



Benefit–cost analysis of RIRDC’s emerging industries program

**A report for the
Rural Industries Research and Development Corporation
by Centre for International Economics**

**June 1998
RIRDC Publication No ??
RIRDC Project No ??**

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ISBN (*RIRDC will allocate this number*)
ISSN 1440-6845

“Title of your report”
Project No:
Publication No. (RIRDC will allocate)

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Foreword

This report summarises the findings of a scoping study, which provided an overview of the completed projects in the emerging industry portfolio. A preliminary judgment was made about the impact of the various projects, and the potential to assess the impact using formal cost–benefit analysis. A number of projects identified in the overview are evaluated in this report.

The overview applied the stage 1 analysis from the *Guidelines for Economic Evaluation of R&D* developed for Rural Industries and Research Development Corporation (RIRDC) and Grain Research Development Corporation (GRDC). It highlighted the need for a systematic recording of project attributes and known outcomes. Making portfolio histories easily available to project managers can improve future project selection, preventing duplication and building on existing knowledge from successful projects.

Conducting export evaluations is an essential component of building historical knowledge. The stage 2 approach developed in the *Guidelines for Economic Evaluation of R&D* is adopted for the evaluations included in this report.

The internal rates of return on projects evaluated in this report range from 3 per cent for a series of breeding projects on cashews, 14 per cent on a set of projects aimed at identifying and developing new flower varieties, 23 per cent on a series of breeding projects on tea tree for oil, to 59 per cent on a cost reduction in farm tree establishment and 61 per cent on increasing yields in boronia oil production.

Peter Core

Managing Director

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Executive summary

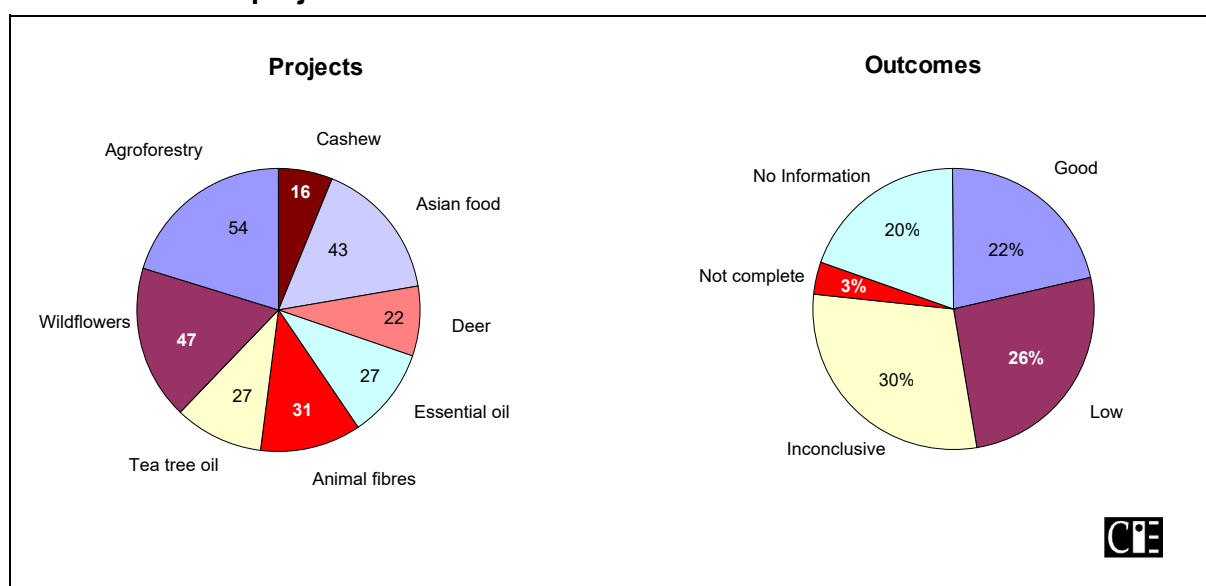
Portfolio outcomes

A cost–benefit appraisal of completed projects in the emerging industries portfolio has been conducted along the lines of the approach in *Guidelines for Economic Evaluation of R&D*. The first stage of this approach requires defining the project and related projects, describing the output of the project, and assessing the best method for estimating the impact of the research. This assessment takes into account market conditions and the welfare implications in terms of who is likely to be affected.

The industries represented in the emerging industries’ portfolio, the number of completed projects in each and the results of a very preliminary assessment are summarised in chart 1. Of the 267 completed projects identified, 22 per cent were judged to have good outcomes, although some of these would be difficult to evaluate formally. Twenty-five per cent of the projects were judged to have relatively low returns, but only 3 per cent were considered to have not produced any outcomes. Of the remaining 50 per cent, 30 per cent were inconclusive, requiring further work to ensure an outcome, and there was insufficient information on 20 per cent to make any judgment.

- In the cashew program, there are several pest control projects that are likely to have positive spillovers for other industries. However, most projects will not provide a high return to the R&D because the industry is still a long way from being profitable. The long lag between the project outlay and payoff results in very low benefit–cost estimates (chapter 4).
- The majority of the projects in the Asian food program focus on identifying market opportunities. The value of providing information is difficult to assess, but has a potentially high payoff if influential.

Chart 1 Portfolio projects and outcomes



Data source: RIRDC (various).

- The deer program has focused on developing the domestic market for venison, which is yet to have any major impact. It is likely that information on the production system has assisted industry, raising the average quality of production. Animal health projects appear to provide modest returns.
- Boronia dominates the essential oil industry. Projects on boronia appear to command modest to good returns (chapter 7). Existing industry members capture most of the benefits. For essential oils generally, pest control projects appear to have the highest returns, and potential for substantial benefits to other industries.
- A set of projects aimed at providing the tools to improving stock selection appears to have been of substantial benefit to the cashmere industry in the rare and natural animal fibre program. Projects on improving the mohair breeding stock increased adoption of higher yielding breeds. Of the animal health and processing projects only one in each category appears to provide good returns on the investment.
- A good return has been generated by the breeding projects in the tea tree oil program (chapter 6). It is likely that the benefits are captured largely by existing producers. Projects examining the properties of the oil and looking for new products are high risk, but potentially high return. No major benefits are yet to be identified as flowing from these projects.
- In the wildflower and native plant program, two of the six projects on pest and weed control appear to have good returns. The set of projects on new varieties is seen to pay off only if a substantial proportion of export market share would be lost in the absence of these new varieties (chapter 2). Projects focusing on quality improvement are thought to have good returns in developing market share and raising returns.
- Most of the projects in the agroforestry program are aimed at providing information to stimulate farm forestry activity. The impact of the RIRDC projects, as distinct from other farm forestry projects, is difficult to assess. The returns to an early cost reduction project evaluated in this report (chapter 3) are found to be substantial.

Lessons from the overview and the assessments in this report

Projects in the early stage of development of an industry are inherently difficult to assess using quantitative methods where:

- the industry is currently not operating at a surplus and the project outcome alone is not sufficient to guarantee survival of the industry (for example, in cashews);
- the output of the project is information that improves the probability of new entrants succeeding (for example, in deer); or
- little is known about the long run demand and supply conditions and hence the impact on price (for example, in tea tree oil).

Projects in the first stage of product development — identification of a new product, new production process or new market — are generally more risky than projects in the second or third stages (chart 2). For these projects to be worthwhile they must have a higher ex ante

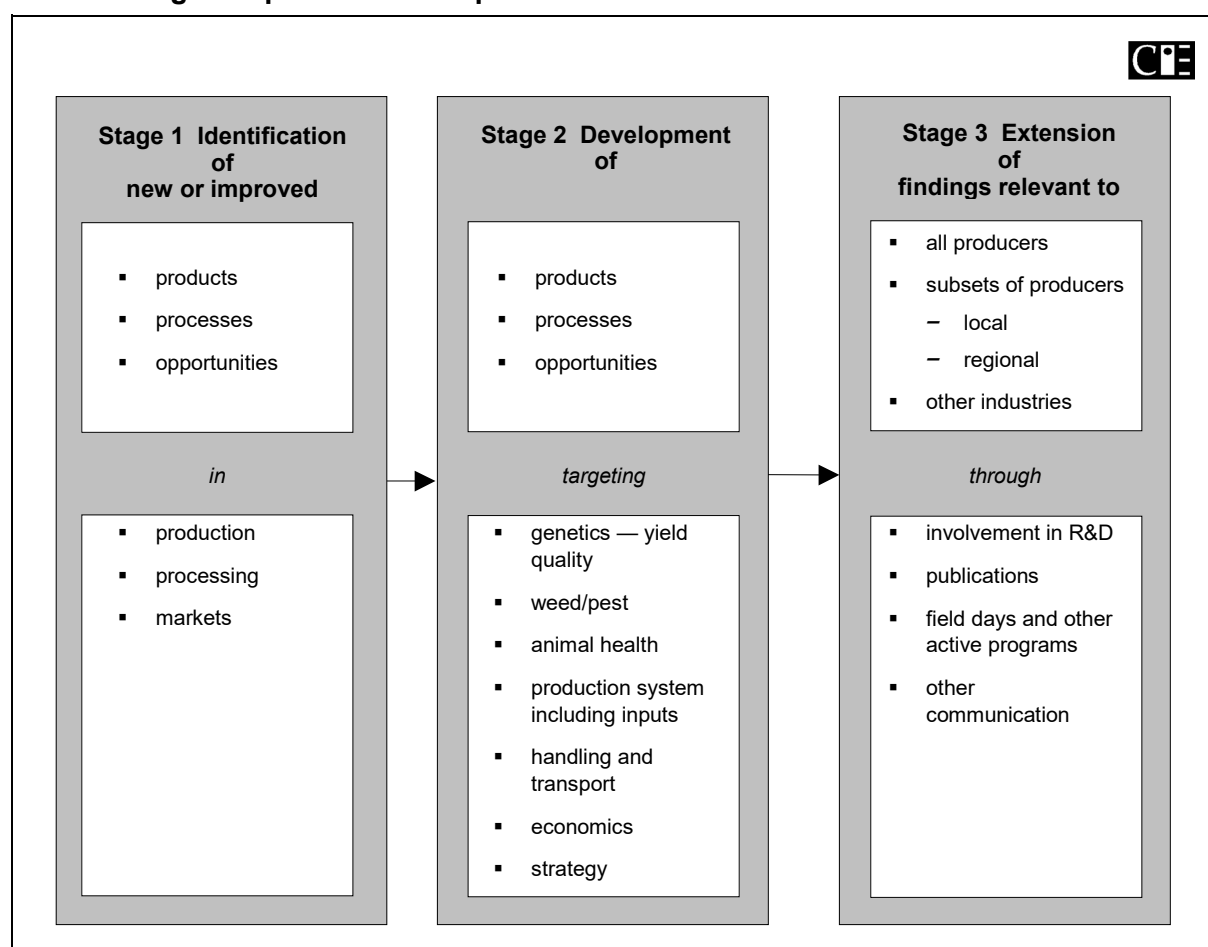
expected return. However, ex post some will by their nature fail to identify a product, process or market opportunity that moves to the development stage. This suggests that sets of projects

within portfolios should be evaluated to find the payoff to first stage projects. This approach is taken in evaluating a set of projects identifying new wildflowers in chapter 2.

Where projects are inputs into other projects, or a combination of projects is required to generate an outcome, it is also sensible to evaluate them together. This approach is taken in evaluating the cashew breeding (chapter 4) and tea tree breeding (chapter 6) programs.

Projects where the main benefits are spillovers — impacts outside the industry, on other industries or on the general public — are generally more difficult to evaluate. The private return can be estimated, but it is costly to quantify the impact on those outside the industry. As a result, estimates of net benefits from these projects will understate the true value. For this reason the net benefit of the agroforestry project evaluated in this report is probably understated.

Chart 2 **Stages of product development**



The welfare gains from R&D expenditure are lower when:

- there is a long lag between the initial expenditure and the impact (as in cashew breeding);
- development requires substantial public funding at the second and, particularly, third stages of product development (as appears to be the case for wildflowers); or
- a minority of private sector producers captures the benefits of the R&D (as appears to be the case in the boronia industry).

Assessing risk and reward

Research is a risky business. That there are some projects that did not produce ‘successful’ outcomes is to be expected. The ‘dry hole’ for the oil geologist is still most instructive: it says where not to drill next time. The key to a successful R&D portfolio is to assess the risks and returns from R&D programs and pitch spending at the desired level of risk–reward tradeoff. Assessing the risks and rewards for proposed projects requires posing some relevant questions.

- Do Australian producers have a source of comparative advantage — current knowledge, resource including skills, location — that can be utilised by the industry?
- Are there any parallel experiences in other industries that indicate the likelihood of success?
- Is there market failure in R&D — are producers too fragmented to organise cooperative R&D, is there potential for substantial public benefit, or spillovers to other industries?
- What is known about the long term potential for the industry — markets, world demand and world production?

1 Overview

This report presents an overview of a preliminary assessment of the outcomes of the emerging industries portfolio conducted as stage 1 of this project – *Benefit–Cost Analysis of RIRDC’s Emerging Industry Program Stage I*. It also presents a number of new benefit–cost evaluations.

Completed projects in the emerging industries portfolio

Over 250 completed projects in the emerging industries’ portfolio have been identified. The review of the portfolio highlighted the need for a consistent, structured recording system, as the details of some of the projects were held only in institutional memory. In the absence of a brief written history for each portfolio, it is not surprising that the review identified projects that were not known about by the current portfolio managers. Such a history does not require formal benefit–cost analysis for every project to develop a sense of the contribution of RIRDC to the industries and the broader community. However, classifying projects by the stage of product development (identification, development, extension), the target of the project (from market intelligence to weed control), and the geographical impact (generic, local, regional), assists in understanding the possible impact of the project on welfare.

In stage I of this project we attempted to classify the completed projects in the emerging industry portfolio using this system. Where possible a preliminary assessment was made of the likely impact on welfare, and a judgment made as to the ability to quantify this impact. Many of the projects in the portfolio are difficult to assess using a formal benefit–cost analysis as they are focused on the identification stage of the product development. The outcomes of these projects are usually building blocks for further research, which may be undertaken by RIRDC or other R&D organisations or by individual producers.

The first part of this overview reviews the programs in the portfolio and provides a brief preliminary assessment of the likely impact of each program. The second part summarises the outcomes of the evaluations, which are given in detail in the following chapters.

Overall assessment

Table 1.1 summarises the preliminary assessment of the outcomes for each of the programs. Overall, 22 per cent of the projects were judged by the program managers to have good outcomes, or to be leading to good outcomes in terms of reducing unit costs, or improving market performance of the projects in the portfolio. Twenty-six per cent were judged to have low returns, while 30 per cent could not be assessed as further research work would be required to yield value from the project. Only 3 per cent of projects were admitted to be clear failures in that they were not completed, or yielded no potentially useful outcome. There was insufficient information on 20 per cent of the projects to make any judgment.

The few benefit–cost estimates made generally have not found very high returns on the research. The estimates suggest internal rates of return in the 10 to 90 per cent range (table

Table 1.1 Summary of preliminary assessment of outcomes of completed projects

<i>Program</i>	<i>Number of projects</i>	<i>Good</i>	<i>Low</i>	<i>Inconclusive</i>	<i>Not completed</i>	<i>No information</i>
		%	%	%	%	%
Cashews	16	19	38	25	19	0
Asian Food	43	9	7	49	0	35
Deer	22	18	14	55	0	14
Essential oils	27	22	48	22	0	7
Rare and natural animal fibres	31	26	19	26	3	26
Tea tree oil	27	33	19	26	0	22
Wildflowers and native plants	47	26	34	15	0	26
Agroforestry	54	22	30	26	9	13

1.2) — but, in general, the high end estimates are based on optimistic assumptions, such as constant prices.

In general, the public benefits of research are more difficult to assess than those accruing to the private sector. The impact of the provision of information to a broad client base is more difficult to assess than the impact on a narrow client base — yet it also has greater potential for good.

The impression across the portfolio is that strategic planning has greatly improved over the last few years, improving project choice. There is a greater focus on the potential payoff of the project. This will not be reflected in this set of completed projects, some of which were initiated under ACRRR. However, a review of completed projects, in addition to forming a historical base, provides a number of lessons. It is not as much the numbers that matter, but how these lessons can help improve future program performance.

Cashews

Several evaluations of the cashew program are included in this report. The cashew industry in Australia is made up of two producers (the third has ceased operation), and currently yields

Table 1.2 Assessments from previous evaluations

<i>Project</i>	<i>IRR</i>	<i>BCR</i>	<i>NPV</i>	<i>At discount rate</i>
	%	%	\$m	%
Development of a viable peppermint oil industry in south eastern Australia (Fearn 1993)	54	11.3	2.30	10
Selection, breeding and field evaluation of Geraldton wax flowers (Fearn 1993)	12	1.3	0.12	10
The insect fauna of <i>Melaleuca alternifolia</i> (tea tree) with emphasis on three known pest species (Fearn 1993)	89	21.5	1.24	10
Development of a low cost method for the objective measurement of goat fibres (WADA 1996)	48	29	3.40	7
Effect of phenotype and genotype on post harvest quality of native Australian cut flowers (WADA 1996)	13	1.4	0.13	7
Summer/Autumn nutrition of deer in a Mediterranean environment: a comparison of tagasaste and lupin seed as supplementary feeds (WADA 1996)	na	2.1	0.10	7

are below those required for the industry to be profitable. Of the 16 projects, six were expected to give a low payoff, three had no outcome, four proved inconclusive or were inputs to following projects, and three appeared to have a payoff.

- Several projects on pest control have potentially good payoffs, with the work on termites being applicable in other areas. A small project on flying foxes (evaluated in chapter 5) was found to have a good return.
- The series of breeding projects (evaluated in chapter 4) are producing low returns despite a significant rise in yields because of the long lag between the initial research and the expected production.

The lessons for the program come from the potential for spillovers in pest control research, and the low possibility of making breeding programs pay when research has to start from scratch and Australia has no natural advantage in production.

Asian food

The Asian food portfolio can be split into processed Asian foods and Asian vegetables. Of the 43 completed projects identified in the Asian food portfolio, 20 of the 25 for which information was available have concentrated on identifying market opportunities and providing information on how to exploit these markets. The impact of these types of projects is difficult to assess — evaluation would require detailed surveys of producers and wholesalers on their access to and use of the information.

- Three related projects on leafy Asian vegetables combined market research with production research. Focused on the East Gippsland region, this set of projects would be interesting to evaluate, and it is expected that the payoff is good.
- There are a number of projects on production of processed food products for the Asian market — domestic and export. There is little information on these projects. An evaluation would be useful to assess the extent to which such projects contribute to broader community welfare.

The lessons from the summary are that the projects that are likely to have the greatest impact on welfare are also those that are by their nature the most difficult to evaluate. Information has considerable public good potential, but its value depends on its use. To develop strategies to ensure the value of the information is maximised requires some analysis of the efficacy of the current projects in achieving this end.

Deer

The deer program is dominated by the projects focusing on the development of a venison market — 8 out of the 22 projects are directly related to this and there are a number of ongoing projects in this area.

- Three projects related to velvet marketing appear to have produced a good outcome and have resulted in the establishment of a marketing scheme with benefits to producers.

- Of the four projects related to animal health and nutrition two have outcomes that could be assessed. One has been assessed as showing modest returns (benefit–cost ratio of 2:1, Wada 1996).
- An evaluation of the set of projects on venison market development is difficult at the current stage as the market is still in the early stages of development, and a number of the projects identified as required for market development are still under way. There is no sound indication of where a benefit–cost assessment would come out in this situation.

A number of publications have provided good information on production systems available to potential entrants to the industry. One of the big benefits to both those proposed entrants and those in the industry might be that some were deterred from entering the industry. Such an effect would be difficult to evaluate.

Essential oils

Twenty-seven projects were identified as completed in the program. A number have already been evaluated, and four more are evaluated in this report. The evaluations have found reasonable returns, although one of the estimates of the net benefit of the boronia projects (evaluated in chapter 7) is 61 per cent.

- There were 10 projects on developing new sources of essential oils. Of these only two appear to have commercial potential.
- Of the two pest control projects, one — *The biology and control of thrips in fennel* — appears to have considerable benefits to other crops so, while difficult to evaluate, is likely to have a high payoff.
- Of the three projects that focused on developing the industry in specific areas, only one area has developed any industry, and that was not in the oil that was the particular focus of the project.

Evaluations in this program are quite difficult if the impact of the project is large enough to change quantity significantly. As Australia is a major source of several of these oils, large changes in quantity could have a major impact on price and this should be taken into account in evaluations. The lesson from this summary is that payoffs sometimes occur from unexpected sources.

Rare and natural animal fibres

There are two main areas in the program — mohair and cashmere — and most projects have concentrated on one or the other. The projects span the full range from market intelligence exercises to animal health. A greater emphasis has been placed on production than in the deer program. This makes more projects accessible to benefit–cost evaluation. Thirty-one projects were identified in the program.

- Of the eight projects on animal health, only one was judged to have a good payoff.
- Of the four projects on genetics (breeding), the mohair projects are considered to have played an important role in improving stock essential for industry survival. However, the

payoff in a benefit–cost analysis may still be low because of the low returns in the industry.

- Three projects relating to improving stock records for breeding are considered successful. An evaluation, which looked only at one project, estimated an IRR of 43 per cent (Wada 1996).
- Of the six projects on processing, only one appears to have potential for a good payoff.

Tea tree oil

Twenty-seven projects were identified in the tea tree program. Of these, seven had no outcome or were inconclusive. A number are considered too hard to evaluate as they examined market conditions and required standards.

- A set of projects examined the properties of the oil, with the purpose of finding new uses for the oil. These projects should be evaluated as a set as they are generally high risk – high return type projects.
- An evaluation of the five tea tree breeding projects is included in this report. The IRR is estimated as 20 per cent.
- A publication on pest control resulted from two projects. An evaluation of the first project in the series put the IRR at 89 per cent (Fearn 1994).

It would be useful to revisit the estimates of net benefit in cases where following projects add much to the value. In the case of the pest control project, a good return is still expected, but with added costs the net benefit may fall unless the second project encouraged greater adoption than assumed in the evaluation.

Wildflowers and native plants

Forty-seven projects were identified in the program. Of these, seven had no outcome or were inconclusive. Quite a number were considered to be possible to evaluate using benefit–cost analysis because they focused on reducing production costs. Projects that focused on improving quality are more difficult to evaluate as the benefit depends on the premium for quality, which is not always known.

- This report includes an evaluation of the set of projects that investigated new varieties for the cut flower market. In the first stage we identified 12 projects of this type, of which two dealt with pot plants. In the benefit–cost analysis in chapter 2 we include 30 projects, some of which are ongoing. The IRR (assuming that up to 10 per cent of our export market share would be lost if new varieties were not developed) is estimated to be 12 per cent.
- Six projects investigated solutions to various pest and weed problems. Two are considered to have had good outcomes.
- Four projects examined production systems, including water and fertiliser regimes. To date none have been adopted.

- A project on improving post-harvest performance of cut flowers was estimated to have an IRR of 13 per cent. (Wada 1996).

The lesson from these program evaluations is that it is important to evaluate sets of projects when projects fall into the high risk – high return category. The evaluation highlighted the sensitivity of the outcome value to the assumptions about market actions without the research. This emphasises the need for program managers to assess the market developments that are likely to occur in the industry as part of project selection procedures.

Agroforestry

The agroforestry program had 54 completed projects. The majority are in the too hard basket for a formal benefit–cost analysis as they compile and provide information aimed at changing attitudes. To assess success in this case all projects aiming to change attitudes — including those under Department of Primary Industries and Energy (DPIE) and National Heritage Trust (NHT) — must be included. There is no doubt as to the effectiveness of this overall set of projects as attitudes are changing. However, even if quantification were possible, estimates of the net benefit are likely to be fairly low because of the long time lag for the payoff in terms of merchantable timber and land care benefits.

Twenty-four of the projects were considered inconclusive as they were inputs into other projects, or required further work to make use of the results of the project. Five projects were considered failures, as they did not deliver any outcome.

- One project on cost reduction of tree establishment is evaluated in this report. This project was very successful and the IRR is estimated at 59 per cent (benefit–cost ratio of 8:1).

A number of the projects in this program have benefits to the wider community. These projects are difficult to evaluate because they require estimation of the value of non-market outcomes. These benefits should still be taken into account in project selection and evaluations must, at a minimum, recognise the benefits even if they cannot be easily quantified. Where the benefits accrue to individuals the analysis is much easier, but it also raises the question of whether RIRDC funding is appropriate.

Summary of estimates presented in this report

The programs for which projects are assessed are as follows.

- Wildflowers (chapter 2).
 - Projects on identifying new species and varieties of Australian wildflowers for cut flowers. This consists of 22 completed or current projects.
- Agroforestry (chapter 3).
 - Cost reduction in farm tree establishment (UNE-16A).
- Cashews.
 - The series on breeding (CSH-8A, CSH-36A, CSH-43A) (chapter 4).

- Impact of flying foxes on cashew yield (NAB-3A) (chapter 5).
- Tea tree (chapter 6).
 - Breeding and selection of Australian tea tree for improved oil yield and quality (DAN-151A, DAN-87A and the set of projects feeding directly into this: ANU-11A and CSF-43A).
- Essential oils — boronia (chapter 7).
 - Integrated control of pests in boronia (UT-2A).
 - Nitrogen and water relations in boronia (UT-5A).
 - Yield and quality of concrete from *Boronia Megastigma* (UT-10A).
 - Genetic resources of *Boronia Megastigma* for the essential oils industry (UWA-16A).

Table 1.3 summarises the results from the benefit–cost analyses presented in this report. The internal rates of return vary from 3 to 61 per cent. At a discount rate of 8 per cent, the net present value (NPV) of this set of projects is estimated at \$28 million. This was from an outlay of \$17 million, implying an average benefit–cost ratio (BCR) of around 2.6. The RIRDC contribution to funding these projects varies, but based on average funding RIRDC can be considered responsible for 30 per cent of this net benefit.

If this sample of projects is a reasonable representation of the performance in the portfolio, the annual expenditure of \$4.6 million a year for the emerging industries portfolio has a payoff of almost 12 million a year in net benefit.

The outcomes vary considerably across the projects evaluated. This diversity reflects the danger in presenting a small number of net benefit estimates. Such an approach may result in severe under or over estimation of the performance of the portfolio.

The evaluations of the wildflower and agroforestry projects was conducted by CIE. The cashew projects and the tea tree evaluations were conducted by Agtrans Research. The boronia projects were evaluated by John Brennan at the NSW Department of Agriculture.

Wildflowers

The set of projects that investigate new flower varieties, both at the identification stage and the development stage, was evaluated. This set was made up of 22 completed or ongoing projects for 13 flower species. The total cost of the set of projects in 1997-98 dollars is \$7.8 million, with RIRDC contributing 30 per cent.

In this set, three of the flowers were considered to be unlikely to reach commercial production — they are the flower equivalent of ‘dry holes’. This is one reason why the case was made that new flower variety projects needed to be evaluated as a set rather than individually. The other reason was that the main impact of the research was felt to be maintaining market share. One project alone cannot be said to contribute greatly to market share, supporting the case for evaluating the set of projects.

Table 1.3 Summary of evaluations in the report

<i>At 8 per cent</i>	<i>NP cost at 1997-98</i>	<i>BCR</i>	<i>NPV at 1997-98</i>	<i>NPV at start date</i>	<i>IRR</i>
	\$'000		\$m	\$m	%
Wildflowers					
▪ New varieties	8 404	1.7	5.6	na	14
Agroforestry					
▪ UNE-16A	801	8.0	5.6	2.8	59
Cashews					
▪ Breeding	4 373	0.0	-4.4	-1.9	3
▪ NAB-4A	103	11.8	1.1	05.	26
Tea tree					
▪ Breeding	1 435	8.9	11.3	6.1	23
Boronia					
▪ UT-2A	406	2.3	0.9	0.2	16
▪ UT-5A	567	1.3	0.58	0.1	11
▪ UT-10A	731	6.8	5.0	3.1	61
▪ UWA-16A	491	4.8	2.4	1.4	35
Total	17 311	2.6	28	na	na

Source: Chapters 2–5.

The net benefit from the set of projects comes from several sources.

- For individual growers the main benefit flows from the premium commanded on new flowers. This premium — as other domestic and foreign growers adopt the new variety increasing supply, and ever-changing tastes — is temporary so the value depends on its magnitude, its duration and the volume of production. Production costs were similar for new varieties as for existing varieties. The net benefit estimates for the premium alone assume that other product is crowded out by the new varieties.
- For domestic wildflower growers there is a benefit from reduced loss of, or maintaining, or increasing domestic market share. With virtually no effect of new varieties on the share of flowers in household budgets, the gain for the wildflower growers is a loss for the growers of traditional flowers.
- The main benefit at the Australian level is the reduced loss of, or maintaining, or increasing export market share. The background is a growing world market for cut flowers. New traditional varieties are constantly being introduced, and foreign growers are developing their wildflower growing capacity. Without new varieties the industry believes that market share will fall substantially.
- Consumers will benefit as they demonstrate a higher willingness to pay for new compared with existing varieties. However, Australian consumers do not display the same fascination with new flowers as the Japanese, Europeans or Americans, so foreign consumers capture most of this benefit. No attempt is made to capture the change in consumer surplus.

Approach

Most of the flowers identified in the projects have yet to reach commercial production. To estimate the likely premiums and the volume of production we surveyed a number of growers,

researchers and wholesalers in the industry. On the basis of the average opinion, and assuming several years between the three stages of identifying a flower (stage 1), development (stage 2) and commercial production (stage 3), we estimated the value of the premiums and when they would occur.

As there is no information on the extent of the fall in domestic or export market share in the without scenario, we ran a number of scenarios to estimate the size of the fall required for the new variety projects to have a significant payoff.

Results

The main findings are as follows.

- Premiums are not sufficient to cover the cost of the research. The assumed premiums or volumes would have to be 300 per cent greater for the research to break even at an 8 per cent discount rate.
- Wildflower producers benefit more than the community as, in addition to the increase in producer surplus from exports, they gain from domestic sales. Assuming a ratio of operating costs to revenue of 25 per cent on average, with the projects delivering up to 5 per cent higher market share in the domestic market and up to 10 per cent higher market share in the export market, the return to the wildflower industry is 17 per cent.
- The benefit to Australia of the set of projects, assuming that export markets share is up to 10 per cent higher than without the set of projects, is 14 per cent, a NPV of \$5.6 million at a discount rate of 8 per cent. This gives a BCR of 1.7:1.

Agroforestry

Most of the projects in the agroforestry portfolio are very difficult to evaluate formally in a benefit–cost framework. Many of the benefits, such as timber and landcare outcomes, will not arise for a number of years. Many of the benefits are also inherently difficult to value, such as reduction in infrastructure costs, from lower water tables that *may* be associated with increased plantings of trees. In addition, the benefits are highly area specific — for example, the shade and shelter benefits of new shelter belts depend on the climatic conditions, topography, the type of stock, and the existing shelter belts.

The project evaluated was chosen as one of the few in the portfolio that could be quantified with any degree of confidence in the limited time and resources available. The project *Cost Reduction in Farm Tree Establishment* was completed in 1993 at a total cost of \$461 000, of which RIRDC contributed 25 per cent. It trialled a number of techniques for reducing the cost of establishing trees on the New England Tablelands. The project effectively combined research with extension, involving a number of farmers in the region. Since the completion of the project the main researchers have been involved in extension as part of their following employment. As a result the findings of the project were disseminated widely and had a considerable impact on tree planting regimes adopted.

Approach

The attitude of farmers and other landholders to trees has changed dramatically over the last decade as a result of education and incentives. The numbers of trees planted in the New England region has risen from 300 000 in 1990 to 800 000 in 1997. It is expected to increase further.

While reductions in the cost of establishing trees would have contributed to the number planted, the project cannot be attributed with increasing the number of trees established. Because of the interest in tree establishment, other projects focusing on reducing costs would have occurred if this project had not. Indeed, many other projects, both private and public, have continued to work to reduce costs. This project has contributed to many of these projects by establishing research protocol, developing research skills (formal and informal), and as a starting point.

The approach to estimating net benefits was to establish the reduction in cost of establishing the trees in the region. This depended on:

- the method of planting adopted;
- the contribution of the project to that method of planting; and
- the share of the trees planted by each method.

Results

Five methods for planting trees were costed, with six establishment costs estimated. The establishment cost depended on the success rate in tree establishment from the planting. For the most common method of planting, the success rates ranged from 85 per cent for farmers in Landcare groups and other skilled tree planting groups to 50 per cent for unskilled farmers. The reduction in costs under the different methods adopted for establishing trees ranged from zero (traditional method) to \$6 per tree (55 per cent fall in cost).

The contribution of the project to the different methods was assumed to decline over time and was set to zero after 2010. The initial contribution to the current level of cost reduction varied from 50 per cent to 5 per cent and the traditional method was not affected. The Armidale tree planting group's planting methods and mechanical planting benefited most from the project. The adoption rates of the different methods also varied over time. In particular, as more farmers join, Landcare group's success rates rise and the number of farmers using traditional planting methods declines.

The NPV of the project at a discount rate of 8 per cent is estimated \$5.6 million, with a BCR of 8:1. The IRR is 59 per cent. Even if an additional \$400 000 was spent on extension, the IRR falls only slightly to 51 per cent. The analysis suggests that this project has delivered considerable benefits in terms of cost savings to the New England region.

Cashews: breeding projects

World production of cashews is made up mainly of low yield – high labour input production. In view of the high labour costs for cashews to be viable crops in Australia, yields of over 4 tonnes per hectare are required.

This set of projects (CSH-43A, CSH-36A, CSH-8A) focused on the selection and development of hybrids to achieve four tonnes by 1994, five tonnes by 1997 and 6 tonnes per hectare by 2000 of high quality nut.

The industry consists of three growers, although only one is currently in production. The Australian product is large, good quality nut, and volumes are likely to remain too small to influence price. Significant capital investment is required and there is long lag between planting and mature yields. Benefits of higher yields are expected to be captured by Australian producers with the register of intellectual property rights.

A model of the cashew industry developed for RIRDC estimated the link between the farm rate of return and the area planted. The effect of improved yields on the return – and hence on the area planted – was included in the assessment of the impact.

Approach

There are no conclusive outputs to the breeding program due to insufficient monitoring and other events — a cyclone destroyed the trees at Weipa and there was a termite attack at Katherine. Individual trees have been found to yield up to 14 kilograms per tree — which, at year 4, is consistent with the target yield. For the evaluation, the output of the projects is assumed to be an increase in:

- yield to 3.5 tonnes per hectare compared with 2.5 tonnes per hectare prior to the project;
- an increase in the average size and quality of the nut, attracting a price premium; and
- the number of trees.

The cost of producing the hybrid is assumed to be the same as the cost of producing lower yielding varieties.

Results

Based on current average cashew prices and an exchange rate of A\$/US\$ of 0.73, the project has an IRR of 2.8, and a NPV of -\$1.9 million at a 8 per cent discount rate. A fall in the Australian dollar improves the outcomes as prices are fixed in US dollars. The analysis demonstrates that average yields must reach 4.5 tonnes per hectare for a significant return on the R&D.

These results are highly sensitive to assumptions about production costs. If insect control is not easily achieved, and if the high individual tree yields are not maintained in a high density plantation, then these estimates overstate the net benefits. The critical questions raised by this evaluation are as follows.

- Is the industry viable in the long run? In particular, what are the returns on alternative activities?
- What is the payoff to any extra investment in breeding? Past expenditure should not be considered — although the difficulties faced by the research should. Further projects should be assessed on the basis of how much they add to yields relative to their cost — with the caveat that there will be an industry to benefit.

Cashews: pest control — flying foxes

Flying foxes were reducing the yields by removing the fruit to which the cashew test is attached at the Wildman River Plantation. The project — *Impact of Flying Foxes on Cashew Yield* (NAB-3A) — estimated the impact on the yield, examined the biology and ecology of the relevant flying fox species, and suggested possible control methods. The total cost of the project was \$45 000.

The project found that up to one-third of the harvest could be lost to flying foxes. The main reason is that the flying foxes carried the fruit to the forest for feeding due to the competition for roosting trees. They did not harm the nut, but removed it from the plantation. The flying foxes were found to prefer roosting in *Ficus spp* trees, and some varieties of trees produced fruit that the flying foxes ignored. Suggested solutions were the planting of roosting trees in the plantation and collecting the fallen nuts.

Approach

The research suggested that the loss was dependent on the alternative, higher quality food sources in the forest, and the flying fox population. This suggests that over time as the yields increase, a lower proportion of the crop will be lost. The assumptions are:

- an average of 15 per cent of production is lost;
- roost trees reduce nut loss by 80 per cent — nuts under the trees are collected by mechanical sweeper at a slightly higher cost of collection; and
- the cost of establishing the roost trees is \$ 6760 per 100 hectares of plantation with no significant upkeep costs.

The without scenario assumes an average yield over the period of evaluation of 3.5 tonnes per hectare without the trees and 3.78 tonnes per hectare with the roosting trees and an increasing area of trees, as predicted by the model of investment response to improving returns. The additional nuts are sold at world prices, as discussed in the previous evaluation. The plantations at Wildman River and in Queensland are affected by flying foxes and have planted roost trees.

Results

The IRR on the project is 26 per cent. At an 8 per cent discount rate the NPV is \$0.5 million and the BCR is 12:1. If the yield loss saved is as low as 1 per cent the project still returns a

positive NPV. As a stand-alone project, this low cost project has an excellent outcome. However, if the industry proves not to be viable the project has less value. It does, however, provide a model of a clever solution that is beneficial to the environment and to biodiversity, and does not impose costs on other industries by driving the flying foxes to find alternative food sources.

Tea tree —breeding

The Australian tea tree industry has grown rapidly over the past decade. Strong growth in demand as new markets are developed has been met by supply growth keeping prices roughly constant. Foreign producers are expected to enter the market, making it imperative for Australian producers to lower unit costs to be competitive. With high labour costs, increasing oil yield is the ideal solution.

Four projects make up the breeding series. The first two (CSF-43A and ANU-11A) explored the potential for the breeding program, and the third (DAN-87A) established the program. There is a RIRDC project (DAN-151A) continuing the breeding work and the cost of this project is included in the evaluation. The objectives were to increase oil yields in new seedling plantations by 30 per cent in five years with a 60 per cent increase at the conclusion of the first generation of breeding — around 2000. The oil must be of desirable quality and mass propagation must be made available.

Approach

The estimation of the impact of the research uses the tea tree investment model developed by Agtrans for RIRDC in 1995.

The assumptions are:

- first generation genetic material will be available in 2001 and will increase yields by 17 per cent (existing yield 140 kg per hectare);
- there will be no additional costs to establishing the trees;
- trees will be established on the replanting cycle — so full adoption will take 15 years with 7 per cent of the existing trees replaced each year; and
- the area under production will expand 3000 hectares based on the investment model by 2001.

The unit cost reduction approach was used to estimate the flow of benefits as world production is assumed to expand to meet any increases in demand, so prices remain constant.

Results

The IRR of the project is 23 per cent. At an 8 per cent discount rate the BCR was 9:1 and the NPV \$6.1 million. If a 60 per cent increase in yields can be achieved by the end of the first breeding cycle, then the IRR is 30 per cent.

The higher yields do not impact on price, implying that the benefit is captured entirely by the existing growers given that beyond 2001 no expansion in area is projected. If current returns are below those in alternative activities and this raises returns to comparable levels, no entry is expected. However, if returns rise relative to alternatives the industry can be expected to expand. The increase in volume would be expected to impact on price. The final impact depends crucially on foreign producers' entry into the market, their costs of production and on their access to the improved genetic material.

Essential oils — boronia

Australia is the main producer of boronia absolute (pure oil) and concrete. It is used mainly as a flavour enhancer and in perfume production. Production is concentrated in Tasmania where the industry is vertically integrated. Bush picked boronia has been the main supply source for oil produced in Western Australia, however cultivated production is increasing in the state. Production is expected to expand over the next decade, and while demand is also increasing it is relatively elastic and prices are expected to fall.

Evaluations of four projects are reported in chapter 7.

- UT-2A developed a pest management program that reduced the number of sprays required to control boronia psyllids. In some cases natural control was reestablished.
- UT-5A developed a technology package on irrigation and application of nitrogen to minimise toxic residues in the oil and to maximise yield. The outcome was a package that reduced fertiliser costs, but did not appear to impact on the quality or quantity of oil production.
- UT-10A undertook research focused on increasing the harvest period, and improving pre and post-harvest handling to raise the yield and quality of oil.
- UWA-16A aimed at promoting the expansion of the cultivation of boronia for oil production by providing more rapid increases in yields that would normally be available in new areas of production. It improved knowledge of the production systems best suited to Western Australia. The expansion of the industry is built into the quantity and price projections.

Approach

The baseline quantity of production and prices is estimated based on a supply elasticity of 1 and a demand elasticity of -5. The first three evaluations estimated the flow of benefits as the reduction in the unit cost of production based on the expected level of production. The last evaluation brought forward yield improvements, and the net benefit was estimated as the higher yield per hectare of new production. This translates to a unit cost reduction for those areas affected. The estimates are based on a parallel shift downward in the supply curve for the relevant production areas, but assume that price and quantity are unchanged. This approach understates the benefits where the projects contributed to the increase in production, and overstates the benefits where the project had a negative impact on price. As the

contribution of the individual projects to the change in quantity and, hence, price is assumed to be small relative to the broader trends these biases are likely to be small.

The estimates are based on the following assumptions.

- Adoption rates are very high and rapid especially in Tasmania due to the concentrated nature of the industry.
- For UT-2A the cost saving per hectare in pesticide and spraying costs per year was \$530.
- For UT-5A the cost saving of \$436 per hectare per year is from reduced application of fertiliser and use of a less expensive input.
- For UT-10A the outcome is an increase in the yield by 30 per cent. There is also a cost saving as fewer harvesters are required due to the longer harvest period.
- UWA-16A resulted in attaining higher yields on new production areas in Western Australia five years earlier than under the baseline.

Results

- UT-2A — pest control — had an IRR of 16 per cent. The net present cost of the project was \$0.35 million, and the NPV is estimated at \$0.46 million at an 8 per cent discount rate. The return depends on the very rapid and high adoption rates.
- UT-5A — fertilisers — had an IRR of 11 per cent. The net present cost of the project was \$0.49 million, and the NPV is \$0.17 million at an 8 per cent discount rate. As with the pest control project, the return depends crucially on the very rapid and complete adoption.
- UT-10A — raising yield — was estimated to have an IRR of 61 per cent. The high NPV estimate of \$3.67 million results from the big improvement in yield, which was assumed to be effective immediately at no extra production cost, along with the very rapid and almost complete adoption. This estimate is more sensitive than the other estimates to the potential impact on price as the project would have increased volume by 1999 by roughly 28 per cent, although the contribution would then decline over time.
- UWA-16A was estimated to have an IRR of 35 per cent, and at an 8 per cent discount rate, a NPV of \$1.74 million, for a net present cost of \$0.46 million. The project resulted in expected productivity gains in new production capacity being brought forward by five years. The outcome is sensitive to the assumed rate of expansion of the industry. This estimate is also sensitive to the potential impact on price.

The first lesson from these evaluations is that projects can have good returns despite a relatively high cost if the benefits are adopted quickly and fully. With low adoption rates or a lag in adoption, the projects on pest control and fertiliser would have not had good outcomes. Similarly, the rapid adoption of yield improvement techniques and varieties developed by the other two projects resulted in very good returns. Some care should be exercised in interpreting these last two results as it is likely that they are responsible for a reasonable proportion of the increase in quantity of production and the resulting fall in price. Being aware of the impact of projects on quantity and price is the second lesson. The third lesson from these evaluations is that there are benefits to the broader community that are not easy to

estimate. The pest control program that dramatically reduced spraying, benefited the environment as well as being potentially transferable to other industries. The project speeding up the cultivation of boronia in Western Australia probably reduced the quantity of bush picked flowers with consequent benefits to the environment and wildlife.

Detailed accounts of these evaluations are provided in the following chapters.

2 Wildflowers — the value of new varieties

New wildflower projects

The purpose of this benefit–cost analysis is to assess the net benefit of a group of projects undertaken by RIRDC as part of the wildflowers program in the emerging industries' portfolio. The group of projects is selected as the set of projects that focused on identifying new varieties of Australian wildflowers for cut flower production. Current projects are included in the evaluation.

Projects at the identification stage (stage 1) are inherently high risk compared with projects that focus on development or extension (stages 2 and 3). Some projects may fail to identify a variety that has commercial potential, but such 'dry holes' need not be valueless as they can prevent further expenditure in these areas, and experience and techniques developed can be used in other projects. For these reasons, an ex post evaluation should include the full set of projects, rather than pick a few at random or, more misleadingly, pick only the winners.

The projects included in this evaluation are given in table 2.1. They include all projects receiving funding from RIRDC where the focus is to identify new varieties for cut flowers. Projects that have gone on to the development stage (stage 2) where the focus is on trials and evaluation is included as they are often an essential stage in viable outcomes. A summary of the projects is provided in appendix A.

An overview of the wildflower industry

Background

The Australian wildflower industry is a subsector of the Australian cut flower industry. The current retail value of the domestic sales is around \$300 million, with a wholesale value of around \$160 million. Around 15 per cent of the domestic market are wildflowers (Agriculture Victoria 1997, Karringal 1997).

Wildflowers (including proteas and leucadendrons) are over 90 per cent of the cut flower exports. Australian wildflower exports earned \$27 million in 1995-96. The main export markets are Japan and the United States. The world value of production of Australian wildflowers is around \$400 million, in a total flower market of \$4 billion. The main competitors for Australia in wildflower production are Israel, Kenya, Zimbabwe, Uganda, and production is increasing in Latin America.

Table 2.1 **Projected included in this evaluation**

Code	Project name
DAQ-166A	Sourcing and vase life evaluation of tropical Grevillea species forms and hybrids
DAQ-127A	Development of Helichrysum Diosmifolium as a cut flower crop
DAV-56A	Development of Baeckea Behri species as cut flowers for export and local markets
BGA-1A	Development of Sturt's Desert Pea for flowering pot and cut flower production
UNE-15A	Clonal propagation of Sturt's Desert Pea for cut flower production
DAW-11A	Evaluation of the Myrtle group as export cut flowers
DAN-5A	Evaluation of Australian native plants as indoor pot plants and cut flowers
DAW-51A	Production, management and handling of quality new native cut flowers for export
UA-26A	Selection of Banksia Cultivars for floriculture
UQ-29A	Propagation and horticultural development of Caustis blakei for export cut foliage market
DAQ-171A	Development of new Asteraceae from the Australian flora to complement the current riceflower industry
DAS-45A	Varietal development and disease management of Ixodia Achillaeodies for cut flower production
DAV-102A	National program to commercially evaluate Baekea behri
ANC-1A	Australian summer flowering plants for the northern hemisphere winter cut flower market
UMU-11A	Collection and selection of Chamelaucium species for floriculture
RBG-1A	Development of the flannel flower as a cut flower crop
DAW-89A	Cultivation of blue smokebush for cut flower production
DAW-76A	The selection, propagation and cultivation of golden cascade for cut flower production
UWA-35A	Development of new and improved cut flower cultivars through selection and sexual hybridisation within the Chamelaucium alliance
DNT-16A	Cut flower potential of centralian species
AFF-1A	Distribution of priming grants for wildflowers and native plants
RBG-2A	Development of flannel flower production system

Source: RIRDC.

The predominant wildflowers are waxflowers, which make up 25 per cent of output. Australia sold around 12 million stems in 1992-93. Kangaroo Paw, thryptomere, proteas and banksia are the other main types of cut flowers. In 1992-93 Australian sales were around 6 million stems of Kangaroo Paw, 2 million stems of proteas, and 6 million stems of other natives. Eucalyptus dominates the foliage market, which is around 7 per cent of exports.

Twenty per cent of Australia's wildflower production is cut from bush stands. The rest is grown mainly in Western Australia and Queensland. The average size of a farm is around four hectares. It was estimated that the total cultivated area of cut flower production is around 4000 hectares in 1993-94. The total area of cultivated wildflowers is not known with certainty. One estimate put it at 1833 hectares in 1992-93, another at 2558 hectares in 1993, indicating the high degree of uncertainty — particularly about yield per hectare, as estimates were based on production data.

Prices for Australian wildflowers have a very wide range depending on the type of flower — filler, focal filler or focal flower — and the quality. Appendix B compiles information on flower prices from a variety of sources. The retail markup and, for exports, transport and handling costs and trade barriers are substantial. The price to the domestic consumer is around 350 per cent of the farm gate price. In export market, the price to consumers is around 500 per cent of the farmgate price. The value chain is described in chart 2.1.

Market structure

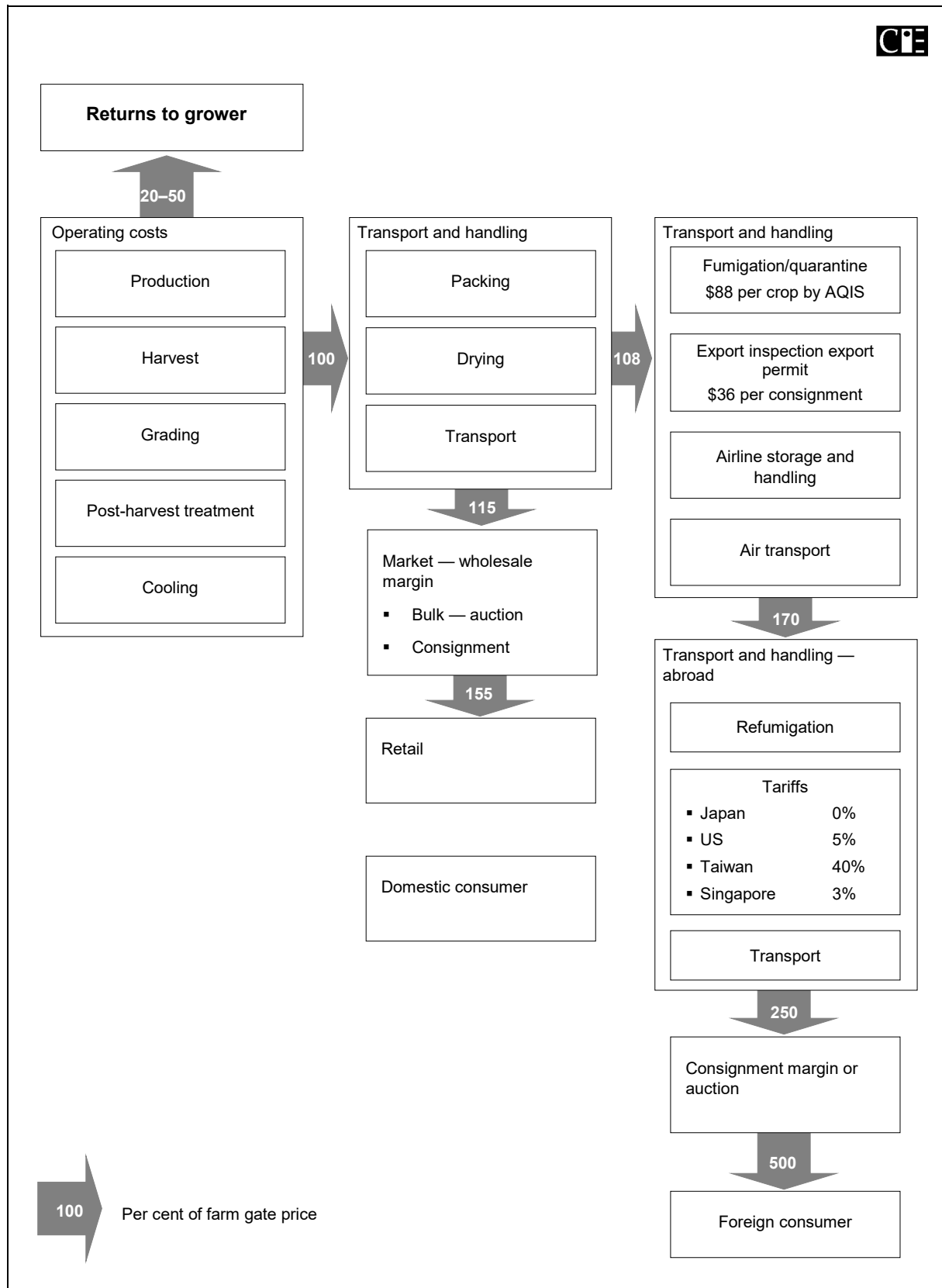
Wildflower production in Australia is largely conducted on small farms with little capital requirements. For small growers, the main requirement is proximity to a market — within an hour of a major airport or market. Large growers can invest in refrigerated containers and more sophisticated initial handling. There are a small number of wholesalers who operate on both domestic and export markets and flower market auctions are available in all major cities. The main barrier to entry is access to genetic material — in particular, when varieties are registered (plant variety rights [PVR]). However, many growers do not bother to register new varieties, as price premiums are generally short lived (2–5 years), so returns are earned only in the early years of production.

The cut flower market is highly competitive, with returns on most flowers pushed down to just cover costs. There is little producer surplus from growing and selling the standard product. Estimates by Karringal (1997) suggest that operating (variable) costs are between 50 per cent and 70 per cent of revenue, so the return to the fixed factors land, capital and the grower's skill are between 30 and 50 per cent of revenue. In general, growers are rewarded for improved quality and consistency by ensuring sales rather than commanding premiums — so these figures, which are based on sale of all production, would reflect best practice growers.

New varieties can command substantial premiums, up to 400 per cent at the wholesale level at certain times. However, premiums are relatively short lived as buyers seek new, novel flowers. The traditional flower growers are constantly introducing new varieties into the market — few become standards.

Aggregate demand for wildflowers is relatively elastic due to easy substitution with traditional flowers and other gifts. However, demand is not perfectly elastic because some buyers will have a strong preference for certain flowers (or a strong preference for flowers on certain days). Demand for new and novel flowers can be inelastic so these flowers can attract a premium. The demand curve for a new variety is higher than the demand for standard flowers. Supply is less elastic as propagation takes time, and growers protect their markets by limiting access to the base stock. The benefit to producers of these new varieties depends on their cost structure — the shape of their supply curve, and the fixed costs. As other producers start to produce the flowers, the supply curve becomes more elastic. In addition, people get used to the new variety and demand becomes more elastic. The demand and supply curves tend toward the long run curves. Price is determined by how:

Chart 2.1 A value chain for Australian wildflower production



Source: ACIAR; Karringal 1997 (table A11, exhibit 1.6); CIE.

- quickly the ‘new’ label is lost — the change on the demand side; and
- quickly other suppliers respond and raise production — which depends on the ease of propagation and the specificity of the production environment.

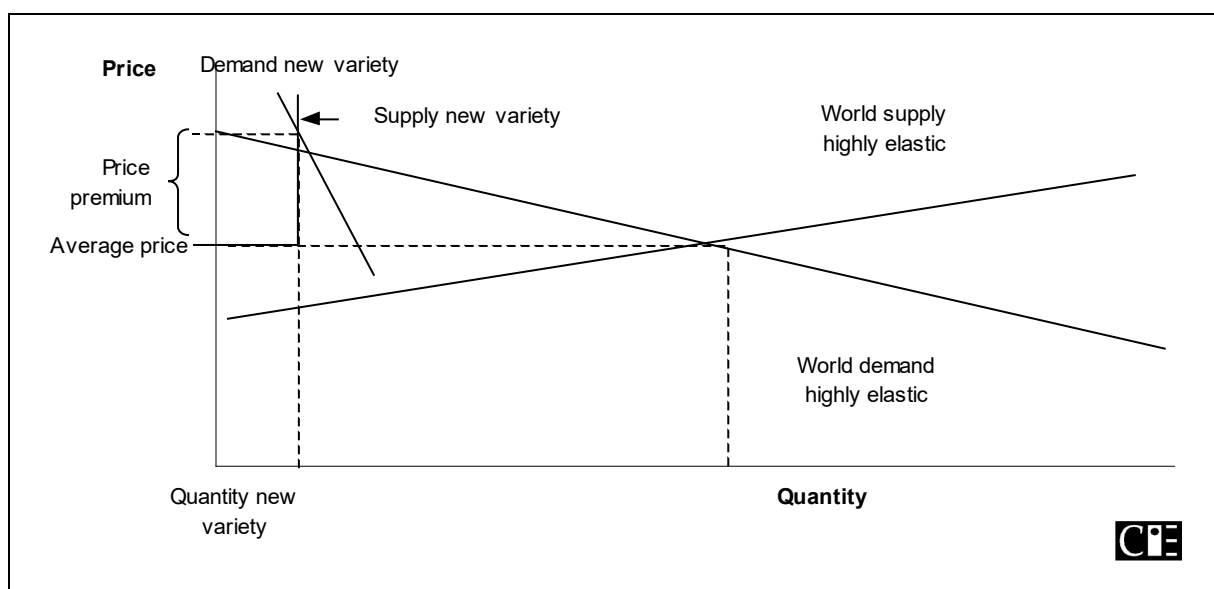
Chart 2.2 summarises this situation. The relatively flat demand and supply curves reflect the world market. There is a steep demand curve for the new variety and supply is likely to be low and relatively inelastic as this is part of the attraction. The premium is the price above the average price for similar types of flowers.

The benefit for the grower (and the wholesaler who takes a percentage of market price) from a new variety is the premium it commands less any additional costs of production and marketing. Additional variable costs of production are likely to be relatively small as growing techniques vary little (except if hydroponics is adopted). However, fixed costs of putting in new perennial plants, and purchasing the licence to propagate may be high in the short run. At any point of time supply is fixed — represented by the L-shaped supply curve

For individual growers the volume of production may rise, but the new flowers will crowd out existing varieties unless there is also market growth. Without market growth, the net benefit to producers comes only from the premium. Clearly, as producers growing the new variety may not lower production of other varieties, marginal growers lose volume.

Traditional flower producers are consistently introducing new varieties. While this no doubt contributes to overall growth in demand, it is likely to be a relatively small component. The price elasticity is also relatively high as a large component of the market is gifts such as chocolate and wine. The main determinants of market growth are per capita income growth and population growth with flowers experiencing a high income elasticity of demand.

Chart 2.2



Estimates prior to the Asian financial crisis were for annual average growth of 9 per cent. Growth is expected to be somewhat lower, at least over the next few years. The big areas of growth are thought to be in Asia, particularly China.

The longer term reason for introducing new varieties is about maintaining market share. This is important for a number of reasons apart from the obvious one of maintaining production quantity. These are:

- maintaining distribution networks;
- maintaining name recognition; and
- advertising potential with ‘named’ products.

At the moment these factors are less important in the wildflower market but they are growing in importance.

The without new varieties scenario is a declining market share for wildflowers relative to traditional flowers. Given the niche nature of the product, this is unlikely to be the dominant effect. For Australian producers the main effect is losing market share to other exporters of Australian wildflowers. There is a strongly held belief that new varieties are required to maintain market share. This belief cannot be tested on available evidence, so we set up several scenarios about the impact on market share in order to undertake an evaluation.

In the domestic market, an increasing share of wildflowers crowds out traditional flowers. As few flowers are imported this implies that, while new varieties increase wildflower growers’ welfare, they decrease traditional growers’ welfare. It is only the premiums commanded by producers, the increase in consumer welfare as demand for new varieties is higher, and the rise in exports that contribute to the total benefit to Australia.

The main contribution of new varieties of wildflower to Australian welfare comes through maintaining or raising the share of Australian wildflowers in the international market. Australian wildflowers compete for market share with both traditional flowers and wildflowers grown by foreign growers. While some Australian companies are growing wildflowers off-shore, so some of the return on foreign sales is of benefit to Australia, this is still a very small share of foreign production. Chart 2.3 summarises the contribution that new varieties might make to Australian wildflower sales.

Approach to evaluation

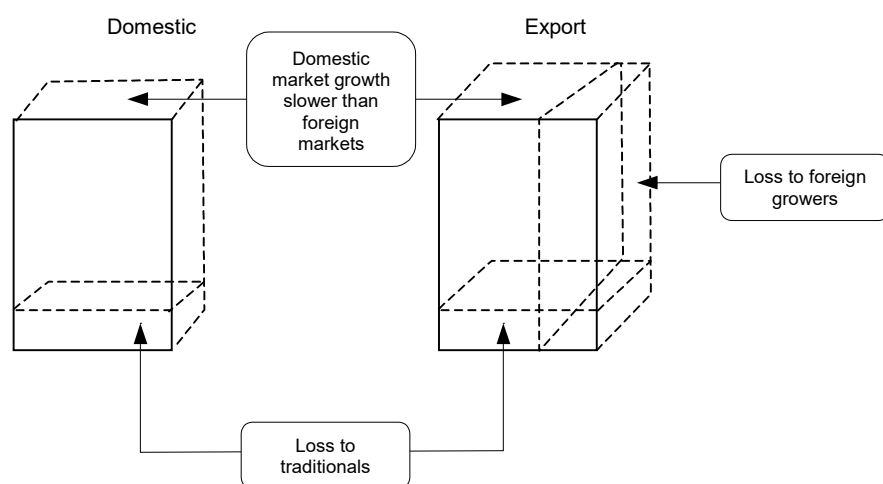
We take a two step approach to estimating the net benefit of the set of flower projects.

Chart 2.3 Outlook for Australian wildflower industry

Current value of industry



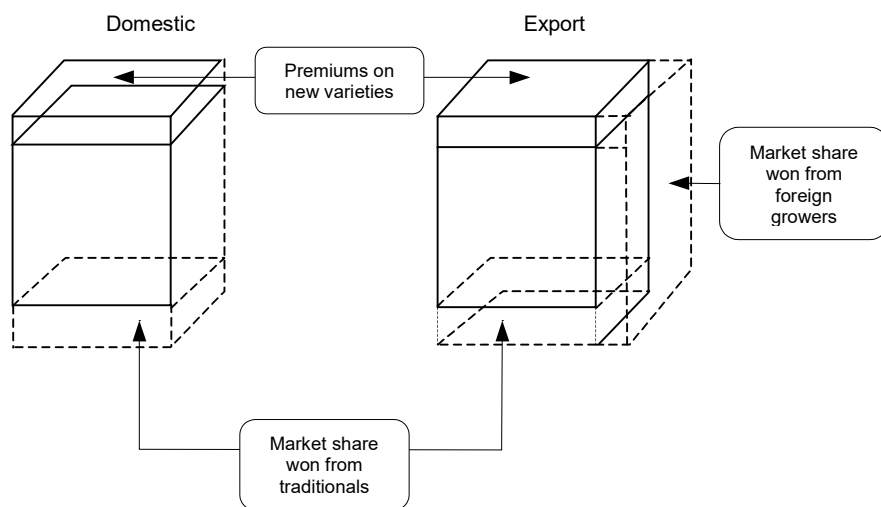
Without new varieties



With new varieties

Scenarios for market share

- Lower loss
- No loss
- Gain from
 - traditional flowers
 - foreign growers



Step 1: Estimate the returns with no impact on market volume

- The first step is to estimate the value of the premiums commanded by the new varieties. The assumption is that the cost of production of the new varieties is the same as those that are replaced at the margin — that is, the cost of production equals the average price.

The estimate is the impact on producer surplus. Demand for the new varieties is relatively inelastic, reducing the consumers' share of surplus. In any case the main market for new varieties is the export market, and foreign consumers' gains do not add to Australian welfare.

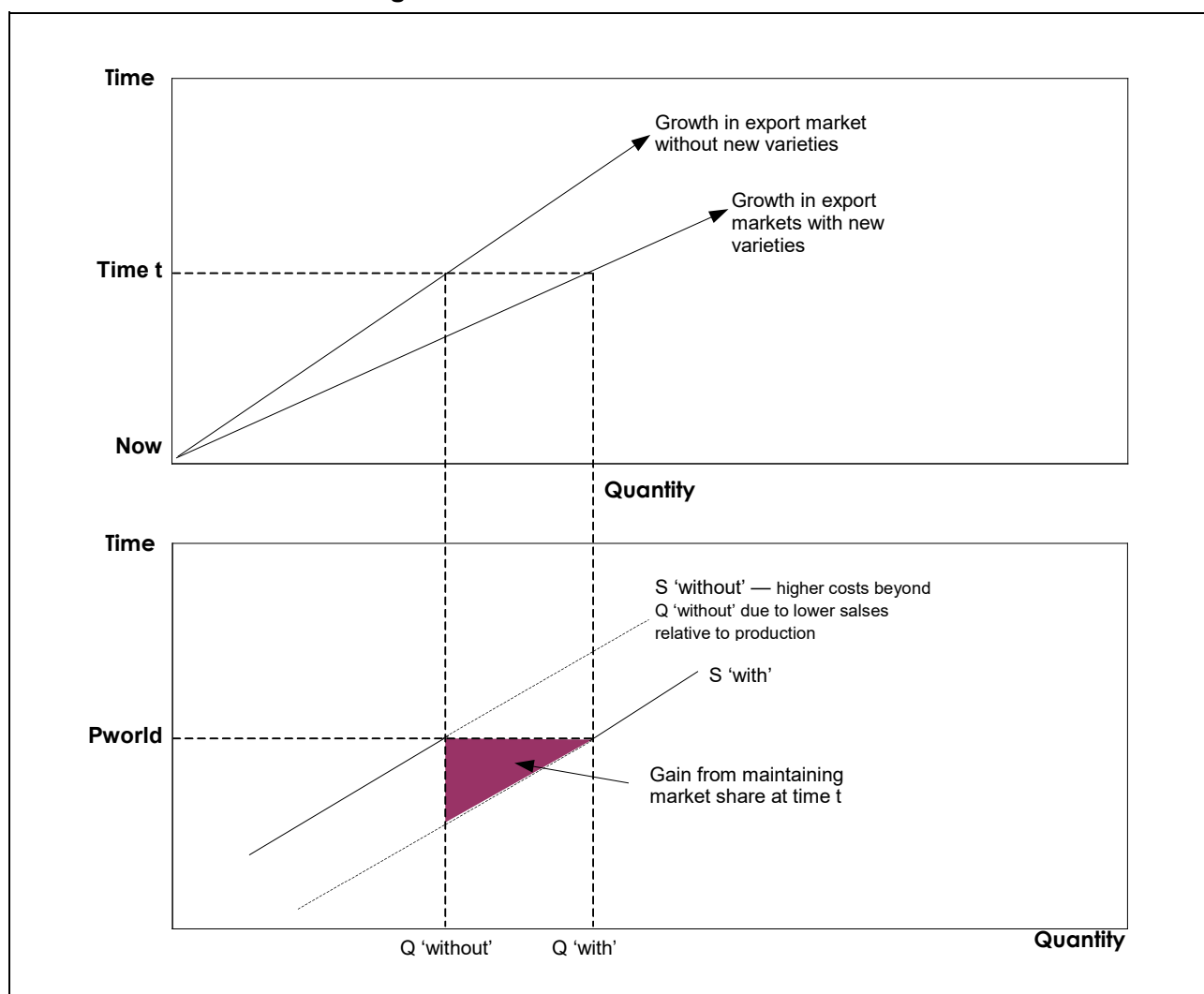
Step 2: Estimate the effect on market volumes

- Market volumes depend on market share and on the size of the market. The markets are the domestic and the export markets.
- The domestic market is growing slowly. While the low per capita consumption of cut flowers suggests considerable potential for strong market growth, there is no indication of this becoming the case. Our baseline assumption is for market growth of 1 per cent a year in line with population growth.
- The export market — world market — is growing strongly. Estimates put growth rates over the next decade at between 6 and 9 per cent a year. Given the Asian crisis, we assume world market growth of 6 per cent.
- While market demand is expected to grow, world flower production is also increasing. Supply is very elastic, with more production by low cost growers coming on-line in Africa and in Latin America. Growth in market value is expected to be volume driven and prices are expected to fall slightly or at best remain constant in real terms.

For Australian wildflower growers the effects on domestic and export market share are both important. We separate the impacts on market share in the domestic and in the export market, as for the latter the effect is on Australia rather than just wildflower growers. We set up several scenarios about the impact on market share based on the combined effect of changes in market share relative to traditional flowers, and relative to foreign wildflower growers.

The purpose of running the scenarios is to assess how important the introduction of new varieties — for the purpose of maintaining or improving market share — might be for welfare. Australian welfare rises with the increase in producer surplus from expanding exports. Welfare increases where marginal operating costs are below marginal revenue. Chart 2.4 summarises our approach. The baseline market growth assumes new varieties. Without these, at any point in time demand for Australian product is lower. The lower average price can be thought to be due to a mix of discounts for stock that has lost 'image' and higher loss through non-sale of stock. The benefit of new varieties is represented by the triangle of sales not lost at the higher average world price. It is not known how big the fall in average revenue is. Scenarios about the impact on changes in market share are tested to assess the critical values for the cost of research to pay off. The slope of the supply curve is estimated based on average gross operating surplus at 25 per cent of revenue.

Chart 2.4 Value of maintaining market share



Project inputs

The costs of the projects are the sum of the total project costs, including RIRDC funding, industry funding and in-kind contributions from researchers and growers. The costs do not include additional costs that might be associated with applying for PVRs. The costs include the budgeted costs for ongoing projects.

Table 2.2 summarises the total cost of the new variety projects over time. In 1997-98 dollars the total cost of the program is \$ 7.0 million with RIRDC contributing \$1.9 million.

In addition to the projects with RIRDC involvement, new varieties are developed by private growers and by research organisations — in particular, the departments of agriculture in the various states. It is estimated that RIRDC has interests in about 50 per cent of the new wildflower projects. As can be seen from table 2.2, RIRDC provides just under 30 per cent of the funding in this category.

Table 2.2 **Total cost of program** Actual and committed costs (Project costs in 1997-98 dollars)

<i>Year</i>	<i>RIRDC</i>	<i>Industry</i>	<i>Organisation</i>	<i>Total</i>
	\$	\$	\$	\$
1985-86	11 438	31 568	0	43 006
1986-87	3 833	0	0	3 833
1987-88	10 371	773 730	0	784 101
1888-89	46 354	144 706	12 238	203 298
1989-90	96 600	38 560	12 188	147 348
1990-91	101 014	51 836	56 487	209 337
1991-92	40 661	73 348	116 454	230 463
1992-93	248 790	6 521	243 688	499 000
1993-94	129 959	106 778	440 349	677 086
1994-95	284 709	139 154	493 583	917 446
1995-96	334 448	197 436	595 414	1 127 298
1996-97	251 383	173 612	469 640	894 635
1997-98	202 911	109 414	330 892	643 217
1998-99	114 710	35 972	251 897	402 579
1999-2000	39 617	26 436	128 573	194 626
Total	1 916 799	1 909 071	3 151 403	6 977 273

Source: RIRDC files, ABS deflator.

Table 2.3 **Estimates of premiums**

	<i>End stage 2</i>	<i>Type</i>	<i>Production start date</i>	<i>Wholesale premium</i>	<i>Average price</i>	<i>Production volume</i>	<i>Duration years</i>
				%			
Waxflower 1	1987-88 (1)	Focal filler	1994-95	75	0.30	700 000	3
Waxflower 2	1997-98	Focal filler	1999-2000	75	0.30	700 000	3
Waxflower 3	1999-2000	Focal filler	2002-03	75	0.30	700 000	3
Riceflower 1	1993-94	Focal filler	1995-96	25	0.35	700 000	3
Riceflower 2	1995-96	Focal filler	1998-99	25	0.35	700 000	3
Flannel flower	1998-99	Focal filler	2001-02	80	0.40	200 000	4
Banksia	1996-97	Focal	2000-01	70	1.30	300 000	5
Koala Fern	1999-2000	Foliage	2001-02	80	0.40	200 000	6
Smokebush	1999-2000	Filler	2001-02	100	0.40	100 000	5
Grevillea	2003-04	Focal filler	2006-07	60	1.50	100 000	4
Baeckea	1997-98	Filler	1999-2000	60	0.45	1 000 000	4
SA daisy	Stage 1 only	Focal filler	2005-06	60	0.20	200 000	3
Golden cascade	2001-02	Focal filler	2004-05	150	0.40	100 000	4
Blood root	2000-2001	Focal	2003-04	100	1.00	100 000	3
Myrtle	Stage 1 only	Focal filler	na	100	0.40	0	3
Sturt's Desert pea	1990-91	Focal	na	100	1.00	0	4

Source: Surveys.

Project outputs

The first step is to identify the projects that were successful in identifying varieties that were considered to be viable for production. These can be identified by:

- further development and extension projects;

- registration of the variety under plant variety rights; or
- growing and sale of the variety.

Chart 2.5 summarises the outputs of the projects.

Impact of the projects on prices and quantities

Unfortunately many of the flowers being investigated are still at stage 1 of product development and their eventual market outcome is unknown. To overcome this problem we surveyed a number of growers, wholesalers and researchers in the wildflower industry about the potential for the different flowers being investigated. These experts were asked their opinion on the expected premium relative to the average price, the likely volumes of production and the duration of the premium. The range of views about each flower is summarised in appendix A.

Table 2.3 gives the assumptions about premiums used in the benefit–cost assessment. The production dates given in the table are estimated based on the finishing date of stage 2. Small volumes may be available prior to these start dates, and the volumes are likely to follow an increasing then decreasing pattern. However, for simplicity, we assumed constant volumes over the years of the premium, so these volumes should be interpreted as the average over the period for which a premium is commanded. Similarly, premiums are likely to decline over the period, and again this should be considered to be an average. Sensitivity tests show that the outcomes are not sensitive to these averaging assumptions, except at very high discount rates.

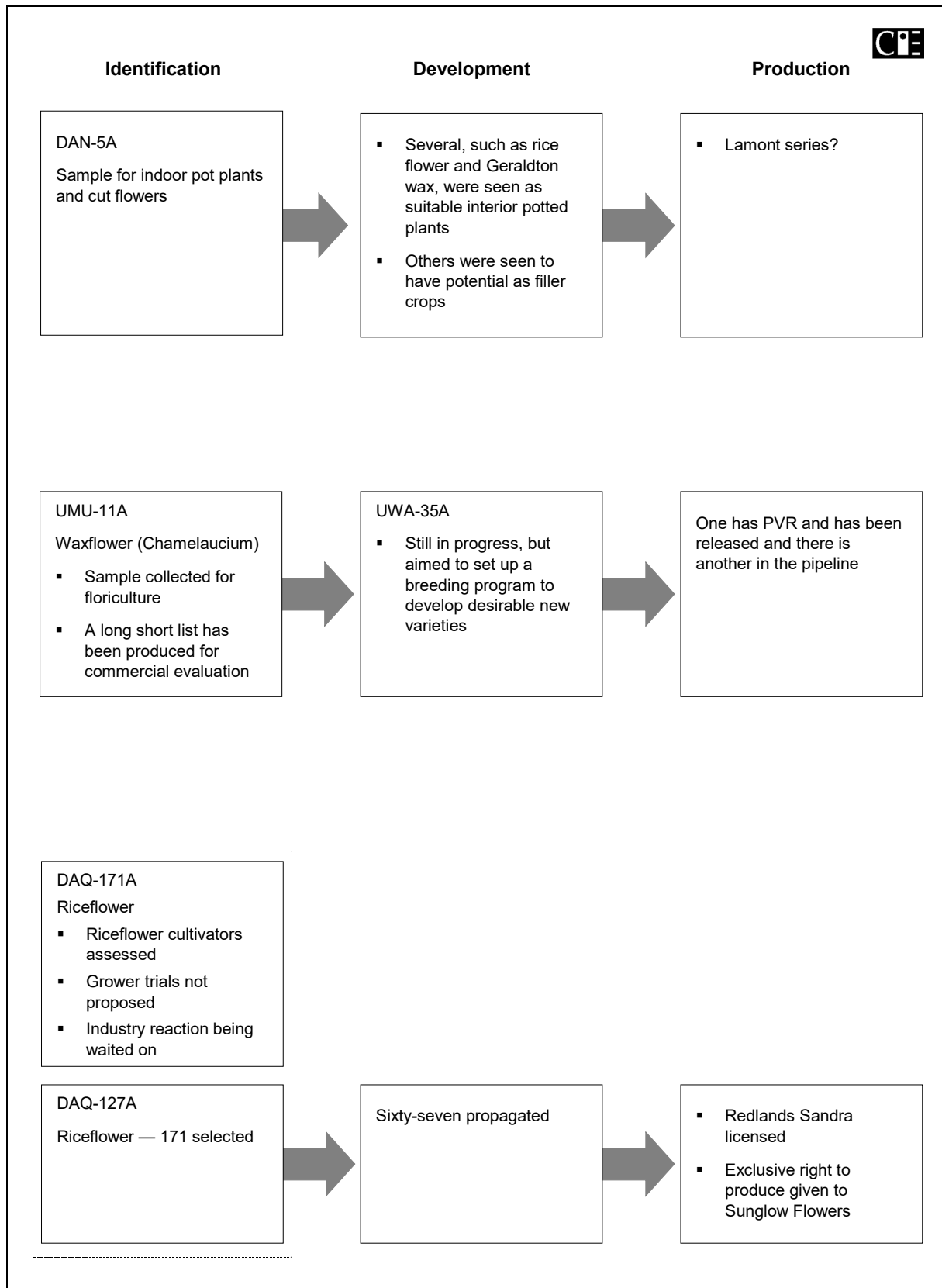
The production of these new flowers is assumed to crowd out production of existing flowers. Production costs (excluding project costs) are assumed to be the same as producing the traditional varieties. The without scenario is that no premium will be earned on these flowers and production of other flowers goes on as before. The effect on market share is considered in the next section.

Table 2.4 gives the NPV and BCR of the set of projects at four discount rates. Even at a zero rate of discount the cost of conducting the projects is not quite compensated for by the premiums earned on the new flower varieties, with an IRR close to zero. Clearly, for such research to payoff there must be an impact on market share.

Table 2.5 gives the IRR, BCR and NPV under several different assumptions to test the sensitivity of the results to the assumptions in table 2.3. To achieve a positive net present benefit at the 8 per cent discount rate, we must have underestimated the premiums and volumes by almost 100 per cent.

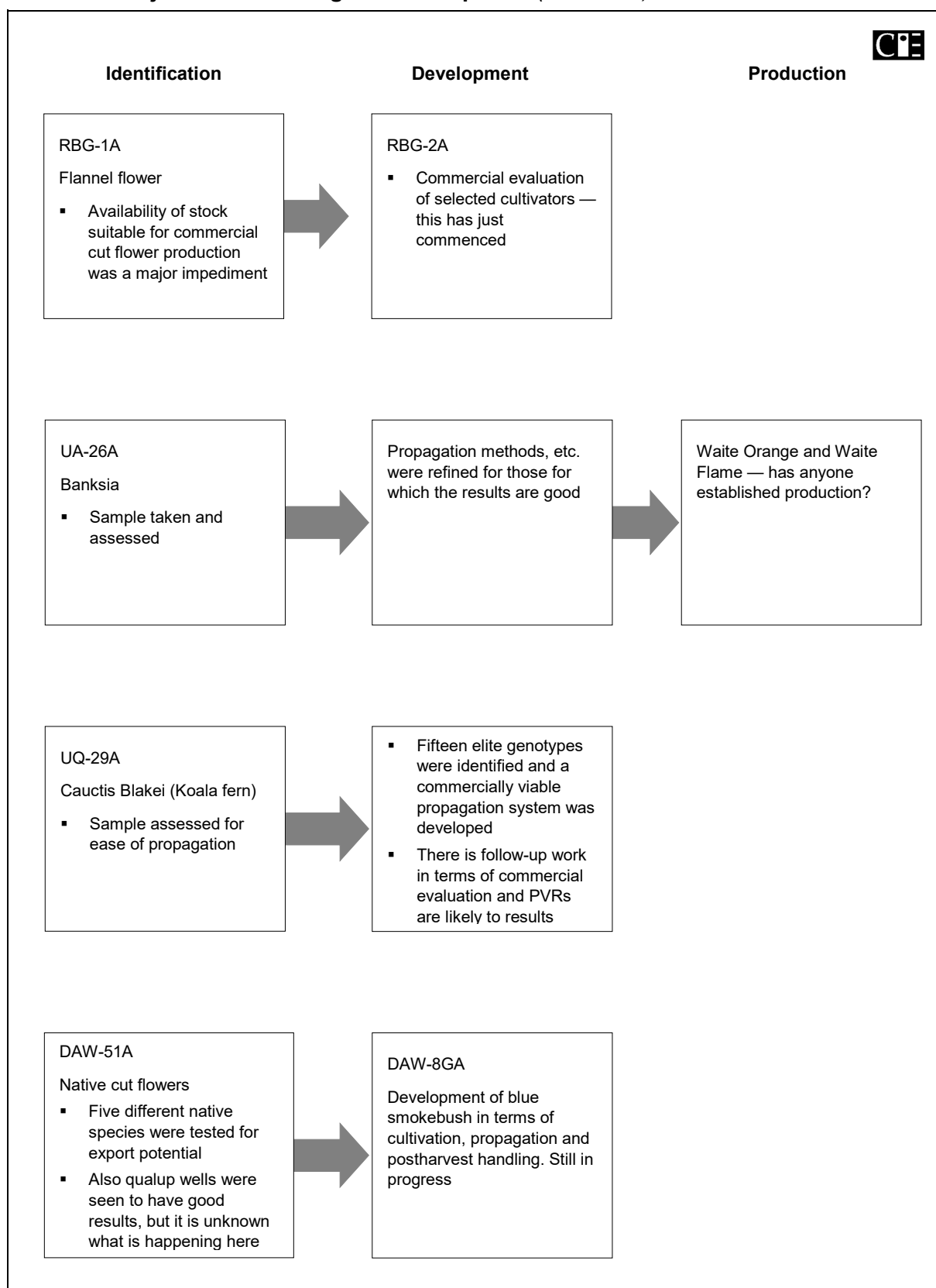
There are a few individual flowers where there is a positive NPV — the premium pays for the research. Table 2.6 summarises the returns to the individual projects.

Chart 2.5 Projects and the stage of development



(Continued on next page)

Chart 2.5 **Projects and the stage of development** *(continued)*



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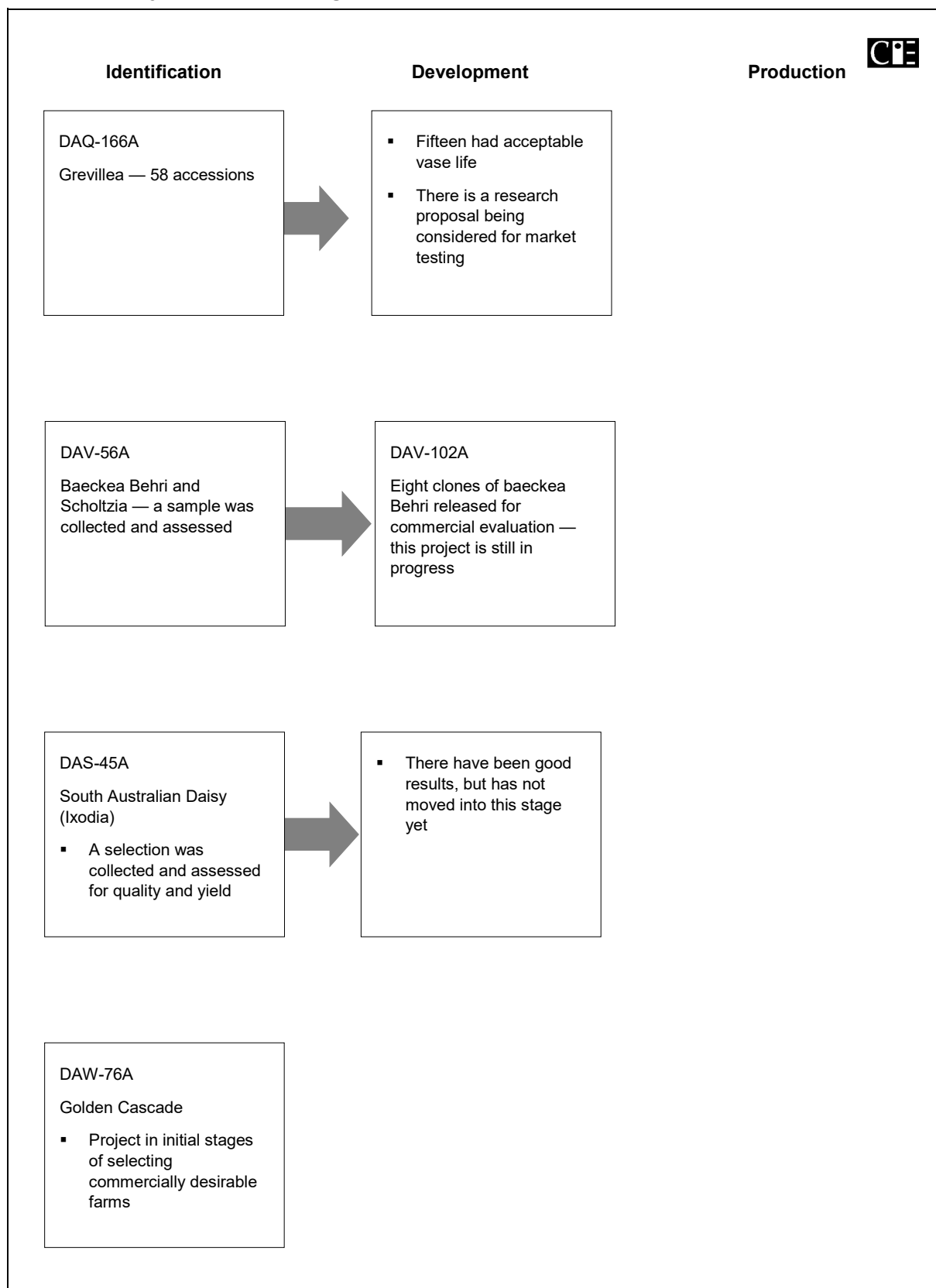
Chart 2.5 **Projects and the stage of development** (*continued*)(*Continued on next page*)

Chart 2.5 **Projects and the stage of development** (*continued*)

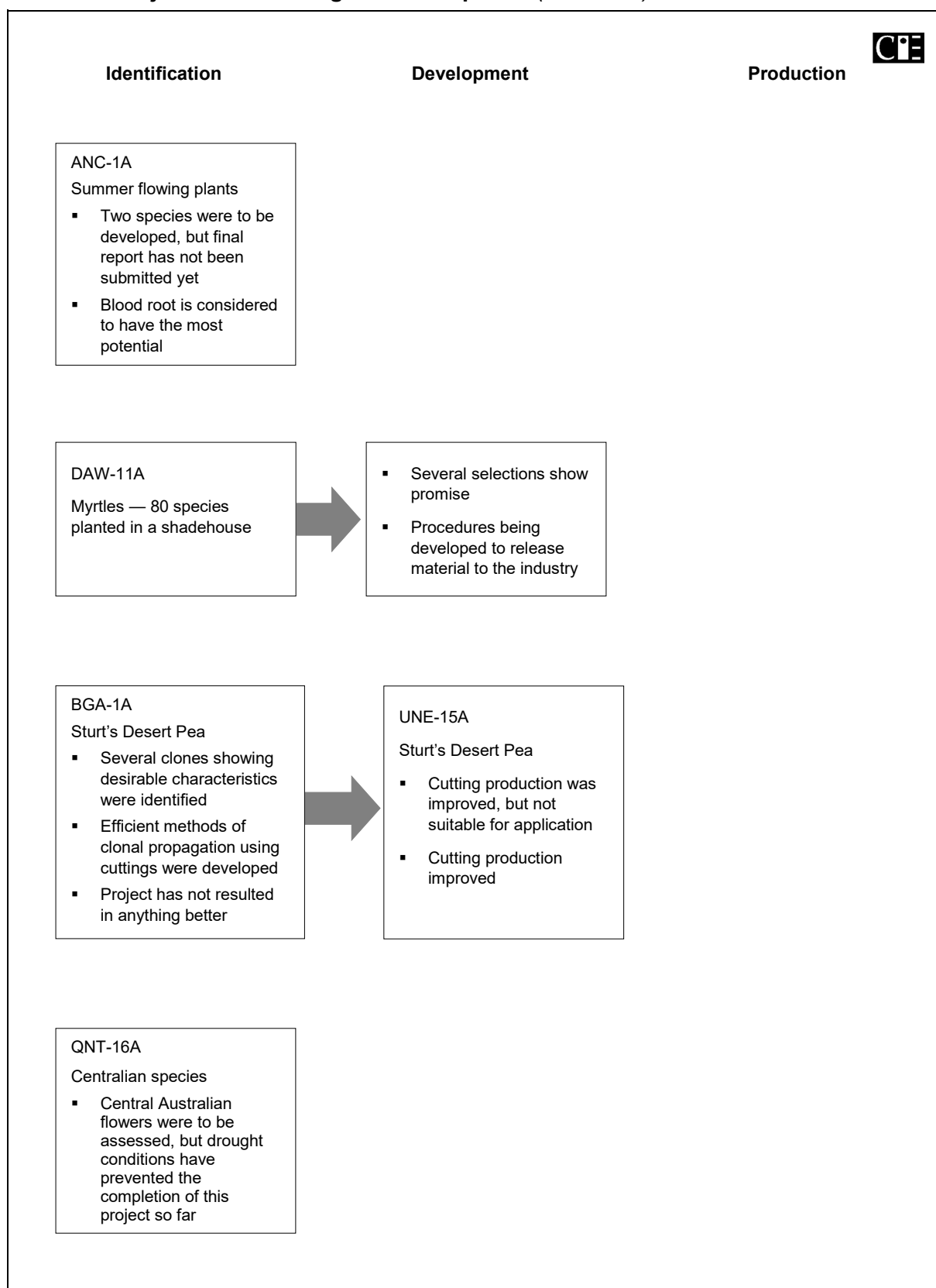


Table 2.4 Net benefits based on the impact of premiums only

<i>Discount rate</i>	<i>PV Benefit</i>	<i>PV Cost</i>	<i>BCR</i>	<i>NPV</i>
1997-98 dollars	\$ million	\$ million	\$ million	\$ million
0%	6.33	6.37	0.99	-0.04
5%	5.15	7.53	0.68	-2.39
8%	4.62	8.40	0.55	-3.79
10%	4.32	9.07	0.48	-4.75
IRR			0.0%	

Source: CIE estimates based on assumptions in table 2.4, and costs table 2.3.

Table 2.5 Sensitivity of estimates to assumptions

<i>Discount rate</i>	<i>Increase premium or production by 100%</i>		<i>Bring forward production by 4 years</i>	
	<i>BCR</i>	<i>NPV \$m</i>	<i>BCR</i>	<i>NPV \$m</i>
0%	2.0	6.3	1.0	0.0
5%	1.4	2.8	0.8	-1.3
8%	1.1	0.8	0.7	-2.1
10%	1.0	-0.4	0.7	-2.7
IRR	9%		0%	

Source: CIE estimates.

Table 2.6 Returns on individual flowers

	<i>IRR</i>	<i>At 0% PV cost</i>	<i>Discount rate</i>		
			<i>At 8 per cent — BCR</i>	<i>NPV at 1997-98</i>	<i>NPV at start of project</i>
Waxflower	16%	772 991	1.3	0.31	0.12
Riceflower	-25%	980 858	0.3	-0.86	-0.32
Flannel flower	-6%	395 890	0.4	-0.28	-0.19
Banksia	19%	383 606	2.3	0.65	0.41
Koala Fern	-1%	427 978	0.5	-0.28	-0.19
Smokebush	-15%	630 853	0.2	-0.58	-0.39
Grevillea	12%	207 435	1.3	0.1	0.0
Baeckea	7%	697 234	0.9	-0.07	-0.04
SA daisy	-18%	467 565	0.1	-0.45	-0.36
Golden cascade	5%	161 129	0.7	-0.04	-0.04
Blood root	0%	301 183	0.5	-0.18	-0.12

Note Grevillea costs include the development costs of \$200 000 over a four year period.

Source: CIE calculations (full results in table A2).

- Assuming the early sale of new varieties of waxflower were contributed to by the early project DAN-5A, which led to the Lamont series, the wax projects have had a good return. The IRR is estimated at 16 per cent.
- Riceflower does not appear to have had the early payoff found for new wax varieties. As a result of the long lag between the research and market outcomes and low premiums the riceflower R&D has not had a positive payoff, with an IRR of –25 per cent.
- Flannel flower was identified as attracting a good premium if stem length was achieved. However, relatively modest expected production resulted in an estimated IRR of –6 per cent.
- Koala fern (*Cautis Blakei*) has reached commercial evaluation and is expected to be a winner for producers with propagation rights. However, modest volumes result in a loss situation despite the longer period of premium. The IRR is estimated at –1 per cent.
- The stage 2 project on smokebush is still under way. The long lag between the initial research and the low volumes expected result in a poor expected outcome. The IRR is estimated at –15 per cent.
- *Grevillea* is yet to enter the second stage. This is expected to cost around \$200 000 over four years, so while their costs were not included in the overall estimates they are for the individual flower. With the extra development costs *Grevillea* returns 12 per cent based on low volumes and a moderate premium on a high average value.
- *Baeckea* has had very mixed reviews. The researchers involved love it, but marketers are less certain. The researcher estimates of 6 million stems at a premium are optimistic as wax is around double the volume and only new varieties command a premium. Assuming *Baeckea* commands a 50 per cent higher average price than wax, and new varieties double the new variety premium, and a volume of 1 million stems, the project returns 7 per cent.
- The South Australian daisy (*Ixodia*) has yet to reach stage 2 of development and it is not clear that it will. The average price is expected to be low, and volumes modest. The project has a negative return of –18 per cent.
- Bush picked Golden cascade has performed very well in the Japanese market, commanding higher premiums on the average bush picked flowers. This flower is assumed to command the highest premium, but production is limited because of growing requirements and market limitation. Without any stage 2 expenditure the IRR is 5 per cent.
- Blood root (*Hemodorum*) is the main flower identified in the project. Most growers and wholesalers were not familiar with the flower. Volumes are expected to be modest, but a good premium on a good average price is expected. The IRR for the project is estimated at zero.
- Projects on Myrtles, Sturt's Desert Pea and Centralian species do not appear to be likely to produce market outcomes.

Effect on market share

We run three scenarios for the export market and two for the domestic market, then two combined scenarios. These are summarised in table 2.7. The effect of these new variety projects is assumed to have commenced its rise in 1994-95, to peak in 2002-03 and decline to zero by 2024-25.

To estimate the effect of these changes in revenue we need to understand the effect of such changes in volume on the costs of production. The industry has comparatively low entry to exit costs so new production should be available at a similar cost to current production. The effect on surplus depends on variable costs. The reports on the industry find that the returns to growers vary considerably, with growers attaining high and consistent quality product achieving good returns, but other growers earning low returns. Based on this and the best practice estimates in Karringal, we assume that producer surplus is 25 per cent of revenue represented by the triangle in chart 2.4.

Table 2.7 Assumptions about change in market share without new varieties

	<i>Impact</i>	<i>1994-95</i>	<i>1998-99</i>	<i>2002-03</i>	<i>2010-11</i>
Scenario 1	Domestic	1	2.5	5	2.5
Scenario 2	Domestic	1	5	10	5
Scenario 3	Export	1	2.5	5	2.5
Scenario 4	Export	1	5	10	5
Scenario 5	Export	1	10	20	10
Scenario 6	Domestic	1	2.5	5	2.5
	Export	1	5	10	5
Scenario 7	Domestic	1	5	10	5
	Export	1	10	20	10

Source: CIE assumptions.

Table 2.8 Impact under different scenarios about market share

	<i>Discount rate</i>	<i>1997-98 dollars at:</i>	<i>0%</i>	<i>5%</i>	<i>8%</i>	<i>10%</i>	<i>IRR%</i>
Scenario 1	BCR		1.6	1.1	0.8	0.7	6
	NPV	\$ million	4.1	0.5	-1.4	-2.6	
Scenario 2	BCR		2.3	1.4	1.1	0.9	9
	NPV	\$ million	8.1	3.2	0.9	-0.6	
Scenario 3	BCR		2.5	1.5	1.1	0.9	9
	NPV	\$ million	9.3	3.6	1.0	-0.6	
Scenario 4	BCR		3.9	2.2	1.7	1.4	14
	NPV	\$ million	18.5	9.3	5.6	3.4	
Scenario 5	BCR		6.8	3.8	2.7	2.3	19
	NPV	\$ million	36.9	20.9	14.7	11.4	
Scenario 6	BCR		5.8	3.2	2.3	1.9	17
	NPV	\$ million	30.6	16.4	11.0	8.0	
Scenario 7	BCR		14.3	7.2	5.0	4.0	24
	NPV	\$ million	84.7	47.0	33.8	27.2	

Source: CIE estimates.

Table 2.8 shows the impact on producer surplus of new flowers under the different scenarios. The estimates include the premiums.

For the wildflower industry (growers and wholesalers) the IRR on the new varieties is estimated at 17 per cent based on maintaining up to 5 per cent higher market share in the domestic market, and up to 10 per cent higher market share in the export market than would be the case without new varieties (scenario 6). If up to 10 per cent of the domestic market and up to 20 per cent of the export market is forgone, the IRR captured by the growers is 24 per cent (scenario 7).

However, RIRDC is concerned with domestic, rather than grower, welfare. The higher share of wildflowers crowds out traditional flowers grown domestically. The return to Australia (based on premiums and export returns) is 14 per cent for maintaining up to 10 per cent higher export market share, and 19 per cent if export market share is 20 per cent higher than without the projects.

Conclusion

The figures in table 2.8 suggest that the without scenarios — decline in market share — must be quite severe for the new variety projects to have a significant payoff for Australia. If scenario 4 is the ‘best bet’ — market share loss of 10 per cent in the export market in the without scenario — then the NPV of this set of 22 RIRDC projects is \$5.6 million at an 8 per cent discount rate, giving a BCR of 1.7:1 and an IRR of 14 per cent.

3 Agroforestry: cost reduction in farm tree establishment

Project description

The project UNA 16A *Cost Reduction in Farm Tree Establishment* commenced in July 1989 and the final report was delivered in April 1993. RIRDC and Greening Australia jointly funded the project, with considerable contributions in-kind from landowners in the region. Over the four year period the estimated total cost of the project is \$461 000, with RIRDC providing \$116 557 (25 per cent).

The project investigated a variety of approaches to reducing the cost of tree establishment. The focus was on planting and direct seeding, although regeneration was also examined. The main conclusion was that costs could be substantially reduced by planting speedlings and by using a mechanical planter — the Chatfield planter. A few traditional inputs — in particular, sawdust mulch — were demonstrated not to provide any significant benefit in terms of establishment rate.

The project was a second stage in the Eucalyptus Regeneration Program that had been developed following a widespread dieback of native trees in the New England Tablelands region in the 1980s. The first stage concentrated on regeneration, and was funded by RIRDC's predecessor, ASRRF.

Farm tree establishment in the New England region

Trees are planted for a variety of reasons and may well provide benefits to the broader community as well as to the landowner. In the New England Tableland region the focus is more on landcare and shade and shelter than wood production. The ABARE survey of trees on farms found that in the wheat-sheep zone in New South Wales 98 per cent of respondents planted trees for shade and shelter purposes, 54 per cent for land rehabilitation and 35 per cent for conservation. Only 10 per cent planted trees for other wood products (for example, firewood and fence posts), 8 per cent for fodder, and 1 per cent for sawlogs.

Tree establishment was conducted predominantly by farmers in the 1980s. Tree planting by farmers slowed from 1991 to 1994 due to the rural recession and drought, which reduced funds available for tree planting. However, small landowners, with nonagricultural income sources, expanded their planting activities. In the last few years farmers have increased their tree planting activity, and it is estimated that in the New England area 42 per cent of farmers are in a Landcare group. In regions with active groups the participation rate is around 70 per cent.

Trees in the region are largely planted as shelter belts, and prior to the 1980s consisted mainly of pines. The main land use activity is grazing, predominantly sheep for wool production. The main benefit of trees is seen to be from shelter belts, which provide shelter for stock.

Reductions in wind speed lower lambing and shorn sheep losses and calorie requirements (Bird and Cayley (1991), Violler (1991)). Bulman (1991) estimated that production of wool rises by 5 per cent, fat lamb production up to 15 per cent and lamb losses are 10 per cent lower than the case without shelter belts. The landcare benefits of the shelter belts can also raise pasture productivity in adjacent areas. Very little tree planting is for wood production, although some farm wood and firewood may be harvested from the shelter belts.

In the 1970s the Tablelands area suffered from considerable dieback of native vegetation. This provided an impetus for research into regeneration, which highlighted the need for improved procedures to reduce the cost of establishing farm trees. Over the past decade there has been a huge change in the attitude of farmers toward planting trees. This has been the result of:

- improved understanding of the role of trees in landcare and benefits of shelter which has led to include tree establishment in farm planning;
- incentives to establish trees through a variety of schemes, including landcare funding through the NHT (incorporating the *One Billion Trees Program* and *National Landcare Program*), Bushcare, Farm Forestry Programs by DPIE and the Joint Venture on Agroforestry to tax deductions of tree establishment costs; and
- falling costs of establishing trees.

This project was one of the first that focused on reducing the cost of farm tree establishment. It set up a protocol that combined extension with research by involving farmers in trials and their monitoring and evaluation. This protocol has been used in other projects — for example, the farm forestry cost reduction project conducted by Dorrigo Greening Australia. By raising awareness of the possibilities and developing the skills of the farmers the project also increased adoption rates of other cost reduction technology, such as the use of hycose which are similar to seedlings.

Opportunity costs

To estimate the net benefit of tree establishment, we need to establish the without tree establishment scenario.

There are three main components.

- Trees reduce the area available for stock and cropping, imposing costs. Reduction in grazing area is the main outcome in New England. This lowers stock carrying capacity, reducing returns from the traditional land use. However, this would be offset to some extent (and estimates suggest more than offset [CIE 1996]) by increased yields due to lower losses during lambing and lower calorie requirements from additional shelter.
- The additional funds spent on establishing trees could have been spent elsewhere. The appropriate cost of such funds is the interest cost if the funds were borrowed, or the returns on the alternative use if the funds were from cash reserves. The lending rate is a reasonable proxy for this. However, where the net benefits stem is discounted by the market rate of interest this is effectively taken into account.

- The funds spent on the R&D project should be costed at the returns from the alternative use. Within RIRDC this would have been the next best project application to the agroforestry program that failed to be funded. For Greening Australia, and the landowners who made contributions, this would be their next best alternative use of the funds.
- Generally the ‘without’ scenario is assumed to be the status quo. In this case the without scenario is an increase in the number of trees planted because of the increasing interest in reversing the clearing practices of the past, and the commitment of organisations such as RIRDC and Greening Australia to promote farm forestry. It is reasonable to assume that alternatives to this project would have had a similar impact in terms of promoting the establishment of trees in the region.

Estimating the impact

- Chart 3.1 describes the possible flow of benefits to arise from the project. In the region there are likely to be substantial benefits from the establishment of trees such as improved stock yield and benefits flowing from landcare, though very little benefit in terms of future timber production.

Estimates of these benefits are not included in the analysis. The contribution of the project in terms of additional trees is estimated to be very small because:

- the price elasticity of demand for tree establishment is relatively inelastic — although highly income elastic. Farmers tend to adopt a target number of trees for planting each year;
- there are substantial financial incentives for planting trees — tax and subsidies — that distort demand in complex ways;
- there have been a variety of sources of lower costs, of which the project contributes a relatively small share particularly in the later years; and
- there are many non-price influences that have greatly increased the numbers of trees planted.

Our approach to estimating the net benefit of the project is described in chart 3.2. The overall reduction in cost plays a part in increasing the number of trees planted, but it is small relative to other drivers of demand. The project contributes only a small share of the price effect. The price elasticity of demand for trees is assumed to be 0.1. The major impact of the project in each year is the contribution to the fall in unit costs — represented by the downward shift in the supply curve — by the number of trees planted. The contribution of the project to the number of trees is included, with the contribution represented by the small triangle on chart 3.2.

Chart 3.1 Outcomes of the project

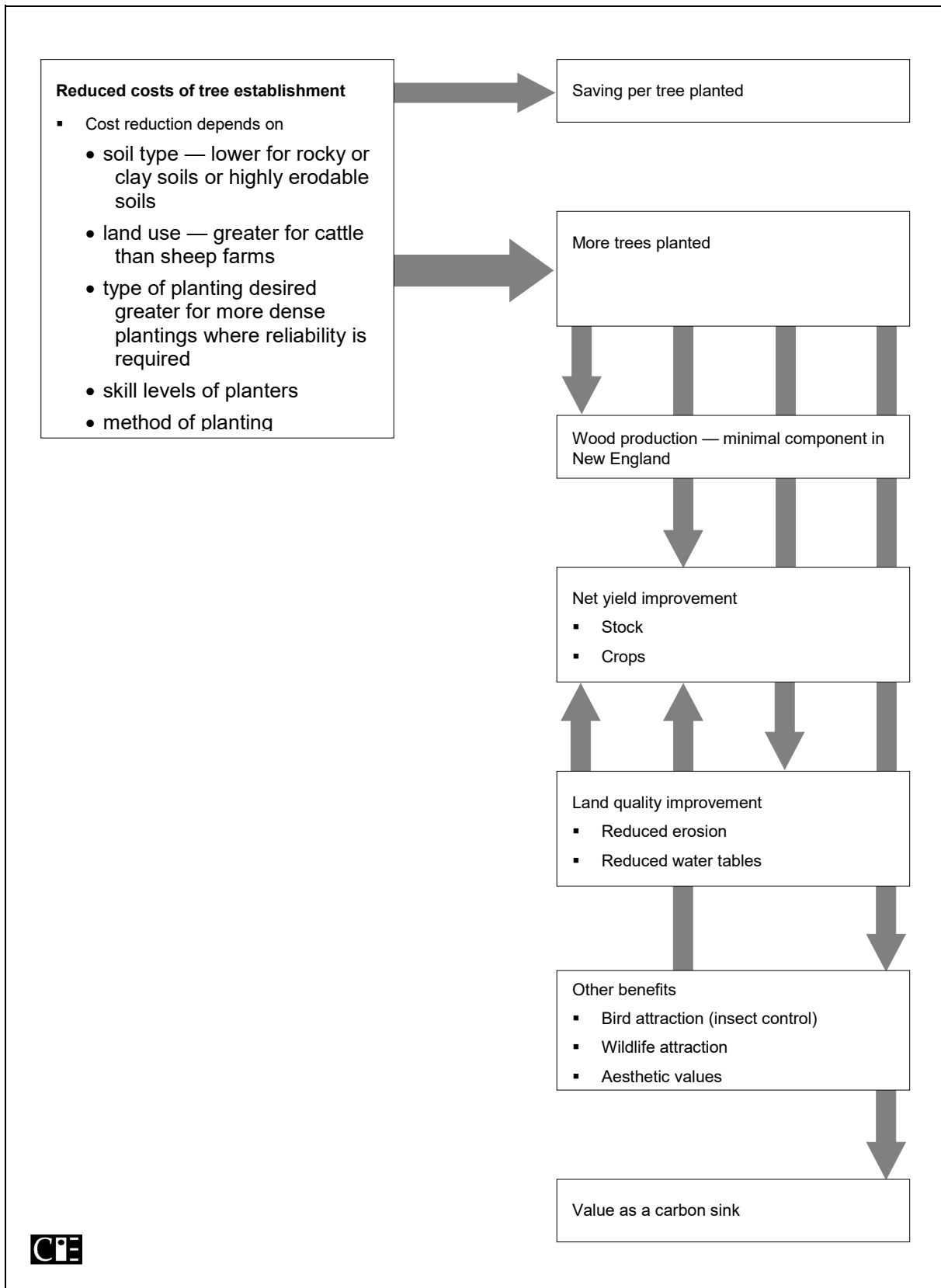
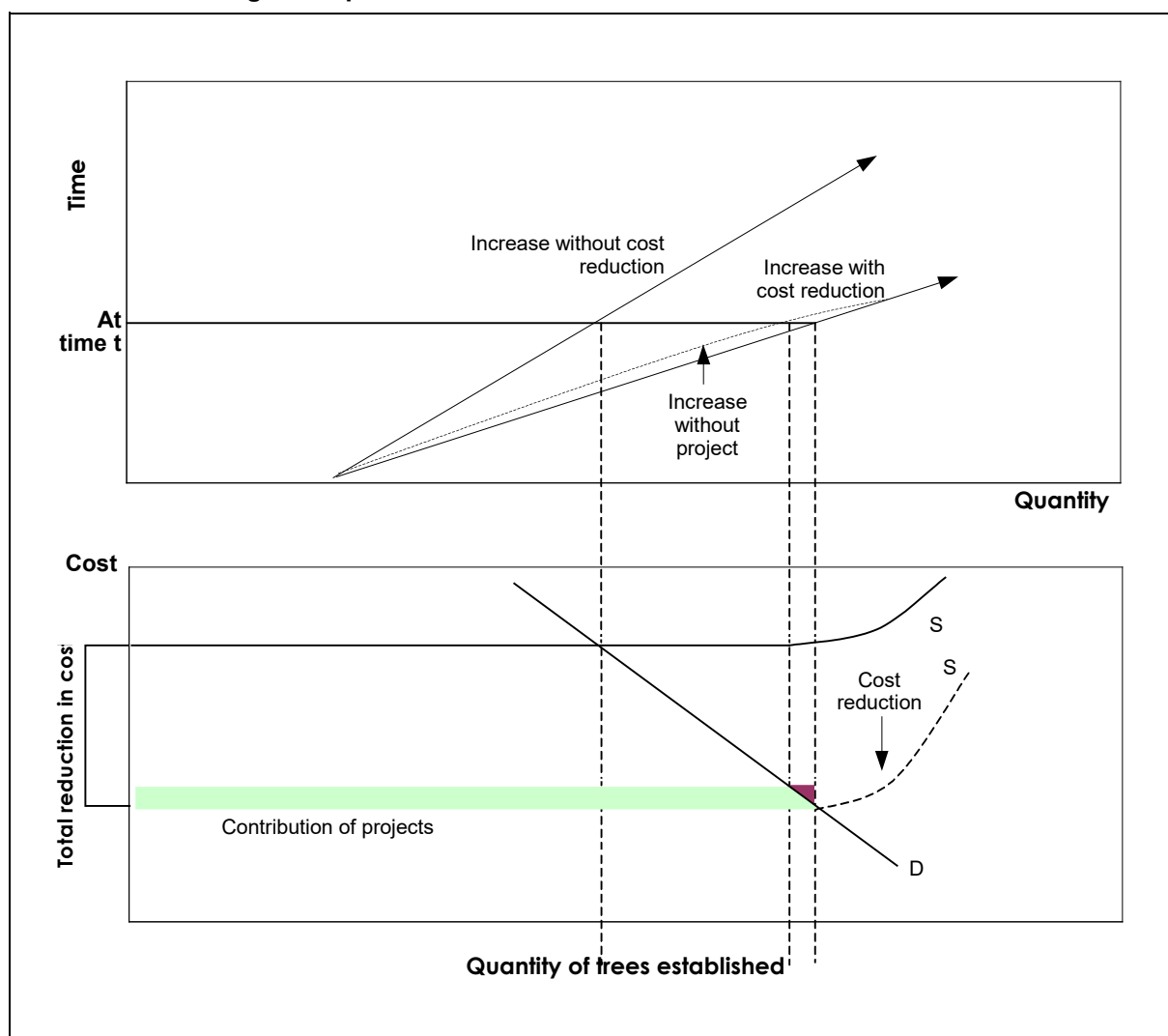


Chart 3.2 Estimating the impact



Project inputs

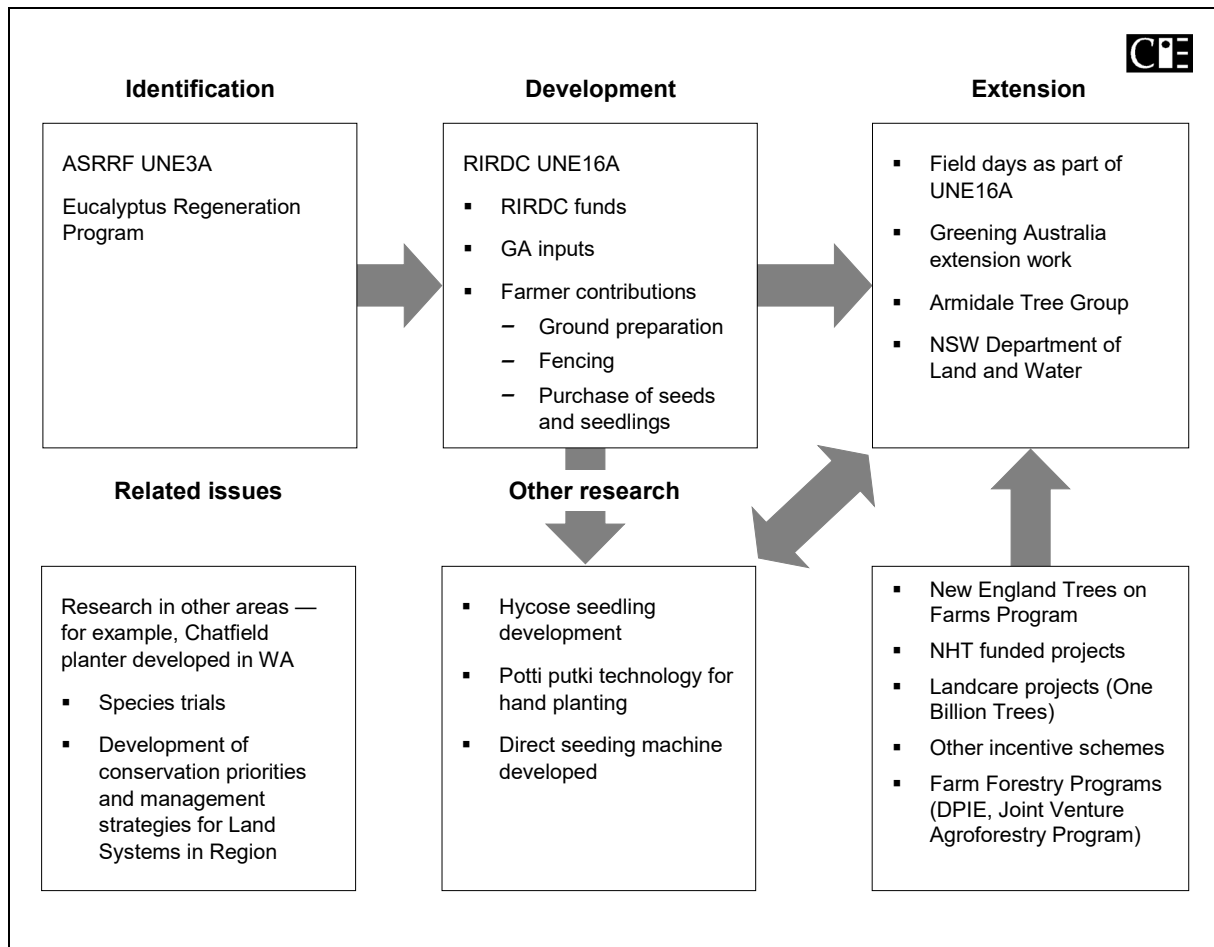
Table 3.1 summarises the direct project costs that include contributions from Greening Australia and in-kind contributions from landowners.

Table 3.1 Direct costs

	1989-90	1990-91	1991-92	Total
RIRDC	45 254	49 250	22 053	116 557
Industry	54 528	49 560	4 000	108 088
Research organisation	94 612	42 000	99 720	236 332
Total	194 394	140 810	125 773	460 977

Source: RIRDC files.

Chart 3.3 Project inputs and related developments



One of the features of the project was the widespread involvement of farmers in the trials, combining research with extension. Since the completion of the project, promotion of the findings has been largely through personal communication by people involved in the project:

- the Armidale Tree Group who raise seedlings and undertake contract planting — Richard Morsley;
- extension work by Greening Australia — David Curtis;
- field days by the Department of Land and Water — Chris Nadolny; and
- dissemination by farmers involved in the project through Landcare groups and other contacts.

Project inputs and related developments are described in chart 3.3. There have been a number of complementary developments that have increased the number of trees planted, raising the returns to cost reduction, and other projects and developments that have also contributed to lowering the cost of tree establishment.

Project outputs

- Projects such as this project and the associated extension activities also raise awareness of the benefits of farm trees. This raises the level of tree planting activities and perhaps the rate of growth. This project is only a relatively small part of the overall program and cannot be attributed with a large share of the increase in tree planting activity, so all the benefits flowing from the higher level of tree planting should not be attributed to the project. However, the saving in establishment costs for these additional trees from the cost reduction techniques developed in the project is a major benefit.

Results

The project examined the inputs to tree establishment and conducted trials to determine the optimal level or type of input.

The main findings are summarised in chart 3.4.

The approach taken in the project of combining research and extension, and the subsequent employment of the key researchers in a variety of influential positions, led to widespread dissemination of the knowledge gained. This raised interest in achieving further cost reductions and stimulated ongoing development of lower cost tree establishment methods.

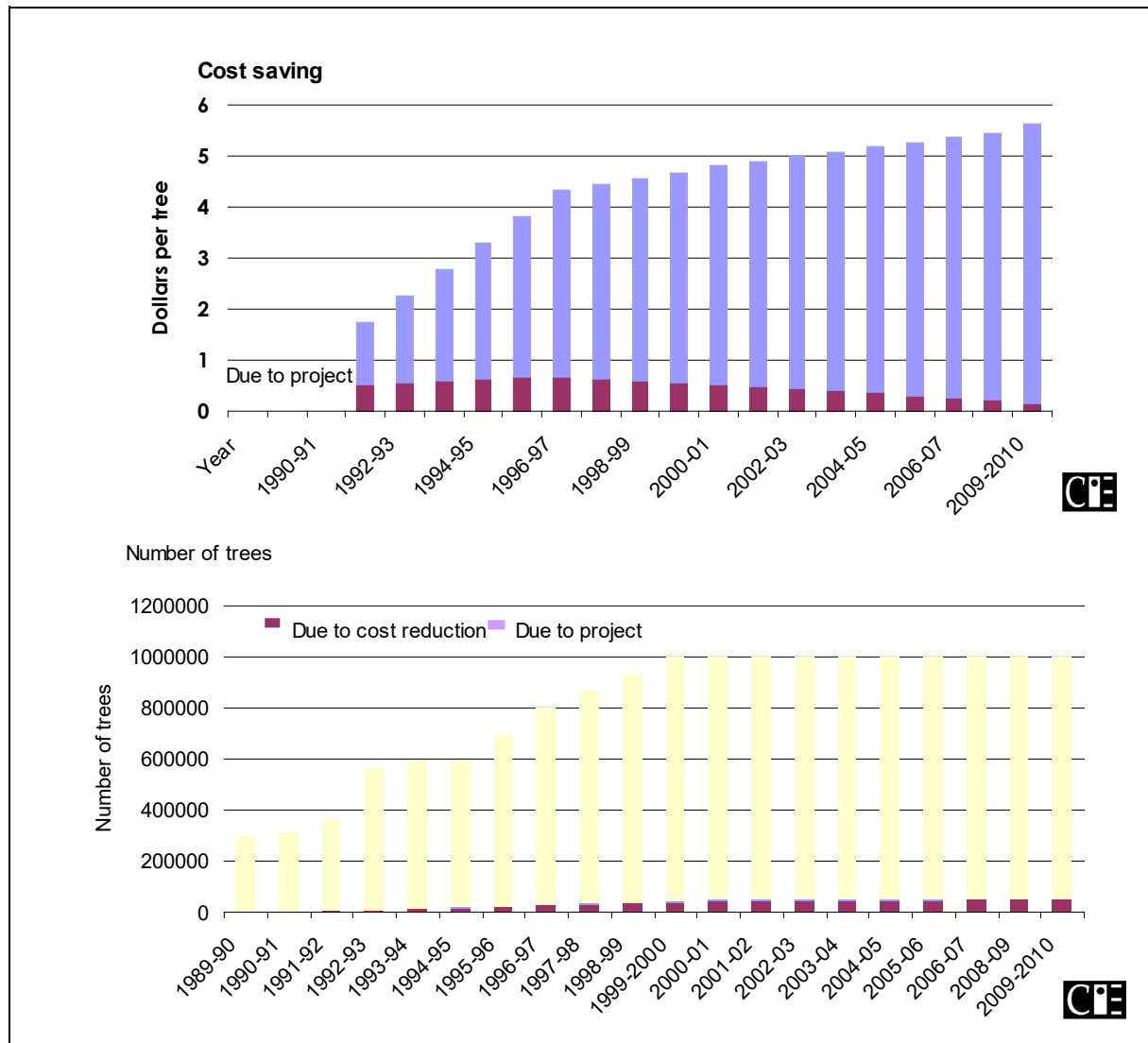
Impact on total cost of tree establishment

The cost saving delivered by the project varies depending on:

- the approach taken to tree establishment; and
- the contribution of the project to the fall in costs of that approach.

We identify four approaches influenced by the project to establishing trees. Table 3.2 summarises the different components of the four approaches. The baseline is the traditional approach. The fourth approach has two final average costs as success rates depend on operator skill. The costings were developed based on information provided by Greening Australia, North West Landcare, Department of Land and Water (Armidale) and the Armidale Tree Group.

Chart 3.4 Cost saving



Data source: Greening Australia; CIE estimates.

Table 3.2 Costs of establishing trees

	Unit	Volume	Cost \$ per unit	Total cost \$
Method 1: speedlings and hand planting				
Speedlings	Tree	200	0.30	60.00
Labour — planting	Tree	200	0.38	76.80
Fencing	M	200	2.80	560.00
Site preparation	Hrs	4	15.00	60.00
Mulching	Tree	200	0.50	100.00
Guards and stakes	Tree	200	0.14	28.00
Total cost				884.80
Survival rate	%			0.90
Cost per tree established				4.92

(Continued on next page)

Table 3.2 Costs of establishing trees (*continued*)

	<i>Unit</i>	<i>Volume</i>	<i>Cost</i> \$ per unit	<i>Total cost</i> \$
Method 2: speedlings and machine planting				
Speedlings	Tree	200	0.30	60.00
Labour — planting	Tree	200	0.27	54.86
Fencing	M	200	2.80	560.00
Site preparation	Hrs	1	15.00	15.00
Mulching	Tree	200	0.50	100.00
Guards and stakes	Tree	200	0.14	28.00
Total cost				817.86
Survival rate	%			0.80
Cost per tree established				5.11
Method 3: hycose and hand planting no mulch				
HIKO	Tree	200	0.40	80.00
Labour — planting	Tree	200	0.10	19.20
Fencing	M	200	2.80	560.00
Site preparation	Hrs	6	15.00	90.00
Mulching	Tree	0	0.50	0.00
Guards and stakes	Tree	0	0.14	0.00
Total cost				749.20
Survival rate	%			0.80
Cost per tree established				4.68
Method 4a: hycose and hand planting (mulch)				
Landcare group				
HIKO	Tree	200	0.40	80.00
Labour — planting	Tree	200	0.48	96.00
Fencing	M	200	2.80	560.00
Site preparation	Hrs	2	15.00	30.00
Mulching	Tree	200	0.50	100.00
Guards and stakes	Tree	200	0.14	28.00
Total cost				894.00
Survival rate	%			0.85
Cost per tree established				5.26
Method 4b: hycose and hand planting (mulch)				
Unskilled farmer				
HIKO	Tree	200	0.40	80.00
Labour — planting	Tree	200	0.48	96.00
Fencing	M	200	2.80	560.00
Site preparation	Hrs	2	15.00	30.00
Mulching	Tree	200	0.50	100.00
Guards and stakes	Tree	200	0.14	28.00
Total cost				894.00
Survival rate	%			0.50
Cost per tree established				8.94
Method 5: traditional practices				
Tube stock	Tree	200	1.00	200.00
Labour — planting	Tree	200	0.77	153.60
Fencing	M	200	2.80	560.00
Site preparation	Hrs	4	15.00	60.00
Mulching	Tree	200	0.50	100.00
Guards and stakes	Tree	200	0.14	28.00
Total cost				1101.60
Survival rate	%			0.50
Cost per tree established				11.02

Source: CIE estimates.

Traditional approach

The traditional approach to establishing trees involved planting tube stock by hand into ground that had been prepared by ripping and spraying for weed control. The plants were watered and surrounded by sawdust mulch. Guards made from milk cartons or Gro-tubes were held in by stakes, and the area was fenced to exclude stock. Success rates were about 40 to 50 per cent on average, although some farmers achieved much higher success rates. Higher success rates were experienced with pines and other exotics and these tended to be the species of preference.

An estimate of the cost of establishing trees in this manner in the early 1990s was \$2.50 to \$3.00 per tree, excluding fencing costs. Average costs at the time of the project were tube stock cost of \$1.20, labour costs of \$1.60, and mulch cost estimated to be around \$0.50 per tree. Labour costs included ground preparation that could be reduced with the use of a machine planter. Milk carton guards and stakes currently cost 14 cents per tree. Not all trees would have been planted with these guards. Gro-tubes at 80 cents each were more expensive than the milk carton guards.

Today some people still follow the traditional method of planting. The cost of the tube stock has fallen slightly, and the success rates are higher for native stands. More native stands are planted, partly in response to improved understanding of the species that perform well, and partly to a greater emphasis on native revegetation to encourage wildlife, particularly birds that can assist in pest control. The project contributed to starting lists of species that perform well in the region. Nurseries now provide appropriate mixes of tree and shrub species that are suited to specific conditions (Landcare personal communication).

Method 1: speedlings and hand planting

The approach developed in the project used speedlings, which are younger versions of tube stock and considerably cheaper. Their survival rate was shown to be similar to tube stock given appropriate handling. The cost of the speedlings at the time of the project was \$0.32, and they now sell for around \$0.30.

The other developments were improved procedures that raised success rates. Success rates of 70 to 80 per cent were achieved with hand planting of speedlings in prepared ground.

Since the project there has been substantial improvement in the rate of hand planting — the number of plants planted in a day. At the time of the project the labour cost of hand planting was \$1.60 a plant. This has fallen to as low as \$0.40 excluding ground preparation costs, based on the Armidale Tree Group's team of four people planting 1000 speedlings a day using trowels (at an hourly wage of \$12). The project contributed to this fall in costs only indirectly as a stepping stone to further development of hand planting techniques and improved skill levels.

Method 2: speedlings and machine planting

The project introduced the Chatfield planter. A farmer in the region (and involved in the project) had developed a tree planting machine in the mid-1980s and had been planting between 20 000 and 70 000 trees a year for landowners (Curtis, Nadolny and Ford 1995). The Chatfield planter was found to deliver higher success rates than this machine.

The main advantage of the planter was the saving in ground preparation (particularly weed control), and the faster rate of planting. The record of planting was more than 1400 trees planted and guarded by a four man crew in a single day, which gave a labour cost of labour \$0.60 a tree. The machine was suitable for all friable soils that were not very rocky, and reasonably flat.

There are currently four tree planting machines operating on the area — two are Chatfield planters. The Armidale Tree Group hires out the Chatfield planter at \$10.00 per hour.

Method 3: HIKO and hand planting — no mulch

The current popular approach is hand planting of a seedling that is more mature than the speedling, but less mature than tube stock. HIKO have been introduced to the region by one of the farmers involved in the project. They are slightly larger than speedlings (at around 2-4 inches compared with speedlings at around 1 inch) and 25 per cent more expensive (40 cents rather than 30 cents). The main reason for their popularity relative to the speedling is availability — more nurseries provide them — and they are considered to be more robust.

Very rapid planting rates can be achieved with the use of a *potti putki*, which is a hand planting device from Finland. With careful ground preparation one person can plant up to 1500 hycose a day. This does not include mulching, or placing guards and stakes around the plant.

Ground preparation requires planning and this is often the barrier rather than cost. The area must be ripped, sprayed, and redone after about three months. For a shelter belt of 200 metres by 15 metres actual time required for ground preparation is only around 1 to 2 hours — however, set up time is probably similar so there are substantial economies of scale in preparation for larger areas.

Method 4: HIKO and hand planting — mulch

With excellent ground preparation and kind weather conditions mulching and guards are not required for high success rates. But guards make the difference between success and failure in hot dry weather, and mulch raises survival in areas where rainfall is more uncertain and retaining soil moisture more difficult. While the project found that mulching did not raise success rates significantly it is still common practice. The cost of mulching is around \$0.50 cents a tree.

Costs of tree establishment under the different methods and operators

The success rate in tree establishment depends very much on the skills of the planter. Good ground preparation makes hand planting quicker and more effective. The Armidale Tree Group attains success rates of 90 per cent, while farmers in the active Landcare groups expect success rates of 85 per cent or better. Unskilled planting achieves success rates for natives of 40 to 50 per cent, slightly higher for pines. Unskilled farmers are assumed to mainly follow method 4 in tree planting. A small and declining proportion use tube stock and traditional methods.

The costs per tree for tree establishment are given in table 3.2. These are based on an average planting of a shelter belt of 200 metres by 15 metres for ground preparation, and planting of 100 trees and 100 shrubs with existing fencing along one side. As fencing costs are the same for all methods this has no impact on the cost saving, but is included to provide an estimate of actual cost per tree (or shrub). The costs given reflect the cost of fencing to exclude sheep.

Of the 800 000 trees planted on the Tablelands in 1996-97 about 40 per cent are planted by professional tree planting groups, around 30 per cent by skilled farmers, and the other 30 per cent by unskilled farmers. The split between trees and shrubs is about 50:50, with eucalyptus as the main tree, and acacia as the main shrub. The extent of direct seeding and regeneration is not known, and is not included in these estimates. The impact of this project on their costs was minimal.

For the purpose of assessing the contribution of the project we assume that only the Armidale Tree Group is using speedlings. Machine planting is relatively low because of the smaller areas. With four machines up to 200 000 trees could be planted annually by machine. The actual share in 1996-97 was around 10 per cent.

The cost savings in method 3 are available only to a few farmers willing to put in the effort of ground preparation. At most, the share is 5 per cent. Skilled farmers and professionals have adopted method 4a. In 1996-97 around 40 per cent of trees were planted using this method. This is likely to rise over time as more farmers join Landcare groups and attain skills. Most unskilled farmers have adopted hycose technology over tube stock, with commensurate savings. The assumption is that about 25 per cent of plantings were by method 4a in 1996-97, and 10 per cent were performed using traditional methods (no cost savings). This will continue to change over time as more farmers join Landcare groups and the average level of skill in tree establishment rises. Table 3.3 summarises these assumptions about adoption.

All the approaches have benefited in differing ways on the results of the project. The contribution of the project to the achieved reduction in cost for each of the different approaches is summarised in table 3.4. As the cost of establishing trees has fallen over the past five years we build this into the share of cost reduction that can be explained by the project.

Table 3.3 Assumptions about the adoption of different methods

	<i>Share planted</i>				<i>Total influenced</i>	<i>Traditional methods</i>	
	<i>Method 1</i>	<i>Method 2</i>	<i>Method 3</i>	<i>Method 4a</i>	<i>Method 4b</i>		
1991-92	5.0	10.0	1.0	10.0	10.0	36.0	64.0
1992-93	5.0	11.0	1.8	16.0	13.0	46.8	53.2
1993-94	5.0	12.0	2.6	22.0	16.0	57.6	42.4
1994-95	5.0	13.0	3.4	28.0	19.0	68.4	31.6
1995-96	5.0	14.0	4.2	34.0	22.0	79.2	20.8
1996-97	5.0	15.0	5.0	40.0	25.0	90.0	10.0
1997-98	5.0	15.0	5.0	42.5	23.8	91.3	8.8
1998-99	5.0	15.0	5.0	45.0	22.5	92.5	7.5
1999-2000	5.0	15.0	5.0	47.5	21.3	93.8	6.3
2000-01	5.0	15.0	5.0	50.0	20.0	95.0	5.0
2001-02	5.0	15.0	5.0	52.2	18.3	95.6	4.4
2002-03	5.0	15.0	5.0	54.4	16.7	96.1	3.9
2003-04	5.0	15.0	5.0	56.7	15.0	96.7	3.3
2004-05	5.0	15.0	5.0	58.9	13.3	97.2	2.8
2005-06	5.0	15.0	5.0	61.1	11.7	97.8	2.2
2006-07	5.0	15.0	5.0	63.3	10.0	98.3	1.7
2008-09	5.0	15.0	5.0	65.6	8.3	98.9	1.1
2009-10	5.0	15.0	5.0	70.0	5.0	100.0	0.0

Source: CIE assumptions based on discussions with Landcare and other groups.

Table 3.4 Impact of project on the cost saving provided by the different methods

	<i>Speedling: method 1</i>	<i>Mechanical: HIKO 1: method 3 method 2</i>	<i>HIKO 2</i>		
				<i>Method 4a</i>	<i>Method 4b</i>
	% impact	% impact	% impact	% impact	% impact
1989-90	0	0	0	0	0
1990-91	0	0	0	0	0
1991-92	50	50	20	10	5
1992-93	48	48	19	9	5
1993-94	45	45	18	9	5
1994-95	43	43	17	8	4
1995-96	41	41	16	8	4
1996-97	38	38	14	7	4
1997-98	36	36	13	7	4
1998-99	34	34	12	6	3
1999-2000	31	31	11	6	3
2000-01	29	29	10	5	3
2001-02	26	26	9	5	3
2002-03	24	24	8	4	2
2003-04	22	22	7	4	2
2004-05	19	19	5	3	2
2005-06	17	17	4	3	2
2006-07	15	15	3	2	1
2008-09	12	12	2	2	1
2009-10	10	10	1	1	1

Source: CIE assumptions based on discussions with Landcare and other groups.

Estimating the impact

- The approach taken is to disaggregate the trees planted by the level of cost reduction. In this way we can assume that for all the trees planted in a particular category they experience the same cost reduction. This is akin to assuming a parallel shift in the supply curve. The cost saving is assumed to apply to all trees planted in the category.

Based on the assumptions described in the previous section, table 3.5 gives the cost saving per tree for each method of planting resulting from the project.

The next step is to estimate the effect of the fall in the cost on the demand for establishing trees. From 1989-90 to 1997-98 the total number of trees planted is based on information provided by Greening Australia on the number of seedlings sold in the region. Chart 3.3 demonstrates the impact of the total change in price on the number of trees planted. The change in total costs relative to the baseline is estimated. This is used to estimate the impact on the number of trees planted. The impact of the falling cost rises over time as the demand curve is shifting out due to other factors. The project contributes a falling share of the cost saving and, hence, a falling share of the additional trees planted.

Chart 3.3 Impact of the project and falling costs on the number of trees planted

Table 3.6 gives the estimates of the stream of net benefits from the project. The NPV and BCR is presented in table 3.7. The IRR of the project is 59 per cent. At a discount rate of 8 per cent the BCR is 8:1, which is an excellent outcome for the project. The high returns are due to the substantial reductions in cost delivered by the project, and the rapid adoption of one of the influenced methods of tree establishment.

Table 3.5 Implied per tree cost saving resulting from project Cost savings

	<i>Method 1</i>	<i>Method 2</i>	<i>Method 3</i>	<i>Method 4a</i>	<i>Method 4b</i>
1988-89	6.10	5.90	6.33	5.76	2.08
1989-90	0.00	0.00	0.00	0.00	0.00
1990-91	0.00	0.00	0.00	0.00	0.00
1991-92	3.05	2.95	1.27	0.58	0.10
1992-93	2.91	2.81	1.20	0.55	0.10
1993-94	2.76	2.67	1.13	0.51	0.09
1994-95	2.62	2.54	1.05	0.48	0.09
1995-96	2.48	2.40	0.98	0.45	0.08
1996-97	2.33	2.26	0.91	0.42	0.08
1997-98	2.19	2.12	0.84	0.39	0.07
1998-99	2.05	1.98	0.77	0.36	0.07
1999-2000	1.90	1.84	0.70	0.33	0.06
2000-01	1.76	1.70	0.63	0.30	0.06
2001-02	1.61	1.56	0.56	0.27	0.05
2002-03	1.47	1.42	0.49	0.24	0.05
2003-04	1.33	1.29	0.42	0.21	0.05
2004-05	1.18	1.15	0.35	0.18	0.04
2005-06	1.04	1.01	0.28	0.15	0.04
2006-07	0.90	0.87	0.20	0.12	0.03
2008-09	0.75	0.73	0.13	0.09	0.03
2009-10	0.61	0.59	0.06	0.06	0.02

Table 3.7 Results

	<i>PV Benefit</i>	<i>PV Cost</i>	<i>BCR</i>	<i>NPV 1997-98</i>	<i>NPV 1989-90</i>
	\$	\$		\$m	\$m
0%	7 045 001	460 977	15.3	6.6	6.58
5%	6 528 327	653 890	10.0	5.9	3.79
8%	6 374 913	800 719	8.0	5.6	2.79
10%	6 324 761	913 914	6.9	5.4	2.29
IRR	59%				

Source: CIE estimate.

Sensitivity of results

To assess the sensitivity of the results to the assumptions we ran a number of scenarios. The results are summarised in table 3.8. We examine three alternative scenarios, and then combine them.

- If the cost reduction delivered by method 4b is assumed to be the baseline rather than the traditional method for estimating the cost saving, the BCR is 3.3 at a discount rate of 8 per cent, and the IRR is 43 per cent.
- If we include additional costs of extension work of \$100 000 a year for the years 1992-93 to 1995-96, the BCR falls to 5:1 at 8 per cent, and the IRR is 51 per cent.
- If we assume that the contribution of the project to the methods is only half of our previous estimate, the IRR is still high at 35 per cent, and the BCR is 4:1 at the 8 per cent discount rate.

Table 3.6 Estimate of net benefit

<i>Year</i>	<i>Number of trees planted</i>	<i>Benefit estimate</i>	<i>Net benefit</i>
	No.	\$	\$
1989-90	300 000	0	-194 394
1990-91	310 000	0	-140 810
1991-92	360 000	186 464	60 691
1992-93	565 000	318 449	318 449
1993-94	590 000	354 555	354 555
1994-95	590 000	372 351	372 351
1995-96	700 000	457 878	457 878
1996-97	800 000	535 387	535 387
1997-98	866 667	550 633	550 633
1998-99	933 333	560 021	560 021
1999-2000	1 000 000	563 175	563 175
2000-01	1 000 000	524 723	524 723
2001-02	1 000 000	484 087	484 087
2002-03	1 000 000	442 087	442 087
2003-04	1 000 000	398 721	398 721
2004-05	1 000 000	353 987	353 987
2005-06	1 000 000	307 885	307 885
2006-07	1 000 000	260 411	260 411
2008-09	1 000 000	211 565	211 565
2009-10	1 000 000	162 622	162 622

Source: CIE estimate.

Table 3.8 Sensitivity analysis

	<i>Baseline: method 4b</i>		<i>Additional extension costs</i>		<i>Half contribution</i>		<i>All cases</i>	
	<i>BCR</i>	<i>NPV \$m</i>	<i>BCR</i>	<i>NPV \$m</i>	<i>BCR</i>	<i>NPV \$m</i>	<i>BCR</i>	<i>NPV \$m</i>
		\$m		\$m		\$m		\$m
0	9.9	4.1	8.2	6.2	7.7	3.1	2.7	1.4
0.05	6.5	3.6	5.8	5.4	5.0	2.6	1.9	1.0
0.08	5.2	3.3	4.8	5.1	4.0	2.4	1.6	0.7
0.1	4.5	3.2	4.3	4.9	3.5	2.3	1.4	0.6
IRR	43.0%		51.0%		35.0%		17.0%	

Source: CIE estimate.

If all these assumptions are imposed, the IRR is still a very healthy 17 per cent, and the BCR falls to 1.6 at the 8 per cent discount rate. The range of NPV at 8 per cent for these scenarios is from \$5.6 million to \$0.7 million.

Conclusion

The project *Cost Reduction in Farm Tree Establishment* was one of the first projects to focus on lowering costs of establishing trees on farms. The focus was on establishment of native trees and shrubs in the New England Tablelands region, following a dieback in native vegetation in 1960s and 1970s. The project combined research and extension in a cost-effective manner and identified a variety of cost saving techniques.

The attitudes to tree establishment have changed dramatically over the past decade, with an increasing willingness to plant trees, particularly for shade and shelter for stock and for Landcare. The reduction in costs identified by this project supported the trend toward establishing trees, but cannot be accredited with increasing the number of trees established, as other cost reduction projects would have been undertaken in response to a strong demand. As the project was one of the first, and developed several protocols for testing outcomes, it contributed in some way to many other cost reductions. As a result, under conservative assumptions the project yielded an IRR of 59 per cent, a BCR of 8:1 (NPV of \$5.6 million) at an 8 per cent discount rate.

4 Cashew — breeding project

Project description

The set of projects evaluated is associated with the improvement of cashew tree genetic material and making it available to existing and prospective Australian cashew producers. The project was designed to develop hybrid trees providing yields of over four tonnes of nut-in-shell (NIS) per hectare from closely planted trees. This would enable a competitive rate of return to be available to prospective producers and expand Australian cashew production.

The projects included in the analysis follow.

- Project CSH-43A: *Evaluating Cashew Hybrids in Northern Australia.*
- Project CSH-36A: *Genetic Improvement of Cashew through Hybridisation and Evaluation of Hybrid Progenies.*
- Project CSH-8A: *Improving Productivity of Cashew in Northern Australia.*
- Research organisation: CSIRO Division of Horticulture in conjunction with industry.
- Project period: nine years.
- Start date: 1 July 1987.
- Completion date: 30 June 1996.
- Principal investigators: Elias Chacko, CSIRO Division of Horticulture.

Overview of the industry to impetus for research

World production of cashew nuts is a low capital input production system characterised by high labour inputs and low yields of about one tonne of NIS per hectare.

The Australian industry in the late 1980s consisted of three commercial growers, one in each of the Northern Territory, Western Australia and Queensland. The impetus for the development of the industry initially came from CSR Limited who had carried out a similar pioneering development for the macadamia industry. It was not possible for Australian production of cashews to be internationally competitive on the basis of a low input – low output system of production, so that increases in yields through improved genetic material and higher levels of inputs were seen as a way in which an Australian industry could become competitive.

With the advent of growing cashews at Wildman River in the Northern Territory in the early 1980s, several government agencies from Northern Territory, Queensland and Western Australia, in conjunction with three private sector groups and the CSIRO Division of Horticulture, evaluated cashew cultivars existing in Australia (originally imported) as well as introductions from Brazil and India. The material evaluated was derived from a number of sources and was seen as a resource from which high yielding cultivars could be bred. Yields

of five to seven tonnes per hectare were expected under intensive production systems with high planting densities and irrigation and fertiliser inputs using hybrids developed from the selected genetic material

All cashew kernel was imported into Australia at the time the research was instigated. The market for cashews was therefore seen as an import replacement market. The international market determined prices received by Australian producers. Given the envisaged quantities produced in Australia, prices would not have been influenced by Australian production. Entry to the industry was difficult as significant capital investment was required and long periods were involved in the trees developing to the stage where they produced mature yields.

New genetic material would have been the property of the researchers and the three industry organisations associated with the program. The intellectual property rights are currently being clarified and it is unlikely that any of the high yielding hybrid material will escape overseas, at least in the short term.

The R&D was to assist a new industry development in Australia. Without this initiative, there would have been little likelihood of an economically viable cashew industry developing in Australia.

Approach to evaluation

One of the difficulties involved in assessing the returns to research investment for new industries is the question of whether the research will actually induce a new industry to emerge and to what size that industry might grow. If the cost of production is lowered due to the research, the industry becomes more attractive relative to existing resource use and production may increase.

Cashew production from the existing genetic material available in the 1980s would provide only a low rate of return. If the breeding program had not eventuated, it is unlikely that much interest in cashew production would have occurred due to the marginal economics of cashew investment. The approach taken in this evaluation is to assume that with improved genetic material available, the rate of return to cashew investment would increase and attract increased investment in cashew production.

A cashew model employing a direct relationship between farm level rate of return and area likely to be planted was developed and reported on in a report to RIRDC in 1996. This model was used in the current evaluation to provide a linkage between the rate of return using the higher yielding hybrid material and the area of trees likely to be planted in the future.

Investment costs of cashew plantings are taken into account and the ensuing net returns from cashews compared with returns from the existing land use, in this case assumed to be grazing. The benefits from the research are then estimated as the difference between the net cash flow generated from the existing land use and the net cash flow from the cashew investments.

Some trees planted at the two existing plantations (Wildman River and Cashews Australia) are hybrids produced from the breeding program. The third plantation in Western Australia

was abandoned in the early 1990s. It might be assumed some benefits from the breeding program will be derived from these two plantations as well as from new plantings. However, the hybrid trees planted at the existing plantations include both low performing and high performing trees and it is unlikely that the overall average of the hybrids will be much greater than the non-hybrids in these plantations. Further, the Wildman River plantation produced very few nuts over the period 1994 to 1997 and the plantation has only just entered recovery mode after three to four years of neglect due to ownership changes. Less than 10 per cent of the 50 000 trees at Cashews Australia are hybrids.

The project

Objectives

The general objective of the breeding program was to develop cashew genotypes capable of producing 4 tonnes of high quality NIS under plantation conditions by 1994, 5 tonnes by 1997 and 6 tonnes per hectare by 2000. The strategies of the program were to:

- undertake a plant breeding program to improve:
 - yield per hectare of cashew nuts,
 - quality and processability of cashew nuts;
- develop suitable tree breeding compatible rootstocks; and
- develop efficient methods of clonal propagation of both scions and rootstocks.

The specific objectives of the breeding program after 1992 were modified to:

- properly maintain and evaluate the growth performance of the hybrids grown under agroclimatic conditions of three representative sites (Darwin, Dimbulah, and Melville Island); and
- to select high yielding trees having upright growth habit, intensive branching with large numbers of terminals capable of producing medium to large sized nuts (6 to 10 grams) and kernels (over 1.8 grams).

Project costs

An estimate of project costs is given in table 4.1.

Description

Crossing took place over three years from 1988 to 1991 and hybrids from each set of crosses were planted as seedlings or grafts in a number of locations across northern Australia. The crossing was mainly between Brazilian parents with high yields of large nuts and Indian cultivars with desirable tree form.

Table 4.1 Costs for project CSH8A, CSH36A and CSH43A

<i>Year ending June</i>	<i>Project</i>	<i>Total resource cost for the projects^a</i>
		\$
1988	CSH8A	241 257
1989	CSH8A	255 175
1990	CSH8A	257 175
1991	CSH36A	188 912
1992	CSH36A	210 161
1993	CSH36A	228 246
1994	CSH43A	292 394
1995	CSH43A	300 190
1996	CSH43A	340 300

^a Total cost includes cost of resources provided by research provider organisations, RIRDC, and industry.

Source: Agtrans Research.

Field evaluations of growth habit, nut yield and quality were carried out at Dimbulah and Wildman River and superior clones selected for more intensive evaluation.

Major problems occurred at several of the sites: a cyclone destroyed plantings at Weipa, termites caused mortality at Katherine and changes in ownership or interest by the industry cooperators severely limited the Melville Island and Wildman River trials.

After 1994 very little information on individual tree yields was obtained due to the rundown situation at Wildman River. However, sufficient information was compiled to provide some indication of the yields that might be expected from later cloning of the superior hybrids.

Project outputs

Because the recording of the hybrid yields over time was disrupted by a series of ownership and logistical problems, conclusions concerning potential yields that could be obtained from the hybrids are uncertain. Based on the measurements available it would appear that the new genetic material will be a considerable improvement over the material that existed before the initiation of the breeding program. Also, the hybrids not only had higher yields but also higher crackout percentages (percentage of kernel weight recovered to total weight of NIS) and larger kernels than the non-hybrid material available. A price premium over the world market price is therefore expected.

Insufficient information has been generated from the hybrid plantings over the five years from 1989 to 1993 to assume any estimates of future yields from the best of the material with a high degree of confidence. Information on individual tree yields from 1993 and 1994 harvests at Wildman River was unreliable due to severe insect damage, and it is likely that tree yields measured were significantly less than what may have been achieved under ideal management conditions. The highly promising individual tree yields obtained in 1991 and 1992 suggest that there may be the possibility of some trees potentially yielding up to, or even more than, four tonnes per hectare. For example, some of the data recorded in the earlier years indicated the best clones could yield up to 14 kilograms at year four, not inconsistent with mature yields targeted in the general objective of the program.

Individual tree yields demonstrated a high yielding capacity but there would still be the formidable task of actually achieving such potential yields in a plantation situation. For example, the trees measured that gave signs of high potential were individual trees at a young age. How these trees would perform in a closed canopy situation was unknown. Hence, the performance of the hybrids when mature could differ from the potential indicated in early years.

Also, there are various other management activities that might constrain any assumed improved genetic potential being achieved such as fertiliser treatment and pest and disease control. For example, how fertiliser, pruning, irrigation, and pest and disease control technologies might interact with the performance of new genetic material was unknown.

The principal output delivered from the breeding program was that improved genetic material is now available in Australia for commercial cashew production. The previous non-hybrid material was capable of yielding only of the order of two to three tonnes per hectare of NIS and previous studies had shown that this would not provide a rate of return sufficient to attract investment into the industry.

Also, the production of high yielding cashews under intensive conditions was shown to be technically viable, even though a number of production problems existed including control of pests such as insects, termites and flying foxes. The improved quality and size of the kernel from the hybrid trees was also a significant output emanating from the breeding program.

Assumptions for estimating benefits

A reasonable estimate of yields that might be derived from genetic material produced in the breeding program would be 3.5 tonnes per hectare, although there is the possibility that higher yields could be attained if the best material were identified and used, and also the management input was of a high order. A price premium of 10 per cent was assumed over the international market price. As reported earlier the few hybrid cashew trees planted on Wildman River and at Cashews Australia were not included in the analysis as they were only being trialled and would constitute the material from which the improved hybrids would be selected.

Table 4.2 provides a list of principal assumptions used in the analysis.

Table 4.2 Assumptions used in benefit–cost analysis

<i>Item</i>	<i>Unit</i>	<i>Level</i>	<i>Source</i>
Yield with previous genetic material	Tonnes per hectare	2.5	Estimate by Agtrans
Yield with hybrid genetic material	Tonnes per hectare	3.5	Estimate by Agtrans
Cashew price	US\$/kg	0.926	Austrade, India
Price premium for quality	%	10	Estimate by Agtrans
Exchange rate	A\$/US\$	0.73	Average for past six years

Source: Agtrans Research.

Table 4.3 Linkage of real rate of return to areas planted

<i>Assumed IRR to cashew producer</i>	<i>Assumed rate of industry development</i>
	ha cashews planted per annum
Less than 10%	0
10-15%	40
15-20%	150
20-30%	400
Over 30%	500

Source: Agtrans Research.

A key aspect of the analysis is the relationship between the rate of return to investment in cashews and the assumed rate of expansion of the industry. The relationships used in the model are shown in table 4.3.

The cashew model was modified to apply to historical analyses of R&D investment and used to ascertain investment parameters for the breeding program. All costs of investment in a cashew plantation, including the cost of the planting material and the opportunity cost of the land, are included in the model. A discount rate of 5 per cent was used and cost and benefits were included from 1988 to 2017, a period of 30 years. All benefits and costs were expressed in 1998 dollar terms and discounted or compounded to estimate a NPV as of 1998 using a discount rate of 5 per cent.

Results

Based on the assumptions reported above, the NPV of the investment in the breeding program was -\$2.3 million. The BCR was 0.4:1 and the IRR was 2.8 per cent. The rate of return to new investors in cashews increased with the new hybrid material from about 3 per cent to just over 10 per cent. This increased the prospective area from 0 hectares per annum to 40 hectares per annum. This assumption is supported by the projection that a further 240 hectares may be planted in the next few years by Cashews Australia.

Results of sensitivity analysis

The sensitivity of the NPV to two factors was explored. All results refer to discount rates of 5 per cent and a yield of hybrids of 3.5 tonnes per hectare unless otherwise specified. Results are presented in tables 4.4 and 4.5.

Table 4.4 Sensitivity analysis Discount rate

<i>Discount rate</i>	<i>NPV</i>
%	\$m
0	4.2
5	-2.3
10	-5.5

Source: Agtrans Research.

Table 4.5 Sensitivity analysis Yield improvement

<i>Yield level of hybrids</i>	<i>NPV</i>
tonnes per ha	\$m
3.5	-2.3
4	-0.9
4.5	7.8

Source: Agtrans Research.

The large increase in the NPV when the yield increases to 4.5 tonnes per hectare is that the rate of return to investors rises above 15 per cent and an increased area of cashews is assumed to be planted.

Conclusion

The analysis has shown that, given the assumptions made, the breeding program is likely to provide only a low rate of return on investment. In fact, at a 5 per cent discount rate the NPV is negative. Nevertheless, the project has produced improved genetic material compared with that previously available. Further selection and crossing could provide material that produces even higher yields than those assumed in the analysis. As shown in the sensitivity table above, yields of 4.5 tonnes per ha would have provided a significant NPV. Funding bodies are now in a position to consider further investment in a breeding program where much of the hard work may have been already effected. The investment in further genetic improvement may be warranted, but such a decision would depend on a judgment of the degree of further improvement that can be made and other potentially constraining factors in the development of the cashew industry.

5 Cashew — flying foxes

Project description

The project was concerned with reducing the losses of cashew nuts due to flying foxes and was designed to study the habits and practices of flying foxes with the aim of introducing interventions to reduce losses of nuts.

The project assessed within this analysis follows.

- Project NAB3A: *Impact of Flying Foxes on Cashew Yield*.
- Research organisation: Wildman River Plantations Pty Ltd (employing biological consultant with assistance from CSIRO and ANU School of Forestry).
- Project period: three years.
- Start date: 1 July 1988.
- Completion date: 30 June 1991.
- Principal investigator: Maria McCoy, Biological Consultant.

Overview of the industry to impetus for research

Flying foxes were observed to be causing significant but unquantified losses to the principal cashew plantation at Wildman River in the Northern Territory in the late 1980s. It was recognised that practices of exclusion and destruction would not be appropriate. For example, netting as used for control of flying foxes for fruit crops would be prohibitively expensive on a relatively extensive tree crop such as cashews. Hence, other control methods were sought. Before this project was undertaken, no other studies had been conducted on the effect of flying foxes on cashew production or on possible control or ameliorative measures.

The flying foxes did not attack the cashew nut itself — rather, the fruit attached to the nut. The fruit is not exploited commercially in Australian cashew production so the loss of the fruit was not important. However, there was concern that the nut might have been damaged through its association with the fruit. More important, there was concern that large numbers of nuts were being lost to the plantation by the removal of fruit for eating outside the plantation in the native forest areas. Since the economics of cashew production in Australia are dependent on mechanical harvesting, collection of nuts from the forest areas would not have been technically feasible.

The research was aimed at saving cashews that had already been grown and, therefore, increasing the effective yield, thus reducing the cost of production of marketed nuts.

The project

Objectives

The objectives of the project were to:

- establish the impact of flying foxes on cashew yield;
- report on the incidence, biology, and ecology of the flying fox species in the vicinity of Wildman River Cashew Plantations; and
- suggest possible control measures.

Project costs

ASSRC (and then RIRDC) supported the project as well as Wildman River Plantations. An estimate of project costs is given in table 5.1.

Description

The project included a number of components including a population survey of flying foxes in the region as well as observations of their roosting and feeding patterns.

Cashews were marked on the trees and the location of marked nuts and their trees was recorded. Transects were taken into the surrounding forest areas to assess the number of nuts that were taken from the plantation and dropped outside where mechanical pickup would not have been possible. Distances that marked nuts were carried by the flying foxes away from their origin were recorded.

This allowed information to be compiled on what proportion of nuts was being taken away from the cashew trees by the flying foxes as well as the distance traveled before the fruit was eaten and the nut dropped.

Nuts dropped in the forest after fruit was eaten were assessed for fractures. Any damage to flowers on the cashew trees from the foraging of flying foxes was also recorded.

An exclusion experiment was conducted where barriers excluded flying foxes on some cashew trees. Measurement of fallen flowers, buds and fruits was carried out.

Table 5.1 **Costs for project NAB3A**

<i>Year ending June</i>	<i>Total resource costs for the project</i>
	\$
1989	15 000
1990	15 000
1991	15 000

Source: Agtrans Research.

A series of interventions were made including the planting of trees at the side of the orchard (including *Ficus spp* and palms), as well as posts for roosts. The reason for this was to assess whether the flying foxes would use the introduced roosts instead of flying to the forest to find roosting areas for eating the fruit.

Project outputs

Fruit loss was largely the result of flying foxes taking the fruit from the plantation into the adjacent native forest where the edible portion of the fruit was eaten and the nuts allowed to fall to the ground.

As marked cashews were found both within the plantation and under forest trees outside the plantation, it was established that flying foxes carry cashews from the site of production and drop them in both the plantation and in the surrounding forest. The average distance carried was 0.19 kilometres and distances up to 1.21 kilometres were recorded. Competition for feeding roosts within the orchard was the explanation supported from the research.

In 1988 and 1989 it was established that flying foxes did have the potential to cause significant damage to cashew enterprises. In 1989 the estimated loss was 3 tonnes of cashew to the forest for an annual harvest of 9 tonnes. In 1990 the estimated loss was 4 to 5.3 tonnes of nut-in-shell from an expected harvest of 16 tonnes.

It was established that a significant number (in excess of 2 million) of flying foxes came within flying distance of the plantation during the fruiting season. While the findings of the study provided important scientific information on the biology and ecology of two species of flying foxes, it was difficult to estimate the flying fox population response to higher per hectare yields of cashews on the Wildman River Plantation, or to other new plantations that might be established in the region.

The study concluded that the flying foxes did not damage flowers or the nut after the fruit was eaten. In fact, the foraging activity accelerated removal of the cashew fruit which would have been necessary in any case to prepare for the nut pick up.

The most important output from the research was the finding that flying foxes carried fruit for eating to the planted *Ficus spp* trees. Although further R&D investment was recommended, the study concluded that the intervention of planting other trees within the plantation area to provide feeding roosts appeared most promising. Other important information reported was that the flying foxes ate some varieties of cashew fruit and ignored others.

A detailed final report was prepared and the researcher submitted a PhD thesis based on the work undertaken in the project.

The project and its outputs were rated highly by industry members in the review of cashew research projects in 1996.

Assumptions for estimating benefits

During the period 1988 to 1991 the absolute annual yield loss estimated for the plantation due to flying foxes did not vary much although the total yield from the cashew plantation was slowly increasing. Hence, the average loss may not be as high as the 33 per cent or 25 per cent recorded in the study after plantation sizes or yields per hectare increase. Regional populations of flying foxes may change, however, although the case has been made that any immigration into the region may be offset by poorer nutrition (cashew fruit is considered a low quality food resource), the seasonal nature of availability of the cashew fruit, and emigration when higher quality food is plentiful in the forests.

In terms of quantifying the losses from flying foxes and reduced losses from interventions such as edging the plantation with tall trees that have an open canopy, an average of 15 per cent of production may be assumed to be lost, irrespective of the size of plantation or yield per hectare of cashews. It may further be assumed that the planted trees will be 60 per cent effective in enabling the nuts to be retained within the plantation areas where they can be picked up by mechanical sweepers. That is, only 6 per cent of nuts will be lost to flying foxes, a net saving of 9 per cent. This avoided loss is assumed equivalent to a yield increase of 9 per cent.

The cost of planting trees will need to be included in any net benefit analysis. If *Ficus spp* trees are planted at the same time as cashew trees, it is likely that, as the cashew trees commence to yield, the surrounding *Ficus spp* will be effective in providing roosts three years after planting. It is assumed there are no maintenance costs for the edged trees although the areas to be swept at harvest time would increase slightly. Other species of trees may be more relevant to use in other areas of Australia.

Further, the flying foxes are still assumed to eat the cashew fruits, therefore the tree planting technology does not drive flying foxes elsewhere to cause economic loss to other cashew producers, mango or banana producers.

The research has produced an intervention to control economic loss, which is also quite beneficial to the environment and to biodiversity.

The investment analysis for this project has been effected with use of a cashew economic model developed in a study for RIRDC in 1996. Although the Wildman River plantation has some roosting trees planted, it is assumed the Wildman River plantation will plant more roosting trees in the future. It is assumed the Wildman River plantation will return to commercial production in 1999. The plantation in Queensland also had problems with flying foxes and as a result of the project has planted trees to provide roosts.

It has been assumed that the improvement in the genetics for the industry to the yield loss avoided by the roosting trees will stimulate further cashew plantings. The extent of the area increase due to the new hybrid material is estimated through the model as 40 hectares per annum. The linkage between rate of return to investors and the area planted is described in the cashew breeding analysis.

Key assumptions are provided in table 5.2.

Table 5.2 Key assumptions for benefit–cost analysis

<i>Item</i>	<i>Unit</i>	<i>Level</i>
Harvested yield without roosting trees	Tonnes per hectare	3.5
Harvested yield increase with roosting trees	%	9
Period from planting of trees to losses being avoided	Years	3
Cost of planting roosting trees	\$ per 100 hectares of cashew plantation	6 760

Source: Agtrans Research.

The cashew model was modified to apply to historical analyses of R&D investment and used to ascertain investment parameters for the flying fox project. A discount rate of 5 per cent was used and cost and benefits covered a period from 1989 to 2018, a period of 30 years. All benefits and costs were expressed in 1998 dollar terms and discounted or compounded to estimate a NPV as of 1998 using a discount rate of 5 per cent.

Results

The additional yield gain from the flying fox intervention does not sufficiently increase the investment returns to investors for an area greater than 40 hectares to be planted each year as a result of availability of improved genetic material. Hence, the yield losses avoided have been assumed to apply to this new area of cashews as well as the cashew area of Wildman River and Cashews Australia.

Based on the assumptions reported above, the NPV of the investment in the flying fox R&D was \$1.6 million at a discount rate of 5 per cent. The BCR was 20:1 and the IRR was 26 per cent.

Results of sensitivity analysis

The sensitivity of the NPV to two factors was explored. Results refer to discount rates of 5 per cent and a yield loss saving of 9 per cent, unless otherwise specified. Results are presented in tables 5.3 and 5.4.

Table 5.3 Sensitivity of NPV to discount rate

<i>Discount rate</i>	<i>NPV</i>
%	\$m
0	3.0
5	1.6
10	0.9

Source: Agtrans Research.

Table 5.4 Sensitivity of NPV to yield loss saved

<i>Yield loss saved</i>	<i>NPV</i>
%	\$m
3	0.4
9	1.6
18	3.3

Source: Agtrans Research.

Conclusion

The analysis has shown that, given the assumptions made, the development of the intervention of providing additional roosting trees to minimise competition between flying foxes for roosting areas within the plantation area is associated with a high rate of return. The corresponding relatively low NPV is due to the fact that, given existing technology, the cashew industry in Australia is only likely to grow quite slowly — and, hence, the magnitude of the losses saved is not overly high. The benefits from this R&D will fall principally to Australian producers of cashews.

6 Tea tree — breeding

Project description

The following analysis refers to a set of three projects supported by RIRDC associated with the improvement of genetic material used in tea tree oil production in Australia. The first two projects in this group gave confidence that the principal breeding project should go ahead and provided valuable information for the third project, the breeding program, which commenced in 1993. The thrust of all projects was to breed and select trees with increased yields of high quality tea tree oil and make improved genetic material available to the Australian industry. The projects included the following.

- Project CSF43A: *Breeding Strategy for Genetic Improvement of Melaleuca Alternifolia*.
- Project ANU11A: *Genetic Variation in Oil Production and Quality in Tea Tree*.
- Project DAN87A: *Improving the Tree Yield Through Breeding and Selection*.
- Research organisations: NSW Department of Agriculture in conjunction with CSIRO Division of Forestry to Forest Products and Australian National University.

Overview of the industry to impetus for research

Background

The Australian tea tree oil industry has demonstrated strong growth over the past decade. Demand for tea tree oil has expanded through extended uses as well as geographically around the world so that the price to Australian producers has remained relatively stable despite significant increases in supply. While commercial production of tea tree oil in other countries is nonexistent or extremely small at present, the Australian industry is aware that producers in other countries are likely to enter the world market in the future so that the need to be internationally competitive is a high priority industry strategy.

Improvements in the genetic potential of commercially producing plants is well recognised as a key aspect of increasing productivity of plant industries in Australian agriculture. Given the imperative of the tea tree industry remaining internationally competitive, the potential for making productivity gains through selection and breeding was pursued within the RIRDC tea tree oil R&D program.

Objectives

The objective of the breeding program (DAN87A) were to:

- increase oil yields in new seedling plantations by 30 per cent in five years with a 60 per cent increase at conclusion of the first generation of breeding, about year 2000;

- ensure that oil produced was of consistent desirable quality;
- establish a broadly based breeding population to enable flexibility and ongoing improvements; and
- identify and make available superior oil producing clones suitable for mass vegetative propagation.

The projects

The first of these three projects (CSF43A) was completed in 1992. This project investigated the feasibility of a plant improvement program in tea tree to improve productivity while retaining quality. The study suggested that progressive gains were likely to be made as a result of a breeding program and recommended a dedicated fund be established for tea tree oil breeding, a breeding program commence, a seed production area be established and work be supported on vegetative propagation.

ANU11A was completed in 1994 and had the objective of defining the degree of genetic variation in tea tree. The project investigated the variation between species and the variation between seed sources. The project confirmed that oil yield and quality were highly heritable. This indicated that a breeding program should be able to produce significant improvements in tea tree oil yields.

DAN87A was completed in 1996 and constituted the first three years of the breeding and selection program. The project concentrated on a widely based breeding population of more than 200 open-pollinated families collected from natural stands. Progressive thinning of the breeding population based on family and individual tree performance was carried out to form a Seedling Seed Orchard.

Results have shown that a significant gain in oil yield could be effected simply by selecting seed from selected natural populations. Significant variation was also exhibited at the family level and a high individual heritability for oil concentration was estimated. The first phase of the breeding program concluded that oil yields could be considerably increased.

As an interim measure some selected seed has been released to industry (1.5 kilograms in 1997), and a further 2.7 kilograms of seed harvested in 1998 will also be released to industry. These releases are expected to provide oil yield increases of about 18 per cent over existing tree yields. This process will continue until the highly improved seed from the Seedling Seed Orchard is obtained. The release of this improved genetic material is likely to occur at the end of this second phase of the project — that is, between 2001 and 2003. The second phase of investment in the breeding program has been approved by RIRDC (DAN151) and is planned to take place from 1996 to 2001.

Approach to evaluation

The evaluation was carried out by assuming that higher yielding trees would emanate after the second phase of the program and that this would provide a cost reduction for the production

of tea tree oil. Key parameters were the increase in oil yield that might occur as a result of the breeding and selection program, and when this might occur. A modified cost-based tea tree investment model constructed in 1995 by Agtrans Research was used to estimate the returns on the investment in the R&D program.

Project inputs

The total project costs for the three projects in question are shown in table 6.1. Costs for the fourth project (DAN151) are also included, as it is apparent this further input is integral to the delivery of the superior genetic material.

Assumptions for estimating benefits

It is assumed that the first generation improvement in the genetic material will be available in the year 2003 and will be available for planting in that year. It is conservatively estimated that this material will be capable of a yield of 40 per cent more than the existing yield of 140 kg per ha — that is, about 196 kg per ha — under conditions of management similar to those currently existing. However, it is possible that the estimate of 60 per cent improvement that has been suggested previously by plant breeders, and the original target of the breeding program, could be reached. It is assumed there will be no additional significant costs to producers planting such material compared with the existing material.

The quantities of seed released of the earlier selected material are only small and, while this seed will contribute to overall industry benefits, the contribution will only be small in relation to the highly improved material expected later. Also, the first set of material from the Seedling Seed Orchard will be released in the year 2000 and could be planted as early as 2001. The second release is expected two years later (2002) and will probably be planted in 2003 and may be double the yield of the material available in 2001.

It is assumed that trees in existing plantations would need replacing every 15 years, although this parameter is uncertain as little experience is available. An even distribution of age over

Table 6.1 Costs for tea tree breeding and selection projects

<i>Year ending 30 June</i>	<i>\$</i>
1991	10 879
1992	11 365
1993	56 438
1994	133 106
1995	125 128
1996	135 201
1997	152 954
1998	158 232
1999	164 826
2000	172 300
2001	179 976

Source: Agtrans Research.

Table 6.2

<i>Item</i>	<i>Unit</i>	<i>Level</i>
Year of availability for planting of highly improved genetic material		2003
Mature yield of existing genetic material	kg oil per hectare)	140
Yield increase expected from genetic material	%	40
Cost of improved seed	\$ per gram	200
Life expectancy of tea tree	Years	15
Proportion of mature yield in first harvest	Year 1	0.5
Proportion of mature yield	Year 2	0.75
Area of tea tree in 2003	Hectares	5000

Source: Agtrans Research.

1 to 15 years is assumed for the trees existing in the year 2001. It was therefore assumed that the new genetic material available in 2001 would be gradually adopted by the existing industry over a period of the next 15 years to the year 2018 when all of the industry is assumed to be using the new genetic material. It is conservatively assumed that in the year 2003 there is approximately 5000 hectares of tea tree under plantation production in Australia.

The cost of production of oil with existing yields and with the new yields was calculated and the cost reduction per kilogram of oil estimated for each year from 2003 onwards. An additional cost of seed for the new genetic material of \$200 per gram was assumed (\$2000 per hectare additional establishment cost). The cost reduction per kilogram for each year was then applied to the original production estimate for each year. Hence, the yield increase was translated into a cost reduction by considering both capital development and operational costs in each year as the old trees are gradually replaced by new trees.

A summary of the principal assumptions is provided in table 6.2.

Results

Benefits and costs were considered over a 30 year period from the first year of R&D investment (1991). All benefits and costs were expressed in 1998 dollar terms. A discount rate of 5 per cent was used and the NPV refers to all costs and benefits discounted or compounded to the 1997-98 year.

The NPV of the R&D investment given these assumptions was \$19 million as of 1997-98 and expressed in 1998 dollar terms. The BCR was 14:1 and the IRR was 23 per cent.

Sensitivity analysis

The key variable in driving the returns to this R&D is the magnitude of the improvement in yield of the new genetic material. Also, as most of the benefits accrue many years after the first R&D investment, the NPV is also quite sensitive to the discount rate chosen. Results of the sensitivity analyses on these two variables are shown in tables 6.3 and 6.4.

Table 6.3 Results of sensitivity analysis of investment criteria to yield increase

Yield increase	20%	40% (base)	60%
NPV \$ million	8	19	27
BCR	6:1	14:1	20:1
IRR %	16	23	27

Source: Agtrans Research.

Table 6.4 Results of sensitivity analysis of investment criteria to discount rate

Discount rate	0%	5% (base)	10%
NPV \$ million	43	19	8
BCR	33:1	14:1	7:1

Source: Agtrans Research.

Table 6.5 Results of sensitivity analysis of investment criteria to period over which existing trees are replaced

Period over which trees are replaced (years)	10	15 (base)	25
BCR	26	19	11
B/C Ratio	20:1	14:1	9:1
IRR %	26	23	20

Source: Agtrans Research.

If trees live to 25 years of age then the rate of uptake of the new genetic material may be slower. On the other hand, if the yield increase of the new genetic material is large enough, existing trees may be replaced before the end of their useful life (earlier than 15 years), thus bringing forward the benefits from the new genetic material. A sensitivity analysis was carried out for this variable and results are provided in table 6.5.

Conclusion

The returns to the investment in the breeding and selection of tea tree oil are likely to be considerable. The estimates made here are likely to be underestimates of the actual benefits as any increases in the area of production of tea tree oil post-2001 are not included in the benefit estimates. Furthermore, the earlier releases of the small quantities of selected seed and the likely first release of the intermediately improved seed in the year 2000 have not been evaluated and may add to the total benefits, even though the magnitude of the improvement would be small.

As most tea tree oil is exported from Australia, a high proportion of any consumer surplus arising from a price fall would be captured overseas. The extent of any price fall due to increasing supply in Australia or elsewhere from increased areas of tea tree, or from increasing yield of Australian tea tree, is difficult to assess as the demand patterns change and the demand for tea tree oil expands. While a trend of slightly decreasing prices has been evident for the past few years, the market has been expanding significantly and absorbing the vast increase in supply. Given this experience it is difficult to assess the elasticities of supply and demand and derive an estimate of producer and consumer surplus from the R&D investment.

7 Boronia — breeding

Introduction to study

Background and origin of study

RIRDC has a wide ranging portfolio of research projects across a number of new and emerging rural industries and multiindustry issues. As part of its management of those research projects, and in view of the requirements for accountability to the providers of funds for the research, RIRDC has a strong interest in the economic outcomes of its research funding.

As a result, RIRDC established a consultancy to undertake a set of benefit–cost analyses for selected projects in the Essential Oils program. That consultancy was carried out by NSW Agriculture in 1996, following a request from RIRDC.

Terms of reference

- Undertake a benefit–cost analysis of the following RIRDC funded projects.
 - UT-2A: Integrated control of pests of boronia crops.
 - UT-5A: Nitrogen and water relations in boronia.
 - UT-10A: Yield and quality of concrete from boronia megastigma (Nees).
 - UWA-16A: Genetic resources of Boronia megastigma for the essential oils industry.
- As appropriate, consult with RIRDC, the research providers and industry representatives to gain an understanding of the objectives, carriage and outcomes of the sponsored projects.
- Provide a written report of the findings of the analysis.

Operation of the study

During the conduct of the consultancy, a number of people were contacted to discuss details of the boronia industry, its research impacts and the research projects to be evaluated. These included the following.

- Department of Agricultural Science, University of Tasmania
 - Professor Bob Menary
 - Dr Hazel MacTavish
 - Dr John Madden
 - Ms Valerie Wayte.
- Essential Oils of Tasmania
 - Ms Lindy Bailey
 - Mr Phil Causon.

- Tasmanian Boronia growers
Mr Rob McEldowney
Dr Lee Peterson.
- School of Agriculture, University of Western Australia
Dr John Considine
Joanne Wann
- Other organisations
Victor Fuchs, Keith Harris and Co., NSW
Kevin Rumble, Bio-Gene Technology, WA.

None of these people bears any responsibility for the views or analysis in this report.

Outline of the report

The report is structured as follows. The next section is a brief description of the known information about the boronia industry in Australia. From that information, some projections of base data are presented for use as the basis for the analysis. In sections 3 to 6, each of the projects is analysed in turn. In section 7, the results are discussed more generally, and in the final section there is a brief summary and some conclusions are drawn.

Boronia industry in Australia

Boronia

The genus *Boronia* (family Rutaceae) is endemic to Australia and includes some of the most desirable plants in the Australian flora. The genus contains about 70 species and one of the more aromatic is *Boronia megastigma* Nees, the brown boronia. Although native to Western Australia, it is found in most parts of Australia and New Zealand as an ornamental.

The plant is a woody shrub, 1 to 2 metres in height, with trifoliate leaves, 10–15 mm in length. It bears strongly scented cup-like flowers that vary in colour from all yellow to dark brown with yellow inside. The flowers develop from the leaf axils and are picked commercially for sale as cut flowers. A unique oil, highly prized by the international flavour and fragrance industry, is distilled from the flowers. *B. megastigma* is now an important essential oil crop for Tasmania. The increasing demands placed on the Tasmanian essential oil industry, especially for boronia oil, from the world perfumery and flavour industries has led to an intensification in the growth of essential oil plants as plantation crops. Floricultural quality and oil production per plant are dependent on high flower yields.

Development of Australia's boronia industry

Australia is the dominant producer of boronia oil. While the industry was originally based on extraction from bush picked flowers in Western Australia, the major source of supply is now

cultivated plants in Tasmania. Commercial production of cultivated boronia is currently being established in Western Australia. Limited production also occurs in New Zealand.

Commercial boronia production commenced in Tasmania in the 1970s, based on a small population of seedlings established about 40 years ago. This industry steadily expanded and by 1991 comprised 55 ha of harvestable crop with a market value of \$0.9 million. An additional 30 ha of crop was expected to be planted in Tasmania before the end of 1992. Co-operative commercial ventures with companies in Western Australia, Victoria and New Zealand have been established.

Boronia is produced as both an absolute (pure oil) and a concrete. Production in 1995 was less than 0.5 t, based on a farm gate price for concrete of \$2500/kg (Peterson and Evans 1996). The flowers are extracted with solvent to produce a high value concrete. Boronia concrete contains many compounds including large amounts of β -ionone and jasmonates that are highly valued in the flavour and fragrance market. The major end use to date is in flavourings, but as production increases the fragrance markets are expected to be developed (Peterson and Evans 1996).

The Tasmanian industry is vertically integrated, centred on Essential Oils of Tasmania. Several clones produced by the University of Tasmania have been released to growers to form the basis of the main crop that is harvested annually. Production is based on the use of specific clones, mechanical planting, cultivation and harvesting, and on rigorously controlled post-harvest procedures and extraction techniques (Peterson and Evans 1996).

The boronia industry in Western Australia is based largely on the collection of flowers from natural populations by bush-pickers. There are quotas for picking sprays and blossom of *B. megastigma*. The quotas have been reduced in recent years due to unusually long and dry summers and an increased incidence of wild fires and prescribed burns that have gone out of control. The bush picking quota was reduced by one-third to 1000 kg of sprays and 2700 kg of blossom in 1995. However, these reduced amounts could not be harvested due to lack of flowering material. Many pickers chose not to take up their quotas and only approximately 900 kg of blossom was harvested. A further 1100 kg was harvested from private land, but the total harvest was not sufficient to meet the current demand for blossom for boronia absolute production. Recent regulations will result in the restriction and eventual banning of this practice because of its detrimental effects on natural populations and on wet lands. Such changes will force the industry to rely on commercially cultivated crops for essential oil production and cut flowers.

Boronia absolute, the crude extract from *B. megastigma* flowers, is currently valued at between \$5000 and \$8000 per kilogram. The absolute is used in cosmetics, high class chypre and fougere perfumes as well as in food flavouring, where it imparts a unique richness to many fruit essences. World consumption for perfumery is about 1 tonne. There is also a larger market for its use as a food additive that is currently met by the use of β -ionone or low grade oils extracted from bush picked flowers. High quality perfumes demand natural oils but this desire is rapidly expanding to include everyday food products. One commercial user (USA) is seeking about 400 kg of oils for this purpose.

Boronia exports from Western Australia were valued at \$63 000 fob in 1992-93 while the total value of boronia exports from Australia was \$236 000 fob in the same year.

Boronia heterophylla has been cultivated for export to Japan for eight years and markets are growing in Singapore, Hong Kong, Taiwan, Europe and Canada. Expansion is likely to occur in the Asian and European markets.

The future of the boronia oil industry will depend on lowering production costs to levels that allow the oil to be sold on a wider range of markets (particularly fragrances) and on adding value by further differentiation of the product during extraction and formulation (Peterson and Evans 1996).

Base data used for analysis

Data on the area, yield and production of boronia for oil production were not freely available from industry sources. As a result, estimates were prepared from the available information and various sources for use in the analysis (table 7.1). Full details of the projected area, yield, production and price are shown in appendix D. An estimated 130 tonnes of flowers were produced in 1996, resulting in approximately 325 kg of absolute (oil), based on a concrete extraction rate of 0.05 per cent and an oil extraction rate of 50 per cent of concrete. There has been substantial growth in area and production in the past eight years. Given the expected upward production trends, flower production is projected to increase to 168 tonnes by 2000, resulting in boronia absolute (oil) production increasing to 420 kg.

The price is estimated to be \$6000/kg for oil, equivalent to \$15.00/kg for flowers. The price is projected to decline by about 6 per cent to \$14.12/t for flowers, because of the expected production increase and an own-price demand elasticity of -5. The value of production is projected to increase to around \$2.37 million in 1996 dollars, compared with the 1996 level of approximately \$1.95 million.

The figures shown in appendix D and summarised in table 7.1 are used for the analysis of future returns from projects, given current information and current technologies. Future Impacts from future research Impacts will be measured from these estimates.

Table 7.1 Summary of boronia industry data 1996

	<i>Unit</i>	
Area harvested	Ha	100
Flower yield	T/ha	1.30
Flower production	T	130
Concrete production	kg	649
Absolute (oil) production	kg	325

Source: NSW Agriculture.

Integrated control of pests of boronia crops

Project summary

- Research Organisation: University of Tasmania, Department of Agricultural Science.
- Researchers: Dr J.L. Madden, Dr R.K. Mensah.
- RIRDC program: *Essential Oils and Natural Plant Extracts*.
- Project number: UT-2A.
- Duration of project: 1987-88 to 1990-91.

Project details

Objective

To develop and introduce an integrated pest management program to minimise losses in oil yield and quality following infestation of the boronia bush by Boronia psyllids *Ctenarytaina thysanura*.

Background

Boronia oil is a high value product much in demand by the international food and flavour industry. However, inability to control Boronia psyllid, despite 10–12 insecticide applications per annum, caused a reduction in yield of 40 per cent on average per year and threatened the viability of the new export essential oil crop.

Research

The basic biology, behaviour and ecology of the pest were identified, and key factors influencing generation survival identified and quantitatively assessed, including the effects of cultural practices.

The application of lower than recommended dosages of the most effective systemic insecticide to boronia stems and not foliage, at a time when parasitoids pupated within mummified hosts, conserved natural enemies by minimising any contact effect. Insecticide applications were reduced from 10–12 to 3 per annum (3-4 to 1 per generation).

The IPM program was four times more profitable than the former conventional program. Boronia growers were kept informed of progress through formal and informal discussions and articles in the industry newsletter.

Outcome

The modified spray program has been adopted by most growers and in some instances the re-established natural control has meant that spraying has not been required. Extension advice to growers is now provided by officers of Essential Oils of Tasmania Pty Ltd.

Economic analysis

Project costs

The total costs of the project were \$209 798, as shown in table 7.2.

Data and assumptions used in analysis

The assumptions used in estimating the benefits of the project are as follows:

- The costs of spray applications.
 - Labour: 2 hours at \$20 per hour.
 - Machinery costs: 1 hour at \$22 per hour.
 - Total application costs: \$62 per spray.
- Insecticide costs.
 - Without project: continued use of D-M-S at \$16.86 per spray.
 - With project: timed application of Mevinphos at \$24.12 per spray.
- Number of sprays required.
 - Without project: 10 applications per year.
 - With project: 3 strategic applications per year.
- Adoption of results.
 - Year first adopted: 1991.
 - Year reached peak adoption: 1994.
 - Level of peak adoption: 90 per cent of total area.
 - Life of technology: 30 years.

Table 7.2 Costs of integrated pest management project

<i>Year</i>	<i>RIRDC</i>	<i>Industry: cash</i>	<i>Industry: in-kind</i>	<i>University of Tasmania</i>	<i>Total</i>
	\$	\$	\$	\$	\$
1987-88	9 520	0	5 333	38 042	52 895
1988-89	6 958	0	5 333	40 819	53 110
1989-90	7 954	0	5 333	44 084	57 372
1990-91	0	0	0	46 421	46 421
Total	24 432	0	16 000	169 366	209 798

Source: NSW Agriculture.

- Discount rate: 8 per cent per annum.

From the above data and assumptions, the saving in cost as a result of the project was \$530.24 per hectare per year.

Results of analysis

The results of the economic analysis are summarised in table 7.3. On the basis of the data and assumptions used, the project has a BCR of 2.3, a NPV of \$455 000 and an IRR of 16 per cent.

Nitrogen and water relations in boronia

Project summary

- Research organisation: University of Tasmania, Department of Agricultural Science.
- Researchers: Dr R.C. Menary and Mr N. Roberts.
- RIRDC program: *Essential Oils and Natural Plant Extracts*.
- Project number: UT-5A.
- Duration of project: 1991-92 to 1993-94.

Project details

Objective

To develop commercial irrigation and nitrogen nutrition strategies for brown boronia based on established physiological principles.

- To investigate the effect of irrigation rate and timing on flower and oil yields and composition.
- To investigate the effect of nitrogen form, rate, timing and interaction with irrigation on flower and oil yields and composition.
- To develop specific agronomic recommendations for irrigation and nutrition of brown boronia.

Table 7.3 Results of analysis for integrated pest management project

	<i>Unit</i>	
Discounted benefits	\$000	803
Discounted costs	\$000	348
NPV	\$000	455
BCR		2:3
IRR	%	16.0

Source: NSW Agriculture.

Background

The potential world market for pure boronia absolute extract has been estimated to be in excess of \$5 million. The full commercial development of this crop has been restricted by inadequate field information on irrigation and nitrogen nutrition. As the plant is known to be highly susceptible to nitrate toxicity, precise management recommendations are needed to ensure maximum benefits.

In 1991, crop yields were reduced by up to 50 per cent due to nitrogen related problems, as a result of inadequate knowledge in relation to sources of nitrogen and timing of application in relation to temperature and irrigation.

Research

The research program provides information on irrigation requirements in relation to nitrogen release from different sources and the quantity and timing of nitrogen application. Information on oil yield and quality in relation to nitrogen nutrition is important to establish economic viability and market acceptance of the product.

Outcome

The output of the project will be a technology package to enable producers to meet market demand. It will provide the database for technology transfer to growers. The technical information on irrigation and nitrogen nutrition of boronia will improve the production efficiency of boronia, and may also have significance for the commercial production of other Australian natives for flowers and essential oils.

Economic analysis

Project costs

The total costs of the project were \$387 014, as shown in table 7.4.

Table 7.4 Costs of nitrogen and water relations project

<i>Year</i>	<i>RIRDC</i>	<i>Industry: cash</i>	<i>Industry: in-kind</i>	<i>University of Tasmania</i>	<i>Total</i>
	\$	\$	\$	\$	\$
1991-92	61 882	19 800	17 667	16 144	115 493
1992-93	62 216	32 700	17 667	16 656	129 239
1993-94	66 566	41 300	17 667	16 750	142 283
Total	190 664	93 800	53 000	49 550	387 014

Source: NSW Agriculture.

Data and assumptions used in analysis

The assumptions used in estimating the benefits of the project are as follows:

- The industry recommendations for nitrogen management prior to the project follow.
 - Osmocote: 100 kg at \$3230/t = \$323.00/ha.
 - IBDU: 100 kg at \$2880/t = \$288.00/ha.
 - Application costs: 2 applications at \$18.22 each = \$36.44/ha.
 - Total costs of N fertilisers per year: \$647.44/ha.
- The industry recommendations for nitrogen management following the project follow.
 - Nitrophoska Perfekt: 150 kg at \$1000/t = \$150.00/ha.
 - IBDU: 50 kg at \$500/t = \$25.00/ha.
 - Application costs: 2 applications at \$18.22 each = \$36.44/ha.
 - Total costs of N fertilisers per year: \$211.44/ha.
- Adoption of results.
 - Year first adopted: 1994.
 - Year reached peak adoption: 1996.
 - Level of peak adoption: 100 per cent of total area.
 - Life of technology: 30 years.
- Discount rate: 8 per cent per annum.

From the above data and assumptions, the saving in fertiliser cost as a result of the project was \$436.00 per hectare per year.

Results of analysis

The results of the economic analysis are summarised in table 7.5. On the basis of the data and assumptions used, the project has a BCR of 1.3 a NPV of \$169 000, and an IRR of 10.9 per cent.

Table 7.5 Results of analysis for nitrogen and water relations project

	<i>Unit</i>	
Discounted benefits	\$000	655
Discounted costs	\$000	486
NPV	\$000	169
BCR		1:3
IRR	%	10.9

Source: NSW Agriculture.

Yield and quality of concrete from *Boronia Megastigma*

Project summary

- Research organisation: University of Tasmania, Department of Agricultural Science.
- Researchers: Dr R.C. Menary.
- RIRDC program: *Essential Oils and Natural Plant Extracts*.
- Project number: UT-10A.
- Duration of project: 1995-96 to 1997-98.

Project details

Objective

To produce boronia concrete at higher yields and with improved quality by developing pre-harvest, harvesting and post-harvest management practices and by value adding the existing product.

Background

Boronia megastigma Nees is grown in Tasmania for production of flowers that are extracted with solvent to produce a high value concrete. Boronia concrete is a significant and well developed product in Tasmania. To take this product into new and higher value markets and for the future development of the crop, higher yields and improved quality, along with increased product variety, are required.

Preliminary work has suggested an earlier harvest with specific post-harvest practices will produce significantly higher yields and improved quality from existing plantations. Refinements to extraction technique and value adding of commercial concrete will increase the value and market share of the product.

Research

The production of volatiles *in vivo*, pre- and post-harvest, will be studied, and management practices tailored to maximise volatile yield. The initial approach will study harvest timing, followed by post-harvest flower treatments. Specific requirements for volatile production will be determined by laboratory work.

Outcome

The expected outcome is that the harvest window will be increased and strategies developed that can be incorporated into existing commercial protocols, so that both yield and quality are increased. The extraction technique and purification of product will be improved.

Economic analysis

Project costs

The total costs of the project were \$668 360, as shown in table 7.6.

Data and assumptions used in analysis

The assumptions used in estimating the benefits of the project are as follows.

- Without the project, the concentration of harvest would mean that an additional two new harvesters would be needed in 1999 and 2004, as the industry expanded, at a cost of \$30 000 each. The project's findings allow harvest to be spread more widely, so that these new harvesters will not be required and that investment will be saved.
- The project's findings will result in a 30 per cent increase in yield throughout the industry. Without the project, yields would have increased to 1.40 t/ha by 1999. With the project, yields will increase by 30 per cent above their level otherwise. This translates to a cost reduction of \$3.26 per tonne of flower.
- Adoption of results.
 - Year first adopted: 1997.
 - Year reached peak adoption: 1999.
 - Level of peak adoption: 95 per cent of total area.
 - Life of technology: 30 years.
- Discount rate: 8 per cent per annum.

Results of analysis

The results of the economic analysis are summarised in table 7.7. On the basis of the data and assumptions used, the project has a BCR of 6:8, a NPV of \$3 665 000, and an IRR of 61 per cent. The relatively high IRR (in relation to the BCR) is a result of the very early adoption of the benefits of the project, well before the end of the project itself.

Table 7.6 Costs of yield and quality of concrete project

<i>Year</i>	<i>RIRDC</i>	<i>Industry: cash</i>	<i>Industry: in-kind</i>	<i>University of Tasmania</i>	<i>Total</i>
1995-96	45 000	75 820	90 667	13 800	225 287
1996-97	46 500	69 820	90 667	13 800	220 787
1997-98	48 000	69 820	90 667	13 800	222 287
Total	139 500	215 460	272 000	41 400	668 360

Source: NSW Agriculture.

Table 7.7 Results of analysis for yield and quality of concrete project

	<i>Unit</i>	
Discounted benefits	\$000	4 292
Discounted costs	\$000	627
NPV	\$000	3 665
BCR		6.8
IRR	%	60.6

Source: NSW Agriculture.

Genetic resources of *Boronia megastigma*

Project summary

- Research organisation: University of Western Australia, Horticultural Science.
- Researchers: Dr J. Plummer.
- RIRDC program: *Essential Oils and Natural Plant Extracts*.
- Project number: UWA-16A.
- Duration of project: 1993-1996.

Project details

Objective

To locate natural populations of *B. heterophylla*, *B. purdieana* and *B. megastigma* and assess their conservation status. The floristic qualities of *B. heterophylla* and *B. purdieana* and essential oil content and quality of *B. megastigma* in representative individuals from these populations will be determined. Propagated plants will be cultivated under different systems at various field sites to determine the requirements for optimum production for flowers and high quality essential oils.

Background

The project examines the diversity of floriferousness, flowering period and oil quantity and quality within natural populations of *Boronia megastigma*, *B. heterophylla* and *B. purdieana* in Western Australia. A field collection of superior lines will be established.

Boronia absolute is an extract of the flowers of *B. megastigma*, and is a valuable essential oil product. Boronia is a native to Western Australia and the industry is currently based on bush picking of flowers.

More knowledge of production systems of boronia is required. Preliminary investigations have shown that shading increases flowering. The influence of a range of shade intensities on

flowering and oil content of flowers from the three species will be investigated. Western Australia has a wide range of climates, and sites have been selected to investigate the influence of local conditions on growth, flowering and oil yields.

The emerging boronia absolute industry is at risk unless oil yields and quality are improved and the diversity of products is increased.

Research

- Evaluation of the ecology, geography and climate of known populations of *B. megastigma* to indicate sites suitable for growth and commercial production of the plant.
- Plant characteristics including flower colour, flower abundance, flowering time and plant growth habit assessed.
- A field trial to compare flowering, growth habit and oil content of different natural populations, and the effect of shading on flowering and oil content.
- Field trials of high yielding clones at a number of sites to assess the influence of local conditions on flowering and plant growth.

Outcome

It is expected that increased productivity utilising site selection, improved genotypes and cultivation systems will increase profitability and help expand the boronia industry. Information from this project will assist in securing local investment in the industry. Sunglow Flowers and Plantex Australia are growers interested in being partners in the project, and would be the main initial beneficiaries.

Bush picking has many detrimental effects on natural populations and wetlands. The information from this project will facilitate control of the conservation of boronia and the associated flora and fauna in its ecosystem.

Economic analysis

Project costs

The total costs of the project were \$419 460, as shown in table 7.8.

Table 7.8 Costs of genetic resources project

<i>Year</i>	<i>RIRDC</i>	<i>Industry: cash</i>	<i>Industry: in-kind</i>	<i>University of WA</i>	<i>Total</i>
	\$	\$	\$	\$	\$
1993-94	47 963	32 185	0	63 558	143 706
1994-95	45 712	27 585	0	66 890	140 187
1995-96	46 807	18 373	0	70 387	135 567
Total	140 482	78 143	0	200 835	419 460

Source: NSW Agriculture.

Table 7.9 Results of analysis for genetic resources project

	<i>Unit</i>	
Discounted benefits	\$000	2 192
Discounted costs	\$000	455
NPV	\$000	1 737
BCR		4.8
IRR	%	35.3

Source: NSW Agriculture.

Data and assumptions used in analysis

The assumptions used in estimating the benefits of the project are as follows.

- Current area harvested for oil production in Western Australia is equivalent to 5 ha of commercial production.
- In the absence of this project, a commercial boronia industry for oil would have developed in a similar pattern to Tasmania, but its growth would lag eight years behind the Tasmanian industry. Thus, the Western Australia industry would grow to reach 50 per cent of the size of the industry in Tasmania, so that by 2004 the industry would be half the size of the 1996 Tasmanian industry.
- With the project, the WA industry will develop in the same pattern, but the development will be brought forward by five years.
- The price received in WA will be the same as that in Tasmania.
- Discount rate: 8 per cent per annum.

From the above data and assumptions, the benefits from the project were from bringing forward the development of the industry.

Results of analysis

The results of the economic analysis are summarised in table 7.9. On the basis of the data and assumptions used, the project has a BCR of 4.8, a NPV of \$1 737 000, and an IRR of 35 per cent.

Results of economic analyses

Contributions to costs of boronia oil research

The contributions of the different organisations to the research into *Boronia megastigma* are summarised in table 7.9. Overall, RIRDC contributed 29.4 per cent of the total funds, industry 43.2 per cent, and the research organisations 27.4 per cent.

Table 7.9 Contributions to research costs

<i>Project</i>	<i>RIRDC</i>	<i>Industry</i>		<i>University of</i>		<i>Total</i>
		<i>Cash</i>	<i>In-kind</i>	<i>Tasmania</i>	<i>WA</i>	
UT-2A	24 432	0	16 000	169 366	0	209 798
UT-5A	190 664	93 800	53 000	49 550	0	387 014
UT-10A	139 500	215 460	272 000	41 400	0	668 360
UWA-16A	140 482	78 143	0	0	200 835	419 460
Total	495 078	387 403	341 000	260 316	200 835	1 684 632
% of total	29.4	23.0	20.2	15.5	11.9	100.0

Source: NSW Agriculture.

Results of project analyses

The results of the analyses (summarised in table 7.10) indicate a range of returns from the four projects. The BCRs range from 1:3 (project UT-5A) to 6:8 (project UT-10A). These results indicate a solid level of return to the funds spent on boronia oil research.

Results of aggregate analysis

In aggregate, the four projects represent a flow of investment in research over the period 1987-88 to 1997-98. Over those 11 years, the average investment in research has been \$154 000 per year. The streams of benefits and costs associated with that research produce net benefits that are expected to reach a peak of \$0.97 million per year in 2003, and to continue to flow until 2029. The four projects have an overall BCR of 4.1 (table 7.10), and NPV of \$6 026 000, and an IRR of 26 per cent.

Summary and conclusions

It is apparent from the analysis of the four selected projects that there are varying economic returns from the research that has been undertaken in recent years into *Boronia megastigma*. The projects examined have shown a range of economic outcomes, with a strong overall outcome. The results indicate that for every dollar spent on research in boronia to date society can expect to achieve a return of approximately \$4. From RIRDC's point of view, it has contributed 29 per cent of the total funds used, and achieved significant gains for the industry.

Table 7.10 Summary of results of economic analyses

	<i>Unit</i>	<i>UT-2A</i>	<i>UT-5A</i>	<i>UT-10A</i>	<i>UWA-16A</i>	<i>Total</i>
Discounted benefits	\$000	803	655	4 292	2 192	7 942
Discounted costs	\$000	348	486	627	455	1 916
NPV	\$000	455	169	3 665	1 737	6 026
BCR		2.3	1.3	6.8	4.8	4.1
IRR	%	16	11	61	35	26

Source: NSW Agriculture.

As research is a risky process, there will always be a spread of economic returns from different research projects. The task for funding bodies such as RIRDC is to identify the likely returns at the time of project development, so that those with lower expected returns can be replaced by others that have higher returns or redefined to increase the likely economic returns from the funds invested.

Appendix A Summaries of the projects

Table A1 **Project costs in actual dollars**

	<i>RIRDC</i>	<i>Industry</i>	<i>Research organisation</i>
	\$	\$	\$
DAN-5A	10 869	11 570	0
UMU-11A	62 531	48 389	85 696
UWA-35A	141 816	35 000	354 526
DAQ-127A	46 032	3 500	59 240
DAQ-171A	169 150	10 859	620 604
RBG-1A	79 387	156 468	20 869
RBG-2A	44 357	9 000	72 443
UA-26A	131 774	15 669	209 845
UQ-29A	70 738	147 515	189 600
DAW-51A	103 306	42 236	193 937
DAW-89A	65 169	51 882	152 308
DAQ-166A	6 000	1 000	—
DAV-56A	153 849	13 500	280 606
DAV-102A	190 269	25 000	369 352
DAS-45A	166 345	24 000	268 061
DAW-76A	25 172	21 050	112 912
ANC-1A	129 383	42 216	115 650
DAW-11A	60 513	0	0
BGA-1A	104 692	252 209	0
UNE-15A	32 201	80 000	19 000
DNT-16A	1 070	0	44 200
AFF-1A	39 240	36 000	18 000

Note For some projects the research organisation and industry contributions are not distinguished.

Source: RIRDC files.

Project: Evaluation of Australian native plants as indoor pot plants and cut flowers

Code: *DAN-5A*

The purpose of this was to identify species of Australian native plants that may be suitable for use as cut flowers or as indoor plants and to evaluate horticultural practices in terms of productivity and post-harvest life. Various plants were found to be suitable, such as Geraldton Wax and Riceflower. The Lamont series may have been a result of this project.

This project appears to have lead to the development of several varieties of waxflower. The project costs are allocated to waxflower returns and half to riceflower in individual flower assessments.

- Stage 1 1985-86 to 1987-88.
- First production date: 1994-95.

- Expected premium: 75 per cent.
- Average price for similar flowers: \$0.30 per stem.
- Volume: 700 000 stems per year.
- Duration of premium: 3 years.

Project: Collection and selection of Chamelaucium species for floriculture

Code: *UMU-11A*

Type: *Focal filler*

The purpose of this project was to explore, describe and cultivate representatives of the genetic resource of this species. To do this the known population was to be mapped, the range of characters and sites was to be documented, and propagation and cultivation was to be investigated. This process was to be repeated for related species and then the process of evaluation and selection was to occur. A long short list of suitable types was produced that has led to commercial evaluation, with one being PVR'd.

- Stage 1 through to production occurred during this project which was completed 1990-91 to the present.
- First production date: 1999-2000.
- Expected premium: 75 per cent.
- Average price for similar flowers: \$0.30 per stem.
- Volume: 700 000 stems per year.
- Duration of premium: 3 years.

Project: Development of new and improved cut flower cultivars through selection and sexual hybridisation within the Chamelaucium alliance

Code: *UWA-35A*

New varieties of waxflower are needed to ensure that Australia realises the full potential of this expanding market. Developments of new varieties include generating better second generation cultivars through systematic breeding. This will offer the opportunity to greatly increase the range of floral form and date of flowering, and will enhance appeal. This project's aims were centered around setting up a breeding program to develop desirable new varieties, with the added goal of better understanding of the reproductive biology of this plant. This project is still in progress.

- Stage 1:
- Stage 2: 1996-97 to 1999-2000.

- First production date: 2002-03.
- Expected premium: 75 per cent.
- Average price for similar flowers: \$0.30 per stem.
- Volume: 700 000 stems per year.
- Duration of premium: 3 years.

Project: Development of *Helichrysum Diosmifolium* as a cut flower crop

Code: DAQ-127A

Type: Focal filler

This project was designed to improve productivity, quality and suitability of riceflowers through identification of superior genotypes and cultural and/or post-harvest practices. A wide variety of genotypes were collected and assessed for ease of propagation, etc. and superior types were identified. Additional work is required to further extend the production season, although at the moment there are three clones that can provide a 3–6 week harvest season. A brochure on best practices is a high priority. Twenty relevant technical publications have been produced and one variety *Redland Sandra* was released for commercial production and licensed. The licensing process has been very slow. Production has commenced in Western Australia. Arrangements for sublicensing for production on the east coast are currently being concluded. Overall, the results were a stable production season, enhanced marketability and improved control of pests and diseases.

- Stage 1: Production included in this one project which started in 1988-89 and finished in 1995-96.
- First production date: 1995-96.
- Expected premium: 25 per cent.
- Average price for similar: \$0.35 per stem.
- Volumes: 700 000 items per year.
- Duration of premium: 3 years.

Project: Development of the flannel flower as a cut flower crop

Code: RBG-1A

Type: Focal filler

The flannel flower is an attractive Australian species that shows horticultural potential as a cut flower. This project aimed to research aspects relating to the domestication and commercialisation of the flannel flower, especially in the export market. Availability of plant material has hampered the development of this crop, so developing techniques for rapid

propagation was focused on. Maximising flower production, vase life and other such aspects were also to be looked at. Progress was made in all areas; however, availability of stock suitable for commercial cut flower production is a major impediment to developing this crop. This can be overcome through commercial development, which is to be undertaken in project RGB-2A.

Project: Development of new Asteraceae from the Australian flora to complement the current riceflower industry

Code: DAQ-171A

Type: Focal filler

Australian riceflower is perceived as not achieving its full potential in terms of exports to Japan, Europe and the US. The flower is constrained by short flowering season, limited variation in flower colour and lack of information on appropriate post-harvest protocols. This project's aims were to select cultivars and locations which would extend the limited and discontinuous flowering season, increase range in colour, and establish post-harvest protocols. The final report was not in the file and therefore the results of the project are not fully known to us. However, grower trials are not proposed just yet as the industry reaction is being waited upon.

- Stage 1: 1994-95 to 1996-97
- Stage 2: Not proposed yet.
- First production date: 1998-99.
- Expected premium: 25 per cent.
- Average price for similar: \$0.35 per stem.
- Volumes: 700 000 per year.
- Duration of premium: 3 years.

Project: Development of a flannel flower production system

Code: RBG-2A

Flannel flowers have been identified as a suitable cut flower crop for the export market and the aim of this project was to commercially evaluate selected cultivars of this plant with particular emphasis on post-harvest requirements. This project has just commenced so its benefits are yet to be determined.

- Stage 1: 1994-95 to 1996-97.
- Stage 2: 1997-98 to 1998-99.
- First production date: 2001-02.
- Expected premium: 80 per cent.

- Average price for similar flowers: \$0.40 per stem.
- Volume: 200 000 stems per year.
- Duration of premium: 4 years.

Project: Selection of Banksia cultivars for floriculture

Code: UA-26A

Type: Focal

Thirty per cent of Banksias are bush picked. This is undesirable in terms of maintaining high quality and also conservation of the environment. This project aimed, first, to select superior genotypes; second, to refine vegetative propagation methods, screening and second stage testing; and third to register those that were deemed successful. Three cultivars were registered for cut flower production as a result of this project. Other advance stage selections have also been made. The propagation and marketing rights for the three cultivars (Waite Orange and Waite Flame) have been sublicensed to a commercial producer, but we are unsure whether anyone has established production. The cut flower industry as a result of this project may experience up to a fivefold increase in productivity over the next twenty years.

- Stage 1 and stage 2: occurred during this project, which went from 1993-94 to 1996-97.
- First production date: 2000-01.
- Expected premium: 70 per cent.
- Average price of similar flowers: \$1.30 per stem.
- Volume: 300 000 stem per year.
- Duration of premium: 5 years.

Project: Propagation and horticultural development of Caustis Blakei for the export cut flower foliage market

Code: UQ-29A

Type: Filler/Foliage

Caustis Blakei is an attractive sedge used for export as cut foliage. Bush harvesting threatens its survival so propagation and horticultural development is seen as essential. Low fruit sets limits the available explants for propagation. This project resulted in the development of a commercially viable propagation system, along with progress in terms of increasing the fruit set. About 15 elite genotypes, which require further testing prior to lodging PVR applications, are currently in commercial trials. Types suitable for both cut foliage (long stemmed) and potted plants are desired commercially and look likely to become available and registered as a result of this project. Nurseries are seeking a funding grant to do a follow-up commercial evaluation.

- Stage 1: 1993-94 to 1996-97.
- Stage 2: 1997-2000.
- First date of production: 2001-02.
- Expected premium: 80 per cent.
- Average price for similar flowers: \$0.40 per stem.
- Volume: 200 000 per year.
- Duration of premium: 6 years.

Project: Production, management and handling of quality new native cut flowers for export

Code: DAW-51A

Many new cut flowers are bush picked and therefore are far from optimum in terms of quality and stem production. This project aimed to compile information, develop protocols and production methods, and test marketability of five different species of native cut flowers that were seen to have export potential. The research approach consisted of, first, selection of superior plant types; second, developing methods of propagation and establishment; third, optimising stem production and quality through irrigation, nutrition and pruning; and fourth, developing suitable methods of post-harvest handling for each species. The best results came from a variety called blue smokebush and a good market response was received in Australia and Japan for it. Results for the other flowers were mixed, some easily propagating but having problems such as short vase life. The main outcome of this project was that it provided information to the industry to established commercial planting of these species, particularly blue smokebush, which DAW-89A centred around. Qualup bells were identified as having potential but no further development has occurred.

Project: Cultivation of blue smokebush for cut flower production

Code: DAW-89A

Type: Filler

Blue smokebush is an attractive flower coming in a range of colours. These plants naturally flower in winter, a time when their substitutes require additional heating and lighting, and they also have a good vase life. However, these plants are difficult to propagate with some requiring tissue culture. This project's aims were to develop superior clones and also investigate what cultivation, propagation and post-harvest practices were optimal for commercial production of blue smokebush. This project is still in its first year, so there is little information available regarding its results.

- Stage 1: 1993-94 to 1995-96.
- Stage 2: 1997-98 to 1999-2000.

- First production date: 2001-02.
- Expected premium: 100 per cent.
- Average price of similar flowers: \$0.40 per stem.
- Volume: 100 000 stems per year.
- Duration of premium: 5 years.

Project: Sourcing and vase life evaluation of tropical Grevillea species forms and hybrids

Code: DAQ-166A

Type: Focal filler

This project was intended to better define the prospects for a Grevillea cut flower industry by looking at vase life and how this can be maximised. The typical vase life of 3-4 days was commercially unacceptable, but this project identified 15 accessions of Grevillea that had a vase life of over the minimum standard (which is 7 days) if picked at the optimum time. This is substantially longer than was previously evident in literature. However, additional research and development is still required — regarding post-harvest handling, etc. — to underpin Grevillea as a commercial crop. A pamphlet was also produced giving information on optimal harvest time. At the present time, proposals have been received to set up market tests over a period of 3–5 years starting in 1999 at a cost of \$45 000 a year.

- Stage 1: 1994-95 to 1995-96.
- Stage 2: 1999 onwards for 3–5 years. End of 2004.
- Expected first production date: 2006-07.
- Expected premium: 110 per cent to wholesaler; 60 per cent to grower.
- Average price for similar: \$1.50 per stem.
- Volumes: 100 000 stems per year.
- Duration of premium: 4 years.

Project: Development of Baeckea Behri species as cut flowers for the export and local markets

Code: DAV-56A

Type: Filler

The advantage of Baeckea Behri is that it flowers from October to December when there is a gap in the market. In this project 118 species and clones were collected for assessment for cut flower production. Post-harvest solution and pulses were tested to determine the best vase solution to extend vase life. Eight clones of Baeckea Behri were released for commercial

evaluation in different geographic regions of Australia to provide information on information on variation in flowering time, growth rates and yield. This project led to DAV-102A.

Project: National program to commercially evaluate Baeckea Behri

Code: DAV-102A

The aims of this project were to assist in the commercial evaluation of Baeckea Behri by, first, collating information obtained from market testing; second, characterising geographic flowering seasons to support the continued supply of floral materials to the market; and third, establishing growth rates and flowering times. Results have been collected and reported for the first flowering season and progress is being made on the second flowering season work. This work is expected to result in several clones applying for PVR.

- Stage 1: 1991-92 to 1994-95.
- Stage 2: 1995-96 to 1997-98.
- First production date: 1999-2000.
- Expected premium: 60 per cent.
- Average price for similar: \$0.45 per stem.
- Volumes: 1 000 000.
- Duration of premium: 4 years

Project: Varietal development and disease management of Ixodia Achillaeodies for cut flowers production

Code: DAS-45A

Type: Focal filler

Ixodia is a unique Australian dried flower that has strong export and domestic demand not being met by current production. This is because there are few named varieties with known characteristics available to assure consistency, uniformity and harvest efficiencies. Also, planting has experienced difficulties due to poor planting stock. This project aimed to collect and assess Ixodia selections for flowering characteristics, quality and yield. This was to be done with a view to producing a range of selections flowering over the period October to February. Disease management research was also to occur. The project is still ongoing, but it appears as though this is not moving into the second stage.

- Stage 1: 1995-96 to 1998-99.
- Stage 2:
- First production date: 2005-06.
- Expected premium: 60 per cent.

- Average price for similar flowers: \$0.20 per stem.
- Volume: 200 000 stems per year.
- Duration of premium: 3 years.

Project: The selection, propagation, and cultivation of golden cascade for cut flower production (*Corynantheria*)

Type: *Focal filler*

Code: *DAW-76A*

Golden cascade is an unusual flower that has been bush picked for several years and has been very successfully marketed in Japan. It has a long vase life, it does not shed, wilt or fade, and is bright yellow — the preferred colour for autumn in Japan. However, this plant is rare and its survival is threatened from bush picking. To ensure the survival of the species it is imperative to bring it into cultivation. Therefore this project was aimed at selecting commercially desirable forms of golden cascade and developing methods of establishment and cultivation of it. This project is still in its initial stages and therefore its results are unknown.

- Stage 1: 1996-97 to 1997-98.
- Stage 2: End in 2001-02.
- First production date: 2004-05.
- Expected premium: 150 per cent.
- Average price for similar flowers: \$0.40 per stem.
- Volume: 100 000.
- Duration of premium: 4 years.

Project: Australian summer flowering plants for the northern hemisphere winter cut flower market (*Hemodoreum*)

Code: *ANC-1A*

Type: *Focal filler*

There is little product available during the Australian summer, even though it coincides with two important times for domestic sales and demand in northern hemisphere markets. Two species appear to have a great deal of potential for solving this problem and there are several more that deserve consideration, one of these being blood root. This project was aimed at evaluating and developing these species. Also, to increase the likelihood of industry acceptance, production protocols were to be developed. These production protocols are in development now but there have been some problems. However, the final report has not been

submitted yet so the success of the project cannot be determined, but we do know that the industry has adopted the growing of blood root.

- Stage 1: 1994-95 to 1997-98.
- Stage 2: 1998-99-2000-01.
- First production date: 2003-04.
- Expected premium: 100 per cent.
- Average price for similar flowers: \$1 per stem.
- Volume: 100 000 per year.
- Duration of premium: 3 years.

Project: Evaluation of the Myrtle group as export cut flowers

Code: DAW-11A

Type: Focal filler

Myrtles are considered to have marketing potential. They are perceived as an attractive filler item and many stems can be packed into an export box. This project was designed to determine the suitability of Myrtles for export cut flower production, potted plants and amenity horticulture. Suitable species were identified and planted in a shadehouse. They were monitored and several selections have shown promise. Procedures are being developed to release material to the industry. This project finished several years ago but at present there is no information on its outcomes.

- Stage 1: 1988-89 to 1990-91.
- Stage 2:
- First production date:
- Expected premium: 100 per cent.
- Average price for similar: \$0.40 per stem.
- Volumes:
- Duration of premium: 3 years.

Project: Development of Sturt's Desert Pea for flowering pot and cut flower production

Code: BGA-1A

Type: Focal

Sturt's Desert Pea has much potential; however, its acceptance has been limited by the large variability in progeny produced from seed and by cultural problems. This project was

designed to develop cultivars of Sturt's Desert Pea, to develop techniques for clonal propagation and to study cultural requirements of the plant. Efficient methods of clonal propagation using cuttings were produced but tissue culture propagation requires further work. Optimal fertiliser treatments and recommendations on cultural conditions were made. Several clones showing desirable characteristics were identified but there was no further output from this project.

- Stage 1: 1989-90 to 1992-93.
- Stage 2: Did not enter stage 2.
- First production date:

Project: Clonal propagation of Sturt's Desert Pea for cut flower production

Code: UNE-15A

Sturt's Desert Pea grown from seed tends to vary too much in terms of attributes important for commercial floriculture. Shoot tip cuttings root readily but there are only a few places where cuttings can be taken from on each plant. This project sought to establish a suitable method of vegetative propagation from selected plants. Cutting production was improved but there is no indication of the extent of application as yet.

- Stage 1:
- Stage 2: 1988-89 to 1990-91.
- First production date:
- Expected premium: 100 per cent.
- Average price for similar: \$1.00 per stem.
- Volumes:
- Duration of premium: 4 years.

Project: Cut flower potential of centralian species

Code: DNT-16A

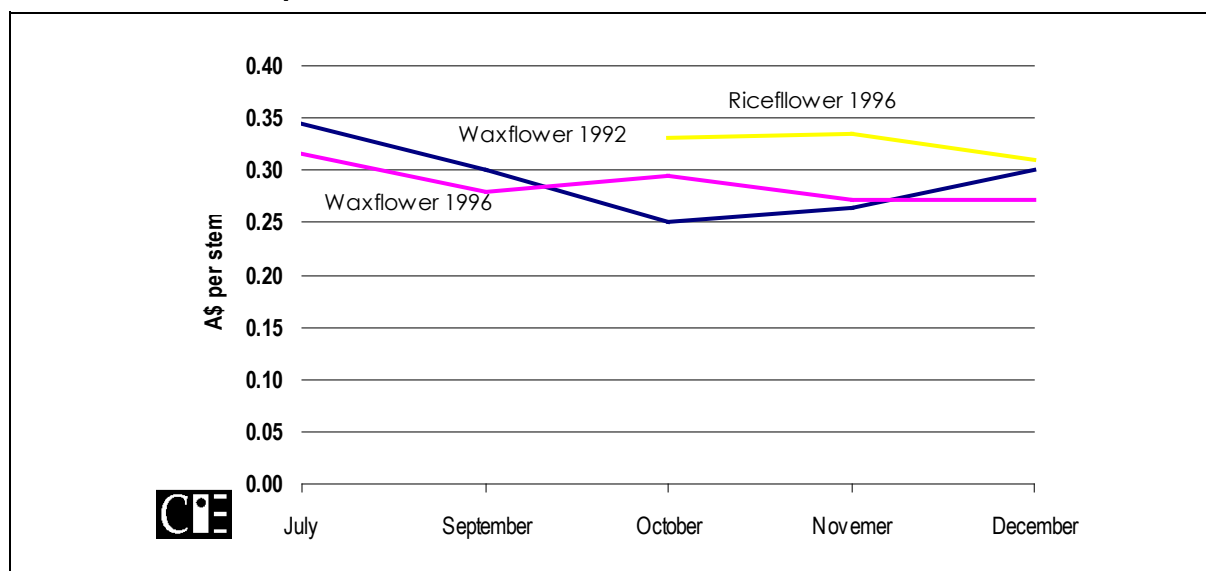
Central Australia is renowned for its native wildflowers but their marketability and potential for production under modern floricultural methods is unknown. This project was aimed to be a study to address these impediments. Wildflowers that are common in the region and easily accessible were to be assessed on floral characteristics, vase life, ease of propagation, and market acceptability in this project. However, severe drought conditions have prevented progress on this project and therefore it appears likely that there will be no results from it.

Project: Distribution of priming grants for wildflowers and native plants**Code: AFF-1A**

The Australian Floral Foundation gives out grants in a similar way to RIRDC but on a much smaller scale. Applications for grants far exceeded the money available, so this project was aimed at giving AFF some extra funds so that more research applications could be funded. Milestone reports suggest some of these projects have been successful, but the final report has not been submitted yet so the full extent of the benefits is unknown.

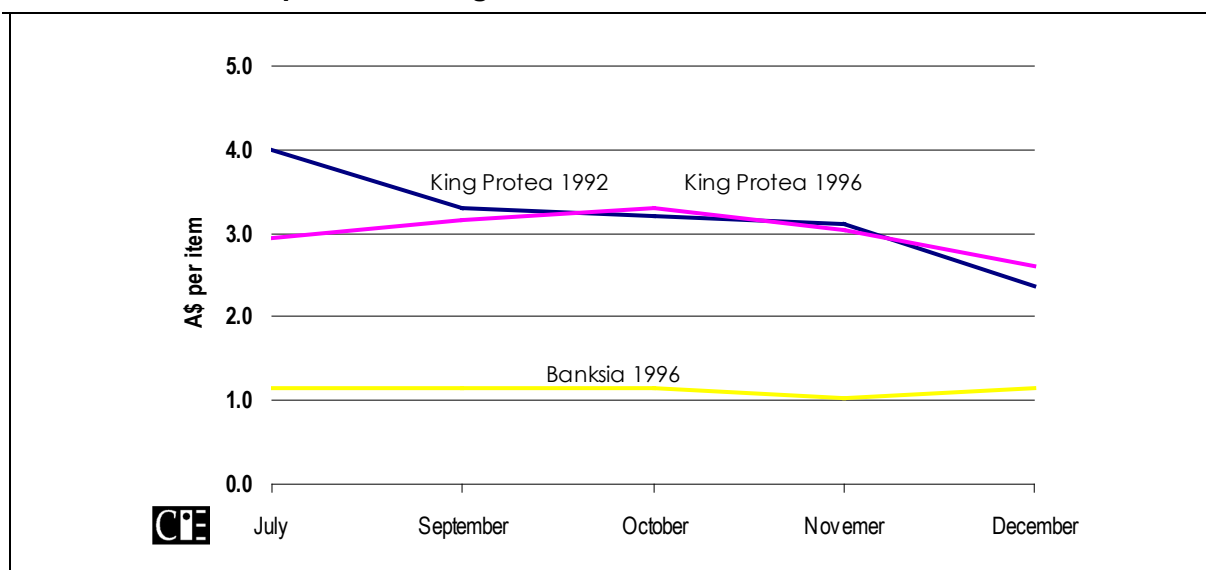
Appendix B Indicators of prices of wildflowers

Chart B1 Domestic prices for waxflower and riceflower



Data source: Karringal report 1997.

Chart B2 Domestic prices for King Protea and Banksia



Data source: Karringal report 1997.

Table B1 **Overseas markets** Australian dollar per stem

	<i>Dutch market</i>			<i>Ota Market^a (Japan)</i>		
	1993	1994	1995	1993	1994	1995
	\$	\$	\$	\$	\$	\$
Waxflower	0.26	0.26	0.22	0.84	0.88	0.86
Protea	1.41	1.80	1.76	4.71	3.76	5.29
Kangaroo Paw	0.44	0.50	0.29	0.84	0.85	0.84
Banksia	1.07	1.58	1.31	1.50	1.65	1.85

^a The Ota Market prices are for King Proteas.

Source: Flower Export Council of Australia (1997).

Appendix C Flows on benefit–cost

Table C1 Boronia projects

	UT-2A		UT-5A		UT-10A		UWA-16A	
	<i>Total cost</i>	<i>Total benefit</i>	<i>Total cost</i>	<i>Total benefit</i>	<i>Total cost</i>	<i>Total benefit</i>	<i>Total cost</i>	<i>Total benefit</i>
	\$	\$	\$	\$	\$	\$	\$	\$
1985-86	0	0	0	0	0	0	0	0
1986-87	0	0	0	0	0	0	0	0
1987-88	52 895	0	0	0	0	0	0	0
1888-89	53 110	0	0	0	0	0	0	0
1989-90	57 372	0	0	0	0	0	0	0
1990-91	46 421	4 283	0	0	0	0	0	0
1991-92	0	11 135	0	0	0	0	0	0
1992-93	0	21 713	97 826	0	0	0	0	0
1993-94	0	28 227	111 572	0	0	0	0	0
1994-95	0	36 695	124 616	8 596	0	0	143 706	0
1995-96	0	47 704	0	22 351	0	0	140 187	0
1996-97	0	50 089	0	43 584	225 287	0	135 567	0
1997-98	0	52 594	0	45 763	220 787	208 141	0	244 874
1998-99	0	55 223	0	48 051	222 287	437 454	0	339 698
1999-2000	0	57 985	0	50 454	0	715 672	0	458 433
2000-01	0	60 884	0	52 977	0	709 641	0	615 005
2001-02	0	63 928	0	55 625	0	733 750	0	814 463
2002-03	0	67 124	0	58 407	0	757 899	0	623 074
2003-04	0	70 481	0	61 327	0	781 971	0	566 290
2004-05	0	71 582	0	64 393	0	835 829	0	485 870
2005-06	0	71 582	0	65 400	0	813 345	0	380 778
2006-07	0	71 582	0	65 400	0	813 345	0	235 733
2008-09	0	71 582	0	65 400	0	813 345	0	247 520
2009-10	0	71 582	0	65 400	0	813 345	0	25 896
2010-11	0	71 582	0	65 400	0	813 345	0	272 891
2011-12	0	71 582	0	65 400	0	813 345	0	243 211
2012-13	0	71 582	0	65 400	0	813 345	0	191 355
2013-14	0	71 582	0	65 400	0	813 345	0	136 907
2014-15	0	71 582	0	65 400	0	813 345	0	79 736
2016-17	0	71 582	0	65 400	0	813 345	0	19 707
2017-18	0	71 582	0	65 400	0	813 345	0	0
2018-19	0	71 582	0	65 400	0	813 345	0	0
2019-20	0	71 582	0	65 400	0	813 345	0	0
2020-21	0	71 582	0	65 400	0	813 345	0	0
2021-22	0	71 582	0	65 400	0	813 345	0	0
2022-23	0	71 582	0	65 400	0	813 345	0	0
2023-24	0	35 971	0	65 400	0	813 345	0	0
2024-25	0	0	0	65 400	0	813 345	0	0
2025-26	0	0	0	65 400	0	813 345	0	0
2026-27	0	0	0	32 700	0	813 345	0	0
2027-28	0	0	0	0	0	813 345	0	0
2028-29	0	0	0	0	0	422 272	0	0
2029-30	0	0	0	0	0	0	0	0

Source: Chapter 6.

Table C2 Cashews

	<i>Cashews: breeding</i>		<i>Cashews: flying fox</i>		<i>Tea tree oil: breeding</i>	
	<i>Total cost</i>	<i>Total benefit</i>	<i>Total cost</i>	<i>Total benefit</i>	<i>Total cost</i>	<i>Total benefit</i>
	\$	\$	\$	\$	\$	\$
1985-86	0	0	0	0	0	0
1986-87	0	0	0	0	0	0
1987-88	341 226	0	0	0	0	0
1888-89	336 199	0	19 763	0	0	0
1989-90	313 628	0	18 293	0	0	0
1990-91	218 902	0	17 381	0	12 606	0
1991-92	238 819	0	0	-16 224	12 915	0
1992-93	256 745	0	0	0	63 485	0
1993-94	323 087	0	0	0	147 079	0
1994-95	321 403	0	0	10 863	133 970	0
1995-96	349 743	0	0	16 627	138 953	0
1996-97	0	0	0	34 086	155 126	0
1997-98	0	0	0	40 737	158 232	0
1998-99	0	-79 460	0	42 084	164 826	0
1999-2000	0	-428 500	0	47 593	172 300	0
2000-01	0	-509 047	0	50 503	179 976	0
2001-02	0	-533 435	0	67 795	0	0
2002-03	0	-542 684	0	73 005	0	-666 667
2003-04	0	-518 499	0	79 988	0	255 238
2004-05	0	-471 764	0	89 300	0	517 143
2005-06	0	-399 217	0	100 939	0	825 238
2006-07	0	-318 130	0	114 906	0	1 133 333
2008-09	0	-228 403	0	130 424	0	1 441 429
2009-10	0	-140 276	0	145 943	0	1 749 524
2010-11	0	176 551	0	161 462	0	2 057 619
2011-12	0	235 918	0	176 980	0	2 365 714
2012-13	0	325 805	0	192 499	0	2 673 810
2013-14	0	415 852	0	208 018	0	2 981 905
2014-15	0	495 819	0	223 536	0	3 290 000
2016-17	0	585 866	0	239 055	0	3 598 095
2017-18	0	595 913	0	254 574	0	3 906 190
2018-19	0	8 196 920	0	270 092	0	4 214 286
2019-20	0	0	0	285 611	0	4 522 381
2020-21	0	0	0	0	0	4 830 476
2021-22	0	0	0	0	0	5 138 571
2022-23	0	0	0	0	0	0
2023-24	0	0	0	0	0	0
2024-25	0	0	0	0	0	0
2025-26	0	0	0	0	0	0
2026-27	0	0	0	0	0	0
2027-28	0	0	0	0	0	0
2028-29	0	0	0	0	0	0
2029-30	0	0	0	0	0	0

Source: Chapter 4; chapter 5.

Table C3 Agroforestry: cost reduction 1997-98 dollars

<i>Year</i>	<i>Total cost</i>	<i>Total benefit</i>
	\$	\$
1989-90	194 394	0
1990-91	140 810	0
1991-92	125 773	186 464
1992-93		318 449
1993-94		354 555
1994-95		372 351
1995-96		457 878
1996-97		535 387
1997-98		550 633
1998-99		560 021
1999-2000		563 175
2000-01		524 723
2001-02		484 087
2002-03		442 087
2003-04		398 721
2004-05		353 987
2005-06		307 885
2006-07		260 411
2008-09		211 565
2009-2010		162 622

Source: Chapter 3.

Table C4 **Wildflowers: value of new varieties** 1997-98 dollars

Year	Premiums only		Scenario 1	Scenario 2	Scenario 3	Scenario 4	Scenario 5	Scenario 6	Scenario 7
	Total cost	Total benefit	Total benefit	Total benefit	Total benefit	Total benefit	Total benefit	Total benefit	Total benefit
	\$	\$	\$	\$	\$	\$	\$	\$	\$
1985-86	26 036	0	0	0	0	0	0	0	0
1986-87	2 493	0	0	0	0	0	0	0	0
1987-88	547 480	0	0	0	0	0	0	0	0
1988-89	152 101	0	0	0	0	0	0	0	0
1989-90	119 824	0	0	0	0	0	0	0	0
1990-91	181 072	0	0	0	0	0	0	0	0
1991-92	207 755	0	0	0	0	0	0	0	0
1992-93	458 260	0	0	0	0	0	0	0	0
1993-94	629 672	0	0	0	0	0	0	0	0
1994-95	860 644	157 500	213 145	213 145	223 583	223 583	223 583	279 228	279 228
1995-96	1 067 922	220 500	299 437	335 318	322 562	368 954	461 738	447 891	576 555
1996-97	872 389	220 500	322 758	395 799	360 500	460 500	660 500	562 758	835 799
1997-98	643 217	63 000	188 412	299 069	243 625	403 000	721 750	528 412	957 819
1998-99	402 579	63 000	212 019	361 037	288 250	513 500	964 000	673 781	1 307 087
1999-2000	194 626	763 500	951 636	1 139 772	1 061 956	1 360 413	1 957 325	1 582 591	2 471 633
2000-01	0	763 500	991 521	1 219 542	1 143 136	1 522 773	2 282 045	1 824 193	3 040 729
2001-02	0	868 500	1 137 185	1 405 870	1 337 984	1 807 467	2 746 434	2 211 973	3 855 138
2002-03	0	868 500	1 178 639	1 488 778	1 437 246	2 005 992	3 143 483	2 545 769	4 752 603
2003-04	0	698 500	989 366	1 280 232	1 258 308	1 818 117	2 937 734	2 397 490	4 791 076
2004-05	0	758 500	1 029 677	1 300 853	1 306 251	1 854 002	2 949 504	2 466 520	5 030 527
2005-06	0	288 000	539 064	790 129	820 231	1 352 463	2 416 926	1 990 045	4 698 871
2006-07	0	238 000	468 523	699 046	750 878	1 263 755	2 289 510	1 916 677	4 734 695
2008-09	0	174 000	383 545	593 090	663 285	1 152 570	2 131 141	1 809 491	4 690 600
2009-10	0	90 000	278 125	466 250	551 015	1 012 031	1 934 061	1 660 070	4 547 630
2010-11	0	90 000	256 255	422 511	517 592	945 184	1 800 367	1 570 053	4 397 265
2011-12	0	0	155 001	310 003	418 382	836 764	1 673 528	1 470 167	4 378 645
2012-13	0	0	143 505	287 011	406 528	813 056	1 626 112	1 448 441	4 407 633
2013-14	0	0	131 764	263 528	391 745	783 490	1 566 980	1 413 430	4 387 032
2014-15	0	0	119 773	239 547	373 725	747 450	1 494 899	1 363 645	4 309 540
2016-17	0	0	107 530	215 060	352 132	704 264	1 408 527	1 297 564	4 167 893
2017-18	0	0	95 030	190 059	326 602	653 205	1 306 409	1 213 644	3 955 019
2018-19	0	0	82 268	164 537	296 741	593 483	1 186 966	1 110 337	3 664 212
2019-20	0	0	69 243	138 485	262 122	524 243	1 048 487	986 102	3 289 314
2020-21	0	0	55 948	111 896	222 279	444 558	889 117	839 425	2 824 905
2021-22	0	0	42 381	84 761	176 712	353 424	706 848	668 839	2 266 490
2022-23	0	0	28 536	57 073	124 876	249 753	499 506	472 936	1 610 687
2023-24	0	0	14 411	28 822	66 185	132 369	264 738	250 396	855 405

Source: Chapter 2.

Appendix D Estimates and projections of production data for boronia in Tasmania

Table D.1

[illegible]

Source: NSW Agriculture.

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