral land).

These data are presented for each sector in the Appendices that generally have an identical format. Therefore the summary information, although detailed and extensive, can be readily assimilated and data identified for particular pesticide classes of interest.

Note the sub-class data are indented and then summed to form the FAO 'other' classes.

The appendices also provide totals (in bold) under each major pesticide category (insecticide/ herbicide/fungicide) for the quantity and loading. The quantity is an objective estimate of the total tonnage of each category used by a sector in a region. However the loading totals are upper limits to the overall average use. This is because the individual class loadings are calculated on a where applied basis and also the accuracy of combining the classes requires knowledge of whether the different individual class data represents combined or alternate uses. The true average use for a category across all land in a crop in kg ai/ha is given by the total quantity applied in kilograms divided by the planted area in hectares. This is a basis for comparisons of overall intensity of pesticide use, for example between countries (Reus 1993).

However the individual pesticide and class loadings as calculated in this report are a more suitable basis for risk assessment of particular use patterns.

The frequency statistic of the average number of pesticide applications for each class is not presented for reasons of space and clarity. However it can be estimated by dividing the loading by the average rate of application. Some frequency data is tabulated for pesticide use in apples (Appendix 6) and selected data are given in the discussion for other sectors where there are points of interest. The rate information (in kg ai/ha) can be calculated from the registered rates of application and formulation composition for the pesticide products (Novachem Manual, 1998). Conversely if the number of applications per annum is known (frequently one) then the average rate of application is given by the loading divided by the number of applications.

It is important to remember that the data for each sector contained in the appendices represent averages and averages of averages. The variation in use patterns between individual properties was often very large with respect to both the variety of pesticides chosen and the frequency of their use. This variation was difficult to quantify and certainly impossible to fully summarise. However some examples are provided in the discussion for apples and kiwifruit.

4. RESULTS AND DISCUSSION

4.1 Current Pesticide Use in New Zealand

Table 2 summarises the estimates of New Zealand agricultural and forestry pesticide usage by FAO class for the year ending 30 June 1998. Data supplied by AGCARM forms the core of this information. Their annual statistics are based on independent surveys of monthly sales by member agrichemical companies. Although not all companies participate in the survey, AGCARM estimates 95% of non-forestry uses of pesticides are included. Non-participating companies, including several now important in the forestry sector, were invited to submit sales data to this project for the purposes of augmenting the AGCARM data. Only one company was prepared to co-operate.

Another problem with the AGCARM statistics is that the pesticide classes do not all directly align with those of FAO, particularly in the herbicide area. AGCARM have chosen to group pesticides more by market segment than by mode of action. For example categories are used such as Brushweed killers, Non-selective non-residual and Cereal broadleafs, each of which contains herbicides from diverse chemical classes and therefore cutting across the FAO categories. The retail herbicide sales survey data (A C Neilsen, 1999) was useful in deconvoluting the AGCARM data into the FAO categories and in providing an independent cross check on much of the herbicide data.

The data in Table 2 covers uses of pesticides in agricultural, horticultural and forestry production and will also include pesticide use in the following sectors: homes and home gardens; conservation estate; road and rail boams; waste land; industrial disinfestation. However the following classes of pesticides are excluded: ectoparasiticides; rodenticides and other vermin control agents; timber treatment chemicals; fumigants. Surfactants and other adjuvants, apart from mineral oil are also excluded.

The total quantities of pesticides used in forestry were estimated from the sector use pattern results of this survey (see Section 4.8). There are large multipliers and uncertainties involved in extrapolating pesticide use from the Central North Island to the whole country. The forestry estimates are tabulated separately in Table 2 to acknowledge the lower level of confidence in the accuracy of these data relative to that for agricultural uses. This also facilitates comparisons with previous statistics that were largely based on the agricultural sectors. Some of the sales into agriculture will be applied to land in preparation or establishment of forestry plantations, particularly smaller wood-lots. Therefore there is the possibility of double counting in Table 2 for some herbicide classes but this is not likely to exceed the margins of error.

The mineral oil class is listed under insecticides by FAO. However the high rates of use tend to distort the insecticide totals and there are a range of uses for mineral oil solely as an adjuvant e.g. in cereals and aerial application of copper to forests. Therefore this class is listed separately. The total quantity used nationally was estimated from the individual use patterns for the sectors in the four regions and then multiplied up. Because of the propagated errors in this accounting, the estimate for national use of mineral oil of about 617 tonnes (Table 2) has considerable uncertainty. Note these quantities are on a weight basis with mineral oil formulations generally being 0.84 kg oil/litre.

The data summarised in Table 2 reveal the following significant features of overall pesticide use in 1998:

- Herbicides at 2,143 tonnes accounted for 68% of total quantities of pesticides used (excluding mineral oil) with fungicides and insecticide use at 24% and 8.2% respectively.
- Phosphonyl herbicides (principally glyphosate) was the largest class (831 T) followed by , phenoxy hormone herbicides (743 T), dithiocarbamate fungicides (366 T) and triazine herbicides (245 T). These four classes accounted for 67% of all pesticides used (excluding mineral oil).
- Mineral oil uses as an insecticide and adjuvant were 617 tonnes.
- The remaining uses after the above five major classes, were spread over a range of relatively minor classes with organophosphorus insecticides, ‘other hormone’ type herbicides, inorganic fungicides and ‘other fungicides’ each having uses exceeding 100 tonnes.

This overall use pattern is mainly determined by the land uses, the spectrum of plant protection and weed problems, the general economics of the land use, the cost-effectiveness of the pesticide products available relative to alternative control measures, and the regulatory environment (national, regional and sector). These issues are discussed in the following sections in the context of national and international trends.

Table 2: Pesticide use in New Zealand, year ending 30 June 1998.

PESTICIDE CLASS (FAO classification)	Kilograms of active ingredient Agriculture	Plantation forestry	Total
Organophosphates	150,000		150,000
Carbamates	39,000		39,000
Synthetic Pyrethroids	5,300		5,300
Botanicals and Biologicals	7,700		7,700
Acaricides (I1)	34,000		34,000
Insect Growth Regulators (I2)	10,000		10,000
Other Insecticides (I3)	21,500		21,500
FAO Other Insecticides (I1 to I3)	65,500		65,500
TOTAL INSECTICIDES	**267,500**	**0**	**267,500**
MINERAL OILS	**450,000**	**167,000**	**617,000**
Phenoxy hormones	745,800		745,800
Triazines	80,300	165,000	245,300
Amides	66,600		66,600
Carbamates	2,000		2,000
Dinitroanilines	15,000		15,000
Urea derivatives	25,000		25,000
Sulfonylureas/amides	8,900	1,100	10,000
Bipyridyls	17,500		17,500
Uracils	5,000		5,000
Other hormone types (H1)	118,200	7,100	125,300
Phosphonyls (H2)	701,100	110,000	811,100
FOPs and DIMs (H3)	4,600	200	4,800
Other herbicides (H4)	56,900	12,8000	69,700
FAO Other Herbicides (H1 to H4)	900,800	130,100	1,030,900
TOTAL HERBICIDES	**1,846,900**	**296,200**	**2,143,100**
Inorganics	77,600	82,000	159,600
Dithiocarbamates	366,200		366,200
Benzimidazoles	6,700		6,700
Triazoles	30,700		30,700
Diazines, Morphs, other EBIs	6,700		6,700
Dicarboximides (F1)	13,600		13,600
Strobilurins (F2)	5,500		5,500
Other fungicides (F3)	195,200		195,200
FAO Other Fungicides (F1 to F3)	214,300		214,300
TOTAL FUNGICIDES, BACT.	**702,200**	**82,000**	**784,200**
PLANT GROWTH REGULATORS	**101,800**	**0**	**101,800**

4.2 Trends in Overall Pesticide Use 1984-1998

Trends in gross sales data for pesticides are a useful primary indicator of the changes in intensity of pesticide use over a period. FAO collects national sales data which is used by OECD for the analysis of regional and global trends (OECD, 1996b). The data gathered here for 1998 and the historical data from the Wilcock (1989, 1990) and Penman (MfE, 1989) reports and from the previous AGCARM annual surveys form the basis for an analysis for New Zealand pesticide use over the past 15 years. Figure 1 plots our estimates for annual quantities of insecticides, herbicides and fungicides over the period. Mineral oils are excluded from this analysis. Figure 2 tracks the uses of several important herbicide classes for 1986-89 (AGCARM 1987, Wilcock 1988, 1989) and for 1998 (present study). Similarly Figure 3 presents the data for several important classes of insecticide and fungicides.

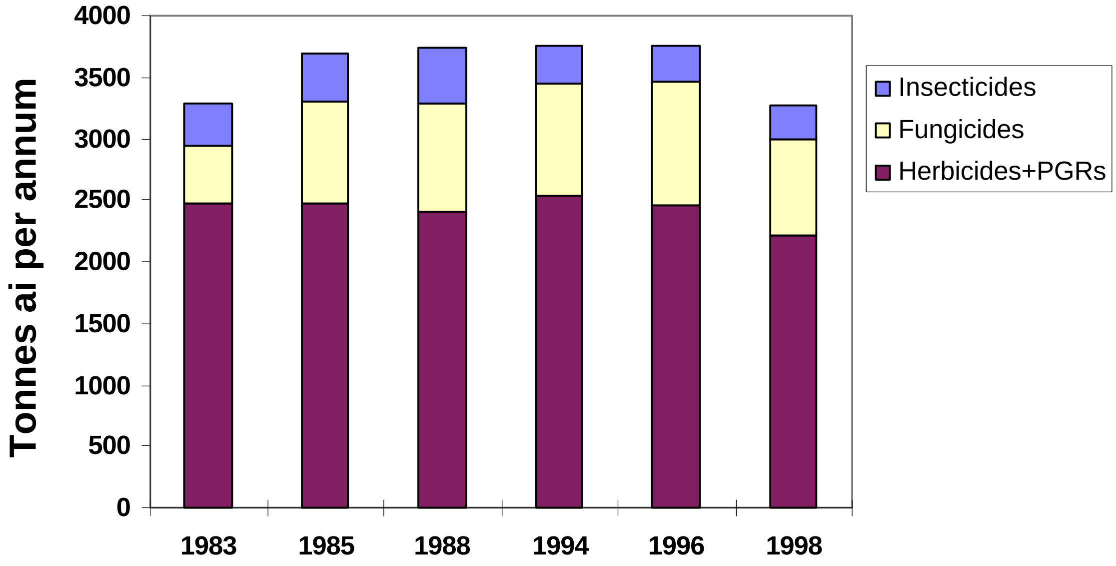

Figure 1: Pesticides use in New Zealand 1984 – 1998 (tonnes of active ingredient).

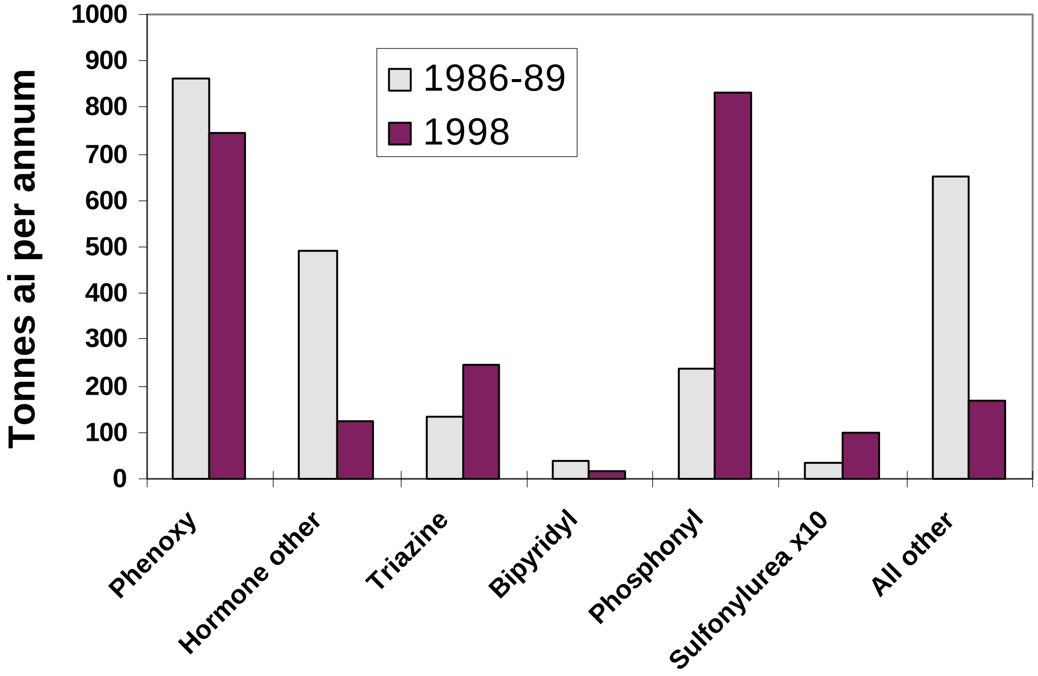

Figure 2: Herbicide use by class – comparison between 1986-89 and 1998.

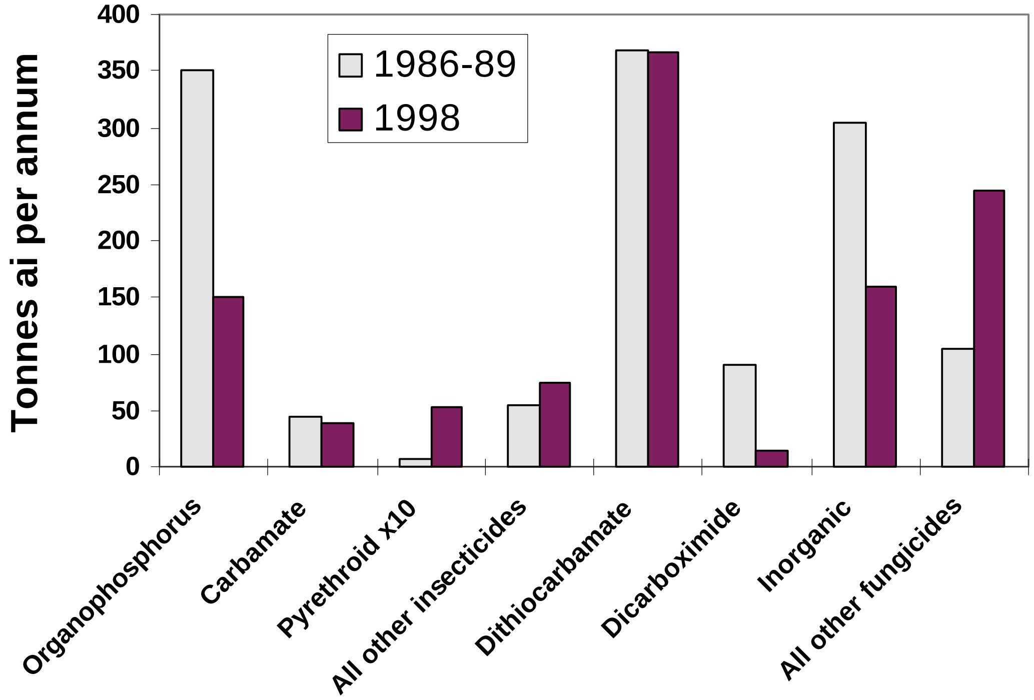

Figure 3: Insecticide and fungicide use by class – comparison between 1986-89 and 1998

Some difficulties arise in the comparability of the data sets used to plot these trends. Each was derived by different means and with varying degrees of detail and inclusiveness. The differences and potential errors are not always transparent but the following particular aspects have been identified which may influence the comparability of data:

1. The majority of data is based on annual sales and thus does not strictly correspond to use in any particular year. However large pesticide stockpiles are not common in New Zealand and changes in use pattern are gradual. Therefore a good correspondence can be expected of annual sales data to actual use on either a calendar year or growing year (July-June) basis.
2. There is a strong dependence on AGCARM surveys for the data in the period 1984-1997 (apart from the Wilcock studies). AGCARM membership is dominated by the multinational agrichemical companies. A number of New Zealand owned companies importing and distributing pesticides are not members of AGCARM, although one contributes to the annual survey. Several of these companies have become significant in the market for some key out of patent herbicides now available as generic commodity chemicals. The current AGCARM survey may not be accounting for about 15% of total sales quantities (excluding mineral oils), mainly to the forestry sector. This survey has made an independent estimate of forestry use for 1998. However the scale of sales in previous years which are not accounted for by AGCARM surveys was difficult to estimate. Based on the Wilcock data it probably did not exceed 10% for the years prior to 1990.
3. Mineral oil is a pesticide in the FAO list. However it has largely been sold by non-AGCARM companies and is consequently heavily under-represented in AGCARM survey data. The Wilcock surveys also did not gather data for mineral oil. The present survey has made a robust estimate of mineral oil usage for 1998. However the lack of reliable reference data for other years means that mineral oil is best left out of the analysis of trends. For the purpose of preparing Figure 1 adjustments were made to the AGCARM sales data for 1983-1987 by subtracting an estimate of the mineral oil component.
4. The Wilcock reports (1988, 1989) contain a very useful detailed baseline data set for pesticide use in the period 1986-89. However there are some discrepancies and deficiencies in the presentation of the quantities by pesticide class. Therefore some adjustments were made to obtain general correspondence with the totals for major classes recorded in the 1987 AGCARM survey and Penman report (MfE, 1989).
5. The uncertainties arising from inefficient or inaccurate data capture in the various surveys and incompatibility or discrepancies between data sets mean that the use estimates have associated errors of at least 10% and perhaps reaching 20% in some cases. The Penman report (MfE 1989) acknowledged errors of similar magnitude in their use estimates.

Taking the above provisions, corrections and potential errors into account, the following points can be made on the trends revealed in overall pesticide use over the past 15 years (Figure 1) and the broad classes (Figures 2 and 3).

- The gross quantities of pesticides use in NZ annually have remained relatively constant with the totals in 1985-1996 averaging 3700 tonnes active ingredient per annum. The totals were approximately 10% less in 1983 and 1998.
- The proportions of the herbicide, fungicide and insecticide classes have also remained relatively constant. Herbicide use has dominated (65-75% of the gross annual tonnages). There is a trend to a reduction in insecticide use.
- About two thirds of total pesticides usage is concentrated in the four classes of pesticides: phenoxy hormones, phosphonyls, inorganic fungicides, dithiocarbamates. These pesticides

have established excellent records over long periods for very low human and environmental risks when used as directed.

Within the herbicide category there has been some significant shifts in use pattern by class over the past decade (Figure 2):

- Phosphonyls, principally glyphosate, now dominate. The dramatic increase in use of this broad spectrum herbicide can be attributed to its wide range of uses and high cost-effectiveness. The latter has been enhanced by the lapse of patent protection with consequent decreases in price in recent years. The low persistence in soil and lack of demonstrated effects on human health or the environment have also encouraged the very widespread adoption of glyphosate as the major general purpose herbicide. There have been corresponding drops in the use of the bipyridyl paraquat and a number of other older herbicides.

- Phenoxy hormone use has undergone a small drop, probably reflecting the overall weakening of the pastoral agriculture sector. Some of the decline in sheep and beef farming will be compensated by the strengthening of dairying where use of 2,4-D and MCPA for broadleaf weed control is common.

- 'Other hormone' herbicide products have greatly reduced in importance. This class is mainly used in brush weed control, principally gorse and broom. Economic factors have led to the continuing of a decline in treatment of weeds in marginal hill country already noticeable in the 1980s (MfE, 1989). Also glyphosate and the sulfonylurea metsulfuron have made significant inroads into this market. The latter is an important example of a new generation herbicide with a high and very specific activity against plants. The registered rates of application for metsulfuron are 5% of those previously used with 2,4,5-T. Consequently the relatively small absolute increases in quantities for the sulfonylurea class (Figure 2) offset much larger quantities of older, lower activity herbicides.

- Triazine herbicide use has increased by 90% in the past decade, probably due to increased use in cropping and forestry. Although these are mainly older products and tolerance has become evident in a few weed species, triazines are still very cost-effective pre-emergence herbicides and dominate this market niche.

The trends in insecticide and fungicide use also show some shifts in the relative importance of categories over the past decade.

- Organophosphorus insecticide (OP) use has decreased to less than half that in the 1980s due to changes in insect control practices in horticulture and the virtual cessation of insecticidal treatments of pasture. These reductions in the use of one of the most toxic classes can be broadly attributed to the adoption of IPM strategies in many sectors.

- Synthetic pyrethroid (SP) insecticide use has increased seven-fold from a small base. The quantity of SPs is small but significant due to their extremely high insect contact activity with use rates typically 2-5% of those for OPs. Uses of SPs in horticulture and cropping are circumscribed by their persistent and broad spectrum of activity that can have deleterious effects on populations of beneficial insect species. However domestic and industrial uses have proliferated.

- Dithiocarbamate (DTC) fungicides remain the most important fungicide class. They are still the most cost-effective broad spectrum fungicides available for use in horticulture. Because they function as protectants, applications tend to be frequent where conditions favour fungal infection.

- Dicarboximide fungicide use has declined due to major reductions of fungicide use in kiwifruit and the development of resistance by some target fungi.

- Inorganic use has also decreased, principally due to reduced frequency and application rates for copper based fungicides/bactericides. Improved formulations of cupric hydroxide have largely replaced Bordeaux mixture and copper oxychloride.
- The remaining insecticides and fungicides ('All other' in Figure 3, by difference from total) cover diverse chemical types with use of older materials declining and a range of new materials coming available, often with significantly lower use rates. For example uses for endosulfan and several older miticides have greatly decreased while the biological control agent *Bacillus thuringiensis* and the high activity synthetics fipronil and imidacloprid have become important insecticides. New fungicides including a number of triazoles and strobilurin analogues are also becoming widely used.

4.3 Pesticide Use in Arable Crops

The summary data for the cereals (wheat and barley combined), field peas, herbage seed production (grasses and legumes) and maize are presented in Appendices 2, 3 and 4 respectively. Herbage seed production is minor outside Canterbury and therefore use statistics are only tabulated for this district. Pesticide use patterns were established by consultation with agronomic and agrichemical experts from the regions who are familiar with pesticide use in these crops. For cereals, the use pattern established for Canterbury was taken as broadly applicable to the much smaller area in Hawkes Bay. The basic use pattern established for maize in the Waikato and BOP/Rotorua was applied to Hawkes Bay. Independent information was obtained for Canterbury where most of the maize production is for green-feed and silage.

Cereal and herbage seed production in Canterbury make extensive use of herbicides. In particular the phenoxy hormone products are still used in a high proportion of the crops (except clover) for broadleaf weed control. These crops typically also receive seed treatments of insecticide and fungicide and a foliar treatment with an ergosterol biosynthesis inhibiting (EBI) fungicide, mainly low rates of the triazole class. Breeding of cultivars resistant to rusts has reduced the intensity of this later spraying and integrated crop protection principles based on monitoring are available to optimise timing for this and other diseases or insect pests. Over 50% of cereal crops are treated with a growth regulator to prevent lodging. The overall pesticide use pattern is similar to that for intensive cereal production in Europe.

Field peas are the major grain legume produced in New Zealand and are mainly grown in Canterbury. This crop has an important place in the arable crop rotation as a fertility-restoring break crop between successive cereal crops (Petrie & Bezar 1997). Herbicide treatments are mainly in the early season (triazines and phenoxy hormones). The use of triazines on shallow stony soils has been implicated in contamination of groundwater (Smith 1994). Triazole fungicide applications for powdery mildew control have become less common with the introduction of resistant cultivars (Falloon et al 1993).

Grain production from maize is concentrated in the North Island while maize grown in the South Island is for silage. Production is intensive and grain yields are high by world standards. The main pesticide uses are herbicides, mainly the amide class (alachlor, acetochlor) applied preplant and triazines used pre- or immediately post-plant. There is some use of dicamba in Northern districts for control of broadleaf weeds. This pattern of very cost-effective herbicide use has remained relatively unchanged for three decades. The triazine loadings are relatively high and there is a threat of leaching of residues to groundwater on a few sites with light, free-draining soils. Insecticides for control of cutworm and other soil dwelling pests are now mainly applied as more targeted seed treatments rather than the prior furrow treatments with granular formulations of organophosphates. Some crops are treated with synthetic pyrethroids around tassle stage for control of tomato fruit worm and other insect pests.

4.4 Pesticide Use in Apples

ENZA made available a database of all their grower spray diaries (pest control records) for the 1998/99 season. This consisted of over 1500 individual grower diaries, many with multiple spray options, which was too many for convenient analysis. Therefore records for blocks of Royal Gala or Braeburn cultivars were selected. These are currently the main cultivars and are early and late maturing respectively. For Hawkes Bay a further random sub-sample of these diaries was necessary to limit the sample to 600-1200 records per region. The relatively large data set means the average pesticide use pattern in this crop could be established with good accuracy. Appendix 5 gives the summary data across districts.

In 1998/99 apple growers chose their pest control programmes according to four ENZA standards set to meet various market and other criteria. This included integrated fruit production (IFP) which is a system of continuous improvement based on IPM introduced to the apple industry over the past 4 years. Pesticide use under the four management systems was compared for the Hawkes Bay region. Appendix 6 lists the average insecticide and fungicide uses by FAO class for the four systems, with statistics given for average use, loading and number of applications. The data in Appendix 5 for Hawkes Bay is effectively a weighted average of the data in Appendix 6 and both are averaged across the Royal Gala and Braeburn crops.

Pesticide use in apple production is characterised by very frequent applications of fungicides, principally to protect against blackspot (*Venturia inequalis*) and powder mildew (*Podosphaera leucotricha*) and frequent insecticide applications, principally for control of lepidopterous pests. Thus loadings for these pesticides are relatively high (Appendix 5). This pattern of use was until recently mainly governed by a calendar spray programme with limitations on pesticides to those compatible with predators of mite pests and residue requirements of local and export markets. The apple industry in 1996 expanded this integrated mite control programme to pilot scale evaluation of a full IFP programme placing broader emphasis on use of biological control, reduced use of pesticides and greater adoption of more selective and environmentally benign products (Manktelow et al 1997; Walker et al 1997). IFP has become a key strategy for the industry which has been introduced gradually. For the 1998/99 growing seasons growers could choose to follow one of four main pest control programmes, two based on IFP. Appendix 6 summarises the four spray programmes followed in the Hawkes Bay. 'General' is basically a standard calendar based programme. 'IFP' is the recommended IFP programme. 'General-USA' and 'IFP-USA' are the above programmes modified by additional late azinphos-methyl sprays to ensure US phytosanitary standards could be met.

Spray programmes for about 40% of the blocks in the Hawkes Bay met the broad IFP recommendations. Significant features of the comparison between 'General' and 'IFP' spray programmes are:

- IFP blocks received 4 less organophosphate applications with a reduction in loading from 5.0 to 1.8 kg/ha.
- Insect growth regulator use was doubled on IFP blocks.
- There were no significant differences in overall fungicide use, despite use of monitoring and weather data to assist with spraying decisions under IFP.
- There was a wide variation between growers in the number of fungicide applications over the season, ranging from less than 5 to greater than 15 with a median of 10.

Overall the IFP programme has resulted in large reductions of OP use without compromising the levels of pest control. However insecticide loadings remain relatively high and grower confidence to reduce the use of fungicides is relatively low.

Herbicide use in orchards is dominated by phosphonyls with some use of residual materials, principally triazines and ureas. Tractor rows are almost universally kept in mowed grass with herbicide treatments confined to the tree rows. In comparison to a decade ago (Berry, 1992) use of residual herbicides (triazines, ureas) has decreased in response to producer board recommendations.

4.5 Pesticide Use in Kiwifruit

Kiwifruit New Zealand supplied 190 grower spray diaries from the Bay of Plenty region for the 1998/99 season. These were the diaries for a random sample of orchards chosen for the annual residue monitoring programme and should be very representative for establishing pesticide use on the Hayward cultivar, especially in the northern regions. Over 90% of kiwifruit is now grown under the Kiwigreen integrated pest control system which includes a rather limited range of pesticide options. There was no basis to subdivide the diaries as for apples and therefore Appendix 7 represents a robust estimate of overall pesticide use in this crop.

Pesticide use in kiwifruit has undergone major reductions over the past decade with the adoption of the Kiwigreen integrated fruit production programme (Bull, 1994).

Spray programmes in the 1980s were characterised by relatively intensive use of organophosphate sprays including the residual and high rate materials azinphosmethyl and phosmet. Dicarboximide fungicides were also routinely applied. An average of 7 post-blossom sprays were used. In response to residue concerns from overseas markets a pilot Kiwigreen programme was initiated in 1992. The uptake was expanded until in 1995 77% of production came under Kiwigreen and in 1997 it was made the standard for the whole industry (excluding organic production). Kiwigreen is characterised by use of pest monitoring to guide insecticide spraying, a reduced choice of pesticides with use at long pre-harvest intervals, greater use of 'soft' pesticides (mineral oil, Bt) and modified canopy management to reduce disease pressure. The 1998/99 grower spray diaries (Appendix 7) indicate that the intensity of organophosphate/pyrethroid/dicarboximide use in the post-blossom period has decreased by more than half over the past decade. About 35% of orchards used oil and 37% used Bt. Dicarboximides were applied on 40% of orchards but only in the immediate post-blossom period. The growth regulator hydrogen cyanamide was used on 50% of orchards as a dormant season spray to improve bud burst. Currently the majority of fruit produced under Kiwigreen has no detectable pesticide residues, meets the phytosanitary standards and has a low incidence of post-harvest rots. However the long pre-harvest intervals set for the 'hard' pesticides make it difficult to control sporadic pests such as passionvine hopper which move in from adjacent land.

4.6 Pesticide Use in Other Horticultural Crops

For avocado and citrus, limited spray diary information was made available by industry groups and the data are summarised in Appendix 8. These crops have more varied pest control practices than kiwifruit and the data are therefore only indicative of the pesticide use patterns. IPM practices are beginning to make an impact in both crops. Spray programmes for export avocado after fruit set, as with other export horticultural crops, are designed to meet residue requirements of the importing countries. As these vary and are very limited in range, choices for recommended pesticides are very restricted. Organophosphate insecticides and copper based fungicides are still important in avocado and citrus with relatively high loadings.

For grapes, spray diary information was supplied by a consortium of Hawkes Bay growers and major wine companies who are beginning to implement an integrated wine grape production (IWGP) system. A total of 38 blocks of both red and white varieties received either standard or IWGP pest management for the 1998/99 growing season. As the differences between the actual spray programmes used under the two management systems were small, the set was averaged to produce a robust estimate of overall pesticide use in wine grapes for Hawkes Bay (Appendix 9). Insect problems tend to be relatively minor in grapes with consequent low insecticide use. However mildews during the growing season and *Botrytis cinerea* at harvest are very significant diseases and relatively intense fungicide programmes tend to be followed in the wine grape industry. There is high use of the inorganics copper and sulphur as well as a range of synthetic fungicides. Dicarboximide use is dropping due to resistance in Botrytis and transfer of residues on fruit into the wine. The new IWG programme is designed to move plant protection measures in grapes in a more sustainable direction. However only minor reductions in pesticides use resulted for the pilot 1998/99 season with disease pressures being difficult to manage.

Berryfruit is a diverse sector and three crops were chosen for study: Blackcurrants, boysenberries and blueberries. All are relatively minor on an acreage basis but have interesting pest control issues that influence the trends in pesticide use. Industry groups made a large number of spray diaries available to enable robust estimates for the average pesticide use in each crop for the regions of greatest production (Appendix 9). In the case of boysenberries, Nelson was included as the district of greatest production, although it falls outside the survey regions. Blackcurrants and blueberries have few serious pest and disease problems and pesticide use is relatively low. Conversely boysenberries require an intensive fungicide programme, principally for downey mildew and Botrytis. Boysenberry decline disease (probably caused by a mycoplasma infection) is reducing acreages of this crop which is being replaced by other cultivars and hybrids being developed from the *Rubus* genus.

4.7 Pesticide Use in Vegetable Production

This again is a very diverse sector characterised by a few large companies and many smaller growers. Several companies made spray diary information available and consultants were also used to make their own estimates of pesticide use based on experience. Data for the crops listed in the Waikato include the Pukekohe district which overlaps the regional boundary with Auckland. Therefore the areas and quantities apply to the whole Waikato/Pukekohe region. Appendix 10 gives the estimates for pesticide use in onion and potato crops in the above region.

Potatoes received intensive protectant fungicide spray programmes with about 10 applications of mancozeb (dithiocarbamate) supplemented by fluazinam (‘Other fungicide’) and other products for the early crop. These fungicide treatments were frequently applied with mineral oil or surfactant adjuvant. Total fungicide loadings exceed 20 kg ai/ha although residues are not transmitted to the tubers.

Onions received the most intensive spray programmes of all the crops studied. The spray practices vary widely between growers so the information in Appendix 10 is only indicative. The crop is very sensitive to weed competition and provides little shading or ground cover to suppress weeds. Therefore there is an emphasis on total weed control over the growing season using selective herbicides applied frequently, often at lower than label rates. The average use of herbicides in onions exceeds 6 kg/ha. Insecticide use is also relatively intense for a field crop. Thrips are a pest and export phytosanitary risk which has proved difficult to control. Fungicide use was even more intense. Concentrated seed treatments are followed by 8-10 applications of mancozeb and 4-6 applications of MBC products (benzimadazole) and several applications of fungicides from other classes. The average use of fungicides in onions exceeds 25 kg/ha. Onion white rot (*Sclerotium cepivorum*) has become established in the Pukekohe district and fungicide resistance is widespread which has led to a crisis in the industry (Webber *et al*. 1999). The production system for onions in this district is now widely regarded as unsustainable because of the disease and insect problems combined with degradation of the soil resource, runoff and leaching. The problems are not easily solved as complex agronomic, economic and social factors are involved. As one example the desirable practice of introducing potatoes as a crop rotation leads to increased herbicide usage in the succeeding onion crop due to the need to control volunteer potatoes. A major project in

Franklin District is attempting to improve management practices in vegetable production, although pesticide use is secondary to addressing erosion, fertiliser use and other soil factors.

Appendix 11 gives pesticide use for lettuce and vegetable brassicas in the Waikato/Pukekohe region. These crops are characterised by separate plantings for summer and winter production with some corresponding differences in pest control requirements. These seasonal uses are listed separately in Appendix 11 and the quantities are per crop rotation (about 3 to 8 months). The summer crops were treated with more insecticide while the winter crops received more fungicide. Insecticide use is now managed to reduce development of resistance in the main pests and Bt was used on a high proportion of brassica crops. Fungicide use was dominated by mancozeb with 4-8 applications on lettuce and brassica in winter.

Pesticide use in the major process vegetables of field tomatoes, asparagus, sweet corn and green peas are summarised in Appendices 12, 13, and 14 respectively. The estimates are based on a combination of company spray diaries and specialist knowledge of consultants. Pesticide use was relatively low in these process crops. Asparagus requires careful attention to weed control and residual triazines, ureas or bromacil (uracil class) early in the growing season are relied on to give long term control. Similarly green pea and sweet corn used triazines and phenoxies early season. Organic production of these crops in Hawkes Bay/Gisborne eliminates these herbicides at the cost of more extensive mechanical cultivation.

4.8 Pesticide Use in Pastoral Agriculture

There are over 13 million hectares of pastoral land in New Zealand. For the purposes of this report a simple division of land use into sheep & beef and dairying was made. Gross estimates of herbicide quantities (kg ai by individual pesticide) were calculated from the national AGCARM wholesale sales data (kg ai by class, 1997/98 year) and the retail sales data ($ value of product, 1998 year, A C Neilsen 1999). Specialist knowledge and consultants were used to convert these sales to quantities used (kg ai/annum) in the sheep & beef and dairy sectors. The land area data in each region then allowed calculation of the percentage of land treated in each class. The potentially treated land area was taken as 80% of the total farm area.

Overall herbicide use in New Zealand pastoral farming is given in Table 3. Appendices 19 and 20 give details of the pesticide use patterns for the two sectors on a regional basis.

Table 3: Herbicide use in New Zealand pastoral agriculture 1997/98 (FAO classification).

	Sheep & Beef farms	Dairy farms
Total area million ha	11.89	1.27
Quantity kg ai		
Phenoxy hormone	301,000	265,000
Other hormone types	48,200	5,400
Sulfonylurea	2,500	300
Phosphonyl	123,000	82,000
TOTAL	474,700	352,700

Pesticide use in pastoral agriculture remains dominated by phenoxy hormone products for control of broadleaf weeds in establishing or established pasture. Although still very cost-effective products, an increasing spectrum of weed species are exhibiting tolerance to these herbicides, such as in nodding thistle (*Carduus nutans*) and giant buttercup (*Ranunculus acris*) in some districts. About 20% of dairy land was treated with phenoxy hormones in 1998. The percentage of area treated was much lower in sheep/beef farms although most of the use would have been on flat to rolling rather than hill country. Brushweed control used metsulfuron-methyl (sulfonylurea class), glyphosate (phosphonyl) and other hormone types with a total of approximately 0.9% of sheep/beef land being treated. Insecticide use was very minor with treatment of most pests being uneconomic and for most soil dwelling pests, also ineffective. Only very small areas of land in northern districts were treated with fungicide for control of the fungus (*Pithomyces chartarum*) causing facial eczema in livestock.

4.9 Pesticide Use in Plantation Forestry

This major sector presents some problems for the gathering of pesticide use statistics. Firstly, the majority of pesticide use involves herbicide applications in the preplant and establishment phases of the production cycle, with differences depending on whether it is replanting or new plantings from pasture. Secondly, much of this herbicide use is by spot spraying around the seedlings which reduces the overall rate of application to 20 – 25% of that for application over the whole area. However cold sites require more thorough vegetation control because bare ground provides better protection to seedlings from frost damage. Therefore these sites are treated by broadcast spray application (generally aerial).

The major forestry companies were co-operative in providing details of the pesticide use in the areas of replant for the Central North Island and Hawkes Bay regions. However there are large areas of forestry, particularly new plantings, under control of smaller companies and landowners. On the other hand plant protection strategies for *Pinus radiata* establishment have become rather standardised through the efforts of Forest Research Institute (Davenhill 1997) and only a few pesticides are commonly used. Pesticide use in forestry nurseries is not included in this survey.

For the purposes of this survey the spraying practices of the major companies dominating forestry in the Central North Island have been taken as typical for this region and the Hawkes Bay. The quantity estimates are again subject to considerable errors because of the relatively large areas involved and the uncertainties as to the actual areas and rates of application. Appendix 17 presents the estimates for pesticide use in the first year of establishing conifers (mainly *Pinus radiata*) with preplant and initial release applications of herbicides dominating. Appendix 18 presents the estimates for pesticide use in year 2 where herbicide is often applied again to re-release the seedlings. The bulk of herbicides currently used in forestry are for these release purposes and the products are mainly triazines. Triazine herbicides have properties which can lead to runoff and leaching under some conditions. However the risks, where they exist, are transient because the treatments are only applied in the first 1-2 years of a 20-30 year tree crop rotation. Development of weed tolerance to the herbicides is unlikely under this regime. The emphasis on hand applied spot spraying also reduces environmental risks.

Appendix 19 presents estimates for pesticide use in plantations during the rest of the growth cycle (years 3 to harvest). Very little pesticide is used over this phase apart from aerial spraying of cupric oxide plus mineral oil for control of *Dothistroma* needle blight. This operation is co-ordinated by the NZ Forest Owners Association who purchase the chemicals in bulk and therefore good tonnage data are available. The amounts used vary from year to year depending on the severity of disease outbreaks which are the subject of large scale industry monitoring.

4.10 Organic Production

This sector prior to 1990 was characterised by a few philosophically committed producers focussing on the domestic market (Saunders *et al* 1997). However over the past decade there has been a rapid increase in organic production directed at export markets. Kiwifruit, honey, vegetables and apples are the most important organic sectors but all forms of agricultural production include organic enterprises. For kiwifruit 555 hectares were organic in 1999 (including conversion status orchards) which is over 7% of the total acreage. Conversion has been slower in the more difficult to manage apple orchards. However the main exporter FreshCo has increased cartons shipped from 15,000 in 1997 to 230,000 in 1999 (ca. 1.5% of total exports). These recent changes have been driven by the substantially higher margins for organic produce combined with research information, environmental, social and grower confidence factors. The effects on synthetic pesticide use are small nationally thus far but are significant in kiwifruit.

Elimination of synthetic pesticides is a central part of the ethos to grow food using biological principles rather than purchase of chemical inputs. However a variety of chemicals and compounds are acceptable pesticides under organic standards (Bio-Gro 1999), usually with limitations on their inputs and the understanding that their use will be minimised. These chemicals include elemental sulphur, mineral oil, copper compounds and sodium bicarbonate. Compounds and extracts from plants include natural pyrethrum, rotenone and neem extracts. Biological pesticides include *Bacillus thuringiensis* (Bt) and viruses pathogenic to insects. Some of these ‘natural’ pesticides are not truly benign because of their appreciable toxicity to non-target organisms such as beneficial insects and in the case of copper, build up of residues in soil. Sulphur and copper compounds are included in the national pesticides statistics (Table 2) under inorganic fungicides. Bt, pyrethrum and neem are under ‘biological insecticides’. The major current usages of mineral oil, biological and botanical insecticides and inorganic fungicides are still in conventional agriculture and forestry. The proportions of these materials used in organic production will increase, although plant breeding for resistance, insect pheromones and other techniques will be the preferred longer term approaches to plant protection.

As the drivers are increasingly economic rather than philosophical there is also likely to be a greater tendency to use permitted pesticide inputs to ameliorate some of the difficult plant protection problems. There will be pressures to permit use of a wider range of ‘biological’ pesticides so long as they meet what at present are rather vague criteria. Many such products are under development, including by major agrochemical companies. Thus there may be a degree of convergence between IPM and organic pest management which will be assisted by exchange of research information and experience at the grower network level.

4.11 Comparisons Between Sectors

The data collected here for pesticide use by agricultural sector and region can form the basis for comparison of trends both within New Zealand and internationally for the future. Table 4 summarises average pesticide loadings for some of the major crops/land uses as calculated by dividing the quantities of each main category used (kg) by the total planted area of crop (Appendices 2-19). Use data for the main growing regions for each crop were used as a basis for the average loading calculations.

Each sector has a typical use pattern and loadings arising from a variety of factors (see Section 4.12 following) some of which differ widely between sectors. Gross national usage or broad categories such as ‘cropping and horticulture’ have been used as a basis for international comparisons (Reus 1993; OECD 1996b). The usefulness of such comparisons in policy making is doubtful. It is also important that the use data is gathered and presented on a consistent basis. The inclusion or exclusion of mineral oil, inorganics or plant growth regulators can make a large difference to the usage totals, particularly in horticultural sectors

(Table 4). Although the above classes are all pesticides according to the FAO definition, they are often separated from synthetic insecticide, herbicide and fungicides because of perceived lower toxicity and environmental risk factors. Their often higher rates of application also tend to disguise shifts in the use data for synthetic pesticides.

Objective comparisons of pesticide usage for the purposes of identifying trends and influencing factors is only possible for similar land uses and with consistent data sets. This report has provided some commentary for the national trends in the sectors studied (Sections 4.3-4.10). The extension to international comparisons by sector would require a thorough review of the available data for other countries.

4.12 General Factors Influencing Pesticide Use.

Factors directly influencing pesticide use patterns and their associated risks in New Zealand include:

Climate – the temperate to sub-tropical growing conditions combined with generally more than adequate moisture levels and soil fertility lead to high pest pressures. A very wide range of weed species flourish and conditions are often favourable for fungal infections of susceptible plants. Global warming has the potential to increase these pest pressures as well as generate environments more favourable for establishment of introduced tropical and sub-tropical pests.

Agricultural systems – pastoral agriculture is relatively intensive by international standards but the low input management systems lead to limited options for control of pests. Horticulture, cropping and forestry systems are intensive and commodity products are generally only economic if labour inputs are kept low and production levels high. There is a trend to niche products, including organics and processed products which can command higher prices than related commodity lines.

Pest pressures – the interactions of climate/location, crop and agricultural system produce a complex but crop characteristic pattern of weeds, insects (pests and beneficials) and diseases. This spectrum of pests is not fixed but shifts from season to season and on a longer term basis. The development of resistance is a major threat to the sustainable use of many classes of pesticides. If suitable management strategies are not put in place then production of some crops can become uneconomic e.g. onions.

Alternative plant protection strategies – development of systems less dependant on pesticides is a common theme of much current plant protection research. A wide range of technologies are associated with IPM, biological production and other strategies. These are the subject of ongoing development through formal research and on-farm studies. Cost/benefit analysis can be used to assist with the evaluation of alternatives. As has frequently been pointed out, this analysis needs to encompass a wide range of on- and off-farm factors, including energy flows.

Export orientation – a high proportion of New Zealand agricultural production is exported to markets which require high quality (appearance, lack of disease or insects). Strict quarantine and phytosanitary protocols are also applied. Pesticide residue levels must be kept within limits imposed by the market (Codex, national or food distributor).

Regulatory – the Pesticides Act 1979 controls pesticides, principally through the centralised system of registration of products for particular uses as currently administered by the Pesticides Board and MAF. This registration system is similar to those operated in most OECD countries. Fitness-for-the-purpose (demonstrating efficacy), human safety (toxicology, product labelling, residues) and environmental protection aspects are considered. The toxicology data and the environmental fate and effects data are almost exclusively from packages developed by international agrochemical companies for primary registration in Europe or the USA. There is not a strong emphasis on enforcing the product label provisions at the end-user level.

Pesticide registration in New Zealand is soon to change to the Environmental Risk Management Authority (ERMA) under HSNO legislation. This will include more rigorous examination of risk factors, public hearings and appeal processes, and changes in protection provisions for submitted proprietary data. The requirement for efficacy data will be removed. MAF through the ACVM Act will continue to administer some aspects of pesticide registration related to export quality assurance animal welfare, and agricultural security particularly in regard to pesticide residues in food. These changes to more complex and expensive registration procedures are also likely to reduce the number of pesticide registrations in future, particularly for minor uses.

International trends in pesticide regulation are also influencing pesticide use in New Zealand. Maximum Pesticide Residue Limits (MRLs) in countries importing our produce set rather rigid restraints on the selection and use patterns of pesticides on food crops (Watts and Holland 1980). Few MRLs are set in major markets for many of our key horticultural export crops, largely due to the cost of developing suitable data and lengthy procedures. Codex MRLs have the potential to ameliorate this situation but again the process of setting new MRLs is very lengthy. Re-registration procedures in many OECD countries are also resulting in the withdrawal of older pesticides. In Europe the use of triazine herbicides is now restricted due to risks from leaching. In USA reviews under the Food Quality Protection Act (FQPA) are likely to result in restricted registrations and fewer MRLs for most organophosphates.

Producer groups often set more specific guidelines for pesticide use so as to ensure market requirements are met for export commodities. The emphasis has been on controlling residues while meeting phytosanitary standards. More recently this has extended to addressing more general environmental and sustainability issues. The Agrichemical Code of Practice (GrowSafe, 1999) is increasingly being applied as the practical standard which applicators should follow to enhance the environmental and user safety of pesticides.

Application technologies – much spray application is ill targeted and inefficient leading to higher rates of use than needed and greater potential for off-site losses. More careful calibration and use of existing equipment (GrowSafe 1999) and research and development of improved technologies can address these problems. Development of safer formulations and adjuvants is also important.

Storage and disposal of waste – surplus formulation or spray mix and empty containers are major hazards associated with pesticide use. Territorial authorities and NGO initiatives (e.g. WaiPAC 1997) are beginning to address this issue. The GrowSafe guidelines (1999) also reinforce manufacturers' information (product labels etc.).

Social – Pesticides have a generally poor public image. The extensive publicity over the past 30 years on actual, potential and alleged adverse effects to people and the environment has led to a greatly reduced acceptance of any risks from pesticide use. This trend has been excaberated by the increased urbanisation of the population who generally regard all exposure to pesticides as involuntary risks. A 1994 survey quoted by the Parliamentary Commissioner for the Environment (Williams, 1997) indicated that 35% of New Zealanders regard pesticides and chemicals used in farming as extremely or very dangerous threats to the environment. There is also concern about the safety of food. Pesticide residues are widely perceived as more serious threats than objective hazards such as microbial contamination or natural toxins. Regulatory authorities and central government have moved only slowly to address these fears. However continued public pressure was a significant factor in the withdrawal of 2,4,5-T (negation of dioxin hazard) and the reformulation of 2,4-D to a less volatile ester (reduction in drift hazard). Local and regional initiatives are currently directly influencing pesticide use through bans on herbicide use in some public areas and the development of regional statutes for control of spray drift. Producer groups are also responding to these social concerns, as well as the market led forces outlined above, in their adoption of more sustainable pest control systems, including IPM and organic production.

Agrochemical Development – Pesticides used in New Zealand are almost exclusively developed by international agrochemical companies and initially registered overseas. The immense costs associated with these phases of pesticide development, and with meeting any re-registration requirements, have led to several significant international trends, including: company mergers; rationalisation of product lines with an emphasis on supporting pesticides for the major global crops (cereals, maize, soybeans, cotton); reduced support for out-of-patent pesticides and minor crop uses; development of "biological" pesticides which can more readily meet, or partially circumvent, regulatory requirements; genetically modified crops. Most of these trends are likely to result in a reduced range of options for pesticide based plant protection, particularly for the many New Zealand uses that are minor by international standards. Older, out-of-patent pesticides are increasingly becoming available as commodity chemicals, principally from manufacturers in developing countries. These products are often of dubious quality. A key issue for the continued use of many of these older pesticides is whether adequate data can or will be supplied to support their continued registration in North America and Europe.

4.13 Risk Assessment and Pesticide Policies

The main task of this study has been assembling information on current pesticide use in New Zealand including the use patterns in various sectors. Assessment of the potential risks, implications for sustainable land use and development of broader policies for pesticide use are important but complex issues which are beyond the scope of this report. However some comments are appropriate to provide possible directions for the continuing debate in a contentious area.

Pesticide use reduction policies have been established in a number of OECD countries in response to the hypothesis that if pesticide uses pose risks then using less will reduce these risks. The problems with assessing effectiveness of reduction strategies using simple volume or frequency measures have been summarised (Watts & Macfarlane 1997). The Ministry for the Environment programme developing environmental performance indicators has also concluded that use *per se* of potential contaminants is not a good indicator and more emphasis is being put on ecological measures for environmental health and sustainability (MfE 1998). More sophisticated analyses e.g. Levitan *et al* 1996, show that pesticide policies must focus on risk reduction. Pesticide registration systems are established primarily for the purpose of managing pesticide risks. The imminent changes of regulation in New Zealand are likely to ensure even more thorough evaluation of pesticides, particularly the environmental aspects of their use. Most inherent hazards of pesticides are well defined by the battery of physical, chemical and biological tests required for primary registration. These tests now also encompass toxicity to a wide range of non-target organisms and put more emphasis on chronic or secondary effects such as endocrine disruption.

A pesticide rating system has been developed for N.Z. fruit industries which uses a range of factors to derive a single numeric score (Walker *et al* 1997). This was used to compare pest control systems in apples. Watts (1997) has also advocated development of a comprehensive pesticide hazard scoring system to guide pesticide use reduction strategies in New Zealand. However these rating systems have weaknesses in ranking probable effects because of difficulties in assigning appropriate weightings to the various hazard factors. To assess the risks to humans or ecosystems these hazard factors must be combined with realistic estimates of exposure from particular pesticides uses. While not without contention, the areas of operator exposure, residues in food and effects on beneficial organisms in crops can be adequately assessed. However risks from off-site movement due to leaching, run-off and spray drift are more difficult to assess because they tend to be very site dependant. Crop, climate, soil type, location of water resources and sensitivity of ecosystems are a few of the factors that may need to be considered. Also some of the main risks posed by modern pesticides arise from careless or illegal uses, handling and disposal of wastes. Thus, although a centralised bureaucracy can ensure that registered pesticides have generally favourable hazard properties, it is more difficult to assess and control many key on-farm environmental risk factors.

There has been some New Zealand research into pesticide movement to ground water (Close 1993, 1996; Hadfield and Smith 1997, James *et al* 1994) and of spray drift (Holland *et al* 1997). However there are few holistic studies of the overall cost/benefit and environmental ledger for pesticides use in our key agricultural sectors. International efforts in this area have been recently focussed on development of pesticide risk indicators which incorporate exposure and can be applied to diverse situations for objective estimates of risks. Development of pesticide risk indicators for use as policy tools at a national or regional level is a current project within the OECD working group on pesticides. A project within the European Union comparing environmental risk indicators has recently published a final report (CAPER 1999). The focus was on influencing pesticide use at the individual farm level and a final recommendation was "*The development of a harmonised scientific framework for EU pesticide indicators. Within such a framework the monitoring and evaluation of pesticide policies could be harmonised and farmers' decision tools could be based on the same principles"*. It was also recommended "*That the different stakeholders (farmers organisations, pesticide industry, environmental community) should be involved in the development of this framework*".

The types of tools investigated in the EU CAPER project would be useful in focussing attention on some of the use practices that are likely to be of greatest risk in New Zealand. However a broader view of risk may be necessary to fully address the sustainability of the use patterns. The type of sector data gathered in this report would be necessary to prioritise such assessments, although site specific elements will need to be introduced. Individual pesticide use data will also be required where the hazards differ widely within a class of pesticides.

The challenge is to build credible pesticide use policies that can act as drivers of change based on synergistic linking of the following elements:

- Identifying unacceptable risks from current uses;
- Developing alternative plant protection strategies and techniques;
- Encouraging use of more targeted application technologies;
- Increasing end-user knowledge and confidence in the adoption of these alternatives;
- Promoting responsible use of pesticides through the agrichemical code of practice and other measures.

In the New Zealand context, strong centralised legislative sanctions or administrative directives are unlikely to be acceptable and therefore national policies will need to be based on support for regional and sector based initiatives. It is also important not to isolate pesticide use as a single issue because many other factors also contribute to the overall sustainability of agricultural systems.

The co-operative nature of many of our agricultural enterprises within free market, export oriented structures continues to provide many strengths for the development, extension and widespread adoption of new technologies, including in the area of plant protection. Most agricultural sectors have IPM systems in place or under research and development. The success of Kiwigreen in kiwifruit is a notable example of what can be achieved by a sector to modify pesticide use in a relatively short time.

Table 4: National pesticide use in various sectors for 1998.

	National acreage 10^3 ha.	Average Use kg ai./ha/annum				
		Insecticides	Herbicides	Synthetic Fungicides[1]	Sub-Total[2]	Total[3]
Arable farming						
Cereals (wheat & barley)	120	0.3	1.3	0.4	2.0	2.8
Grass Seed	26	0.2	3.1	0.2	3.5	3.8
Legume Seed	14	0.2	0.7	-	0.9	1.1
Field peas	20	0.03	1.7	0.02	1.8	1.8
Maize (grain & silage)	28	0.7	4.5	-	5.2	5.2
Horticulture						
Apples	15	7.3	3.2	14.5	25	55
Kiwifruit	10	3.6	1.7	0.4	5.7	20
Grapes	10	0.3	2.9	5.8	9.0	22
Vegetables						
Potatoes[4]	14	1.3	1.6	20.3	23	25
Onions	5	2.1	6.8	29.1	38	40
Brassicas[4]	4	2.8	0.3	6.3	9.4	9.4
Green Peas	10	-	1.6	0.5	2.1	2.1
Field Tomatoes	2	0.02	3.6	11.4	15	16
Pastoral						
Sheep & Beef	11,890	-	0.04	-	0.04	0.04
Dairy	1,270	-	0.28	-	0.28	0.3
Forestry (year 0/1 and 2)	205	-	4.0	-	4.0	4.0

1. Excluding inorganics
2. Insecticides, herbicides and synthetic fungicides (excluding inorganics)
3. Including mineral oil, inorganic fungicides and plant growth regulators
4. Use on a per crop basis (1-2 crop rotations per year)

5. CONCLUSIONS

This study has established current usage of pesticides in New Zealand on a tonnage basis. The pesticides were divided into categories and classes according to FAO which proved useful for associating with major uses. Further sub-classes were generated for some specific pesticides of current or growing importance in New Zealand. The overall use data relied mainly on AGCARM sales data as a source and some difficulties with this were identified due to the AGCARM survey not covering all sales and due to differences in the classification schemes. A comparison was undertaken between the current usage and data gathered in previous surveys. Although there were some uncertainties as to the full comparability of the data sets, the overall conclusions are that total pesticide use (excluding mineral oil) grew between 1984 and 1994 reaching a peak of about 3700 tonnes per annum and has declined to the 1998 total of 3270 tonnes. Herbicides continue to dominate pesticide use followed by fungicides and insecticides. About two thirds of total use is concentrated in four classes of pesticides (phenoxy hormones, phosphonyls, inorganic fungicides, dithiocarbamates) which have excellent records of very low human and environmental risks when used as directed.

Changes in use of the major pesticide classes were tracked over the past decade with the most significant features being declines in ‘other’ hormone herbicides, organophosphorus insecticides and dicarboximide fungicides, while phosphonyl herbicides (mainly glyphosate), triazine herbicides, sulfonylurea herbicides and pyrethroid insecticides all increased. These changes reflect trends in land use (more forestry), cost-effectiveness (more glyphosate and sulfonylureas, less ‘other’ hormone herbicides) and adoption of IPM strategies (more biologicals, less organophosphates, less dicarboximides).

Detailed end-user data at the sector level has also been gathered which provides a unique data set and serves as a baseline to measure future trends. The patterns also provide interesting insights on specific plant protection issues and strategies within each sector. Pesticide use in pastoral agriculture is static or declining and focuses almost solely on herbicides for broadleaf and brush weed control. Cereals and other arable crops also mainly use herbicides, with resistant cultivars and IPM techniques contributing to reduced insecticide and fungicide inputs. Orchard crops overall still have relatively high uses of pesticides despite increased adoption of IFP strategies. However the Kiwigreen (IFP) and organic production systems used by all the kiwifruit industry are notable successes for more biologically oriented insect and disease control.

Pesticide use in process vegetables such as asparagus, green peas and sweetcorn is relatively low and is mainly concentrated on early season weed control. In contrast, fresh vegetables such as lettuce, brassicas and potatoes tend to have intensive spray programmes throughout the growing season. Onions receive very frequent pesticide applications and there are concerns over the sustainability of current plant protection strategies in this crop.

Pesticide use in plantation forestry is concentrated on weed control during the establishment phase of the crop rotation. Consequently overall impacts of pesticide use in the timber production cycle are minimal.

Overall, control of weeds is the main priority with herbicides continuing to be the most cost-effective technology, often with no realistic alternatives. IPM techniques are making significant contributions to reductions in use of insecticides and accaricides in most areas of agriculture. However fungal infections continue to provide many challenges for more sustainable plant protection in horticultural and cropping sectors. The rapid increases in organic production in all agricultural sectors will have a significant effect on pesticide use statistics in the future.

The wide range of factors influencing pesticide use in New Zealand and the differences between sectors make it difficult to establish credible use reduction policies for pesticides at a national level. However some key drivers for change in this area have been highlighted for further development as part of strategies to enhance the sustainability of agricultural production systems.

6. RECOMMENDATIONS

The authors' recommendations follow. These have not been discussed with MAF, or other parties, prior to publication.

1. The FAO classification system for pesticides should form the basis for summarising pesticide use data. Advice should be provided to FAO on the corrections and further sub-classes necessary to stabilise and normalise the FAO disaggregated data set for future use.
2. AGCARM should be encouraged to continue their surveys of national pesticide sales and to make annual summaries available to MAF for policy purposes.
3. AGCARM should be encouraged to assemble their survey data for reporting on the basis of the FAO classification system as adapted in this report for New Zealand use.
4. MAF should strongly encourage all significant importers and manufacturers of pesticides in New Zealand to participate in the AGCARM surveys.
5. Sector and producer groups to MAF should be encouraged to gather end-user data on pesticides and make summaries available for policy purposes. The spray diary recording systems used by many sectors are a good basis but more emphasis should be put on entry of full data, including all dormant season sprays and herbicide applications.
6. Other regular market surveys (retail or end-user) should be encouraged for determining pesticide use patterns in sectors such as pastoral agriculture which are less amenable to spray diary recording systems. These surveys should preferably be on a regional and sub-sector basis and the data reporting should include summaries of sales tonnages of pesticides in the FAO classes.
7. Further analysis of pesticide use patterns should be carried out at the sector and individual end-user level to establish uses and practices which are significant continuing risks (applicator, sustainability of the production system, environmental, food chain etc.). For this purpose linkages should be developed to the OECD, EU and other international initiatives on development of pesticide risk indicators. Linkages will also be needed to Ministry for the Environment (Environmental Performance Indicators programme) and ERMA as well as industry and sector groups.
8. MAF should develop policies on pesticide use which are integrated into strategies for sustainable agriculture and which address the key issues of identifying unacceptable risks from current use practices, development of alternative plant protection strategies, encouraging safer pesticide handling and more targeted application, and increasing end-user confidence to adopt alternative practices.
9. Sectors should be given guidance and encouragement to implement these MAF policies on pesticide use as part of a national strategy. This should include provision of convenient and consistent data recording/reporting templates and appropriate technologies for by-sector risk analysis.

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Appendices

Appendix 1: Pesticide (FAO classification) for products registered in New Zealand

INSECTICIDES

Organophosphates
acephate
azinphos-methyl
chlorpyrifos
demeton-S-methyl
diazinon
dichlorvos
dimethoate
disulfoton
fenamiphos
fenitrothion
isazophos
maldison
methamidaphos
naled
omethoate
parathion-methyl
phorate
pirimiphos-methyl
prothiofos
terbufos
trichlorfon

Carbamates
bendiocarb
carbaryl
furathiocarb
methiocarb
methomyl
oxamyl
pirimicarb
propoxur
thiodicarb

Synthetic pyrethroids
alphacypermethrin
bifenthrin
cyfluthrin
cypermethrin
deltamethrin
esfenvalerate
lambda-cyhalothrin
permethrin
taufluvalinate
tetramethrin

Insect Growth Regulators (I1)[2]
buprofezin
diflubenzuron
lufenuron
pyriproxifen
tebufenozide

Acaricides (I2)
azocyclotin
bromopropylate
clofentezine
dicofol
fenbutatin-oxide
fenpyroximate
hexythiazox
propargite
tebufenpyrad

Other Insecticides (I3)
endosulfan
fipronil
metaldehyde
pymetrozine
imidacloprid
thiamethoxam

Mineral Oils
various

Botanicals and Biologicals
abamectin
Bacillus thuringiensis
Neem
potassium soap
pyrethrum
Serratia entomophila
spinosad

HERBICIDES

Phenoxy hormones
2,4-D
2,4-DB
dichlorprop
mecoprop
MCPA
MCPB

Triazines
atrazine
cyanazine
hexazinone
metribuzin
prometryn
simazine
terbumeton
terbuthylazine
terbutryn

Amides
acetochlor
alachlor
metolachlor
propachlor
propyzamide

Carbamates
asulam
carbetamide
chlorpropham
desmedipham
phenmedipham
propham

Dinitroanilines
oryzalin
pendimethalin
trifluralin

Urea Derivatives
diuron
fenuron
isoproturon
linuron
methabenzthiazuron

Sulfonylureas/amides
chlorimuron
chlorsulfuron
flumetsulam
metsulfuron-methyl
primisulfuron
thifensulfuron-methyl
tribenuron-methyl

Bipyridyls
diquat
paraquat

Uracils
bromacil
terbacil

Other hormone types (H1)[2]
clopyralid
dicamba
picloram
triclopyr

Phosphonyls (H2)
glyphosate
glufosinate-ammonium

FOPs and DIMs (H3)
clethodim
clodinafop-propargyl
fenoxaprop-methyl
flamprop-isopropyl
fluazifop-butyl
haloxyfop-methyl
sethoxydim
tralkoxydim
quizalofop-ethyl

Other herbicides (H4)
amitrole
bentazone
bromoxynil
chloridazon
chlorthal-dimethyl
clomazone
dalapon (2,2-DPA)
diclobenil
difenzoquat
diflufenican
dimethenamid
EPTC
ethofumesate
fluoxypyr
imazapyr
imazathpyr
ioxynil
norflurazon
oxadiazon
oxyfluorfen
pyridate
triallate
trichloroaceticacid

Inorganics
copper compounds
phosphorous acid
sulphur

Dithiocarbamates
mancozeb
maneb
metiram
propineb
thiram
ziram

Benzimidazoles
benomyl
carbendazim
fuberidazole
thiabendazole
thiophanate-methyl

Triazoles and Diazoles
azaconazole
bitertanol
cyproconazole
difenoconazole
epoxiconazole
etridiazole
flusilazole
flutriafol
imazalil
myclobutanil
penconazole
prochloraz
propiconazole
tebuconazole
tridimefon
triadimenol

Diazines, Morpholines & other EBIs
bupimarate
fenarimol
fenpropimorph
dimethomorph
tridemorph
triforine

Strobilurins (F1)
azoxystrobin
kresoxim-methyl

Dicarboximides (F2)
iprodione
procymidone
vinclozolin

Other fungicides (F3)
benalaxyl
captan
carboxin
chlorothalonil
cyprodinil
dichlofluanid
dichloran
dithianon
dodine
folpet
fluazinam
fosetyl-Al
furalaxyl
metalaxyl
nitrothal-isopropyl
pencycuron
propamocarb
pyrazophos
pyrimethanil
toclofos-methyl
streptomycin

PLANT GROWTH REGULATORS
1-napthylacetic acid
4-CPA aminoethoxyvinyl-glycine
benzyladenine
chlorethepon
chlormequat chloride
gibberellin
hydrogen cyanamide
maleic hydrazide
mepiquat chloride
paclobutrazol
trinexepac-methyl

[1]A few of the pesticides listed have been withdrawn from registration recently but stocks may remain.

[2]In the FAO classification the sub-classes I1, I2 and I3 are combined as class ‘Other insecticides’. Similarly the sub-classes H and F have been generated from the broader FAO categories of ‘Other herbicides’ and ‘Other fungicides’ respectively.

Pesticide (FAO classification)	Canterbury Use %	Area ha: 110,000 Loading kg/ha/yr	Quantity T/yr	Hawkes Bay Use %	Area ha: 2050 Loading kg/ha/yr	Quantity T/yr	Canterbury Use %	Area ha: 16,600 Loading kg/ha/yr	Total Use T/yr
Organophosphates	22	0.96	23.2	22	0.96	0.43	10	0.22	0.36
Carbamates	40	0.13	5.50	35	0.13	0.09			
Synthetic Pyrethroids	10	0.01	0.11	10	0.01	0.00	30	0.02	0.10
Acaricides (I1)									
Insect Growth Regulators (I2)									
Other Insecticides (I3)	25	0.08	2.20	25	0.08	0.04			
FAO Other Insecticides I1-3	25	0.08	2.20	25	0.08	0.04			
Botanicals and Biologicals									
TOTAL INSECTICIDES		**1.2**	**31**		**1.2**	**0.6**		**0.24**	**0.46**
MINERAL OILS	**10**	**1.0**	**11**	**10**	**1.0**	**0.2**			
Phenoxy hormones	65	0.83	59.4	60	0.90	1.11	75	1.25	15.6
Triazines							80	0.75	9.96
Amides									
Carbamates									
Dinitroanilines									
Urea Derivatives	80	0.40	35.2	80	0.40	0.66			
Sulfonylureas	20	0.02	0.33	20	0.02	0.01	20	0.05	0.15
Bipyridyls							10	0.35	0.58
Uracils									
Other hormone types (H1)	5	0.11	0.61	10	0.11	0.02			
Phosphonyls (H2)	10	3.00	33.0	10	3.00	0.62	5	1.10	0.91
FOPs and DIMs (H3)	30	0.22	7.3	30	0.22	0.14	15	0.2	0.5
Other herbicides (H4)	16	0.64	11.2	16	0.64	0.21	50	0.18	1.49
FAO Other Herbicides H1-4	61	3.97	52.1	66	3.97	0.98	125	1.48	2.90
TOTAL HERBICIDES		**5.5**	**147**		**5.6**	**2.8**		**3.9**	**29.2**
Inorganics									
Dithiocarbamates	20	0.08	1.65	20	0.08	0.03			
Benzimidazoles	5	0.02	0.08	5	0.02	0.00			
Triazoles	170	0.15	27.7	155	0.13	0.43	25	0.06	0.25
Diazines, Morphs, other EBIs	15	0.56	9.28	10	0.56	0.12			
Dicarboximides (F1)									
Strobilurines (F2)									
Other fungicides (F3)	100	0.05	4.95	100	0.05	0.09			
FAO Other Fungicides F1-3	100	0.05	4.95	100	0.05	0.09			
TOTAL FUNGICIDES, BACT.		**0.8**	**44**		**0.8**	**0.7**		**0.06**	**0.25**
PLANT GROWTH REGULATORS	**55**	**0.71**	**43**	**55**	**0.71**	**0.8**			

Appendix 2: Pesticide use in cereals (wheat and barley) and field peas 1998/99

Pesticide (FAO classification)	Grass seed			Legume seed (clover, lotus)		
		Area ha:	23,900		Area ha:	12,600
	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr
Organophosphates	25	0.76	4.5	50	0.22	1.39
Carbamates	20	0.15	0.72	30	0.13	0.50
Synthetic Pyrethroids				100	0.02	0.24
Acaricides (I1)						
Insect Growth Regulators (I2)						
Other Insecticides (I3)	6	0.01	0.01	2	0.01	0.00
FAO Other Insecticides I1-3	6	0.01	0.01	2	0.01	0.00
Botanicals and Biologicals						
TOTAL INSECTICIDES		**0.92**	**5.2**		**0.4**	**2.1**
MINERAL OILS	**30**	**1.0**	**7.2**	**25**	**1.0**	**3.2**
Phenoxy hormones	100	2.62	62.7	5	1.25	0.79
Triazines				20	1.00	2.52
Amides						
Carbamates						
Dinitroanilines						
Urea Derivatives						
Sulfonylureas/amides				20	0.05	0.11
Bipyridyls				20	0.35	0.88
Uracils						
Other hormone types (H1)	100	0.07	1.6			
Phosphonyls (H2)	5	1.10	1.3	5	1.10	0.69
FOPS and DIMs (H3)	60	0.52	7.4	30	0.45	1.70
Other herbicides (H4)				90	0.18	2.06
FAO Other Herbicides H1-4	165	1.69	10.3	125	1.73	4.45
TOTAL HERBICIDES		**4.3**	**73**		**4.4**	**8.8**
Inorganics						
Dithiocarbamates						
Benzimidazoles						
Triazoles	100	0.17	4.1			
Diazines, Morphs, other EBIs						
Dicarboximides (F1)						
Strobilurines (F2)						
Other fungicides (F3)	5	0.02	0.02			
FAO Other Fungicides F1-3	5	0.02	0.02			
TOTAL FUNGICIDES, BACT.		**0.2**	**4**			
PLANT GROWTH REGULATORS						

Appendix 3: Pesticide use in herbage seed and crops in Canterbury, 1998/99

Pesticide (FAO classification)	Canterbury			Hawkes Bay			Waikato			BOP/Rotorua		
	Area ha: 500			Area ha: 1000			Area ha: 5500			Area ha: 4400		
	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr
Organophosphates				2	0.50	0.01	18	0.28	0.275	12	0.29	0.154
Carbamates				30	0.30	0.09	30	0.30	0.50	30	0.30	0.40
Synthetic Pyrethroids							8	0.01	0.01	5	0.01	0.00
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)	100	0.07	0.04	55	0.09	0.05	70	0.08	0.31	55	0.09	0.21
FAO Other Insecticides I1-3	100	0.07	0.04	55	0.09	0.05	70	0.08	0.31	55	0.09	0.21
Botanicals and Biologicals												
TOTAL INSECTICIDES		**0.07**	**0.04**		**0.9**	**0.1**		**0.7**	**1.1**		**0.7**	**0.76**
MINERAL OILS												
Phenoxy hormones												
Triazines	100	1.50	0.75	100	1.50	1.50	100	1.50	8.25	100	1.50	6.60
Amides				65	2.81	1.83	100	2.58	14.16	70	2.64	8.14
Carbamates												
Dinitroanilines				35	1.50	0.53	15	1.50	1.24	25	1.50	1.65
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls												
Uracils												
Other hormone types (H1)				30	0.25	0.08	40	0.25	0.55	40	0.25	0.44
Phosphonyls (H2)	10	1.10	0.06	10	1.10	0.11	10	1.10	0.61	10	1.10	0.48
FOPS and DIMs (H3)												
Other herbicides (H4)												
FAO Other Herbicides H1-4	10	1.10	0.06	40	1.35	0.19	50	1.35	1.16	50	1.35	0.92
TOTAL HERBICIDES		**2.7**	**0.8**		**7.2**	**4.0**		**6.9**	**24.8**		**7.0**	**17.3**
Inorganics												
Dithiocarbamates												
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 4: Pesticide use in maize 1998/99

	Canterbury			Hawkes Bay			Waikato			BOP/Rotorua		
		Area ha:	1000		Area ha:	6625		Area ha:	727		Area ha:	
PESTICIDE CLASS	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**
(FAO classification)	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr
Organophosphates	69	2.04	1.4	96	6.06	38.5	95	3.37	2.32			
Carbamates	32	1.80	0.58	62	1.59	6.53	12	1.65	0.15			
Synthetic Pyrethroids												
Acaricides (I1)							35	0.32	0.08			
Insect Growth Regulators (I2)	82	0.46	0.37	74	0.59	2.91	87	0.66	0.42			
Other Insecticides (I3)												
FAO Other Insecticides I1-3	82	0.46	0.37	74	0.59	2.91	122	0.98	0.50			
Botanicals and Biologicals	5	0.01	0.00	1	1.00	0.07	25	0.01	0.00			
INSECTICIDES TOTAL		**4.3**	**2.4**		**9.0**	**48**		**6.0**	**3.0**			
MINERAL OILS	**75**	**33**	**25**	**97**	**30**	**193**	**85**	**30**	**19**			
Phenoxy hormones												
Triazines	10	2.52	0.25	25	2.98	4.93	30	3.20	0.70			
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives	5	1.00	0.1	10	1.00	0.66	10	1.00	0.07			
Sulfonylureas/amides												
Bipyridyls	10	0.60	0.06	10	0.60	0.40	12	0.60	0.05			
Uracils												
Other hormone types (H1)				2	0.38	0.05	2	0.4	0.0			
Phosphonyls (H2)	82	2.1	1.7	95	2.1	13.0	95	2.2	1.5			
FOPS and DIMs (H3)												
Other herbicides (H4)	17	1.10	0.2	31	0.97	2.01	20	1.08	0.16			
FAO Other Herbicides H1-4	99	3.2	1.9	128	3.4	15.0	117	3.6	1.7			
HERBICIDES TOTAL		**7.3**	**2.3**		**8.0**	**21**		**8.4**	**2.50**			
Inorganics	48	4.6	2.2	33	3.2	6.9	25	3.15	0.6			
Dithiocarbamates	52	3.7	4.7	97	9.7	62.5	99	12.04	8.7			
Benzimidazoles	20	0.4	0.1				38	0.42	0.1			
Triazoles	77	0.1	0.1	91	0.2	1.0	88	0.15	0.1			
Diazines, Morphs, other EBIs	68	0.6	0.4	49	0.6	1.8						
Dicarboximides (F1)												
Strobilurines (F2)	61	0.6	0.4	55	0.4	1.63	76	0.54	0.3			
Other fungicides (F3)	90	5.2	4.7	100	4.5	29.5	100	4.91	3.6			
FAO Other Fungicides F1-3	151	5.8	5.0	155	4.9	31.2	176	5.46	3.9			
FUNGICIDES, BACT. TOTAL		**15.2**	**12.5**		**18.5**	**103**		**21.2**	**13.3**			
PLANT GROWTH REGULATORS	**21**	**0.01**	**0.00**	**42**	**0.01**	**0.03**	**14**	**0.02**	**0.00**			

Appendix 5: Pesticide use in apple production 1998/99

PESTICIDE CLASS (FAO classification)	General Area ha: 520			Integrated Fruit Prod'n. Area ha: 1900			General - USA Area ha: 3500			IFP - USA Area ha: 730		
	Use %	Loading kg/ha/yr	Applications sprays/yr	Use %	Loading kg/ha/yr	Applications sprays/yr	Use %	Loading kg/ha/yr	Applications sprays/yr	Use %	Loading kg/ha/yr	Applications sprays/yr
INSECTICIDES												
Organophosphates	92	5.0	6.0	86	1.8	2.0	100	7.9	9.7	100	3.9	4.4
Carbamates	58	2.2	1.2	76	1.5	1.5	56	2.2	1.2	64	2.0	1.1
Synthetic Pyrethroids												
Acaricides												
Insect Growth Regulators	73	0.35	2.0	100	0.72	3.8	59	0.46	1.8	100	0.80	4.3
Other Insecticides												
Botanicals and Biologicals							2	0.01	1.0			
FUNGICIDES, BACTERICIDES												
Inorganics	27	2.3	1.0	30	2.5	1.1	32	2.8	1.2	55	2.3	1.0
Dithiocarbamates	92	8.8	4.9	98	8.4	4.6	95	7.2	5.3	97	9.1	4.8
Benzimidazoles							1	0.4	1.0			
Triazoles	70	0.2	2.9	84	0.2	2.3	96	0.2	2.9	97	0.1	2.1
Diazines, Morphs, other EBIs	35	0.3	1.3	51	0.4	1.8	47	2.0	2.0	63	0.3	1.3
Dicarboximides												
Strobilurines	60	0.4	2.7	59	0.4	2.9	47	0.4	2.5	88	0.5	3.4
Other fungicides	92	3.5	6.2	100	3.5	6.8	100	5.2	9.0	100	3.7	6.8
PLANT GROWTH REGULATORS	25	0.01	1.1	48	0.01	1.2	40	0.01	1.2	57	0.01	1.0

Appendix 6: Insecticide and fungicide use in apple production, Hawkes Bay 1998/99. Grouped by plant protection programme.

PESTICIDE CLASS (FAO classification)	Canterbury Area ha:			Hawkes Bay Area ha: 136			Waikato Area ha: 237			BOP/Rotorua Area ha: 6550		
	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr
Organophosphates				95	3.2	0.42	95	3.2	0.73	95	3.3	20.3
Carbamates												
Synthetic Pyrethroids				85	0.1	0.01	85	0.06	0.01	85	0.1	0.3
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals				32	1.5	0.07	32	1.5	0.11	32	1.5	3.2
TOTAL INSECTICIDES					**4.8**	**0.5**		**4.7**	**0.85**		**4.9**	**23.8**
MINERAL OILS				**35**	**25.1**	**1.2**	**35**	**25.1**	**2.1**	**35**	**25.1**	**57.4**
Phenoxy hormones												
Triazines				2.7	2.1	0.01	2.7	2.1	0.01	2.7	2.10	0.4
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives				1.4	1.2	0.00	1.4	1.2	0.00	1.4	1.20	0.1
Sulfonylureas/amides												
Bipyridyls				6	0.5	0.00	6	0.5	0.01	6	0.47	0.2
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)				91	1.7	0.21	91	1.7	0.36	91	1.7	10.1
FOPS and DIMs (H3)												
Other herbicides (H4)				1.9	1.5	0.00	1.9	1.5	0.01	1.9	1.5	0.2
FAO Other Herbicides H1-4				93	3.2	0.21	93	3.2	0.37	93	3.2	10.3
TOTAL HERBICIDES					**7.0**	**0.23**		**7.0**	**0.4**		**7.0**	**11**
Inorganics				11	1.4	0.02	11	1.4	0.04	11	1.44	1.0
Dithiocarbamates												
Benzimidazoles				23	0.5	0.02	23	0.5	0.03	23	0.50	0.8
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)				37	0.8	0.04	37	0.8	0.07	37	0.75	1.8
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3				37	0.8	0.04	37	0.8	0.07	37	0.75	1.8
TOTAL FUNGICIDES, BACT.					**2.7**	**0.07**		**2.7**	**0.13**		**2.7**	**3.6**
PLANT GROWTH REGULATORS				**50**	**18**	**1.2**	**50**	**18**	**2.2**	**50**	**18**	**59**

Appendix 7: Pesticide use in kiwifruit 1998/99

	Avocado – Bay of Plenty Area ha: 950			Citrus – Bay of Plenty Area ha: 400			Wine Grapes – Hawkes Bay Area ha: 2100		
PESTICIDE CLASS (FAO classification)	**Use** %	**Loading** kg/ha/yr	**Quantity** T/yr	**Use** %	**Loading** kg/ha/yr	**Quantity** T/yr	**Use** %	**Loading** kg/ha/yr	**Quantity** T/yr
Organophosphates	80	4.70	3.6	90	3.00	1.08	45	0.49	0.47
Carbamates	13	1.50	0.19	10	1.50	0.06			
Synthetic Pyrethroids	55	0.25	0.13				11	0.01	0.00
Acaricides (I1)				10	1.20	0.05			
Insect Growth Regulators (I2)				5	0.60	0.01	3	0.26	0.02
Other Insecticides (I3)									
FAO Other Insecticides I1-3				15	1.80	0.06	3	0.26	0.02
Botanicals and Biologicals	72	3.17	2.2						
INSECTICIDES TOTAL		**10.4**	**6.1**		**40**	**14.6**		**1.8**	**0.6**
MINERAL OILS	**7**	**0.84**	**0.06**	**80**	**33.6**	**10.7**	**39**	**9.9**	**8.1**
Phenoxy hormones									
Triazines				10	1.20	0.05	21	0.93	0.41
Amides									
Carbamates									
Dinitroanilines									
Urea Derivatives				5	2.40	0.05	5	1.2	0.13
Sulfonylureas/amides									
Bipyridyls									
Uracils				5	2.40	0.05			
Other hormone types (H1)									
Phosphonyls (H2)	15	1.10	0.15	60	1.10	0.26	95	2.6	5.2
FOPS and DIMs (H3)									
Other herbicides (H4)							12	1.5	0.38
FAO Other Herbicides H1-4	15	1.10	0.15	60	1.10	0.26	107	4.1	5.6
HERBICIDES TOTAL	**7**	**1.1**	**0.15**		**7.1**	**0.40**		**6.2**	**6.1**
Inorganics	67	4.08	2.60	100	3.60	1.44	100	9.0	18.8
Dithiocarbamates				50	6.00	1.20	50	4.2	4.4
Benzimidazoles	25	0.50	0.12	30	0.50	0.06			
Triazoles							42	0.03	0.03
Diazines, Morphs, other EBIs							17	0.03	0.01
Dicarboximides (F1)							23	1.72	0.83
Strobilurines (F2)									
Other fungicides (F3)							89	3.69	6.90
FAO Other Fungicides F1-3							112	5.4	7.7
FUNGICIDES, BACT. TOTAL	**92**	**4.6**	**2.7**		**10.1**	**2.7**		**19**	**31**
PLANT GROWTH REGULATORS									

Appendix 8: Pesticide use in avocado and citrus (Bay of Plenty 1998/99) and wine grapes (Hawkes Bay 1998/99).

PESTICIDE CLASS (FAO classification)	Blackcurrants - Canterbury Area ha: 437			Boysenberries - Nelson Area ha: 123			Boysenberries – Hawkes Bay Area ha: 21			Blueberries - Waikato Area ha: 210		
	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr	Use %	Loading kg/ha/yr	Quantity T/yr
Organophosphates	7	0.28	0.0	98	2.5	0.31	98	2.5	0.05	64	0.93	0.13
Carbamates	73	0.68	0.22	63	0.4	0.03	63	0.4	0.01	21	0.24	0.01
Synthetic Pyrethroids				1	0.0	0.00						
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals				17	1.50	0.03	17	1.50	0.01	7	0.5	0.01
TOTAL INSECTICIDES		**1.7**	**0.3**		**5.5**	**0.47**		**5.5**	**0.08**		**1.7**	**0.15**
MINERAL OILS										7	6.3	0.1
Phenoxy hormones												
Triazines												
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls	10	0.20	0.01	10	0.20	0.00	10	0.20	0.00	10	0.20	0.00
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)	90	0.90	0.4	90	0.90	0.1	90	0.90	0.02	90	0.9	0.17
FOPS and DIMs (H3)												
Other herbicides (H4)												
FAO Other Herbicides H1-4	90	0.90	0.4	90	0.90	0.1	90	0.90	0.02	90	0.9	0.17
TOTAL HERBICIDES		**1.1**	**0.4**		**1.1**	**0.10**		**1.1**	**0.02**		**1.1**	**0.17**
Inorganics	89	1.7	0.66	91	3.9	0.44	91	3.9	0.07	46	1.5	0.14
Dithiocarbamates	39	2.0	0.33	78	15.3	1.47	78	15.3	0.25	11	2.1	0.05
Benzimidazoles				5	0.5	0.00	5	0.5	0.00	11	0.25	0.01
Triazoles												
Diazines, Morphs, other EBIs	16	0.03	0.00									
Dicarboximides (F1)	3	0.75	0.01	25	1.2	0.04	25	1.2	0.01	5	0.45	0.00
Strobilurines (F2)												
Other fungicides (F3)	83	2.5	0.91	96	5.0	0.59	96	5.0	0.10	54	2.1	0.24
FAO Other Fungicides F1-3	86	3.3	0.92	121	6.2	0.63	121	6.2	0.11	59	2.6	0.25
TOTAL FUNGICIDES, BACT.		**6.9**	**1.9**		**26**	**2.5**		**26**	**0.4**		**6.4**	**0.45**
PLANT GROWTH REGULATORS												

Appendix 9: Pesticide use in blackcurrants (Canterbury), boysenberries (Nelson and Canterbury), blueberries (Waikato) 1998/99

	Field tomatoes - Hawkes Bay			Potatoes - Waikato, early crop			Potatoes - Waikato, main crop			Onions - Waikato		
		Area ha: 1000			**Area ha:** 1000			**Area ha:** 1400			**Area ha:** 5400	
PESTICIDE CLASS	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**	**Use**	**Loading**	**Quantity**
(FAO classification)	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/crop	%	kg/ha/yr	T/crop	%	kg/ha/yr	T/yr
Organophosphates				90	0.8	0.73	100	1.8	2.5	50	1.9	5.3
Carbamates	5	0.48	0.02									
Synthetic Pyrethroids	23	0.06	0.01	100	0.03	0.03	115	0.03	0.05	99	0.05	0.28
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)										50	2.1	5.9
FAO Other Insecticides I1-3										50	2.1	5.9
Botanicals and Biologicals	26	0.03	0.01									
TOTAL INSECTICIDES		**0.6**	**0.0**		**0.8**	**0.75**		**1.8**	**2.6**		**4.0**	**11.5**
MINERAL OILS							**20**	**2.38**	**0.7**	**10**	**3.6**	**2.0**
Phenoxy hormones												
Triazines	93	0.78	0.73	100	0.53	0.53	25	0.45	0.16			
Amides	93	3.1	2.9							75	1.9	7.9
Carbamates				5	0.04	0.02	5	0.04	0.03	55	0.60	1.8
Dinitroanilines										100	0.81	4.5
Urea Derivatives				5	0.40	0.02	55	0.50	0.39	25	0.76	1.1
Sulfonylureas/amides												
Bipyridyls				75	0.35	0.26	75	0.70	0.74	50	0.60	1.7
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)				100	1.6	1.6	70	1.1	1.1	50	0.81	2.27
FOPs and DIMs (H3)										100	0.30	1.67
Other herbicides (H4)				100	0.24	0.24	15	0.12	0.03	100	2.86	16.0
FAO Other Herbicides H1-4				200	1.9	1.9	85	1.2	1.1	250	4.0	19.9
TOTAL HERBICIDES		**3.9**	**3.6**		**3.2**	**2.8**		**2.9**	**2.4**		**8.7**	**36.9**
Inorganics	100	4.3	4.3									
Dithiocarbamates	75	4.86	3.6	100	24	24	100	22	31	100	26	146
Benzimidazoles										100	1.5	8.2
Triazoles							50	0.13	0.09	25	0.42	0.59
Diazines, Morphs, other EBIs				50	0.38	0.19	35	0.38	0.19	50	0.40	1.1
Dicarboximides (F1)	5	0.48	0.02							10	2.3	1.3
Strobilurines (F2)												
Other fungicides (F3)	100	3.4	3.4	100	0.83	0.83	125	0.29	0.41	50	0.11	0.30
FAO Other Fungicides F1-3	105	3.9	3.46	100	0.83	0.83	125	0.29	0.41	60	2.4	1.6
TOTAL FUNGICIDES, BACT.		**13.1**	**11.4**		**25**	**25**		**23**	**31**		**31**	**157**
PLANT GROWTH REGULATORS	**84**	1.36	**1.1**				**35**	2.5	**1.2**	75	2.4	**10.1**

Appendix 10: Pesticide use in field tomatoes (Hawkes Bay), potatoes and onions (Waikato/Pukekohe) 1998/99

PESTICIDE CLASS (FAO classification)	Lettuce - summer			Lettuce - winter			Brassicas - summer			Brassicas - winter		
	Area ha: 170			Area ha: 230			Area ha: 430			Area ha: 550		
	Use %	Loading kg/ha/yr	Total Use T/crop	Use %	Loading kg/ha/yr	Total Use T/crop	Use %	Loading kg/ha/yr	Total Use T/crop	Use %	Loading kg/ha/yr	Total Use T/crop
Organophosphates	100	1.2	0.20	50	0.80	0.09	100	2.8	1.2	80	1.48	0.65
Carbamates	25	0.13	0.01	25	0.13	0.01	10	0.7	0.03	10	0.26	0.01
Synthetic Pyrethroids	100	0.04	0.01	100	0.03	0.01	100	0.06	0.03	100	0.03	0.02
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)							2	1.4	0.06	2	1.4	0.08
FAO Other Insecticides I1-3							2	1.4	0.06	2	1.4	0.08
Botanicals and Biologicals							75	2.0	0.65			
TOTAL INSECTICIDES		**1.3**	**0.2**		**1.0**	**0.11**		**6.9**	**2.0**		**3.2**	**0.76**
MINERAL OILS												
Phenoxy hormones												
Triazines												
Amides	40	2.1	0.14	40	2.1	0.19	25	1.4	0.15	25	1.4	0.20
Carbamates	25	1.5	0.06	25	1.5	0.09						
Dinitroanilines	80	0.8	0.11	80	0.8	0.15						
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls	40	0.6	0.04	40	0.6	0.06	25	1.0	0.11	25	1.0	0.14
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)	40	1.1	0.07	40	1.1	0.10						
FOPs and DIMs (H3)												
Other herbicides (H4)												
FAO Other Herbicides H1-4	40	1.1	0.07	40	1.1	0.10						
TOTAL HERBICIDES		**6.1**	**0.43**		**6.1**	**0.59**		**2.4**	**0.26**		**2.4**	**0.34**
Inorganics	75	0.76	0.10	75	0.76	0.13						
Dithiocarbamates	100	8.0	1.36	100	12.0	2.8	100	6.0	2.6	100	16.0	8.8
Benzimidazoles				80	3.0	0.55				20	4.8	0.53
Triazoles										50	0.08	0.02
Diazines, Morphs, other EBIs				40	0.30	0.03				25	0.38	0.05
Dicarboximides (F1)				20	1.5	0.07						
Strobilurines (F2)												
Other fungicides (F3)	25	5.2	0.22	50	5.3	0.60				25	4.9	0.67
FAO Other Fungicides F1-3	25	5.2	0.22	70	6.8	0.67				25	4.9	0.67
TOTAL FUNGICIDES, BACT.		**14**	**1.7**		**23**	**4.1**		**6.0**	**2.6**		**26**	**10.1**
PLANT GROWTH REGULATORS												

Appendix 11: Pesticide use in lettuce and vegetable brassicas (cabbage, cauliflower, broccoli) in the Waikato/Pukekohe region 1998/99

Pesticide (FAO classification)	Canterbury Area ha:			Hawkes Bay Area ha: 550			Waikato Area ha: 550			BOP/Rotorua Area ha: 450		
	Use %	**Loading** kg/ha/yr	**Total Use** T/yr	**Use** %	**Loading** kg/ha/yr	**Total Use** T/yr	**Use** %	**Loading** kg/ha/yr	**Total Use** T/yr	**Use** %	**Loading** kg/ha/yr	**Total Use** T/yr
Organophosphates												
Carbamates				2	0.30	0.00	2	0.30	0.00			
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES					**0.3**	**0.0**		**0.3**	**0.00**			
MINERAL OILS												
Phenoxy hormones				2	0.20	0.00						
Triazines				64	1.8	0.64						
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives				62	1.8	0.61	100	1.8	1.0	100	1.8	0.83
Sulfonylureas/amides												
Bipyridyls												
Uracils				11	1.8	0.11	100	1.8	1.0	100	1.8	0.81
Other hormone types (H1)				2	0.1	0.00						
Phosphonyls (H2)				51	1.3	0.36						
DIMs (H3)												
Other herbicides (H4)				11	1.8	0.11						
FAO Other Herbicides H1-4				64	3.2	0.48						
TOTAL HERBICIDES					**8.8**	**1.8**		**3.6**	**2.00**		**3.6**	**1.64**
Inorganics												
Dithiocarbamates				2	3.84	0.04						
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)				30	0.45	0.07	80	0.41	0.18			
FAO Other Fungicides F1-3				30	0.45	0.07	80	0.41	0.18			
TOTAL FUNGICIDES, BACT.				**32**	**4.3**	**0.1**	**80**	**0.4**	**0.18**			
PLANT GROWTH REGULATORS												

Appendix 12: Pesticide use in asparagus 1998/99

Pesticide (FAO classification)	Canterbury			Hawkes Bay			Waikato			BOP/Rotorua		
	Area ha: 650			Area ha: 2340			Area ha: 200			Area ha: 150		
	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr
Organophosphates				3	0.60	0.04						
Carbamates	2	0.48	0.01	2	0.48	0.02	2	0.48	0.00	2	0.48	0.00
Synthetic Pyrethroids				23	0.01	0.01						
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES		**0.6**	**0**		**1**	**0.1**		**0.6**	**0**		**0.6**	**0**
MINERAL OILS	**1**	**2.9**	**0.0**	**1**	**2.9**	**0.1**	**1**	**2.9**	**0.01**	**1**	**2.9**	**0.00**
Phenoxy hormones												
Triazines	48	1.3	0.39	74	1.3	2.16	100	1.3	0.25	100	1.3	0.19
Amides	76	2.3	1.1	90	2.3	4.86	90	2.3	0.42	80	2.3	0.28
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls												
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)												
Fops and DIMs (H3)												
Other herbicides (H4)	6	2.5	0.1	6	2.5	0.35	10	2.5	0.05	10	2.5	0.04
FAO Other Herbicides H1-4	6	2.5	0.1	6	2.5	0.35	10	2.5	0.05	10	2.5	0.04
TOTAL HERBICIDES		**6.1**	**2**		**6.1**	**7.4**		**6.1**	**0.72**		**6.1**	**0.50**
Inorganics												
Dithiocarbamates												
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 13: Pesticide use in sweet corn 1998/99

Pesticide (FAO classification)	Canterbury Use %	Area ha: Loading kg/ha/yr	5000 Total Use T/yr	Hawkes Bay Use %	Area ha: Loading kg/ha/yr	1000 Total Use T/yr	Waikato Use %	Area ha: Loading kg/ha/yr	100 Total Use T/yr	BOP/Rotorua Use %	Area ha: Loading kg/ha/yr	150 Total Use T/yr
Organophosphates												
Carbamates												
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES												
MINERAL OILS												
Phenoxy hormones	90	1.25	5.63	80	0.54	0.43	80	0.54	0.04	80	0.54	0.06
Triazines	100	0.9	4.5	100	1.0	1.3	100	1.0	1.0	100	1.0	0.15
100												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides	10	0.05	0.03									
Bipyridyls	10	0.35	0.18									
Uracils												
Other hormone types (H1)												
Phosphonyls (H2)	5	1.10	0.28									
FOPs and DIMs (H3)	10	0.45	0.22									
Other herbicides (H4)	5	2.50	0.63	6	2.5	0.15	10	2.5	0.03	10	2.5	0.04
FAO Other Herbicides H1-4	20	4.05	1.13	6	2.5	0.15	10	2.5	0.03	10	2.5	0.04
TOTAL HERBICIDES		**6.6**	**11.5**		**4.0**	**1.6**		**4.0**	**0.17**		**4.0**	**0.25**
Inorganics												
Dithiocarbamates												
Benzimidazoles	100	0.25	1.25	80	0.25	0.2	80	0.25	0.02	80	0.25	0.04
Triazoles	20	0.06	0.06	20	0.06	0.01	20	0.06	0.00	20	0.06	0.00
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)	100	0.4	2.0	80	0.40	0.32	80	0.40	0.03	80	0.40	0.05
FAO Other Fungicides F1-3				80	0.40	0.32	80	0.40	0.03		0.40	0.05
TOTAL FUNGICIDES, BACT.		0.65	3.3		**0.65**	**0.53**		**0.65**	**0.05**		**0.65**	**0.09**
PLANT GROWTH REGULATORS												

Appendix 14: Pesticide use in green peas 1998/99

PESTICIDE CLASS (FAO classification)	Canterbury	Area ha: 2.44m		Hawkes Bay	Area ha: 0.640m		Waikato	Area ha: 0.757m		BOP/Rotorua	Area ha: 0.234m	
	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr
Organophosphates	0.25	1.1	6.9	0.11	1.1	0.77	0.12	0.85	0.77	0.12	0.85	0.21
Carbamates												
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES	**0.25**	**1.1**	**6.9**	**0.11**	**1.1**	**0.77**	**0.12**	**0.85**	**0.77**	**0.12**	**0.85**	**0.21**
MINERAL OILS												
Phenoxy Hormones	2.8	1.1	61.7	2.8	1.1	16.2	2.8	1.1	19.1	2.8	1.1	5.9
Triazines												
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides	0.26	0.10	0.50	0.26	0.10	0.13	0.26	0.10	0.16	0.26	0.10	0.05
Bipyridyls												
Uracils												
Other hormone types (H1)	0.13	4	9.9	0.13	4	2.6	0.13	4	3.1	0.13	4	0.9
Phosphonyls (H2)	0.48	2.7	25.3	0.48	2.7	6.6	0.48	2.7	7.9	0.48	2.7	2.4
FOPS and DIMs (H3)												
Other herbicides (H4)												
FAO Other Herbicides H1-4	0.61	6.7	35.2	0.61	6.7	9.2	0.61	6.7	11.0	0.61	6.7	3.3
TOTAL HERBICIDES		**4.0**	**97.4**		**4.0**	**38.4**		**4.0**	**30.3**		**4.0**	**9.4**
Inorganics												
Dithiocarbamates												
Benzimidazoles							0.3	0.15	0.34	0.2	0.15	0.07
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 15: Pesticide use in sheep & beef pastoral farming 1997/98

		Canterbury			Hawkes Bay			Waikato			BOP/Rotorua	
		Area ha:	63.6 k		**Area ha:**	8.5 k		**Area ha:**	370.5 k		**Area ha:**	69.1 k
PESTICIDE CLASS	**Use**	**Loading**	**Total Use**	**Use**	**Loading**	**Total Use**	**Use**	**Loading**	**Total Use**	**Use**	**Loading**	**Total Use**
(FAO classification)	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr	%	kg/ha/yr	T/yr
Organophosphates	0.25	1.1	0.2	0.11	1.1	0.01	0.35	0.8	1.0	0.20	0.9	0.12
Carbamates												
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES	**0.25**	**1.1**	**0.2**	**0.11**	**1.1**	**0.01**	**0.35**	**0.8**	**1.0**	**0.2**	**0.9**	**0.12**
MINERAL OILS												
Phenoxy hormones	22	1.2	13.3	22	1.2	1.8	22	1.2	77.5	22	1.2	14.4
Triazines												
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides	0.27	0.10	0.014	0.27	0.10	0.002	0.27	0.10	0.080	0.27	0.10	0.015
Bipyridyls												
Uracils												
Other hormone types (H1)	0.13	4	0.27	0.13	4	0.04	0.13	4	1.56	0.13	4	0.29
Phosphonyls (H2)	3.0	2.7	4.1	3.0	2.7	0.6	3.0	2.7	24.0	3.0	2.7	4.5
FOPS and DIMs (H3)												
Other herbicides (H3)												
FAO Other Herbicides H1-4	3.1	2.7	4.4	3.1	2.7	0.6	3.1	2.7	25.6	3.1	2.7	4.8
TOTAL HERBICIDES		**6.7**	**17.7**		**6.7**	**2.4**		**6.7**	**103**		**6.7**	**19.2**
Inorganics												
Dithiocarbamates												
Benzimidazoles							0.5	0.15		0.4	0.15	0.04
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 16: Pesticide use in dairy pastoral farming 1997/98

PESTICIDE CLASS (FAO classification)	Canterbury			Hawkes Bay			Waikato			BOP/Rotorua		
	Area ha: 5000			Area ha: 6000			Area ha: 14,000			Area ha: 10,000		
	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr
Organophosphates												
Carbamates												
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES												
MINERAL OILS												
Phenoxy hormones												
Triazines	79	4.92	19.5	79	4.92	23.4	79	4.92	54.5	79	4.92	39.0
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas	83	0.03	0.11	83	0.03	0.13	83	0.03	0.31	83	0.03	0.22
Bipyridyls												
Uracils												
Other hormone types (H1)	3	3.32	0.42	3	3.32	0.50	3	3.32	1.16	3	3.32	0.83
Phosphonyls (H2)	83	3.00	12.50	83	3.00	15.0	83	3.00	35.0	83	3.00	25.0
FOPs and DIMs (H3)	2	0.20	0.02	2	0.20	0.02	2	0.20	0.06	2	0.20	0.04
Other herbicides (H4)												
FAO Other Herbicides H1-4	88	6.50	12.9	88	6.50	15.5	88	6.50	36.2	88	6.50	25.9
TOTAL HERBICIDES		**11.5**	**32.5**		**11.5**	**39.0**		**11.5**	**91.0**		**11.5**	**65.1**
Inorganics												
Dithiocarbamates												
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 17: Pesticide use in plantation forestry 1998/99 (year 0/1 - replant and new plantings)

PESTICIDE CLASS (FAO classification)	Canterbury Area ha: 6600			Hawkes Bay Area ha: 8800			Waikato Area ha: 17,800			BOP/Rotorua Area ha: 12,400		
	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr
Organophosphates												
Carbamates												
Synthetic Pyrethroids												
Acaricides (I1)												
Insect Growth Regulators (I2)												
Other Insecticides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES												
MINERAL OILS												
Phenoxy hormones	2	0.4	0.05	2	0.4	0.07	2	0.4	0.14	2	0.40	0.10
Triazines	47	4.1	12.8	47	4.1	17.1	47	4.1	34.6	47	4.13	24.1
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls												
Uracils												
Other hormone types (H1)	2	3.4	0.23	2	3.4	0.26	2	3.4	0.60	2	3.4	0.42
Phosphonyls (H2)												
FOPs and DIMs (H3)	2	0.2	0.03	2	0.2	0.04	2	0.2	0.07	2	0.2	0.05
Other herbicides (H4)												
FAO Other Herbicides H1-4	4	3.6	0.26	4	3.6	0.3	4	3.6	0.67	4	3.6	0.47
TOTAL HERBICIDES		**8.1**	**13.1**		**8.1**	**17.5**		**8.1**	**35.4**		**8.1**	**24.7**
Inorganics												
Dithiocarbamates												
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.												
PLANT GROWTH REGULATORS												

Appendix 18: Pesticide use in forestry 1998/99 (year 2 - replant and new plantings)

PESTICIDE CLASS (FAO classification)	Canterbury	Area ha: 92,500		Hawkes Bay	Area ha: 102,000		Waikato	Area ha: 306,000		BOP/Rotorua	Area ha: 190,400	
	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr	Use %	Loading kg/ha/yr	Total Use T/yr
Organochlorines												
Organophosphates												
Carbamates												
Synthetic Pyrethroids												
Other Insecticides (I1)												
Insect Growth Regulators (I2)												
Acaricides (I3)												
FAO Other Insecticides I1-3												
Botanicals and Biologicals												
TOTAL INSECTICIDES												
MINERAL OILS				**10**	**1.7**	**17**	**15**	**1.7**	**77**	**15**	**1.7**	**48**
Phenoxy hormones												
Triazines												
Amides												
Carbamates												
Dinitroanilines												
Urea Derivatives												
Sulfonylureas/amides												
Bipyridyls												
Uracils												
Other hormone types (H1)	0.2	0.4	0.07	0.2	0. 4	0.08	0.2	0.4	0.24	0.2	0.4	0.16
Phosphonyls (H2)	0.2	3.3	0.61	0.2	3.3	0.67	0.2	3.3	2.0	0	3.3	1.3
FOPs and DIMs (H3)												
Other herbicides (H4)												
FAO Other Herbicides H1-4	0.2	3.7	0.7	0.2	3.7	0.8	0.2	3.7	2.2	0.2	3.7	1.5
TOTAL HERBICIDES		**3.7**	**0.7**		**3.7**	**0.8**		**3.7**	**2.2**		**3.7**	**1.5**
Inorganics				10	0.83	8.5	15	0.83	38	15	0.83	24
Dithiocarbamates												
Benzimidazoles												
Triazoles												
Diazines, Morphs, other EBIs												
Dicarboximides (F1)												
Strobilurines (F2)												
Other fungicides (F3)												
FAO Other Fungicides F1-3												
TOTAL FUNGICIDES, BACT.					**0.8**	**8.5**		**0.8**	**38**		**0.8**	**24**
PLANT GROWTH REGULATORS												

Appendix 19: Pesticide use in forestry 1998/99 (years 3-30)