AN ENVIRONMENTAL AUDIT OF THE AUSTRALIAN COTTON INDUSTRY

BY

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Date ..... 4th October 91 .....

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It is intended that this assessment will be of use to the cotton industry in guiding it towards the setting and achieving of appropriate environmental standards and goals. Cotton growing is a capital intensive business and so members of the industry have a vested interest in ensuring that their practices are genuinely sustainable in the long term. The industry also shares environmental resources such as land and water with other members of the community and with the fauna and flora, and thus has a responsibility to ensure that it uses these resources wisely. It is hoped that the audit will contribute towards the achievement of these aims and ideals.

Finally, it is intended that the audit will be of value to those outside the industry who wish to understand what the environmental issues are, and how they can be addressed. A significant degree of polarisation has developed between supporters of the industry, on one side, and its critics on the other, with diametrically opposing views sometimes expressed on the same issues. This situation fosters anxieties and mistrust in cotton growing communities and it is hoped that by providing an independent view, the audit will contribute to reducing and resolving such issues.

1.3 SCOPE OF THE STUDY

The brief of the audit team was to investigate the environmental impacts of cotton production from the establishment of new cotton farms to the production of ginned, raw cotton. This corresponds to the range of activities engaged in by the members of the Australian Cotton Foundation (ACF), who commissioned the study.

The study was intended to give an overview of the industry and identify key issues and concerns associated with its practices; detailed audits of individual sites or issues were not part of the brief. This approach allows particular problem areas or aspects of the industry whose environmental impacts are poorly understood to be identified and further detailed studies of these areas to be recommended as appropriate.

The audit was based on the reviewing of existing data; no physical monitoring or investigation was conducted to produce new data on any of the issues addressed by the audit. Such a review of the present state of knowledge was seen as a crucial first step in understanding and addressing environmental problems associated with the industry.

Considerable data already exist on environmental aspects of cotton growing, although this information is dispersed over a variety of different sources, including published and unpublished reports and the knowledge and experience of people associated with the industry. Much of it is not readily accessible. Drawing these different sources of information together and objectively reviewing them allows the real problems to be identified and facilitates the resolution of these issues.

There are, of course, limitations to this process. Whilst the audit aims to reach conclusions on environmental performance, where the data support them, it is inevitable that in many cases insufficient data exist to allow firm conclusions to be drawn. An important aspect of the study, therefore, is the identification of gaps in present understanding and knowledge of the environmental impacts of cotton production. New studies can then be initiated which plug these gaps.

The Australian cotton industry is made up of a large number of separate organisations, including ginners, small family farms and corporate growers, as well as associated professionals such as crop consultants and aerial crop sprayers. Each of these components of the industry has its own policies and practices and each contributes to the overall impact of the industry. In addition to the many people and organisations working within the industry there are many others with an interest in its environmental performance. It was considered important to interview a selection of these different bodies and to briefly visit as many sites (farms, gins, aerial operators bases etc.) as possible in order to obtain a picture of the industry. The constraints of timescale and distance meant that only a sample of people and sites could actually be visited but every effort was made to ensure that the "key" organisations were represented in the sample.

Many of the people and organisations interviewed are entirely independent of the audit instigators, the ACF, and were thus under no obligation to cooperate with the audit. In fact there was a high degree of cooperation and many people, were very generous both with their time and in allowing us access to information they held or access onto their properties.

1.4 METHODOLOGY

The environmental audit of the Australian cotton industry was conducted in three distinct stages over a period of six months. Stage One consisted of an initial review of the background information available on the cotton industry and preliminary appraisal of the key environmental issues. Stage Two was a data gathering phase involving interviews, site inspections and detailed research. Stage Three consisted of an assessment of the environmental data collected, the formulation of recommendations and the production of a final audit report. Stages one and three were carried out in the UK, while stage two was undertaken in Australia. During each of the phases, a variety of data gathering and data assessing techniques were pursued.

(i) Stage 1

In Stage One an environmental questionnaire was sent out to the key organisations in and associated with the industry. Questionnaires were also sent out to environmental groups known to be critical of the industry. The questionnaire was a first step in the identification of what environmental issues are considered to be associated with cotton production and the assessment of the attitudes and perceptions of different organisations involved in the industry. The questionnaire was not designed as a statistical survey and no quantitative analysis of the responses was intended or undertaken.

A total of 40 questionnaires were sent out to a variety of cotton industry and government bodies, environmental groups, other agricultural land users, chemical industry bodies, aerial operators, individual growers, concerned citizen groups, medical and university researchers and crop consultants. A list of those to whom the questionnaire was sent is given in Appendix 1.

Eighteen responses were received: seven from growers and cotton industry bodies, five from government departments, three from other agricultural land users, and one each from the environmental organisations, chemical industry and aerial operators.

(ii) Stage 2

Stage two of the audit, the principal data gathering phase, took place during a seventeen day period in February-March, 1991. During this stage the audit activities included interviews with key individuals within and outside the industry. Considerable effort was made to seek the views of all the sections of the community with an interest in cotton production, including industry critics.

A total of 71 interviews were conducted during site and field visits. A list of those interviewed is given in Appendix 2. The interviews could be broken down into the following categories:

COTTON INDUSTRY

15	Farmers in Queensland and NSW
6	Gin personnel
5	Corporate cotton managers
3	ACF*
4	CSD
1	Cotton research
1	Crop consultant

CHEMICAL INDUSTRY

3	AVCA

AVIATION

1	AAAA
3	Aerial Operators

MEDICAL

2	Medical Practioners

ENVIRONMENTALISTS

3	Concerned Citizens,
1	T.E.C

UNIVERSITY

3	Research scientists

GOVERNMENT

20	Queensland DPI, CSIRO, NSW SPCC, NSW DEPT AG & FISH, NSW DEPT WATER RESOURCES.

(* Note a list of the abbreviations used frequently in the text is given at the front of the report)

The level of co-operation, both from within the industry and outside, was high. Many of the questionnaires were filled out in great detail. The interviews were conducted in an open style. Although questions were prepared for each interview, the audit team were flexible in their approach and would pursue any issue that the interviewee felt important.

Site visits ranging in length between several hours and a day were made to thirteen farms and seven processing plants (six gins and one seed processing plant). These visits were intended to allow a first hand inspection of facilities and normal practices and procedures but did not involve any physical monitoring or measurements.

The selection of persons and organisations to interview and sites to visit was at the discretion of the audit team; the Australian Cotton Foundation provided assistance in contacting people and transport to sites but exercised no control over these matters. Interviews were conducted in private with only the interviewee(s) and the audit team in attendance.

The contents of individual questionnaires and interviews are confidential. For the purposes of this document, the results have been summarized with no identification of individual interviewees or respondents.

In addition to the interviews and questionnaires, further information was obtained in the form of reports (both published and unpublished), articles, books and raw data from a variety of sources within and outside Australia. These sources are cited in the text and full details are given in the List of References at the end of the Report.

The Australian Cotton Foundation hold an extensive library of press cuttings, videos of news items/documentaries, and radio broadcasts relating to the cotton industry. These were reviewed and were particularly useful in identifying the issues of greatest public concern and the perceptions held about the cotton industry.

(iii) Stage 3

Stage Three of the audit consisted of a detailed appraisal of the of data collected in Stage Two, the formulation of conclusions and recommendations and the production of the final audit report.

1.5 FORMAT OF THE AUDIT REPORT

This Audit report is divided into seven chapters. The first two chapters consist respectively of a general introduction outlining the reasons for the study, its scope and methodology (Chapter 1) and a general background to the Australian cotton industry, the environmental issued involves and the perceptions that are held of the industry (Chapter 2).

The following four chapters are the main body of the report and present the findings and recommendations of the study. These chapters follow a **functional approach**, each chapter being based on key activities of the industry. These are pesticide use (Chapter 3), land use (Chapter 4), water use (Chapter 5) and cotton processing (Chapter 6). These were considered to be the chief areas of cotton industry activity with potential for causing environmental impacts.

Although there is a degree of overlap between each of these activities, in terms of the environmental issues they involve (eg between pesticide use and water use for the problem of fish kills) this format best lends itself to the exposition of recommendations which could be readily put into practice by the industry.

Each of the main chapters are subdivided into sections dealing with separate aspects of the principle activity considered. In each case the main environmental issues concerned are described and followed by an outline of the relevant legislation and other controls. The available information concerning the performance of the industry is then presented and assessed in relation to the issues outlined. Finally the conclusions drawn, together with appropriate recommendations are presented.

The final chapter (Chapter 7) summarises the principle conclusions and recommendations of chapters 3, 4, 5 and 6 and identifies priorities amongst the recommendations given.

CHAPTER 2 AN OVERVIEW OF THE AUSTRALIAN COTTON INDUSTRY

CHAPTER 2 CONTENTS

2.1 THE COTTON INDUSTRY

2.1.1 History of Cotton Production in Australia

The first attempts to grow cotton in Australia took place in the late eighteenth century but these early attempts were unsuccessful. There were several further attempts, mainly in Queensland, to establish cotton farming in the nineteenth and early twentieth centuries but any success that these enjoyed was usually limited and short-lived in the face of competition from overseas.

All of these early ventures were based on dryland cotton but the modern cotton industry finally took off with the introduction of irrigated production methods. In the 1960's irrigation started in the Lockyer Valley in Queensland and, with the completion of the Keepit dam, in the Namoi Valley in New South Wales. American growers pioneered irrigated cotton growing in New South Wales and, with their expertise, yields began to improve and total production increased.

Since these early beginnings the industry has expanded greatly in both New South Wales and Queensland (see Figure 1) and in recent years the total area planted to cotton has been in excess of 160,000 hectares (395,000 acres) and in 1989-90 exceeded 230,000 hectares (556,000 acres) (Cotton Year Book 1990). Production exceeds one million bales per year (Cotton Year Book 1990) and stood at 1.3 million bales in 1988/89 (see Figure 2). As a result of this expansion cotton has become the fifth most important agricultural export earner in Australia. Average yields are extremely high and, at around 1300 kilos per hectare, are bettered only in Israel (all data from the Cotton Year Book 1990). The quality of the lint produced is also consistently high.

The predominance of irrigated cotton farming has led to the cotton industry being closely associated with river valley's with suitable supplies of water for irrigation. As a result a number of distinct cotton growing areas have developed. These are indicated on Figure 3 and briefly described below.

Macquarie Valley, NSW - This is the most southerly of the cotton growing regions and has a shorter growing season than other areas. Cotton production was started in the area in 1967. Between 20,000 hectares and 24,000 hectares are planted to cotton each year. Water is supplied from the Burrendong Dam.

Bourke, NSW - Between 4,000 and 7,500 hectares of cotton are planted at Bourke each year. Water is taken from unregulated river flows from the Darling River and pumped into off-river storage. Cotton has been grown in the Bourke area for about ten years.

Namoi Valley, NSW - The Namoi Valley is the longest established cotton growing area in New South Wales. It is the second largest cotton producing area in Australia and in most years 40,000 - 50,000 hectares of cotton are planted. Most of the irrigation water is supplied from the Keepit Dam with further supplies coming from the Split Rock Dam.

Figure 1. Annual variations in the area of cotton grown in Australia.

From: Australian Cotton Grower (1990).

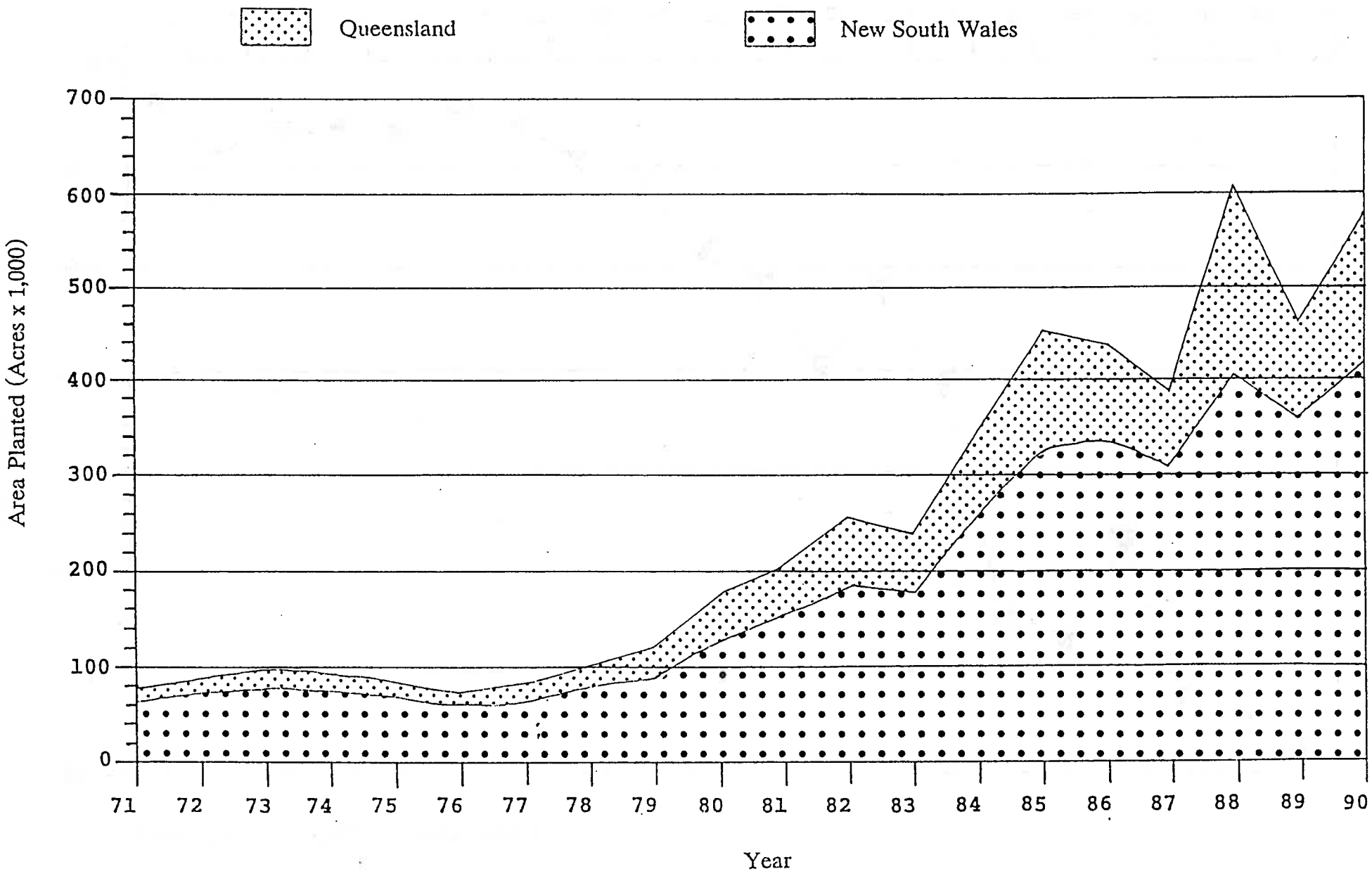


Figure 2. Annual variations in cotton production in Australia.

From: Australian Cotton Grower (1990).

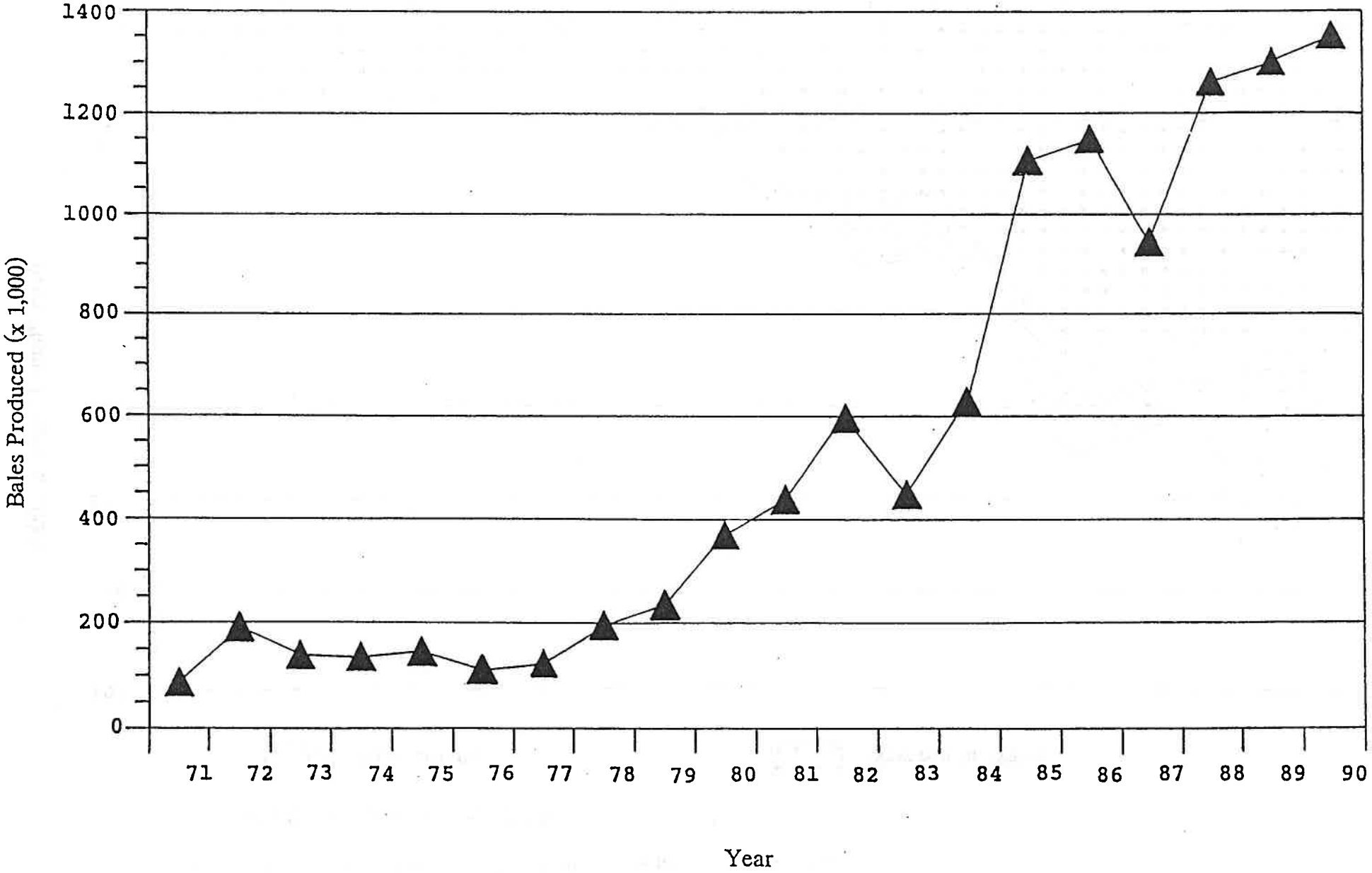
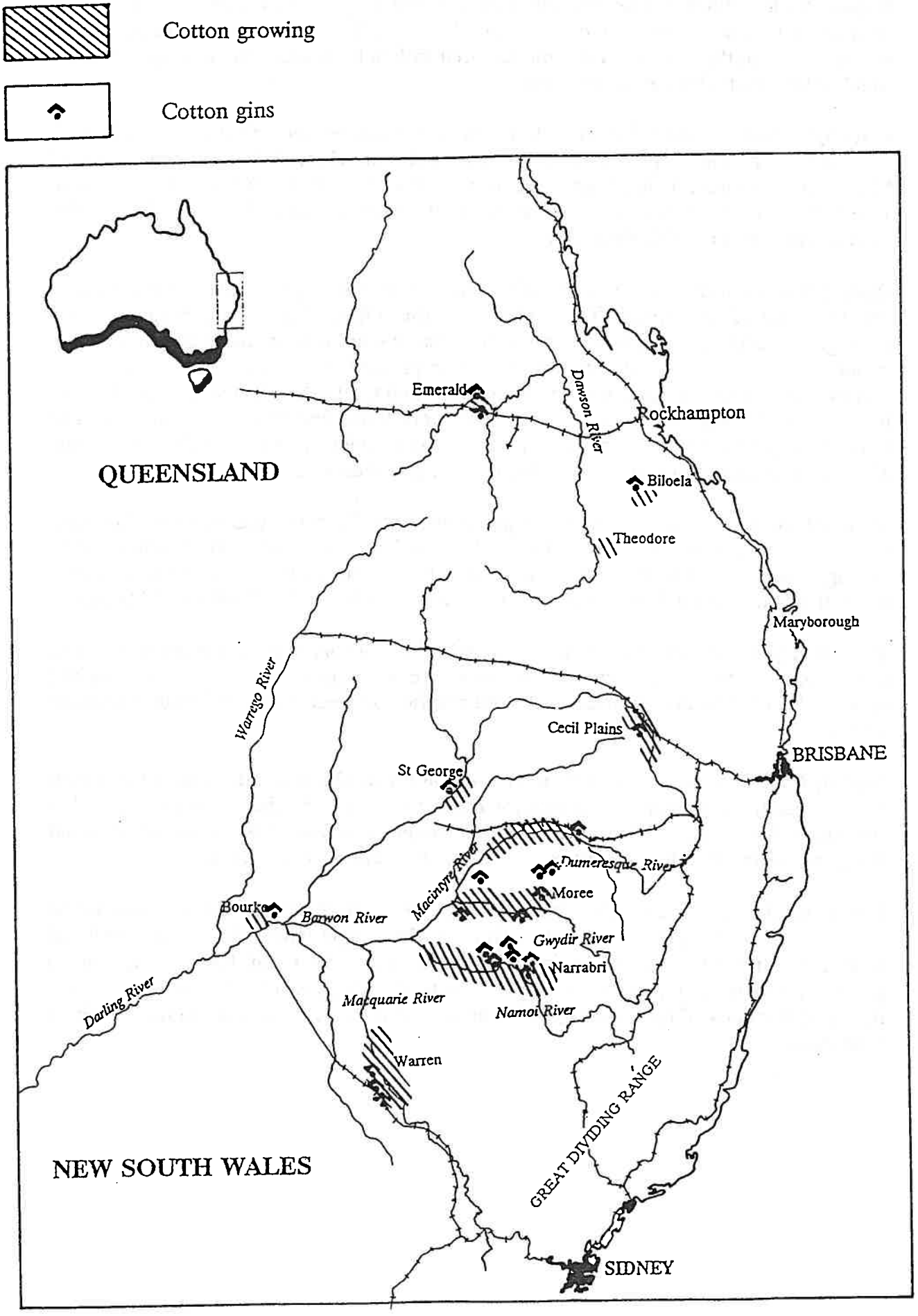


Figure 3. Cotton growing areas of Australia.



Gwydir Valley, NSW - The Gwydir Valley is the largest cotton producing area in Australia with annual planting of between 50,000 and 75,000 hectares. Irrigation water is supplied from the Copeton Dam but the area suffers from a chronic shortage of water which often limits the size of the crop.

Macintyre Valley, NSW - This river forms the boundary between New South Wales and Queensland; cotton is grown on both sides between Goondiwindi in the east and Mungindi in the west. Cotton has been grown in the area since 1977 and approximately 16,000 hectares of cotton are planted annually. Irrigation water is supplied from the Pindari Dam and the Glenlyon Dam.

Darling Downs, Qld - This area has a long history of cotton growing stretching back to the beginning of the century. The versatility of the soils enables a wide range of crops to be grown in the area with the consequence that the amount of cotton grown is rather variable and price sensitive. The area of cotton planted varies between 4,000 hectares and 24,000 hectares. Irrigation water is supplied from the Leslie Dam on the Condamine River although many farmers have their own bore holes and ring tanks which capture cross country water flows. Dryland cotton is also a major crop on the Darling Downs although it is even more price sensitive than irrigated cotton.

St George, Qld - This irrigation area depends upon the Beardmore Dam on the Balonne River. The irrigation scheme was initiated in 1957 and the early settlers tried cotton amongst other crops but with little success. Successful cotton production in the area only really took off in the 1970's and the area planted annually is now 7,000 - 9,000 hectares.

Theodore, Qld - Theodore is another area with a long history of cotton growing. Situated in the Dawson Valley the area derives irrigation water from a series of weirs on the Dawson River. The area planted with cotton varies between 5,000 and 16,000 hectares annually.

Biloela, Qld - As with other cotton growing areas in Queensland, Biloela has grown cotton since the early part of this century. Production has expanded since the late 1970's with the construction of the Callide Dam. Between 4,000 and 12,000 hectares of cotton are grown annually. Dryland cotton is still an important crop in the area.

Emerald, Qld - The Emerald irrigation scheme was established in 1968 in association with the construction of the Fairbairn Dam on the Nogoa River which was completed in 1972. Cotton is the major crop in the irrigation area with about 8,000 hectares being grown each year. A similar area of dryland cotton is also grown in the area. Emerald is the most northerly of the cotton growing areas of Australia, lying close to the Tropic of Capricorn.

2.1.2 Overview of Cotton Production

To assess the environmental issues associated with cotton production it is necessary to understand the processes involved. General methods adopted in the industry are outlined below.

(i) Planting

The initial establishment of a cotton farm requires scrub clearance and extensive engineering works to create the necessary irrigation infra-structure and level paddocks. These works are of a more or less permanent nature and thereafter only require general maintenance. The cotton year is shown diagrammatically in Figure 4. After initial field preparation cotton is planted in the Spring, usually in September, and the harvest occurs about 200 days later. Between planting and harvest the crop requires intensive management, especially irrigation and control of weed and insect pests.

(ii) Irrigation

Soil moisture content and the water requirement of the crop are closely monitored and irrigation periods are timed accordingly. The flood irrigation method is used, whereby water is introduced into the higher end of the field (usually by syphoning out of a header canal) and allowed to run down between the rows of plants to the opposite end of the field where it is released into a tail-water canal. Irrigation water is drawn from river or, less frequently, ground water sources and a system of licences and allocations is operated to control this use.

(iii) Weed Control

Weed control is carried out by a mixture of mechanical cultivation, manual weeding ("chipping") and the use of chemical herbicides. Chipping plays an important role in weed control since cotton is itself susceptible to broad-leaf herbicides which could otherwise be used to control typical weeds and because the nature of the crop makes it impractical or difficult to get machinery onto the paddock throughout much of the growing season.

(iv) Insect Control

Insects are a major problem as cotton attracts a large number of species which can potentially destroy the crop or seriously reduce the yield. Of these the most serious are the larvae of the two species of Heliothis moth, *H.armigera* and *H.punctigera* which attack the cotton bolls. Insect pest control is largely effected through the aerial application of insecticides although anti-insect strategies also involve the selection of less susceptible cotton varieties and, at least experimental use of biological control, mating disruption and other non chemical alternatives.

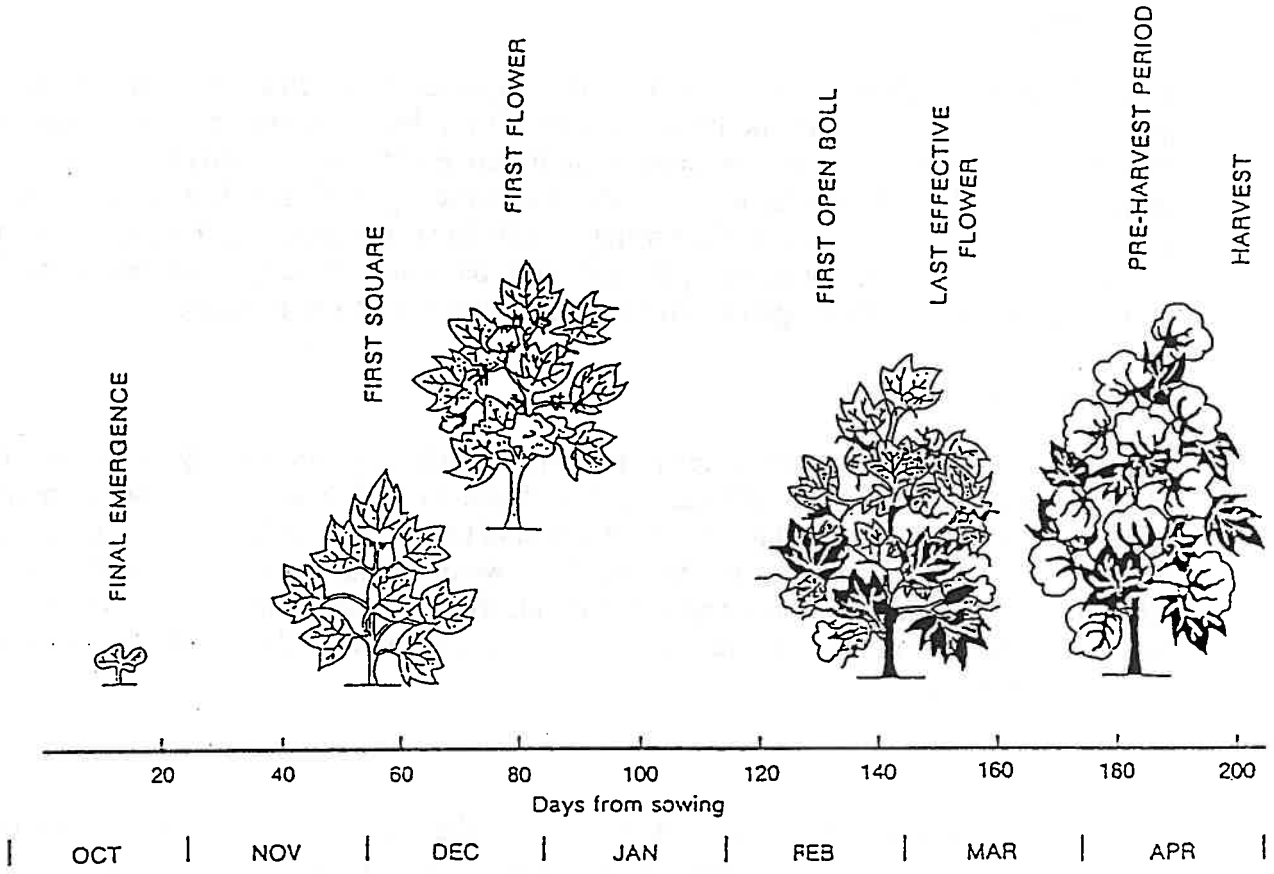


Figure 4. The annual cotton growing cycle in New South Wales. After: Browne (1984)

(v) Harvest

Harvesting is carried out when the majority of bolls on the plant have opened, revealing the white cotton fibres. Immediately prior to the harvest the crop is sprayed with a defoliant which causes the plants to shed their leaves, thereby reducing the amount of trash in the cotton sent to the gin. Harvesting is carried out by machines which straddle the rows of plants and pluck the bolls from the bushes. The harvested cotton is transferred into massive containers known as modules and subsequently transported to the gin for processing.

2.1.3 Overview of Cotton Processing

On arrival at the gin cotton modules are usually stored in a large yard until they can be processed. Modules are transported, one at a time, from the yard to the gin itself and the contents placed on a large conveyor which feeds them into the ginning system. The raw cotton is initially dried and separated from sticks and other trash before being fed into the gin stands. These essentially consist of a series of rapidly rotating saws which draw the cotton fibres (lint) through fine ribs. The seeds are too large to pass through the ribs and are thus separated from the lint.

After separation from the seeds, the lint is combed and smoothed before being passed to a press which packs it into 225 kg bales. These are stored prior to transportation to centralised warehouses and subsequent sale and exportation.

The seeds which, after ginning, are covered in short 'linters' and described as 'fuzzy' seeds are also taken to storage. These seeds may be processed further to produce cotton oil and animal fodder or they may be used as animal fodder without further treatment. A proportion of the seed crop, derived from certified sources, is processed and sold as planting seed for the next years' crop.

Processing of planting seed involves the removal of the linters by a combination of physical and chemical means to produce 'black' seed. The black seed is coated with fungicides and systemic insecticide and is then bagged and stored ready for distribution to growers.

2.1.4 Structure of the Industry

(i) Growers and Processors

The majority of cotton farms in both New South Wales and Queensland are run as family concerns although there are also a number of very large corporate growers, notably Auscott Ltd., Colly Farms, Darling River Cotton and Twynam Cotton. Cotton

is generally grown as the economic mainstay of the farm with other crops, such as wheat, sunflowers, sorghum and legumes, grown primarily as rotation crops.

The average area of cotton grown by non-corporate growers in New South Wales is around 500 hectares, whilst farmers growing cotton in the Queensland irrigation areas such as Emerald tend to operate smaller areas than this. The largest corporate growers may grow in excess of 12,000 hectares of cotton annually. Cotton farming in Australia is intensive and highly mechanised, at all levels, with significant inputs of pesticides and chemical fertilisers.

At present there are seven processing organisations which gin and subsequently market all of the raw cotton produced in Australia (an eighth organisation, Northwest Ginning is currently building a gin and will shortly come on-line). These corporations operate gins in all of the major cotton growing areas:

Namoi Cotton Co-operative, NSW - Established in 1962 the Namoi Cotton Co-operative is the largest processor in Australia and the largest grower controlled processing and marketing cooperative in the world. Namoi Cotton Co-operative operates gins in the Namoi, Gwydir and Macintyre Valleys. Custom Ginning is also carried out for cotton sold through other merchants.

Auscott Ltd, NSW - Auscott Ltd are major corporate growers who also operate their own gins in the Macquarie, Namoi and Gwydir Valleys. In addition to ginning cotton produced on its own farms Auscott also provides a ginning and marketing service for other growers.

Colly Farms, NSW - Colly Farms, although relatively recently established (1979), has expanded rapidly to become the largest single producer of cotton. The company operates its own gin at its Collymongle property where it processes cotton for itself and other growers.

Twynam Cotton, NSW - Twynam Cotton is a corporate cotton grower in the Macquarie Valley, which operates its own gin at Warren. The company gins cotton produced on its own farms and that produced by other growers.

Darling River Cotton, NSW - Darling River Cotton is also an integrated growing, processing and marketing organisation. Based at Bourke, the company gins its own cotton and that produced by the small number of other growers in the Bourke area.

Dunavant Enterprises Australia, NSW & Qld - Dunavant Enterprises Australia is a subsidiary of Dunavant Enterprises Inc. of Memphis, Tennessee who are the worlds largest cotton ginning company. Dunavant Enterprises Australia operate two gins, in Moree and Emerald, and provide a processing and marketing service for growers.

Queensland Cotton Holdings Ltd, Qld - Queensland Cotton Corporation was initially established in 1926 as the Queensland Cotton Marketing Board to process and market the Queensland crop. In 1990 the Board was deregulated and its assets and liabilities transferred to the Queensland Cotton Corporation which is 100% owned by Queensland Cotton Holdings Ltd. Growers have been issued shares in Queensland Cotton Holdings Ltd and are paid dividends out of the profits earned by the Corporation. Queensland Cotton Corporation operates gins in Biloela, Emerald, Cecil Plains and St George and provides a ginning and marketing service to growers.

Cotton growers and processors are represented by the Australian Cotton Foundation which promotes the industry and represents its views and interests to the general public, government and industry and on bodies such as the National Farmers Federation. The ACF has a small full time staff and a board comprising delegates from each of the cotton processing organisations. Individual growers are represented by these delegates and by their regional growers' associations. The ACF is financed by growers through a levy on each bale of cotton produced.

(ii) Cotton Consultants

The technical nature of cotton growing is reflected in the prominence in the industry of professional crop consultants. Crop consultants provide advice to growers on agronomic problems, irrigation and pest control and in some cases on financial matters. Their role in the control of insect pests is of particular importance as they are largely responsible for monitoring pest pressure in crops and they advise farmers on the timing of sprays and the selection of insecticides.

The crop consultants in each state are represented by their own professional associations: the Queensland Crop Management Consultants Association and the New South Wales Cotton Consultants Association.

(iii) Aerial Operators

Virtually all of the insecticides applied to the Australian cotton crop, as well as much of the herbicides and all of the pre-harvest defoliants are applied from aircraft. Specialist contractors carry out this service for growers using purpose built agricultural spraying aircraft.

For logistical reasons aerial operators store most of the pesticides which are applied aerially at their own bases. Some large growers have their own facilities for mixing and loading aircraft with spray chemicals and maintain their own stores but most growers only store relatively small amounts of those pesticides which they apply themselves from the ground.

The majority of aerial operators are members of the Aerial Agricultural Association of Australia (AAAA) whose aims are to improve standards within the industry. AAAA is currently establishing an accreditation scheme as part of its "Operation Spray Safe". This scheme, which is voluntary, seeks to accredit operators and individual pilots who meet a required standard. Individual pilots are required to sit and pass an examination based upon the "Operation Spray Safe" manual whilst operators must employ accredited pilots and demonstrate satisfactory facilities and procedures for the safe handling and application of agrochemicals. Accreditation is subject to regular review.

(iv) Chemical Suppliers

The manufacturers, distributors and marketers of the majority of the agrochemicals used by the cotton industry are represented by the Agricultural and Veterinary Chemicals Association of Australia (AVCA). AVCA is establishing an accreditation scheme aimed at maintaining or improving standards at storage and warehouse premises in both the retail and manufacturing sectors of the industry.

(v) Seed Suppliers

Until recently the sole suppliers of cotton seed for planting was Cotton Seed Distributors Ltd. CSD is a non-profit making company which has the joint functions of providing planting seed to growers and developing new varieties with improved qualities. The company has a factory at Wee Waa in New South Wales where seed is cleaned, treated and packaged prior to distribution.

The development of new varieties is carried out in collaboration with the CSIRO. The role of CSD is particularly in the organisation of small scale and field trials and carrying out seed bulking.

It has recently been agreed that an independent commercial company could start supplying its own varieties of cotton seed in competition with CSD.

(vi) Research

The rapid development and commercial success of cotton growing in Australia has been based upon a high level of research. Two separate bodies are responsible for the administration of research within the industry.

> **The Australian Cotton Growers Research Association (ACGRA)** - This was formerly the sole body administering cotton research and at that time it was also responsible for raising finance from grower and government contributions. The fund raising side of its activities has now passed to the Cotton Research and Development Corporation and ACGRA's current functions include encouraging research, identifying research needs and facilitating communication between researchers and growers. ACGRA organises the biennial Australian Cotton Conference.

The Cotton Research and Development Corporation (CRDC) - This is a statutory body responsible for financing research. A grower levy is deducted from each bale of cotton processed and the funds raised are then matched by a Commonwealth government grant. Research projects are generally funded in line with a five year research and development plan for the industry. A wide range of studies are funded including projects on plant breeding and physiology, soil science, pest control, environmental problems, irrigation and economic issues.

Cotton related research is carried out by a large number of different institutions. These include the CSIRO/New South Wales Department of Agriculture and Fisheries (DA&F) research facility at Myall Vale, various DA&F and Queensland Department of Primary Industries field stations and numerous universities and colleges.

(vii) Regulatory and other Government Bodies

The cotton industry is regulated by a variety of different government organisations. Of these the most important ones are:

State Pollution Control Commission (SPCC) - The SPCC operate in NSW and are responsible for pollution control.

Department of Agriculture and Fisheries (DA&F) - The DA&F also operate in NSW and are responsible for the registration of pesticides, the regulation of aerial spraying and agricultural research and extension.

Department of Water Resources (Dept WR) - The Dept WR are responsible for administering water resources within NSW, through the allocation of pumping and abstraction licences.

The Department of Primary Industries (DPI) - The DPI operate in Qld and have a similar responsibility to the NSW Dept WR, they are also the parent organisation of the Water Resources Commission.

Water Resources Commission (WRC) - The WRC are responsible for administering water resources within Queensland through the allocation of pumping and abstraction licences.

WorkCover Authority - WorkCover are responsible for implementing occupational health and safety regulations within NSW.

Department of Health - In Queensland the Department of Health is responsible for implementing legislation relating to occupational health and safety.

In addition to their regulatory role government departments such as the DPI and the DA&F have extension services providing advice and information on agronomic and other issues.

(viii) Other Bodies

Other organisations closely involved with the cotton industry include the Raw Cotton Marketing Advisory Committee (RCMAC) which coordinates domestic marketing of cotton and provides a forum between cotton processors, marketers, spinners and the government. The RCMAC maintains industry statistics.

The Australian Cotton Shippers Association represents the independent merchants who provide growers with alternative marketing options to the seven processing corporations.

Finally the industry interacts directly or indirectly with many other organisations and individuals. These include machinery and other merchants, financial institutions, environmental lobby groups and, not least of all, the general public.

2.2 PERCEPTIONS ABOUT THE ENVIRONMENTAL PERFORMANCE OF THE AUSTRALIAN COTTON INDUSTRY

As outlined in the introduction, the Australian Cotton Industry has been criticised by the public, media and environmentalists, for its perceived environmental performance. The industry itself refutes many of the environmental criticisms levelled at it. This section summarises the general and specific concerns which have been expressed by these various groups. The issues identified in this section have been included in the items addressed by the audit and are considered in relation to the main cotton production processes to which they relate. These are dealt with, in greater detail, in the following chapters.

Perceptions held by different parties, concerning the environmental issues facing the cotton industry were identified from various sources including questionnaire responses, interviews and a review of press cuttings and videos of news items. It should be stressed that this review was not designed as a formal statistical survey; questionnaire respondents and interviewees were not a random cross-section of society but largely people and organisations with a known interest or involvement in the cotton industry. For this reason, this section merely records concerns that have been expressed and does not attempt to assess how widely they are held.

From the interviews and questionnaires it was clear that perceptions of the impacts of the cotton industry on the environment vary greatly, both within and outside the industry. Certain environmental issues are generally perceived to be much more important than others. Typically these are the issues that are highlighted by the media.

The principal perceived environmental issues relating to the Australian cotton industry are summarised below:

Fish Kills

Major fish kills have been reported in some cotton growing areas and most of these have been attributed, by the press and local people, to the release of pesticides into watercourses.

The issue of fish kills is one of the most (if not the most) highly publicized environmental issue associated with the cotton industry. Almost all of the televised news items that were reviewed were concerned with fish kill issues. The news items were all short (less than five minutes in duration), concentrated on pesticide use and usually involved on-site interviews either with local people, growers or government inspectors. The news items did not go into any great detail.

Questionnaire respondents tended to confirm the view that fish kills are the most publicized environmental issue relating to the cotton industry. Interviews revealed that there is widespread concern over this issue, and that the cotton industry, government, environmentalists and the general public are keen to firstly prevent it happening and secondly to make the culprit pay. Both within the industry and outside it, fish kills caused by pesticide contamination of water bodies are recognised to be highly undesirable. However, not all reported fish kills have been scientifically confirmed to be due to pesticide releases and some industry members expressed the view that there are other possible causes.

Use of Pesticides

The cotton industry in Australia, as in many other parts of the world, relies heavily on the use of pesticides. There are many perceived environmental issues relating to the use of pesticides in the cotton industry. These issues can broadly be divided into ecological pesticide issues and health-related pesticide issues.

Various ecological problems have been associated with pesticide use, including fish kills, aerial spray drift, contamination of land and water, impacts on other non-target species (principally bird life), and long term cumulative effects of pesticides.

Health problems which have been alleged to be related to pesticide use include increased risks of illnesses such as cancer, asthma, skin rashes, throat and eye complaints and miscarriages. Health threats to the community at large tend to be more widely publicised than occupational risks associated with pesticide use.

Ecological and health issues relating to pesticide are amongst the most widely publicised of all the environmental issues facing the cotton industry. Some critics have maintained that the problems are serious and unacceptable and have called for an immediate ban on aerial spraying or even on all pesticide use.

Spokesmen for the cotton industry expressed the view that there is considerable public misunderstanding about the use of pesticides. In particular the industry feels that the public is misinformed about the quantities used and about their short and long term affects on the environment and on health.

In addition to the actual use of pesticides, the disposal of the empty containers is an issue in its own right. Most empty containers are disposed of by farmers or aerial operators on their own properties. This has led to criticism of the methods used and concern has been expressed that inappropriate disposal methods can allow pesticide residues to escape into the environment and lead to pollution of soil and water courses.

Cotton farmers interviewed generally expressed the view that they are responsible about container disposal. However several felt that disposing of containers themselves on their own properties was not ideal, but argued that they had no alternative disposal strategies open to them as Local Authorities will often not accept these wastes.

Soil Degradation

There are many forms of soil degradation that can occur as a result of agricultural land use. These include soil compaction and erosion. None of the recent television news items, that were reviewed, covered soil degradation as a cotton farming related environmental issue, neither has it been dealt with in any detail by the local or national press.

In contrast many of the interviewees and questionnaire respondents with a direct involvement in the cotton industry considered soil compaction to be a genuine environmental issue, although not the main issue facing the industry. Soil compaction is seen as an important issue, but one which is largely preventable and treatable.

Water Use

As a major water consumer the cotton industry has been criticised for diverting water resources from other water users and from downstream wetlands. Media attention paid to water use has been limited although some concern has been expressed over the impact of water abstraction on wetland habitats.

There is also significant concern, expressed by people within the industry as well as government officials and non industry members as to the disposal of water after it has been used for irrigation on some farms. Flood irrigation invariably entails a certain amount of surplus water (tail water) running out of the field at the bottom of the cotton rows. This water is often contaminated by traces of pesticide remaining on the soil surface and plant stems and, if allowed to return to natural water bodies, can cause pollution problems including fish kills.

Release of contaminated tail water into rivers and other natural water bodies is more or less universally recognised as a serious potential problem but there is dispute over the extent to which it actually occurs. Critics allege that tail water release is widespread and persistent whilst industry spokesmen suggest that it is the exception rather than the rule.

Habitat Loss

The clearance of native natural and semi-natural vegetation for cotton farming operations can result in the removal and loss of natural and semi-natural habitats. Very little attention appears to have been given to this issue either by the media or the environmental campaigners. The issue was not dealt with in any significant detail by any of the filmed documentaries, televised news items, or press cuttings reviewed.

Cotton Processing

Cotton processing (ginning and seed processing) does not appear to be widely viewed as causing environmental problems. Occupational health and safety is the principal issue facing cotton processing plants but, whilst this is recognised as an area of concern by the relevant government departments, it appears not to be seen as an important issue beyond the factory gate.

Potential hazards to worker health and safety are considered to include high noise levels, affecting hearing, high dust levels affecting respiratory function and, as in any industrial activity, the risk of accidents.

Seed processing entails the use of pesticides and is therefore associated with some of the issues surrounding pesticide use on cotton farms, notably disposal of pesticide containers and waste pesticide.

CHAPTER 3 PESTICIDES

CHAPTER 3 CONTENTS

3.1 INTRODUCTION

The cotton industry in Australia, as in most parts of the world, is heavily reliant upon the use of chemical pesticides. Pesticides are used to control both insect and weed pests; in addition chemical defoliants are also applied to the cotton crop prior to harvest to facilitate picking. Although, strictly speaking, defoliants are not pesticides, they are considered in this chapter as they involve many of the same issues.

In the absence of control, cotton is a host to a wide array of insects and other invertebrates which can seriously reduce yields or even destroy the crop; chemical insecticides have become the main tools used to reduce or eliminate these potential losses. Four species are of particular importance in Australia because of their prevalence and their capacity to damage the crop. These are the two heliothis species, native budworm (*Heliothis punctigera*) and cotton bollworm (*Heliothis armigera*), the spider mites (*Tetranychus* spp.) and the cotton aphid (*Aphis gossypii*). A further thirty odd species are of lesser importance because of their more sporadic occurrence (see Appendix 3).

The majority of the chemicals used on cotton are insecticides and of these the most heavily used is the organo-chlorine endosulphan (commercial names: Thiodan®, Endosan®, Vermosca®). Endosulphan is used to control both *Heliothis* species as well as a variety of other pests. Endosulphan is applied either as an emulsifiable concentrate (EC) or as an ultra-low volume (ULV) formulation at a rate of 735g active ingredient per hectare. DDT was formerly the most important pesticide used to control *Heliothis* but is no longer used as the pest developed resistance to it and its continued use was banned because of problems of persistence and bio-accumulation. After endosulphan the next most widely used insecticides are the synthetic pyrethroids, followed by the organophosphates and carbamates. Piperonyl butoxide (PBO) is used as a synergist with pyrethroids to overcome pyrethroid resistance in *Heliothis armigera*. A list of the most widely used insecticides is given in Appendix 4 and typical application rates are given in Appendix 5.

Weed control is also necessary for successful cotton production as weed populations can reduce yields through competition with the crop, reduce harvesting efficiency and act as reservoirs for diseases (eg verticillium wilt) and insect pests. Pre-emergence herbicides are the principal tools used to control weeds although inter-row cultivation and hand weeding are also important after the emergence of the crop. Post emergence spraying is carried out but the susceptibility of the cotton crop to many herbicides limits its use.

The range of herbicides used on cotton is rather restricted. As noted above pre-emergence herbicides are the most important and four account for the bulk of current usage. These are fluometron, diuron, prometryn and trifluralin. Organic arsenicals, MSMA and DSMA are used as post emergent herbicides but may only be used as directed sprays (ie directed at the weed and away from the crop) because of their phytotoxicity to cotton and must not be used after the appearance of the first flowers because arsenic residues are left in the seeds. Weed control on fallows and seed beds

is sometimes achieved using glyphosphate (Roundup®) or paraquat (Sprayseed®) although cultural control is also important. 2,4-D may sometimes be used to control difficult weeds six weeks or more prior to planting cotton.

Defoliants are applied to the crop shortly before harvesting and, as their name implies, their purpose is to cause the cotton bushes to shed their leaves. The purpose of this is to facilitate harvesting and ginning of the cotton by reducing the proportion of trash picked up with the cotton bolls. A variety of different types of product are used, with different modes of action. These include sodium chlorate which is caustic on all green parts of the plant and ethephon which releases ethylene, a plant hormone which stimulates the formation of abscission layers. A list of defoliants used on cotton in Australia is given in Appendix 6.

The use of pesticides, particularly insecticides, is undoubtedly the most controversial aspect of the Australian cotton industry. All of the questionnaire responses received identified pesticide use as an issue in one respect or another. Many critics of the industry believe that the overall quantities of pesticide used are excessive and furthermore that the pattern of use gives rise to a number of threats to community health, wildlife and the continued productivity of the land. These criticisms are generally refuted by the industry itself. Specific issues relating to pesticide use are discussed in each of the following sections.

3.2 APPLICATION OF PESTICIDES

Environmental issues relating to the application of pesticides are discussed below:

3.2.1 Environmental Issues Relating to the Application of Pesticides

(i) Spray Drift

The aerial application of pesticides is a contentious issue and many questionnaires and interviews referred to this aspect of pesticide use. The main concern is the potential for the spray to drift off-target. Spray drift is of concern because it can expose local communities and non-target fauna and fauna to hazardous chemicals. Both the extent to which drift occurs and the hazards that this then imposes on community health, neighbours crops and natural habitats and wildlife are disputed. A further problem associated with drift is the unpleasant odour produced by certain insecticides.

(ii) Community Health

Opponents of the industry argue that spray drift is a chronic problem which will always occur as long as aerial spraying occurs and that a number of serious health problems occur as a result. The most serious health problem alleged is an increased risk of developing leukaemia and other cancers in the cotton growing areas but it is also alleged that allergies, asthma and other complaints are also caused or aggravated by pesticide exposure occurring as a result of spray drift. On the other side people involved in the industry refute the health risks and maintain that significant spray drift occurs very infrequently because of the high standards of application.

(iii) Occupational Health

A second health issue associated with the application of pesticides concerns the occupational health and safety of people working within the industry. The most direct exposure to pesticides is likely to be experienced by the people working most closely with them. This includes mixers and fillers, markers and to a lesser extent pilots amongst the aerial operators employees. After a paddock has been sprayed various field workers are also potentially at risk of exposure to pesticide including agronomists, insect monitors, chippers and irrigation workers.

(iv) Effects on Flora and Fauna

In addition to the possible health risks associated with the application of pesticides it is also alleged that their use can lead to an impoverishment of the fauna and flora of the area. Concern is particularly focused on rivers and lakes. There have been a number of well publicised fish kills and there is controversy over the extent to which cotton

pesticides or other causes were responsible for these. It is feared by opponents to the industry that the fish kills are a symptom of a less obvious and more insidious attrition of aquatic ecosystems and that pesticide residues, will persist in the environment and possibly bio-accumulate within the food chain with ultimately catastrophic effects.

(v) Quantity of Pesticides Used

The quantity of pesticide used is also an issue; opponents of the industry believe that the quantities used are excessive and that this exacerbates other problems associated with spraying and furthermore "kills" the land. Within the industry there is also pressure for reduced spraying because of the need to keep costs down.

(vi) Insecticide Resistance

The development of pesticide resistant strains amongst *Heliothis* and other pests is an important issue facing the industry. This is a low profile issue amongst the public but is seen as an important priority by growers and by the research organisations servicing them. Ostensibly this issue is not so much an environmental problem as an economic one affecting the viability of the industry. However, the classic response to pesticide resistance, wherever it has occurred around the world, has been to use ever increasing quantities of pesticide in the frantic attempt to achieve control and this does have environmental implications. Furthermore many of the pests which affect cotton also affect other crops.

(vii) Pesticide Mixtures

The mixing of two or more pesticides in the sprayer tank is a practice which can save growers on application costs and can lead to more effective weed control. Mixing of certain products in this way is explicitly permitted by compatibility statements on their product labels (which outline the registered uses of a product and constitute legal documents - see section 3.2.2) and indeed some products may be designed to be used in this way. However, the mixing of chemicals without proper guidance could potentially lead to uncontrolled chemical reactions with implications for the environmental safety of the resultant mixture. This has not been highlighted by third parties as an issue affecting the cotton industry but was nevertheless considered to be a potential problem during the present study.

(viii) Noise

Finally, although it is not a chemical issue, noise caused by crop spraying aircraft is a significant issue with a high public profile. Noise is the cause of a greater number of complaints concerning aerial pesticide application than spray drift or odour problems. This is partly related to the practice of spraying at night.

3.2.2 Legislation and Controls Relating to the Application of Pesticides

(i) Registration of Chemicals

All pesticides in use in Australia must first have received clearance from the government. This clearance occurs at two levels. Initially the manufacturer must satisfy the National Health and Medical Research Council (NHMRC) that the product is safe to use. During the development of the product extensive safety studies are carried out. These include studies to determine the environmental fate of the product and its metabolites (breakdown products) under likely patterns of use (for example do residues persist in the soil or accumulate in the fatty tissues of animals?) and toxicological studies on a wide range of taxa to assess the risk of acute or chronic (including carcinogenicity and birth defects) effects on species other than the target organism. The NHMRC reviews the data from these studies before approving the use of the chemical.

The safety studies are conducted by the manufacturer and, in the case of imported products, may not all be carried out within Australia. The reliability of the data is controlled by the requirement that the studies are conducted in laboratories that comply with internationally monitored standards of good laboratory practice.

After a pesticide has been approved at the Commonwealth level by the NHMRC it must then be cleared for use by the State governments for use within each State. In New South Wales this clearance is given when the product is registered under the Pesticides Act (1978) by the Pesticides Registrar within the Department of Agriculture and Fisheries. In Queensland registration is given under the Agricultural Standards Act (1952 - 1981) by the Registrar in the Department of Primary Industries.

In both States registration only permits use of the chemical in a prescribed manner. The permitted uses and conditions of use are set out on the product label which has the force of a legal document. The label defines which pest or pests and crops the product may be used on, the rate at which it should be applied (in Queensland it is permissible to use a pesticide at less than the rate specified on the label) and any other conditions such as withholding periods (ie the interval which must lapse after spraying a product before that product can be eaten or marketed). It is an offence in both States to use a pesticide in a manner contrary to the label instructions or to remove or deface the label on a pesticide container.

(ii) Application of Pesticides

The application of registered pesticides, particularly from aircraft, is principally controlled under the Pesticides (Amendment) Act (1985) in New South Wales and, in Queensland, under the Agricultural Chemicals Distribution Control Act (1966 -1983). These acts make provision for the licensing of pilots and operators, record keeping and insurance and the investigation of off-target complaints. The Agricultural Chemicals Distribution Control Act in Queensland also provides for the designation of "chemical control areas" where the use of certain pesticides (notably certain herbicides) is restricted or banned because of the threat to neighbouring crops.

A number of other acts are relevant to the application of pesticides and particularly to pollution events. Of these the most important are the Clean Waters Act (1970) and the Clean Air Act (1961), administered by the State Pollution Control Commission in New South Wales and the Clean Waters Act (1971 - 1981) and the Clean Air Regulations (1982), administered by the Water Quality Council and the Air Pollution Council respectively in Queensland. Offenses under these acts can attract heavy fines; for example breaches of the Clean Waters Act in New South Wales can be punished with fines of up to $40,000 for a corporation and $20,000 for an individual.

Forthcoming legislation in New South Wales (Environment Bill 1991) will rationalise the legal controls concerning pollution control with the creation of a new Environmental Protection Agency which will encompass many of the separate laws and government bodies currently in place. It is anticipated that this agency will be better funded than the bodies that it will bring together are at present.

(iii) Occupational Health and Safety

The health and safety of employees working with pesticides is covered by the Work Place Health and Safety Act (1937 - 84) in Queensland and the Occupational Health and Safety Act (1983) in New South Wales, administered respectively by the Queensland Department of Health and the New South Wales WorkCover Authority.

(iv) Voluntary Controls

In addition to legal controls on spraying the cotton industry also operates several self regulation schemes and codes of practice. The Aerial Agricultural Association of Australia (AAAA), the professional association for aerial crop sprayers is currently establishing a scheme called "Operation Spray Safe" which aims to raise standards within the industry.

The cornerstone of Operation Spray Safe is the education and accreditation of pilots and operators. Accreditation is voluntary and over and above the statutory licensing required. Pilots are required to sit an examination based on the Operation Spray Safe manual which covers all aspects of the safe application of agrochemicals from aircraft. Accredited operators must employ only accredited pilots and must demonstrate that they have suitable facilities and procedures for handling pesticides. Accreditation is subject to annual review and in the future will involve regular site inspections by an officer of AAAA.

The only formalised voluntary control affecting pesticide use by growers is the Pyrethroid Strategy. This scheme was introduced as a response to concern that the major pests of cotton might develop resistance to the available pesticides and in particular the synthetic pyrethroids. The strategy aims to control the way in which pesticides are used in order to minimise the chances of selecting for resistant strains of *Heliothis armigera*. Compliance with the Pyrethroid Strategy is voluntary and depends upon peer pressure amongst growers.

3.2.3 Industry Performance Relating to the Application of Pesticides

The following sections summarise the evidence concerning the performance of the Australian Cotton industry in relation to the application of pesticides:

Spray Drift

Spray drift can occur in a number of different ways depending upon atmospheric conditions and the product and formulation being used. Some drift or movement of the spray off-target is probably inevitable but the likelihood of significant quantities of pesticide travelling any distance away from the target is strongly influenced by the conditions prevailing at the time of spraying.

As a result of a considerable body of research, within Australia and overseas, the application conditions which minimise the extent of off-target drift are well known. Insecticides are typically applied as 'ultra-low volume' formulations with small droplets. For these a moderate wind strength is required (which should be blowing away from dwellings or other features which might be adversely affected if exposed to spray drift). Under these conditions air turbulence just above the crop canopy has the effect of sweeping the spray droplets into the canopy where they are intercepted. Inversion layers, light and variable breezes or conditions likely to produce thermal updraughts should be absent as these can all lead to the spray cloud moving upwards through the air and drifting in unpredictable directions.

Herbicides and defoliants are usually sprayed, using larger droplet sizes and for this purpose slightly different conditions are required, notably lower wind speeds.

The AAAA Operation Spray Safe pilot training covers the factors affecting the behaviour of spray clouds produced by agricultural aircraft and how these should affect decisions about when and how to spray. According to the AAAA training has been successfully completed by 70% of the crop spraying pilots operating in the cotton growing areas and efforts are being made to increase this proportion.

The general impression obtained was that the majority of aerial operators and their pilots are aware of what constitute inappropriate conditions for spraying and responsible about not spraying when these prevail. However some interviewees felt that a small percentage of operators were poor performers and that the faults of these included occasionally spraying when conditions were marginal. One critic of the industry believed that the majority of operators were unprofessional with very low standards and another believed that spraying often occurred when conditions were unsuitable.

Spray drift into towns and other areas where its occurrence is undesirable has undoubtedly occurred on occasion although there is little or no scientific data yet available to indicate the frequency with which this occurs or the chemical concentrations which are experienced. There have, however been complaints filed with various regulatory authorities (Whyte and Conlon 1990) concerning drift and, on occasion, gardens and trees have been affected by defoliants (Stollznow Research 1990).

Except in cases where herbicide or defoliant has caused visible damage to plants it is usually impossible to substantiate these complaints after the event. The Queensland Department of Primary Industries have appointed a spray monitor in Emerald who is monitoring the occurrence of pesticide drift at various stations throughout the town. The publication of the results of this study will provide valuable information on this issue.

A limited amount of data are available from the Emerald Childhood Leukaemia Enquiry, during which air sampling was carried out at four sites around the town in December 1986 - January 1987. This indicated that endosulphan was detectable within the town on most days after spraying had occurred but at very low levels, generally less than 0.1 $\mu g/m^3$ and between two and three orders of magnitude lower than the Threshold Limit Value for endosulphan of 0.1mg/m^3 (Donald 1987). Two other pesticides were detected at very low levels and much less frequently than endosulphan; methomyl (sprayed on cotton in conjunction with endosulphan) and malathion (used in Emerald to control mosquitoes).

These data suggest that drift of minute traces of pesticide over significant distances does occur regularly but it should be stressed that the detection of pesticide does not imply that harmful quantities are present. The Emerald Enquiry concluded that exposure at the levels detected over the three month spraying period of the year would be highly unlikely to produce any adverse health effects (Donald, 1987).

It is argued by growers and others associated with the industry that many of the "spray drift" complaints are triggered by odour drift and are not actually cases of pesticide drift. Some organophosphate pesticides, such as profenofos, give off strongly smelling mercaptans as they break down after application. These mercaptans are very mobile and can drift long distances. Since they are released after the pesticide has been applied there is no way of controlling the direction of this drift. Although they pose no health problem themselves, the smell of mercaptans is widely but erroneously perceived to indicate exposure to pesticide. The smell is unpleasant, however, and constitutes a public nuisance problem in its own right.

Research has been conducted which has demonstrated that spray drift clouds can be effectively trapped by vegetation (Harden and Woods 1990). This research shows that a screen of trees or other tall vegetation can greatly reduce the quantity of spray particles in an air current passing through it. It is important however that the screen has sufficient porosity to air currents otherwise the entire spray cloud can be swept over the top of the screen. This work has obvious practical implications and these have been put into practice in Emerald with the 'Tree line' project.

Community Health Effects

The most significant evidence to date that pesticide use might be causing serious health problems in the cotton growing areas has been the Emerald leukaemia cluster. Between 1980 and 1985 eight children who had lived for part of their lives in Emerald were diagnosed as having leukaemia. Taking the all Queensland rate as the 'normal' rate of

occurrence for childhood leukaemia, this rate of occurrence was approximately 13 times what would be expected in a community of the size of Emerald and the probability of so large a discrepancy between the observed and expected frequencies was calculated at 0.000004 (Donald, 1987).

The proximity of the Emerald irrigation area to the town, its great expansion just before the first of the 8 leukaemia cases was diagnosed and the high profile use of insecticides on cotton were taken as circumstantial evidence that the cluster was possibly pesticide linked. The cluster was subsequently widely perceived, particularly by the public and the media to have been caused by cotton spraying.

An Enquiry was conducted to investigate the scientific basis for these fears (Donald 1987) but it was unable to find conclusive evidence for any causal factor including pesticide use. This may have been because the very small numbers of people involved made it impossible to detect any differences between leukaemia cases and control cases by statistical analysis. The Enquiry did conclude that the current level of contamination (air and water) by agricultural chemicals was "unlikely to pose a significant [health] risk over a prolonged period". However, it did recommend that pesticide contamination should be kept to a minimum and proposed a number of measures to achieve this.

Concern about links between cancer and pesticide usage has also been fuelled by the occurrence of 4 cases of neuroblastoma in children in the cotton growing areas of New South Wales (3 in Moree and one in Narrabri). As with the Emerald leukaemia cluster, the link with pesticide usage is circumstantial and conclusive evidence that this cluster is anything other than a statistical anomaly has not yet been produced. This form of cancer is known to sometimes occur in clusters (eg within families) but has not previously been reported in association with pesticides. The cases are being investigated by the New South Wales Department of Health.

Population monitoring in six cotton growing shires in New South Wales (Clarke 1990) did not detect any increase in the rate of leukaemia compared with other parts of the state and found the incidence of cancer to be generally low, in line with other rural areas. The same study also found that rates of congenital abnormality were low in these shires compared with other parts of the State and with Australia as a whole.

The extent to which pesticide related asthma, allergies and other health disorders may occur within cotton growing areas is difficult to assess objectively because medical records have not previously been maintained in a manner which facilitates investigation of the issue. The Agricultural Health Unit at Moree is currently addressing this problem (Clarke 1990).

Health officials interviewed indicated that there are not currently any strong grounds for believing that cotton industry pesticide use is having a significant adverse effect on community health (though more monitoring is required) but occupational health of cotton industry workers may be at some risk.

Occupational Health Risks

Occupational exposure to pesticides in the cotton industry is most likely to occur primarily amongst workers applying the chemicals (especially mixer/fillers and markers for aerial operations) and workers employed in the crop fields themselves after pesticides have been applied (especially bug checkers and chippers). For workers involved in the application of chemicals, avoidance of exposure is primarily achievable through the use of appropriate clothing and safety equipment and the use of careful methods to avoid spillage or splashing of chemicals. For field workers avoidance of exposure involves the use of appropriate clothing and the avoidance of fields during and for an appropriate period after spraying operations.

Site visits to farms and to aerial operators bases indicated that the use of clothing and safety equipment was not rigorous. Occupational exposure to pesticides is generally dermal (ie across the skin rather than through ingestion or inhalation) and it has been demonstrated that wearing long sleeved and trousered cotton overalls can greatly reduce exposure levels in workers using pesticides (Davies et al., 1982). In spite of this, it was observed that workers in the two areas of employment at risk tended to wear shorts and t-shirts. This is clearly related to the hot weather prevailing during the cotton spraying season but it is notable that the study of Davies et al. (1982) was conducted in Florida in hot and humid conditions. Several workers participating in that study stated that they found the cotton overalls more comfortable than their own clothes.

Conversations with workers indicated that, although masks and other safety equipment were provided, they were often not used because they were considered uncomfortable in hot weather. Workers were also seen using other potentially hazardous chemicals such as anhydrous ammonia without adequate protective clothing and equipment.

All growers interviewed indicated that they kept workers out of fields after spraying until re-entry periods expired. The length of these re-entry periods varied between growers (from "as soon as the product is dry" to 72 hours) but was generally about 24 hours. Re-entry periods seemed to be arbitrarily decided upon and apparently no guidance is provided on product labels for most pesticides.

Blood testing services are provided for agricultural workers by the health services and by the WorkCover Authority in New South Wales to test for cholinesterase inhibition, a symptom of organophosphate and carbamate exposure. Testing focuses on these pesticides both for practical reasons (endosulphan has a short half life in the blood and so it is necessary to take and analyse samples very rapidly after exposure to be sure of detecting it) and because these are the groups of pesticides which pose the most significant threat. Organophosphate and carbamate pesticides interfere with nerve function by suppressing the enzyme cholinesterase and depending on the dose and the exact chemical in question can produce a range of symptoms and in serious cases major illness or death.

The tests are voluntary as compulsory blood testing is opposed in some quarters on civil liberty grounds. Ideally workers are tested at the start of the season to provide a baseline level and then re-tested immediately after working with or near to pesticides. Unfortunately rather few workers avail themselves of the service especially as it can entail travelling long distance to testing centres at busy times of year. An interview with the New South Wales WorkCover Authority suggested that as few as 1% of workers are tested.

Results of the testing indicate that between 5 and 10% of workers tested have been exposed to pesticide (Clarke and Leatherman, 1989; personal communication from government interviewee). It was suggested, however, that the actual incidence may be higher as the sample of workers tested might be biased towards the more concerned workers who are likely to take precautions to prevent being contaminated. The Agricultural Health Unit at Moree and the WorkCover Authority both indicated that they had significant concerns over the occupational exposure of these types of workers to agricultural pesticides.

Chippers frequently complain of skin rashes but the opinion of medical personnel interviewed was that the symptoms displayed were generally more consistent with plant induced rashes than with pesticide poisoning.

A number of people interviewed made the point that occupational exposure to pesticides would be increased by a general switch to ground rig spraying from aerial spraying, as many more people would need to be employed to get the job done as the method is so much slower. This would also mean that there would be greater pressure on growers to spray when conditions were not ideal, increasing the risks of community exposure and other off-target drift problems. The number of people involved would also make it difficult to regulate.

The interviewee from WorkCover Authority (New South Wales) stated that during the period when there was compulsory urine testing of workers using chlordimeform, ground rig operators were found to have a higher incidence of exposure than aerial spray crews (including the ground staff).

Although comparisons have not been made between ground rig and aerial operators for other chemicals this result demonstrates that ground spraying is not necessarily inherently safer than aerial spraying.

Effects on Flora and Fauna

The most frequent complaint concerning the effect of pesticides on fauna and flora is the periodic killing of fish which has occurred in several of the rivers in cotton growing areas. It appears that the usual route by which pesticide enters rivers is through the release of contaminated irrigation water and that spray drift is relatively unimportant (possibly partly because riverside trees are effective at screening out spray clouds). For this reason this issue is dealt with primarily in the next section on water use. One fish kill, which occurred in Moree, whilst the audit team were still in Australia, was alleged to have been caused by over-spraying but at the time of writing this has not been confirmed.

Other evidence of direct impacts of pesticide spray on flora and fauna is extremely limited. Many of the insects and plants present within the cotton crop itself are obviously destroyed making these areas extremely poor habitats but it is not clear that significant adverse effects are caused in adjacent habitats. A variety of wildlife was seen in or near to cotton farms demonstrating that these areas are certainly not "dead", as claimed by some critics, but no comment can be made as to changes in the diversity or abundance of wildlife as data are not available.

The effects of endosulphan on a range of different taxa have been extensively studied in Africa where it is used to control tsetse fly, an important vector of human and livestock diseases . These studies (reviewed in Whyte and Conlon 1990) demonstrate the extreme vulnerability of fish to this pesticide but show mammals and birds to be tolerant to it at levels likely to be produced within the environment. Invertebrates vary in their sensitivity and this does give rise to a degree of selectivity. One of the advantages of endosulphan for Australian cotton growers is that, at the rate at which it is applied, control of the pest is achieved but beneficial predatory insects survive and so there is no "flaring" of secondary pests (N. Forrester pers. comm.).

Studies in Africa have revealed indirect effects of endosulphan in some cases, such as the depression of breeding success in little bee-eaters because of reduced prey availability (Douthwaite 1986) but in others found insectivorous passerines to be unaffected (Douthwaite 1980). Use of endosulphan and other insecticides on Australian cotton could potentially have similar indirect effects on insectivorous birds (and other insectivores). However the relevance of the African studies to Australian is limited by differences in the pesticide application techniques used in the two places. To achieve tsetse control in Africa, operators aim to cause very fine droplets to drift over extremely wide areas of country in order to knock down flying insects.

By contrast the aim on Australian cotton is to control non-flying, larval insects and the spray is aimed at the crop only and every attempt is made to limit drift. For this reason tsetse control has much greater potential to affect local populations of insectivores, particularly aerial insectivores such as bee-eaters and swallows.

Although used less than endosulphan, pyrethroids, organophosphates and carbamates are all used in significant quantities (see Appendix 5) and could potentially affect non-target organisms directly. In particular many of the organophosphates are moderately to highly toxic to a wide range of taxa including birds and mammals; parathion, for example, has been associated with bird kills in the United States (Smith, 1987). It should be stressed however that toxicity alone does not imply that environmental problems will occur; the likelihood with which non-target organisms will experience concentrations at or above harmful levels is clearly of critical importance. At present there is no evidence that the use of any of these pesticide groups has caused any environmental problems in cotton growing areas (Whyte and Conlon, 1990). One interviewee claimed that on one occasion spraying of an un-named pesticide resulted in "literally thousands of dead and dying birds" but no evidence was found to corroborate this claim.

Whyte and Conlon (1990) did not consider that significant environmental damage was caused by the use of herbicides or defoliants on cotton although they stressed that very little research has been conducted into this issue. Complaints about damage to gardens by defoliants or herbicides (Stollznow Research 1990) suggest that on occasion some damage to natural plant communities may occur. However, the lack of reports of any such events suggests that if they do occur they are unlikely to be extensive or permanent in effect. No evidence of chemically stressed vegetation in natural habitats nearby to cotton fields was observed during any of the site visits.

A major concern with any pesticide is whether or not residues persist and whether bio-accumulation occurs. Bio-accumulation refers to the inability of organisms to metabolise or expel chemical residues from their body tissues so that repeated ingestion results in an increase in the levels present in the body tissues. Consequently, the concentrations of pesticide can rapidly increase along a food chain and even when general environmental concentrations of a chemical are low, high concentrations may be found in the body tissues of top predators. This can have severely disruptive consequences for populations of predators through impacts on breeding success and survival rates. The pre-marketing safety testing of modern pesticides has included assessment of whether or not these phenomena are likely to occur since problems with DDT in the 1960's and 70's and most countries will not register new products which show any tendency to bio-accumulate.

Studies carried out in Africa (Matthiessen et al. 1982) have sampled predators such as crocodiles, fish eagles, cormorants and insectivorous birds in areas where endosulphan had been sprayed up to 12 months previously and found no evidence of endosulphan bio-accumulation. In Australia, Llewellyn et al. (1987) sampled mammals, birds, reptiles and amphibians in the Namoi and Gwydir valleys nine months after the last endosulphan sprays and found no traces of endosulphan residues; this also suggests that endosulphan is non-persistent and that bio-accumulation does not occur.

Nowak (1990) sampled catfish *Tandanus tandanus* in the Gwydir River in two summer (spraying) seasons and one winter season and detected endosulphan residues in each season, demonstrating that residues can persist for several months at least in an aquatic environment. She suggested that the residues present in the winter fish may have been the result of endosulphan persisting in sediment layers and then being released to the water column after flooding or similar agitation.

Nowak (1990) found that the concentration of pesticide residues in the fish sampled in the second summer was significantly higher than in the first summer and that there was no statistically significant difference between the levels detected in the first summer and the winter. She tentatively suggested that this might indicate an increase in endosulphan residues from year to year. Alternative explanations are probably more plausible, however, including that offered by Nowak herself that the fish sampled in the second summer were fatter and that endosulphan residues were significantly correlated with fat levels. These data do not suggest that bio-accumulation of endosulphan is occurring.

Quantities of Pesticide Used

Claims that the quantities of pesticide used are excessive need to be assessed in the light of evidence that they are causing adverse environmental impacts. Evidence for adverse effects on community and occupational health and on flora and fauna is discussed above. It is also claimed by some critics of the industry that the heavy pesticide load is "killing" the soil. No direct evidence for this claim was obtained, however. Cotton yields have been recorded over the years that cotton has been an established industry and the records indicate a general improvement in yield over this period, a fact which is not consistent with the "killing the land" hypothesis. It is conceivable that, at some point in the future, yields could begin to fall but there is no evidence of this at present.

Many critics of pesticide use on cotton advocate integrated pest management (IPM) as an alternative to dependence on chemicals or at least as a means of reducing the quantities used. IPM can include the use of pesticides but is essentially the integration of a variety of control methods. A key feature of IPM is the idea that the grower does not need to apply artificial control methods as soon as (or even before) the pest species is detected in the crop but only when pest populations pass threshold levels at which crop losses exceed the costs of control. Predators occurring naturally within the crop are first given the chance to control the pest. In addition to chemical controls alternative methods such as biological control and cultivation techniques are also used to prevent pests passing threshold levels.

The Australian cotton industry has in fact used a system of IPM since the late 1970's. The SIRATAC system was developed by the CSIRO and the New South Wales Department of Agriculture as a computer based pest management system. This system was designed to take advantage of natural pest mortality, used "soft" pesticides (ie those that kill the target pest and a minimum of other species) as much as possible and depended upon regular and close monitoring of the crop and its pests. SIRATAC was marketed to growers by a company specially set up for the purpose. The scheme was widely taken up by growers but eventually failed as a commercial venture.

Although SIRATAC Ltd was not a commercial success, many of the pest management principles it enshrined continue to be used. All of the growers and consultants interviewed confirmed that their pest control was based upon monitoring of insect populations and spraying when thresholds are passed, as opposed to prophylactic spraying. However some interviewees believed that there is now a tendency for a small number of growers to spray by rote.

Some interviewees suggested that some of the assumptions of the SIRATAC model had been incorrect and that this limited its usefulness and possibly increased the number of sprays applied to a crop by extending the length of time it was standing in the field and therefore vulnerable to attack from insects. The issue of the role of "earliness" as a means of coping with pest pressures is currently the subject of considerable debate within the industry. This method involves producing a crop which is ready for harvest early, thereby reducing exposure to insect attack (particularly during the mid to late season

peak in *Heliothis armigera* numbers); the means of achieving earliness (ie through cultural methods and the use of fast maturing varieties or through the prophylactic use of insecticides to prevent any damage to the earliest formed bolls) is also subject to debate.

An updated system the "ENTOMOLOGIC" program has been proposed. This is an upgraded threshold system which encompasses a higher definition of pest/predator threshold than its predecessor SIRATAC.

The use of alternatives to chemical pesticides as part of an overall pest control strategy is also practised in the Australian cotton industry. Some techniques are widely used such as the planting of Okra leafed cotton varieties. Such varieties are less attractive to mites and to *Heliothis*, and allow better penetration of sprays into the canopy thereby giving better control and allowing the quantity and frequency of pesticide spraying to be reduced. Other techniques are less widely applied. These include the use of *Bacillus thuringensis*, *Trichogramma* wasps (a group of wasps which parasitise and ultimately destroy the eggs of moths) and mating disruption techniques (reducing the ability of male moths to locate unmated females by swamping the females pheromone scent with large quantities of synthetic pheromone).

Researchers interviewed argued that field trials of these methods have indicated that whilst they can contribute to a reduction in pest numbers none is sufficient on its own to achieve pest control. Mating disruption, for example, is undermined by the great mobility of *Heliothis*; disruption may occur locally but already mated females fly in from other areas and lay their eggs unhindered. The most promising of the alternatives is perhaps *Bacillus thuringensis* (Bt); new commercial formulations of this bacterium appear to offer good control when applied with endosulphan, allowing a halving of the rate at which the chemical is applied.

Despite the limitations of alternative control methods it was believed by many of the people interviewed that further development of such techniques is desirable. The reasons given for this included the environmental desirability of reducing the amount of chemical used and the desirability of having a multi-armed strategy for managing pesticide resistance. For growers, the possibility of reducing expenditure on pest control is also important. Research into these and other alternative pest control methods is ongoing and results are presented at the biennial Cotton Growers Conferences.

Insecticide Resistance

Resistance of pests to insecticides has been a recurring phenomenon in cotton farming and there are a number of well documented cases in different parts of the world where cotton production has collapsed or been severely reduced for this reason. Places where this has occurred include the Cañete Valley in Peru in the 1950's, the Ord River Scheme in Western Australia in the 1970's, the Rio Grande in Texas, Nicaragua and Thailand. Resistance of *Heliothis armigera* to pyrethroid insecticides was noted in New South Wales and Queensland in the early 1980's and, concerned at the potential loss of this valuable

group of insecticides, the New South Wales Department of Agriculture and Fisheries introduced a resistance management strategy (the "Pyrethroid Strategy" - see Appendix 7). This strategy which also aims to control resistance to other pesticides has been pursued since the 1983 - 84 season.

The scheme depends upon a high level of compliance amongst growers as *Heliothis* moths are very mobile and if resistance develops on one farm can rapidly spread to others through out- migration, thereby undermining the strategy. In spite of this, compliance with the strategy is entirely voluntary and depends upon peer pressure and growers recognising their own long term interests. Interviews with growers, consultants, extension workers and researchers indicated that the scheme has been highly successful from this point of view and compliance with the time 'windows' for the use of different classes of insecticide is virtually total.

Since the strategy was first implemented researchers at the New South Wales Department of Agriculture and Fisheries Research Station at Myall Vale have monitored *Heliothis* resistance to pyrethroids in the principal cotton growing areas (Forrester 1990). The results of this monitoring in two areas are shown in Figure 5. These graphs indicate that in each year the percentage of pyrethroid resistant individuals in the population increases during stage two (the pyrethroid stage) of the season but the use of non pyrethroid pesticides in stage three reduces this percentage so that low levels of resistance are experienced again by the beginning of the following season.

However the graphs also reveal that the percentage of resistant individuals at the end of stage two has increased steadily over the years and peak resistance levels above 70% are now being experienced. As a corollary to this, there has been a gradual increase in the levels of resistance experienced at the beginning of each season and a very rapid rise in pyrethroid resistance is now experienced each season during the second stage of the season when pyrethroids are actually in use.

These data demonstrate that the strategy has been successful in postponing resistance but has not eliminated the problem. The use of Piperonyl Butoxide (PBO) as a synergist with pyrethroids has successfully overcome the high levels of resistance recently experienced in the late stages of the stage two window as shown in Figure 6. Whilst PBO enables resistance to be suppressed effectively at the moment there are fears that *Heliothis armigera* could eventually develop resistance to the PBO-pyrethroid mixture. For this reason the Pyrethroid Strategy allows the use of PBO only once a season on the second spray in the pyrethroid window.

Endosulphan resistance has also been monitored but there does not appear to be any across year trend towards increased resistance (Figure 7).

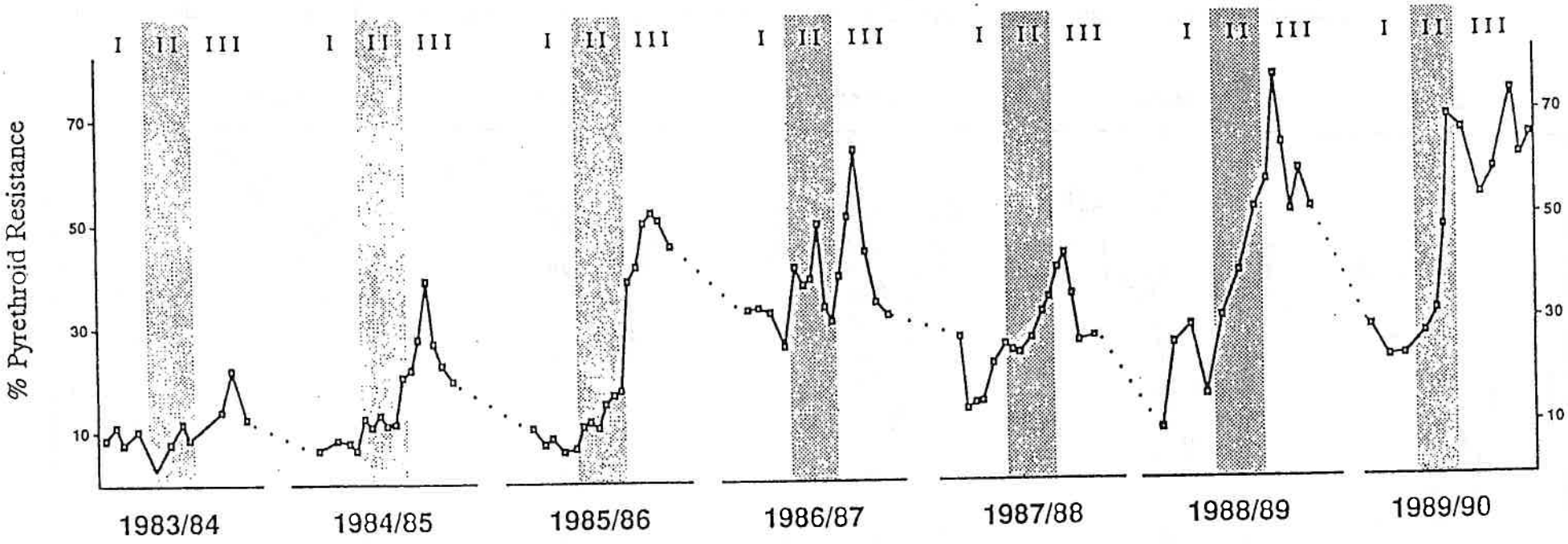


Figure 5 (a). Annual and within season variation in the levels of pyrethroid resistance in field populations of *Heliothis armigera* in the Namoi/Gwydir area. Succesive stages of the Pyrethroid Strategy are indicated within each year.

Reproduced from Forrester (1990).

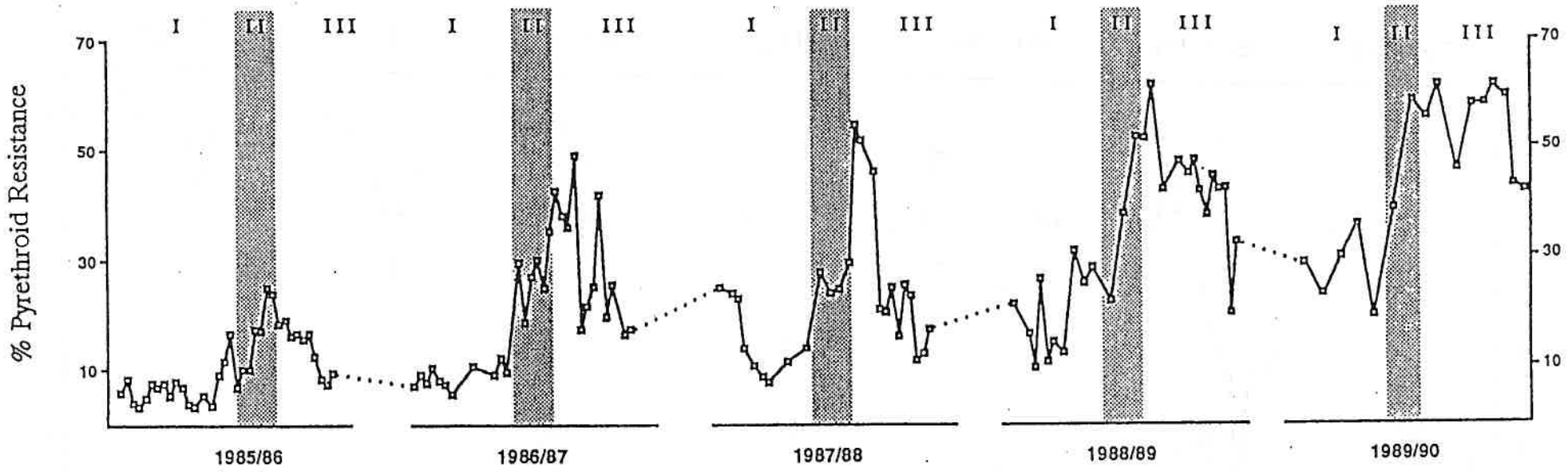


Figure 5 (b). Annual and within season variation in the levels of pyrethroid resistance in field populations of *Heliothis armigera* in the Emerald area. Successive stages of the Pyrethroid Strategy are indicated within each year.

Reproduced from Forrester (1990).

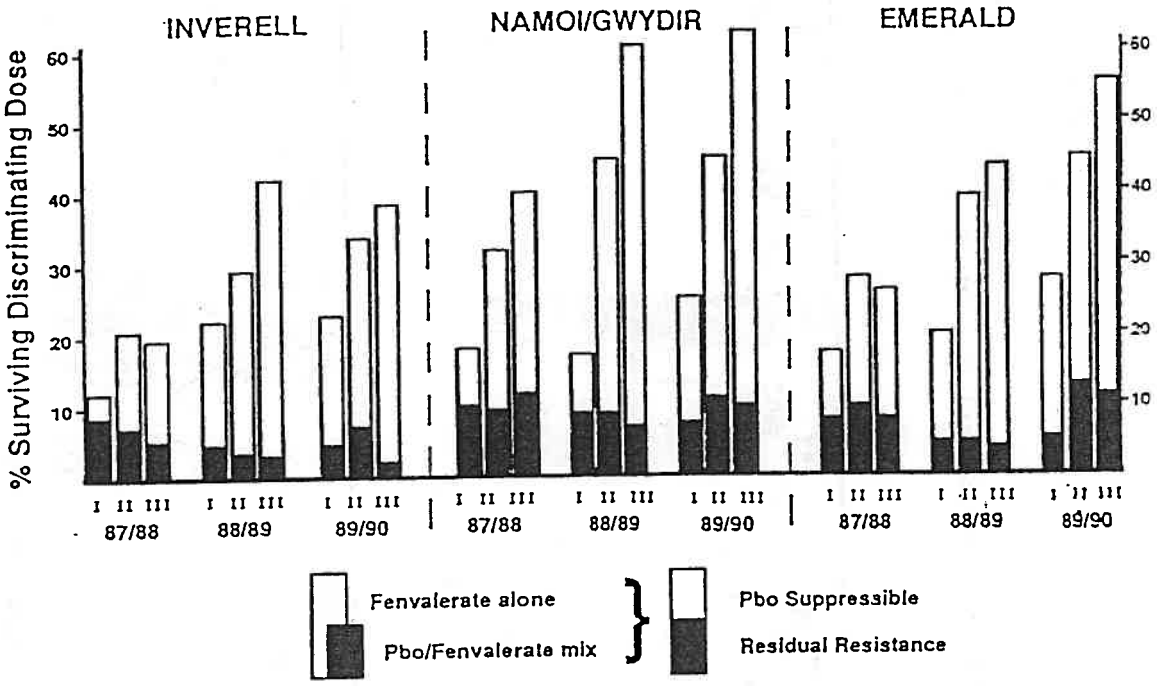


Figure 6. Suppression of resistance to a pyrethroid insecticide in field caught *Heliothis armigera* by PBO.

Reproduced from Forrester (1990).

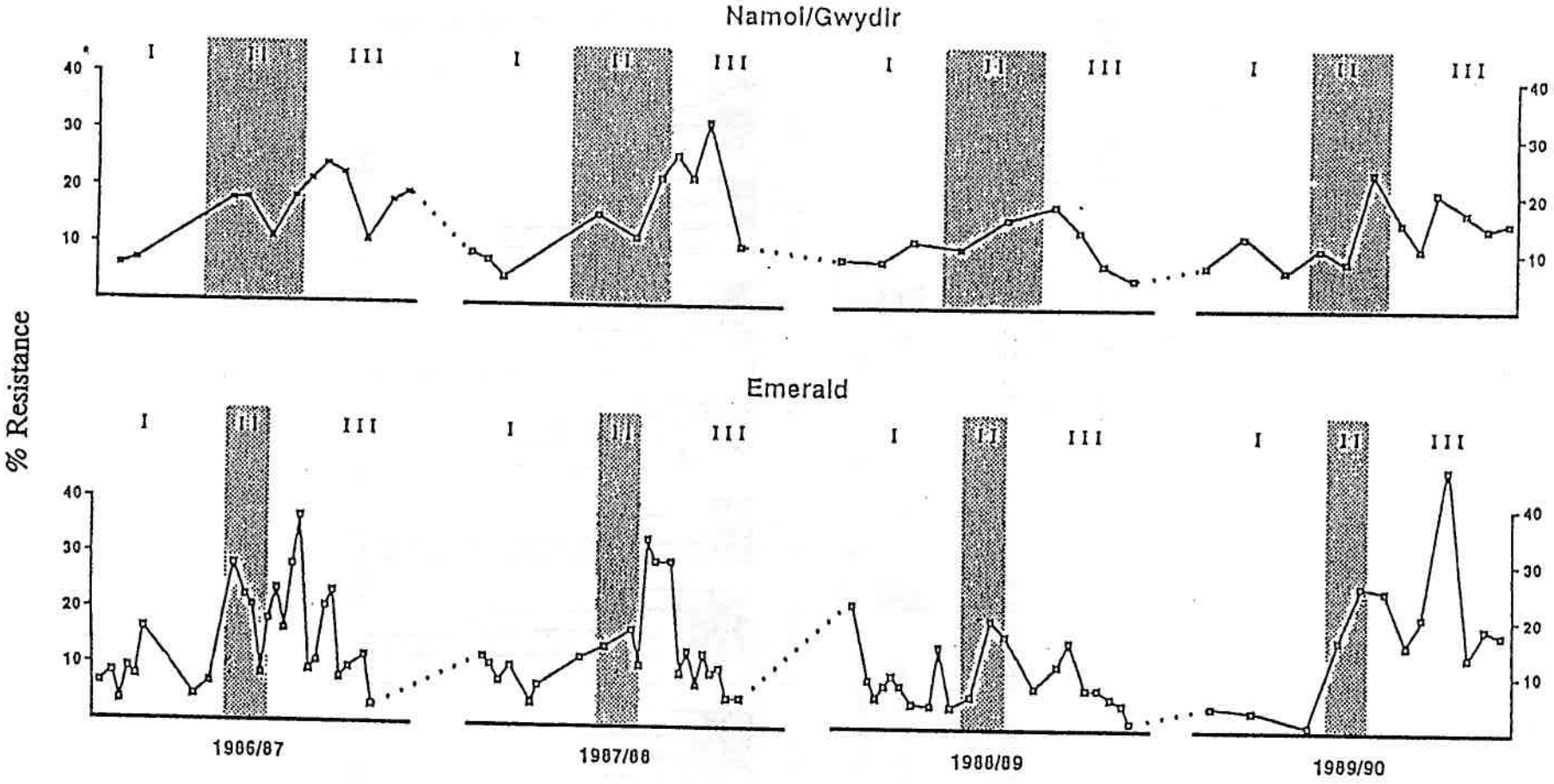


Figure 7. Annual and within season variation in the levels of Endosulphan resistance in field populations of *Heliothis armigera*.

Reproduced from Forrester (1990).

Pesticide Mixtures

Interviews with aerial operators revealed that the mixing of different chemicals for application during the same flight is common practice. Many of these mixtures are not explicitly listed on compatibility data on product labels but the view offered was that operators know by experience what works. When mixtures that have not been tried before are used a 'jug' test is used to verify their compatibility. This consists of mixing small quantities of the two chemicals in a flask, agitating and waiting to see if any obvious problems such as precipitation occur.

This test will verify the physical compatibility of the products but cannot guarantee that chemical reactions which might affect the safety of the product have not occurred. Nevertheless the practice is endorsed by AVCA whose guidelines (Hock *et al.* 1990) recommend trial mixing in this way; in addition to the formation of precipitates or scums this guide also recommends that the operator should look out for the production of heat which would be an indication of chemical reaction. However it should be noted that not all reactions are exothermic and failure to detect heat cannot be interpreted as confirmation that undesirable chemical reactions have not occurred.

Noise

Noise caused by crop spraying aircraft was formerly the cause of a large number of complaints particularly around towns such as Moree. This appears to be less of an issue at present (Stollznow Research 1990). This is due to a number of factors. Aerial operators are switching from piston engined aircraft to turbine engines which are much quieter, flight routes into and out of airfields have been adopted which avoid overflying residential areas and aerial operators observe voluntary curfews during night flying (eg not after 10.30 at night or before 7.30 in the morning and not on Sundays if possible) to avoid the most anti-social times.

Without these measures noise can be a serious nuisance and a legitimate source of complaint. Uncomfortably high noise levels caused by piston engined spray planes flying nearby were experienced by the audit team during the course of the study.

3.2.4 Conclusions and Recommendations Relating to the Application of Pesticides.

No convincing evidence was produced to support claims that aerial pesticide application causes unacceptable levels of environmental damage and should therefore be outlawed. The environmental benefits of banning aerial spraying would be small and possibly offset by problems associated with alternative methods. Nevertheless every effort should be made to reduce the risks associated with spraying, including reduction of the quantities of pesticide applied wherever possible (eg through cultivation practices which discourage build up of pest populations and research into alternative methods).

Spray Drift

The control of spray drift through the correct setting-up of aircraft and application systems and avoiding unsuitable conditions is well understood and the majority of operators are responsible about following these rules. However, a small minority of operators seem to be less responsible than the rest (although their performance probably falls short more in the area of storage and disposal rather than application of pesticides). These less responsible operators are more likely to cause drift problems.

Although off-target drift does occur, the available evidence suggests that it is probably rare for towns or villages to be exposed to more than trace levels of pesticide. However there is a paucity of data on this issue and the appointment of the spray monitor in Emerald is therefore to be welcomed. The publication of the results of the spray monitor will provide valuable new information.

Although blanket monitoring of the entire cotton growing area would not be worthwhile, the introduction of similar schemes in one or two other strategic locations (eg Moree and Wee Waa) would be valuable. In addition to providing information to help determine the risks associated with pesticide use, monitoring helps to maintain good application standards by operators. Such a monitoring scheme could be expanded to other areas if the results suggested that drift of agrochemicals into towns was a more frequent occurrence than currently believed.

Many of the complaints that are made about spray drift entering towns are triggered by the drift of strong smelling mercaptans released by decomposing organophosphate pesticides and do not actually involve the drift of pesticide into the town. Whilst it is fair for the industry to defend itself by saying that such odour drift is distinct from pesticide drift and that there is no health hazard, the smell is highly unpleasant and there is no reason why it should be considered acceptable.

Community Health

The potential health threat posed to communities in the cotton growing areas by exposure to spray drift is probably the single greatest fear of cotton industry critics. However, we believe that the limited available evidence does not suggest that pesticide usage is causing increased cancer levels or other serious health problems in the general public. Nevertheless further data are required for a full understanding of the health risks associated with low level exposure to pesticides. As data are collected this issue should be continually re-assessed. Exposure to pesticide is never desirable and so it is obviously prudent that measures to prevent or limit the movement of spray drift into populated areas should continue to be implemented.

In addition to any adverse effects, it is probable that cotton growing has had some positive effects on community health through the increased affluence it has brought to these areas. This should also be taken into consideration when assessing the impact of the industry on community health.

Occupational Health and Safety

Occupational exposure to pesticide is an issue of greater concern than community health effects. It has been shown that the risks of exposure are higher for those working in the industry than for those living nearby. Blood testing has demonstrated that a significant proportion of cotton workers do show signs of exposure. Despite this there seems to be a rather poor level of utilisation of appropriate safety equipment and clothing. We believe that the use of suitable clothing, in particular, is an area where significant improvements in performance must be made.

Whilst growers appear to be generally good about keeping field workers away from fields during and immediately after spraying operations, decisions about the length of re-entry periods seem to be made more or less arbitrarily by each grower. Guidance on this issue from the pesticide manufacturers is inadequate.

The frequency of occupational exposure to pesticides is likely to be greatly increased if aerial application is ever abandoned in favour of ground rigs because of the very much larger number of people that would be involved. This is an important reason why a ban on aerial spraying would not be desirable.

Effects on Fauna and Flora

With the notable exception of fish kills in rivers we do not believe that there is evidence that pesticide use or the methods of application are generally having significant effects on non-target wildlife outside the actual cropped areas. The effects of clearing land for cotton (or other agricultural purposes) is in our view of much greater significance for local wildlife populations than pesticide use; this is dealt with in Chapter 4.

Fish kills do occur as a result of pesticide use but the general view is that they are not normally caused by mis-application but rather through the release of contaminated irrigation water and so they are discussed in Chapter 5.

Bio-accumulation was a serious problem with the pesticides in use in the 1970's but there is a significant body of evidence that this is not the case with those in present use. The available evidence suggests that this is no longer a serious issue with respect to the cotton industry in Australia.

Quantity of Pesticides Used

Current evidence does not support the view that excessive pesticide use is making the land barren, as yields have shown no sign of tailing away. There was very little indication that significant numbers of growers use quantities of pesticide that are greatly in excess of the levels required to achieve adequate pest control. Interviews revealed that many growers are keen to minimise their reliance on pesticides and try to limit their use. Most growers follow the basic premises of the SIRATAC integrated management system to at least some extent.

Nevertheless, any moves to reduce the quantities of pesticide used would be welcome. This would reduce occupational exposure to pesticides and minimise other environmental risks associated with their use.

The industry, through a commitment to research funding, is developing alternative methods of pest control. Although these are unlikely to be able replace chemical methods entirely, their further development is welcome, particularly because of the role they can play in helping to minimise problems with insecticide resistance.

Insecticide Resistance

The industry has demonstrated remarkable cohesiveness in its compliance with the voluntary Pyrethroid Strategy for resistance management. This has delayed resistance problems considerably but has not entirely overcome the problem. The delay has allowed researchers time to address the problems of resistance, however and the strategy has proved to be flexible in allowing modifications to be introduced. Continued achievement of resistance management will depend upon strict observance of the strategy and a continued research effort to keep one step ahead of the pest.

Pesticide Mixtures

Uncontrolled mixing of pesticides, where this is not indicated on the product labels, is an undesirable practice since the properties of the constituents of the mixture could be radically changed by chemical reaction. Mixed products could have synergistic or antagonistic effects which could greatly modify their impacts on the environment from those identified by pre-registration safety testing.

It is recognised that mixing can greatly benefit growers and operators by reducing costs and time spent spraying. It is also the case that product labels could not realistically list all possible permutations. A practical solution may be for the chemical companies to poll consultants and growers to identify the most frequently required mixtures so that these can then be tested under scientifically controlled conditions to verify their compatibility.

Noise

Although noise from agricultural aircraft can be a significant environmental problem by causing disturbance to local communities, there is evidence that the industry has resolved some of the problems by avoiding flying over sensitive areas and at unsocial times. The introduction of turbo-prop aircraft has also reduced problems and it is desirable that eventually they should replace all piston engined aircraft.

The following recommendations are made concerning the application of pesticides.

- Poor performers amongst aerial operators and growers give rise to the most problems and should be brought into line. This could be primarily achieved by industry (ACF, AAAA and AVCA) education programmes and peer pressure.

- AAAA should continue to exert pressure on all operators to improve standards and to join the Association and become accredited.

- The ACF should encourage growers to use AAAA accredited aerial operators and should exert pressure on all growers to pursue responsible practices with respect to pesticide use.

- Better resourcing and consequently tighter control by regulatory bodies will also help to improve performance with respect to pesticide use.

- More monitoring of spray drift in populated areas is required. The appointment of the spray monitor at Emerald is a useful example. It is not considered necessary to appoint similar monitors in all areas but it would be most desirable to implement air monitoring in a small number of other key sites (eg Wee Waa, Moree). Methods used should be comparable with those of the Emerald study to facilitate analysis.

- Tank mixing of several chemicals to be simultaneously applied should not be carried out without firm guidance on the compatibility of the products concerned. Chemical manufacturers should find out which mixtures are commonly used and ensure that they are safe.

- Chemical handlers should be provided with and required to use proper protective equipment including full overalls - cotton would be suitable.

- Field workers such as bug checkers and chippers should also wear appropriate clothing, including long trousers and shirt sleeves.

- Employers should provide laundry facilities at the place of work for the washing of pesticide contaminated work clothes.

- Aerial spraying should remain as the current best method as it has many advantages over boom spraying. These include: a requirement for fewer operators and thus less occupational exposure to pesticides, easier control and less soil compaction.

- New farms should be designed with aerial spraying in mind so that potential spray drift problems are avoided.

- Rural communities surrounded by cotton farms should plant tree-lines as biological buffers. Species should be chosen to maximise effectiveness as barrier to spray drift.

- Trees should be planted as biological buffers around the boundaries of cotton farms and around homesteads and employees living areas.

- Pesticides likely to produce strong, drifting odours should be avoided in areas where their use could lead to public nuisance.

- Planning authorities should exert controls to ensure that new housing is not sited too close to existing cotton farms and new cotton farms not close to existing houses. This will help to minimise community exposure to spray drift.

- Doctors/health workers should be encouraged to maintain statistics on incidence of cancers, asthma, allergies to allow investigation of possible links between spraying and these illnesses. A coordinated approach will be required to ensure data are collected in a form which will facilitate analysis and comparison.

- Chemical companies should provide information on the minimum re-entry periods which should be observed after crops are sprayed for all products. State Registrars of Chemicals could issue criteria.

- Research into integrated pest management techniques should be continued and encouraged. This can help to avoid problems of pesticide resistance and contribute to a reduction in the quantities of pesticide used.

- Continued observance of the Pyrethroid Strategy is essential in order to continue to avoid pesticide resistance undermining current ability to control pests with available products.

- Research into all aspects of pesticide resistance should be maintained and encouraged.

- Aerial operators should be encouraged to purchase turbine engined aircraft when current piston-engined aircraft are due for replacement. In areas where noise complaints are frequent the immediate replacement of piston-engined aircraft should be considered.

3.3 STORAGE OF PESTICIDES

This section of the study covers the storage of pesticides by the end users, that is growers and aerial operators. Storage of chemicals by re-sellers, manufacturers and at distribution warehouses is an important area of concern but was beyond the scope of the present study.

3.3.1 Environmental Issues Relating to the Storage of Pesticides

The storage of pesticides prior to application is probably the least controversial aspect of their use by the Australian cotton industry; whilst every questionnaire received identified application and container disposal as areas of concern only one (from Greenpeace) referred to storage. The reasons for this difference may lie partly in the fact that pesticide storage is the least conspicuous part of the overall crop spraying operation and partly in the reasoning that the chemicals concerned must pose least threat to the environment when they are safely sealed in containers. Nevertheless it is generally the case that environmental damage can result during the storage of chemicals, particularly when accidents occur.

Poor storage procedures can potentially give rise to exposure of workers to pesticides, pollution of ground and surface waters and potential fire hazards. Stored pesticides may also fall into the wrong hands (eg children) and be subject to misuse unless subject to adequate security measures.

3.3.2 Legislation and Controls Relating to the Storage of Pesticides

Farm storage of pesticides is covered by essentially the same legislation as that covering application. The principle Acts are the New South Wales Pesticides Act (1978) and the Queensland Agricultural Standards Act (1952 - 1981). These Acts provide for the registration of agrochemicals, which in turn prescribes conditions for their use including their storage.

The Dangerous Goods Regulations (1978) in New South Wales also covers the storage of pesticides as these come under Risk Class 6 (Poisons) and, for certain products, other subsidiary Risk Classes as well (eg Class 3, Flammable and Combustible Liquids). These regulations place responsibility for safe storage on the owner or occupier of premises and also include specific requirements such as bunded storage areas for quantities exceeding 1000 litres of liquid chemical, separation distances to be observed between poisons and foodstuffs for human or animal consumption, fire protection and the marking of the storage area with the appropriate hazard warning signs. Similar measures are required by Queensland law under various Acts.

As part of their accreditation scheme for re-sellers, the Agricultural and Veterinary Chemicals Association of Australia (AVCA - the trade association for Australian agricultural and veterinary chemical manufacturers) have produced detailed guidelines for all aspects of the use of agrochemicals including storage. These guidelines have been made available in very similar form to growers as the Farm Chemicals Manual.

Accreditation of aerial operators under the Operation Spray Safe scheme includes assessment of the operators facilities for storage of pesticides.

3.3.3 Performance of the Australian Cotton Industry in Relation to the Storage of Pesticides

Little information was received from interviews, questionnaires or in the form of published material on the performance of the industry with respect to storage of pesticides. The visits made to a number of aerial operators and growers premises therefore provide the basis for the conclusions drawn in this section of the report. It should be emphasised that only a small sample of sites could be visited during the time available for the audit and that each visit was limited to a few hours.

Quantities Stored

The majority of growers store only relatively small quantities of pesticides on their own premises. This is because most pesticides are applied aerially by contractors who store the chemicals on their own premises and because the chemicals have limited shelf lives. Growers tend to store small quantities of the chemicals (chiefly herbicides) they apply themselves with ground rigs. The large corporate growers are an exception to this rule and tend to have purpose built pesticide storage facilities more comparable to those of the aerial operators.

All aerial operators service a number of farms and some of the largest operators cover huge areas of cotton each season. Consequently they are obliged to store large quantities of chemical often exceeding tens of thousands of litres. The majority of the chemicals stored are contained in 44 gallon metal drums but the most heavily used chemicals, notably endosulphan are sometimes stored in large, dedicated bulk storage tanks. A small quantity of pesticide is also stored in re-useable "mini-bulk" containers.

Compound Security

The large pesticide storage compounds associated with the aerial operators and large corporate growers visited were generally surrounded by adequate fencing and had lockable gates. However, storage security on small farms is often unsatisfactory. In a number of instances pesticides were observed stored in a small shed without a lock and at one farm drums were observed stored outdoors with no protection from the elements and with no security although children were living nearby.

Storage Conditions

At all the large pesticide storage compounds visited the main storage area was floored with a concrete base in accordance with the codes of good practice. However in a number of cases the concrete pad showed signs of chemical stains and were observed to be cracked giving rise to a potential, if small, risk for pesticides to leach down into the soil beneath and eventually into ground water. In one case pesticide containers were observed stored outside the concreted area and outside the fenced security area. This was associated with the main storage area being over-filled at the time of the visit with some drums stacked three high.

All of the bulk storage tanks observed during the audit were surrounded by individual bunds. Bunding of the overall storage area was also observed. It was not possible to ascertain the volume of the bunded areas in relation to the volume of stored chemicals although in some cases it appeared insufficient. According to the NSW Dangerous Goods Regulations bunding should have the capacity to withhold 25% of the volume of the liquids stored on the compound and in the case of bulk storage tanks individual bunding to hold 100% of the tank contents.

The overall impression of the large storage areas for cotton pesticides was variable: some were reasonably tidy and others looked as if housekeeping could be improved. At several storage sites, including some of the best operators, the concrete base had stains from chemical spillage on it. One site had small bushes growing alongside which showed signs of severe chemical stress. These were indications of poor pesticide handling and suggest that practices could give rise to occupational health hazards and pollution.

Storage conditions at some small farms visited also fall short of ideal standards. One farm storage comprised a small shed containing a variety of different products including insecticides (profenofos) in proximity with herbicides (recommended practice is to keep herbicides separate from other pesticides to avoid cross contamination). A number of containers were part empty and some of the cardboard containers were damp and the labels illegible. A drum of Stomp® (Pendimethalin) had crystals of the product encrusting the spout on the top of the drum.

Safety

The large pesticide storage compounds visited all had prominent hazardous chemicals signs displayed on the fences and gates. These compounds also all had emergency shower and eyewash facilities. However, they were not always prominently marked and in cluttered compounds could be awkward to reach in an emergency situation.

As discussed in section 3.2 (Application) the use of appropriate protective equipment and clothing by workers witnessed handling chemicals was poor.

3.3.4 Conclusions and Recommendations Relating to the Storage of Pesticides

The impression gained through the site visits was that although Operation Spray Safe and other industry initiatives (such as AVCA grower education programmes) have probably improved attitudes with respect to pesticide storage and handling, there is still significant need for improvement. Even the best operators have some practices which are less than ideal, whilst some storage compounds were rather poor.

In contrast to other aspects of pesticide use, there is an apparent complacency regarding storage facilities within the industry, exemplified by one interviewee who touched his compound floor with his fingers and then licked them to demonstrate his confidence in the cleanliness of the floor. This action did not so much demonstrate "good housekeeping" as an insufficient appreciation of the need to observe strict common-sense precautions when using pesticides.

The industry is not without suitable models for the correct standards to apply when storing pesticides. AVCA provides detailed advice on all aspects of pesticide use, including storage. Gatton College, Queensland has facilities of its own which provide a good example of the way agrochemicals should be stored. Both organisations provide courses on pesticide use for growers, aerial operators and other members of the industry. The industry should avail itself of these courses, and organisations such as AVCA, AAAA and Gatton College should continue to strive to improve standards.

The following recommendations are made with respect to the storage of pesticides.

- All pesticides and herbicides should be stored under lock and key and preferably under cover.

- Pesticide storages should have adequate storage space for the quantities of chemical to be kept, have proper bunding, segregation of different products and security controls.

- Chemical storage and handling needs improving. ACF, AVCA and AAAA should have a strong education policy to ensure that growers and aerial operators are aware of the correct procedures and the dangers of ignoring them.

3.4 DISPOSAL OF PESTICIDES

3.4.1 Environmental Issues Relating to the Disposal of Pesticides

As with the application of pesticides, the disposal of empty containers and rinsings, is a high profile issue which is the cause for much criticism of the industry. All sections of the community including growers, aerial operators, government bodies and industry critics seem to consider the current waste disposal practices as unsatisfactory. Poorly controlled waste disposal at a wide variety of sites gives rise to concern that pesticide residues might contaminate water supplies or other parts of the environment.

A further concern is that the creation of large numbers of unlicensed and unrecorded disposal pits could give rise to problems in future when different land occupiers might wish to develop land for other purposes without knowing the waste disposal history of the site.

3.4.2 Legislation and Controls

The principal products left for disposal after the use of pesticides in agriculture are the pesticide-contaminated rinsate from washing down empty containers and equipment, and the empty containers themselves. These two forms of waste present different problems.

Basic guidelines and requirements for the disposal of these wastes are provided by government and industry. The registration of a pesticide under the Pesticides Act (1978) in New South Wales and the Agricultural Standards Act (1952 - 81) in Queensland require that the product label should include instruction for disposal.

The State Pollution Control Commission in New South Wales publish guidelines (SPCC 1988) which typify those pertaining in other states. These guidelines allow for the disposal of containers either at a disposal facility (eg. a Local Authority managed site) or, as a second best option in a safe spot on site.

For on-site disposal of containers it is recommended that they are triple rinsed with water (or another suitable solvent), punctured and crushed and then buried. The guidelines also cover the siting and specifications of the burial pit including minimum depth (half a metre), location to avoid pesticide effluent contaminating water tables, wells and watercourses. The SPCC guidelines also allow for the burning of combustible (excluding moulded plastics) in remote places "where smoke will not affect residents, roads, waterways, trees, crops or livestock".

It is recommended that the rinsate produced from washing out empty containers should, if possible, be emptied back into the sprayer tank and used. If this is not possible, the rinsate should be channelled to an impermeable flood-free evaporation basin. The guidelines do not require destruction and burial of all pesticide containers. Re-use, reconditioning and recycling of the component materials are all permitted within certain

limits (eg. plastic containers have specified life-spans and certain types of container are not considered for re-use or recycling). The legislation precludes the re-use of pesticide containers for any other purpose but certain container types (eg. mini bulks and shuttles) may be returned to the distributor for refilling with the same product. The transporting of empty containers from the site of use to reconditioning or recycling centres is covered by the Australian Dangerous Goods Transport Code (1987) as the containers are considered as full (although documentation and segregation from other classes of dangerous goods are not required).

3.4.3 The Performance of the Australian Cotton Industry in Relation to the Disposal of Pesticides

Container Disposal Sites

The majority of growers and aerial operators interviewed indicated that they disposed of their empty containers on their own properties. This is in spite of recommendations that the preferred option is to take them to a disposal facility. The reason for this was invariably given as the refusal of the local authority to accept the waste for disposal on their facilities.

A minority of growers in Queensland (eg. Cecil Plains and Jondaryan) stated that they sent their containers for disposal by the local authorities.

Container Disposal Practices

All pesticide users who were interviewed claimed to follow the guidelines provided by the SPCC, AVCA and other bodies for the disposal of pesticide drums on site, particularly those relating to rinsing out drums. Drums are usually crushed and are then buried in trenches. Interviews and site visits indicated that these disposal pits are not generally back-filled with soil on a daily basis but rather in a single operation once the pit is filled.

Although it is recommended that drum disposal pits should not be used for other purposes some growers admitted to using a single pit for all their farm and household wastes. This is not good practice and, where waste is not immediately covered by soil, risks attracting domestic and wild animals into the pit to scavenge food wastes and thereby exposing them to the risk of pesticide contamination. A number of growers indicated they burn combustible containers in an oil-drum burner on the property.

New waste pits are dug as old ones are filled and covered over. Most interviewees claimed that they knew where they had buried wastes in the past but there was no indication of formal records being maintained of tip locations and contents or the locations of covered burial sites marked on the surface.

Not all containers are disposed of, as many get put to a variety of uses once they are empty. The use of 44 Gallon drums as trash-cans was witnessed in many areas and in Queensland smaller plastic containers are widely used as swathe markers to assist pilots to spray crops accurately.

Not all containers are buried immediately after they are emptied and on several sites stock-piles of empty containers were seen. In some cases these were just piled up on the property without any fencing or other restriction of access to them. It was not known if these had been rinsed out or not. One interviewee reported a case where empty containers had been allowed to roll into a creek but the general understanding obtained was that such a large lapse of disposal standards is unusual.

Most growers and aerial operators interviewed recognised that disposal practices were not ideal but felt that they were making the best of the situation in which no-one else seemed prepared to accept responsibility for the disposal of drums. One grower was accumulating a small pile of empty containers on his property because he did not want to bury them as his land was above a relatively shallow water table. His local authority would not accept them for disposal on their sites.

Alternatives to Disposal

Various strategies are coming into operation which help to minimise the disposal problem by reducing the number of containers to be disposed of. The most heavily used pesticides such as endosulphan, are already largely supplied in bulk to aerial operators and stored in large, re-fillable tanks. Bulk supply is more problematic for less heavily used products but two systems have been introduced. Monsanto supply Roundup in "shuttles" and several products are now available in refillable 1000l "mini-bulk" containers; however, supply of pesticides in this manner is still relatively rare.

Collection of steel 44 gallon drums for recycling also occurs on a small scale in Queensland through a recycling plant in Brisbane. The view expressed by AVCA and others in the industry is that the large distances between farms and recycling centres and the Hazardous Goods Transport Regulations (which treat empty containers as if full) pose serious obstacles to recycling on a wider scale. Nevertheless AVCA have indicated cautious enthusiasm (Watt 1990) for the recovery and recycling of crushed, washed drums. All sections of the industry highlighted the costs of this kind of operation and who should bear the costs still needs to be resolved.

Disposal of Liquid Wastes

All of the large scale users who were visited disposed of rinsings in the manner broadly prescribed by the SPCC guidelines, by channelling them to an evaporation pit. These were all simple pits dug into the ground with little or no lining. Guidelines recommend that all evaporation pits should be buried with an impermeable liner. In areas of high self mulching clay, concrete lined pits are subject to excessive movement and pose a risk

of cracking and are therefore unsuitable. Channels to evaporation pits were invariably open rather than piped and often without adequate safeguards of fencing and sign posting.

The siting of evaporation pits should be above flood levels and on impermeable soils. No evidence was seen that any were in floodable sites. One grower stated that his evaporation pit had been dug only after trial pits had been carried out to verify the site was impermeable. Other operators and growers referred to the depth of clay beneath the pit. Most growers were aware of potential hazards to ground and surface waters. Nevertheless the SPCC mentioned a possible concern that if pits are filled, allowed to dry out and subsequently refilled with water, cracking of the clay during the dry phase could potentially lead to ground water contamination. The AVCA Farm Chemicals Manual recommends lining pits dug into cracking clays but this does not appear to be widespread practice. Breakdown of chemical residues is apparently not monitored in evaporation pits.

Security of Disposal Areas

Some drum and liquid waste disposal pits observed were fenced but in many cases it was felt that the type of fencing should have been more secure. One aerial operator had an unfenced pit because it was within the fenced perimeter of an airfield. Disposal pits were not generally signed.

3.4.4 Conclusions and Recommendations Relating to the Disposal of Pesticides

The majority of growers and aerial operators appear to dispose of their waste drums and liquid wastes in a manner which, by and large, satisfies the minimum guidelines provided by government and AVCA. However these guidelines are themselves relatively lax and waste disposal was considered to be generally of poor standard. The creation of large numbers of private waste tips is undesirable and is certainly a "second-best" option even within the current guidelines. It is recognised that this situation is a reflection of a general lack of chemical disposal facilities in Australia as a whole, and also the remoteness of some cotton-farms. Ideally local authorities should be pressured to provide controlled disposal facilities available to at least the majority of growers.

The lack of proper records of the location and contents of burial sites also raises concern about possible future developments on land being used for disposal.

The assumption that most of the chemical wastes present in evaporation pits will degrade rapidly is probably largely correct and the pollution risks consequently relatively minor. However, in the absence of monitoring this cannot be guaranteed and it would be re-assuring if at least occasional monitoring of sites were conducted.

Where self operated disposal operations are unavoidable these could be improved by a variety of measures including frequent covering of drums with soil, better fencing and signage, evaporation pits should be engineered, ideally with impermeable linings.

Use of empty containers for secondary purposes such as trash-cans, markers (even in one case as a flotation device to activate a pump) is contrary to the law and a poor advertisement for the industry. It should be discouraged stopped.

It should be stressed that in general most people within the industry are trying to operate responsibly with respect to waste disposal but performance is inevitably limited by the fact that they are cotton professionals and not trained in waste disposal. Problems encountered by the cotton industry are exacerbated by the large volumes of pesticide used and the remoteness of many sites but these problems are not unique to Australia.

The most promising moves to reduce the problem of drum disposal are in the areas of bulk delivery and the use of re-fillable shuttles and mini-bulks. The fact that these systems are already in use demonstrate their feasibility although the large distances involved may make their wider application more difficult because of transport costs of container recovery It is hoped that the various interested parties can agree on how these costs should be shared.

The following recommendations are made with respect to waste disposal:

- Proper waste disposal facilities should be provided so that pesticide containers can be disposed in a more environmentally acceptable way than at present. The ACF should lobby government to provide facilities.

- The industry as a whole, including chemical manufacturers, aerial operators and growers should work together to increase the proportion of chemicals supplied in bulk or in re-useable containers. The best way to reduce the waste disposal problem is to reduce the number of containers requiring disposal.

- The industry as a whole should seek ways to increase the proportion of steel drums which are recycled instead of being buried.

- The use of empty pesticide containers for secondary purposes such as trash cans should be discontinued.

- Where burial of pesticide containers on-site is unavoidable growers and aerial operators should ensure that the highest possible standards are pursued. AVCA and the ACF should provide a strong lead and promote disposal standards within the industry which go beyond the current legal minimum standards.

- As a minimum standard, on-farm tips should be regularly covered over with soil (not just when the pit is full), should be securely fenced and well signed. After completion, detailed records must be maintained of the location of tips.

- Evaporation pits should only be dug on sites where adequate testing has ensured that the ground is impermeable. Evaporation pits should be lined.

- Some monitoring of evaporation pits should be conducted to determine whether or not a build up of pesticide residues is occurring and to assess whether or not there is any movement of these down through the soil profile and consequent risk to water tables.

- Evaporation pits should be securely fenced and signed to prevent general access.

CHAPTER 4 LAND USE

CHAPTER 4 CONTENTS

4.1 INTRODUCTION

The cotton industry occupies large tracts of land throughout inland regions of New South Wales and Queensland. Between 70 and 80 per cent of the total land under cotton is grown in New South Wales and the rest is in Queensland. In New South Wales, most cotton is grown under irrigation with comparatively little dryland cotton. In Queensland, dryland cotton constitutes a higher proportion of the total area of cotton grown in the state.

Production estimates for the growing season 1989/90 are shown in Table 1. In New South Wales 389 thousand acres of irrigated cotton were grown compared to 92 thousand acres in Queensland. The figures for dryland cotton were 53 thousand acres for Queensland and 22 thousand acres for New South Wales respectively. These figures give a total area of 556 thousand acres of cotton grown in 1989/90 (an 18% increase in acreage over the previous season 1988/89).

Most farms grow cotton as the principle (but not the sole) crop. Specialist cotton growers also rotate crops. On dryland farms, where the crops are rain-fed only with no artificial water supply, cotton is usually grown in rotation with other crops. The establishment of a cotton farm, however, does involve significant modifications to the landscape and considerable infrastructure works. On most irrigated cotton farms land is completely cleared of natural vegetation, levelled, and have the necessary infrastructure (i.e. irrigation channels, water storage facilities, pumping stations, roads, storage barns and airstrips) constructe. Land clearance is essentially a feature of all arable agriculture regardless of the crop type.

The majority of cotton farms are owned and operated by cotton farming families; however in the last 20 years a number of large corporate cotton farming operations have become established.

Individual cotton farms vary greatly in size, character and facilities. Cotton farms can range from small family run concerns that grow dryland cotton on an "ad hoc" basis, in rotation with their other major crops, to the large scale corporate irrigated cotton producers that employ large numbers of people. Although the average number of acres of cotton grown per farm in the 1989/90 growing season was 1200 acres, the figure is rather meaningless given the enormous range of cotton farming enterprises.

The industry is at present characterized by a high level of inputs, together with high establishment and operating costs, which produce a high-yield, high-value crop. The establishment of the large corporate cotton farms are major financial investments and the lifespan of a large cotton farm is a crucial factor dictating its financial success. Because of the cost involved in establishing large irrigated cotton farms, long term sustainability is viewed as being crucial to their viability as commercial ventures.

Future expansion of the Australian cotton industry would be accommodated through a combination of increases in irrigated and non-irrigated production. The cotton growing districts with potential for further expansion were identified by G.W Kyneur of the

TABLE 1: AUSTRALIAN COTTON PRODUCTION ESTIMATES 1989-1990

	Irrigated			Dryland			Total	
	Acres	Yield	Bales	Acres	Yield	Bales	Acres	Bale
QUEENSLAND	(b/acre)			(b/acre)				
Emerald	27000	2.7	72900	10000	0.8	8000	37000	80900
Biloela/ Theodore	12000	2.3	27600	13000	1.3	10400	25000	38000
Darling Downs	30000	2.3	69000	30000	1.3	39000	60000	108000
St George	23000	2.6	59000	-	-	-	23000	59800
TOTAL	**92000**	**2.5**	**229300**	**53000**	**1.08**	**57400**	**145000**	**286700**
NSW								
Namoi	118000	2.4	283200	2000	1.2	2400	120000	285600
Gwydir	137000	2.6	356200	10000	1.0	10000	147000	366200
Macintyre	55000	2.7	148500	10000	1.2	12000	65000	160500
Macquarie	62000	2.3	142600	-	-	-	62000	142600
Bourke	17000	2.7	45900	-	-	-	17000	45900
TOTAL	**389000**	**2.51**	**976400**	**22000**	**1.11**	**24400**	**411000**	**1000800**
AUSTRALIAN TOTAL	**481000**	**2.5**	**1205700**	**75000**	**1.09**	**81800**	**556000**	**1287500**

Source: Cotton Year Book 1990

Bureau of Rural Resources (1989), and these are given in Table 2. The report showed that further expansion of irrigated cotton is anticipated in the Namoi and Macintyre valleys in NSW, and in South Burnett in Queensland. Dryland cotton production is also expected to increase in northern NSW and central Queensland.

According to the above report, the demand for additional irrigated cotton could be met by the 37,000 - 42,000 hectares with adequate water resources that have been identified in Queensland and New South Wales and this could be augmented by new irrigation in the Hillston area of New South Wales. The potential area of new land for non-irrigated cotton was estimated at between 94,000 - 122,000 hectares.

4.2 ACQUISITION OF LAND

4.2.1 Issues Relating to the Acquisition of Land

Habitat Clearance

Clearing land and establishing a cotton farm, as with other irrigated and dryland cropping enterprises, can have a sizeable adverse impact on the environment. Woodlands, wetlands, pasture and a wide range of other ecologically diverse habitats may have to be removed in order to make way for landscaped fields, irrigation channels and ditches, water storage facilities, service roads and air strips.

Cotton farming, as with any other monoculture, requires large areas of land to be cleared of natural vegetation and this affects the fauna and flora by destroying their habitats. Extensive areas of cotton farming can fragment both vertebrate and invertebrate populations and in some cases may act as barriers for dispersal. The impact of cotton farms on natural habitats in this way will depend on the prior use of the land (ie. where farms are converted from the production of another arable crop the land is likely to have already been cleared of natural vegetation). The significance of habitat loss is also related to the rarity of the habitat types concerned.

Land Rights

Issues relating to land rights are extremely sensitive in Australia, particularly in relation to Aboriginal rights and sacred places. Various reserves for the Conservation of Aboriginal Cultural Heritage have been established throughout Australia. These sites are protected under international, federal and state legislation.

The cotton industry has not been associated with land rights issues; however as a significant land user, Aboriginal land rights may have a bearing on land ownership and, particularly on the potential for expansion of the industry. Some cotton farms are located close to Aboriginal sacred sites, while others retain close links with Aboriginal cultural heritage.

TABLE 2: COTTON GROWING DISTRICTS WITH POTENTIAL FOR FURTHER EXPANSION

Production District	Probability of Expansion	Area Available (Hectares)
Irrigated Cotton		
M.I.A. (NSW)	very low	not assessed
Ord (WA)	very low	5 - 6,000
Burdekin (Qld)	very low	not assessed
Lachlan (Hillston, NSW)	medium	25,000
Emerald (NSW)	medium - high	14,000
South Burnett (Qld)	high	5,000
Namoi (NSW)	high	3 - 8,000
Macintyre (NSW)	high	15,000
Dryland Cotton		
Southern Queensland	low	not assessed
Northern New South Wales	medium	34 - 44,000
Central Queensland	high	60 - 80,000
Total Irrigated	medium	25,000
	medium - high	14,000
	high	25,000
	Sub total	64,000
Total Dryland	medium	34,000
	medium - high	60,000
	Sub total	94,000
Grand Total		**158,000**

Source: Bureau of Rural Resources (1989)

4.2.2 Legislation Relating to the Acquisition of Land

The legislation concerning the planning and control of land use predates most of the other forms of environmental legislation in Australia by many years. The legislation has been modelled on British precedents and usually zones areas of land to identify appropriate and inappropriate forms of land use.

Whilst routine planning and control functions may be performed at the local government level a considerable degree of responsibility has been assumed and exercised by state governments through state level departments and statutory authorities. At this "central" level, government bodies have been charged with responsibility for establishing land use plans over large areas of each state, or for the state as a whole. These central government bodies also exercise development control powers with respect to controversial proposals. In Queensland, there is no central body that undertakes regional strategic planning on a legislative basis, although it may be done on a policy basis. Future expansion of the cotton industry will be governed to a certain extent by state planning policy.

In all states, the increased awareness of environmental problems has meant that fresh approaches have emerged both within and outside land use planning systems to direct greater attention to the ecological perspective when planning and controlling land use. Some states have attempted to reform their existing land use planning systems in order to incorporate environmental matters into all aspects of land use planning and control. The most noticeable examples in this respect are New South Wales and South Australia.

A recent development in environmental management is the Environmental Impact Assessment process (EIA). Every state government has accepted the desirability of EIA procedures, although not all have chosen to respond by adopting legislation. Legislation concerning EIA procedures have however been adopted in both Queensland and New South Wales.

In New South Wales under the Environment Bill 1991 Environmental Impact Assessments are required for major developments which have "an impact on the environment". While EIA's are currently not required for agricultural changes in land use, this may change under the newly formed Environmental Protection Agency (EPA).

Interviews with Government officials indicated that plans for new, large-scale cotton farms which either involve the clearance of natural habitats or are likely to have significant adverse effects on valuable neighbouring wildlife habitats may, in the relatively near future, be required to undertake independent Environmental Impact Assessments.

In New South Wales the State legislation relevant to land acquisition by the cotton industry includes the following Acts:

The Aboriginal Land Rights Act 1983 - This act provides for the constitution of local Aboriginal Land Council areas administered by Local Aboriginal Land Council under the supervision of the New South Wales Aboriginal Land Council. The agency responsible for this Act is the Premieres Department. It affects the cotton industry in that it may limit areas for future expansion.

The Environmental Planning and Assessment Act 1979 - This Act institutes an environmental planning system, which gives statutory force to a system of environmental assessment with procedures applicable to private as well as public sector developments. The agency responsible for this Act is the Department of Environment and Planning.

The Protection of the Environment Act 1991 - The Protection of the Environment Act institutes the Environment Protection Authority and the powers that are vested in the Authority. The new Authority is intended to streamline the existing regulatory framework and bring together many of the fragmented responsibilities for environmental programmes.

In Queensland, the State legislation relevant to land acquisition by the cotton growing industry includes the following Acts:

The Aboriginal Relics Preservation Act 1967-1976 - This Act establishes an advisory committee responsible for the preservation of anthropological, ethnological, archaeological and prehistoric aboriginal relics. As in NSW this legislation may serve to limit areas of expansion for the cotton industry.

In addition to this state-level legislation, there is Commonwealth legislation covering land use issues in Australia. The most relevant Commonwealth legislation concerning land use is covered under the **Environmental Protection Act 1974** and the **Soil Conservation Act 1975.**

Despite the above legislation there are few controls on land use that affect farming. Local authority control preventing urban expansion may be quite strict but this is not, at present, the case with farming.

4.2.3 Performance of the Industry in Relation to the Acquisition of Land

Land Clearance

There is very little information available on the pre- and post uses of land currently under cotton, although it is evident that most cotton farms have been developed on land previously used for agricultural purposes.

In New South Wales there is very little readily available information on the previous uses of land currently under cotton production. The industry does not keep a formal register of pre- and post land uses. In New South Wales, however, it is believed that much of the expansion of the cotton industry has involved the clearance of land already modified by past uses such as grazing, rather than the destruction of natural native communities (Whyte and Conlon 1990). The development of irrigated cotton fields in the Namoi Valley, for example, has involved conversion of land used for sheep grazing and wheat.

While the conversion of land from wheat (or other arable monoculture) production to cotton may not involve additional habitat clearance, the conversion of grazing to cotton will involve clearance of lightly wooded semi-natural habitats. Thus while the growth of the cotton industry may have essentially involved a change in land use from one form of agriculture to another, it has nevertheless, in some cases, resulted in the removal of semi-natural habitats greatly reducing habitat diversity.

In Queensland there is very little readily available information on the previous use of land presently used for cotton production, although, as with New South Wales expansion of the industry has mostly involved the use of land already used for agriculture.

Very little research has been done on the effects of changes in agricultural land use on animal and plant species diversity. A few studies have been carried out on the impacts of growing large areas of cotton on local bird population. The study by Broome et al. (1978) showed that bird communities in the lower Namoi valley have been severely disrupted in areas where large tracts of land have been converted to cotton production. Only a few bird species use cotton fields. These include swallows, martins and the Australian pratincole *Stiltia isabella* which are aerial foragers and can take advantage of the wide open spaces provided by cotton production.

A positive impact of clearing land for cotton production has been the provision of artificial habitats for some species through the creation of large areas of open water for water storage. These are frequented by a number of waterbird species, who readily exploit these habitats particularly during drought. While the design of these waterbodies is not optimal for wildlife (i.e. steep-sided open waterbodies with few islands, fringing vegetation or convoluted edges) their very presence may make them of some local value for certain species.

Land Rights

The cotton industry is not generally considered to have had an adverse impact on Aboriginal Heritage or sacred sites. As far as the audit team are aware, there has only been one accusation of the cotton industry causing an adverse impact on Aboriginal sacred sites.

The cotton industry along with a number of other water users has been cited as causing environmental damage to Boobera lagoon which is an Aboriginal sacred site. All the water used for cotton irrigation is extracted under licence from the Department of Water Resources. Thus if water extraction is causing an environmental problem it is primarily the responsibility of the Water Resources Department rather than individual growers.

Future expansion of the cotton industry could potentially come into conflict with Aboriginal land rights through the acquisition of Aboriginal Heritage/sacred sites, and through the use of water extracted from Aboriginal Heritage/sacred sites. The legislative apparatus is however in place to ensure that Aboriginal land rights are not adversely affected by encroachment from the cotton or any other agricultural industry.

4.2.4 Conclusions and Recommendations Relating to the Acquisition of Land

There is no planning and policy committee within the cotton industry to oversee the planned expansion and development of new areas for cotton. An overall rationale and planned future expansion policy would be highly desirable. Not only would it provide information for the industry and outside bodies, but it would also help to co-ordinate future expansion and minimise or avoid damage to previously undisturbed natural habitats. A planned expansion would demonstrate that the cotton industry is prepared to address one of the most important land use issues facing all agricultural industries.

Little information is currently available on the original uses of land now under cotton production. Thus it is extremely difficult to quantify the impact cotton production has had on natural and semi-natural habitats. However, the rapid growth of the industry has undoubtedly resulted in the clearance of large areas of land. This has probably been the most significant ecological impact of the industry.

Quite a large number of cotton farms already retain large areas of semi-natural habitat on their farms, which are beneficial for wildlife. While this directly reduces the amount of land under cultivation, it demonstrates a sympathetic attitude toward the natural environment (i.e. putting environmental concerns above economic concerns) and it may also prevent the need to carry out habitat creation and enhancement schemes in the future. This would be an excellent way of advertising the fact that cotton farmers care for their environment, and are sensitive to the needs of the environment.

Overall the cotton industry is not considered to have had a significant impact on Aboriginal heritage or sacred sites. However, there has been at least one instance where indirect damage, through the licensed abstraction of water from such a site, may have occurred.

The following recommendations are made regarding the industry's use of land:

- The cotton industry, through the ACF, should work together with local and state government to ensure sensible planning of cotton farms in relation to residential areas.

- The cotton industry should produce an environmental policy statement on land acquisition. This should state what environmental factors will be adhered to during the future expansion of the industry. This should include where new cotton farming developments should be encouraged and where they should not, and should also cover aspects such as the layout and design of newly established cotton farms and their proximity to residential areas and sensitive wildlife habitats.

- The cotton industry should keep a detailed formal register of the land coming into, and going out of cotton production. The anticipated expansion of the cotton industry should be documented in more detail than it has been in the past.

- The environmental implications of all new large scale cotton farming operations should be documented either by the ACF or the Raw Cotton Advisory Committee. This environmental database should include for newly established cotton farms what the land use was prior to cotton, what habitats were/are present on the site and for farms no longer involved in cotton farming what the land was used for subsequently.

- Growers who want to grow cotton on land which possess natural habitats, or whose proposals could adversely affect sensitive neighbouring wildlife habitats should be encouraged to undertake an independent environmental assessment of the site. This would reduce the growth of the cotton industry into environmentally sensitive areas and prevent controversial development taking place. This could take the form of an industry-wide environmental land acquisition policy.

- In the design of new large scale cotton farms, the layout of the cotton farm should comply with a discrete set of environmental constraints which take into account such factors as proximity to watercourses, residential areas and sensitive wildlife habitats.

- In establishing new cotton farms growers should be encouraged to retain, where possible, areas of natural vegetation. The practice of retaining areas of semi-natural habitat on farms should be encouraged.

- New habitats, such as large open waterbodies, should be created and enhanced for their wildlife potential. Farmers should be shown what potential habitats exist on their farms and encouraged to enhance these habitats, wherever possible, for wildlife.

4.3 TREATMENT OF LAND

4.3.1 Issues Relating to the Treatment of Land

On agricultural land generally , degradation can result in a loss of productive capacity. As yields decrease, costs will increase while the land user attempts to maintain a constant level of production. Land can become totally useless for rural production if degradation levels are extreme. Land degradation associated with agriculture are primarily concerned with soil quality issues. Problems with soil that result in a decline in crop yield are, by convention, thought to be problems of an agricultural nature and generally not perceived to be "an environmental issue" per se.

Soil is a resource that growers cannot afford to damage and therefore its conservation and maintenance is of paramount importance to cotton growers. Should the grower not practice good soil management, the soils can become degraded either permanently or for extended periods. Consequently the soil would lose some of its value as a natural resource and become not only an agricultural problem but also an environmental and economic one.

There are many different forms of land degradation on agricultural land. These include sheet and rill erosion, mass movement, wind and soil erosion, dryland and irrigation salinity, induced soil acidity, scalding, and soil compaction. Soil compaction and smearing are the two major forms of land degradation associated with cotton farming and are the issues of most concern.

Wind and soil erosion can cause problems locally but are not a wide scale problem. Induced soil acidity and irrigation and dryland salinity are not a problem for the vast majority of cotton farms as has been demonstrated by the NSW land Degradation Survey of 1987-88. However detailed mapping and monitoring may be required to ensure that it does not become a problem in the future.

Land forming on cotton farms can cause degradation problems, mainly in exposing sodic subsoil. It may also degrade the soil especially if it has the wrong water content. This is caused by poor soil management and can be easily avoided by ensuring that farmers are well informed about soil care issues.

Soil Compaction

Australian cotton is typically grown on cracking clay soils. these soils are prone to compaction as a result of farming operations, particularly when heavy machinery such as cotton pickers are used when the soil is wet.

Soil structure is dependent upon the arrangement of the soil particles and the air spaces between them. The stable soil structure is important for optimal water infiltration and aeration to allow good seedling emergence and maximum root growth. A stable soil structure also reduces the erosion potential of the soil.

Compaction (increasing soil density) and smearing (rearrangement and disruption of channels in the soil without increasing density) are the major forms of soil structure degradation leading to sub-optimal growing conditions for plant roots.

Soil compaction produces a very dense layer known as a plough pan which forms at the base of the cultivation layer. Crop roots are not able to penetrate this dense layer and typically produce the "right-angle root condition". Other problems associated with soil compaction are: reduced soil aeration; reduced infiltration of water; and an increase in denitrification.

Wind Erosion

Wind erosion is the detachment and transport of soil by wind, and is a significant problem in the dry areas of New South Wales where the more sandy soil types can be blown away if they are not protected by plant cover. The repeated disturbance of soil surface by, for example ploughing, will break down soil aggregates into sizes which make them more susceptible to wind erosion.

A particular problem associated with wind erosion is the loss of the finer soil particles leaving only the larger particles. This has the effect of reducing nutrient levels and the ability of the soil to retain moisture for plant growth. Another significant consequence of wind erosion is the burying of cropping land, roads and fences by soil drifts.

Water Erosion

Water erosion is caused by surface water run-off and can result in the creation of gullies. The water can carry silt and other soil particles into water bodies including ditches and rivers.

Soil Slip

Soil slip involves the downward movement of soil under the influence of gravity. The process is complex and the movement of material may be continual, episodic or catastrophic. Soil slip can be triggered in many ways, however it can often be attributed to rising water levels in the soil. Water penetrates the soil profile to unstable zones, reducing the strength of the soil mass, which may then slide down slope.

Fertilizer Application Rates

Cotton growers make a wide use of nitrogenous fertilisers which are applied either as anhydrous ammonia or urea. Application rates are commonly very high with a heavy treatment before planting and a smaller additional treatment during the season via irrigation water.

The rates of nitrogen fertilizer use for cotton are highly variable and can range from zero on new land where the season is short, up to 200kg of nitrogen per ha on heavily cropped land in warmer districts. Higher estimates of nitrogen application have been quoted although most sources state that 150 - 200kg of nitrogen per ha is approximately the amount required for optimum yields. Dryland cotton generally requires only half the amount of nitrogen fertilizer necessary for an irrigated crop.

Traditionally nitrogen fertilizer is applied to cotton prior to planting and for this purpose anhydrous ammonia (marketed as "Big N") is the most economical source. Anhydrous ammonia can be put into water, although this practice is not recommended as it adheres strongly to soil and organic matter and tends to concentrate at the top end of the field. Recent trends have been to follow the pre-plant application with side-dressings of urea in irrigation water, and to use foliar fertilizers. Urea remains in solution during application and is therefore distributed with irrigated water through the field.

There is little concern about nitrogen dispersal from cotton fields when the fertiliser is applied to the soil as anhydrous ammonia or urea before sowing. However, nitrogen is easily dispersed when it is applied as a side-dressing of urea in irrigation water. These can be most significant if heavy rainfall occurs after the surface application of fertilisers but are greater with cropping than pasture applications.

Fertilizer Take Up Rates

Cotton exhibits a recovery rate of applied nitrogen of only 50-60 per cent and thus varying quantities of unused nitrogen are lost. According to NSW Dept of Agriculture and Fisheries research the first two thirds of the nitrogen fertiliser applied is the most important in increasing crop yield; for example, if 150kg of nitrogen per ha is required for maximum yield in a particular field, the first 100kg will increase yield by about 30%, but the next 50kg will only increase it by around 10%. Added nitrogen increases yields primarily by prolonging growth and increasing the numbers of bolls set. It also has a secondary effect of increasing boll weight.

Results from a joint study by CSIRO and NSW Department of Agriculture and Fisheries (Humphreys et al. 1990) have shown that only a very small amount of fertilizer nitrogen is lost by ammonia volatisation and leaching, but that large amounts can be lost by denitrification.

Environmental Effects

Although cotton needs a lot of nitrogen fertilizer (considerably more than wheat or soyabean), excessive quantities can create not only production problems in reducing yields and quality but also may cause environmental problems of increase in run-off and nitrous oxide release through denitrification.

Anhydrous ammonia not taken up by the crop may be leached to the groundwater supply, drained from the field in runoff, or lost as nitrogen or oxides of nitrogen after denitrification. Nitrous oxide which is released to the atmosphere by denitrifying bacteria is a greenhouse gas. Anhydrous ammonia may also be lost to the atmosphere as ammonia.

The amount of nitrogen lost depends on the time of application, soil conditions and plant vigour at the time of application. Losses of fertilizer nitrogen have been found to be very large from early (summer/autumn) applications when followed by heavy rain creating wet soil conditions. The practical consequences of this are that in order to prevent nitrogen loss, a grower preparing land for cotton following wheat or fallow needs to wait until winter before applying nitrogen fertilizer particularly if heavy rain is common in summer and autumn. If rain does fall, the nitrogen application may have to be performed on wet soil, quite possibly creating soil compaction problems. The decision, as to whether nitrogen should be applied, thus depends on the relative penalties of nitrogen loss and soil compaction.

For cotton grown back to back, it is recommended by NSW Department of Agriculture and Fisheries that some nitrogen be applied before sowing. If nitrogen is applied in winter when temperatures are low, denitrification will be lower than in the summer months.

Nitrogen from fertilizers, when added to natural water courses promotes the undesirable growth of aquatic micro-flora such as algae which deplete the oxygen supply by forming algal blooms. These can lead to fish kills. Clearly there is the potential to cause an array of undesirable environmental effects where nitrogen is used heavily to boost agricultural productivity, as in the cotton industry.

Habitat and Species Loss

The clearance of land involved in setting up a cotton farm can result in the loss of large tracts of natural and semi-natural vegetation with the concomitant loss of species associated with those habitats. While little research has been carried on how individual

species are affected by the conversion of say, grazing pasture to cotton wheat or soyabean fields, it is widely accepted by the scientific community that land that is intensively farmed as a monoculture is very limited in its range of habitats and species.

All farms, however intensively managed nevertheless have some wildlife potential, and there are many opportunities to enhance the wildlife potential of the few habitats that are present. There are several examples in the cotton industry of individual growers and corporate farms improving the potential of wildlife habitats that occur on their properties and creating valuable wildlife refuges. However there is no industry-wide policy to encourage these environmental improvement initiatives.

4.3.2 Legislation Relating to the Treatment of Land

The main legislation covering land use in New South Wales is:

The Protection of the Environment Act 1991 - The Protection of the Environment Act institutes the Environment Protection Authority and the powers that are vested in the Authority. The new Authority is intended to streamline the existing regulatory framework and bring together many of the fragmented responsibilities for environmental programmes.

The Soil Conservation Act 1938 - This Act establishes the service which promotes, researches and co-ordinates the conservation of soil resources and mitigation of erosion. The agency responsible for enforcing this Act is the Soil Conservation Service.

In Queensland the most relevant legislation concerning land use is:

The Soil Conservation Act 1965-1982 - This Act establishes the Soil Conservation Authority to undertake programs for the conservation of soil and prevention, or mitigation, of soil erosion. The agency responsible for this Act is the Soil Conservation Authority which is part of the Department of Primary Industries.

The legislation concerning land degradation has been inadequate, in that it has not prevented soil degradation occurring on a very large scale throughout Queensland and New South Wales. While soil degradation issues are important in cotton farming, they are much less of an issue than in some other forms of agriculture.

In order to address the shortcomings of state legislation the government, in 1989, established a network of "Landcare" groups to overcome the principle land degradation problems that occur throughout Australia.

The Prime Minister's statement on the environment "Our Country, Our Future" released in 1989 was a commitment by the government to provide renewed impetus and new directions in tackling environmental problems. One of the key elements of the Prime Minister's statement was the promulgation of the years 1990 to 2000 as the Decade of Landcare. One of the most important initiatives announced in the statement included making the provision for more than $260 million to attack the problem of land degradation through the National Soil Conservation Programme.

Landcare groups enable all members of the community to become involved in the issue of reducing land degradation. They receive advice and technical information from the Soil Conservation Service.

The formation of farm and community organisations into landcare groups has been a major contribution to tackling the most important environmental issues. The idea behind the landcare groups is to bring together local land holders and related parties, and - without formal government intervention, aside from technical and organisational assistance - identify and tackle specific land use problems in each district.

Landcare groups range in size from a dozen to more than 50 people although most groups have between 15 and 30 members. From early to mid 1989 the number of officially recognised and funded groups increased from 200 to around 350. This is well on the way to the 1200 target set by the Federal Government in August last year.

Landcare groups work on a water catchment or sub-catchment basis. A catchment is the area of land that drains into one water system and has shared characteristics such as topography. Some catchments can be several thousand square kilometres in area, though most are small. Landcare groups have a vital role to play in preventing land degradation taking place across farm boundaries and provide a focus for increased government expenditure and community involvement.

Landcare groups have an important role to play for the following reasons:

1 Land and soil degradation do not follow farm boundaries. The way one farm is managed can have a significant effect on others. It is important that farmers and co-operatives recognise that a regional approach to land care issues is essential.

2 Growers are more likely to receive government recognition and support as groups rather than as individuals. Groups are more efficient users of limited resources such as suitably trained soil conservation officers. At the same time groups are better at lobbying for extra resources and place more pressure on advisers for sound advice and assistance.

3 Groups can pool ideas, resources and labour. Individual growers benefit from the diversity of skills and backgrounds within a group.

4 Landcare groups are sustained by a complex mixture of peer pressure, leadership from committed individuals and support from external agents. Peer group pressure is the best way of tackling environmental issues and is the favoured option of most politicians, growers and government departments.

5 Landcare groups provide an opportunity for non-farming residents of a district to interact in a constructive way. Group formation can be stimulated and their activities enhanced by individuals outside the mainstream farming community.

In summary there is considerable government and industry support for the Landcare initiative and Landcare groups are regarded as being a successful way of narrowing the divide that farmers not only feel is present between city and country but also between themselves and their neighbours.

4.3.3 Performance of the Industry in Relation to the Treatment of Land

Soil Compaction

The full extent and cost of this form of soil degradation has been only recently realised. The Murray-Darling Basin Environmental Resources Study recently estimated the cost of soil structure decline within the Basin at $144 million per year (Murray-Darling Basin Environmental Resources Study). This is much more than for any other form of land degradation studied. The areas of principal concern however lie outside the main cotton growing areas.

All cotton growing areas, including the Namoi and Gwydir river valleys and the Macquarie river valley in New South Wales have experienced soil degradation problems after five years of farming. Similar problems with soil compaction have also been experienced in the Emerald irrigation area of Queensland. It is generally considered both within the industry and outside it, that it is virtually impossible to grow cotton without incurring some soil compaction and smearing problems.

Soil compaction however is considered to be reversible. There are a variety of techniques that can prevent soil compaction occurring and that can also deal with it once it has occurred.

To help prevent or reduce problems with soil compaction the NSW Dept of Agriculture and Fisheries have produced a soil management manual specifically for cotton growers called "SOILpak". The manual presents various options for growers rather than specific hard and fast rules. The manual is aimed at cotton consultants, field officers, growers and researchers. As stated above, SOILpak is aimed at cotton growing and the management advice contained within the manual is based on the assumption that cotton is the major crop in the rotation. The manual, however, is applicable to all irrigated crops and most dryland crops that are grown on cracking clay soils.

The manual offers practical guidelines in soil management for cotton growers and will help to refine the approach to soil problems facing growers. In particular the manual explains how back-hoe pits can be used to examine the soil profile in cotton fields for symptoms of compaction or smearing. The manual also describes what remedial action can be taken to prevent soil compaction from occurring.

SOILpak has initially been aimed at the cotton industry in northern New South Wales and southern Queensland and has concentrated on cracking clay soils. The SOILpak concept, however can also be applied to other soil types such as the red-brown earths which together with the cracking clays, are the most common of irrigated soils in eastern Australia.

These techniques include growing wheat as a rotation crop. This is extremely effective at drying out the soil. This has the effect of cracking the heavy clays and breaking up the plough pan. While the wheat market is very poor, the beneficial effects on soils make it worthwhile for cotton growers to rotate wheat with cotton. Although the typical crop rotation is quoted as being one in three ie. 2 years cotton to 1 year alternative crop, some of the growers we interviewed had longer crop rotation cycles.

On well established farms cotton is grown in rotation with other crops. Crop rotation is an effective way of maintaining soil structure and preventing soil compaction problems. It also prevents the spread of disease (eg verticullum wilt and bacterial blight) from one growing season to the next and helps to maintain high yield levels.

The usual pattern of crop rotation for a newly established cotton farm is to grow cotton every year (or "back to back") for the first three to five years, because of the need for a rapid return to service bank loans, and thereafter to grow cotton in a crop rotation cycle with an alternative crop i.e. wheat. Some farms grow continuous cotton for many years (up to 15 in a row) without alternating, however this practice is contrary to that recommended.

Well established farms can usually afford to grow cotton in rotation. A cotton comparative analysis for the 1989-90 crop produced by the Chartered Accountancy firm Michael Boyce & Co demonstrated that the top 20% of economic performers were either growing cotton on land that had grown only two or three crops or was subject to rotation, whereas all of the farmers in the bottom 20% of economic performers were growing cotton back to back for many years.

Soil compaction problems can also be prevented by reducing or avoiding landforming or tillage when the soil is wet. This results in fewer machines passing over the soil and therefore less soil compaction, greater moisture conservation, improved nutrition and greater fuel economies.

Tillage of wet fields is always detrimental to soil structure. It is a difficult management decision based on the desire to retain soil quality while seeking viable returns. Equipment options are available to minimize the effects of this difficult decision.

The area of compacted soil can be reduced by using permanent beds (ie. tracks across the field which can be permanently used). These reduce the area over which vehicles have to travel and hence reduce the area of compacted soil. The impact of traffic on cotton growing soils can be further reduced by using four-row instead of two-row pickers and using lighter vehicles. While some growers are certainly adopting permanent beds and minimum tillage systems, there are no figures available to indicate what proportion of growers are practising these soil conservation procedures.

Soil compaction can also be treated mechanically by deep ripping or "chisel ploughing". This is particularly common in heavy grey soils although the benefits of this practice is short-lived in soils with high silt and fine sand contents.

Other soil problems such as erosion and build up of salinity are of less concern than soil compaction and only cause problems on certain farms. This has been verified by the 1987 - 1988 Land Degradation Survey carried out in New South Wales by the Soil Conservation Service.

Soil Erosion

The heavy clay soils in most cotton areas lie on flat plains and are not, therefore, very susceptible to down slope water erosion. On irrigated cotton farms the fact that cotton is grown on heavy moist soil reduces susceptibility to wind erosion.

However, because the soil is exposed for much of the year and a great deal of earthmoving and earthworks are integral to the infrastructure of irrigated cotton growing, some wind erosion and siltation does occur, and grading, levelling and dredging of irrigation channels and ditches is often necessary.

In Queensland some cotton is grown on sloping terrain and this is much more susceptible to soil erosion, however growers are generally aware of this and manage the land accordingly, utilizing short rows on the steepest slopes. Growers also use narrow siphons to put water onto steep cotton paddocks to slow the rate of water flow and hence erosive force. Slopes may also cause problems with waterlogging which can have serious consequences for the viability cotton plants. Soil erosion, while it can cause problems locally, is largely preventable through good irrigation design and management.

Wind and soil erosion are to a certain extent preventable. It is in the farmer's best interests to prevent them occurring and improved performance would increase efficiency and avoid adverse environmental impacts. There are no figures available to show how much soil erosion is being caused by the cotton industry. It is however known to occur and cause significant problems locally.

Fertilizer Use

Interviews with growers and the NSW dept of Agriculture and Fisheries revealed that although many farmers were careful in the amount of fertilizer applied to soils using the NRATE computer program (included within SIRATAC) to assess nitrogen concentrations and application rates, there was a general tendency throughout the industry to use more, rather than less nitrogenous fertilizer. While there are no data available to substantiate this statement it should be noted that the over-use of fertilizers could potentially result in a number of adverse environmental impacts (these are dealt with in more detail in chapter 5).

It was suggested that fertilizers were sometimes used to counteract problems arising from a decline in soil structure. Over-use of fertilizers results in unnecessary cost and waste, rank growth of weed species contributing to a reduction in yield, and delayed maturity which can increase the risk of wet weather hampering the harvest and damaging fibre quality.

In summary, nitrogenous fertilisers can have a significant impact on waterways by causing eutrophication of waters leading to algal blooms. The potential contribution from the cotton industry is greatest during high rainfall, but otherwise with proper control of irrigation tail waters need not be a problem. Tighter control and more efficient use of fertilizers may be required.

Habitat Creation and Enhancement

While the establishment of cotton farms can have large and adverse impact on the local environment, it may also provide new habitats for certain species. On cotton farms which have water storage lagoons, there is an increased availability of surface water and several species of water birds readily exploit these new habitats, particularly during periods of drought.

Water storage facilities have some potential as habitats for wildlife. Much could be done by individual farmers and throughout the industry to improve the wildlife potential of these water storage facilities. For example the provision of cover, and tree stumps to perch on would be of benefit to local birdlife.

Occasionally small remnants of native vegetation within the boundaries of cotton farms remain in good condition due mainly to the absence of grazing. Some individual growers recognize the need to retain natural vegetation on their farms and keep parts of their farms out of cultivation for this very purpose. Others actively support tree planting programmes; some large corporate owned farms plant large numbers of trees (up to a 1000 trees a year in some cases) as a matter of policy.

4.3.4 Conclusions and Recommendations Relating to the Treatment of Land

Soil compaction has caused significant problems in the past for the majority of cotton farms. However, the methods for preventing its occurrence and treating it are now fully understood and many of these techniques are being widely used in the industry.

Similarly the methods by which soil erosion can be reduced are well established and many farms are taking measures to prevent its occurrence. Wind erosion problems on cotton farms can be minimized by practising good soil management techniques. The best ways to reduce the threat of wind erosion include: the retention of cotton stubble; the sowing of successive crops into stubble residues; the use of reduced tillage systems; and increasing the lengths of pasture rotations between crops.

Information on soil management is widely available and the introduction of SOILpak and the activities of the Soil Conservation Services, the New South Wales Department of Agriculture and Fisheries, and the Queensland Department of Primary Industries, have done much to reduce the incidence of soil degradation.

The heavy use of fertilisers on cotton farms has the potential to cause significant environmental damage. Principally through the eutrophication of waterways, but also as a result of fertiliser volatisation which causes nitrous oxides to be released into the atmosphere.

The establishment of cotton farms has resulted in the loss of both habitat and species diversity although there is insufficient data to determine the extent to which this has occurred. Some small areas of habitat have been created, specifically new waterbodies. While some farmers have taken the opportunity to increase the wildlife potential of these new habitats, the majority have not.

The following recommendations are made regarding the treatment of land:

- Greater promotion of Landcare groups. This is an effective way of disseminating information, putting pressure on poor performers and liaising with the local community. Both the number and status of cotton farming Landcare groups should be increased and their activities promoted.

- Habitat enhancement and creation measures should be encouraged throughout the industry to make it the normal practice rather than the province of a few environmentally aware companies and individuals. The channels of communication are in place to promote this initiative (i.e. the landcare groups).

- Measures to reduce and prevent the incidence of soil compaction and soil erosion should be one of the cotton industry's main landcare environmental objectives. The techniques and "know-how" are available, it is simply a question of the dissemination of up-to-date information (through Landcare groups, seminars, conferences, fairs) to as large an audience of cotton growers as possible.

- Fertilizer use is not currently causing major environmental problems in the cotton industry, but it has the potential to cause significant damage if not carefully controlled. Over-use should be discouraged not only on economic grounds but also on environmental grounds.

CHAPTER 5 WATER USE

CHAPTER 5 CONTENTS

5.3.4 Conclusions and Recommendations Regarding Water Management

Tail Water Management
Ground Water
Water Storage

5.1 INTRODUCTION

The Australian cotton industry is largely dependent upon the availability of water for irrigation, although a certain amount of rain-fed cotton is also grown. The creation of major dams on rivers in New South Wales and Queensland in the 1960's and 70's provided a reliable supply of irrigation water and thereby provided the impetus for the massive expansion and present commercial success of the cotton industry. The great majority of the cotton now grown in Australia is flood irrigated and hence the industry represents a large regional demand on water resources.

Furrow irrigation (also called flood irrigation) is the main method used by Australian cotton growers. Water is syphoned into the field from a header ditch located up gradient and runs down between the rows of plants. The run-off is collected in a tail-water ditch and generally channelled to another part of the farm for re-use or storage. Water is applied to the crop at intervals throughout the season, the timing of these irrigations being controlled in relation to water demand by the crop.

Water-use is limited by a system of licences and allocations (see section on legislation and controls) in all areas, but the way in which it is provided varies. Typically growers pump water out of the river themselves but in some of the Queensland irrigation areas, such as Emerald, a water supply network was built by the government and this supplies water to the farm boundary. Some growers use boreholes, either instead of or in addition to river water supplies. Many growers supplement their water allocations by collecting storm run-off in purpose built storage reservoirs. Alternatives to furrow irrigation are available, notably drip irrigation and sprinkler irrigation (Browne 1984) but these methods are rarely used in the Australian cotton industry.

5.2 WATER ABSTRACTION

5.2.1 Issues Relating to Water Abstraction

Surface Water

Issues concerning the abstraction of water for irrigation purposes revolve around the conflict over a limited resource. Australia is the world's driest continent and consequently water resources are at a premium.

Water use is strictly controlled in the cotton growing areas of both Queensland and New South Wales and resolving potential conflicts between different groups of water users is the responsibility of the authorities who allocate water resources. Nevertheless the cotton industry is regarded by some as a particularly heavy water consumer at the expense of other water users. It is felt by some that the financial muscle of the cotton industry enables it to exert greater influence with the water resources departments than other groups.

Surface Water

Allocations are renewable and transferable. Irrigation licences are limited within each river catchment and new licences are only granted when a dam has sufficient spare capacity.

Water off-take from the river is metered and charged for the quantities used. Growers are obliged to inform the Department of Water Resources in advance when they wish to pump. The required volume of water may then be released from a dam and the grower may commence pumping when this water reaches his pumping station; this may take up to fourteen days, depending on how far downstream from a dam the farm is situated.

During periods when surplus water is present in the dam, higher flows are released downstream and growers may take water during these periods without debiting their licensed allocation. Periods when off-allocation pumping is permitted are announced in advance.

Illegal pumping - 'water theft' is punishable by a fourteen day suspension of the pumping licences (after a second offence) but the offender is not prevented from using the illegally obtained water. Peer pressure is considered to be the principle restraint against unauthorised water use.

Ground Water

Use of water from boreholes is licensed and controlled in a similar manner to the use of river water, although off-allocation allowance obviously do not apply.

5.2.3 Performance of the Industry in Relation to Water Abstraction

Surface Water

Water usage within the cotton industry is very high; Department of Water Resources figures indicate, for example, that irrigators in the Gwydir Valley divert an average of 350,000 megalitres of water per year which represents over 40% of the 820,000 megalitres/year flow in the Gwydir River at Pallamallawa where the plains commence. The offtake of this water has inevitably had an impact upon downstream water availability and has certainly led to a reduction in the extent of the floodplain wetlands. Information is not currently available on the extent of the impact on aquatic ecosystems.

The general view encountered amongst water officials, researchers and growers was that the actual usage of irrigation water is fairly efficient. Most growers monitor water movement in the soil with sophisticated electronic meters ('neutron probes') which enable them to schedule the timing of irrigations very accurately to achieve maximum benefit to the crop and minimise wastage.

Water uses with which cotton irrigation may potentially conflict include the irrigation of other crops, industry, domestic water supply and, in particular, the provision of water for livestock. Questionnaires were received from three graziers, which referred to monopolisation of water resources by the cotton industry.

Offtake of water for irrigation also affects riverine wildlife, reduces the flow through down-stream wetlands and alters the seasonal pattern of high and low flows. Wetland areas are generally of great importance for wildlife, but this value is vulnerable to modification of the flow regime.

Ground Water

Where ground water is used for irrigation, a potential problem is the depletion of the aquifer which occurs when consumption rates significantly exceed recharge rates. The result could be a diversion of water resources away from other users.

5.2.2 Legislation and Controls Relating to Water Abstraction

General Control

The use of water by cotton growers in New South Wales is regulated by the Department of Water Resources. Growers apply for an irrigation licences and, if successful are given an allocation based upon the area of land they wish to irrigate. This allocation is set at 6 megalitres/hectare/year but this is provisional upon adequate water resources being available at the start of the season and it is common for growers to receive less than 30% of their allocation in seasons following a dry winter. In Queensland the control of water usage is vested in the Water Resources Commission, a division of the Department of Primary Industries. The system of licensing is similar to that employed in New South Wales.

Australia is a signatory of the Ramsar Convention on Wetlands of International Importance and consequently has accepted obligations to designate wetlands as Internationally Important and to conserve the value of these areas. Australia has designated three such wetlands, including the Macquarie marshes which share a common water supply with irrigated cotton farms in the Macquarie valley. Membership of the Ramsar Convention also involves an undertaking to manage all wetlands wisely. Diversion of water from wetlands to cotton farms upstream of them is not necessarily a breach of these obligations provided that sufficient flows are maintained to allow the continued and proper functioning of the wetlands.

The principle area of water wastage is in evaporative losses from channels and water storage areas. These losses can amount to as much as 25% of the water used. Losses from channels could be greatly reduced by piping the channels (cutting seepage losses as well as evaporation) but this would entail prohibitive costs (McGowan International 1986).

The allocation of the available water resources between different groups of users is inevitably politically complicated. Interviewees from the water resource authorities claimed that different interest groups have fair access to water resources and that in-stream wetlands are also a recognised 'water use' for which adequate flows are maintained (eg the Macquarie marshes are allocated 50,000 megalitres/year).

Ground Water

A number of growers were met by the Audit team who used ground water either instead of or, more usually, as well as surface water supplies for irrigation purposes. This was particularly the case in the Darling Downs area. One grower indicated that one of his boreholes had failed. There were no other indications that exhaustion of ground water reserves as a consequence of cotton or other crop irrigation had occurred.

5.2.4 Conclusions and Recommendations Relating to Water Abstraction

Surface Water

It is beyond the scope of the present study to judge between the quotas of water allocated to different sectors of the community. Clearly the authorities responsible for the allocation of the resource have a duty to ensure that this is not only as equitable as possible, but also that water-use achieves maximum economic benefits to the whole community. In this last respect the use of water for cotton irrigation has clearly been successful as the crop has undoubtedly been responsible for a general increase in the prosperity of the regions in which it is grown. It is also essential that the water requirements of important wetlands are considered by the water authorities in their allocation of water quotas.

Water use on cotton farms in general appears to be relatively efficient and there is perhaps little scope for reducing the major element of wastage, evaporative losses. Nevertheless research into methods of cotton growing which could reduce water requirements (eg use of short season varieties, better scheduling of irrigations, improved soil management) could reduce the volume of water wasted and should therefore be pursued.

Ground Water

The limited evidence available to the audit team suggests that exhaustion of ground water reserves is not currently a problem other than at a local level. Use of ground water reserves is controlled in the same way as surface waters and the water resource authorities can avoid excessive offtake through the limitation of licences and allocations. Clearly an independent assessment of ground water reserve depletion would be desirable.

5.3 WATER MANAGEMENT

5.3.1 Environmental Issues Associated with Water Management

Tail-water Management

The handling of irrigation water is one of the most controversial aspects of the industry because of the potential for polluting rivers through the release of tail water. Many of the questionnaires received identified this as an issue and interviews revealed that it is a major concern of regulatory bodies such as the SPCC and the Water Resources authorities of both states as well as industry critics and growers themselves.

Furrow irrigation gives rise to a small proportion of surplus water which runs off the bottom of the field. This 'tail water' will often be contaminated with pesticide residues washed from the soil and the crop stems as it flows down the field. If subsequently released into a river, these pesticide residues can form a hazard to aquatic wildlife and potentially to human communities through contamination of drinking water.

Many of the insecticides used on cotton are known to be toxic to fish and there have been occasional fish kills which have been widely attributed to releases of, pesticide contaminated tail-water. These incidents are widely reported in the press, radio and television and were considered by nearly all questionnaire respondents to be the most widely publicised issue. It is argued by the industry, however, that fish kills can be caused by other factors and that tail water release is often not responsible for fish kills.

In addition to contaminating receiving waters with pesticide residues, tail water releases can also affect water quality by importing nitrogen and other nutrients from fertiliser applications and by increasing silt loads. Increased nutrient levels, referred to as eutrophication, can potentially promote excessive growth of aquatic algae which in turn can choke other aquatic life and, in extreme cases, completely de-oxygenate the water. Algal 'blooms' provoked by excessive nutrient levels can sometimes involve Blue-green algal species which produce toxins that are potentially fatal to wildlife, livestock and people drinking the water.

In addition to surplus irrigation water, storm water run-off from cotton fields can potentially lead to the same pollution problems, if allowed to enter rivers.

Ground Water Contamination

Contamination of ground water through the leaching down of pesticide and fertiliser residues is an area of potential concern, especially as contaminated aquifers may take extremely long periods of time to recover, depending on the nature of the recharge. This does not, at present, constitute an issue of major public concern with respect to the cotton industry, although some monitoring could provide useful information on this issue.

Water Storage

Many growers have on-farm water storage facilities. In most cases these consist of purpose-built 'ring tanks' but some growers opportunistically use natural billabongs for this purpose. Although not an issue of major public concern, there is concern in some quarters that this practice could have deleterious effects on the ecology of these ephemeral wetlands by interfering with the natural wetting and drying cycle. Billabongs are important habitats for breeding waterfowl and in wet years can be biologically very productive.

5.3.2 Legislation and Controls Relating to Water Management

In New South Wales, water pollution currently falls under the jurisdiction of the State Pollution Control Commission who implement the Clean Waters Act (1970). Under this Act it is an offence to discharge pollutants to any water body without a discharge licence. Offenses against the Act carry penalties of up to $40,000 for a corporation and $20,000 for an individual. The SPCC is also empowered under Regulation 21 of the Clean Waters Act to order growers to carry out appropriate works to prevent tail-waters contaminating rivers. Effectively these laws amount to an obligation on growers to recycle all of their tail water (and storm run-off) within the farm and not release it to any rivers.

After July 1991 the SPCC will be brought under the umbrella of the newly formed Environmental Protection Agency. This will have implications for resources and hence the implementation of legislation but otherwise will probably not significantly alter the legal position with respect to tail water control.

In addition to the SPCC, the Department of Water Resources also imposes conditions on growers before granting irrigation licences. These include installing adequate tail-water control systems. The Department of Water Resources indicated that conditions are likely to become more stringent and include requirements for management plans and environmental impact studies.

In Queensland the principal legislation relating to pollution from tail-water releases is the Clear Waters Act (1971-82) administered by the Water Quality Council. This Act prohibits indiscriminate and uncontrolled discharge of waste water and other polluting matter into State's waters. Pollution is defined as "any change in the properties of any

waters such as to cause or be likely to cause a nuisance or render such waters harmful, detrimental or injurious to public health, safety or welfare or to domestic, commercial, agricultural, recreational or other legitimate uses thereto or to livestock, wild animals, birds, fish or other aquatic life". The Act also imposes a "Duty of Care" on occupiers of all premises to ensure that water pollution is not likely to arise from their activities.

The Clean Waters Act notwithstanding, the Queensland authorities apparently pursue a more laissez-faire policy with respect to irrigated farming and do not actually impose tail water recycling on growers.

5.3.3 Performance of the Industry in Relation to Water Management

Tail Water Management

Release of Tail Water

In New South Wales all of the growers interviewed claimed to have reticulated irrigation systems designed to recycle all of their tail water. Most also possess water storage impoundments enabling them to hold at least a proportion of the run-off from storms although a number of farms were observed from the air which did not possess water-storage reservoirs. Corporate farmers visited also had fail-safe systems (e.g. locked sluices with only one key held by the responsible irrigation manager) to minimise the possibility of unauthorised release of tail-water. In spite of these precautions there is evidence that releases do occur, at least occasionally.

Interviews with government officials (SPCC and Department of Water Resources) indicated that they consider the majority of growers are good performers with respect to tail water control but that a small percentage are careless. It was suggested by one interviewee that few breaches of the Clean Water Legislation were blatant abuses, the majority being stress related. Small new cotton farms servicing heavy bank loans are likely to be most economically stressed and to have the least adequate precautions against tail-water and storm water release; and this may explain why fish kills appear to occur more frequently in the more recently established cotton growing areas.

An area of confusion concerning water releases to rivers is the amount of storm water that growers should withhold in the event of heavy rains. In New South Wales the SPCC did at one stage suggest that all storm water from a six inch storm should be retained but growers argued that this was unrealistic. These volumes of water would be technically difficult to contain and in any case the dilution levels would be so great that any pesticide residues in the run-off would have negligable impact. It is generally agreed that, because of this dilution effect, only the 'first flush' of a major storm needs to be retained but there is currently no guidance on how to calculate the first flush (i.e. the accceptable pesticide permissable for release).

Fish Kills

The most conspicuous 'evidence' of tail water release is the occurrence of fish kills. Other evidence suggests that at least some of the reported fish kills are the result of pesticides released with tail-water. The industry suggests that alternative causes include anoxia (especially after storms which stir up sediments into the water column) and sudden temperature changes (as when a dam releases a 'slug' of colder water downstream). In warm weather high nutrient levels (eg from sewage effluent) can promote high algal and microbial activity which can also cause anoxia. The State Pollution Control Commission acknowledges (interview) that such factors can also potentially cause fish kills.

The frequency with which fish kills occur is uncertain but may be in the region of about 6 incidents a year according to the SPCC, although Whyte & Conlon (1990) refer to only 8 kills between 1983-84 and 1988-89. These are apparently not randomly distributed throughout the cotton growing areas but seem to occur in certain 'hot-spots'. One such hot spot is the Mungindi area on the Macintyre River where several fish kills have occurred in recent years.

There are great difficulties in determining the true cause of fish kills when they occur because low staff levels of SPCC and other bodies combine with the great distances involved, to make it rare for fresh samples of the river water and dead fish to be collected for laboratory analysis. Only one case has resulted in a prosecution, when a Mungindi grower was successfully prosecuted for causing a fish kill by a tail-water release (though this case is currently under appeal). Whyte and Conlon (1990) cite several cases where endosulphan was found to be present in the water but uptake by the dead fish (and therefore the cause of their death) not proven. In two of these cases storm conditions likely to create unfavourable conditions for fish preceded the incident.

It is not known what impact these fish kills have on population levels within the river as this has not been studied. Elsewhere, Johnston and Cheverie (1980) found that 10 months after a large kill of a population of Brook Trout *Salvelinus fontinalis* and Rainbow Trout *Salmo gairdnera* in a Canadian stream the population levels had only recovered to 38% and 73% respectively of their 3 year average before the kill. However, as that study demonstrated, different species can be expected to differ widely in speed of recovery from population crashes, depending on many factors such as life-history strategies, behaviour and the availability of other populations from which re-colonisation can occur. The relevance of that study to Australian cotton-related fish kills is therefore limited. Furthermore, although large numbers of dead fish have been observed when fish kills have occurred, no known attempt has ever been made to estimate what proportion of the local population has been affected.

It is not known to what extent aquatic invertebrates are affected when fish kills occur. Mortality of these organisms is likely to be much less conspicuous than fish deaths and the potential for it to occur cannot be excluded.

Other than in the border region along the Macintyre River, fish kills appear not to have been reported in the Queensland cotton growing areas in spite of the fact that there appears to be less stringent observance of tail-water recycling. In Emerald, for example,

the government constructed irrigation infrastructure designed so that growers release their tail water into a drainage network which eventually debouches into the natural river system (though growers may pump free water from the drainage system as it passes their own property). In spite of the apparent risks with this system, no fish kills have been reported and the Local Authority water sampling (see below) has not revealed any problems. Regional differences in the extent to which fish kills are reported may be partly due to some rivers or creeks being more vulnerable to fish kills (for example because they are slow flowing, or located adjacent to a cotton farm) and partly because incidents are more likely to be observed in some areas than others.

Many growers claimed to have fish populations within their own water storage and irrigation systems and cited this as evidence that the problems with tail-water are exaggerated (since these water bodies would be expected to be more contaminated than rivers). The presence of piscivorous birds including herons, cormorants and darters in a number of the water storage lagoons observed during the audit, to some extent bears out this claim. Growers stated that they did not experience fish kills in these lagoons but this could not be independently verified.

Water Sampling

Water sampling programmes have until recently been carried out on an *ad hoc* or incident-related basis and consequently there is a shortage of data on pollution levels in most water bodies. However a number of studies have been conducted which have provided some evidence on the extent to which releases of tail-water occur and the extent to which water bodies are contaminated with pesticides.

The SPCC conducted a water sampling survey on the Gwydir, and Macintyre/Barwon river systems in 1986-87 (Knowles 1987) and detected various pesticides in several samples. These included the banned insecticides dieldrin and chlordimeform as well as endosulphan and diazinon. Concentrations of endosulphan detected ranged from traces up to 3.0 µg/L and in several cases exceeded levels which in Australian conditions could potentially provoke fish kills (0.3 µg/L; Whyte and Conlon 1990). The levels were in all cases well below the levels permitted in drinking water by the World Health Organisation (40.0 µg/L).

Knowles (1987) suggested that the results of his survey (which also measured other water quality parameters including turbidity, suspended solids and nutrient levels) indicated that most tail-water releases may be occurring at the end of the growing season after growers have no further need for irrigation water.

Water sampling has also been conducted in the Emerald area by the Local Authority. This initially covered eight sites around the town, including the raw water intake for the town's domestic supply, on a fortnightly basis. Analysis covered the range of pesticides in use in the area. The programme, has only revealed trace levels of any of the pesticides concerned and consequently has been scaled down. For example in the 1989-90 season only one sample contained detectable levels of pesticide. This sample contained 0.3 µg/L endosulphan which, whilst well below acceptable level for human drinking water is sufficiently high to be potentially dangerous to fish.

In New South Wales, a more complete data set should soon be available to allow assessment of the extent of pollution of water courses through tail-water releases as the Department of Water Resources has recently commenced a pesticide monitoring programme in the Namoi, Gwydir, Barwon and Macquarie valleys. This programme is being partly funded by cotton growers through a levy on the cost of irrigation water of ¢25/megalitre. The survey is intended to determine the sources of undesirable chemicals and ways of reducing them and to provide public information on these issues. Results are not yet available from this survey.

Fertilizer Run-off

The impact of fertiliser use on water quality is also an area of potential concern as large quantities of nitrogen are applied to cotton crops. Water Resources officials in New South Wales and Queensland were interviewed and confirmed that eutrophication is considered a problem in Australian Rivers but urban sewage and effluent from feedlots and abattoirs were suggested to be main causes. As with pesticide residues, the potential for eutrophication of rivers by the release of fertiliser enriched tail-water is limited by the legal and physical infrastructure designed to keep tail-water on-farm.

There is evidence that losses of nitrogen applied as fertiliser to irrigated cotton crops consist chiefly of denitrification (ie losses to the atmosphere) rather than run-off or leaching below root level (Humphreys *et al.* 1990). This may indicate that, in any case, tail waters are not particularly nutrient enriched. Excessive algal growth did not appear to be a problem within the irrigation systems and water storage lagoons of farms observed during the audit, supporting this view since these water bodies would otherwise appear to offer ideal conditions for algal blooms.

Ground Water

Most of the cotton farms in the Australian industry are situated above relatively thick deposits of impermeable clays and so the contamination of ground water supplies represents a reasonably small risk. Where growers who farmed on different soil types or on land with aquifers close to the surface, were interviewed they demonstrated an awareness of the risks of ground water contamination and took precautions to avoid it including avoiding persistent soil active insecticides and avoiding burial of pesticide containers.

The risks to ground water posed specifically by irrigation practices are also potentially less than those posed by pesticide disposal practices since the timing of irrigations and the amount of water supplied each time are calculated to make the most efficient use of the water resource. This includes ensuring that as small a proportion as possible descends down the soil profile beyond the reach of the crop roots. The greatest potential for irrigation water to penetrate deeply down the soil profile and possibly into ground water is through seepage from poorly sealed channel bottoms and water storage lagoons.

Studies of the fate of nitrogen applied as fertiliser on irrigated cotton crops on typical grey clay soils have indicated that the principle losses are due to denitrification and that losses to leaching are negligible (Humphreys *et al.* 1990) suggesting that nitrate contamination of ground water is not a significant threat. Similar studies on other soil types would be useful to support this conclusion.

An interview with the Department of Water Resources in New South Wales indicated that the Great Artesian basin, one of the largest aquifers in eastern Australia does not show any signs of pesticide or nitrate contamination. There are however many smaller aquifers closer to the surface and it is not known if any of these have been contaminated. The SPCC interviewees believed that the good aquifers are reasonably protected.

Water Storage

Little information is available on the extent to which billabongs are used for water storage on cotton farms although the practice is known to occur (Whyte and Conlon 1990). All of the cotton farms visited during the audit had purpose built ring tanks for water storage purposes and no billabongs were observed in use as water storage facilities. One of the farms visited had a billabong area which was maintained as an 'unofficial nature reserve'

Research has not been carried out into the effects of storing water in billabongs but there is concern that interference with the natural wetting and drying cycle could upset the ecology and reduce the productivity of these ephemeral wetlands. Potential impacts include the death of plant species which cannot tolerate prolonged inundation or waterlogging (eg Red River Gums) and their replacement with aquatic flora (animals dependent on the original flora then lose habitat) and the upsetting of nutrient cycles (Department of Water Resources 1990).

In contrast to the potentially adverse effects of using billabongs, the construction of ring tanks has a potentially positive impact by providing additional habitat for aquatic wildlife. Some of the water storage impoundments seen during the audit were of some value to wetland bird species with various heron, egret, cormorant and wildfowl species present on them in reasonable numbers. However most storages observed contained little bird life. The standard design of these storage lagoons aims to maximise storage capacity and minimise the area occupied, with the result that typically they are relatively deep (3 - 5 metres) with steeply shelving banks. These characteristics do not favour most aquatic wildlife.

5.3.4 Conclusions and Recommendations Regarding Water Management

Tail Water Management

The majority of growers are responsible about recycling tail water and preventing its escape into natural water courses. Water shortage and the resulting pressure to make the very best use of available water encourages good practice in this respect. Nevertheless there is evidence that breaches do sometimes occur. These are likely to be caused by a minority of poor operators, who affect the reputation of the entire industry.

When tail water is contaminated with pesticides, its release can cause fish kills and this will have been the cause for some of the fish kills that have been observed. However, the proportion of fish kills occurring which can be attributed to tail water releases remains open to question as the data necessary to determine the cause is not always available.

It is to be hoped that the creation of the new Environmental Protection Agency in New South Wales will result in greater allocation of resources to effective monitoring of incidents so that professionally competent agents can rapidly obtain the appropriate samples. The cotton industry should welcome such a development and encourage it, since independent, authoritative decisions will be very much in its favour when fish kills are not caused by tail-water release, whilst the greater probability of being caught should reduce the frequency with which tailwater releases occur.

Fish kills, when they do occur, are possibly the worst publicity for cotton farming and the industry should make a concerted effort to ensure that all of its members apply the highest standards of control possible. Although clearly undesirable, the wider implications of fish kills should not be exaggerated. Fish are particularly sensitive to endosulphan and so a fish kill does not necessarily imply a human health risk. The levels of pesticide that have been recorded in river water to date have been well within the levels considered safe by the World Health Organisation.

The introduction of a systematic pesticide monitoring scheme by the Department of Water Resources in New South Wales is very welcome, particularly as the available water quality data is patchy. This survey will have various benefits including increasing public confidence in the safety of the water supply, encouraging higher standards amongst growers and identifying any problem areas so that they can be appropriately dealt with.

The lack of guidance on 'first flush' calculations in the event of heavy rainfall is an area of concern. Constructing sufficient storage capacity to withhold all of the run-off produced by the most extreme storm events would involve growers in unjustified expenditure, but clearly the first flush of a storm can potentially contain significant quantities of pesticide and should be withheld. Calculating how large this first flush should be is amenable to a relatively simple modelling study. Such a study should be conducted.

It is recognised that the design of the irrigation system in Emerald did not include allowance for tail water recycling and that growers have operated within this system without apparent water quality problems, or fish kills. Nevertheless it is recommended that, even there, recycling of tail-water should be implemented.

Available evidence does not suggest that cotton growing is contributing to significant eutrophication problems in rivers. Nevertheless the potential for this to occur cannot be completely excluded and this provides a further argument for ensuring that tail-water control should be strictly observed.

- All tail water should be recycled. This minimises the risk of contaminating natural water courses with pesticides and nutrients or otherwise impairing water quality. Peer pressure amongst farmers and government inspections should be used to encourage the worst performers to improve their performance.

- At least the first flush of storm water run-off should also be withheld and the water storage capacity on cotton farms should make allowance for this.

- Studies should be conducted to provide realistic guidelines as to how this first flush should be calculated. The cotton industry should commission an appropriate research programme.

- In areas such as Emerald, where the entire irrigation scheme was set up without provision for tail-water recycling, growers should set and work towards a realistic date for complete reticulation of tail-waters.

Ground Water

Currently available evidence does not suggest that irrigation practices on Australian cotton farms are causing problems with the quality of underground water supplies. It is considered unlikely that such problems will generally occur in the future as the recharge for most aquifers is not straight down through the soil but often at some distance from cotton growing areas. Nevertheless, the industry should remain aware of the potential for ground water contamination and monitoring programmes should be maintained at sensitive sites. The water holding capacity of channels and storage lagoons should be tested and ensured. In addition to protecting ground water this has the benefit of avoiding wastage of water supplies through seepage.

Water Storage

The majority of water storage occurs in purpose built lagoons and to some extent these provide an ecological benefit by providing new habitat for wetland birds and other aquatic wildlife. In most cases this habitat is of limited value because of the unfavourable design of ring-tanks but in some cases relatively attractive habitats have been created. The use of billabongs for water storage should not be encouraged as this may have adverse effects on their ecology. Studies on the ecological impacts of this use of billabongs would be useful.

CHAPTER 6 COTTON PROCESSING

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6.3.4 Conclusions and Recommendations Relating to Cotton Seed Processing

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6.1 INTRODUCTION

After harvesting, the cotton crop is subjected to various treatments and processing steps including: ginning; de-linting and crushing; or carding, spinning, knitting, weaving, dying and finishing. The scope of the present audit included assessment of the environmental health and safety aspects of ginning and cotton seed processing, but did not cover subsequent processes such as carding, spinning and weaving.

Ginning

There are now eight Australian processors: Auscott Pty Ltd, Colly Farms Pty Ltd, Darling River Cotton Pty Ltd, Dunavant Enterprises Pty Ltd, Namoi Cotton Cooperative, Northwest Ginning, Queensland Cotton Corporation Pty Ltd, and Twynam Cotton Ltd.

Table 3 below summarises the status of the existing ginning facilities in Queensland and NSW. There are currently 21 ginning facilities (15 in NSW and 6 in Qld). Namoi Coop has plans for new ginning plants in Goondiwindi and Mungundi.

TABLE 3 LOCATION AND STATUS OF GINNING FACILITIES

PROCESSOR	No GINS	LOCATION	AGE
Auscott	6	Namoi (Narrabri and Wee Waa), Gwydir (Moree) and Macquarrie (nr Warren) valleys	Has some of the older facilities.
Colly Farms	1	Collarenebri	
Darling River	1	Bourke	7-8 years
Dunavant	2	Moree Yamala (nr Emerald)	 1 year
Namoi Coop	9	Namoi (Narrabri & Wee Waa and Tulladunnah), Gwydir (nr Moree) and Macintyre (Goondiwindi) valleys	Tulladunna plant is the oldest gin
North West	1	Moree	
Qld Cotton	4	Cecil Plains St George Biloela Emerald	
Twynam Cotton	1	Macquarrie (nr Warren) valley	

During the short ginning season (April- July), the gins operate 24 hours a day (2 x 12 hour shifts), 7 days per week. The remainder of the year, the equipment remains idle or is being maintained in preparation for the next season.

Operation at a typical gin is as follows: cotton modules are delivered to the site by lorry, covered with a tarpaulin and stored outdoors on the module storage pads. When ready for ginning, the modules are conveyed to the module feeder by a module buggy "moon buggy". As it enters the plant each module is broken down pneumatically, the dispersed cotton then passes through a series of hot air driers to reduce the moisture content and trash in the cotton. Trash is removed using a series of rollers which clean the cotton and remove nep-producing particles, grit, sticks, burrs, green leaf and bark all of which can degrade cotton quality. The drying and cleaning can be a single pass or double pass (two stage) system. After cleaning the cotton proceeds to the gin feeder. In the ginning process, a series of high speed circular saws rotate through a series of fine ribs. This action pulls the fibre through the ribs leaving the seed behind. High speed brushes are used to remove the fibre from the saws.

The resultant fuzzy seed is mechanically and pneumatically transported to the seed storage shed and the lint cotton removed from the seed is passed through a series of rollers which act to further remove dust and fine trash before being smoothed, combed and pneumatically conveyed to a bale press. The 227kg bales are then tagged, bagged, and moved by forklift to the bale storage area. Like the module pad, the bale storage area is outdoors, but this area is typically roofed.

Nearly all gins in Australia are saw-type gins which are better suited to the short staple length of Australian cotton. All the sites visited had either Lummus and/or Continental equipment. Gins typically process about 45 bales per hour.

The most modern facilities have a free standing console which is enclosed in a separate control room. The console has a series of locks which allow the safe isolation of a given machine. In older gins the console is not isolated in this way.

Gins rely on a core staff, typically 4 or 5 in number, of experienced, full time employees. During the ginning season, casual and temporary staff are recruited for more routine tasks; the number of casual workers varies according to plant size. Ensuring personnel receive adequate training is made more difficult by the high turn over amongst casual employees.

Cotton Seed Production

Currently, the Central Seed Distributors (CSD) is the only organisation which processes and supplies the cotton industry with planting seed, although, there are plans for a new company, Pioneer, to become established later on this year. This new enterprise will supply, but not process seeds.

The CSD is a non-profit organisation responsible for processing and supplying the cotton growers with high quality seed. This requires on-going research and field trials in all the cotton growing areas. The CSD has a processing plant, seed storage silos and a laboratory in Wee Waa which was visited in February.

Annual maintenance starts in December and proceeds through to late March. The plant is completely stripped down and worn parts replaced. At the time of the site visit, the plant was undergoing its annual maintenance; nothing was operational and much of the equipment was in pieces on the floor, awaiting new parts, refurbishment, etc. Consequently, no first hand knowledge of the operation was experienced at this plant.

Seed processing begins in April as the seed must be ready for planting in September. Ginned cotton seed is received from ginning plants and is stored in a controlled environment prior to processing.

Seed processing, like ginning, is mechanically intensive. The ginned seed is often referred to as 'fuzzy seed' because the small cotton lint fibres still attached to the seed give it a white and fuzzy appearance. The fuzzy seed is first dried with hot air in machines similar to those found at ginning sites, it is then weighed.

The seed is then put through a rotating drum for delinting. Anhydrous hydrochloric acid gas is used to facilitate removal of the lint fibres from the seed. This process is temperature controlled to ensure minimal damage to the seed and efficient operation. After delinting, the lint fibres which have become brittle are removed from the seed in buffing and polishing drums. Fine lint from the buffing stage is collected by a vacuum dust collection system.

The acid residue which is left on the black (delinted) seed is neutralised with ammonia. The plant uses both forced and natural ventilation to reduce the ammonia and hydrochloric acid fumes. CSD will shortly be switching from ammonia to calcium carbonate to improve health and safety. When the seed reaches the appropriate pH, it is air cleaned by means of a series of vibrating screens located above gravity tables.

At this point, the good seed is separated from the off-grade material. The heavy seed (good seed) receives further treatment while light seed (off-grade) is rejected and sent for crushing to make cotton seed oil or stock feed. The seed crushing process however is outside the scope of this Audit.

All acceptable seed is chemically treated with 2 fungicides (not named) to impart biological resistance. Addition of fungicide is electronically controlled and a homogenous application is achieved with a roller drum. The processed seed is finally pelletised and transported away.

Fungicide treatment is demanded by the growers as CSIRO/CSD trials have shown that treated seeds yield better results than untreated ones and that the treatment seems to allow the elimination of an early pesticide spray. The fungicides applied to the seed must first be approved by the State Registrar of Pesticides as being chemicals which do not leave a residue which is harmful under normal seed handling operations. CSD state

that the quantities of fungicide used are just enough to protect the seedling and then naturally degrade. Minimising the use of chemicals is also important because the chemicals are relatively expensive; CSD aim for zero stock levels at the end of the processing season; the shelf life of the chemicals is reported to be 2 years.

As with the research part of the work, quality assurance is key to the successful production of high quality seed used by the Australian industry. An on-site laboratory is used for:

testing the presence of residual acid on the seed product; separating product and off-grade seeds; checking germinability and vigorability.

The operation requires 12 full-time process & maintenance employees. The staff turnover rate was given as 2 employees per year.

6.2 GINNING OPERATIONS

6.2.1 Environmental Issues Relating to Ginning Operations

In general, the gins do not pose an environmental problem for the local community because they are usually located several kilometres away from nearest neighbour and emissions to the environment are low. However, noise and dust can be a problem for neighbours located within several hundred metres of a ginning facility.

The principal environmental problems at gins relate to the indoor environment. Such problems are related to occupational hygiene and safety and arise from dust, noise and work time accidents. Problems can also arise from the handling and storage of hazardous chemicals and from the incineration of trash. The principal problems are discussed below:

Dust

Dust can be an issue of environmental quality (outdoor air quality) or occupational health (indoor air quality). Cotton dust, consisting of broken cotton fibres and airborne plant debris, minerals, fungi and bacteria, is a recognised health hazard. Historically byssinosis has been associated with cotton spinning and weaving, which may be contracted if an individual is subject to prolonged exposure at high atmospheric cotton dust levels. Byssinosis symptoms may take 5 years or more to become apparent (HMSO, 1979). No case of byssinosis has ever been reported in relation to any ginning operation in Australia, nonetheless medical surveillance of employees is important - especially in cases of liability & workers compensation.

Sax (1979) lists other hazards attributable to cotton dust including: illness due to allergens or fungi in cotton; bronchial asthma, sneezing and eczema resulting from inhalation in sensitised individuals. Symptoms will generally disappear if affected individuals are removed from the source of exposure; however, medical attention will be required to ascertain if there has been fibrosis of the lungs.

Cotton dust is also a flammable material and can cause environmental problems in this respect.

Noise

Noise can be a hazard to health causing hearing problems in workers exposed to high levels of noise over long periods. This is an occupational health and safety issue; at greater distances, noise from the plant is unlikely to cause health problems but it can cause general environmental disturbance especially to residents in proximity to ginning plants.

Accidents

Cotton ginning equipment has many moving parts, making it difficult to achieve effective machine guarding. Consequently considerable care must be taken to avoid workplace accidents. Although accidents involving machinery are relatively few, they can be very serious. The cleaning of machinery while it is operational is an important cause of accidents.

Hazardous Substances

Ginning is a mechanical process; consequently, very few chemicals are handled and/or stored on-site. Most gins store small quantities of fuel and lubricating oils, as well as oxygen and acetylene (kept in small quantities) for welding. Gas bottles are typically stored above ground. Environmental problems relating to hazardous substances can occur during storage, handling and disposal.

Disposal of Wastes

Cotton arriving at the gin contains approximately 7-10 % trash, therefore a gin site with an 80,000 bale per season capacity can generate 2000 tonnes trash. Trash can include: green sticks, leaves and other material from the cotton plants, bales which have caught fire, lint and dust. Trash is disposed of in several ways; filtered dust is often given away for use as garden mulch; other wastes are disposed of in waste pits on site where they are often burned.

There are few environmental problems associated with the disposal of trash. There is no data to suggest that ginning trash is contaminated with pesticide residue levels warranting concern although conclusive evidence is lacking. The relatively uncontrolled burning of large quantities of trash can give rise to local air pollution and the generation of harmful combustion products such as polycyclic aromatic hydrocarbons and dioxins which are suspected human carcinogens.

6.2.2 Legislation and Controls Relating to Ginning

Dust

In NSW, ambient outdoor dust levels in close proximity to the gin are regulated by the SPCC while regulation of indoor levels are the responsibility of WorkCover Authority; in Queensland, both responsibilities belong to the Department of Health.

The SPCC advise that the general particulate standard of 0.25 g/m^3 applies ambient (outdoor) for cotton dust concentrations, unless the site licence specifies otherwise. The method of control is by the "best practicable means" (BPM). BPM is a moving target which is defined by the competent regulatory body (ie SPCC). In Queensland, the regulatory body is now requiring fabric filters or equivalent to control ambient dust emissions. Fabric filters typically have efficiencies of about 96%.

The work place (indoor) cotton dust limit set by WorkSafe Australia, is 0.2 mg/m^3 (measured by 15 mm mesh); and the respirable dust limit is 10 mg/m^3.

Other international occupational hygiene standards are similar or even less stringent.

> The USA, Time Weighted Average (TWA), Occupational Safety and Health Administration (OSHA) statutory limit for worker exposure = 0.2 mg/m^3, lint free (8-hour TWA); lint free measured by vertical elutriator.
>
> The UK Occupational Exposure Limits (OEL) statutory limit for worker exposure = 0.5 mg/m^3 total dust, less fly (8-hour TWA); note: fly is large airborne particulate material suspended in atmosphere which fails to pass through a nominal 2mm wire gauze mesh filter.

Noise

In NSW, the Noise Control Act (1975) gives the SPCC control for preventing excessive noise from scheduled plants. For premises which are not scheduled, control is the responsibility of local councils. In Queensland, the responsibility for controlling noise is jointly vested with the Noise Abatement Authority of the Department of Health, local authorities and the police.

The statutory occupational exposure limits for noise in NSW and Qld are identical: 90 dBA averaged for an 8 hour day; where a daily noise dose exceeds this limit action must be taken to reduce exposure to the allowable limit. It should be noted that there is a quantifiable risk of hearing damage for employees exposed to a daily exposure level of between 85 and 90 dBA. Even below 85 dBA some small risk remains, demonstrating the need to take practical steps to minimise noise exposure.

The Factory Shops And Industries Act (FSAIA) is currently in the discussion stage in NSW. The bill may lower the statutory noise limit to 85dBA (in line with Europe and the US) in the very near future. It is expected to come into law this year. This bill deals with noise and heat in the work environment.

Noise surveys are required in NSW under 1978 Noise Regulations. Noise regulations are now 10 years old and WorkSafe Australia is now tightening up. The WorkCover Authority (NSW)) indicated that only 10% of Australian industry seems to be complying with the current regulations. State Health & Safety Inspectors are now requiring employers to comply with noise testing requirement within 28 days of official notification.

Accidents

The health and safety of employees in the workplace is the responsibility of the employer and is controlled through the relevant commonwealth and state legislation. In addition some of the large corporate gin owners have their own safety policies relating to health and safety in the workplace.

In New South Wales responsibility for enforcing health and safety regulations is vested in the Workcover Authority under the Occupational Health and Safety Act (1983). In Queensland the Department of Health is given the responsibility for enforcing health and safety regulations under the Workplace Health and Safety Act (1937-84).

Hazardous Substances

In New South Wales the use, storage and disposal of hazardous substances is currently controlled by the SPCC under the Environmentally Hazardous Chemicals Regulations (1985). New legislation is currently being enacted which will require employers to minimise and control the exposure of employees of substances hazardous to health; this new legislation is based on the British Control of Substances Hazardous to Health Regulations (1989).

The SPCC is requiring that impervious bunds with capacity of 110% of the largest tank volume be constructed around all liquid storage areas containing fuel, oil, and other hazardous chemicals.

Disposal of Wastes

The principal environmental impacts associated with the disposal of ginning wastes relate to the burning of trash. Currently this is not a licensed activity.

In NSW the control of air pollution is covered by the Clean Air Act (1961) administered through the SPCC. The act is concerned with preventing and minimising air pollution from all premises, mobile equipment and vehicles and provides for the licensing of premises, scheduled under the act. In Queensland the Clean Air Act (1963-64) is administered through the Air Pollution Council. The aim of the act is to prevent and minimise air pollution.

6.2.3 Industry Performance Relating to the Ginning of Cotton

The ginning facilities visited were not operating at the time of the visits; consequently, the audit results presented in this section are largely based on information received from questionnaires and interviews with gin operators, workers, and regulatory bodies. However, site visits did allow some general conclusions to be drawn.

Dust

(i) Equipment

Dust levels at a given facility are dependent on a number of factors including: the presence and location of dust handling equipment (cyclones, fabric filters, etc), plant layout, quality and quantity of cotton being processed, and air movement through the plant.

Some plants, especially the older ones, have no provisions for dust collection nor air purification. Some newer plants, and plants which have recently been upgraded, include systems which have been designed to minimise environmental (outdoor) dust levels. These plants also show an appreciable improvement in the indoor air quality. Older gins (10-20 years old) have either no dust collection or simple cyclones. The newest facilities and some upgraded ginning plants have been fitted with fabric filters.

(ii) Dust Levels

There is very little dust monitoring undertaken at cotton ginning facilities. The monitoring that has been done has been largely the result of WorkCover inspections and follow-up. Few facilities had dust monitoring results available for the audit team, although results were obtained from surveys of two gins. One of these facilities had a dust collection system, the other did not. The management at these facilities were more environmentally aware than many of their counterparts and thus commissioned dust surveys.

The results, shown in Table 4, indicate that dust levels in all parts of the gin which was not fitted with dust handling equipment, exceeded the statutory limit of 0.2mg/m^3 (note: data in Table 4 are shown in micrograms/m^3 - 100 μg = 0.1mg). Even in the gin fitted with dust abatement equipment, dust levels were in excess of the limit in some areas of the plant.

Although dust abatement had resulted in much better working conditions, the level of improvement was not generally sufficient to satisfy the statutory dust limit. In areas where the limit was not exceeded there was little or no margin for comfort. The levels of dust recorded at both plants were not considered acceptable for unprotected workers (eg. without dust masks).

The Audit Team was informed that it is common practice to clean the dust film from equipment using compressed air. Dust monitoring has shown that blow down significantly increases dust burden by re-suspending the dust and creating areas of high localised dust levels. This can significantly increase the health hazard.

The Audit Team was informed that a dust mask for coarse dust (5 fold level of protection) is considered standard equipment at ginning sites. However, the monitoring report examined states that very few staff at either site wore the dust masks supplied by their employers. It is likely that, by not using the protection supplied, many workers are exposing themselves to dust levels higher than those permitted by the statutory regulations and may be compromising their health.

The plant areas found to have the highest dust levels were directly in front of the gin stands and areas in immediate proximity to the bale press. Under such conditions all floor personnel should don protective equipment. Because visits were only made to gins during 'down time', the extent of employee compliance with the wearing of protective gear cannot be fully assessed in this study.

(iii) Occupational Health

WorkCover undertook a survey of ginning workers in New South Wales in 1987. Unfortunately this survey was not made available to the Audit Team. However, the survey was discussed during an interview conducted by the Audit Team with a representative of WorkCover. He indicated that the survey found no cases of byssinosis, allergies and asthma which could be attributed to the work environment. However there is concern that gin workers could suffer a reduction in lung capacity and an increase of bronchitis.

WorkCover have informed the Audit Team that they consider that the cotton processing plants in NSW do have a real problem with occupational exposure to dust. The WorkCover Authority has, thus far, been lenient in enforcing dust limits at gins, but they say that this policy will soon be changing. WorkCover consider that most facilities will only be able to comply with current dust limit standards if they use the best control technology available and the best working and operating practices.

(iv) Fire

No serious fires due to cotton dust were reported but interviews held with ginning staff indicate that small smouldering fires caused by damp cotton are not uncommon. In the case of such fires equipment is isolated, turned off, and the smouldering cotton removed. Down time in the case of fire can vary between 5 minutes and 2 hours.

TABLE 4 COTTON DUST CONCENTRATIONS (MICROGRAM/M^3): ACTIVITY AVERAGES

Activity	Site with Dust Collect. & Air Filtration	Site without Dust Abatement
Press Operator	300	685 *
Asst Ginner/ control room operator	200	893 * +
Feeder Attendant	100	7228 *

* Level higher than expected because plant configuration was such that contaminated air was being concentrated in a corner of the site.

\+ Dust ingress from outside contributed significantly to elevated dust level.

TABLE 5 OUTDOOR NOISE LEVELS (DBA) MEASURED NEAR TO A COTTON GINNING PLANT IN NSW

Distance (m) from Building	Noise Level (dBA)
10	70
640	34
1280	28
2560	22
Rural Background	20-25

Note: A 3 dBA difference in sound level is typically required to differentiate sounds from background levels.

Noise

(i) Outdoor Noise

WorkCover have informed the Audit Team that a number of gins have caused neighbours to complain about excessive noise; this was confirmed by discussions with several gin mangers. Noise is a potential problem at sites located in close proximity to residential areas.

Outdoor noise levels for a ginning plant in NSW have been measured, the results are presented in Table 5. From this table it can be seen that neighbours within 1 km would be expected to be subject to discernable noise levels. People living within this range may suffer some disturbance especially since gins operate 24 hours per day during ginning season. However, it should be noted that most gins are located more than 1 km from the nearest housing.

(ii) Indoor Noise

In contrast to external noise (environmental noise), there is considerable evidence that noise within the workplace is a significant environmental problem.

As with dust, of the sites visited, few facilities had any type of records on noise levels and exposures which were available for the Audit Team. Noise monitoring data, were obtained from the same two sites which were monitored for dust. The highlights of these tests are:

- The noisiest part of plant is generally directly in front of gin stands.
- Noise levels at one gin varied between: 86 dBA (min) and 139.1 dBA (maximum peak) and the average dBA for employees monitored at the gin varied between 86.7 dBA and 97.1 dBA. In addition to the 8 hour daily exposure levels indicated, there is a danger of inducing hearing damage should peak noise levels exceed 140 dBA (ie 200 pascals reached or exceeded).
- Many gin employees: ginners, feeder attendants, press operators, dust box operators and truck cleaners are exposed to noise levels in excess of those set down in the regulations. Employees operating the bale press probably experience the highest noise exposure.

WorkCover has undertaken a noise survey of NSW cotton ginning operations (1987) and report that nearly all facilities are in breach of the statutory limits. Furthermore, the Authority reports that noise levels of 96 dBA are common at cotton gins and that pulse vibrations can produce noise levels of 105-110 dBA. Such levels are considerably in excess of those known to harm human hearing and thus the majority of work areas within gins constitute definite hearing risks.

Ear plugs and muffs can provide adequate protective measures against excessive noise levels. Muffs provide 30 dBA attenuation; plugs provide 23 dBA attenuation. In addition, in supplying ear protection regard must be given to the frequency content of the noise source to ensure that adequate attenuation is achieved throughout the frequency spectrum and hence provide adequate protection. At the time of the Audit Teams visits, many employees were wearing hearing protection whilst carrying out maintenance and equipment testing; the extent to which plugs and muffs are utilised at other times is not known.

Accidents

Accidents experienced at ginning plants include foreign matter into eyes, back strain, fingers hit/jammed/lacerated, sprains to wrists and ankles, and falling. Severe accidents include the mutilation of limbs.

Generally the machines seen were fairly new. On certain machines, the opening of panels for inspection could result in the exposure of employees to unguarded dangerous parts. Most plants seem to have at least some degree of guarding and locking.

Of the small sample of cotton processing plants visited, about half do not maintain accident books. This is a matter of concern as records from other plants indicate that a given facility could experience 10-20 accidents per year.

The Audit Team was informed that one company in NSW is undertaking in-house health and safety audits at its facilities in an effort to improve standards. WorkCover will be referring to this programme as it tries to implement industry-wide health and safety standards.

Some plants have had to pay workers compensation claims ranging from several hundreds of dollars to thousands of dollars. One particular plant which was visited had 16 claims filed against them in less than 5 years.

Fire protection was satisfactory at the sites visited. All had on-site water supply in the form of above ground reinforced concrete tanks and fire tenders.

The remote location of many sites means that doctors, ambulances, and fire brigades could not reach the site rapidly in an emergency, stressing the need for high standards of accident prevention. Some gins have an airstrip which enables medics to be flown in and seriously injured personnel to be flown out of the site in the event of an accident.

Hazardous Materials

Very few hazardous chemicals are handled or stored on-site. Materials recorded included: fuel and lubricating oils, sulphuric acid, oxygen and acetylene gas bottles. Gas bottles were typically stored above ground at most facilities. The housekeeping at most sites was somewhat untidy, but this could easily be improved with some resolve from plant management and staff.

At some facilities, it is common practice to minimise dust on access roads by wetting the road with waste oil. This constitutes a soil pollution risk. The practice should be stopped immediately and alternative means should be adopted for controlling dust.

Disposal of Wastes and By-Products

There was little evidence of adverse environmental impacts associated with the disposal of wastes. In some facilities, large quantities of trash are burnt and this can give rise to local air pollution. It is well established that the uncontrolled burning of organic matter can result in the generation of harmful by-products such as polycyclic aromatic hydrocarbons and dioxins which are suspected human carcinogens.

6.2.4 Conclusions and Recommendations Relating to the Ginning of Cotton

Dust

The audit concludes that occupational exposure to dust is potentially significant and that not all employees are making use of the safety equipment available. This is an issue which needs to be addressed by the employers and employees at cotton ginning plants.

At present, many facilities do not know if they have a dust problem because no monitoring has been undertaken. This may be partially attributable to lax enforcement, but the duty is on the employer to furnish a safe working environment. The limited data available suggest that even plants fitted with dust handling equipment may not necessarily be in compliance with the statutory limits.

There is no doubt that dust control and monitoring at gins can be improved, given the results of dust monitoring tests discussed in 6.2.3 and the availability of appropriate dust extraction technology. Employers should implement a routine programme of dust monitoring as well as require annual lung function tests for all permanent staff (tests for casual employees may not be warranted if there is a very high turn over rate). Records of the routine monitoring and annual medical examinations should be kept by the company for at least 30 years.

There is evidence that employees are generally aware of cotton dust's potential to impair human health, however, reports suggest that adherence to good working practices is patchy. The use of the appropriate masks should be enforced and dangerous practices such as the use of compressed air to clean machines and especially floors, should be stopped.

It is acknowledged that portable vacuum systems may not work for intricate surfaces on some machines but they should be used for cleaning floors. If employees will not comply willingly; then, employers must find ways of ensuring compliance.

The following recommendations to reduce the environmental risks associated with dust should be followed:

- Dust abatement systems (ie fabric filters) should be fitted to all ginning sites. Obscuration meters should be fitted to the fabric filter outlets with visual and audible alarms and recording charts. The system will require regular maintenance. Monitoring records should be kept for at least 30 years.

- Annual lung function tests should be carried out on all permanent staff. The records should be kept by the company for at least 30 years.

- Plant layout should be such that air entering the gin building should be from a clean area and suction points/ doors/exit ports should be located near areas of high dust levels. Also plant layout should allow employees to proceed from the outside to rest and lunch rooms without having to traverse through the ginning area.

- Floors and equipment surfaces should be **vacuumed** down frequently during a shift;

- Doors of enclosed console room should be kept shut;

- All indoor personnel should use respiratory protection (class L disposable masks). Note that the masks offer adequate protection only if used correctly.

- A programme of employee education should be undertaken to emphasise the risks of dust inhalation and to demonstrate the best practicable means for reducing dust levels and for avoiding excessive particle inhalation.

Noise

The rural location of many of the ginning sites, ensures that environmental noise is not generally a significant issue. However, there is some evidence that in areas where neighbours are within 1 Km of the plant some nuisance occurs. Where environmental noise is a problem, the facility should alter its working schedule, or introduce engineering controls (isolating noise sources and muffling them) to minimise the nuisance.

In contrast, the evidence from surveys undertaken to date clearly demonstrate that noise within ginning plants could pose a significant occupational health problem. Very few sites seem to carry out testing although where testing has been undertaken noise levels may well exceed legal requirements.

Whilst ear plugs and muffs can provide adequate protection against excessive noise, the extent to which plugs and muffs are utilised by employees is not known. Given the threat to hearing posed by noise levels in gins, a programme of employee education should be undertaken to communicate the risks and to demonstrate best practice methods for avoiding harm.

The ginning companies should ensure that employees have regular hearing tests, this will assist in the assessment of workers compensation claims.

The most effective way of dealing with a noise problem is to reduce noise at source. Reducing noise from a gin is difficult to accomplish and will require a strategy which combines several noise abatement methods. Recommended noise abatement strategies are outlined below:

- **Engineering Control:**

  a) Isolate noise and minimise the employee contact with the noisy environment (eg work from "quiet rooms").

  b) Isolate fan room.

  c) Consider controls on individual pieces of equipment.

  d) Perform regular maintenance to minimise vibration.

- **Administrative Controls:**

  Rotate staff to minimise duration of exposure.

- **Personal Protection:**

  This strategy should be considered only after engineering and administrative solutions have proved insufficient. Management should take an active role in persuading employees to make use of personal protective equipment.

- **Regular monitoring of noise levels should be undertaken:**

  The appropriate actions should be undertaken to bring levels to within legal limits. Records should be kept for at least 30 years.

- **Annual hearing tests should be carried out on all permanent staff.**

  The records should be kept by the company for at least 30 years.

Accidents

In general the audit suggests that serious accidents are not a persistent problem at the gins. Newer machines tend to have more and better guarding such as fencing, photoelectric cut-offs and electrical and mechanical interlocks. A time delay feature on doors fitted with the door interlocks is advisable.

In-house health and safety audits should be undertaken at all facilities. This should include a review of previous accidents and of current safety procedures. This will help to improve standards of safety.

The keeping an accident log book at all facilities is important. Information such as the nature of injury, part of body involved, where accident occurred (ie machine room,etc), date, time, person to whom accident was reported, lost time, activity undertaken when accident occurred, other people or vehicles involved etc, will greatly assist in the assessment of workers claims for compensation. An account of all accidents will also help individual facilities to formulate strategies to minimise health and safety risks to workers.

Hazardous Substances

All chemicals must be handled with due care; however, the types and quantities of chemicals used in cotton ginning can be readily controlled so as not to pose any significant risk to the environment. In general bunding around storage tanks was insufficient and should be increased to contain 110% of the largest container. Drainage sumps should not lead to a watercourse or public sewer. Where the concrete base of chemicals handling areas show signs of stress, they should be repaired before chemicals can find their way down to the underlying soil.

More appropriate methods of reducing road dust, such as damping down with water or laying down a permanent road surface should be considered.

Disposal of Wastes.

Guidance on the suitability of cotton waste as a garden mulch should be obtained from the competent government agencies. In the absence of such approval all solid waste should be sent a competent waste disposal contractor who is licensed to accept and/or treat the specified waste stream. Waste treatment and disposal must be undertaken in a controlled manner.

The uncontrolled burning of large volumes of trash should be avoided.

6.3 COTTON SEED PROCESSING

6.3.1 Environmental Issues Relating to Cotton Seed Production

The environmental issues relating to cotton seed production are very similar to those arising from ginning. These are discussed below:

Dust

Dust is generated during the drying, de-linting and cleaning stages of cotton seed processing and can give rise to health problems. The health problems associated with cotton dust are discussed in section 6.2.1 above.

Noise

The production of cotton seed is mechanically intensive and can lead to elevated noise levels in many areas of the plant. The environmental impacts associated with exposure to high levels of noise are discussed in section 6.2.1 above.

Accidents

The machinery used in the production of cotton seed includes many moving parts. Considerable care must be taken to avoid workplace accidents. Although accidents involving machinery are relatively few, they can be very serious. Cleaning of machinery while the machine is operational is an important cause of accidents.

Hazardous Substances

The production of cotton seed involves the use of several hazardous chemicals, such as liquid chlorine, hydrogen gas, liquid ammonia and LPG. Significant quantities of these are stored on-site.

Considerable care must be taken in the storage, handling, use and disposal of these materials. Hydrogen and LPG are highly explosive. Both chlorine and ammonia are corrosive and toxic. The hydrogen is used, with chlorine to produce anhydrous hydrochloric gas, which is also corrosive and toxic.

The production of cotton seed also requires the use of fungicides and care needs to be exercised when handling these. The issues relating to the storage, use and disposal of such pesticides are discussed in Chapter 3.

Disposal of Waste

The principal issues relate to the treatment of the seed with pesticides. Pesticide contaminated effluent is treated in a Sentinal® waste treatment plant which entails chemical flocculation and filtration, first through a gravel filter and then through two activated carbon filters. Whilst this system produces an effluent virtually free of contaminants, the filters and sludge produced are highly contaminated with organic pollutants.

6.3.2 Legislation and Controls Relating to Cotton Seed Processing

The legislation relating to dust, noise, accidents, hazardous substances and wastes are dealt with in section 6.2.2 above. The regulations relating to pesticides are discussed in chapter 3.

6.3.3 Industry Performance Relating to Cotton Seed Processing

Note: as previously stated Cotton Seed Processors are the only organisation processing cotton seed for planting in Australia.

Dust

No information on actual dust levels CSD's plant were available. However, dust control systems were fitted in the plant and included local exhaust ventilation (forced extraction) and a multi-cyclone dust handling system with a baghouse. The system, like the rest of the plant is cleaned annually. New dust control equipment is continuously being installed and the plant is currently being upgraded with the installation of fabric filters.

CSD is being sued by a former employee under the Workers Compensation legislation for dust-related illness and as a result CSD have now introduced mandatory respiratory testing, starting this year.

Noise

Outdoor noise levels at the CSD site are not considered to be a significant environmental problem.

Results of a single noise survey (taken within the last 5 years) indicate that noise levels were significant and that employees should routinely wear ear protection. Interviews at the plant indicate that employees generally comply with ear protection requirements although the Audit Team was not in a position to confirm this.

A single audiometry test was carried out on all employees in 1988. This has not been repeated.

Accidents

The CSD give issues of health and safety a level of importance significantly higher than what was witnessed at the cotton ginning facilities. The site has a safety committee comprised of 3 factory employees plus the Production Manager. The management ensure that employees see films on health and safety (using appropriate respiratory protection, etc) and attend periodic seminars.

The Audit Team were told that the Namoi Cotton Cooperative has initiated a study on protecting workers' health and that Namoi's 11 member in-house Safety Audit team is working with CSD to improve conditions at the seed processing site.

WorkCover frequently inspect the site and have recommended longer guards and more isolation switches on equipment.

Four relatively serious accidents have been recorded over the last 6 years. Since these accidents all moving parts have been checked and fitted with additional gates and locks.

Hazardous Materials

Since significant quantities of hazardous materials are stored on-site, the CSD management have developed emergency response procedures for major accidents and the local authority has been given details of the chemical storage facility. Site personnel run practice exercises in coordination with the local fire brigade and hospital. The ambulance crew monitor and criticise performance.

In 1985, there was an explosion resulting from the manufacture of HCl. To avoid a repeat accident, control equipment with greater sensitivity has been installed.

CSD have reported that their employees have an annual blood test and that thus far all results indicate that there is no problem with exposure to fungicide.

A study was undertaken by Lanfax consultants which focused on indoor air quality issues within the plant. A copy of this report was made available to the Audit Team. The study involved 83 days of on-site monitoring for employee exposure to ammonia and HCl fumes. It is difficult to interpret Lanfax's monitoring results because they do not represent personal exposure measurements. In addition the survey did not conform to standard occupational hygiene principals for hazard recognition, evaluation and control.

However, the results do show that airborne contamination did occur and that levels of contaminants were highly variable in concentration and composition. The levels of ammonia and hydrogen chloride were, at times, sufficient to pose a health hazard for site staff. They also concluded that there was a need to reduce airborne contamination through improved efficiency and standardisation of procedures.

Disposal of Wastes and By-Products

The small Sentinel plant for the treatment of pesticide contaminated waste water produces about 90 - 130 gallons of treated effluent each year. This is discharged to a settling and evaporation pond located at the back of the site. This pond is lined with black clay and was therefore considered impermeable. The pond did not appear to be well safeguarded since it lacked a fence, warning signs or a lock. However, provided that the Sentinel plant is properly maintained and the filters regularly replaced, pollution levels in this part of the plant are likely to be low.

The sludge from the initial settling and flocculation tank is likely to be contaminated with high levels of organic pollutants. This sludge is currently buried on-site with lime in waste pits. This practice is compatible with SPCC guidelines but is not recommended. Ideally waste disposal should be managed by professional waste disposal contractors. It should be noted that the local authority have refused to accept these wastes and the facility has few options other than to bury this material.

Whilst the carbon filters of the treatment plant are effective for absorbing a wide range of organic contaminants (manufacturers test results indicate that the process can, under at least some conditions, remove in excess of 99.99% of agricultural chemicals), it is not known how the contaminated filters are disposed of. They could pose a serious pollution hazard if disposed of incorrectly.

Pesticide containers are burnt on-site. This uncontrolled burning is permissible under SPCC guidelines, but is certainly not recommended since it can lead to the release of toxic substances.

There are no written records concerning the quantities and location of buried hazardous materials.

6.3.4 Conclusions and Recommendations Relating to Cotton Seed Processing

Dust

As with cotton gins the CSD seed processing site represents a potential dust hazard and all employees are asked to use suitable masks. Routine monitoring and employee testing is not undertaken.

- It is recommended that an appropriate programme of dust reduction, dust monitoring and employee testing, should be implemented. Details should be similar to those recommended for cotton gins as described in section 6.2.4.

Noise

- Routine monitoring and audiometry tests should be undertaken.
- A new noise survey should be undertaken if the process or equipment is significantly altered.
- If noise levels are close to, or in excess of, the statutory limits, the appropriate measures should be implemented. These are discussed in section 6.2.4 above.

Accidents

The CSD appear to give issues of employee health and safety due consideration. Plant management seem to have the commitment to improving environmental, health & safety performance; it is now important to start undertaking regular evaluations and monitoring programmes.

Hazardous Substances

Fumes emanating from the process may adversely affect worker health. The Lanfax report indicates that the concentrations of HCl and ammonia may be in excess of legal limits. It is also possible that ammonium chloride could be generated and airborne levels of this compound should be included in future assessments.

- A routine monitoring programme for HCl, ammonia and ammonium chloride should be implemented at the plant. Future monitoring should assess personal exposure limits (short and long term) and should compare these to existing statutory limits and international guidelines. Checks should be made on the performance and efficiency of the local exhaust ventilation controls. In addition the suitability and extent of use of personnel protective equipment should be evaluated. Future monitoring studies should also assess what engineering and/or administrative controls the company could implement to minimise employee exposure to hazardous substances.

Disposal of Wastes and By-Products.

The use of the Sentinel waste treatment system for the handling of pesticide wastes generated by seed treatment is considered acceptable. Whilst this should produce effluent of a high quality under ideal conditions, it should be borne in mind that this is entirely dependant on correct maintenance and regular replacement of filters.

The effluent in the evaporation pond probably does not contain sufficient quantities of pesticide residue, but occasional monitoring of water quality, to verify this, should be undertaken. Proper security fencing and signing of the evaporation pond should be installed.

The on-site burial of sludge produced by the system is an undesirable practice although permissable under SPCC guidelines. Ideally this waste, along with spent filters, should be disposed of by a competent licensed contractor.

If on-site disposal of sludge is unavoidable, detailed investigations should be undertaken to ensure the integrity of the disposal site and the location and quantities of buried sludge should be recorded.

CHAPTER 7 SUMMARY OF CONCLUSIONS AND RECOMMENDATIONS

CHAPTER 7 CONTENTS

7.1 GENERAL CONCLUSIONS

The present document presents the findings of an overview of the environmental performance of the cotton industry in Australia. This industry is not a single entity but a heterogeneous assemblage of a large number of different organisations and individuals, including family and corporate growers, processing companies and cooperatives. In addition to growers and processors there is a large body of professionals servicing the industry including chemical suppliers, crop consultants and aerial crop sprayers. These associated professionals are intimately involved in the process of cotton production and thus contribute in a significant way to the overall performance of the industry.

Inevitably, there are differences in the environmental standards practised within such a diverse group and some parts of the industry should be expected to perform better than others. Nevertheless, the impression gained during the audit was that the majority of people working in the industry are conscientious about environmental standards and, within the limits of their knowledge and abilities, take care to minimise the damage they cause.

The diversity of different organisations involved in the industry also has implications for any moves to improve its environmental performance. In contrast to a single company the cotton industry cannot dictate absolute requirements to individual members. Rather the approach has to involve the adoption of policies by the industry's leading bodies such as the ACF, AAAA, AVCA and agricultural colleges. The use of peer pressure and education programmes to ensure that these policies are pursued by individual members of the industry is of paramount importance.

Organisations which are not directly involved in the industry can also contribute to improving its environmental performance. Regulatory authorities clearly have a role to play in this respect by discouraging poor practises, if necessary through the application of any sanctions within their power. Other examples are more indirect. For example local authorities can minimise conflicts and problems by careful zoning of residential development and agricultural land use; health authorities can contribute to achieving a fuller understanding of the impacts on health of cotton growing practises by maintaining suitable data bases. The ACF should use its influence as a lobbying group to encourage outside organisations to take appropriate actions.

A particular strength of the cotton industry is the well developed research and development system which has evolved in parallel with the industry itself and the strong channels of communication between growers and researchers. Although the bulk of this research effort has been aimed at improving yields, much research has been carried out into ways of avoiding or reducing environmental impacts. Potentially the cotton industry can make great use of this research system to develop more environmentally sound ways of producing cotton.

7.2 PESTICIDE USE

7.2.1 Conclusions Concerning Pesticide Use

(i) Community Health

The biggest public fear concerning the cotton industry is that pesticide use threatens the health of people living within cotton growing areas. The currently available evidence suggests that these fears are exaggerated and no specific community health problems can be conclusively linked with pesticide use. Nevertheless it is clearly prudent that health authorities should continue to monitor for possible long term, low level effects of chronic pesticide exposure. Actions by the local health authorities must be coordinated in order to facilitate meaningful progress in understanding the health implications of pesticide exposure.

(ii) Occupational Health

Occupational exposure to pesticides is a more significant health hazard and there is evidence that this is not taken sufficiently seriously. Responsibility lies with both employers and employees to ensure that the latter are adequately protected against pesticide exposure. The use of proper protective clothing and equipment is of paramount importance as well as a general vigilance against poor practise.

(iii) Fauna and Flora

The effects of pesticide use on flora and fauna have been a subject of concern all over the world for several decades. Pesticide use on cotton crops in Australia does affect aquatic wildlife insofar as occasional fish kills are recorded and at least some of these seem to be due to pesticide entering rivers. The impact of these events on population levels of fish and other species and thus their real ecological significance is not known. Nevertheless, fish kills are clearly extremely undesirable.

The effect of pesticide use on terrestrial fauna and flora outside the cropped areas is not well documented but is probably not great (this may not have been the case when persistent organo-chlorines such as DDT were still in use). On a regional basis the effects of clearing land for all forms of arable agriculture, including cotton, is likely to have had a far more significant effect on the abundance and diversity of wildlife.

(iv) Resistance to Pesticides

Resistance of cotton pests to insecticides is a threat which constantly hangs over the industry. As well as being a threat to the financial viability of the industry, resistance is also a potential environmental problem, since the classic response to it where it has occurred in other parts of the world, has been the use of ever increasing quantities of pesticide at ever shorter intervals, resulting in a massive pesticide load on the environment. *Heliothis armigera* has developed resistance to some of the pesticides in use on Australian cotton, particularly the synthetic pyrethroids. Careful management of

the way pesticides are used has prevented this resistance developing into an intractable problem and the industry has so far avoided the spiral of increasing pesticide use. The problem has not been completely overcome, however, and continued research effort into the control of resistance and the application of the results of this research are essential.

(v) Application Methods

In general the Audit revealed that pesticides are applied in a responsible manner. The techniques for limiting spray drift have been well researched and aerial operators appear to have a good understanding of these. The evidence suggests that incidences of serious drift are uncommon. However, since spray drift is an important mechanism through which non-occupational exposure to pesticides can potentially occur it is essential that the crop spraying industry should continue to strive for higher standards and that research into safe application technology should be encouraged.

One application practise which is widespread but which is undesirable from an environmental viewpoint is tank mixing of different products where their chemical compatibility is not known. Although in most cases this may not give rise to problems, it is not possible to rule out the occurrence of chemical reactions between the products, leading to the formation of unknown compounds whose safety cannot be guaranteed. The practice of tank mixing is sensible where the compatibility of products can be guaranteed. The solution to this problem lies in the provision of more comprehensive guidelines from the chemical manufacturers as to the compatibility of products.

(vi) Storage

The storage of pesticides prior to use is not a major issue facing the industry at present. The Audit revealed that there are few signs of serious abuses in this area generally, although there was evidence that standards could be improved. Storage compounds that were visited showed some signs of spillages having occurred, and in some cases compounds were cluttered with inadequate space for the quantity of pesticide being stored. Other problems witnessed (on small farms) were inadequate segregation of different product types and inadequate security. These are all problems which could be rectified without considerable effort or expenditure. Guidance on correct storage practices is readily available to the industry from AVCA and from agricultural colleges.

(vii) Disposal

The disposal of the wastes is more controversial and there are concerns that inappropriate practises could result in pesticide contamination of soil and water resources in particular. The evidence suggests that the great majority of pesticide containers are disposed of on the property of the user by burial in shallow pits. Whilst this is permissible within the law it is not the practice which we would recommend. The problem of inadequate disposal of waste reflects the lack of suitable facilities for the disposal of difficult and intractable wastes in Australia.

Pesticide users basically follow the disposal guidelines provided by authorities such as the New South Wales State Pollution Control Commission, and there is no evidence that significant environmental damage is occurring as a result of the practice. However, there have been no on-site investigations or monitoring to assess the actual impact. The proliferation of uncontrolled,, unrecorded dumps is highly undesirable.

Most pesticide users are aware of the undesirability of this situation and its basic cause does not lie with an unwillingness to adopt more appropriate methods so much as with a general lack of suitable facilities in New South Wales and Queensland to deal with the problem.

There have been developments within the industry which address the problem by reducing the number of containers to be disposed of. These include the supply of chemicals in bulk or in re-useable containers such as "mini-bulks" and "shuttles" and the introduction of recycling initiatives for certain types of pesticide drum. It is hoped that these initiatives can spread through the industry as this will certainly have benefits for the waste disposal problem.

7.2.2 Recommendations Concerning Pesticide Use

A number of measures can be introduced which will have the effect of reducing the environmental problems associated with pesticide use. Some of these are of greater urgency than others. Measures which are considered high priority and which should be acted on as soon as possible are indicated in this section with bold text. Recommendations given in normal text are considered desirable but of less immediate urgency.

- **Poor performers amongst aerial operators and growers should be reformed or removed from the industry. This should be primarily achieved by industry (ACF, AAAA and AVCA) education programmes and peer pressure.**

- **AAAA should continue to exert pressure on all operators to join and become accredited.**

- **The ACF should encourage its members to use AAAA accredited aerial operators.**

- **Regulatory authorities should maintain tighter control of pesticide use as a disincentive against poor standards.**

- More monitoring of spray drift in populated areas is required. Air monitoring should be introduced in a small number of key sites (eg Wee Waa, Moree). Methods used should be comparable with those currently used in Emerald.

- Tank mixing of several chemicals to be simultaneously applied should not be carried out without firm guidance on the compatibility of the products concerned. Commonly required mixtures should be identified and research conducted to confirm their compatibility.

- **Chemical handlers should be provided with and use proper protective equipment including full overalls.**

- **Field workers such as bug checkers and chippers should also wear appropriate clothing, including long trousers and shirt sleeves.**

- Employers should provide laundry facilities at the place of work for the washing of pesticide contaminated work clothes.

- Aerial spraying has many advantages over boom spraying These include: fewer operators required and thus less occupational exposure to pesticides, easier control by regulatory authorities and less soil compaction.

- **New farms should be designed with aerial spraying in mind so that potential spray drift problems are avoided.**

- Rural communities surrounded by cotton farms should plant tree-lines as biological buffers. Species should be chosen to maximise effectiveness as barrier to spray drift.

- Cotton farmers should plant tree lines around their own properties (with due allowance for the safety of crop spraying aircraft) to limit the drift of spray off the property.

- **Planning authorities should exert controls to ensure that new housing is sensibly zoned in relation to existing cotton farms to avoid potential spray drift problems. Zoning of new cotton farms should similarly take account of existing residential development.**

- **Doctors/health workers should be encouraged to maintain long term data bases on incidence of cancers, asthma and allergies in cotton growing areas.**

- **Chemical companies should provide information on the minimum re-entry periods which should be observed after crops are sprayed for all products.**

- Pesticides likely to produce strong, drifting odours should be avoided in areas where their use could lead to public nuisance.

- **Research into integrated pest management techniques should be continued and encouraged. This can help to avoid problems of pesticide resistance and contribute to a reduction in the quantities of pesticide used.**

- **Continued observance of the Pyrethroid Strategy is essential in order to continue to avoid pesticide resistance undermining current ability to control pests with available products.**

- **Research into all aspects of pesticide resistance should be maintained and encouraged.**

- Aerial operators should be encouraged to purchase turbine engined aircraft when current piston-engined aircraft are due for replacement. In areas where noise complaints are frequent the immediate replacement of piston-engined aircraft should be considered.

- **All pesticides and herbicides should be stored under lock and key and preferably under cover.**

- **Pesticide storages should have adequate storage space for the quantities of chemical to be kept, have proper bunding, segregation of different products and security controls.**

- **Chemical storage and handling needs improving. ACF, AVCA and AAAA should have a strong education policy to ensure that growers and aerial operators are aware of the correct procedures.**

- **Proper facilities should be provided for the disposal of pesticide containers. The ACF should lobby government to achieve this.**

- **The industry as a whole, including chemical manufacturers, aerial operators and growers should work together to increase the proportion of chemicals supplied in bulk or in re-useable containers.**

- **The industry as a whole should also seek ways to increase the proportion of steel drums which are recycled instead of being buried.**

- **The use of empty pesticide containers for secondary purposes such as trash cans should be completely avoided.**

- **Where burial of pesticide containers on-site is the only option, growers and aerial operators should ensure that tips are managed to the highest possible standards. Detailed records should be kept of the location and contents of pits.**

- **Evaporation pits should only be dug on sites where adequate testing has ensured that the ground is impermeable. Ideally evaporation pits should be lined.**

- **Evaporation pits should be securely fenced and signed to prevent people or animals accidentally entering them.**

7.3 LAND USE

7.3.1 Conclusions Concerning Land Use

Cotton production in Australia occupies over 560,000 acres of land in New South Wales and Queensland. Whilst this is a small proportion of the overall areas of these States, at a local level cotton production is a major land use in some areas. Environmental issues associated with land use for cotton growing fall into two broad categories: potential conflicts with other land uses and potential environmental degradation arising out of poor agricultural practices.

Cotton farms are essentially extensive mono-cultures of an exotic plant species and, in comparison with virgin bush, represent poor habitats for wildlife. Because of this the occupation of large areas of land by cotton farms is likely to be of much greater significance in limiting the abundance and diversity of wildlife in cotton growing regions than the use of pesticides.

The extent to which cotton growing has contributed to this impact is difficult to assess because detailed information on previous uses of cotton farms is not readily available. Some cotton farms were previously arable (wheat) land and as such would have already been largely cleared, but others were previously grazing properties with considerable woodland cover and others may have been at least partly virgin bush. It is also evident that the impact of land clearance on wildlife needs to be assessed in relation to the area of important wildlife habitats which remain, but again data with which to analyse this question are not readily available.

Whilst the impact of past development of the industry on wildlife habitats cannot be readily determined these considerations should be recognised as important and should play a role in determining the environmental impacts of any future development of the industry.

European settlement of Australia has resulted in well documented conflict with the Aboriginal population that was already present. Although Aboriginal rights are now legally recognised the potential for land use conflicts still exists particularly where sites held sacred by Aboriginal peoples might be damaged or otherwise adversely affected by new land uses. As with any other commercial activity affecting extensive areas of land in Australia, the cotton industry is potentially affected by this situation. Little evidence was obtained that this has been a significant problem for the cotton industry although some sites may have been affected. This issue could well affect any future development of the industry, however there is an established legal apparatus to resolve any conflicts which arise.

The chief problem of land degradation associated with cotton growing is the compaction of soils by heavy machinery. This occurs particularly when operations are carried out in wet weather and some degree of compaction is considered almost unavoidable on cotton farms. If unchecked soil compaction can seriously reduce the productivity of the soil.

Fortunately, however, the problem is widely considered to be reversible when it occurs and cultural methods have been developed which can greatly reduce the extent to which it occurs in the first place. Guidelines on these techniques have been produced (SOILpak) and these are readily accessible to the industry. Most growers are aware of the problems of soil compaction and how they can be avoided and farm their land accordingly. For these reasons soil compaction is not likely to affect the long term productivity of any significant area of land in the cotton areas.

Soil erosion is a major cause of land degradation in many parts of the World, including parts of Australia. The evidence suggests that it has not been a problem associated with the cotton industry. The gentle gradient in most cotton growing areas is not conducive to water-induced erosion and the clay soils typical of cotton growing areas are not very vulnerable to wind erosion.

7.3.2 Recommendations Concerning Land Use

- **The ACF should develop an environmental policy or code of good practice on land acquisition. This should not only detail where new cotton farming developments should be encouraged (and where they should not), but should also cover aspects such as the layout and design of newly established cotton farms and their proximity to residential areas and sensitive wildlife habitats.**

- Land use changes involving the cotton industry should be documented in detail. A data base should be established to include details of previous land uses (and, in cases where land ceases to be used for cotton, subsequent land uses), details of adjacent land uses and information on natural/semi-natural habitats present on the land before and after the change.

- **Growers who wish to develop large areas for growing cotton where this could give rise to significant environmental impacts should be encouraged to undertake an independent environmental assessment of the proposals.**

- Where it is compatible with their overall farming operations, growers should be encouraged to retain areas of natural vegetation on their farms to encourage wildlife.

- Growers should be encouraged to incorporate features to promote wildlife in water storage lagoons insofar as this is compatible with the primary function of the lagoons.

- The practice of good agricultural methods to minimise problems of soil compaction and erosion should be encouraged .

- Landcare groups should be promoted. This is an effective way of disseminating information, putting pressure on poor performers and liaising with the local community. Both the number and status of cotton farming Landcare groups should be increased and their activities promoted.

7.4 WATER USE

7.4.1 Conclusions Concerning Water Use

The great majority of cotton grown in Australia is irrigated; this consumes considerable quantities of water (more than six million litres per hectare per season) and gives rise to a number of potential problems. The impacts associated with the use of water for irrigation fall into two categories: competition for a limited resource and impacts on water quality in rivers and other water supplies.

The use of water by the cotton industry potentially conflicts with the demand for water by other sectors of the community and by downstream wetlands and their associated wildlife. The responsibility for ensuring that all the different interests get a fair share of the water resource does not lie with the cotton industry, but is vested in the relevant departments of the State governments.

The cotton industry does have an obligation to ensure that it uses its share of the water resource as efficiently as possible. Irrigation methods appear to be relatively efficient although large volumes of water are lost through evaporation from channels and storage lagoons. It is difficult to see how these losses could be significantly reduced.

Cotton irrigation can also potentially give rise to water pollution as the run-off at the end of the field may be contaminated with the pesticides and fertiliser which have been applied to the crop. The run-off from storms falling on the crop can be contaminated in the same way and if any of this water is allowed back into natural water courses it can pollute the receiving water body.

The majority of cotton farms have reticulated irrigation systems designed to keep all of the water on the farm and most growers appear to be very responsible about avoiding tail water releases. However there is evidence that pesticide contaminated tail water does enter rivers on occasion. Fish kills have certainly resulted from such breaches although the possibility that some reported fish kills have been caused by other factors cannot be ruled out. The industry should make strenuous efforts to prevent any contaminated water reaching rivers and other water bodies.

The levels of pesticide contamination necessary to cause mortality in fish are extremely low. The available data on actual pesticide concentrations present in rivers has indicated that contamination is far below the maximum permitted levels in water intended for human consumption and so this source of pollution is unlikely to constitute a significant health threat.

Although eutrophication is considered a problem in some Australian rivers the evidence suggests that use of nitrogenous fertilisers on cotton crops is not a significant contributory factor. Although large quantities of fertiliser are used in cotton production studies have indicated that the major losses are to the atmosphere through denitrification.

Most releases of tail-water probably occur as a result of stress rather than blatant disregard. Severe storm conditions in particular can give rise to very large quantities of water in a short space of time and exceed the capacity of farms to hold it. It is generally agreed that after the first flush pesticide levels are likely to be so dilute as to not present a problem. It is therefore theoretically acceptable to hold back the first flush and allow the remainder of a flood to flow into the river system. Unfortunately no realistic guidance is available as to how large this first flush needs to be in order to give adequate protection to aquatic wildlife.

Although data is not readily available, the current evidence suggests that water quality has not been adversely affected by cotton farming practices in any important ground water supplies. Such a situation is not considered very likely though it will clearly be prudent to monitor for any indications of ground water pollution.

A final problem associated with the use of water for irrigation is the practice of some growers of using natural billabongs as water storage facilities. This practice is probably not very widespread but has lead to some concern in certain quarters as the impacts of this usage on billabong ecology is poorly understood. Such a change from a highly ephemeral flooding regime to more or less permanent inundation is likely to produce distinct changes in vegetation and associated fauna and the practice should generally be discouraged.

7.4.2 Recommendations Concerning Water Use

- **The water requirements of important wetlands should be recognised by the water authorities in their allocation of water quotas.**
- Research into methods of cotton growing which could reduce water requirements (eg use of short season varieties, better scheduling of irrigations, improved soil management) should be encouraged.
- The rate of depletion of ground water reserves should be monitored.
- **All tail-water should be recycled. Both peer pressure amongst farmers and government inspections should be used to encourage the worst performers to improve their performance.**
- **At least the first flush of storm water run-off should also be withheld and the water storage capacity on cotton farms should include allowance for this.**

- **Studies should be conducted to provide realistic guidelines as to how to calculate the size of this first flush. The cotton industry should commission appropriate studies.**

- **In areas such as Emerald, where the entire irrigation scheme was set up without provision for tail-water recycling, growers should set and work towards a realistic date for complete reticulation of tail-waters.**

- Research into the impact of pesticide contamination on population levels of fish and other aquatic wildlife would be useful.

- **Fish kill incidents should be promptly investigated by the responsible authorities to a set of specified criteria. This will provide a disincentive against illicit tail-water releases and help identify any other causes of catastrophic mortality.**

- **Ground water supplies should be monitored for signs of contamination by pesticides or nitrate.**

- The use of billabongs for water storage should be discouraged.

7.5 COTTON PROCESSING

7.5.1 Conclusions Concerning Cotton Processing

Although cotton gins and seed processing plant can potentially cause environmental impacts beyond the factory boundary, notably through noise pollution and dust emissions, these problems are of limited significance because these facilities are generally constructed well away from residential areas. The principal environmental problems associated with cotton processing therefore concern occupational health and safety.

Noise and dust are the principal health hazards associated with the working environment in gins and the available data from monitoring of these suggests that levels of both are consistently higher than statutory limits. Old gins tend to be much worse than new ones in this respect. The use of appropriate protective equipment (breathing masks and ear plugs or muffs) can provide satisfactory protection despite the ambient dust and noise levels recorded. However, employee negligence in using this equipment is likely to be quite high and so this cannot be relied on to ensure their health is not compromised. The Audit was conducted outside the ginning season and so it was not possible to observe the level of use of safety masks and ear protection. Measures to reduce ambient noise and dust levels in gins are seen as being highly desirable.

Accidents at gins are most frequently of a minor nature and although serious accidents and even fatalities have occasionally occurred this is probably not a persistent problem. Accident record books do not appear to be maintained in many gins. This should be

rectified as detailed records of accidents, with assessment of their causes, can provide crucial information for formulating safety strategies to minimise the chances of their occurring again.

Seed processing involves similar types of hazards to employee health and safety although the use of hazardous chemicals produces some additional problems. The use of hydrochloric acid for delinting, for example, produces harmful fumes which may at times exceed legal limits. Large quantities of various gases which are either toxic (chlorine) or explosive (hydrogen, LPG) are kept on site and these pose a potential threat in the event of accidents. Emergency procedures for such eventualities have been formulated and regular practices are conducted.

Waste disposal is also an issue affecting cotton processors. Gins produce large quantities of cotton dust, leaves, sticks and other trash and dispose of this in various ways including burial, burning and using it as garden mulch. Uncontrolled burning is the least desirable of these options as it can contribute to local air pollution.

Seed processing also entails the disposal of pesticide wastes. The only seed processing plant in Australia treats these using a Sentinel treatment plant which, if properly maintained, should produce effluent of satisfactory quality. The sludge produced is buried on site. The conclusions relating to this last practice are the same as those reached for pesticide disposal practices, ie. it is undesirable but unavoidable at present because of a lack of alternative facilities. Pesticide containers are burnt on site; this practice must be discontinued.

7.5.2 Recommendations Concerning Cotton Processing

- **Dust abatement systems (ie fabric filters) should be fitted to all ginning sites. Obscuration meters should be fitted to the fabric filter outlets with visual and audible alarms and recording charts. The system will require regular maintenance schedule. Monitoring records should be kept for at least 30 years.**

- **Annual lung function tests should be carried out on all permanent staff. The records should be kept by the company for at least 30 years.**

- **Plant layout should be such that air entering the gin building should be from a clean area and suction points/ doors/ exit ports should be located near areas of high dust levels. Also layout should allow employees to proceed from the outside to rest and lunch rooms without having to traverse through the ginning area.**

- **Floors and equipment surfaces should be vacuumed down frequently during a shift; use of compressed air for clearing dust from surfaces should be discontinued.**

- **Doors of enclosed console room should be kept shut;**

- **All indoor personnel should use respiratory protection (class L disposable masks). Note that the masks offer adequate protection only if used correctly.**

- **A programme of employee education should be undertaken to emphasise the risks of dust inhalation and to demonstrate the best practicable means for reducing dust levels and for avoiding excessive particle inhalation.**

- **Employee exposure to noise in gins and seed processing plant should reduced. Methods used should include:**

  Engineering Control:

  a) Isolate noise and minimise the employee contact with the noisy environment (eg work from "quiet rooms").

  b) Isolate fan room.

  c) Consider controls on individual pieces of equipment.

  d) Regular maintenance to minimise vibration.

  Administrative Controls (Rotate staff so that individual workers are not exposed to high noise levels continuously for long periods).

  Personal Protection: provision of ear muffs and plugs. This strategy should be considered only after engineering and administrative solutions have proved insufficient.

- **Regular monitoring of noise levels should be undertaken:**

- **Annual hearing tests should be carried out on all permanent staff.**

- **In-house health and safety audits should be undertaken at all cotton processing facilities. This should include a review of previous accidents and of current safety procedures.**

- **Accident Books should be maintained at all processing facilities. Information such as the nature of injury, part of body involved, where accident occurred, date, time, person to whom accident was reported, lost time, activity undertaken when accident occurred, other people or vehicles involved etc. should be recorded.**

- More appropriate methods of reducing road dust at gins such as damping down with water or laying down a permanent road surface should be considered. The spreading of waste oil for this purpose should be ceased.

- All solid waste should be sent a competent waste disposal contractor who is licensed to accept and/or treat the specified waste stream. Waste treatment and disposal must be undertaken in a controlled manner.

- The uncontrolled burning of trash should be avoided.

- A routine monitoring programme for HCl, ammonia and ammonium chloride should be implemented at the seed processing plant. Future monitoring should assess personal exposure limits (short and long term) and should compare these to existing statutory limits and international guidelines.

- The 'Sentinel' waste treatment system for the handling of pesticide wastes generated by seed treatment should be regularly maintained and the filters replaced to ensure satisfactory performance.

- The water in the evaporation pond receiving effluent from the treatment plant should be subjected to occasional monitoring to verify that high levels of pesticide residues are not building up. Proper fencing and signing of the evaporation pond is also required.

- The on-site burial of sludge produced by the system is an undesirable practice although permissable under SPCC guidelines. Ideally this waste, along with spent filters, should be disposed of by a competent licensed contractor.

- Where on-site disposal of sludge is unavoidable, investigations should be undertaken to ensure the suitability of the disposal site and the location and quantities of buried sludge should be recorded.

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APPENDIX 1

LIST OF QUESTIONNAIRE RECIPIENTS

Australian Cotton Foundation (ACF)
Aerial Agricultural Association of Australia (AAAA)
Agricultural and Veterinary Chemicals Association of Australia (AVCA)
Raw Cotton Marketing Advisory Committee (RCMAC)
Queensland Crop Management Consultants Association
New South Wales Cotton Consultants Association
Cotton Seed Distributors (CSD)
Namoi Cotton Co-Operative, NSW
Auscott Ltd, NSW
Colly Farms Cotton Ltd, NSW
Twynam Cotton Ltd, NSW
Darling River Cotton Ltd, NSW
Dunavant Enterprises Australia, NSW & Qld
Queensland Cotton Corporation, Qld

Australian Cotton Growers Research Association (ACGRA)
The Cotton Research & Development Corporation (CRDC)

Individual Growers & Graziers

State Pollution Control Commission, NSW (SPCC)
Department of Agriculture & Fisheries, NSW (DA & F)
Department of Water Resources, NSW (Dept WR)
Department of Primary Industries, Qld, (DPI)
Department of Heritage & Conservation, Qld
Department of Forestry, Qld
Workcover Authority
CSIRO

Greenpeace
Total Environment Centre
The Australian Conservation Foundation
Concerned Citizen Groups & Environmentalists

Note: Some large organisations received more than one questionnaire, addressed to different individuals or departments within the organisation.

APPENDIX 2

INTERVIEWS AND SITE VISITS

Organisation	Interviewee	Location
ACF	Alan Brimblecombe	Lochyer Valley
	Peter Cone	NSW
	Stuart Gordon	Queensland
CRDC	Ralph Schulze	Narrabri
Auscott Ltd	Bruce Loder	Sydney
Auscott Ltd	David Anthony	Narrabri
Queensland Cotton Corporation	Tal Hamilton	Cecil Plains
Clyde Agriculture	Kim Packer	Bourke
Colly Farms	Bucky Rowlands	Collarenebri
	Phil Glover	
	Peter Morrison	
Cotton Seed Distributors	David Swallow	Wee Waa
	Bill McDonnell	
	Keith Davies	
	Geoffrey Taylor	
Dunavant Enterprises	Josie Volck	Emerald
	Jim Griffith	
Dunavant Enterprises		Moree
Growers	Fred Barlow	Mungindi
	Harley Bligh	Darling Downs
	Steve Brimblecombe	Emerald
	Peter Corish	Goondiwindi
	Jamie Cupples	Jondaryan
	Mostyn Fletcher	Emerald
	Ralph Grey	Mungindi
	Paul McVeigh	Darling Downs

Farmers cont.	Carl Morowitz	Emerald
	Glenn Price	Mungindi
	Lindsay Smith	Mungindi
	Graham Volck	Emerald
	Jack Warnock	Wariella
	Charlie Wilson	Emerald
North West Gin	Ron Jett	Moree
Crop Consultant	Greg Kauter	Goondiwindi
AVCA	Allen Morley	Sydney
	Ian Douglas	
	Connie Comber	
AAAA	Peter Weatherstone	Sydney
Agricultural Aviation	Dean von Einem	Emerald
Gwydir Air	Fred Nolan	Moree
Central Air		Emerald

Government Bodies

Department of Primary Industries	Mike Artlett	Emerald
	Paul Waterhouse	Brisbane
	Neil Smith	
DPI (forestry)	Craig Whiteford	Emerald
DPI (Water Resources Commission)	Ross Krebs	Emerald
Department of Sustainable Agriculture	Don Saville	Orange
	Len Banks	

Government Bodies cont.

Workcover	Fred Fattal Dr C Goldfinch	Sydney
NSW Dept Ag & Fisheries	Ian Daniels Neil Forrester Gus Shaw	Myall Vale
	Bob Coulton Dr Vic Edge	Sydney Sydney
NSW Dept of Water Resources	Hugh Suttor	Moree
CSIRO	Dr Greg Constable Dr Peter Cox	Narrabri
SPCC	Dr David Leece Dr Richard Whyte	Sydney
Dept of Environment and Heritage	Robert Crasswell	Brisbane

University

University of Queensland	Dr John Harden John Whitehead Nicholas Woods	Gatton College

Medical Community

Agricultural Health Unit	Dr Lynn Clarke	Moree
General Practitioner	Dr Quinn	Emerald

Environmental Organisations

	Col Brown Pat Jackson	Moree Mungindi

Environmental Organisations cont.

Emerald Concerned Citizens Group	Jeff Newsome	Emerald
Total Environment Centre	Dr Kate Short	Sydney

APPENDIX 3

COTTON PESTS IN AUSTRALIA

Pests of major importance

Crop Stage attacked	Scientific name	Common name
Early to mid season	*Heliothis punctigera*	native budworm
Mid to late season	*Heliothis armigera*	cotton bollworm
	Tetranychus urticae	two-spotted mite
	Aphis gossypii	Cotton aphid

Pests of sporadic occurrence

Crop stage attacked	Scientific name	Common name
Early seedling	*Agrypnus variabilis*	true wireworm
	Pterohelaeus darlingensis	false wireworm
	Gonocephalum macleayi	southern false wireworm
	Saragus sp.	false wireworm
	Agrostis spp.	cutworms
	Smynthurodes betae	bean root aphid
	Spodoptera exigua	lesser armyworm
	Loxostege affinitalis	cotton webspinner
	Thrips imaginis	plague thrips
	Frankliniella schultzei	tomato thrips
	Order Collembola	springtails
	Sub-family Halticinae	flea-beetles
	Austracis guttulosa	spur-throated beetles
	Teleogryllus spp.	field crickets
Late seedling to squaring	*Austroasca viridigrisea*	vegetable leafhopper (jassid)
	Creontiades dilutus	green mirid
	Taylorilygus pallidulus	broken-back bug
	Campylomna livida	apple dimpling bug (yellow mirid)
	Crocidosema plebeiana	cotton tipworm
	Bucculatrix gossypii	cotton leaf perforator
	Anomis flava	cotton looper
Boll production and maturation	*Tetranychus ludeni*	bean mite
	Myzus persicae	green peach aphid
	Trialeurodes vaporariorum	greenhouse whitefly
	Bemisia tabaci	whitefly
	Dysdercus sidae	cotton stainer
	Tectocoris diopthalmus	cotton harlequin bug
	Nezara viridula	green vegetable bug
	Oxycarenus luctuosus	cotton seed bug
	Earias huegeli	rough bollworm

APPENDIX 4

PRINCIPAL PESTICIDES FOR COTTON

INSECTICIDES

COMMON NAME	TRADE NAME	CHEMICAL GROUP
Acephate	Orthene 750 SP	Organophosphate
Aldicarb	Temik	Carbamate
Alphamethrin	Dominex	Pyrethroid
Azinophos ethyl	Gusathion	Organophosphate
	Kilathion	Organophosphate
Carbaryl	Bugmaster 80	Carbamate
Chlorfluazuron	---	Chitin inhibitor
Chlorpyrifos	Chlorfos	Organophosphate
	Lorsban	Organophosphate
	Predator	Organophosphate
Cyhalothrin	Karate	Pyrethroid
Cypermethrin	Cymbush	Pyrethroid
	Ripcord	Pyrethroid
	Nurelle	Pyrethroid
	Polytrin	Pyrethroid
Deltamethrin	Decis	Pyrethroid
Demeton-s-methyl	Metasystox	Organophosphate
Dimethoate	Dimethoate	Organophosphate
	Perfekthion	Organophosphate
	Rogor	Organophosphate
	Roxion	Organophosphate
Disulfoton	Disyston	Organophosphate
	Solvirex	Organophosphate

Endosulfan	Endosan	Organochloride
	Endosulfan	Organochloride
	Thiodan	Organochloride
	Vermosca	Organochloride
Esfenvalerate	—	Pyrethroid
Fenvalerate	Sumicidin	Pyrethroid
Fluvalinate	Mavrik	Pyrethroid
Formothion	Anthio	Organophosphate
Methomyl	Kipsin	Carbamate
	Lannate	Carbamate
	Nudrin	Carbamate
Monocrotophos	Azodrin	Organophosphate
	Cronofox	Organophosphate
	Nuvacron	Organophosphate
Omethoate	Folimat	Organophosphate
Parathion	E605 Folidol	Organophosphate
Permithrin	—	Pyrethroid
Phorate	Thimate	Organophosphate
Profenofos	Curacron	Organophosphate
Pyrethroid/PBO	—	—
Sulprofos	Helothion	Organophosphate
Thiodicarb	Larvin	Carbamate
Thiometon	Ekatin	Organophosphate

HERBICIDES

Amitrole	Lane amitrole Amitrole lplus Amitrole T
Atrazine	Atrazine 80
Diquat	Reglone
Diuron	Diuron Karmex
Fluazifop	Fusilade
Flometuron	Cotoran Flometuron
Glyphosate	Roundup
Haloxyfop	Verdict
Monosodium methyl arsonate	Daconate MSMA
Paraquat	Sprayseed
Prometryn	Gesagard
Trifluralin	Treflan Trifluralin

APPENDIX 5

INSECTICIDE APPLICATION RATES FOR THE NAMOI AND LOWER GWYDIR AREAS. FIGURES REPRESENT MEAN APPLICATION RATE FOR THE 3 YEARS TO 1986 IN KG/HA/SEASON

Organochlorines	Endosulfan (ground)	1.08
	Endosulfan (aerial)	1.70

		TOTAL 2.88
Pyrethroids	Cypermethrin	0.18

		TOTAL 0.18
Organophosphates	Chlorpyrifos	>0.01
	Monocrotophos	0.23
	Parathion	0.17
	Profenofos	0.71
	Sulprofos	0.21

		TOTAL 1.33
Carbamates	Methomyl	>0.01
	Thiodicarb	0.07

		TOTAL 0.08
		GRAND TOTAL 4.47

Data from Forrester (1986)

Note: These are mean figures for a 3 year period.
The quantity of each insecticide varies from season to season

Eg. Monocrotophos - 0.56 Kg/Ha (1983-84)
- 0.14 Kg/Ha (1984-85)
- 0.10 Kg/Ha (1985-86)

As new insecticides become available on the market, the use of older brands will change. Cypermethrin was the principle pyrethroid during the period represented on this table but subsequently Cyhalothrin has displaced it to become the most widely used pyrethroid.

APPENDIX 6

DEFOLIANTS AND CONDITIONERS USED ON COTTON CROPS IN AUSTRALIA

COMMON NAME	TRADE NAME
Dimethipin	Harvade
Diquat	Reglone
Endothal	Accelerate
Ethephon	Prep
Oleyl alcohol Ethylene oxide condensate	Catapult
Petroleum oil	D-C-Tron
Sodium chlorate	Atlacide Leafex
Thidiazuron	Dropp
Tributyl phosphorothioate	Folex
S,S,S-Tributyl phosphorothioate	Def

PYRETHROID STRATEGY

Synthetic pyrethroids, when introduced in the 1970's, were regarded as the almost perfect insecticide. They were cost-effective at low application rates on a broad range of agricultural and public health pests. They were favoured in cotton because of their contact mode of action and good efficacy against previously resistant pests. By the mid-1980's they accounted for 49% of the world cotton insecticide market.

However, in January 1983, pyrethroids failed to give satisfactory field control of Heliothis armigera in central Queensland.

In response to this, an insecticide use strategy was developed for heliothis-susceptible crops in northern NSW and southern and central Queensland. The strategy was designed to manage pyrethroid resistance in particular but also to manage resistance to the other main insecticide groups. The resistance management was designed on an alteration strategy based on the rotation of 3 unrelated chemical groups, with 3 different sites of action on a per generation basis.

This integrated approach, which is reviewed annually, was designed to spread the selection pressure over a number of mortality factors and so limit the opportunity for resistance to develop to any one control measure.

The basis of the pyrethroid strategy is to restrict its use to a maximum of 3 sprays against only one H. armigera generation, of the 4 or 5 generations that can occur in a season. For this stategy the season is divided into 3 time stages - early-, mid- and late-season. Pyrethroid use is limited to the mid-season.

It is not used in early-season as this would select out resistant individuals from the first generation and could lead to problems with secondary pests, particularly mites and aphids.

The mid-season, when pyrethroids can be used, runs from January 10th - February 13th in northern NSW and central Queensland. This period of time is approxiamately that required for one full heliothis life cycle. It is also a vulnerable period of the cotton growth cycle and the high efficacy of the pyrethroid insecticide is required. The use of pyrethroid is discontinued for cotton on February 13th and any pyrethroid-resistant survivors are controlled by alternative chemicals after this date.

For the 1990-1991 season, the addition of piperonyl butoxide (PBO) to the second pyrethroid spray was recommended. This synegistic chemical overcomes the dominant pyrethroid resistance mechanism in current field populations of H.armigera during the mid-season. This chemical is not to be over-used as H.armigera could develop resistance to PBO as well as to pyrethroid and so one spraying per season is recommended. As moths are the main target for PBO, early evening spraying is suggested.

APPENDIX 7

A further insecticide with an important role in heliothis control is Endosulfan. Resistance to this insecticide was prevalent in the mid-1970's and care must be taken to avoid this reoccurance.

Endosulfan use is approved for both the early and mid-season stages. The cut-off date, February 13th, is in line with the pyrethroid window. It is not to be used in the late season. This restriction is designed to remove selection pressure on the late season populations which over-winter and are subject to heavy endosulfan pressure during the eraly and mid season of the following year. The risk of reselecting resistance is thereby reduced.

The frequent and thorough scouting of crops is an essential part of the strategy to minimise the need for sprays and to maximise their effectiveness, particularly when short pesistance pesticides are used.