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ECONOMICS

# *Cotton breeding & decision support*

*A benefit-cost analysis of  
CSIRO's research programs*

*Prepared for*

*CSIRO and*

*Cotton Research and Development Corporation*

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## **CANBERRA**

Centre for International Economics  
Ian Potter House, Cnr Marcus Clarke Street & Edinburgh Avenue  
Canberra ACT

GPO Box 2203  
Canberra ACT Australia 2601

Telephone +61 2 6248 6699 Facsimile +61 2 6247 7484

Email [cie@thecie.com.au](mailto:cie@thecie.com.au)

Website [www.thecie.com.au](http://www.thecie.com.au)

## **SYDNEY**

Centre for International Economics  
Level 8, 50 Margaret Street  
Sydney NSW

GPO Box 397  
Sydney NSW Australia 1043

Telephone +61 2 9262 6655 Facsimile +61 2 9262 6651

Email [ciesyd@thecie.com.au](mailto:ciesyd@thecie.com.au)

Website [www.thecie.com.au](http://www.thecie.com.au)

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# *Cotton breeding and decision support*

## **Summary**

CSIRO and the Cotton Research and Development Corporation (CRDC) commissioned the Centre for International Economics (CIE) to undertake a benefit cost analysis of the research work done by the CSIRO Cotton Research Unit which was established in 1972. This work included the Unit's cotton breeding program, as well as its development of several management tools for cotton farmers and their advisers. These tools include SIRATAC which was used from 1984 to 1989, entomoLOGIC which was released in 1994, and more recently, CottonLOGIC. Separate analyses were undertaken for the cotton breeding programs, SIRATAC and entomoLOGIC/CottonLOGIC.

The results show that CSIRO's cotton research has provided significant economic benefits to the Australian community. Taking CSIRO's cotton breeding and decision support research as a whole, and assuming a 5 per cent discount rate, the research has returned a present value net benefit of over \$5 billion since 1973, with a benefit:cost ratio of 51 and internal rate of return of 31 per cent.

Most of the benefit has come from the cotton breeding programs which have returned net benefits of \$4.9 billion in present value, with a benefit:cost ratio of 86 and internal rate of return of 34.

The present value of net benefits from entomoLOGIC/CottonLOGIC were estimated at just over \$200 million with a benefit:cost ratio of 18.5. The earlier SIRATAC had a present value of net benefits of \$36 million with a benefit:cost ratio of 2.1.

The environmental consequences have not been taken into account. Much of the CSIRO cotton breeding research has been focussed on producing better adapted varieties with better resistance to pest and diseases. The research on management tools has also had a strong focus on this aspect. The result has been a significant reduction in the number of insecticide

sprays and use of chemicals on established areas, providing an environmental benefit compared with what would have happened if the original varieties had continued to be used. The new varieties are also at least 11 per cent more water-use efficient. But the CSIRO research has also stimulated the expansion of both irrigated and dryland cotton, which may have meant increased use of insecticides and irrigation water depending on what alternative crops might have been grown in the absence of the research.

## Background

From the early 1960s, the modern Australian cotton industry developed rapidly, especially after the construction of several dams for irrigation in northern New South Wales and southern Queensland. Through the 1960s and 1970s Australian cotton production was based on US varieties and much of the early technology was adopted from cotton farmers with experience in the United States. In 1975 cotton production was still only 110 000 bales.

The industry at that time faced several problems. The US varieties in use at the time were not well adapted to Australian conditions and yields were relatively low. Pests were also a significant problem. The most significant of these was and still is the *Helicoverpa* species, the larvae of which feed on the cotton plant causing a severe reduction in yield. *H. armigera*, in particular, tends to quickly develop resistance to insecticides. Spider mites appear most seasons, while other pests can appear intermittently. Certain diseases endemic to Australia such as bacterial blight, Verticillium wilt and Fusarium wilt have the potential to reduce the yield of cotton crops.

Insecticides and herbicides are available to deal with these pests, but these need to be applied carefully. There is increasing community concern about the effects of some of these insecticides. Endosulfan, commonly used to control *H. armigera* in many crops, can have adverse environmental effects, and recent regulatory changes have restricted use of and conditions for application of endosulfan.

The importance of developing cotton varieties and control methods to deal with Australian conditions and pests was underlined by the experience of Western Australia's Ord River cotton industry. Repeated and heavy spraying for pests such as *H. armigera* allowed insecticide resistant insects to evolve. As a result, the Ord River's cotton production became unsustainable in 1974, with the final year of cotton production requiring 34 sprays to achieve an uneconomic yield.

The CSIRO cotton breeding research program began in earnest in Narrabri in 1972. It aimed to develop Australian cotton varieties that were better yielding and, in particular, more resistant to disease and insect attack. Pest resistance became a major breeding goal in the Narrabri full season breeding program.

The cotton breeding program developed varieties that have higher yields, increased disease resistance and reduced need for insecticides. In addition, computer programs such as SIRATAC and its successor, entomoLOGIC/CottonLOGIC, have been developed by CSIRO to help cotton growers make management decisions to apply the minimum amount of insecticide at the time it is most needed.

This report is an economic evaluation of CSIRO cotton breeding and pest management decision support systems projects.

## Cotton Research Unit

The CSIRO Cotton Research Unit was established at Narrabri in 1972. The Unit had the advantage of proximity to the major cotton production regions. Its establishment brought together breeding programs, with diverse goals, from around the country and combined that with crop and insect management scientists.

### *R&D objectives*

The Cotton Research Unit aimed to develop cotton varieties designed to maximise productivity and quality under Australian conditions. Its major breeding goals were:

- pest resistance, especially to *Helicoverpa*;
- resistance to diseases such as bacterial blight and Verticillium wilt;
- increasing yield and regional adaptation; and
- increased fibre length and strength to compete in premium export markets.

CSIRO's management tools, the centralised computer program SIRATAC and the desktop program, entomoLOGIC, were based on conclusions from scientists that, with the proper timing and proper choice of chemicals, growers could reduce the number insecticide sprays required to maintain their crop. SIRATAC was used to manage around 25 per cent of the cotton

crop from 1984 to 1989, with a small group of farmers using it from 1989 until the release of entomoLOGIC in 1994 (Hearn and Bange, 2002).

## Approach to the analysis

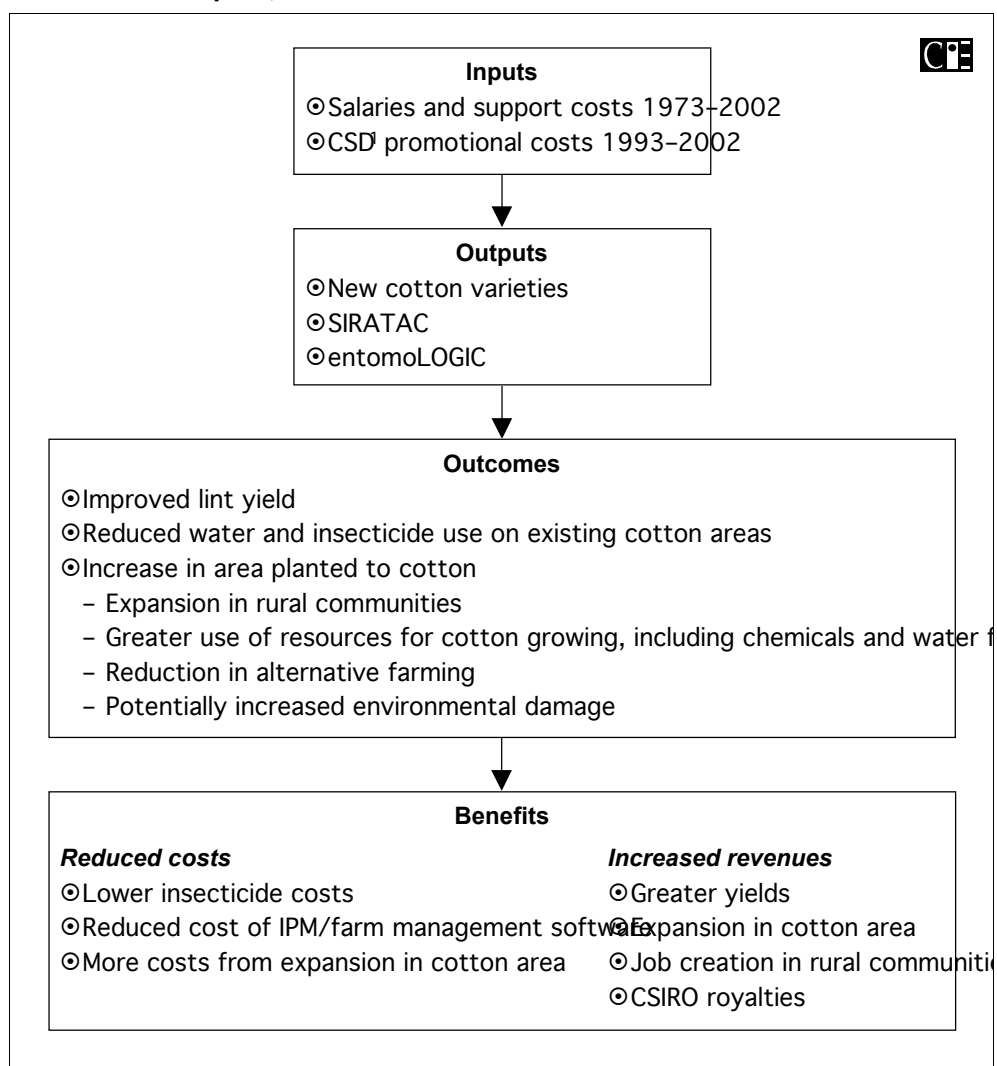
In undertaking this economic evaluation of CSIRO's cotton research program, four factors were considered:

1. *Inputs*. This is the amount that CSIRO has spent on research over the period of analysis (1973–2002). It includes salaries, support costs and other overheads involved in the research, and the costs of promoting cotton varieties developed by CSIRO.
2. *Outputs*. These are the products that come from CSIRO research; namely new cotton varieties and the decision support tools, SIRATAC and entomoLOGIC (now named CottonLOGIC).
3. *Outcomes*. These are ways in which the outputs change the world. There are two elements to consider: first, the effects that CSIRO research has had on improving yields, changing behaviour, and second; the share of the environment that the changes are applicable to; ie the adoption rate.
4. *Benefits*. The eventual impacts on the welfare of Australians. These include increased profits from the sale of cotton and the expansion of rural communities, less any additional costs of implementation of the R&D outputs in production. They may be positive or negative.

Chart 3.1 shows the flow of inputs, outputs, outcomes and benefits from CSIRO's cotton research.

Based on these factors, the evaluation compares the state of the world with CSIRO research, with what is thought might have happened without it (the counterfactual). The 'with R&D' scenario estimates the impacts on cotton farming of CSIRO research, including improved yield, reduction in spraying costs and so forth. The 'without R&D' scenario must estimate how the cotton industry would have developed in the absence of CSIRO research. The analysis measures the increase in profits of the 'with' scenario over the 'without' scenario – this, plus royalties from the sale of seed overseas, is the gross benefit of CSIRO research. The gross benefit will be compared to the R&D costs to assess the net return on investment.

## 3.1 Flow of outputs, outcomes and benefits from CSIRO research



In evaluating the gross benefits, it is assumed that the additional profits generated in cotton can be attributed to the CSIRO cotton breeding research. This implicitly assumes that additional labour and capital, which are valued at their opportunity cost, can be freely employed elsewhere in the economy in the absence of the CSIRO cotton program. This also applies to land and water where the area of cotton is expanded as a result of the CSIRO research.

## Inputs

CSIRO funding for the Cotton Research Unit comes from the government, the Cotton Research and Development Corporation (CRDC), Cotton CRC and from royalties from the sale of cotton seed.

Inputs to the Cotton Research Unit are valued by estimating the cost of employing and supporting the staff who have worked on the project. This was done by taking the salaries of staff members and multiplying it by 2.86 to reflect overhead and support costs. Staff numbers and present values of research costs are shown in table 3.2. the cost of the research since 1973, including overheads, is estimated at \$48 million (2002 dollar values), which in present value terms is equivalent to \$103 million, assuming a 5 per cent discount rate.

### 3.2 Research inputs – professional staff units per annum (full time equivalents)

	<i>Breeding</i>	<i>SIRATAC</i>	<i>EntomoLOGIC/ CottonLOGIC</i>	<i>Total funding</i>
	Full time equivalents	Full time equivalents	Full time equivalents	2002 dollars
1973		2		541,296
1974	2.5	2.5		1,205,470
1975	2.5	2.5		1,205,470
1976	2.5	2.5		1,205,470
1977	2.5	2.5		1,205,470
1978	2.5	3		1,340,794
1979	2.5	3		1,340,794
1980	2.5	3		1,340,794
1981	2.5	3		1,340,794
1982	2.5	3		1,340,794
1983	2.5	3		1,340,794
1984	2.5	3		1,340,794
1985	2.5	3		1,446,564
1986	2.5	3		1,446,564
1987	2.5	3		1,446,564
1988	2.5	3		1,446,564
1989	2.5	3		1,030,015
1990	2.5			897,458
1991	3.5			1,113,963
1992	3.5		3.5	1,995,596
1993	3.0		3.5	1,936,290
1994	2.4		3.5	1,712,980
1995	2.7		3.5	1,787,884
1996	2.7		3.5	1,734,908
1997	2.7		3.5	1,785,810
1998	3.3		3	1,780,568
1999	3.5		3	1,926,909
2000	3.5		3.8	2,202,252
2001	3.5		3.8	2,493,495

Source: CSIRO, Johnston et al 1992

## Project outputs

Since its inception, the cotton breeding unit has produced a number of cotton varieties with properties of pest and disease resistance, better yields,

early maturity, heat tolerance and fibre length and strength. Some of the major varieties produced include:

- Siokra: resistant to bacterial blight, *Helicoverpa* and mites due to its okra leaf shape. Eleven other cultivars have been developed from the original Siokra, two of them transgenic.
- Sicala V-1: has a high degree of resistance to Verticillium wilt. It was released in 1991, and its replacement, Sicala V-2, was released in 1994. The latter had 41 percent adoption by 1997. Continued use of Verticillium resistant cultivars is reducing the level of the disease in the soil of cotton growing areas.
- Sicala 40: a short maturity variety with high fibre strength and yield, and good disease resistance. Originally intended as a short season variety, it is now used for managing the timing of the harvest.

### *Transgenics*

Cotton varieties genetically modified with the Bt gene, developed by Monsanto Ltd are currently marketed as 'Ingard'. This gene produces a natural insecticide that kills *Helicoverpa*. One Bt gene is added to most current varieties, and there is concern that *Helicoverpa* may start to develop a resistance to this gene. Planting of transgenic cotton is thus limited to 30 per cent of the total cotton crop. A new cotton variety with two transgenic genes, Bollgard II, has just been released. The chance of *Helicoverpa* developing a resistance to Bollgard II is up to 50 times less than the likelihood of resistance to the Bt gene used alone in Ingard cotton.

CSIRO uses the Bt gene in several of its varieties. Deltapine, a US cotton breeder, also produces transgenic cotton varieties for Australian use, and holds about 50 per cent of the transgenic cotton market. These transgenic cotton varieties are more expensive than conventional cotton breeds, but make up for their expense by reducing spraying costs by around 50 per cent (Constable, Reid and Stiller, 2000).

### *Decision support tools*

Scientists recognised early the importance of applying minimum quantities of insecticide and herbicide without compromising on maximum effectiveness. Not only does this save growers money on sprays, but it also reduces harm to the environment from overspraying and reduces the likelihood of pests developing resistance to sprays.

The SIRATAC prototype was developed in 1976. It consisted of several simulation models and a decision model. It simulated the development and feeding habits of pests, the production of cotton, and recommended which spray to use, when and where spraying should take place, and if any should be used at all. In 1981 a private company was established to market the system, and within three years 25 per cent of the area planted to cotton in Australia was managed by SIRATAC (Hearn and Bange, 2002).

In 1992, a benefit cost analysis was conducted on SIRATAC. It assumed a ceiling adoption rate of 50 per cent and that SIRATAC would save growers two sprays per season at \$20 per hectare, with a \$10 per hectare fee payable to SIRATAC Ltd. Based on this, at a five per cent discount rate it measured a benefit cost ratio of 3.4 (Johnson et al, 1992).

EntomoLOGIC replaced SIRATAC in 1992. It contains models of the *Helicoverpa* life cycle including pupae activity and a mite pressure model. Users can input characteristics of their farm, such as stage of crop development, weather and soil types, with information on pest prevalence. EntomoLOGIC then provides advice on whether insecticide is required to maintain the grower's management strategy. Due to developments in computer technology, entomoLOGIC was designed for desktop use.

In 1998, a new package was released called CottonLOGIC, which combined entomoLOGIC with another program called nutriLOGIC; the latter being a nitrogen fertiliser management tool. Both entomoLOGIC and CottonLOGIC are distributed free to growers. HydroLOGIC, a decision support tool, is being released in 2003 to assist with irrigation scheduling to maximise water use efficiency. In response to consumer comments about the inconvenience of returning from the field to the office to use CottonLOGIC, CSIRO has just released CottonLOGIC for the PalmPilot™ which allows farmers and consultants to enter data and use CottonLOGIC in the field.

## **Project outcomes and potential benefits**

It has been suggested that CSIRO's breeding and decision support developments are significant contributors to the success of the modern cotton industry. It is certainly true that if cotton growers were still using the cultivars they had used in the late 1970s and early 1980s, the Australian cotton industry would not have expanded to the same extent as it has. In the absence of the CSIRO Cotton Research Unit, it is unlikely that industry bodies would have established a program with similar aims.

In order to measure the benefit provided by CSIRO's research program, we must also assess what would have occurred in its absence. This section considers the way in which CSIRO's cultivars and decision support programs have affected the cotton industry and outlines assumptions about what would have happened in its absence in the 'without' scenario (the counterfactual).

### *Conventional cotton varieties*

It can be readily assumed that, in the absence of CSIRO's breeding program, Australian cotton growers would have continued to use US varieties, mostly developed by Deltapine, a US cotton breeder. Among others, Deltapine's varieties were used by CSIRO in its first breeding programs. Deltapine have bred many new varieties since the 1970s, but these were designed for US conditions, and do not provide resistance to bacterial blight and Verticillium wilt, two cotton diseases which have a significant impact in Australia.

It is difficult to estimate which Deltapine varieties would have been used in the absence of CSIRO's breeding program. Since 1995, almost all cotton sold on the Australian market has either been bred by CSIRO or based on CSIRO cultivars. Deltapine established a breeding program in Australia in the early nineties and started to breed varieties from CSIRO-bred cultivars suited to Australian conditions, but this was only in response to competition from CSIRO for the Australian cotton seed market. In CSIRO's absence, it is highly unlikely that Deltapine would have established a breeding program here, and Australian cotton farmers would still be using varieties bred for US conditions. The Deltapine variety most likely to be used for conventional cotton breeding would be Deltapine 90, which was released in 1984. It remained on the market until 1998; and is still sold as a transgenic variety with a Bt gene. Deltapine 90 is superior in strength, yield and maturity to Deltapine 16, which CSIRO use as their control variety in tests. Thus, we will assume that in the absence of the CSIRO program, Australian cotton growers would have planted Deltapine 90 or a variety with an equivalent yield under Australian conditions.

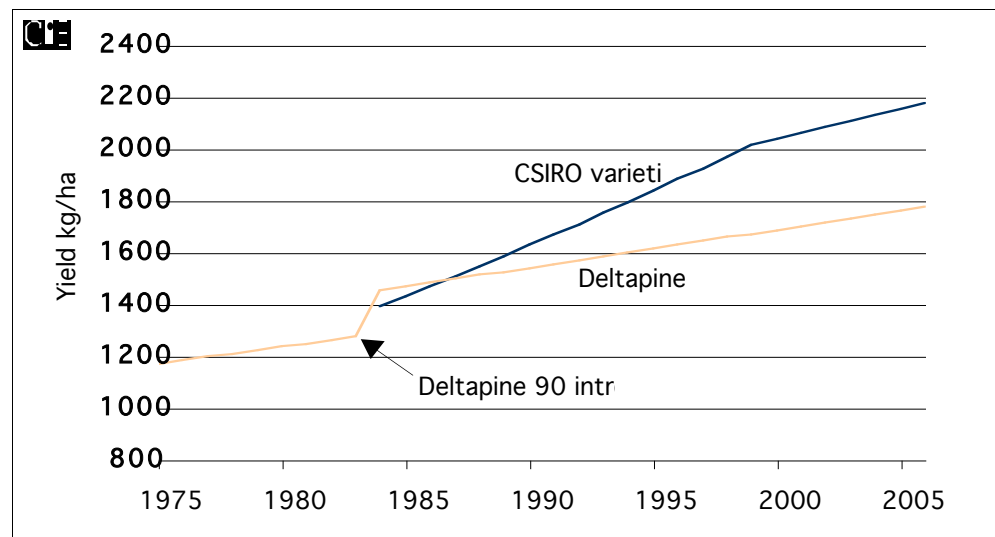
It is likely that other cotton varieties would have been available to Australian cotton growers other than Deltapine 90, but these would have been bred for increased yield and quality in the US, and may not have produced such results in Australia. Major factors affecting yield in Australia, bacterial blight and Verticillium wilt, which can cause reductions in yield of 25 per cent and 15 per cent respectively, have not been addressed in US cotton varieties.

### *Increased yield*

In spite of expansion of cotton farming into new regions and lower-yielding rain grown cotton farms, yields have steadily increased since CSIRO's breeding program was established. Average yields from new CSIRO cultivars have increased by an average of about 23 kilograms of lint per hectare per year. By comparison, yields from control cultivars Deltapine 16 and Namcala have increased by 13 kilograms per hectare per year. This suggests that 45 per cent of the average yield increase is due to CSIRO's breeding efforts; that is, yield has increased by 10 kilograms per hectare per year due to CSIRO varieties. This yield increase is likely due to improved yield potential and improved resistance to disease. The other 55 per cent is likely due to improved management practices.

CSIRO has provided data on yield trends of Deltapine 16 from 1974–2002 and the actual yield of the cotton industry. Since Deltapine 90 yields, on average, 13 per cent more than Deltapine 16 (Greg Constable, personal communication) we have multiplied the Deltapine 16 yield by 1.13 to estimate the increase in lint yield of Australian cotton if CSIRO had not developed new cotton varieties and Australian growers continued to use Deltapine 90. The annual average increase in yield of Deltapine 90 is 14.6 kilograms per hectare per year, which means that CSIRO varieties provide around an extra 8 kilograms per hectare per year over what the Australian cotton industry would have achieved in the absence of CSIRO's cotton breeding research.

#### 3.3 Cotton yield from Deltapine and CSIRO varieties (smoothed)



Data source: CSIRO

Chart 3.3 shows the yield trends of Deltapine varieties (DP 16 until 1983, then DP 90 from 1984 onwards) and CSIRO varieties, projected up to 2006.

The increase in yield of the Deltapine varieties is due to improved management. The difference between the increase in yield of CSIRO and Deltapine varieties is due to CSIRO's breeding program.

#### *Pest and disease resistance*

Disease resistance is a very important trait for cotton varieties in Australia. CSIRO breeding has been extremely effective in dealing with diseases in cotton. All CSIRO varieties are resistant to bacterial blight, eliminating a disease that was a problem in the late seventies. Verticillium wilt resistant varieties have significantly reduced the presence of the disease in the soil of affected areas. US Deltapine varieties did not have effective blight and Verticillium resistance in Australia.

Resistance to *Helicoverpa* has been one of the main targets of most CSIRO cultivars. Reducing the number of sprays required leads to environmental benefits, saves growers' money and reduces the likelihood of *Helicoverpa* developing resistance to insecticides. Both new varieties and decision support packages are integral components of Integrated Pest Management. CSIRO's Siokra cultivars have proved useful in improving the efficiency of insecticides dealing with *Helicoverpa* and mites and reduced susceptibility to these pests. Its effectiveness comes from its okra leaf shape, which is shunned for aesthetic reasons by US and European breeders. Use of okra leaf varieties saves, on average, 0.5 sprays for *Helicoverpa* and 0.5 sprays for mites (CSIRO, personal communication).

When it was discovered that okra leaf varieties were more susceptible to Verticillium wilt than other varieties, CSIRO developed Siokra V-15 and V-16, which have Verticillium wilt resistance. However the okra leaf varieties are also less resistant to Fusarium wilt, a more recent disease, and CSIRO is yet to develop varieties with significant Fusarium resistance, so the okra varieties are declining in popularity.

Due to *H. armigera*'s ability to adapt quickly to new cultivars and insecticides, it still remains the most significant pest to cotton growers. Transgenics have substantially more *Helicoverpa* resistance than conventional breeds, requiring around half the sprays necessary for conventional varieties.

#### *Transgenic cotton varieties*

CSIRO has a far smaller share of the transgenic cotton seed market than the conventional cotton seed market; holding around 50 per cent of the former compared to 80 per cent of the total cotton seed market (CSIRO data).

Deltapine's transgenic cottons hold the rest of the transgenic market. In the absence of CSIRO's breeding program, transgenic cotton varieties would have still been available in Australia, however they would not have had the additional benefits from being bred for Australian conditions. Thus the benefits of CSIRO's transgenic research in terms of lower costs and increased yields extend only to their conventional traits, such as Verticillium resistance, not the benefits of the transgenics.

### *Expansion of the cotton industry*

If the cotton industry had continued using Deltapine 90 as its staple variety, it is unlikely that some of the newer areas would have commenced cotton growing. In the absence of cotton breeds with resistance to Australian pests and diseases, cotton growing in these areas would not be viable.

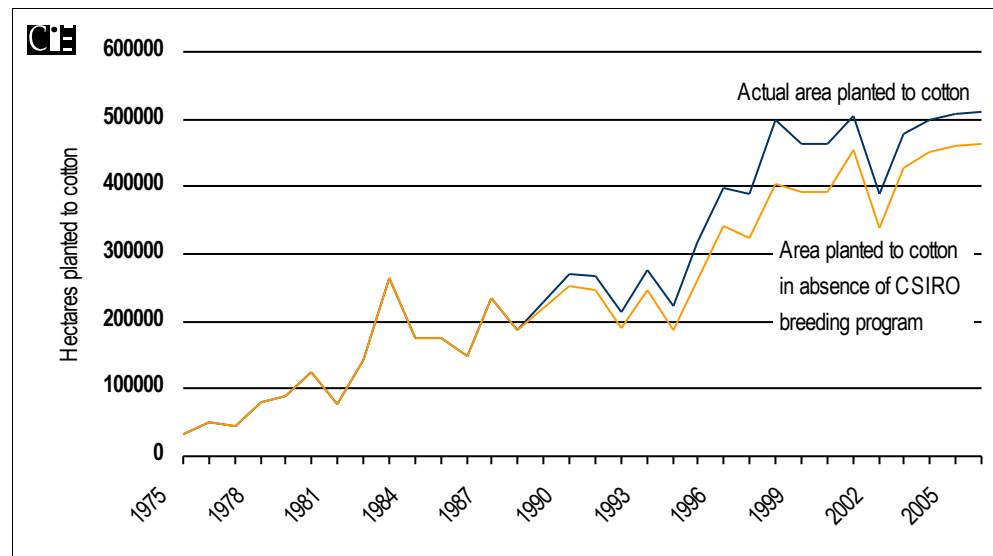
The Darling Downs is a good example of this. The area east of Dalby has expanded significantly due to earliness and increased disease resistance in cotton varieties developed by CSIRO. In the absence of these varieties, the eastern Darling Downs would not be a viable cotton growing area. The area of cotton planted in the Darling Downs averaged around 10 000 hectares during the eighties, after which the region boomed. Twenty four thousand hectares were planted in 1989 and 37 000 hectares were planted in 1990 (Australian Cotton Grower, 1989-2002). John Marshall from Cotton Seed Distributors estimates that CSIRO's breeding program is responsible for 50 percent of the increase in irrigated area and 75 per cent of the increase in the dryland area planted.

The expansion of cotton growing into the upper Namoi region is also due to the greater disease resistance of CSIRO varieties (Rob Eveleigh, Cotton Seed Distributors, personal communication.) This area, around Gunnedah, represented about 1000 hectares of cotton in 1990 and expanded rapidly, peaking at 40 000 hectares planted in the 1998-99 season.

Recently, cotton growing has become a significant industry in Hillston, central New South Wales, again due to earliness, yield, pest and disease resistance of CSIRO varieties.

These estimates of the contribution of the CSIRO breeding program to the cotton industry suggest that just over thirty per cent of the expansion in the area of cotton planted between 1983 and 2001 is due to CSIRO breeding; or twelve per cent of the total cotton growing area. Chart 3.4 shows the actual expansion of cotton growing areas since the 1970s, and the expansion estimated to have occurred in the absence of the CSIRO breeding program.

### 3.4 Growth of area planted to cotton due to CSIRO research



Data source: CSIRO and CSD estimates

If these areas had not decided to grow cotton, we can assume that the land would have been used for alternative agriculture (irrigated or dryland). This return is not as high as the return to cotton. The average return to agricultural land over the period 1994–2000 was \$281 per hectare (ABS 1997, 2000). The expansion of the cotton industry only provides benefits to the extent that the net returns to cotton are greater than the net returns to other forms of agriculture.

#### *Flow on effects*

The benefits of the cotton industry are widespread in the areas discussed. Not only does cotton farming provide income for growers, but it also creates jobs from service, retail, ginning, transporting and so forth. Assessments of the contribution of an industry to the economic activity of a regional area will usually make an assessment of the flow on effects of the industry – this is known as the multiplier.

The multiplier is difficult to measure. A study on the cotton industry in the MacIntyre Valley catchment by Powell, Chalmers and Fisher (1993) provided estimates of regional multipliers for the cotton industry in this area. These can be used to estimate the flow on effects from the expansion of the cotton industry.

These multipliers cannot be applied to total cotton production, as in the absence of cotton, other farming activities would have taken place. For this study, regional multipliers were applied to the returns to cotton in excess of the returns to alternative agriculture.

The primary analysis detailed in this report does not include the multiplier effects. These multipliers are very uncertain estimates of the flow on effects of CSIRO's cotton breeding research, because:

- these multipliers were estimates for the 1991–1992 season;
- they are regional multipliers, while this analysis measures the benefit to the whole of Australia of CSIRO's cotton research; and
- they specifically measured the economic impact of the Macintyre Valley catchment area, which is very dependent on cotton income. Other areas may show a much lower dependence.

The benefits of the flow on effects of the cotton industry expansion triggered by CSIRO research are not measured in the primary analysis, but are included in the sensitivity analysis. The multiplier effects are shown in table 3.5. For example, the irrigated cotton multiplier is 0.4890. This means that for every \$1000 revenue generated by the cotton industry, an additional \$489 of economic activity is generated.

### 3.5 Flow on effects from the expansion of the cotton industry

<i>Output</i>	<i>Initial effect</i>	<i>Production induced</i>	<i>Consumption induced</i>	<i>Total flow-on</i>
Irrigated cotton	1	0.3684	0.1207	0.4890
Dryland cotton	1	0.4448	0.1166	0.5614

Source: Powell et al, 1993

### *Licence fees for CSIRO seed sold overseas*

In recent years, CSIRO has sold some of its Australian-developed varieties overseas, in association with Cotton Seed International and Bayer. These varieties, marketed as FiberMax Cotton, include both transgenics and conventional varieties. FiberMax is gaining an increasing share of the US cotton seed market, achieving 11 per cent of the market in 2002, a 100 per cent increase from its 2001 market share. Royalties from 1997–98 to 2001–02 were \$1.099 million, which was shared equally between CSIRO and CSD (Pat Walsh, personal communication, 2002). These returns to CSIRO offset some of the costs of future research and reduce its reliance on other sources of funding.

The royalty figures for CSIRO cotton sold to Australian growers are not considered as this amounts to a transfer from growers to CSIRO rather than a net benefit to Australia.

## *Management software*

### *SIRATAC*

CSIRO was responsible for introducing integrated pest management (IPM) to farmers through SIRATAC. It has been credited with saving two sprays for *Helicoverpa* per year worth \$26 per hectare each (\$20 in 1990 dollars), on average, as more efficient application of sprays reduced the need for insecticides. The SIRATAC fee was \$13, or \$10 in 1990 dollars (Johnston et al, 1992).

Some criticisms were made of the assumptions made in the 1992 benefit cost analysis, namely that the adoption rate of 50 per cent was too high and extending the benefits until 2010 was excessive (Hearn and Bange, 2002). The present analysis uses a 50 per cent adoption rate to allow for SIRATAC management techniques 'leaking over the fence' that is, non-users of SIRATAC receiving its benefits through picking up SIRATAC advice from other farmers. With the benefit of hindsight, the extension of benefits until 2010 was definitely excessive. The present analysis assumes that 50 per cent of cotton area used SIRATAC directly or indirectly from 1986 – 1989, when SIRATAC Ltd was closed; and that 25 per cent of cotton area was managed by SIRATAC, from 1990 to 1994, representing loyal SIRATAC users and former users who still applied the knowledge gained from SIRATAC, until the release of entomoLOGIC in 1994.

SIRATAC was developed at a time when personal computers were rare, and was intended as an advisory service supported by software rather than a commercially available program for use by cotton farmers. If SIRATAC had not been developed, it is unlikely that a commercial software house would have developed equivalent software.

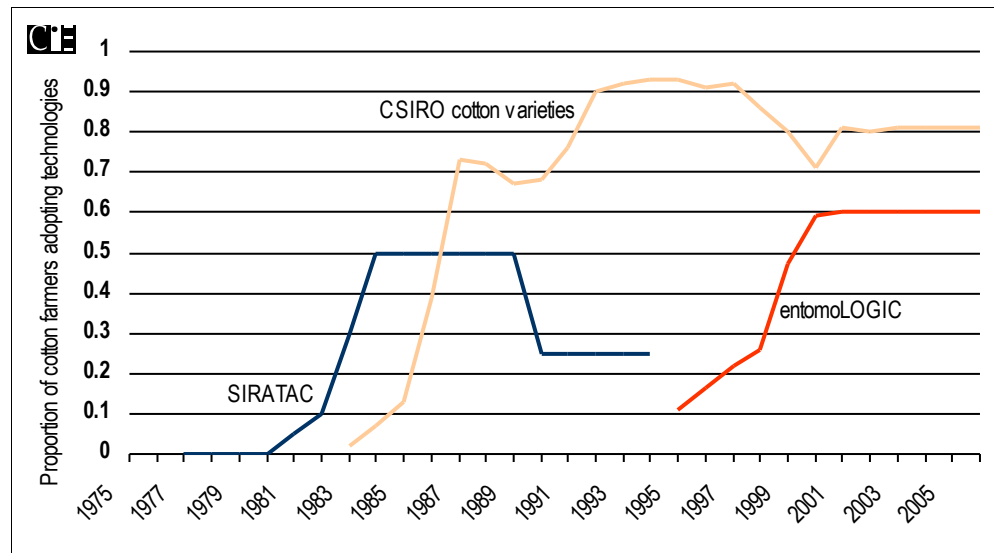
### *EntomoLOGIC*

SIRATAC's successors, entomoLOGIC and CottonLOGIC, are credited with saving, on average, 1.3 sprays per year (Deutscher et al, 2002). In the absence of entomoLOGIC, it can be readily assumed that pest management software would not have been developed. However, entomoLOGIC and CottonLOGIC have been popular for their record keeping functions as well as their pest management functions. Twenty one per cent of farmers and 24 per cent of advisers use CottonLOGIC for record keeping only, not pest management, compared to 25 per cent of farmers and 46 per cent of advisers who use it for both purposes (Hearn and Bange, 2002).

Programs exist that can perform farm record keeping similar to the functions of CottonLOGIC , such as Farm Office, and PAM QA Plus, and its equivalent PocketPAM for the PalmPilot. These programs are developed by private software houses and can be expensive, however the only alternative is keeping records manually or in software not specifically designed for cotton farming, which is very time consuming. EntomoLOGIC and CottonLOGIC for Palm provide cotton management decision support and are unique. We will assume that if entomoLOGIC and CottonLOGIC had not been released, half of the growers and advisers who used the programs would have invested an average of \$700 on desktop software to perform record keeping functions, and the reduction in sprays from entomoLOGIC would not have been realised (Michael Bange, personal communication).

CottonLOGIC for the PalmPilot saves growers and consultants time compared to the desktop CottonLOGIC. Some commercial software firms have developed Palm software to accompany their cotton farm management software, which must be purchased separately. We will assume that in the absence of CottonLOGIC for the Palm, half of the growers and all of the consultants who purchase alternative desktop software will also purchase Palm farm management software. The cost of such software is assumed to be \$300, which is the price of PocketPAM for the PalmPilot (Fairport, 2002).

3.6 Adoption profiles of CSIRO cotton technologies



Data source: CSIRO

In addition to saving growers 1.3 sprays per year, CottonLOGIC saves growers up to \$1000 each in software expenses, providing software for free that they would otherwise need to purchase.

The CSIRO cotton research has outcomes spanning over twenty years. Adoption profiles of these outcomes are shown in chart 3.6.

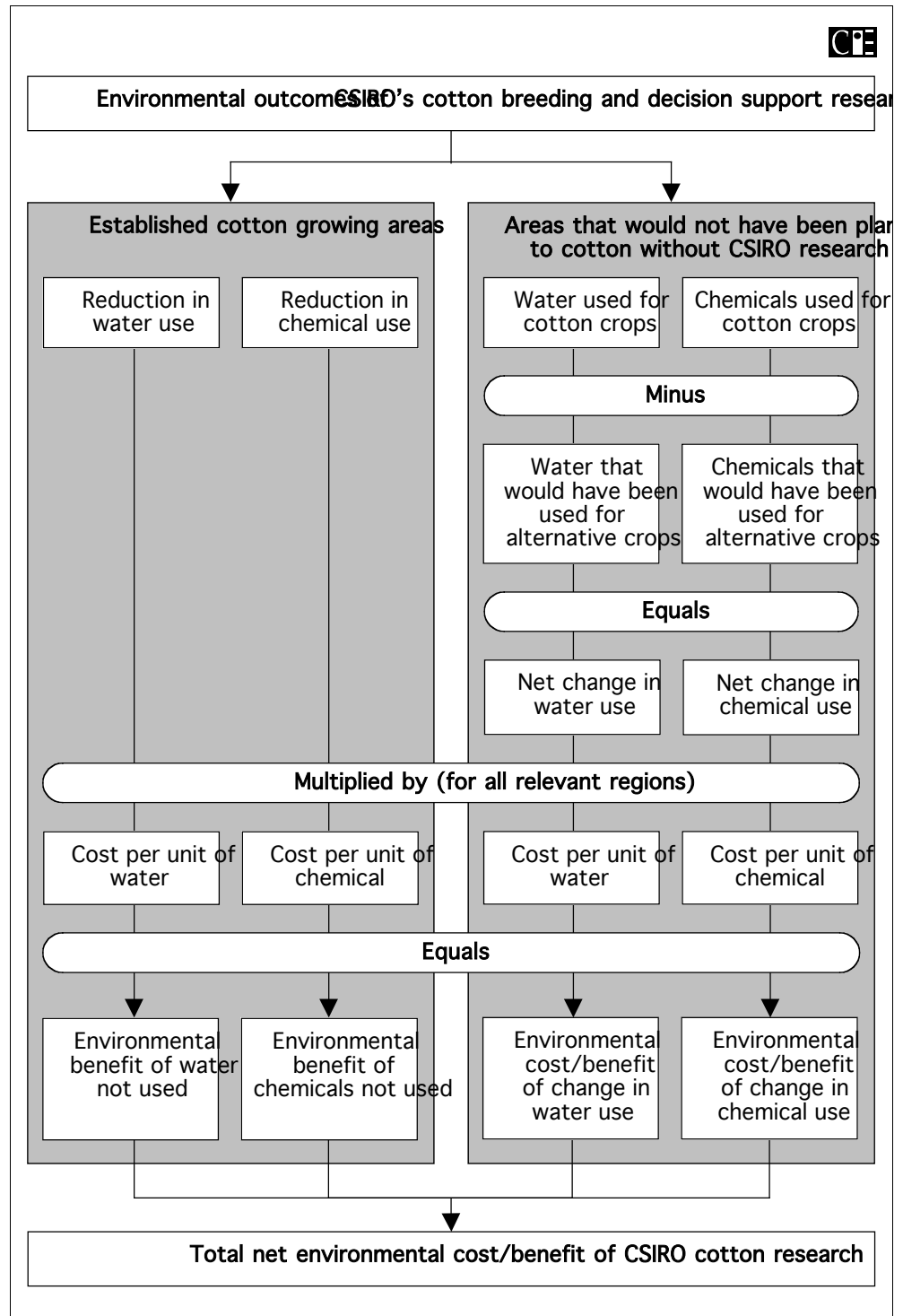
## **Environmental effects – could potentially provide both costs and benefits**

While the cotton industry has economic benefits for Australia, some concerns exist about its cost to the environment. Most of these concerns relate to water used for irrigation and chemical use. CSIRO's research program has aimed to lower environmental costs associated with cotton growing by reducing the use of chemical sprays and irrigation water. However, it has also stimulated an increase in the area planted to cotton, with a potential expansion in environmental problems arising from cotton growing.

It is important to differentiate between the environmental effects of CSIRO research on cotton growing that would have existed in the absence of that research, and the environmental effects of the expansion in the cotton industry. Chart 3.7 provides a theoretical framework for the assessment of environmental outcomes from CSIRO cotton breeding and management tools research.

A thorough analysis of the potential environmental costs and benefits is beyond the scope of this Study. Thus the net benefits from CSIRO's cotton breeding and management systems research reported here should be viewed as purely economic benefits.

3.7 Environmental outcomes of research



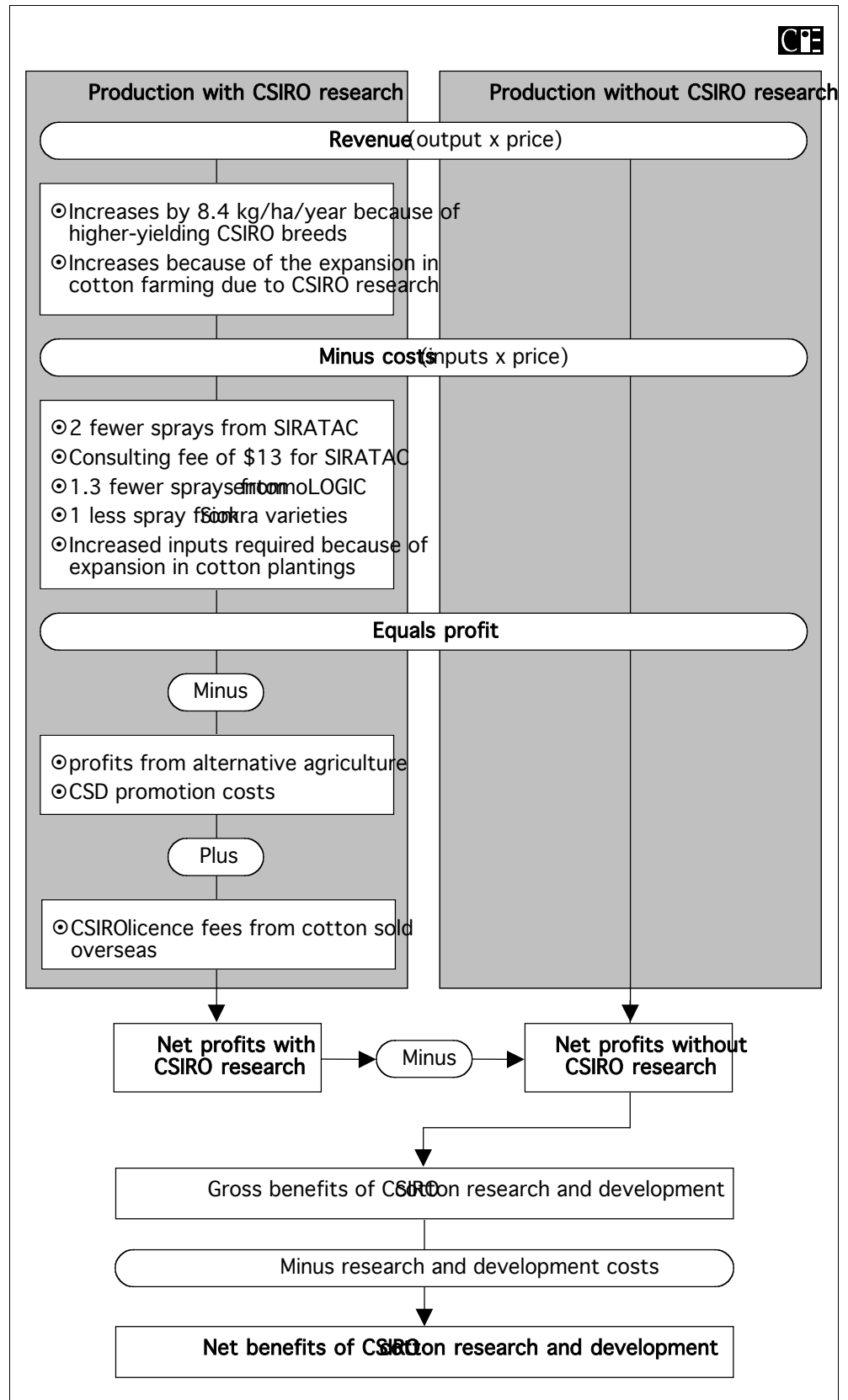
## Quantifying the benefits

The benefits of CSIRO's research on breeding and decision support tools, explained earlier in the chapter, were quantified by estimating the changes that the outputs caused in the production process. The analysis measures the impact of CSIRO research on:

- the quantity of cotton produced;
- the costs incurred in producing cotton;
- the opportunity cost of producing cotton;
- flow on or multiplier effects from producing cotton; and
- royalties from CSIRO cotton varieties sold overseas.

Chart 3.8 demonstrates the method used to calculate the net benefits of the research, while table 3.9 summarises the assumptions made.

3.8 CSIRO research and its effect on the production process



### 3.9 Assumptions used in the analysis

<i>Assumption</i>	<i>Unit</i>	<i>Value</i>
<b>SIRATAC</b>		
Sprays saved	no./ha	2
Cost of sprays saved	\$/ha each	26
SIRATAC fee	\$/ha	10
Peak adoption rate	%	50
Implementation cost	\$/ha	13
<b>entomoLOGIC</b>		
Sprays saved	no./ha	1.3
Cost of sprays saved	\$/ha each	50
Farmer adoption rate	%	25
Consultant adoption rate	%	46
Cost of alternative desktop software	\$	700
Cost of alternative Palm software	\$	300
Adoption rate of alternative desktop software if entomoLOGIC not released	%	50
Consultant adoption rate of alternative Palm software if entomoLOGIC not released	%	100
Farmer adoption rate of alternative Palm software if entomoLOGIC not released	%	50
<b>Cotton breeding</b>		
<i>Yield increase</i>		
Annual increase in yield from CSIRO varieties	kg/ha/yr	23
Annual increase in yield from Deltapine 90	kg/ha/yr	14.6
<i>Reduction in insecticide sprays</i>		
Sprays saved	no./ha	1
Cost of sprays saved	\$/ha	50
<i>Expansion in area planted to cotton in 2002 attributable to CSIRO research</i>		
Namoi area	ha	14 000
Darling Downs area	ha	19 800
Hillston area	ha	15 000
<b>Data sources</b>		
Cotton prices are drawn from ABARE data and projections:		
<ul style="list-style-type: none"> <li>▪ 1973–2001: average gross unit value used</li> <li>▪ 2002–2006: ABARE projections of cotton export unit value used</li> </ul>		

## Timeframe

The Cotton Research Unit has been in existence since 1973. The net benefits are measured from 1973 onwards and projected forward until 2006 because:

- it is likely that CottonLOGIC will be replaced by new cotton decision support software in 2006; which, due to its free distribution, will be adopted very quickly; and

- most popular CSIRO cotton varieties currently available are likely to be obsolete by 2006. This is particularly so because of the release of Bollgard II.

The benefits and costs of the SIRATAC, entomoLOGIC and the breeding program have been analysed separately and concurrently. It is important to state that CSIRO's breeding research has produced benefits significantly greater than its management software research, although the latter provides a healthy return.

## SIRATAC

The results of this benefit cost analysis produce a slightly different result than the previous analysis conducted by Johnson et al in 1992; as some of the assumptions have been altered with the benefit of hindsight. Table 3.10 shows the results of the benefit cost analysis.

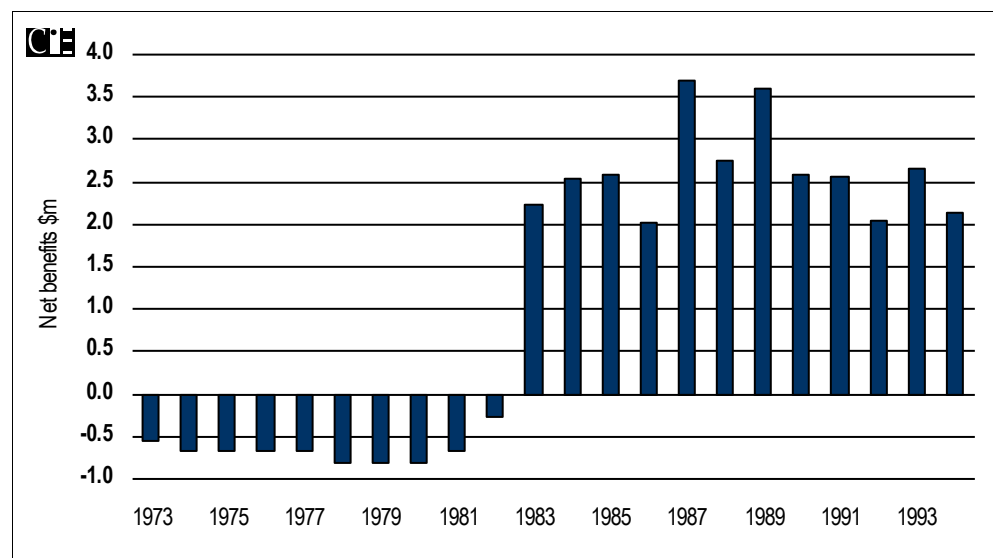
### 3.10 SIRATAC benefits

<i>Discount rate</i>	<i>Present value of project costs</i>	<i>Present value of project benefits</i>	<i>Present value of net benefits</i>	<i>Benefit cost ratio</i>	<i>Internal rate of return</i>
%	\$m	\$m	\$m		%
0	13.0	37.8	24.8	2.9	15.5
5	33.1	68.8	35.8	2.1	
10	84.8	125.0	40.2	1.5	

<sup>a</sup> Benefits are measured in 2002 dollars

Source: CIE calculations

### 3.11 Net benefit flow from SIRATAC



<sup>a</sup> Benefits are measured in 2002 dollars

Source: CIE calculations

The benefits of SIRATAC have, in this analysis, been found to be slightly less than those found in the 1992 analysis, but SIRATAC still shows a positive return. With a five percent discount rate, the program provided net benefits of \$35.8 million and a benefit cost ratio of 2.1. Chart 3.11 shows the net benefit flow from SIRATAC.

*entomoLOGIC*

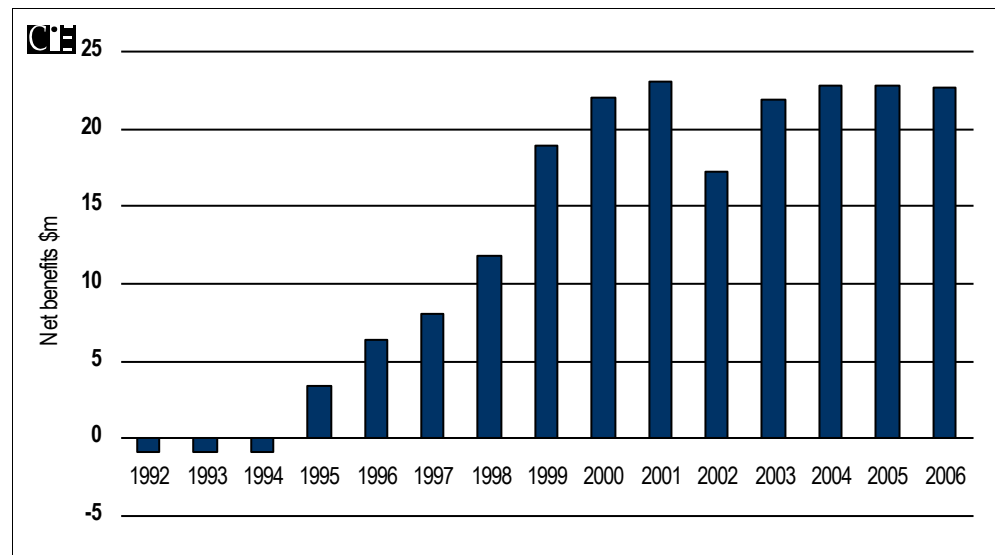
EntomoLOGIC has produced a healthy return on investment. With a five percent discount rate, the program provides a net present value of \$201.7 million and a benefit cost ratio of 18.5. Table 3.12 shows the results of the analysis and chart 3.13 shows the net benefit flows from entomoLOGIC.

**3.12 entomoLOGIC benefits**

<i>Discount rate</i>	<i>Present value of project costs</i>	<i>Present value of project benefits</i>	<i>Present value of net benefits</i>	<i>Benefit cost ratio</i>	<i>Internal rate of return</i>
%	\$m	\$m	\$m		%
0	8.9	207.5	198.6	23.3	103
5	11.5	213.2	201.7	18.5	
10	15.1	223.2	208.2	14.8	

<sup>a</sup> Benefits are measured in 2002 dollars  
 Source: CIE calculations

**3.13 Net benefit flow from entomoLOGIC**



<sup>a</sup> Benefits are measured in 2002 dollars  
 Source: CIE calculations

## Breeding program

CSIRO's breeding program has provided the highest level of net benefits and the highest return on investment of the programs assessed in this report, with a benefit cost ratio of 85.8 and a net present value of \$4.9 billion. The size of the benefits of the breeding program is due to the length of time the program has been running successfully, the high adoption rate and the improvement that CSIRO breeds have shown over their American counterparts. Table 3.14 shows the results of the analysis and chart 3.15 shows the net benefit flows from the breeding program.

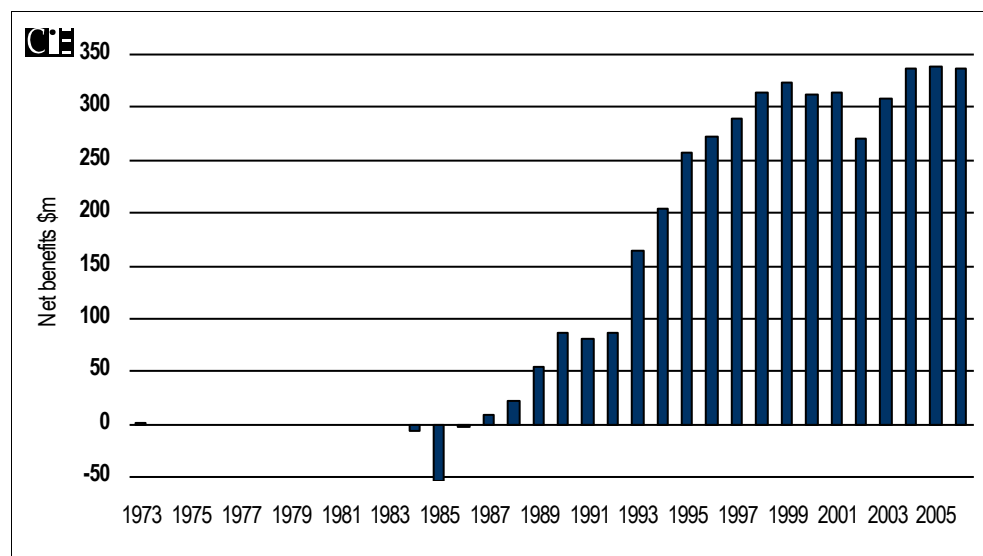
### 3.14 Breeding program benefits

Discount rate	Present value of project costs	Present value of project benefits	Present value of net benefits	Benefit cost ratio	Internal rate of return
%	\$m	\$m	\$m		%
0	26.0	4 335.2	4 309.2	166.6	34
5	58.3	5 007.4	4 949.1	85.8	
10	152.7	5 978.2	5 825.5	39.1	

<sup>a</sup> Benefits are measured in 2002 dollars

Source: CIE calculations

### 3.15 Net benefit flow from breeding program



<sup>a</sup> Benefits are measured in 2002 dollars

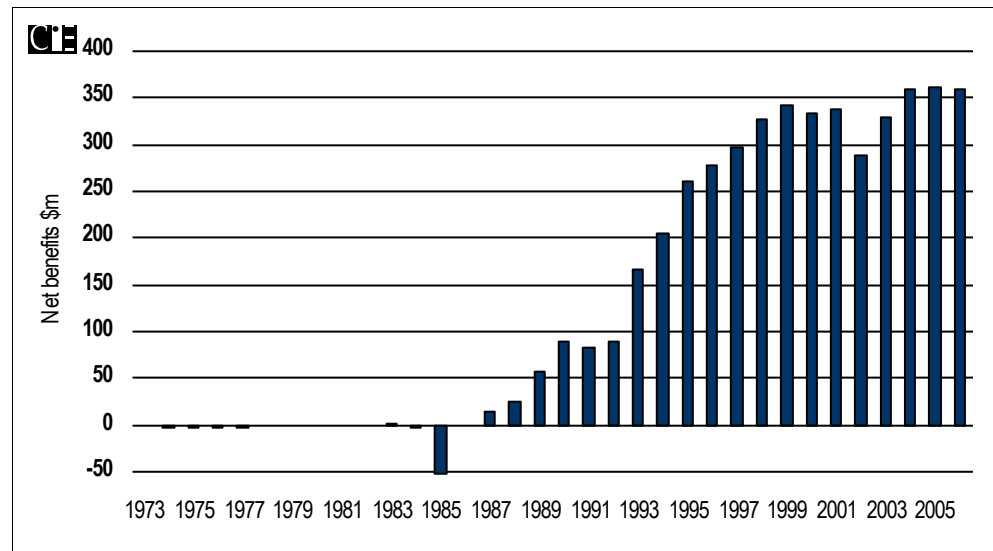
Source: CIE calculations

Returns on the cotton research did not outweigh costs until 1987 – the year when the yield of CSIRO cotton breeds exceeded those of Deltapine breeds; hence the negative returns up to that year. The significant drop in net benefits in 1985 is from a high proportion of growers switching to CSIRO breeds which, at the time, yielded slightly less than Deltapine 90. This drop is particularly noticeable due to the high cotton price at the time.

### Benefits from both research programs

Overall, CSIRO's cotton breeding and decision support research has been a resounding success. Chart 3.16 shows the net benefit flows from the research programs. Clearly the research outlays have been minimal compared to the benefits.

3.16 Total net benefit flow from CSIRO research



<sup>a</sup> Benefits are measured in 2002 dollars

Data source: CIE calculations

The net present value, benefit cost ratio and internal rate of return are shown in table 3.17. At a five percent discount rate, the research program showed a net present value of over \$5 billion and a benefit cost ratio of 51. It is clear from these results that CSIRO research into cotton breeding and decision support has been a success, with very high benefit cost ratios at various discount rates and an internal rate of return of 31 percent. These values do not include any possible environmental benefits or disbenefits.

3.17 Success of CSIRO's cotton breeding and decision support research

Discount rate	Present value of project costs	Present value of project benefits	Net present value	Benefit cost ratio	Internal rate of return
%	\$m	\$m	\$m		%
0	47.9	4 580.5	4 532.6	95.6	31
5	103.0	5 289.5	5 186.5	51.4	
10	252.6	6 326.4	6 073.9	25.0	

Source: CIE calculations

### *Sensitivity analysis*

To test the robustness of these results to uncertainty in the measurement of key parameters, we conduct a sensitivity analysis around the assumptions made. This gives an idea of the range of outcomes that the actual values should fall within. The sensitivity analysis tests both upper and lower likely bounds on key parameters.

- Cotton varieties in the absence of CSIRO's breeding program yield between 10 to 20 percent more than Deltapine 16, with an average of 13 per cent.
- Returns to alternative agriculture are varied from \$350/ha to \$200/ha with an average of \$281/ha.
- In the base case, it is assumed that on average, 30 per cent of the expansion in cotton area since the mid 1970s was as a result of CSIRO research. This is varied from 15 per cent to 45 per cent.

The program AtRisk was used to conduct the sensitivity analysis. It allows several alternative assumptions to be tested at the same time and provides a 95 percent confidence interval for the benefit measures to be tested. Table 3.18 shows the results of the sensitivity analysis.

#### 3.18 Sensitivity analysis

	<i>Mean</i>	<i>Lower bound of confidence interval (2.5%)</i>	<i>Upper bound of confidence interval (97.5%)</i>
Net present value	5 240.1	4 576.1	6 502.3
Benefit cost ratio	53.8	45.4	64.1

<sup>a</sup> A 5 percent discount rate was used

Source: CIE calculations

The results of the sensitivity analysis show that, based on these assumptions, we can say with 95 percent certainty that the net present value of the breeding and decision support research falls between \$4.5 billion and \$6.5 billion, and that the benefit cost ratio for the research falls between 45 and 64. Even with the alternative assumptions, the CSIRO research has still provided enormous returns on its research investment. It is clear that CSIRO's research efforts in breeding and decision support have had a highly beneficial effect on the Australian cotton industry, and are a major factor in its success.

### *Flow on effects*

The flow on, or multiplier, effect improves the already impressive results of this benefit cost analysis. The multiplier effect for the increased area

planted to cotton due to CSIRO breeding and decision support research, was calculated by taking the *increase* in value added from farming cotton instead of alternative agriculture, and multiplying this by the multiplier effects show in table 3.5.

The present, discounted value of the multiplier effect was measured at 0, 5 and 10 percent discount rates. As table 3.19 shows, taking into account multiplier effects increases the total benefits of the research considerably. It should be noted, however, that the multipliers used here are regional multipliers which are generally higher than national multipliers.

### 3.19 The multiplier effect on net benefits of research

<i>Discount rate</i>	<i>Multiplier effect</i>	<i>Present value of project costs</i>	<i>Present value of project benefits</i>	<i>Net present value</i>	<i>Benefit cost ratio</i>
%	\$m	\$m	\$m	\$m	
0	794.1	47.9	5 374.6	5 326.7	112.1
5	1 099.0	103.0	6 388.5	6 285.5	62.0
10	1 558.8	252.6	7 885.2	7 632.7	31.2

<sup>a</sup> All values are in 2002 dollars

Source: CIE calculations

It is also important to note that the results from this analysis represent only the economic net benefits from CSIRO's cotton R&D, as the scope of the study has not allowed for possible environmental impacts, which on the evidence available could be either positive or negative, to be taken into account.

## Conclusion

CSIRO's cotton research has provided significant economic benefits to society. It has allowed Australia to produce cotton of high quality, facilitated the expansion of the industry and provided jobs for rural communities. The final economic benefits to the community are vastly in excess of the original research funds invested.

## *References*

- ABARE (Australian Bureau of Agricultural and Resource Economics) 2002, *Australian Commodities*, Vol. 9, No. 1, March quarter 2002, ABARE, Canberra.
- — 2001, *Australian Farm Surveys Report 2001: Financial Performance of Australian Farms 1998-99 to 2000-01*, ABARE, Canberra.
- — 2001, *Australian Commodity Statistics 2001*, ABARE, Canberra
- ABS (Australian Bureau of Statistics) 2002, *Average Weekly Earnings, States and Australia*, Cat. no. 6302.0, ABS, May, Canberra.
- — 2001, *Agriculture, 1999-2000* Cat. No. 7113.0, ABS, Canberra.
- — 1998, *Agriculture, 1996-1997* Cat. No. 7113.0, ABS, Canberra.
- — 1989 - 2002, *The Australian Cottongrower Cotton Yearbook*, The Australian Cottongrower, Towoomba
- Colwell, J.D. 1977, *National Soil Fertility Project, Volume 1: Objectives and Procedures*, CSIRO Division of Soils, Canberra.
- Constable, G.A., 2000 *The components of high yields in Australia*, CSIRO Cotton Research Unit, ICAC Recorder, 18(3), pp3-8
- Constable, G.A., Reid, P.E. and Thomson, N.J. 2000, *Approaches utilised in breeding and development of cotton cultivars in Australia*,
- Constable, G.A., Reid, P.E. and Stiller, W.N. 2000, *Australian cotton varieties*, CSIRO, Cotton Outlook, Australia 2000 Special Edition, pp 58-60
- Deutscher, S., Bange, M., Plummer, C., and Larsen, D 2002, *CottonLOGIC: Good results from field evaluation*, CSIRO, Canberra, accessed 31-10-2002. <http://www.cotton.pi.csiro.au/CottonLogic/newspro/viewnews.cgi?newsid1024967934,97524>,
- Fairport Pricing Guide, accessed 21-10-2002 <http://www.fairport.com.au/site/pricing.asp>
- Hearn, A.B., and Bange, M.P. 2002, 'SIRATAC and CottonLOGIC: persevering with DSSs in the Australian cotton industry', *Agricultural Systems*, vol 74, pp27-56
- Horizon Agriculture 2002, *GrazFeed Pricing: Nutritional Management System for Grazing Animals*, <http://www.hzn.com.au/gfdprice.htm>, Accessed 14 October 2002.
- Johnston, B., Healy, T., I'ons, J., and McGregor, M. 1992 *Rural Research – the pay-off: The returns from research undertaken by the CSIRO Institute of Plant Production and Processing*, CSIRO and ABARE, Canberra
- MLA (Meat & Livestock Australia) 2002, *Sub-program 3 – (Prograze) Report Outline*, [http://www.mla.com.au/uploads/templates/otherpdf/SGS\\_Sub\\_Program\\_3](http://www.mla.com.au/uploads/templates/otherpdf/SGS_Sub_Program_3), Accessed 18 October 2002.

REFERENCES

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NLWRA (National Land and Water Resources Audit) 2000, *Australian Water Resources Assessment 2000*, Natural Heritage Trust, Canberra

NSW Agriculture 1999, *Australian Prime Hard Wheat in South-Eastern Australia: a growers' guide*, NSW Agriculture.

Powell, R., Chalmers, L., and Fischer, S. 1993, *The Economic Impact of the Cotton Industry in the Macintyre Valley*, Centre for Agricultural and Resource Economics, University of New England