Soil and land pollution

Environmental indicators reported on in this section as originally listed and defined in Hamblin (1998):

Environmental indicator	
L6.1	Total immobile contaminant load on land area by catchment
L6.4	Condition of environments surrounding high-radiation sites
L6.5	Quality of mining operations relative to total mine sites, and regulation requirements by drainage basin
L6.6	Estimated area of pesticide application by catchment
L6.7	Rate of violations in residue levels (metals and organics) in harvested rural produce and foodstuffs
L6.11	Implementation of integrated pest management (IPM) and agrichemical risk reduction by rural industry

Small, localised pollution of ecosystems has occurred from mining activities for millennia in the form of spoil heaps, slag and localised vegetation changes. The great change in the 20th century came from the massive expansion in industrial, urban and high-input agricultural activities that were reliant on advanced technologies. However, the extent of this impact, the need for regulatory controls, and the consequent high cost of cleaning up the most contaminated sites have only slowly been accepted in western countries.

Australia instituted a Commonwealth Environmental Protection Agency in 1992. The CEPA was incorporated into Environment Australia in 1995. Australia's States and Territories established separate Environmental Protection Agencies from 1970 to the 1990s (Table 33).

Table 33: Environmental legislation by jurisdiction.

State or territory agencies	Key environment Acts affecting land
ACT Environmental Management Authority (established 1997)	*Environmental Protection Act 1997* *Environmental Protection Operations Act 1997*
New South Wales EPA (established 1992)	*Protection of the Environment Establishment Act 1992* *Waste Minimisation and Management Act 1995* *Protection of the Environment Operations Act 1997* *Contaminated Land Management Act 1997* *Environment Trust Act 1998* *Pesticides Act 1999* 14 other pieces of existing legislation
Northern Territory No separate EPA. Department of Lands, Planning and Environment administers Acts.	*Environmental Assessment Act 1996* *National Environmental Protection Council (NT) Act* *Uranium Mining Environment Control Act* and *Mine Management Act* regulate radioactive mineral mining
Queensland EPA (established 1999)	*Environmental Protection Act 1994* *Nature Conservation Act 1992* *Coastal Protection and Management Act 1995* *Queensland Heritage Act 1992* 20 other pieces of existing legislation
South Australia EPA (established 1993)	*Environmental Protection Act 1993* *Environment Protection (Burning, Waste Management, Milking Shed Effluent, Marine) Policy Acts 1994* *Coast Protection Act 1972*
Tasmania No separate EPA. State of the Environment reports under Department of Environment and Land Management	*Environmental Management and Pollution Control Act 1994* *Environmental Management Amendment Act 2000* *State Policy and Projects Act 1993* *Land Use and Planning Approvals Act 1993*
Victoria EPA (established 1970)	*Environment Protection Act 1970*, revised 1996 to incorporate 25 other pieces of existing legislation dealing with control of pollution on land, water, air and noise
Western Australia EPA (established 1986)	*Environmental Protection Act 1986* Environmental protection policies have been separately developed under this omnibus Act

Other major National initiatives in managing waste, and protecting all environments from the effects of anthropogenic pollution have occurred very recently. These include:

- *Agricultural and Veterinary Chemicals (Administration) Act 1992* and subsequent establishment of the National Registration Authority for Agricultural and Veterinary Chemicals in 1993,
- the National Strategy for the Management of Scheduled Waste in 1994,
- the National Strategy for the Management of Agricultural and Veterinary Chemicals in 1998,
- the Australian Minerals Industry Code for Environmental Management in 1996, revised in 2000,
- the establishment of the National Pollutant Inventory in 1998, and
- setting up of a working group to developed a national pesticides database in 1999.

Some of these initiatives have become operational, and have progressed from planning to action; others remain more as an acceptance of principle rather than implemented in fact. The degree to which governments have been able to engage and cooperate with industry sectors has varied (see later sections).

PRESSURE

Total immobile contaminant loads across major regions [L Indicator 6.1]

The total contaminant load occurring across different types of land use and industry activity in Australia is not known. The total number of sites was estimated at 80 000 (NEPC 1999a) with 30 000 each in NSW and Victoria. Despite their relatively small areas, even Tasmania and the ACT were estimated to contain 500 sites each. For more detail see the Human Settlements Theme Report. These are relatively small figures compared with the 1.5 million highly contaminated sites identified in the USA, but nevertheless represent a significant potential hazard to health and the environment (Naidu et al. 1998). While currently operating installations are increasingly regulated and monitored (see Box: 'Scheduled wastes'), the safe management of closed and abandoned sites is a significant environmental challenge. Such sites include agricultural dip-sites where arsenic and organochlorine products were used, old metal smelting sites (especially copper and lead), and 'orphan sites', under disputed ownership in cities, such as closed tips, gas plants, garages, and power stations where buried hydrocarbons (in tanks) and heavy metals occur.

Contaminants can be classified in various ways. The National Pollutant Inventory classifies by chemical substance, industry, emission destination (air, water, land) and location. Amounts of emissions are being measured at 1200 sites for 23 of the categories of industry out of a total 90 categories of industry that will eventually be monitored. During the past two years, standard protocols for monitoring and reporting have been developed for 78 industry handbooks, including the 23 that are currently contributing emissions data. To date the inventory has excluded all dispersed contaminant loads, such as those that occur through extensive aerial application in agriculture and forestry, and small-scale emitters of industrial wastes.

Table 34: Summary of National Pollutant Inventory categories.

Chemical type (substance)	Industry (facility)[A]	Location
Heavy metals	Petroleum industry	Catchment/air shed
Hydrocarbons	Mineral mining	National
Mineral salts	Mineral smelting	State or Territory
Particulates	Petrochemicals	Local government
Oxides of N, S, C	Chemical manufacture	Town
Organic acids, ketones	Manufacturing (paints)	
	Manufacturing (metals)	
	Processing (food, fibre)	
	Processing (pulp, paper)	

[A] 23 of 80 listed to date.

Source: Environment Australia (2001).

Scheduled wastes

Scheduled wastes are wastes that are:

- organic in nature,
- resistant to degradation by chemical, physical or biological means,
- toxic to humans, vegetation or aquatic life; accumulate in humans, flora and fauna and are likely to be carcinogenic or mutagenic,
- intractable or impossible to dispose of without specialised facilities or technologies.

Those prescribed are:

- hexachlorobenzene, produced from the production of carbon tetrachloride by ICI at Botany Bay, NSW,
- polychlorinated biphenyls (PCBs), used as coolants in electrical equipment,
- organochlorine pesticides (OCs): 18 compounds including DDT and dieldrin,
- other chlorinated hydrocarbons.

Use of these chemicals is now banned, or being phased out, but the disposal of current stocks and wastes will be an on-going issue for some time. A national approach to their disposal has been developed in stages, as part of the Australian and New Zealand Environment and Conservation Council's (ANZECC) National Strategy for the Management of Scheduled Waste. One example is ChemCollect, which is a nationally coordinated, free collection scheme to ensure that unwanted and de-registered agricultural and veterinary chemicals, particularly organo-chlorines and phosphates, are safely collected from rural areas and destroyed in a socially and environmentally acceptable manner. ChemCollect is a three-year program undertaken by states, with funding shared between states and commonwealth. It is estimated that ChemCollect will result in the safe disposal of up to 1300 tonnes of hazardous chemicals.

To ensure stocks do not build up again after the program is completed, the agricultural industries have agreed to institute ChemClear, an ongoing program of regular collections of unused, registered farm chemicals which are otherwise non-returnable. Another program to reduce waste in the agricultural sector is drumMUSTER (see later in this section; also http://www.ea.gov.au/industry/chemicals/swm/review.html).

The database is set up so that information on the chemistry of substances, methods used to obtain the emissions data for each substance, and organisation and company details are reported publicly. The database will in time become an invaluable resource for environmental and human health assessment.

Implications

The past five years has been one of substantial government activity in introducing a coordinated regulatory framework in all jurisdictions for the management of pollutants and contaminants that may be hazardous either to human health or the environment. It is too early to say whether this regulatory and monitoring activity is as yet being translated into a reduction in contaminant pressure on the environment. What is now possible is to get a balanced and comprehensive view of where the major point source pressures exist. The diffuse source pressures are less well defined, but are most likely to be associated with rural activities.

CONDITION

What is the condition surrounding current mining and mineral processing sites? [L Indicator 6.4 and 6.5]

Australia earns much more from minerals and energy exports than from rural products (A$38 billion and A$24billion respectively in 1999–2000), yet the area of land affected by the whole energy and mineral sector is tiny by comparison. However, some types of mining operation can have a large effect beyond the mine site itself. The mining industry has made vigorous efforts to manage operations to high environmental standards, in collaboration with government agencies.

About 375 companies have mining operations across Australia, of which about 50 produce nearly 90% of the mineral value. State and Territory EPAs and mines departments regulate all mining. The Australian Minerals and Energy Environment Foundation, created in 1991, and funded through combined company and government sponsorship, provides a wide range of information, conferences, scholarships and awards to stimulate best practice community consultation; ecological components; planning; rehabilitation; and noise, dust, tailings, waste and water management. Its activities, and those of CSIRO, ANSTO, and other specialised research centres, assist companies to improve their environmental management, site design, monitoring, safety and rehabilitation after mining operations cease.

The 1996 Code of Environmental Management, updated as Code 2000

In 1996 the Australian Minerals Council developed an environmental management code aimed at changing values and behaviour in the industry. Signatories accept environmental responsibility, integrate environmental management with all operations, and minimise environmental impacts. The revised code now commits companies to producing an annual public environmental report, progressively implementing all features of the code wherever they practice, and verify the results with an accredited auditor every three years.

By May 2000, 50 companies, representing over 85% of the minerals industry, had signed the Australian Minerals Industry Code of Environmental Management; of these, 34 have produced a first report.

Mine condition and management

The following case studies illustrate how the mining industry deals with a range of environmental issues.

Acid drainage

Acid drainage is one of the most technically challenging problems facing the mining industry. It occurs as a consequence of the oxidation of sulphide minerals and subsequent leaching by rainfall and transport in drainage waters. The most threatening situations occur where acid drainage dissolves and incorporates other minerals, such as heavy metals, including radioactive ones. Whenever new sulfide-rich minerals and coal deposits are mined, the potential risk of acid drainage is high. Some of the highest impacts in the past have come from abandoned mines at Rum Jungle (NT), Captains Flat (NSW) and Mt Morgan (Queensland), and the still operational mine at Mt Lyell (Tasmania). Remedial action at such sites has substantially reduced their impact and has overcome most of these problems.

An example of an operating mine dealing with this problem is the Gregory open cut (strip) coal mine in the Bowen Basin, central Queensland. From the first exploration of the site in the late 1970s, it was recognised that acid drainage would be a problem, and the mine was designed to minimise acid generation and impact.

All wastes are managed to reduce their potential to generate acid drainage. The fine wastes from coal washing, tailings, are deposited as a slurry, under water, with the water recovered and reused in coal washing, after neutralising with lime. Coarse waste products are returned to mine pits, which are then covered with spoil. This negates the need for special reject dumps and their subsequent rehabilitation. Selective handling is used to locate and place

Norwich Park mine in the Bowen Basin.

Note: Topsoil removed prior to mining is spread over mined land. This view shows stockpiles of topsoil, with good grass and shrub growth after rehabilitation in the foreground.

Source: BHP.

pyrite layers into deep parts of the mine, which are then covered in spoil before revegetation is undertaken. All drainage is captured and reused, because of the potential threat of acid drainage occurring in any water used.

Dealing with cyanide

Telfer Gold Mine is located 485 km south-east of Port Hedland in the north of Western Australia, in the Great Sandy Desert. The mine produces 5 million ounces of gold per year. It uses the ‘carbon-in-leach’ process that extracts gold with cyanide, after concentrating the sulfide ore by flotation. Risk analysis demonstrated potential for ground water pollution and, faunal deaths. This could occur from bursting pipes, and leakage of tailings storage. Consequently the leach pads are constructed on an impermeable base, and any potential leakage is monitored by 20 surrounding bores. All ponds, dumps and pads are designed to take a 1-in-50-year rainfall event. A supplementary retention pond has been constructed to cover extreme events. No cyanide has been detected in any bore over 12 years of monitoring.

Rehabilitation after mining mineral sands

Eneabba Mineral Sands mine is 300 km north of Perth, and is a surface strip mine extracting titanium and rutile by wet dredging. A total of 1200 ha has been rehabilitated to the original low heathland vegetation, which contains very high numbers of species endemic to WA.

A full botanical survey is carried out before mining, and seeds collected. Topsoil is stripped and placed in properly sequenced layers where it is stockpiled. Rehabilitation of earthworks recreates the subsoil surface, and topsoil is then replaced and mulched and a cover crop is sown with native seeds incorporated. The cover crop protects germinating seedlings. Many seeds are recalcitrant propagators, and require special pre-treatment, such as exposure to smoke from burning bush, or firing in mulch. Research has been undertaken to assist propagation of the full range of original species.

Radiation sites

Radiation is an issue for uranium mines and some mineral sands mines that extract minerals such as monozite and zircon. There are three mines in Australia that currently mine uranium. The longest established are Ranger mine in the Northern Territory, surrounded by Kakadu National Park; and Olympic Dam, in arid pastoral country in the north of South Australia. The Commonwealth’s Office of the Supervising Scientist was established to supervise the environmental aspects of uranium mining in the Alligator Rivers region that includes Ranger. Ranger is also subject to regulation by the Northern Territory Government whilst Olympic Dam is regulated by South Australian government agencies. In addition the Australian Radiation Protection and Nuclear Safety Authority (ARPANSA) issues licences to operate and is responsible for guidelines on human health issues in association with the NHMRC. As with other mine sites, monitoring of the sites for acid drainage is carried out regularly. Current operations are carried out to very strict standards, but former operations have left legacies of environmental contamination. For example at Rum Jungle, after mine closure in 1961, a combination of both tailings and acid mine drainage waters to the Finniss River impacted on the downstream environment for about 16 kilometres. During the mid-1980s an extensive rehabilitation program relocated tailings and waste materials to secure containments, including a former open cut. Other work included capping of waste rock stockpiles, and revegetation of the site. The Finniss River downstream of the mine has recovered well.

Ranger

The Ranger mine site extends over approximately 6 km^2 and includes extensive waste rock dumps, low-grade ore stockpiles and a 1 km^2 tailings dam. Rainfall runoff, which may not meet water quality criteria for direct release, is directed into retention ponds designed to accommodate the very high rainfall in the wet season. Some of the better quality wastewater is used to irrigate vegetation around the mine site in the dry season. The composition of the water is monitored regularly and a comprehensive monitoring program checks the quality of both ground and surface water, as well as atmosphere, soil and vegetation around the site. Since 1997, tailings have been deposited in the worked-out Pit 1 rather than the tailings dam, which is now used as an evaporation pond. When the site is rehabilitated, all the tailings in the tailings dam will be returned to the pit that will then be capped and revegetated.

Operations at Olympic Dam, a modern and sophisticated complex of mining, processing and rehabilitation activity.

Source: Western Mining Corporation Ltd.

Olympic Dam

This mine is the largest in Australia. It is an underground mine, with over 200 km of shafts and tunnels. The principal metals extracted are copper and uranium oxide concentrate, with smaller amounts of gold and silver. The acid tailings are pumped out into sealed settling ponds, which presently cover 380 ha. Workers at Olympic Dam metallurgical processing plant and mine are located in the purpose-built township of Roxby Downs, which is 16 km south of the Olympic Dam operations, and has a population of about 4500. The mine site is open to tourists and environmental officers work with local community members on a range of ecosystem management issues. The company, WMC, is a signatory to the Australian Minerals Industry Code, and has recently completed an ambitious expansion plan that required stringent environmental impact assessment. This expansion more than doubled the production of copper from 85 000 to 200 000 tonnes of copper per annum, with associated increase in the other metals produced.

When mine shafts are exhausted they are filled with cemented waste rock (mullock) and other waste products to reduce the amount of above ground materials. One of the main pressures on the environment comes from the use of artesian water to run the operation and supply the township. However, from a total of 425 ML/day of water entering the South Australian part of the Great Artesian Basin, Olympic Dam and Roxby Downs use about 32 ML/day, compared with pastoral bore usage of 110 ML/day.

Tailings disposal areas are a potential hazard at any time, and on the scale of this operation they need very high engineering standards. The tailings waste streams and tailings liquor evaporation systems are designed in a closed loop and conservatively engineered to minimise the possibility of failure. Such structural failures have occurred in other countries and companies. The tailings liquor evaporation pond system is designed so that there is no discharge of water from the mine site. The environmental plan requires reporting of all spillages. In 1999–2000 there were no toxic spills or radioactive leakages, but a few saline water and hydrocarbon spills occurred.

Chemical analysis of the emissions from all operations at Olympic Dam are now posted in the National Pollutant Inventory (http://www.npi.gov.au) and on WMC's website (http://www.wmc.com/sustain/environ/npi/coppertable_npi.html).

Implications

Australia's low level of population density, lack of past industrial economy, and highly urbanised population distribution mean that we have little of the types of highly toxic waste disposal problems of other OECD countries, and very large tracts of land that have had very little anthropogenic input. However, there are still many contaminated sites, including some, such as the Olympic site in Sydney, in populated areas. This issue is covered more fully in the Human Settlements Theme Report.

Table 35: Emission estimates for solid and liquid wastes from Olympic Dam, 1998–1999.

Substance	NPI emission estimates (t/year)	Main sources
Arsenic and compounds	67	waste stream
Chromium and compounds	0.017	waste stream
Particulate matter	98	combustion, stockpiles, vehicle emissions, ventilation
Polycyclic aromatic hydrocarbons	5.5	diluent usage (process chemicals)
Sulfuric acid	979	waste stream (process chemicals)

The mining and mineral processing industries are highly organised in their approach to environmental (and safety) management. As with petrochemical and industrial chemical industries this is critical from an occupational health and safety aspect, because of the potential dangers in their activities. However, these industries have also found that being good environmental corporate citizens pays, in terms of public relations and cost savings (in operational and restoration expenditure). The cohesiveness of the industries and their commercial focus have made it easier for them to address such issues than is the case for some rural industry sectors.

Land as a receiving environment

Land is used for disposing of a range of domestic and industrial waste. This is dealt with in the Human Settlements Theme Report.

How much agricultural pesticide goes where? [L Indicator 6.6]

Government responsibility for decisions on agricultural chemical use and practices is split between a number of bodies. The National Registration Authority is responsible for registration of chemicals, while state and territory agencies are responsible for actual control over use. Inter-governmental agreement on standards and policies are overseen by the Agriculture and Resource Management Council of Australia and New Zealand (ARMCANZ). This body has developed a National Strategy for the management of agricultural and veterinary chemicals (ARMCANZ 1998) with the goal of developing best practice management for ecologically sustainable and socially acceptable food and fibre production in the use of agrichemicals. However, the monitoring and assessment of practices is not supported either by legislation or by government funding at present.

Information on agricultural and veterinary chemical usage is not collected on a regular, formal basis across Australia. Herbicides, insecticides, fungicides and a range of animal parasiticides have been routinely used in Australian farming systems for between 20 and 40 years, but often in lower frequencies than in many other countries. Large parts of the grazing lands have not been subjected to any regular spraying, and would be able to make a valid case for being considered ‘pesticide-free’ if monitoring and reporting were systematically undertaken. The value of such a program has been well demonstrated by the National Residue Survey (see page 117 for details on assessing residues in agricultural commodities).

All forms of pesticide use have increased over the past two decades (see Figure 71). Herbicides form by far the greatest part of the total cost, and are most widely applied, but pose much lower environmental or human health risks in most situations than do insecticides (see Table 36 (page 117) and Box: PIRI (page 121)). Herbicides, insecticides and fungicides (plus growth regulants) applied to crops and pastures account for 65% of the total expenditure on agricultural and veterinary chemicals, and animal products (endo- and exo-anthelmintics to control animal parasites, and veterinary products) account for the remaining 35% (Avcare pers. comm.).

Although agriculture is without doubt the largest user of pesticides, significant quantities of herbicides are also used by local councils and road and rail authorities for weed control. ABARE has recently mapped the expenditure on agrichemicals and livestock veterinary materials by farm type, which shows some striking differences among broadacre farming regions, as well as the much larger expenditure on cotton and sugar farms in localised districts. In these districts, and in the grain belt of south-west Western Australia, central and southern Queensland and north-east New South Wales, total expenditure on

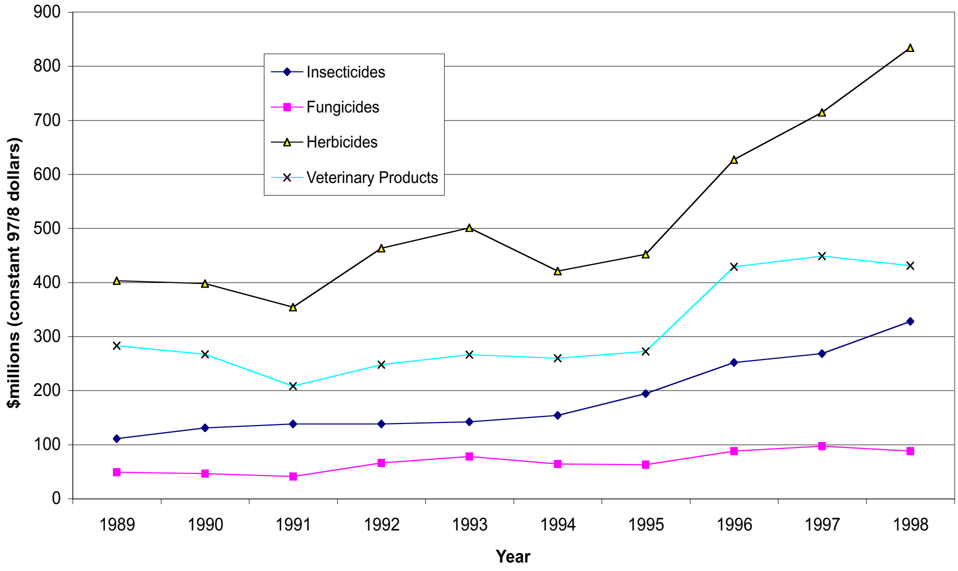

Figure 71: Total pesticide expenditure on herbicides, insecticides, fungicides/plant growth regulants, 1987–1997.

Source: ABARE (unpublished data).

crop chemicals was estimated at over $50 000 in 1998–99. In contrast, the expenditure in the rest of the mixed farming regions ranges from $5000 to $30 000. In the rangelands and high rainfall grazing districts the expenditure on farm chemicals is under $2000, but livestock chemicals (drenches and veterinary products) range from $3000 to $5000 in additional costs. This work did not include expenditure on horticultural farms, which would increase the total expenditure in irrigated regions of the Murray–Darling Basin, eastern Tasmania, and the east coast regions of the Sydney Basin and wet tropic coast of Queensland. Nevertheless the intensive irrigation and rain-fed cropping regions can be clearly distinguished from both the higher and lower rainfall grazing areas, where expenditure is less than $5000 per farm.

Some industries, notably the wine industry, some orchardists, sugarcane and cotton growers, and some beef producers, have developed self-monitoring systems in recent years as part of their need to satisfy stringent environment and safety standards for certain market outlets. Avcare Ltd has been a catalyst to encouraging good stewardship in agricultural use of chemicals. Some rural industries, local government councils and transport authorities, however, are not so well organised. Demonstrating responsible pesticide management remains an ad hoc and patchy activity, requiring leadership from stakeholders to overcome this.

At present, there are no data available on the proportion of agricultural and veterinary chemical expenditure attributable to local government, transport authorities and conservation agencies.

At the time of writing, the proposed database, to be set up under a joint body of Standing Committee on Environmental Protection (SCEP) and Standing Committee on Agriculture and Resource Management (SCARM) has not received expected funding support, nor have all the consulted stakeholders agreed to it. A feasibility study has been undertaken to identify methods for obtaining estimates on a national and/or catchment scale, and concluded that a national scale was feasible with regular repeats every two years. Catchment scale databases would be much more expensive. The Bureau of Rural Resources is currently undertaking a pilot study of such a database.

Implications

The dollar value is too crude a measure to be able to assess the impact of pesticides on the environment. While the value continues to increase this should not be construed as an ever-increasing pressure, since many older, cheaper chemicals were less specific in their target action, and were used widely simply because they were cheap (when out of patent protection). Similarly, to replace a dollar indicator with weights or volumes of active ingredient will not provide adequate information on the environmental impact of agricultural chemicals, as the examples of two widely used products, one a herbicide and one an insecticide show (see Box: ‘Herbicides and insecticides are not the same’).

Herbicides and insecticides are not the same

The word 'pesticide' is often used very broadly to describe any agricultural chemical, but among the thousands of chemicals produced, groups of compounds differ, designed for different purposes. A very widely used example of a herbicide and an insecticide are described below to demonstrate the differences in two such groups.

Glyphosate (Roundup®)—a herbicide

Glyphosate is a broad-spectrum, non-selective herbicide that is used as a 'knock-down' spray. Knock-down herbicides are the basis of 'direct-drill' (and no-till) systems of crop production which are practised across 5–10 million hectares per year.

Glyphosate kills virtually all annual and perennial plants, but has very low toxicity to other life forms, is adsorbed on soil and then safely metabolised by soil organisms. It was the subject of a special review by the National Registration Authority in 1996 because of reports from Western Australia of toxic effects on frogs and tadpoles. The review found that certain surfactants used in some glyphosate formulations are acutely toxic to tadpoles, but the active ingredient was not harmful. Seventy-five registered products were assessed, and the NRA has redefined the surfactant formulations for products that will be used near drains, channels, dam margins etc.

Glyphosate is regarded as a vitally needed herbicide to control aquatic weeds (eg salvinia, and *Mimosa pigra*) which threaten many waterways. It is used by many government agencies in controlling weeds of national significance.

Endosulfan—an insecticide

Endosulfan ($C_6H_6Cl_6O_3S$) is an organochlorine insecticide that has been used in Australia for over 30 years. In 1999, the NRA undertook a very comprehensive review of it. It has many attributes that make it very valuable to agricultural crops that suffer from sucking, boring and chewing insects, especially cotton, stone and pome fruit, vegetables, cereals, lupins, peanuts, sunflowers, pastures and tree crops.

Other organo-chlorine insecticides (dieldrin, chlordane, aldrin etc) have been withdrawn from use. Endosulfan has a different chemistry, with low toxicity to beneficial insects and no evidence of long-term health effects on people. However, although it volatilises from soil in 1–2 days, and is totally dispersed by 3–6 months, runoff and soil erosion can transport particles containing endosulfan into streams and other water bodies.

The most serious consequences of endosulfan are to aquatic life forms. It is acutely toxic to fish at very low concentrations (<1µg/L), and many other life forms are sensitive at concentrations that can occur when heavy rains and high water flows bring endosulfan into water with large quantities of soil.

The review concluded that endosulfan should not be withdrawn from use in those industries where its removal would only lead to the substitution of other insecticides that would be likely to have more harmful effects.

However, the review has not closed, and the NRA has regulated a number of changes to the registered use and operational constraints on use of endosulfan in the cotton industry. These include no more than three sprays per season; notification of neighbours; and, from 1999 onward, only spraying between November and January.

For further information see NRA's website: http://www.nra.gov.au

Pesticide contamination of surface and groundwater

While open water presents an immediate problem to health and aquatic organisms, groundwater contamination will persist for very long periods, and may affect future generations as well as current users.

The pathway depends on the degree to which the chemical is inactivated in soil by undergoing a chemical transformation such as hydrolysis or sorption, or whether it combines with organic matter and clay in forms where the activity is not altered. In this case the pesticide will still affect sensitive organisms, even though now adhering to particles that can be transported by overland flow or through preferred pathways in the soil profile (Kennedy et al. 1995).

Surface water contamination

Certain chemicals, such as atrazine and endosulfan, are regularly found in catchments where pesticides are applied to bare-soil cropping systems, as the result of runoff events that occur unexpectedly shortly after spraying. The problems are worst for summer-grown crops in regions of summer-dominant rainfall and irrigation (National Symposium on Pesticide Management in Catchments 1998, LWRRDC/CRDC/MDBC 1997).

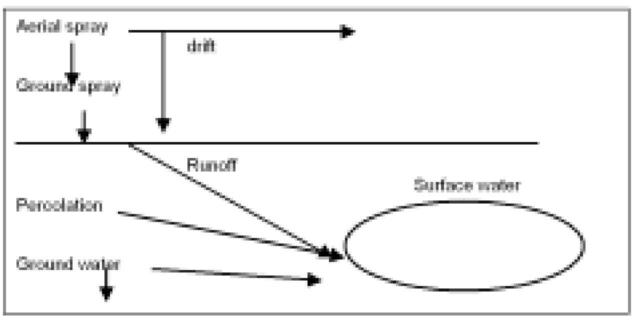

Figure 72: **Off-target pathways of agricultural pesticides.**

If high intensity storms occur at a time when there is bare soil in irrigated paddocks, it is impossible to prevent substantial erosion and runoff. This is therefore a particular problem in irrigated cotton and vegetable production systems in the north-eastern tributaries of the Darling River, such as the McIntyre, Gwydir, Namoi, Macquarie, Bowen, Condamine, and Balonne. In these catchments there has been an increase in the number of chemicals detected in water at monitoring sites since 1995, following the end of the severe drought of the early 1990s and the expansion in cotton planting. However, the levels of endosulfan detected in water have been decreasing since the early 1990s, as education on management and regulatory control of this important but dangerous chemical has improved (Spence and Titmarsh 1998).

In most other farming systems conservation tillage (maintaining a trash cover) and 'chemical fallowing' in inter-row areas of orchards and vineyards used to maintain a surface cover reduces the risk of erosion. The extent to which this is achieved depends on the degree to which cover retention is seen as a high priority. Recent survey estimates are about 30% of broadacre crop land has stubble cover after planting (ABARE 2000), and grazed pastures maintain over 80% cover except in drought seasons, when the cover level may drop to less than 30%.

Groundwater contamination

Detailed investigations of groundwater quality have been undertaken by Commonwealth and State agencies in selected key aquifers from 1990 to the present, under the Australian Groundwater Quality Assessment Project (Bureau of Rural Sciences 1997, 1998, 1999, 2000). Groundwater provides 20% of the nation's total water requirements, but this rises to 100% in some remote mining settlements. This project is of great importance in providing baseline information on the status of groundwater, both in terms of natural contaminants that occur as the result of hydro-geological processes, and as a record of pollutants that can only have arisen as the result of inappropriate anthropogenic activities. Groundwater that underlies populated areas is frequently used for domestic and town water supplies, and for irrigation. However, it may become contaminated by agricultural and industrial activities with far-reaching effects on whole communities, if aquifer water quality is not monitored.

Figure 73 summarises the extensive data that has been published from nearly 300 bores and many thousands of analyses in these aquifers to date. The most important conclusion that comes from this work is that any contamination by pesticides is very low in nearly all bores, and the most frequent occurrences are s-triazine type herbicides, which have a very low ability to bind with soil, but also a short half-life. While the Australian Drinking Water Guidelines state that drinking water should contain no pesticide, the record to date is satisfactory (NHMRC/ARMCANZ 1996). Of the low percentage of exceedances found, nearly all are at very low concentrations, well below any concentration with environmental or health concern. Three of the aquifers have no detectable pesticides.

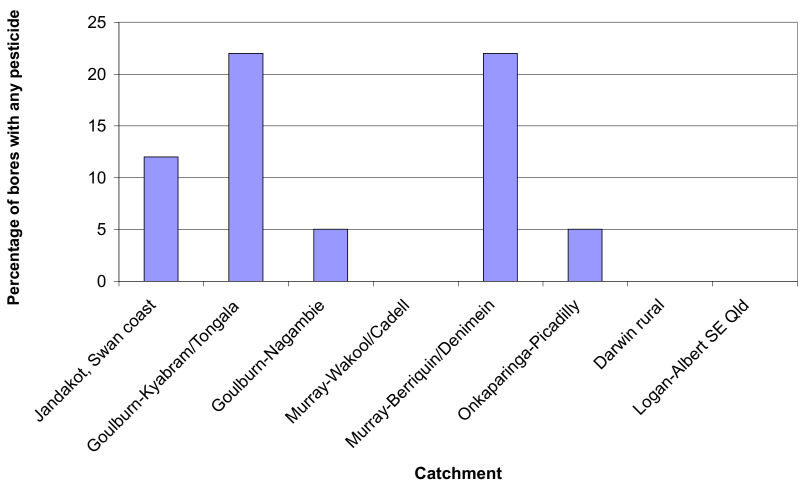

Figure 73: Proportion of all bores in surveyed aquifers that have any detectable pesticide.

Sources: (Bureau of Rural Sciences 1997, 1998, 1999, 2000).

Residues in foods: what is the record? [L Indicator 6.7]

In 1961, the Australian government established a program to monitor the presence of residues in certain agricultural and veterinary chemicals in meat products. Since then the National Residue Survey (NRS) has expanded and now undertakes testing on a large number of residues and contaminants in a range of animal and plant food commodities. By 1999, 16 animal, 14 plant and selected fishery and aquaculture products were being monitored on a regular basis (Table 36). These monitoring and surveillance programs are funded by industry, and are primarily aimed at providing information for trade, not for environmental or health purposes. Frequent audit by major trade partners assures the quality and accuracy of the NRS programs and their data are therefore available as a surrogate measure of chemical residues that could be transmitted through food chain to organisms other than humans.

Residues and contaminant levels in agricultural products do not necessarily reflect the absence or level of residues that may be in soil, native biota or in water, because of diverse spatial distribution and management practices of agricultural and fisheries production. In addition the complexity of many of the metabolic pathways involved can impact on the temporal presence of the chemicals and their breakdown products. However, the continuity of the record, the scale of monitoring, and the number of products and compounds tested make the NRS data an indirect environmental indicator, in the absence of direct monitoring programs of off-target environments, such as soil, native fauna and flora, and water. Ideally a national environmental monitoring program is needed with a database that can provide evidence of the degree and extent of environmental impact from agrichemical usage.

Selected food commodities are analysed for a large number of possible contaminants as appropriate (Table 36).

Table 36: Chemicals tested by the National Residue Survey.[A]

Animals	Plants	Honey
Hormones (4)	Organochlorines (5–10)	Organochlorines (16)
[beta]-agonists (3–6)	Organophosphates (6)	Organophosphates (11)
Androgens (3)	Growth regulators (1–5)	Synthetic pyrethroids (9)
Organochlorines (4–14)	Synthetic pyrethroids (6)	Heavy metals (5)
Organophosphates (3–14)	Carbamates (1–4)	
Synthetic pyrethroids (7)	Preharvest fungicides (2–15)	
Benzoyl ureas (4)	Postharvest fungicides (6)	
Heavy metals (7)	Heavy metals (3)	
Antibiotics (15)	Scald inhibitors (2)	
Anthelmintics (12)		

[A] Numbers in parentheses refer to the number of chemicals tested in each category.

NRS results reported against maximum residue levels (MRLs) for agricultural and veterinary chemicals and maximum permitted concentrations (MPCs) for metals and contaminants established in the Australian Food Standards Code show very few detectable levels against those permitted.

The NRS has continued to monitor meat samples for organochlorines, such as DDT and dieldrin, that have been withdrawn for more than a decade, but which have long-lived persistence and derivatives in the environment. The program also monitors meat samples from wild animal meats, derived from a wide range of farming, rangeland and forested environments as well as animals from more intensive agricultural areas. Over the period 1994–1999, these tests have included water buffalo (360 specimens), possum (373), camel (564), emu (771), feral pig (3120), feral goat (4120), and kangaroo (4065). In none of these has there been any detectable level of residue.

The NRS has monitored honey for a number of years. Australian honey producers set hives in a wide range of environments throughout the agricultural zone where a large range of pesticides are frequently used, for examples close to horticultural orchards as well as within open woodland and forests; such sites are often close to open waterways. A total of 7449

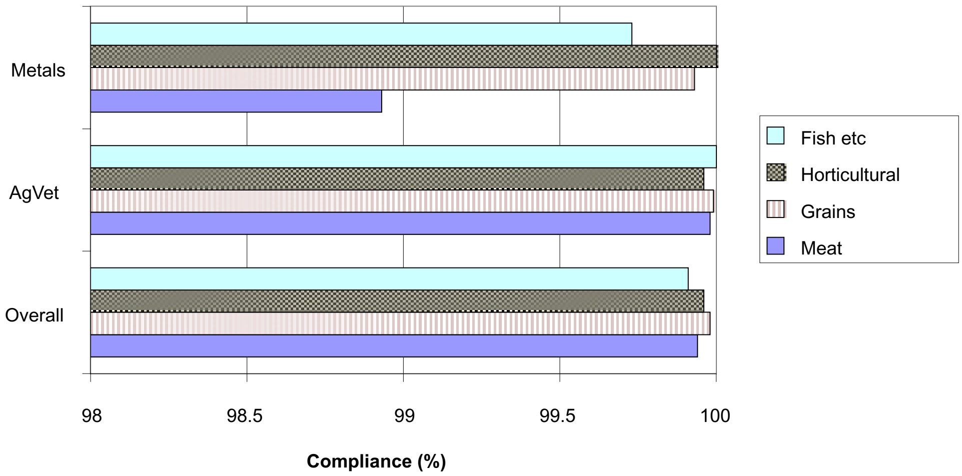

Figure 74: Percentage samples analysed that did not exceed the Maximum Residue Level (MRL) or Maximum Permitted Concentration Level (MPC) as percentages of total number of samples.

Source: National Office of Food Safety (1999).

analyses were performed on 406 samples in 1998–99, in which there were no detectable residues (National Office of Food Safety 1999).

Dealing with pesticide containers

The association of chemical companies and distributors called Avcare Ltd was incorporated in 1982. Together with a number of participating organisations, it has been proactive in developing a professional attitude to safe agricultural and veterinary chemical handling in all spheres of operation. These participating organisations include: The Australian Local Government Association, National Farmers Federation, Chemcert (farm operators accreditation), Veterinary Manufacturers and Distributors Association, DrumMUSTER, ChemClear, Herbicide resistance management strategy and AgSAFE (manufacturers and distributors accreditation).

Avcare's main activities aim to encourage rural industries to work in a co-regulated and self-disciplined approach to chemical use. This includes:

- systematic chemical drum collection and safe disposal across all farming systems,
- accreditation of manufacturers and distributors in approved handling practices, and
- assistance in all aspects of safe stewardship, including development of guidelines and support information, in association with obligatory chemical labelling requirements.

Industry Waste Reduction Scheme

The agricultural and veterinary chemical industry Waste Reduction Scheme has two objectives:

- reduction in the amount of packaging at source, encouraging manufacturers to use bulk or refillable packs, and new packaging technology such as water soluble sachets, gel packs etc.
- ensuring non-returnable agricultural and veterinary chemical containers have a defined route for disposal.

The drumMUSTER program

The national drumMUSTER program aims to collect and recycle empty, cleaned, non-returnable agrichemical containers. Managed by AgSafe for the National Farmers Federation, Avcare Ltd, the Australian Local Government Association, and the Veterinary Manufacturers and Distributors, it is funded by a levy on crop protection and farm animal health products sold in non-returnable containers of over 1 kg in content. The scheme focuses on handler education and safety and good environmental standards. Rinsing and collection procedures are given out in brochures at point-of-sale.

By 2001 the target is to:

- reduce the weight of container packaging by 32%, reducing waste from this source into landfill by 68% compared with 1990,

Typical chemical containers collected in the drumMUSTER program.

Source: AVCARE (unpublished data).

- recover 66% of empty clean and rinsed containers, and
- supply 50% of the raw materials in recyclable packaging.

A recent study on farmers' behaviour in rinsing chemical containers found that those who do not are more likely to be livestock producers, to have large farms and to have tertiary education (Turrell and McGuffog 1997). This was an unexpected finding, and demonstrates that better management practices are not necessarily related to formal educational level.

To ensure that stocks of unused farm chemicals are safely disposed of, the agricultural industry agreed to institute ChemClear, a continuing program for the regular collection of registered farm chemicals that are otherwise non-returnable. ChemClear will begin after ChemCollect has finished in each State. It is a joint initiative of Avcare Ltd, the Veterinary Manufacturers and Distributors Association and the National Farmers' Federation.

These programs are good examples of the industry's increasing recognition of its 'cradle to grave' responsibility for its products.

Agrichemical Reviews, 1995–2001

As in many countries, organochlorine chemicals such as DDT, developed in the 1940s, were initially used to control malarial mosquitoes and other insect pests such as termites and Argentine ants. Until the 1980s these organochlorines were used in agricultural and horticultural situations to control many pests. Concern for their effects on human and environmental health led to phasing out of organochlorines, except for specific local use under permit, during the 1980s.

The National Registration Authority (NRA) was established in 1995, and inherited over 5000 chemical registrations from the States and Territories. Some of these were issued in the 1950s. For example Parathion was developed by Bayer in 1940 and has been used in Australia for over 50 years. Many regulations have not changed since first registration, although there is now more data on the toxicology, environmental effects, safer alternatives and site-specific behaviour for many chemicals than were available when they were first registered. A minority of chemicals have been withdrawn after review, but nearly all others are now subject to much more stringent regulations for use. Environmental concerns have triggered about half the

Table 37: Reviews of agricultural chemicals undertaken by the National Registration Authority.

Chemical and type	Reason	Review status
Glyphosate—herbicide	Threat to frogs and tadpoles	Completed 1996[A]
Atrazine—herbicide	Groundwater and stream contamination	Interim report 1997[A]
Mevinphos—OP insecticide	Worker safety, human toxicity	Interim report 1997[A]
Metham sodium, Dazomet, MITC—soil fumigants	Worker safety, human toxicity	Completed 1997[A]
Vinclozolin—systemic fungicide	Human toxicity	Completed 1997[B]
Chlorpropham—selective herbicide	No MRLs established	Completed 1997[A]
Tribufos—OP defoliant	Worker safety, environmental impact from drift	Completed 1998[B]
Macrocyclic lactones—endoparasite control in animals	Worker safety, residues in food products	Completed 1998[A]
Ethylene dibromide—soil fumigant	Human toxicity	Completed 1998[B]
(ethyl) Parathion—OP insecticide	Worker safety (aerial sprays)	Final report 1998[A]
Endosulfan—insecticide	Toxicity to aquatic life forms	Interim report 1998[A]
(methyl) Parathion—OP insecticide	Toxicity to bees, aquatic organisms	Interim report 1999[A]
Streptomycin/penicillin products and combinations—veterinary antibiotics	Human health, residues in animal products	Completed 1999[B]
Fenitrothion—locust and stored grain insecticide	Toxicity to birds and beneficial insects	Interim report 1999[B]
Chlorfenvinphos—insecticide for animal ectoparasites	Worker safety, potential runoff impacting aquatic life forms	Draft report 1999[A]
Monocrotophos—OP insecticide	Human toxicity, worker safety	Completed 2000[B]
Chlorpyrofos—OP insecticide	Toxic to beneficial insects and fish, worker safety	Draft review 2000[A]
Dichlorvos—OP insecticide	Poisoning risk in workers	Draft report 2000[A]

A Retained after revision of registration, reformulation, or labelling and/or restrictions on use (e.g. no aerial spraying, only in low volume, early morning, no wind, ground sprays etc.)
B Withdrawn, registration cancelled; Fenitrothion allowed under special licence for quarantine purposes in sealed containers.
OP Organophosphate.

Source: National Registration Authority (unpublished data).

reviews. Pesticide risk evaluation therefore uses sensitive aquatic and/or invertebrate organisms as 'model' or indicator organisms of environmental risk.

Progress in Integrated Pest Management and risk reduction in agricultural industries: case studies

Risk assessment

Today environmental impacts can only be estimated by consideration of the types of chemicals habitually used in rural industry relating to land use. CSIRO is trialling a Pesticide Impact Ranking Index (PIRI) (Kookana et al. unpubl.; see Box: PIRI: Pesticides Impact Ranking Index) that has the potential to provide relative assessment of the potential impact of different chemicals used in rural industries.

Integrated Pest Management: cotton [L Indicator 6.11]

The collapse of the cotton industry in the Ord Irrigation Area in the 1970s, following the build-up of resistance to pesticides, was an object lesson to the cotton industry. Cotton communities remain concerned with insecticide risks and careful monitoring and control programs are in place across Australia. The industry and its research collaborators have worked to develop Integrated Resistance Management (IRM) and Integrated Pest Management (IPM) systems that are now widely practiced. Almost all the irrigated cotton in Australia is intensively 'bug checked' every 3–4 days. Insecticides are applied only after threshold numbers are reached, with more selective products used in preference to older broader-spectrum groups

PIRI: Pesticide Impact Ranking Index

PIRI assesses the environmental ranking of individual pesticides causing damage to waterways. It is an index, not a model. PIRI allows managers and farmers to assess which chemicals may migrate and harm water ecology, quality or aesthetics. The index is also able to rank which pesticide combinations (and therefore land uses) are most likely to put water assets at risk.

The value of the water body is assessed by a simple scoring system. The overall pesticide load is considered in relation to the area, application rates, toxicity and distance to water bodies. If the pesticides are mobile it estimates the transport distance for each chemical including spray drift, direct runoff, soil erosion and leaching to groundwater as separate pathways. It includes important factors such as droplet size, local soil type, slope, and rainfall, as well as the special properties of each chemical (such as oil or water solubility, and persistence). The overall impact is the sum of all these impacts within a particular land use.

Key environmental variables	Key pesticide variables
Distance to water	Pesticide's half-life
Erosion rate (rainfall intensity, slope, bare soil)	Toxicity to algae, water fleas, fish
Amount of organic matter in soil	Solubility in oil and water

Tests carried out show PIRI can predict which pesticides and land use combinations are likely to impact on the environment with over 80% reliability. The highest impact is likely to come from market gardens, cotton and fruit orchards. Field crops are less likely to have environmental impact, and grazed pastures and forests have a lower risk of impact.

wherever possible. In addition, different insecticide groups are rotated in an attempt to manage insect resistance. The Australian Cotton Cooperative Research Centre has recently developed practical IPM guidelines. These include breeding varieties that are least attractive to insects, management of fertilisers, timing of irrigation and defoliation. While environmental audits undertaken for the cotton industry show good levels of compliance with such guidelines, episodes of pesticide contamination in beef, waterways or the atmosphere still occur, and present a significant risk to communities, trade and the environment.

Of the 400 000 to 500 000 hectares of cotton grown in Australia each season about 30% is now genetically modified 'Bt' (Ingard®) cotton. In the past three years there has been an average 42% reduction (ranging from 30% to 60%) in insecticidal spray used against cotton bollworm or 'heliothis' (*Helicoverpa armigera*) on Ingard® cotton crops. This has resulted in 1.75 million litres less pesticide being used on such crops. The pesticides in question were mainly endosulfan, but carbamates, organophosphates and pyrethroids are also used (ACIL Consulting 2000). Other components of IPM include the fostering of conditions that encourage beneficial insects, such as foliar food sprays, and using alternatives to 'hard' chemicals such as foliar-Bt sprays, and trap crops grown alongside cotton.

The remaining 70% of conventional cotton crop still requires a total of 10 to 18 spray applications of herbicides, insecticides and fungicides each year. New transgenic crops may need from three to ten sprays of similar chemicals. (Holloway pers. comm., ACCRC 2000). However, research has indicated that the use of Bt cotton has caused changes in soil microbial populations (Gupta et al. 1998). This would suggest a more precautionary approach may be required in the use of these genetically modified crops.

Integrated Pest Management: horticultural crops [L Indicator 6.11]

Australia, and other western countries, now sell over 75% of fresh fruit and vegetables through supermarket retail chains. Sales depend on the product being attractive, unblemished and of a sufficiently regular size to attract consumers. In addition, consumers require that there is no health risk from pesticides.

Horticultural crops are often grown in small blocks, mostly under irrigation and close to settlements. The crops are very vulnerable to many pests and diseases. To control the full range of pests, diseases and weeds that would make the product unsaleable, most crops require around 20 to 30 sprays of all kinds per growing season. The adoption of IPM will normally reduces this by about 20%, but also reduces the off-site impacts by up to 50% (Juffs et al. 1999).

A recent study of tomato growers found that most processing-tomato growers, all of whom are located in Victoria, started to use IPM in 1995. By 1998, 89% of them had adopted the full range of IPM practices, principally because processing companies demanded certified product (Juffs et al. 1999). The same study found all fresh tomato growers in the Bowen region of Queensland had fully adopted IPM, and in the Bundaberg region, 95% of the tonnage was produced with restricted pesticide use, although only 77% of growers had adopted full IPM. Eighty percent of apple and pear growers have adopted some form of IPM in the past nine years. 20 to 30% of larger growers are in transition to a system of Integrated Fruit Management in which the whole farm or even the district is managed in the most sustainable manner currently possible (Agtrans Research 1999).

IPM in horticultural crops requires some or all of the following measures:

- change in farm practice,
- employment of a crop scout or training in scouting for all pests and diseases,
- use of sprays only when the pest level reaches a described threshold,
- rotation of chemicals to reduce build-up of resistance,
- use of more targeted chemicals, and
- production breaks or rotations for paddock hygiene.

Additional, more sophisticated levels of IPM include:

- using beneficial insects such as ladybirds, lacewings and sucking bugs that parasitise pests,
- using pheromone mating disruption systems to confuse male pests (very valuable in orchard crops),
- understanding the life-cycles and epidemiology of pests and diseases,
- growing companion crops, buffer strips, wind breaks and green manures, and
- adjusting spray technology to ultra low volumes, improved targeting and calibrations.

GM crops

During the past five years genetically modified (GM) crops have become a commercial reality in certain industries and regions of the world, but their introduction has become a matter of great public debate.

Australia has taken a cautiously positive approach to the development of GM crops, with joint government and industry funded research and development in grains, horticulture, cotton, pasture legumes, sugarcane, and tree crops. Biosafety and ethical standards were regulated through the Genetic Modification Advisory Committee (GMAC) until 1999, when the Commonwealth government developed the Interim Office of the Gene Technology Regulator. Subsequently initiatives to improve community understanding and information on a wide range of biotechnology issues have been undertaken. These have included a consensus conference to obtain community views in 1999, and the establishment of Biotechnology Australia, a consortium of government science, technology and industry groups that aims to improve information and education on genetic modification technologies. The Council of Australian Governments (COAG) agreed to guidelines and legislation on labelling, use and segregation management of GM crops in October 2000. At the time of writing the main points in these guidelines are:

- States and territories, or geographically defined parts thereof, may identify areas that may declare themselves GM crop free or GM crop occupied if this is the consensus of the community.
- Crops being tested must go through the current scheduled procedure before field evaluation, but once being grown, any damage done to the test crop will be judged illegal and prosecuted. Field trial sites must be identified as such.
- Food will be labelled as to whether it contains a GM ingredient: if labelled GM free it must not knowingly have GM ingredients, but can contain up to 1% of inadvertent contamination.

The majority of broadacre GM crops being developed in Australia, and those that have been produced in other countries, and may be grown here, have been designed to withstand commonly-used herbicides. The intention is that the farmer can then use a herbicide to which the crop would normally be susceptible (such as a broadleaf herbicide used against *Brassica* species of weeds in a crop of canola, which is itself a *Brassica*). In the case of canola, naturally occurring herbicide resistant varieties have also been identified from conventional plant breeding selection procedures.

A few examples exist of crops that have been produced for improved quality (such as tomatoes with a higher proportion of solids), and market fashion (such as inserting ‘blue’ colour into non-blue flowers such as carnations and roses). There is intense research interest in such quality attributes as maintaining ripe fruit and vegetables without browning. Most of these transformations are possible with conventional breeding techniques but are less easy to protect by patent.

Implications

Irrigated cotton poses the highest environmental risk from pesticides in Australian agriculture, both because of the number of chemicals used and the frequency of use. Because of the very poor state of knowledge on total chemical usage, not only in agricultural industries, but across all sectors, the relative risks from the conventional and GM crop production systems are difficult to compare.

The issue of resistance to pesticides is a complex one. The early use of some pesticides was over-enthusiastic and profligate, and resistant populations have built up in many instances. As a result, Australia now possesses some of the most challenging examples of herbicide resistance known. Examples include the multiple-herbicide resistance displayed by weeds such as wild oats, capeweed and ryegrass (*Lolium perenne*). Such weed species frequently develop cross resistance to chemical groups to which the particular plant population has never had exposure, simply because it has had exposure to another chemical group. For example, exposure to sulfonyl ureas can lead to resistance to FOPS (the aryloxy phyonxyproprionate group) (Gill 1994).

While integrated pest, weed or disease management is the ideal solution to resistance, the examples given in this section demonstrate how challenging it is to implement such management across a whole district or industry. This is especially so when the pest, weed or disease is highly destructive, very widespread and where conventional plant breeding has not been able to confer resistance or competitive survival.