CENTRAL VICTORIAN FARM PLANTATIONS INC.

cvfp
occasional paper
private forestry for a sustainable future
01/09

Use of Agricultural Chemicals in Plantation Forestry

By Barry Tomkins, GreenTree Forestry Services

The purpose of this paper is to provide factual information on the use of pesticides in plantation forestry to policy makers and the broader community. In particular, the paper provides up-to-date information relevant to specific community issues including water quality and aerial spraying. The paper places plantation pesticide use into context with more general use of pesticides in rural and urban/industrial settings.

Agricultural chemicals are used in many rural and urban/industrial situations including primary industries like plantation forestry. Agricultural chemicals are an essential component in the establishment of tree crops. These chemicals include pesticides such as herbicides to control competitive vegetation, insecticides to control insect pests, and fungicides to control fungal infestations. Also included are poisons to control browsing animals such as hares and rabbits, and fertilisers to promote tree growth. Use of pesticides is common practice for both commercial and non-commercial plantations, such as roadside and other amenity plantings. In particular, the use of herbicides in the first two growing seasons of plantation development is required to control competitive vegetation to ensure successful establishment. The use of pesticides in commercial plantations is often more stringently regulated than similar pesticide use in other agricultural and urban industries, or indeed domestic usage.

In 2004–05, total sales of agricultural pesticides in Australia, excluding chemicals associated with animal health products and fertilisers, were $1.69 billion (Section 89, Australian Bureau of Agricultural Resource Economics [ABARE], Australian Commodity Statistics 2005). Herbicides accounted for almost $1 billion, or approximately 60% of the total sales cost in 2004–05 (Section 105, ABARE). Agricultural industries comprising broad acre cropping and horticulture including fruit and vegetables consume the majority of the herbicide product. By comparison, the forestry share for herbicides was less than 2%, and only about 1% for all pesticides excluding animal health products (Jenkin & Tomkins 2006).

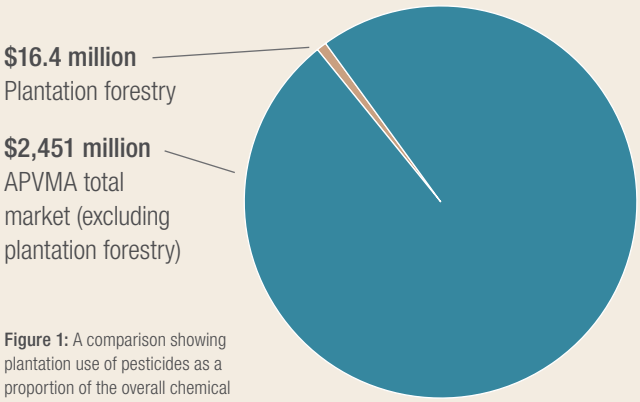

Figure 1: A comparison showing plantation use of pesticides as a proportion of the overall chemical pesticides market.
Source: APVMA 2003–04

In 2004, detailed surveys gave a plantation forestry expenditure on pesticides of $16.4 million, the majority on herbicides (ibid 2006). Compare this with the total overall expenditure by agricultural industries on pesticides, estimated at $2.45 billion (see Figure 1).

About the author

Dr Tomkins is an independent consultant and an Honorary Senior Fellow of the University of Melbourne. A chemist, he has a B.Sc. and Ph.D. from the University of Melbourne. He has carried out research in the development of new herbicides and herbicide mixes for possible use in plantation forestry for 16 years. He conducts an independent collaborative program of small-scale and operational herbicide trials. The work is supported by 19 forestry organisations including state departments, and by the research agricultural chemical companies. Every two years he conducts a forest plantation pest management seminar/workshop, which has always been attended by 80 or more representatives from plantation organisations, public authorities, research organisations and agricultural chemical companies. He is the co-author with Braden Jenkin of a major Forest and Wood Products Australia report titled 'The use of chemical pesticides by the Australian plantation forest industry.' Dr Tomkins is well placed to discuss the use of chemicals in plantation forestry.

Background

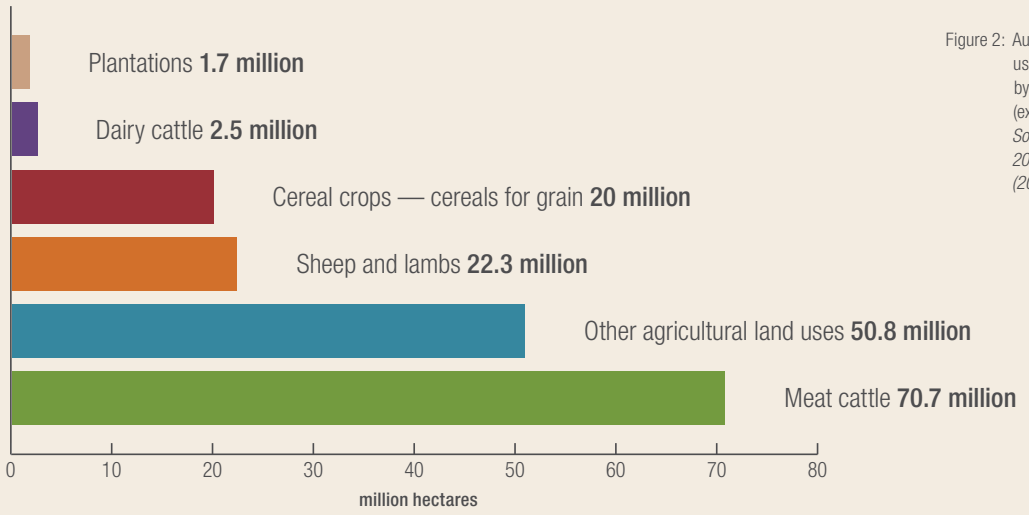

Figure 2: Australia's agricultural land use in hectares (millions) by primary enterprise (excluding rangelands). *Source: ABS (2006a) for 2003–04 and Parsons* et al. *(2006) as at Dec. 2005.*

In 2008, Australia had around 1.97 million hectares of plantations, including almost 950,000ha of hardwood and 1.01 million ha of softwoods, according to the Bureau of Rural Sciences' National Plantation Inventory. Victoria's share was 422,112ha, the largest area under plantation of any state or territory.[1] Under the *Plantations for Australia: The 2020 Vision strategy*, it is intended further expanding the national area to a notional target of three million hectares by 2020.[2]

There are many reasons to develop and maintain a viable plantation industry in Australia. Domestic and international demand for timber and timber products continues to grow and Australia currently has a trade deficit in timber products, including paper, of about $2 billion. The expected increase in demand can be met through the development of plantations to produce timber efficiently and intensively on relatively small areas. In addition, plantation development will reduce the pressure on the native forest resource to meet increasing demand for wood products.

Plantation development can address long-term environmental degradation issues like salinity and erosion. Plantation development can also enrich regional economies through buffering fluctuations in other rural industries. Recent socio-economic studies in the Great Southern Region of Western Australia and the South West Slopes Region of New South Wales support this assertion (Schirmer 2005 a,b). Socio-economic impacts of private forestry and land use change have also been addressed in some depth by Petheram *et al* (2000), Cameron *et al* (2004), Schirmer *et al* (2008) and briefly in a publication available from the Department of Primary Industries (DPI), which reviews the science behind plantation forestry in Victoria (Turner *et al.* 2004). Social benefits can include direct employment, often of expertise imported into an area, and the development of new local support businesses and skills allied with an increase in the variety of employment opportunities for local communities.

Victorian plantation estate

Plantation forests have been established in Victoria since the early 1920s using softwood species dominated by radiata pine (*Pinus radiata* D. Don). Rapid expansion of radiata pine plantations through the 1960s to 1980s has established a large resource that sustains viable industries in rural Victoria. The major areas of softwood plantations include the far south-west in the Green Triangle region, the north-east and central regions, and central and southern Gippsland including the Strzlecki Ranges. Smaller areas include the Ballarat and Otway regions. Although these plantation developments were largely established on ex-native forest sites, the practice of clearing native forest areas for plantations has been proscribed since the late 1970s.

Rapid expansion of hardwood plantations in Victoria commenced in the early 1990s into non-traditional forestry areas on cleared or ex-agricultural land in the Green Triangle region. The Green Triangle developments followed those in south-west Western Australia, and has in turn been followed by developments in Central Victoria and Gippsland. Short rotation hardwood plantations are managed for the production of products made from wood fibre like paper. The main eucalypt species are southern blue gum (*Eucalyptus globulus* subsp. *globulus*) and shining gum (*E. nitens*). Long rotation hardwood plantations produce sawn products in conjunction with pulpwood production and include mountain ash (*E. regnans*) and other species.

1 http://adl.brs.gov.au/mapserv/plant/NPI2009Update.pdf

2 www.plantations2020.com.au

Pesticides have been used in Victorian plantation forestry for decades. Development of herbicides for establishment of softwood plantations began in the early 1960s (Flinn and Fagg 1984). As plantation establishment in Victoria now occurs on agricultural land, it is likely that pesticides have previously been applied to the land for agricultural pursuits, such as control of weeds including thistles, capeweed, wild radish and many others, and in pasture re-sowing.

It is important for communities to analyse the issue of pesticide use in plantations in the broader context of pesticide use throughout our society, and to understand the governance and regulatory framework around such use for all agricultural industries.

Community perceptions are influenced by many factors including the scientific community and media. Media reports surrounding plantation development in non-traditional areas have increased community interest.

The Australian regulatory systems

Australia has well-established and advanced chemicals regulatory systems, including those for human health products and industrial chemicals. For pesticides, there is a system of Commonwealth and state regulations that are reviewed regularly.

Commonwealth legislation

Agricultural and Veterinary Chemicals Act 1994

This Act sets out the functions and powers of the Australian Pesticides and Veterinary Medicines Authority (APVMA) — see next section.

Agricultural and Veterinary Chemicals Code Act 1994

The Schedule to this Act incorporates the Agricultural and Veterinary Chemicals Code (the AgVet Code), which deals with the approval and registration of pesticide products and their constituents (controlled by the APVMA), as well as the control of pesticide products in relation to their supply.

Agricultural and Veterinary Chemicals Code Regulations 1995

This covers various matters outlined in the Agricultural and Veterinary Chemicals Code Act 1994.

The Australian Pesticides and Veterinary Medicines Authority

All animal health products and pesticides used for industrial (roads, railways etc), domestic and agricultural purposes including plantation forestry, are registered by the Australian Pesticides and Veterinary Medicines Authority (APVMA). The APVMA is the peak body set up under Commonwealth legislation, and is responsible for all issues surrounding pesticides and animal health products up to the point of retail sale. State or territory legislation takes over following retail sale, and also governs the use of fertilisers.

Before a pesticide can be registered it must undergo substantial and systematic trial work. For a new pesticide product, three years research is usually required, and for an existing registered pesticide product, usually at least 1–2 years is required for a new use. These trials are governed by a permit system under the APVMA, and the information relating to permits is available on the APVMA web site (www.apvma.gov.au).

Registration of a pesticide requires the submission of data for evaluation. Several sections apply, including data relating to Occupational Health and Safety (OH&S) and Environmental Health and Safety (EH&S), and must include environmental data from testing in Australian conditions. A draft label must be supplied relating to use, as well as a Material Safety Data Sheet (MSDS).

Once approved, the label is a legally enforceable document that specifies the quantities and applications of the pesticide product for particular uses.

The Material Safety Data Sheets (MSDS) contain product formulation and physical properties, effects, first aid, toxicity data (LD50 and LC50)[3], flammability, storage and transport, and spills and disposal requirements. It is not required to be provided with the label, but must be requested from the supplier. It is mandatory to carry MSDSs for pesticide products when they are in transport.

If the APVMA is not satisfied with the submissions, it may and does, reject registration until the concerns are addressed by further trial work. Registration for a new pesticide chemical in a product can take up to 6–7 years. Such pesticide products requiring registration for Australian conditions are usually already registered for use in other countries.

Pesticide products used in plantation forestry are specifically registered for forestry. Products may also be used under APVMA permits, which are temporary and are designed for research purposes and to lead to the use being placed on the label. These permits are known as off-label permits. It is important to note that almost all pesticides used in plantation forestry have generally been developed from other agricultural uses.

The APVMA is not responsible for the regulation of fertilisers. This comes under State Control of Use Acts.

3 LD50 is, like the LC50, a measure of acute toxicity, and is defined as the single dose in mg/kg of body weight sufficient to kill half of a test population of a particular animal. Rats and rabbits are commonly used.

Victorian state legislation

Once a pesticide is registered, state legislation becomes the ongoing governance.

The key Victorian acts and regulations are:

- The Agricultural and Veterinary Chemicals (Control of Use) Act 1992;
- Agricultural and Veterinary Chemicals Control of Use (Fertilisers) Regulations 2005;
- Agricultural and Veterinary Chemicals (Control of Use) Regulations 2006.

Other acts and regulations of relevance are:

- The Occupational Health and Safety Act 2004, and various regulations made under that Act;
- The Dangerous Goods Act 1985, and Dangerous Goods (Storage & Handling) Regulations 2000;
- The Environment Protection Act 1970 — and various regulations and policies made under that Act ;
- Drugs Poisons and Controlled Substances Act 1981, and Drugs, Poisons & Controlled Substances Regulations 1995.

Spray drift, aerial application and off-label use

Concerns are often raised about pesticide spray drift from ground based or aerial applications. While the method of application is generally ground based, in steep terrain or over large contiguous areas of plantations, aerial application is commonly used.

Pesticides need to be applied under suitable conditions to ensure intended outcomes are achieved. Ground based spraying does not usually result in any significant drift, because spraying should only be carried out under the most favourable conditions, and in accordance with relevant legislation and codes of practice. In the second season autumn, or later after planting, ground based treatments may be applied to the rows and inter-rows using directed nozzles and/or a dual sprayer, and pose little risk of spray drift, as the trees themselves constitute a significant barrier to spray drift.

Plantation forestry companies minimise the likelihood of spray drift from aerial applications by using helicopters. Their low speed and the configuration of the spray equipment makes aerial spraying by helicopter more accurate and reduces the probability of off-site spray drift. Legal constraints further minimise the risks of aerial spraying.

There is a greater probability of spray drift from applications of pesticides by fixed wing aircraft, because speeds are higher. Fixed wing aircraft are usually only used in plantations where there are large contiguous areas of relatively flat terrain, such as in the radiata pine plantation regions of far south-west Victoria and the south-east of South Australia.

Spray drift regulation and training

Spray drift is regulated by the Agricultural and Veterinary Chemicals (Control of Use) Act 1992. Section 40 of this Act makes it an offence to cause damage from spray drift by agricultural spraying, which injuriously affects any plants or stock outside the target area; or injuriously affects any land outside the target area. Growing plants or keeping stock within the target area could be reasonably expected to result in contamination of the stock or of the agricultural produce.

This regulation applies to all pesticide users (company, government, professional) and all types of spray application (aerial, spot spraying, misters, ground driven boom sprays etc).

All ground-based operators must be licensed (usually the Commercial Operators Licence) and this Act also creates licensing requirements for aircraft and for the aerial application of pesticides.

For aerial application, the Centre for Pesticide Application and Safety at Gatton College, University of Queensland, Toowoomba conducts week-long advanced training courses for operators.

To fully scope regulation, the APVMA released a discussion paper relating to spray drift risk in 2003 that outlined operating principles and registration requirements. The discussion paper was open for public comment until October 2005 and after due consideration, a draft final document was released in July 2006. In July 2008, the 'APVMA Operating Principles In Relation to Spray Drift Risk' were released.[4]

These operating principles describe the methods and scientific principles the APVMA uses to assess and manage spray drift issues. The APVMA's standard spray drift scenarios provide detailed information about spray drift behaviour for a range of ground and aerial spray drift application methods. They include APVMA modelling input parameters.

Under the operating principles, the APVMA requires no-spray zones as a buffer between an application area and an area downwind that needs to be protected. The APVMA sets the size of no-spray zones based on the inherent hazard the pesticide presents and an assessment of the specific risk.

In Victoria, the Department of Primary Industry (DPI) regularly audits ground and aerial contractors for compliance to law and good practice standards. DPI investigates spray drift and where

4 www.apvma.gov.au/users/spraydrift_principles.shtml

appropriate will launch prosecutions. DPI officers can direct owners of any defective agricultural spraying equipment not to use that equipment until it has been repaired.

Also in Victoria, the Code of Practice for Timber Production 2007[5] provides further regulation and control of various forest management activities with potential environmental impacts, such as chemical usage.

It must be emphasised that aerial applications in plantation forestry are small in comparison to other industries. Aerial application of pesticides by the plantation forest industry accounts for a maximum of 0.5% or 50,000ha of the total 10 million ha of land aerially treated with a range of pesticides each year across Australia (Jenkin & Tomkins 2006).

There are extensive annual aerial pesticide treatments of crops such as rice, cotton, wheat and other grain crops, and canola.

Similarly, for example, multiple applications of fungicides are required in the growing of some varieties of potatoes. In Victoria, one potato variety used for crisp production is routinely treated with a rotation of two fungicides up to five times at 10 to 14 day intervals, by helicopter. Comparable pesticide regimes apply in other Australian states.

The plantation sector is sometimes the target of criticism for undertaking aerial applications of pesticides in water supply catchments. However, the use and aerial application of pesticides is strictly regulated through the requirements of state legislation and codes of practice; for example, the Victorian Code of Practice for Timber Production 2007. In any case, not all plantations are in water supply catchments, and not all catchments are forested — many have large tracts of land used for other (primarily agricultural) purposes.

Off-label use in Victoria

Off-label refers to the use of pesticides other than that specified on the label. In some circumstances in Victoria, it is not illegal to use a registered pesticide 'off-label.' For example, use of any registered product at rates and frequencies lower than label rates is not illegal providing that there are no label restrictions against such use. However, most off-label use is on pests, weeds and minor crops that are not on the label.

Some products have statements on the label restricting use at a lower rate than on the label, due to demonstrated lack of efficacy at lower than label rate. If a product was used in contravention of that particular label restriction, it would be an offence.

Since March 1995, the use of a pesticide product above the maximum label rate, or in contravention of a specific label restriction or more frequently than specified, is an offence unless a permit from the APVMA has been obtained. Although the Victorian Agricultural and Veterinary Chemicals (Control of Use) Act 1992 does not require a permit to be obtained for use of products at lower rates or lower concentrations than the maximum specified on the label, it is an offence to apply a particular pesticide if it is stated on the label not to use specified equipment. Otherwise it is not an offence to use non-specified application methods.

Schedule 1 of the Control of Use Regulations prohibits off-label use of certain restricted use pesticides without a DPI permit, including S7 poisons, esters of triclpyr, 2,4-D, MCPA and 2,4-DB, and atrazine and metham sodium.

The responsibility for off-label use of a registered product lies with the user. Should problems arise from that off-label use (i.e. residues, phytotoxicity, lack of efficacy), the user has no recourse against a chemical company that warrants its products unless it can be shown that the product was faulty. (Products of some generic companies do not carry a warranty, but the major research based agricultural chemical companies warrant their products).

It is a product that is registered, not the active constituent. As an example, there are several registered products, with the same level of active constituent (Products A, B, C, D), but only one is registered for use in forestry (Product B). While Product B may have a rate of use for forestry of 5 L/ha, the highest rate on the Product A label may only be 2 L/ha, which is then the highest rate that Product A can be used without a permit.

5 Available for downloading from the website of the Victorian Department of Sustainability and Environment www.dse.vic.gov.au

Forestry use of chemicals

Perspective

The use of pesticides in forestry is small in comparison to other agricultural industries, industrial uses (roadsides, railway lines, around factories etc), and domestic uses (household & garden). Further, expenditure on insecticides in plantation forestry in 2004 was only 1% of all pesticide expenditure in plantation forestry. The domestic/recreation market was estimated at $159 million in 2004, and the expenditure on all pesticides in plantation forestry was less than 16–19% of that spent on household insecticides (Jenkin & Tomkins 2006).

While the market value for pesticides used in the 10,000 ha of land managed for turf, including sports grounds, golf courses and bowling greens, is about the same as that for plantation forestry (Jenkin 2006), the latter treats significantly larger areas on a less frequent basis. Also, land treated for plantation forestry is not intensively used by the general population, and is generally located in non-urban areas. This would suggest that the public have

greater opportunity to come in contact with chemicals through recreation than through chemicals used in plantations.

A casual inspection of the garden pesticide section in any major hardware store indicates that over 30 active ingredients are used to control garden weeds, insect pests and fungal infestations. Purchasers of these domestic pesticides can use the products without any specific training, although safety measures are recommended. However, home garden products are specially packaged and labelled for home garden use, and do not include commercial pack sizes nor any restricted use products available to agriculture and forestry.

Very detailed comparisons with pesticide use in a variety of crops are available (Jenkin & Tomkins 2006).

Atrazine use

To provide another comparison, the use of atrazine, a residual herbicide, in forestry is relatively low nationally, about 30–40 tonnes (a.i.) per annum (pa). The national atrazine use is about 2000–2500 tonnes a.i. pa in tt-canola, sugar cane, cotton, sorghum and others. Ninety per cent of the atrazine sold in Victoria goes into the triazine-tolerant (tt-) canola market, with about 80,000ha grown annually in western Victoria. Atrazine is the most important herbicide used for tt-canola, and is applied at 2 kg a.i./ha per crop. Simazine instead of atrazine is also used in the growing of canola, and there are about 1 million ha of canola (about 60% of which is tt-canola) grown annually across Australia. The indicative tonnage of atrazine for tt-canola is therefore in the range 1,200-1,500 tonnes a.i. pa.

However, atrazine labels state that the maximum use rate for all crops except plantation forestry is 3 kg a.i./ha, and this rate is used in other crops such as sorghum, sugar cane and maize/corn. The maximum label rate in plantation establishment is 8 kg a.i./ha, but it is rarely used above 4.5 kg a.i./ha.

Forestry use of atrazine in Victoria has declined. The blue gum plantation companies do not use atrazine, and use in pine is minimal; e.g. the largest Victorian pine growing company, HVP Plantations, ceased its use after 2003. Simazine use has been higher because some simazine products are specifically registered for use in the establishment of hardwood eucalypt plantations.

Like other agricultural industries, plantation forestry companies have an ‘as-of-right’ use of chemicals including fertilisers on their land subject only to labelling and Control of Use Acts and Regulations and other relevant acts which may connect; e.g. OH & S, EH & S/EPA, Transport and Dangerous Goods Acts. The Code of Forest Practice does not regulate chemical use beyond what is already in place through the Agricultural and Veterinary Chemicals (Control of Use) Act.

Drinking water guidelines

The Australian Drinking Water Guidelines were developed by the National Health and Medical Research Council (NHMRC) and were last revised in 2004. The guidelines are intended to provide a framework for good management of drinking water supplies. The Australian Guideline and Health Values for many pesticides are listed. There are two measures of water quality within the guidelines, GLV and HLV. The GLV is the important level for drinking water, not the HLV.

The Guideline Value for safe drinking water

The GLV, or Guideline Value, for safe drinking water for human consumption refers to the limit of detection, that is, the minimum level of a chemical in water that analytical chemists are able to determine. Analytical methods have improved considerably over time, and as a result there has been a downward revision of levels. In short, the GLV is the minimum that can be specified, because it is impossible to state that a chemical is not present below that limit.

For example, the GLV for atrazine is currently 0.0001 mg/L (milligrams per litre) or 1/10th of a part per billion (0.1 ppb). The GLV for simazine is 0.5 ppb, or 0.0005 milligrams per litre of water.

The Health Level Value

The Health Value or HLV is best described as an environmental value, and does not relate directly to the levels set for drinking water for human consumption.

The HLV is determined differently to the GLV. Firstly, a determination is made of an animal NOAEL or **N**o **O**bservable **A**dverse **E**ffect **L**evel. This involves feeding test groups of animals with increasing amounts of a chemical until an adverse effect is observed. A quantity called the Acceptable Daily Intake or ADI for humans is then determined, which is 1/100th of the NOAEL. This is described in terms of milligrams per kilogram of body weight per day.

This value is then used to determine a Health Value, which is based on 1/10th of the ADI or 1/1000th of the NOAEL, but it is also converted to a concentration in water.

For atrazine and simazine, the ADI is 0.005 milligram/kg of body weight. A 70 kg person, for example, would have to ingest 70 times 0.005 mg to reach their ADI, or 0.35mg/day.

If the level in drinking water of simazine was the maximum GLV allowed of 0.0005 mg/L, that person would have to drink 700 litres of water per day to reach their ADI, and for atrazine, the volume would be 3,500 L per day.

For simazine, the HLV is 0.02 mg/L or 20 ppb. To reach their ADI a 70 kg person would have to drink nearly 18 L per day. For atrazine, the HLV level is 0.04 mg/L or 40 ppb. To reach their ADI a 70 kg person would have to drink nearly 9 L per day.

The APVMA have conducted a long running review of atrazine under the Existing Chemicals Review Program, and released a final report in May 2008 available on their website as download[6]. The conclusion of this final component of the review will see the APVMA implement a small number of additional regulatory actions proposed in an interim report in 2004, whose effect will be to further tighten and better define restrictions applied since 1997. In addition, the APVMA has acted on new information suggesting a potential risk of atrazine entering waterways through the use of the chemical post-emergence on tt-canola in raised bed cropping systems. The APVMA is requiring registrants to collect data to enable it to further evaluate this issue.

In a recent APVMA 'hot topics' document on the website re frequently asked questions concerning atrazine, the following was provided[7]:

> *'Some have suggested that Australia allows a far higher concentration of atrazine in drinking water than other countries, thereby exposing its citizens to greater potential risk. Is this the case?*
>
> *'Not at all. The values are actually quite similar [to standards in other countries].'*

The current Australian Drinking Water Guidelines (ADWG) were developed by the National Health and Medical Research Council (NHMRC) in collaboration with the Natural Resource Management Ministerial Council (NRMMC). Two values have been set for atrazine, a Guideline Value of 0.1 parts per billion (ppb) and a Health Value of 40 ppb.

The Guideline Value is used to alert water authorities to chemical contamination. If a pesticide is detected at or above the guideline value, water authorities should identify the source of contamination and take action to prevent further contamination.

The Health Value defines the maximum concentration of a chemical in drinking water that, when considered together with amounts an individual might obtain from other dietary sources, does not exceed a level of concern. This value can be used to guide risk communication and risk management in case of a major incident such as an accidental spillage.

The Australian Guideline level of 0.1 ppb compares favourably with the equivalent United States and European Union values of 3 ppb and 0.1 ppb respectively, while the American health value (called the Drinking Water Level of Comparison) at 68 ppb for the general population is slightly higher than the equivalent Australian Health Value of 40 ppb. Other authorities have also set drinking water 'guideline' values for atrazine which are not dissimilar to the Australian Health guideline value. For example, Canada has established a 'Chronic Drinking Water Level of Concern' for atrazine of 41.9 ppb and the 1996 EU proposal was for a Maximum Allowable Concentration (MAC) of atrazine in water of 15 ppb.

6 http://www.apvma.gov.au/chemrev/downloads/atrazine_finalMay08.pdf

7 http://www.apvma.gov.au/new/hottopics_atrazine.shtml

Criticisms of the use of atrazine, simazine and amitrole in plantation forestry

Criticisms of plantation use of atrazine, simazine and amitrole are based on claims that these herbicides are carcinogens and endocrine disruptors.

The triazines/triazole and cancer

The World Health Organisation, the International Agency for Research on Cancer (IARC), states unequivocally that there is no credible evidence that atrazine, simazine or amitrole are human carcinogens (IARC 1999)[8]. Before 1999, these herbicides were considered by IARC to be possible human carcinogens on the basis of laboratory tests conducted on rats. High doses of atrazine given to the **female(s)** of one particular strain of test rat (Sprague–Dawley rats — a large white rat) caused an increased incidence of a specific female mammarian cancer. In one experiment a similar result was obtained with simazine. The biological mechanism behind this has been determined, and, according to Eldridgea, J.C *et al*. (1999) it cannot occur in humans because human physiology is quite different.

The US Environment Protection Agency (US EPA) could not conclude the cancer risk associated with atrazine from available data. In 2003 the US EPA wrote:

> *'Based on the available scientific work on the potential association between atrazine and cancer, the Agency does not at this time find compelling data that would lead the Agency to conclude that potential cancer risk is likely from exposure to atrazine. However, EPA will continue to review new studies on this issue as they become available, and plans to convene another independent Scientific Advisory Panel (SAP) meeting concerning atrazine and its potential association with carcinogenic effects in light of any new data.'*[9]

Simazine and atrazine were re-classified in 1999 from 'possible human carcinogens' (IARC Class 2B) to 'not classifiable as to its carcinogenicity to humans' (Class 3). Amitrole is also classified as Class 3.

8 http://monographs.iarc.fr/htdocs/indexes/vol73index.html

9 www.epa.gov/pesticides/factsheets/atrazine_addendum.htm#q12

Endocrine disruption

There was also speculation that atrazine (and by association simazine) causes hermaphrodism, the presence of both male and female reproductive organs, in frogs and fish. An American scientist originally reported the results (Hayes 2002), but subsequent attempts by other scientists to repeat and verify the research have been unsuccessful[10].

The US EPA produced a white paper on the potential effects of atrazine on amphibian gonadal development. This was considered at a meeting of their Science Advisory Panel (SAP) on October 9–12, 2007[11]. The Panel's 'Conclusions from laboratory and field studies' follow:

'The Agency has reviewed 36 open literature and registrant-submitted studies related to the potential effects of atrazine on gonadal development in amphibians. Overall, the weight-of-evidence based on these studies does not show that atrazine produces consistent, reproducible effects across the range of exposure concentrations and amphibian species tested. In laboratory studies where environmental and animal husbandry factors were controlled, atrazine exposures (0.01–100 µg/L) did not affect time to or size at metamorphosis, sex ratio, or gonadal development.

'While there were several effects on secondary gross and histological endpoints that were statistically significant, their relationship to apical endpoints of intersex and/or gonadal development effects is not considered relevant.

'Because of the uncertainties associated with all the laboratory and field studies conducted prior to 2003, the 2003 SAP recommended that additional studies be conducted to determine if exposure to atrazine affects amphibian gonadal development. In their report, the SAP recommended using X. laevis as the test species as well as indigenous species. Because the SAP report did not identify what benefits the indigenous species would provide, the Agency concluded that testing with X. laevis would be sufficient for a Tier 1 study. Based on the recent nineteen studies reviewed, including the recently submitted DCI studies showing no effects of atrazine on amphibian gonadal development, the Agency has further concluded that the higher tiers of testing proposed in the 2003 White Paper (USEPA 2003) are not needed at this time.'

Other facts about atrazine and simazine

Atrazine and simazine have been in general use for about 40 years. In Western Australia, simazine is registered for use as an algicide in dams, tanks and troughs, and it was initially developed as an algicide and slimicide as well as a herbicide. As noted above, the US EPA does not consider that environmental levels of atrazine or simazine pose a risk to human health.

Nevertheless, the APVMA is to conduct a review of simazine use under its Existing Chemicals Review Program (ECRP), because claims have been made that use of simazine as an algicide in swimming pools may expose children 'to five or six times the Acceptable Daily Intake (ADI), that children may ingest levels of simazine in pool water that are higher than those allowed in domestic water supplies, and the suggestion that simazine promotes cancer.' These claims do not accurately reflect the facts.

Simazine is not 'a common ingredient' in swimming pool anti-algae products. It is present in only 11 of over 500 registered pool algicide products. Information available to the APVMA reveals that, in terms of sales, simazine pool products account for only 0.6% of the total value of all pool product sales. It is predominantly used by commercial pool operators to treat outdoor pools over winter, when the pool is not used for swimming. It is, therefore, unlikely that children will be exposed to the chemical in practice[12].

The regulation of atrazine differs throughout the world. Atrazine is the major herbicide used for weed control in the growing of corn, soybean and sorghum in the USA. It has been partly proscribed in the European Union (EU), despite a pan-European expert committee recommending that the prohibition be removed.

In the APVMA questions and answers document referred to previously, the following was provided.

'Atrazine has been banned in Europe so why is it still registered for use in Australia?

'The EU has never adopted the recommendation from the expert committee. Atrazine has not been 'banned' in Europe. In 2004 the European Commission decided not to list atrazine on its schedule of approved active constituents for plant protection products (its so-called Annex I). It did not do this because of any specific toxicological reasons but because it was concerned that residues in ground water might exceed its nominal limit of 0.1 ppb which it had set for all chemicals for which specific values have not been established.

'Essential' uses (on maize and in forestry in Ireland and the UK and on maize in Spain, Portugal, Hungary and Poland) were still permitted in Europe until December 2007.'

10 www.syngentacropprotection-us.com/prod/herbicide/Atrazine/index.asp?nav=nrdc

11 www.epa.gov/scipoly/sap/meetings/2007/october/2007_amphibian_white_paper.pdf

12 http://www.apvma.gov.au/chemrev/downloads/simazine_update.pdf

In fact, atrazine is not 'banned' anywhere in the world.

The Department of Primary Industries conducted surveys into atrazine use in Victoria from 2001 to 2003.

The following is part of a letter sent to the author when he requested the forestry survey. The survey results cannot be quoted without written permission, but the author can quote from the accompanying letter.

'The Chemical Standards Branch of DPI in Victoria conducted surveys into the Forestry, Pasture seed and Triazine Tolerant Industries during 2001, 2002 and 2003. The aims of the surveys were to demonstrate that users of atrazine based chemical products in Victoria can manage potential chemical risks effectively as outlined in the recommendations from the APVMA review on atrazine, and to establish a benchmark on the level of knowledge and adherence to legislative requirements by atrazine users in Victoria.

'Results from the survey have revealed that the level of overall professionalism is a reasonable indicator of awareness of environmental concerns relating to atrazine use, adherence to label directions and legislative requirements for chemical use across Victoria.

'The industry sector that was able to demonstrate the highest degree of knowledge regarding atrazine use and compliance with relevant legislation was the forestry industry. The survey revealed a high level of awareness of the Industry Code of Practice and the implementation of documented quality assurance programs such as ISO 9002 & 14000.'

In addition to the DPI survey, the APVMA reviewed atrazine extensively (APVMA 2004). The process involved reviewing about 500 peer reviewed papers and other authoritative literature. The conclusion was that there were no major identifiable health risks associated with the label compliance requirements. The 2004 draft review deals extensively with the cancer and hermaphrodism issues discussed above. Further public comment was called for and the APVMA have released the final report.

Environmental monitoring

The main developments in environmental monitoring have concerned water quality. In some regions of Australia community perception is that plantation forestry use of pesticides has resulted in significant and frequent contamination of streams and water supplies. In response to such perceptions in Tasmania, the Department of Primary Industries and Water (DPIW) set up a system of stream monitoring in 2005. The monitored streams are located throughout the state from the north-west around to the south and cover a number of land uses including plantations and other agricultural industries. Wilderness areas to the south-west were excluded.

The baseline monitoring program commenced in January 2005 at 28 sites (streams) with no detections of agricultural chemicals. In the second round in April 2005, again at the 28 sites, there was one detection, of 0.08 parts per billion (ppb) of simazine. The program was expanded to 56 sites and after 14 quarterly rounds monitoring for 19 pesticides there were only 23 detections, mostly at levels below GLVs, some of which have been non-forestry pesticides, in particular MCPA. However, two-thirds of the detections have been of forestry related chemicals, including atrazine, simazine and hexazinone.

Four streams have been intensively monitored in the flood monitoring program, which involves a number of samples taken successively when stream levels are rising (events). In about 70 events, and many hundreds of samples, there have been 96 detections, 64 of which have been non-forestry related (MCPA and 2,4-D) and 32 possibly forestry related (including metsulfuron methyl and terbacil, although metsulfuron methyl is used in grain growing and brushweed control and terbacil is also an orchard herbicide). Again, detection levels have been very low, rarely exceeding GLVs. The program has continued and the above numbers relate to monitoring prior to July 2008.

These results are publicly reported, quarterly on the DPIW website, by media statement, and notices to health, water authorities and local councils (Mollison 2006), and are summarised in table form in pdf files.

Such exercises are inevitably very expensive and time consuming. The results to date strongly indicate that any community perception of contamination of streams by pesticides, in particular from forestry operations, is unfounded. Given the results of the water testing, it is difficult to justify the cost involved with water testing for forestry operations.

Chemical weed control in plantations

General considerations and recording

Herbicides are applied only in the first and second season of establishment of plantations. These are products that are fully registered or under APVMA permit for the purpose of weed control in plantation forestry. For the remainder of the rotation (about 30 years for radiata pine and 10–15 years for blue gum) there is no or very little pesticide application. There may be limited applications of insecticides to blue gum or pine, but, for example, one major company has indicated to the author that only about 2% of its (roughly) 100,000ha estate across Victoria, South Australia and Western Australia, annually receives an insecticide application. As noted previously, insecticide expenditure in 2004 was just 1% of the total forestry pesticide expenditure.

Only those products that are registered for the purpose, and/or are registered for aerial application, are used. It is mandatory to observe buffer requirements near permanent streams of 20 metres (m) and 5m for other drainage lines under the label requirements. While site preparation and planting are allowed closer to the drainage lines, chemical application is not permitted.

Under the Agricultural and Veterinary Chemicals Control of Use Regulations, it is required that all users keep records of these operations.

Companies also keep these. Records kept by employees must include all the basic information; that is, what products/chemicals were used, at what rates, how much was used (area), times of application, and weather conditions. Most herbicides specify a 'rain-fast' period of up to a few hours and if there is a forecast for rain, spraying should not take place.

If using drums of liquids, these are required to be triple rinsed and the rinsing added to the spray mix, before possible return under the 'drumMuster' scheme, which is a levied (money) scheme. Otherwise packaging is required to be placed in an authorised landfill.

An important point to note is that professional contractors usually carry out applications of pesticides to plantations. The prescriptions applied are decided by the forestry organisation, and must be within the legal limits, and the products applied must be those registered or allowed for the purpose.

Chemicals used in plantations

For pre-site preparation general weed control, the main herbicides used by organisations growing radiata pine and blue gum include combinations of glyphosate and metsulfuron methyl. These are foliar active herbicides, so are sprayed onto foliage. Glyphosate is exceptionally soil fast, and it is useless applying it to bare soil. Its common (original) name is Roundup.

Metsulfuron methyl does have a short residual period in the soil, but when applied to foliage it is rapidly metabolised (i.e. broken down while it does the weed killing) to harmless by-products (metabolites). Rates vary depending on the site; for example, for second rotation radiata pine sites infested with blackberry and other woody weeds, maximum rates of glyphosate and up to 60 g a.i./ha of metsulfuron methyl may be used.

Metsulfuron methyl is also a cereal grains herbicide used to control broadleaved weeds.

Herbicides may be applied either pre-planting or post-planting, with the former preferred for blue gum and the latter often preferred for radiata pine.

The herbicides used for radiata pine include hexazinone. The use rate in radiata pine establishment is in the range 1.5 kg a.i./ha to 3.8 kg a.i./ha. The high rates are used on second rotation woody weed sites. Hexazinone is soil residual and applied as dry, soil applied granules or sprayed. The granule applications are very accurate, even when applied by helicopter.

Rainfall is necessary to release the herbicide from the granule. Ground based spot and strip treatments with granules are frequently used and reduce the amount of herbicide applied compared to broadcast treatments. However, because hexazinone is very mobile and because spray drift in Victorian legislation includes off-target movement through or over soil, its use by some organizations in sensitive water catchment areas has been discontinued.

Another herbicide used is clopyralid, for wattle control in radiata pine, and thistle, capeweed and other broadleaved weed control in eucalypts.

Clopyralid is also used in grains cropping to control thistles and capeweed, in particular.

The forestry product is a powder supplied in a water soluble plastic bag, as a Water Dispersible Herbicide (WDH), pre-measured on a per hectare application basis. Both dry granular (G & GR) and WDH products have considerable OH & S advantages over liquid products or other solids that have to be measured out before mixing.

As noted earlier, little or no atrazine is used in Victorian pine plantation establishment, although there are both granular and WDH products in combination with hexazinone. In radiata pine, the use rate is usually 4.5 kg a.i./ha.

The herbicides mostly used by the eucalypt growers in Victoria include glyphosate, metsulfuron methyl, simazine, clopyralid, terbacil and sulfometuron methyl. Simazine is the main residual herbicide used. It is fairly soil fast, for example, it is about three times as soil fast as atrazine.

Sulfometuron methyl is a soil residual herbicide, not used in agriculture, but registered for industrial use at rates of 150–600 g a.i./ha. The maximum forestry use rate in a product is 60 g a.i./ha. However, it also is very soluble and mobile in soil.

The sulfonyl urea herbicides sulfometuron methyl and sulfometuron methyl applied at low rates provide effective control of weeds such as sorrel, docks, and clovers, which are not well controlled by glyphosate except at very high rates.

During the establishment of a blue gum plantation on ex-pasture, the site is usually broadcast sprayed before any soil preparation with a mixture of glyphosate and metsulfuron methyl to kill all existing pasture vegetation. The metsulfuron methyl rate is low, usually not more than 10 g a.i./ha. Following mounding, the site is usually treated with a mixture that includes simazine, but if there has been weed germination after mounding, the mix will include glyphosate and often sulfometuron methyl or metsulfuron methyl.

In some cases, the inter-rows are treated without the inclusion of simazine. Clopyralid may be added to the mounding mixture at low rates – about 150-180 g a.i./ha, to give residual control over thistle regeneration and capeweed, which are often the most 'opportunistic' weeds in terms of their rapid regermination.

Another combination of herbicides used for eucalypt establishment is terbacil and sulfometuron methyl. The product used is a WDH in a water soluble 1 kg plastic bag. This is applied at 1 kg/ha (broadcast) or about 0.5 kg/ha or less for mound treatment. 1 kg contains 880 g of terbacil and 40 g of sulfometuron methyl. Terbacil is also a fruit orchard herbicide.

In the second season, amitrole may be used in combination with either or both of simazine and sulfometuron methyl, as a directed spray onto the mounds under the trees. An alternative second season treatment is a terbacil/sulfometuron methyl dry granule, which also has to be activated by rainfall. This has a rate of 30 kg/ha of product if applied broadcast, and contains 1.32 kg of terbacil and 60 g of sulfometuron methyl in 30 kg of granules. It is usually only applied to the rows or even as a spot application of 2 to 3 g to each tree.

There are a few other herbicides that may be applied for a specific weed problem. Metosulam is used in agriculture and in plantation establishment to control wild radish and wild turnip and other brassica weeds. Its use rate is less than 10 g a.i./ha. Oxyfluorfen and pendimethalin may be used in some situations, for example, pendimethalin applied to bare soil is very effective at preventing re-emergence of wireweed and rye grass.

For a complete review of all the herbicides used in plantation forestry the reader is referred to Jenkin & Tomkins (2006).

Conclusion

This document provides factual information concerning chemical use in plantation forestry in the broader context of chemical use through other industries and domestic uses. The author is often asked by various community members to provide similar information, simply because it cannot be expected that the community at large has the necessary chemical knowledge or knowledge of the regulatory environment for chemicals and their use.

Plantation forestry uses registered chemicals in accordance with regulatory requirements, and in accordance with the Code of Practice for Timber Production. The industry is, demonstrably, a small user of agricultural chemicals in comparison with other agricultural or urban industries and even domestic uses. The chemicals used for plantation forestry are the same as those used in many non-forestry applications, and registration of these chemicals for forestry has always followed their introduction for other purposes. Community concerns about the use of agricultural chemicals in plantations should be considered in the broader context of chemical use rather than focusing on a particular industry.

Abbreviations

ABARE	Australian Bureau of Agricultural Resource Economics
ADI	Acceptable Daily Intake
ADWG	Australian Drinking Water Guidelines
a.i	active ingredient
AMA	Australian Medical Association
APVMA	Australian Pesticides and Veterinary Medicines Authority
DPI	Department of Primary Industries (Victoria)
DPIW	Department of Primary Industries and Water (Tas.)
EH&S	Environmental Health and Safety
EPA	Environmental Protection Authority
EU	European Union
G or GR	Granular
GLV	Guideline Value
HLV	Health Level Value
IARC	International Agency for Research on Cancer
ISO	International Standards Organisation
MSDS	Material Safety Data Sheet
NHMRC	National Health and Medical Research Council
NOAEL	No Observable Adverse Effect Level
OH&S	Occupational Health and Safety
SAP	Scientific Advisory Panel
ppb	parts per billion (microgram/kilogram or /litre)
ppm	parts per million (milligram/kilogram or /litre)
ppt	parts per trillion (nanogram/kilogram or /litre)
USA	United States of America
WDH	Water Dispersible Herbicide

References

Barr, N. (2005). The Changing Social Landscape of Rural Victoria. Department of Primary Industries, Bendigo.

Cameron, J. N., Meynink, R., and Crawford, H. 2004. Regulation of Private Forestry in Victoria. A report prepared for the Private Forestry Council, Victoria by MBC Consulting. 71 pp.

Eldridgea, J.C, Wetzel, L.T., Tyrey, L. 1999. Estrous cycle patterns of Sprague–Dawley rats during acute and chronic atrazine administration. Reproductive Toxicology Volume 13 Issue 6.

Flinn, D.W. and Fagg, P.C. 1984. Review of weed control practices in radiata pine plantations in Australia. Proc. 7th Aust. Weeds Conference, Vol. 1, Perth W.A. Sept. 1984. Pp 220-232.

Hayes, T.B. 2002 — see: e.g. www.mindfully.org/Pesticide/2002/Frogs-Deformed-Atrazine-Hayes31oct02.htm

Jenkin, B. and Tomkins, B. 2006. The use of chemical pesticides by the Australian plantation forest industry. Australian Government. Forest and Wood Products Research and Development Corporation. 183 pp.

www.fwpa.com.au/content/pdfs/new%20pdfs/FWPRDCPN06.4016_fullreport.pdf

Jenkin, B. 2006. Useage patterns of chemical pesticides by Australian plantation industries. Presentation at the 4th Plantation Pest Control Seminar, Mt Gambier, 28 February to 2 March, 2006.

Keenan, Rodney J., Gerrand, Adam, Nambiar, Sadanandan and Parsons, Mark. 2006. 'Plantations and Water: Plantation Impacts on Stream Flow'. Science for Decision Makers. Australian Government, Bureau of Rural Sciences, Department of Agriculture, Fisheries and Forestry.

Mollison, J. 2006. Pesticides and water quality issues in Tasmania. Presentation at the 4th Plantation Pest Control Seminar, Mt Gambier, 28 February to 2 March, 2006.

Parsons, M., Gavran, M and Davidson, J. (2006). Australia's plantations 2006. National Forest Inventory, Bureau of Rural Sciences, Canberra.

Petheram, J., Patterson, A., Williams, K., Jenkin, B., & Nettle, R. (2000). *Socioeconomic impact of changing land use in South West Victoria*. Institute of Land and Food Resources, University of Melbourne, Melbourne — see: www.gtplantations.org/publications

Schirmer, J., Parsons, M., Charalambou, C., and Gavran, M. 2005.
a. Socio-economic impacts of plantation forestry in the Great Southern region of WA.
b. Socio-economic impacts of plantation forestry in the South West slopes of NSW.

Reports produced for FWPRDC Project PN04.4007 (Australian Government, Forests and Wood Products Research and Development Corporation — see: http://www.fwpa.com.au/content/pdfs/PN04.4007%20WA.pdf

Schirmer, J., Williams, K., and Dunn, C. (2008). *Preliminary summary of findings of the Land Use Change project*. Report prepared for the *Socio-economic impacts of land use change in the Green Triangle and Central Victoria project*, Cooperative Research Centre for Forestry — see: http://www.landusechange.net.au/downloads/Land-use change_summaryreport.pdf

Turner, John, Wareing, Kevin, Flinn, David and Lambert, Marcia. 2004. Forestry in the Agricultural Landscape. A Review of the Science of Plantation Forestry in Victoria. 56 pp.

Acknowledgements

The author thanks David Fisken, Dr Glen Kile and Les Toohey for their constructive comments during the preparation of this paper.

The Central Victorian Farm Plantations Committee (CVFP) is an incorporated, regionally based and multi-stakeholder organisation operating as a Private Forestry Development Committee (PFDC).

CVFP is committed to supporting the development of private forestry in the region in a way which delivers significant environmental, social, agricultural and economic benefits to the community, landholders, as well as forest owners and investors.

The CVFP region incorporates that part of Victoria west of Geelong and Melbourne, and east of the Green Triangle region of south west Victoria.

CVFP was established in 1996, and as with other PFDCs, it received funding from the Commonwealth and the State Government to assist the implementation of various government plantation and farm forestry strategies. Following the cessation of government funding at the end of 2007/2008, CVFP has continued to operate from its own resources including sponsorship and membership subscriptions.

Since its inception CVFP has undertaken many projects designed to support the development of private forestry of all types within the region, and to assist the community better understand the implications of this development.

CVFP is pleased to publish this occasional paper by Dr Barry Tomkins, as part of the committee's role of providing information on the benefits and impacts of plantation forestry as a responsible and sustainable land use.