Australian Government
Forest and Wood Products Research and Development Corporation

Pesticides IN PLANTATIONS

The use of chemical pesticides by the Australian plantation forest industry

SUMMARY REPORT

FWPRDC
PO Box 69, World Trade Centre
Melbourne 8005, Victoria
T +61 3 9614 7544 F +61 3 9614 6822
www.fwprdc.org.au

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This report summarises a major study that examined the usage of chemical pesticides by the Australian plantation forest industry. The report was prepared for the Forest and Wood Products Research and Development Corporation by BM Jenkin of Sylva Systems Pty Ltd and B Tomkins of GreenTree Forestry Services. Final report received September 2006.

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RESEARCHERS:

BM Jenkin
Sylva Systems Pty Ltd
PO Box 1175
Warragul Victoria 3820
Australia

B Tomkins
GreenTree Forestry Services
Creswick Victoria 3363
Australia

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Photos by Braden Jenkin

Forest and Wood Products Research and Development Corporation
PO Box 69, World Trade Centre
Melbourne Victoria 8005
T +61 3 9614 7544 F +61 3 9614 6822
Email: info@fwprdc.org.au
Web: www.fwprdc.org.au

Use of chemical pesticides by the Australian plantation forest industry

KEY FINDINGS

- Plantation forestry is a minor component of Australian chemical pesticide use, its estimated $16.2–20.9 million expenditure in 2003-04, accounting for 0.7 per cent of the $2.4 billion national total;
- Australian plantation forestry chemical pesticide spending is estimated to be 99.0 per cent on herbicides (including adjuvants) and 1.0 per cent on insecticides;
- The chemical pesticides used by plantation forestry in Australia have been developed for other uses and have been adapted to the needs of the plantation industry;
- All chemical pesticides used by the Australian plantation forest industry are also used in food production systems by Australian agriculture with the exception of sulfometuron methyl, which is approved for other industrial uses in Australia;
- Of the 13 major herbicides used (based on expenditure) by the Australian plantation industry, five are also available for purchase 'off the shelf' in hardware stores and/or supermarkets;
- The adaptation and use of chemical pesticides by the Australian plantation industry is regulated under the same framework as all other chemical pesticide users. Because of the general use of licensed application contractors, plantation forestry has an additional regulatory overlay for the use of chemical pesticides compared to the greater use of unregulated operators in other industries;
- There are fundamental differences in the way chemical pesticides are used by the Australian plantation industry compared to agriculture. Use in plantations is usually confined to the first two years of a plantation crop cycle (for example a 10-year crop cycle for pulpwood or a 30-year crop cycle for softwood sawlogs); for the rest of the life of the plantation pesticide application is very limited and generally only occurs in reaction to pest or disease outbreaks. Agricultural crops tend to have a higher frequency of use, and in some cases, have multiple applications in each year or for each crop;
- The area over which chemical pesticides may be applied within a plantation can vary from 100 per cent to about 30 per cent of the planted area, depending on the management objective;
- Industry survey results indicate most chemical pesticides are used at less than 50 per cent of the maximum label rate;
- The Australian plantation forest industry has developed and adapted a range of application technology to meet industry needs;
- Aerial application of chemical pesticides by the plantation forest industry accounts for a maximum of 0.5 per cent of the total 10 million hectares of land aerially treated with a range of chemical products each year across Australia; and
- Environmental monitoring is generally conducted on a risk management basis by individual plantation managers. Where conducted on a systematic basis, water monitoring on a whole-of-catchment basis in Tasmania has shown few detections of chemical pesticides from any source.

Introduction

The use of chemical pesticides by the Australian plantation forest industry is sometimes a contentious issue. Chemical pesticide use is a function of crop, regulatory and pest issues. To extend the understanding of the use of chemical pesticides in the plantation forest industry, this study reviewed and assessed the:

- Regulatory controls at Federal, State and Local Government levels;
- Evolution of, and change in, chemical pesticide use by Australian agriculture and in plantations;
- Use of chemical pesticides in plantation and agricultural crops industry; and
- Typical use regimes in plantation forestry.

The study utilised published information on a range of issues relating to chemical pesticide use and attributes, included contact with industry experts and a confidential industry survey. This survey collected responses from plantation forestry managers responsible for the management of more than 92 per cent of the Australian plantation forestry estate. The information collected provides details of the type, rates of application and scale of use across a range of species and sites. The survey information provided a profile of the active ingredients and rates used by the industry. It was also the basis of the development of comprehensive chemical pesticide use models for six zones across Australia.

Pesticide definition

In the context of plantation forestry, the definition of a pesticide used in this study was:

Any chemical or chemical mixture used for controlling weeds, insects, fungi, nematodes and animals, which adversely affect growth (quantity and quality) and the health of plantations.

Pesticides are usually subdivided into groups depending on target organisms, or by their action on living organisms. The main subdivisions are herbicides; insecticides (including miticides, nematicides, molluscicides); fungicides; rodenticides; plant regulators; defoliants; desiccants and anti-transpirants; other types of poisons and repellents; adjuvants (all additives to chemical pesticides mixtures); and animal health products.

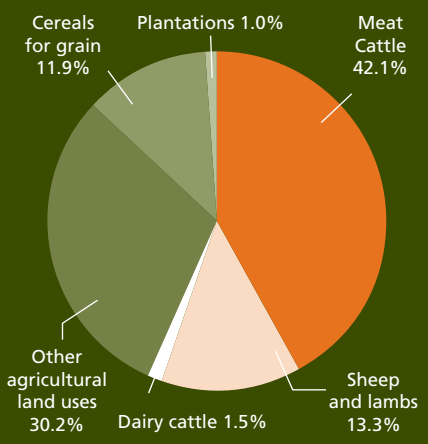

FIGURE 1 Australia's land use over the 168 million hectares of non-rangeland land use based on ABS (2006) for 2003-04 and Parsons *et al*. (2006).

Australian land use

The total area of Australia is 7,692,024 square kilometres or 769 million hectares (Geosciences Australia, 2006). The ABS reports on an area of 440,109,578 hectares, and has captured land use data for 437,107,239 hectares for 2003-04 (ABS, 2006). It is estimated, based on ABS specific statistics (for non-livestock enterprises) and by applying stocking rates to ABS livestock numbers, together with the National Forest Inventory data (Parsons *et al*. 2006) that 168 million hectares is used for more intensive land management than occurs in the rangeland estate (Figure 1). Plantations with an area of 1,716,173 hectares represent 1.0 per cent of the intensive land use.

Regulatory framework for chemical pesticide use

Chemical pesticide use in Australia is regulated by the Australian Pesticide and Veterinary Medicines Authority (APVMA) and State agencies. The APVMA is responsible for agricultural and veterinary chemicals and there are three other bodies responsible for regulating industrial chemicals (eg. dyes and solvents), medicines and medical products (eg. for human use) and food additives, contaminants and natural toxins (eg. food colouring).

The process applied by the APVMA is consistent across all uses and users of chemical pesticides. Registration of an active ingredient involves three years of field testing and analysis for a new active ingredient and two years of testing to register a new use of an existing active ingredient.

In the case of the active ingredients used by the Australian plantation forest industry, only one – sulfometuron methyl – was not developed for agricultural use. With the exception stated, all other active ingredients used by the plantation forestry industry are employed by agriculture for food production. Of the 13 most used active ingredients by the plantation forestry industry (based on purchasing expenditure), five are available for unrestricted purchase from hardware stores and supermarkets. Table 1 indicates the agricultural uses of the major chemical pesticides used by the plantation forestry industry.

The maximum industry rate shown is based on the reported rates of use from the industry survey.

A key reason the plantation forestry industry adapts chemical pesticides developed for other uses is because its usage does not warrant the significant costs associated with developing and registering its own specific active ingredients.

Production/management use of chemical pesticides

Use of chemical pesticides is necessary for cost-effective production in plantation forestry. Weeds in a plantation may compete for water, nutrients and space. Pest insects and browsing animals may defoliate or destroy the entire commercial value of a tree.

Much of the research on weed control has focused on the impact on survival of the planted trees and, where the trees do survive, the change in growth rates due to competition and physical damage. For example, effective weed control has been shown to improve growth rates by 120 per cent over an untreated control as assessed by volume in a softwood plantation. In the case of 66 per cent insect defoliation in eucalypt seedlings, a loss of growth resulted where the defoliation occurred multiple times in the one season.

The plantation forestry industry has undertaken significant applied research on how to use active ingredients developed for other uses. This has been successful in addressing a number of objectives including:

- Improved efficiency in the control of target species;
- Reduced environmental impacts on non-target species and water bodies;
- Improved environmental impacts on non-target species and water bodies;
- Reduced costs.

Developments have included the adaptation of application technology and the creation of new technology. Delivery systems, such as dry granule application, were introduced utilising proprietary active ingredient mixes to be applied over the top of the planted trees. The granules activate once they become moist and the active ingredient contained within begins to leach out. Plantation forestry specific systems have been developed to address issues such as culling non-crop trees within plantations, such as silver wattle in a radiata pine plantation.

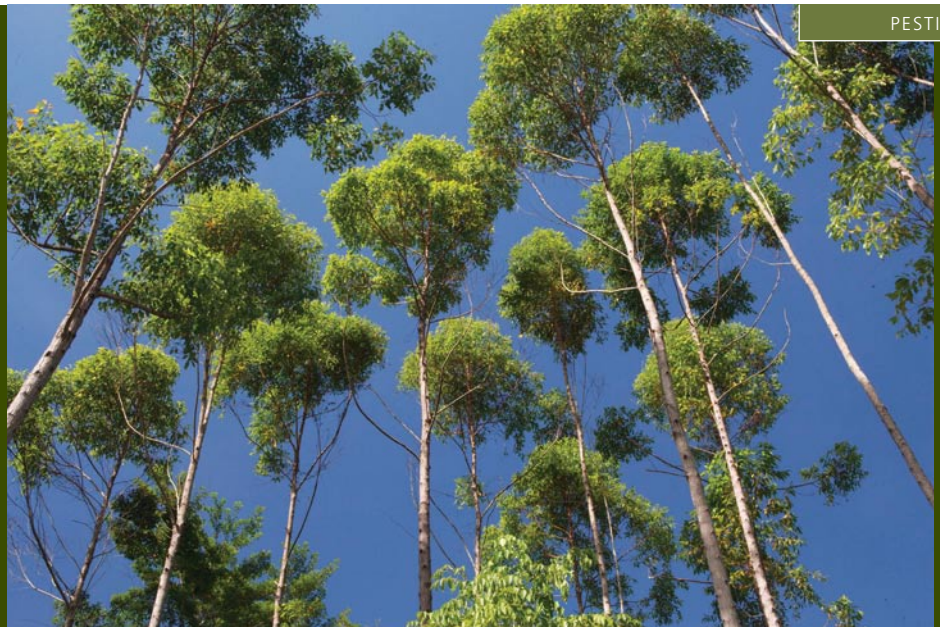

TABLE 1 Twelve chemical pesticide active ingredients used in plantation forestry and other uses of the same chemicals. The rates shown are based on the labels of products that contain the active ingredient. The industry maximum rate is from the industry survey.

ACTIVE INGREDIENT (A.I.)	CURRENT ACTIVE INGREDIENT USE	APPLICATION RATE LABEL (a.i. g/ha)	INDUSTRY MAXIMUM (a.i. g/ha)
Amitrole	Eucalypt plantations	250-1,500	1,600
	Radiata pine (silver wattle control) plantations	1,400-2,000	
	Water couch: in drains, channels, margins of streams, lakes & dams	990	
	Pre-planting rye grass & wild oats control in wheat & barley	1,232	
	Pre-harvest preparation for potatoes.	2,750	
	Vineyards and orchards	4,000	
Atrazine	Eucalypt plantations	4,500-8,000	5,600
	Radiata pine plantations	4,500-8,000	
	Canola	2,000	
	Sorghum, maize, sweetcorn, sugar cane and roadsides	2,970	
Clopyralid	Radiata pine (silver wattle control) plantations	2,550	2,000
	Eucalypts plantations	150-180	
	Barley, oats, triticale & wheat in combination with MCPA amine	150	
	Pastures and fallow land	600-1,200	
Fluroxypyr	Sugar cane for specific weed control	300	500
	Woody weeds in all non-crop areas and rights of way	600	
	Woody weeds in forests	600	
	Softwood plantations	159-848	
	Hops, citrus and a range of orchard species	424-848	
Glyphosate	Plantation forestry	360-2,160	3,200
	Broadacre control of a range of grasses and bracken fern	3,240	
	Pasture manipulation	495 - 2,160	
	Sugar cane – control of ratoons	2,160-3,240	
Haloxyfop	Plantation forestry	208-416	330
	Couch and rhodes grass control	208-416	
	Control of a wide range of grasses in agriculture, horticulture, etc.	104-416	
	Vineyards, various orchards	208-416	
Hexazinone	Radiata pine plantations	1,500-3,750	3,800
	Commercial and industrial areas	3,000-6,000	
	The combination with diuron is used in sugar cane	1,872	
Metosulam	Plantation forestry	3.6-7.0	7
	Wild radish control in lupins	3.6-7.0	
Metsulfuron methyl	Plantation forestry on ex-pastures	Up to 9	60
	Established pastures: control of Paterson's Curse	9	
	Common bracken	36	
	Wheat, barley, triticale and cereal rye: a range of weeds	3 to 4	
	For woody weeds on second rotation plantation sites	60	
	Blackberry control on native pastures, rights of way, industrial areas	96	
Simazine	Plantation forestry	1,440-6,030	6,000
	Pome fruit, apples and pears	3,600	
	Summer rainfall areas, non-crop residual control of grasses / broadleaved weeds	43,200	
Sulfometuron methyl	Proprietary mixture, lower rates otherwise	52.5	60
	Grass / broadleaved weed control for wide range of industrial purposes	150-600	
Triclopyr	In sorghum: control of prickly paddy melon	48	2,880
	Fallow cropping land: control of prickly paddy melon	96	
	Blackberry control over broad areas	2,880	

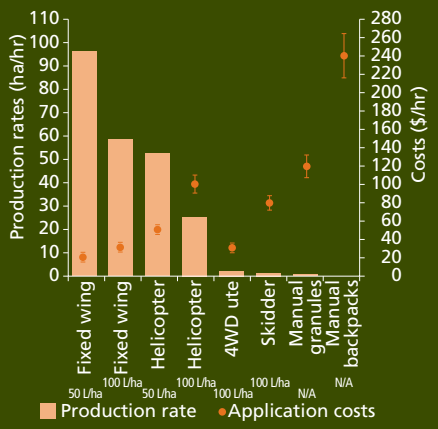

FIGURE 2 Generic production rates for the application methods shown and the costs of each method (with +/- 10 per cent deviation shown). In general, the slower the process, the higher the cost per hectare treated.

Application of chemical pesticides

Plantation forestry varies in scale and intent across Australia, and, with that variation in estate size, the realistic options to manage or react to issues will vary. In the case of small estates, it may be possible to conduct manual/non-chemical pesticide forestry (such as hand-weeding or tree guards to stop browsing animals). In a large-scale industrial plantation mechanical application of chemical pesticides is required. Further, the production rates (area treated per hour) of aerial application methods allow rapid response to pest insect outbreaks or the ability to apply herbicides during limited fine weather. Once the trees are planted, access restriction, due to the 'crop height', makes aerial application an invaluable tool. A total of 10 million hectares of crops and pastures per year are treated by aerial application of chemical products across Australia, and of that area, less than 0.5 per cent is plantation forest.

Figure 2 demonstrates the impact of time constraints. For example, if a plantation manager must spray 1,000 hectares at 100 L/ha, using any of the methods shown in Figure 2, it would take 17 hours by fixed wing, 39 hours by helicopter, 400 hours with a 4WD utility vehicle or 800 hours by skidder. With a two-week window of opportunity (maximum spray time of 14 days by 6 hours per day equals a total of 84 hours) it would require one fixed wing or helicopter operation, or at least five utility vehicles or 10 skidders. The actual choice of application method depends on the nature of the operation.

The usual chemical pesticide regime for forest plantations is to apply herbicides in the first two years and insecticides or fungicides in response to pest outbreaks. The active ingredients used are a function of the target pest, the crop tree species and the climate. A range of regimes may be used. Weed control usually takes place pre-plant as an initial site clean-up to remove difficult-to-kill species prior to planting the crop trees. This is usually applied (broadcast) across the whole plantation area. After site cultivation, the planting lines may be strip sprayed (eg. treating 50 per cent of the net planted area) or the site broadcast sprayed.

Once planted, and depending on weed growth, follow-up weed control may be required in the same planting season or later in the following year. The active ingredient and rates used will be a function of the active ingredient and rates of the previous treatment. That is, if a site is initially well treated, there may be reduced requirement to undertake additional applications of chemicals.

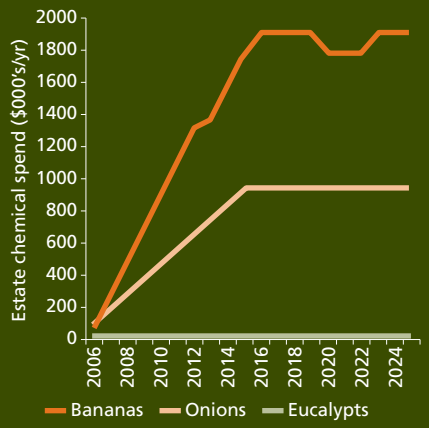

FIGURE 3 Total annual expenditure on chemical pesticide inputs for three crops increasing as the area expands up to a total estate of 1,000 hectares.

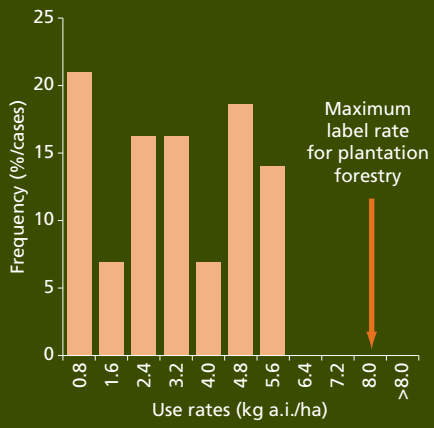

Figure 4 Plantation forest industry usage rates for atrazine. Industry reporting indicates most use is less than 50 per cent of the maximum label rate.

Plantation forestry compared with agricultural crops

The plantation forestry approach contrasts with the annual use of chemical pesticides in many agricultural crops. Specific analyses were undertaken to compare the chemical pesticide inputs to manage a Tasmanian blue gum plantation with a banana plantation and a vegetable-growing (onion) enterprise.

In the case of the Tasmanian blue gum plantation, weed control occurs in the first two years and then does not occur again until the crop is harvested and a new crop planted in the 11th year after the initial plantation development. In the scenario analysed, the plantation required insecticide application at age three years. This compares with the banana plantation with annual repeated applications of herbicides, insecticides and fungicides over the seven years of the crop, or an annual onion enterprise with multiple applications of herbicides, insecticides and fungicides. If an estate of the three crops were developed by planting 100 hectares per year for 10 years (up to a total estate of 1,000 hectares), the total chemical pesticide input for the three crops would be as follows (as indicated in Figure 3):

- Tasmanian blue gum plantation: $10,918/yr (or $10.92/ha/yr);
- Onions: $933,340/yr (or $933.34/ha/yr);
- Banana plantation: $1,979,081/yr (or $1,911.08 /ha/yr).

Application rates of chemical pesticides

The legal rate of application of chemical pesticides is stipulated on the product label. The label rates are the maximum rates allowed. In practice, the plantation forestry industry has developed regimes that may utilise the active ingredient up to that maximum rate, but the financial imperative to reduce the cost of inputs means that often the application is at less than the allowed maximum.

The results of the industry survey indicated that for all active ingredients in use (except simazine), the actual application rate was at less than 50 per cent of the allowed maximum in more than 50 per cent of applications considered. In the case of simazine, more than 50 per cent of the applications considered were at less than 70 per cent of the maximum allowed.

Figure 4 summarises application rate data for atrazine reported in the industry survey. For atrazine, the maximum allowed application rate is 8.0 kg active ingredient/ha, and the frequency distribution classes are given in units of 0.8 kg active ingredient/ha. Any use greater than 8.0 kg active ingredient/ha (> 8.0) is in excess of the label maximum rate. The data shown are not weighted for area, as they represent the industry survey rates reported for 2003 to 2005.

The true measure of chemical pesticide use is the rate per hectare combined with the total hectares treated. For atrazine, the maximum allowed rate for plantation forestry is 8 kg active ingredient/ha and the industry survey showed a maximum use rate of 5.6 kg active ingredient/ha. For canola cropping in Western Australia (WA), atrazine may be applied twice per crop at 1.0 kg active ingredient/ha. For 2005, the industry survey showed that the WA plantation industry used 7,444 kg active ingredient of atrazine. The WA canola industry for 2003-04 grew 318,000 hectares of canola, and if standard regimes were applied this would have resulted in the use of an estimated 636,000 kg active ingredient of atrazine, or more than 80 times the amount used by the plantation forestry industry in WA the same year.

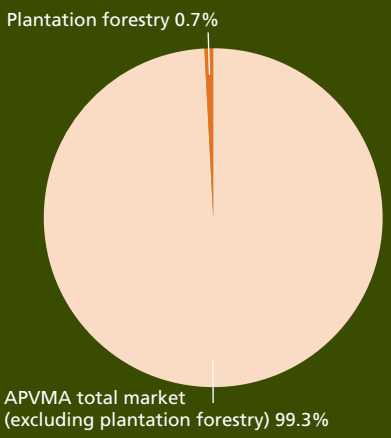

FIGURE 5 Estimate of the overall chemical pesticide market attributable to plantation forestry.

Chemical pesticide expenditure

The APVMA maintains and reports on the total chemical pesticide market in Australia. For 2004, the total spend on chemical pesticides was $2.45 billion (APVMA, 2005a: Table 2). This total includes uses such as domestic insecticides ($105.4 million).

Table 2 Australian 2004 pesticide market based on APVMA (2005).

BROAD CLASSIFICATIONS	($/yr)
Herbicides[1]	$996,719,444
Fungicides/PGR[1,2]	$170,106,518
Insecticides[1]	$374,193,750
Animal health[1]	$607,747,775
Additives[3]	$44,801,098
Domestic / recreation	$159,200,377
Industrial	$77,089,086
Vertebrate poisons[4]	$15,325,621
Others	$6,037,204
Totals	$2,451,220,873

Note:

1. The allocation of nematicides, molluscicides and miticides to 'insecticides' is not strictly correct, but has been done so to match the ABARE applied classifications.
2. PGR: plant growth regulators.
3. Additives include surfactants and adjuvants.
4. Vertebrate poisons include sodium fluroacetate (1080) and pindone.

Chemical pesticide expenditure information was estimated for the plantation forestry sector by:

- Data from the industry survey: total expenditure for 2005 was estimated to be $16.2 million after pro rata adjustment to 100 per cent of the estate; and
- A simple model of plantation forestry expenditure to estimate the maximum (based on maximum product label rates and/or industry best practice): total expenditure estimated for 2005 that gave an estimated expenditure of $20.9 million.

Therefore, the total expenditure on chemical pesticides in plantation forestry is estimated at $16.2–20.9 million per annum, or 0.7 per cent of the total Australian expenditure on chemical pesticides (Figure 5). Expenditure on chemical pesticides in plantation forestry is less than 16–19 per cent of that spent on household insecticides. If the estimated expenditure on household herbicides is also included (a total household spend of $175 million on herbicides and insecticides), expenditure by plantation forestry is 9–11 per cent of Australian household/domestic spending.

Figure 6 shows a breakdown of the estimated chemical pesticide expenditure by main chemical type and plantation management regime. The plantation forestry industry use is 99 per cent on herbicides and 1 per cent on insecticides.

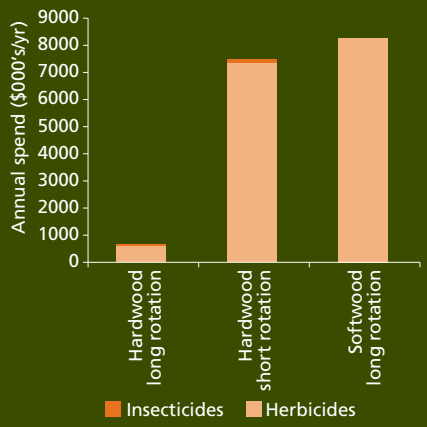

FIGURE 6 Estimated plantation forestry expenditure on chemical pesticides for short rotation hardwood (pulpwood crops), long rotation hardwoods (sawlog crops) and long rotation softwoods (sawlog crops).

Sodium Fluroacetate (1080)

Two hundred kilograms of sodium fluroacetate (1080), was used across Australia in 2003-04 (APVMA 2005b). The industry survey indicated that the plantation forestry sector used 5.5 kg in 2005 to kill declared pest animals, such as rabbits and native browsing animals that damage plantation trees. An additional 8.8 kg of 1080 was used to kill foxes and pigs to comply with pest animal legal requirements and to effect good land management.

Regional usage patterns

Regional profiles of chemical pesticide use were developed for six regions of Australia. Regions were defined based on combined National Forest Inventory (NFI) zones and the Statistical Divisions (SD) used by the Australian Bureau of Statistics (ABS) to report on farming practices. Figure 7 shows the combined zones used in the study. Where National Forest Inventory plantations were shown in an ABS SD, all the SD were included in that zone.

The regional profiles were developed based on generic chemical pesticide input regimes to manage the main crops produced in each region. The generic profiles were sourced from gross margin analysis reports published by various government agencies and other agricultural data. The areas of the non-plantation forestry enterprises were sourced from the ABS (2006). The combined data allowed the development of chemical input profiles on a per hectare managed basis and for each crop in each zone. Plantation forestry regimes were developed based on the industry survey, industry knowledge and specific discussions with a range of individuals. These profiles provide an understanding of the use of chemical pesticides in plantation forestry in each region and allow comparison with applications for typical agricultural land use in those regions. The six data sets were aggregated to give an overall estimate for Australia.

FIGURE 7 A summary of the National Forest Inventory and Australian Bureau of Statistics combined zones used for chemical pesticide market analysis and reporting. (Based on Wood *et al*. 2001).

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Environmental monitoring

Environmental monitoring of chemical pesticides mainly occurs on an 'as needed' basis or in response to perceived risk of off-site movement. Individual plantation forestry managers may conduct water sampling associated with operations and report these as part of compliance with code of practice or other regulatory requirements including sustainable forest management reporting to comply with certification schemes.

The only systematic programme of water sampling relevant to plantation forestry is the Tasmanian Department of Primary Industries and Water (DPIW, 2006) set of 54 water monitoring sites across Tasmania, where water samples are collected to test for 19 active ingredients. Samples are taken on a quarterly basis and up to seven rounds have been concluded. The sample sites cover all land uses in the catchments tested. Sampling commenced in January 2005 with no detections – but there have subsequently been four detections generally below guideline values and all below health values.

A similar initiative in the cotton-growing areas of Queensland showed a 100 per cent rate for the detection of atrazine for 2000-01 (13 samples). Time series data for cotton production areas of the Macintyre, Gwydir, Namoi and Macquarie valleys showed a decline in the detection rate for atrazine from 46 per cent of samples in 1991-92 (296 samples) down to 19.8 per cent of samples (350) in 2002-03.

Conclusion

The use of chemical pesticides in plantation forestry is limited, restricted to particular stages of crop development and actively regulated.

The plantation forestry industry continues to undertake research and development to ensure the most efficient, cost-effective and environmentally friendly use of chemical pesticides. In addition, work is undertaken to develop alternatives to chemical pesticide use in order to meet the requirements of forest certification and to reduce the costs of production.

FWPRDC
PO Box 69, World Trade Centre
Melbourne 8005, Victoria
T +61 3 9614 7544 F +61 3 9614 6822
www.fwprdc.org.au

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